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The Fiber Society 2025 Spring Conference

Future Fibers for Wellbeing, Intelligence, and Sustainability

May 21-23, 2025

Conference Chair

Dahua Shou

Venue

The Hong Kong Polytechnic University
Hong Kong

Final Program

Wednesday, May 21

- 7:00 Registration, Fashion Gallery, Jockey Club Innovation Tower (V230)
- 7:30 Continental Breakfast, Jockey Club Innovation Tower (Block V, Third Floor)
- 8:30 Welcoming Remarks and Announcements (Jockey Club Innovation Tower, V322)

Dahua Shou, Conference, Chair Meifang Zhu, President, The Fiber Society

Christopher Chao, Vice President (Research and Innovation), The Hong Kong Polytechnic University

9:00 Plenary Lecture: Meifang Zhu, Donghua University

Fibrous Materials for Sustainable Energy Plenary Lecture: Rudolf Hufenus, Empa

9:40

Challenges and Opportunities of Bicomponent Fiber

Moderator: Xungai Wang, The Hong Kong Polytechnic University

10:20–10:30 Break (Jockey Club Innovation Tower (Block V, Third Floor)

Morning Sessions

	V322	V302	V303	V313
	Session: New and	Session: Intelligent Fibers	Session: Healthcare and	Session: Fibers for Comfort
		and Wearable Technologies		and Protection
	Materials			Chairs: Dong Wang;
	Chair: Pibo Ma			Dongliang Zhao
10:30	8		Electrospun Fibers in	Study on Preparation and
Keynote		Sensitive E-fabric via Contact		Industriliaztion of Smart
		1 0 33 3	Sensors, Thermal,	Thermo-moisture
	*	of Everything Smart Home	Management, and Biomedical	
	8			Dong Wang, Wuhan Textile
			Jinlian Hu, City University of	University
		-	Hong Kong	
10:50			3	Permanent Antibacterial and
	2 0		Braided Electrospun	Odor-absorbing Nylon
			Polycaprolactone Graft for	Through Extrusion Chemistry
			Anterior Cruciate Ligament	Vitali Lipik, Nanyang
	1	,	Reconstruction	Technological University
	Nebraska-Lincoln	University	Jinrong Lin, Botnar Research	
			Centre	
11:05	0 1	Tough and Conductive	Multifunctional Artificial Skin	
			for Accelerating Wound	Fabrication of Functional
				Materials for
				Electromagnetic Pollution
	Polytechnic University	Polytechnic University	University	Elimination
				Hailong Xu, Northwestern
				Polytechnical University
11:20			open	High-performance
		Liwen Huang, Hong Kong		Waterproof and Breathable
		Polytechnic University		Nanofibrous Membranes
	Enhanced Resilience and			Xiaobao Gong, Hong Kong
	Mechanochromic Sensitivity			Polytechnic University
	Wenwen Wang, Wuhan			
	Textile University			

11:35	Cu2O/PLA Composite	open	open	Diapers with Next-to-Skin
	Fibers with Trace			Moisture-adaptive
	Coordination Bond			Embossment for Improved
	Crosslinking Networks:			Comfort
	Enhanced Mechanical			Lijun Wang, Hong Kong
	Properties, Antibacterial			Polytechnic University
	Activity, and Recycling			
	Menglong Du, Anhui			
	Agricultural University			

11:50–1:30 Lunch (U Garden)

Afternoon Sessions

	V322	V302	V303	V313	
	Session: New and Advanced Fibrous Materials Chair: Pibo Ma	Session: Intelligent Fibers and Wearable Technologies Chair: Mingwei Tian	Session: Healthcare and Biomedical Applications Chairs: Jinlian Hu; Xianfeng Wang	Session: Fibers for Comfort and Protection Chairs: Dong Wang; Dongliang Zhao	
1:30 Keynote	open	Acoustic Fibers and Fabrics Wei Yan, Donghua University	Smart, Personal, Microclimate Health Management Textiles Xianfeng Wang, Donghua University	Flexible Radiative Cooling Fiber Meta-fabric with Prolonged Phase-change Thermal Storage Properties Dongliang Zhao, Southeast	
1:50	High-performance Liquid Crystalline Polyarylate and Its Composites Qingbao Guan, Donghua University	Intelligent Wearable Impact with Core-Shell Fiber Technology Haiqing Liu, Hong Kong Polytechnic University	Biomimetic Dry Spinning of Touch and Bioactive Protein Fibers Zhangyuan Cheng, Westlake University	University Development of Flexible Aerogel Blanket for Thermal Insulation Harun Venkatesan, IIT- Delhi	
2:05	3D Self-folding All-weather Fabric Xiaohui Zhang, Hong Kong Polytechnic University	Elastic Smart Fibers and Integrated Wearable Smart Textile System for Human Motion and Physiological Monitoring Yuting Wu, Soochow University	Thermal Transfer, Printed, Flexible, and Wearable Bionic Skin with Bilayer Nanofiber for Comfortable, Multimodal Health Management Xinshuo Liang, City University of Hong Kong	Bioinspired Multilayered Knitted Fabric with Directional Water Transport and Collection for Personal Sweat Management Qing Chen, Donghua University	
2:20	open	Mechanical Assembly of Double Carbon Coupling Enhancement for Highly Stretchable, Flexible, and Smart Wearable Applications Gazi Farhan Ishraque Toki, Hong Kong Polytechnic University	open	Thermal Responsive Hydrogels with Programmable Shape Memory Properties by Phase Separation for Personal Protective Equipment Wen Mei, Hong Kong Polytechnic University	
2:35-3:00	O Break (Jockey Club Innov	ation Tower, Block V, Third F	loor)		
3:00	Stretchable Ceramic Aerogels with Binary Topology Network for Thermal Insulation Xuan Zhang, Donghua University	Multilevel Feature Representation Learning for Wearable Sensor-based Gesture Recognition Zhuang Li, Hong Kong Polytechnic University	Design, Fabrication, and Characterization of Fibrous Acoustic Sensing Membrances for Biomedical Applications Wenbo Li, Hong Kong Polytechnic University	Smart Thermoregulating Fabric: Passive Radiative Cooling with Comfortable Breathability Qingtao Liu, Wuhan Textile University	

3:15	open	AI-driven Multimodal	Construction of Self-	Shock-resistant
		Sensors for Object	reinforced Networks with	Triboelectric Generator for
		Recognition	High-crystallinity Silk	Intelligent Firefighting Suit
		Chengzhao Kuang, Hong	Nanofibrils for Ultrafine	Guanwei Liang, Hong Kong
		Kong Polytechnic University	and Biodegradable	Polytechnic University
			Recycled Regenerated Silk	
			Fibroin Monofilament	
			Sutures	
			Xin Zhang, Soochow	
			University	
3:30	open	open	Bionic Micro-nanofibers	An Oriented Layered Nano-
			and Sustainable Materials	CaCO3 with Enhanced Fire
			Shuo Shi, Hong Kong	Resistance and Acoustic
			Polytechnic University	Insulation Performance
				Jiawei Pan, Anhui
				Agricultural University

4:00-6:00 Poster Session and Reception, Fashion Gallery, Jockey Club Innovation Tower, V230

Thursday, May 22

8:00 Continental Breakfast, Jockey Club Innovation Tower (Block V, Third Floor)

Jockey Club Innovation Tower, V322

9:00 **Plenary Lecture:** Lim Chwee Teck, National University of Singapore Liquid Metal Innovation: Development of Next-Gen Wearable Sensors

9:40 **Plenary Lecture:** Greg Rutledge, Massachusetts Institute of Technology Nanofiber Technology for Respiratory Personal Protection Equipment (PPE)

Moderator: Dahua Shou, The Hong Kong Polytechnic University

10:20–10:30 Break (Jockey Club Innovation Tower V, Third Floor)

Morning Sessions

	V322	V302	V303	V313
	Session: Sustainable Fibers and Textiles Chair: Yang Si	Session: Fiber-based Sensors, Actuators, and Batteries Chairs: Jian Fang; Gang Wang	Session: Fibers for Energy and Environment Chairs: Zhigang Chen; Jian Zhou	Session: New and Advanced Fibrous Materials Chairs: Xuqing Liu; Wei Zhang
10:30 Keynote	Development of Reusable, Biodegradable, and Biocidal Fibrous Filtering Materials for Facemasks Gang Sun, University of California-Davis	Electroactive Fibrous Materials and Textile Structures Jian Fang, Soochow University	Photothermal Fabrics for Solar-driven Seawater Desalination Zhigang Chen, Donghua University	Fiber Surface/Interface Modification: Functionalization and Advanced Applications in Multifunctional Fiber Xuqing Liu, Northwestern Polytechnical University
10:50	3D Printing Flexible Textile Using Polyester- Textile-Recycled Filaments Lingquan Hu, Hong Kong Polytechnic University	Developing Bicomponent Conductive Fibers for Smart Wearables via Experimental and Simulative Approaches Hang Liu, Washington State University	Multifunctional Mxene@CNT Coaxial Fiber for Balanced Mechanical Properties, Electrical Conductivity, and Specific Capacitance Jizhen Zhang, National Institute for Materials Science	Synthetic Reversible Fibrous Network Hydrogels Based on a Double-Helical Polyelectrolyte Yongjun Men, Donghua University

11:05	Cellulose Dissolution for	Metallic Yarn Coating as a	High-safety, Fiber-based	Effect of Electrospinning
	Sustainable Fibers: Can New Lithium-ion Battery		Battery Separators	Environmental Conditions
	Machines Aid Our	Electrode Configuration:	Guiyin Xu, Donghua	on the Morphology of
	Leaning?	Formulation and	University	Aramid Nanofibers
	Lucas Rosson, Deakin	Implementation of Filled		Dominique Adolphe,
	University	Polymer Blends		Université de Haute-Alsace
		Aurélie Cayla, Université de		
		Lille		
11:20	open	A Novel Gold, Nanoparticle-	Assessing the Energy	MXene Fibers for Future
		modified, Laser-induced	Harvesting Performance of	Textiles
		Graphene Electrochemical	Electrospun Nylon	Ken Usman, Deakin
		Sensor with a Multistate Pore	11/Glycene	University (on behalf of
		Structure for Dinotefuran	Nanocomposite: Unique	Joselito Razal)
		Pesticide Detection	Soft Material for	
		Xinliang Mei, Nanjing	Piezoelectric Applications	
		Agricultural University	Swagata Banerjee, IIT-	
			Delhi	
		L	Penn	L

11:35–1:30 Lunch (U Garden)

Afternoon Sessions

	V322	V302	V303	V313
	Session: Sustainable Fibers and Textiles Chair: Yang Si	Session: Fiber-based Sensors, Actuators, and Batteries Chairs: Jian Fang; Gang Wang	Session: Fibers for Energy and Environment Chairs: Zhigang Chen; Jian Zhou	Session: New and Advanced Fibrous Materials Chairs: Xuqing Liu; Wei Zhang
1:30 Keynote	Nanofibrous Aerogels: Progress in Materials, Properties, and Applications Yang Si, Donghua University	Fiber-shaped Organic Electrochemical Transistors and Proactive Healthcare Applications Gang Wang, Donghua University	Nature-inspired Strategies for High-performance Fibrous Aerogels Jian Zhou, Sun Yat-sen University	Microfluidic Fiber Spinning Chemistry (FSC) and Beyond Su Chen, Nanjing Tech University
	A Novel Method for Producing High-quality Yarn and Fabric from Recycled Fibers (Cotton/Polyester) at High Speeds Ruihua Yang, Jiangnan University	The Design of Fiber- based Bacterial Sensors Zhentan Lu, Wuhan Textile University	Wearable PEDOT: PSS/DVS-coated Yarn- type, Transpiration-driven Electrokinetic Power Generator with High- power Efficiency and Water Stability Byungil Hwang, Chung- Ang University	MXene-functionalized Textile Wastes and End-of-Life Garments for Wearable Electronics and Thermal Regulation Ken Usman, Deakin University
2:05	The Eco-friendly Choice of R-PET: Which is the Best Way? Yurong Yan, South China University of Technology	High-performance Fiber Strain Sensors for Wearable Healthcare Shaowu Pan, Donghua University	Turning Waste into Treasure: One-way Fluidic Janus Evaporator from Discarded Fabrics for Efficient Solar Desalination Xinghang Liu, Hong Kong Polytechnic University	Skin-like Sweating Simulator Qirui Zhang, Hong Kong Polytechnic University
2:20	Protein Paper from Microfibrillated Silk Limna Suja Shaji, Deakin University	Fiber Bragg Sensors for Precise Monitoring for the Next Generation Secondary Batteries Chunghyeon Choi, Chung-Ang University	Research on Bio-inspired Nanofibrous Electrocatalyst with Confined Channels for Enhanced ORR/OER Performance Han Li, Hong Kong Polytechnic University	Biomimetic Graphite-Aerogel Conductors with Interface- coherent Superlattices Ting Wang, Donghua University

2:35	Green Fabrication of	Smart Liquid Crystal	Influence of Nonwoven	Hydrovoltextile
	Chitosan Fibrous Membrane	Elastomer Fibers: From	Manufacturing	Ning Li, Hong Kong
	via Organic-Inorganic	Actuator to Soft Robots	Methodologies on the	Polytechnic University
	Hybrid Strategy for Anti-	Zhongqiang Yang,	Energy Harvesting	
	adhesion Applications	Tsinghua University	Performance of Nonwoven-	
	Liping Zhu, Donghua		based Triboelectric	
	University		Nanogenerators	
			Chirantan Shee, IIT-Delhi	
2:50	Functional Synergy	open	Beyond Powder Catalysts:	Biomimetic Bouligand Chiral
	Mechanism and Textile		Fiber-immobolized ZIS and	Fibers Array Enabales
	Application Innovation of		CZS Photocatalysts with	Strong and Superelastic
	Biobased PLA and Wool		Electron-mediated and	Ceramic Aerogels
	Blended Materials		Piezoelectric Synergy for	Hongxing Wang, Donghua
	Yihu Yang, Shenzhen Esun		Scalable Hydrogen	University
	Industrial Co., Ltd.		Generation	
			Yu-qing Liu, Soochow	
			University	

3:05-3:15 Break (Jockey Club Innovation Tower V, Third Floor)

	V322	V302	V303	V313
	Session: Sustainable Fibers and Textiles Chair: Yang Si	Session: Fiber-based Sensors, Actuators, and Batteries Chairs: Jian Fang; Gang Wang	Session: Fiber Composites and Industrial Textiles Chair: Kelvin Fu	Session: Healthcare and Biomedical Applications and Interdisciplinary Research Chair: Zhengwei You
3:15 Keynote	open	Enabliing All-Solid-State Lithium-Sulfur Batteries with Functional Fibers and Nanofibers Xiangwu Zhang, NC State University	Continuous Fiber Composite 3D Printing Kelvin Fu, University of Delaware	Versatile Dynamic Poly(oxime-urethane)s Enabling Covalently Crosslinked Fibers Zhengwei You, Donghua University
3:35	Fibrillation of Bacterial Cellulose: Its Characterization and Applications Thabisile Jele, Deakin University	Dual-responsive Yarn- based Artificial Muscles Mengjiao Pan, Hong Kong Polytechnic University	Mechanical Property Analysis of Wool Fiber- reinforced Composite Materials Marcin Barburski, Lodz University of Technology	Theranostic Wound Dressings: Four Strategies for Enhancing Sensitivity and Accuracy in Detecting Bacterial Infections Without False Positives Song Liu, University of Manitoba
3:50	A Green Strategy to Recycle Waste PP Meltblown Materials: From 2D to 3D Construction Xiaoxia Sun, Donghua University	Nanocellulose and Two- dimensional, Flexible, Conductive Composite Materials Sufeng Zhang, Shaanxi University of Science & Technology	Experiment and Numerical Analysis of the Impact Performance of Wool/PLA Composites Zbigniew Stempien, Lodz University of Technology	Assessment of Wearable Cooling and Dehumidifying System Used Under Personal Protective Clothing Through Human Subject Testing Yiying Zhou, Hong Kong Polytechnic University
4:05	Mimicking the Hierarchical Structure of Spider Silk: Pseudoprotein Nanofiber Yarns with Unprecedented Toughness Lin Tan, Sichuan University	Van de Waals Fibers for Flexible and Stretchable Electronics Ziqi Li, Hong Kong Polytechnic University	Fabrication and Optimization of Continuous, Fiber- reinforced, Suspended Architecture by Self- supporting Suspension Printing Ke Dong, Hong Kong Polytechnic University	Wound Dressing with Janus Fabric Xuchen Wang, Hong Kong Polytechnic University
4:20	Recycling Post-consumer Cotton Waste for Lightweight Foams Hongqing Shen, Cotton Incorporated	open	Machine Learning-based Method of Damage Detection in Fiber- reinforced Plates Evgeny Morozov, University of New South Wales	Fibrous Materials for Medical Implants: Durability Issues Frédéric Heim, Université de Haute-Alsace

1.35 1.15	Brook (Lockey	Club Innovation	Tower V. Third Floor)

	V322	V303	V312	V313
	Session: Sustainable Fibers and Textiles Chair: Yang Si	Session: Fiber-based Sensors, Actuators, and Batteries Chairs: Jian Fang; Gang Wang	Session: Fiber Composites and Industrial Textiles Chair: Kelvin Fu	Session: Healthcare and Biomedical Applications and Interdisciplinary Research Chair: Zhengwei You
4:45	Applicability of Asian Urticaceae Fibre Isolation Protocol to European Species Samica Sadik, University of Helsinki	Chiral Origami Impact Protector and Sensor Zhen Wang, Hong Kong Polytechnic University	Robust PBO/Liquid Crystal Polymer Composites for Flexible Triboelectric Nanogenerators in Harsh Environment Xiaolan Qiao, Donghua University	Rational Design of Micro- and Nano-fibrous Spheres for Efficient Stem Cell Delivery and Tissue Repair Xiaopei Zhang, Qingdao University
5:00	Rc-TPA-based MOF from PET Fiber for Dye Removal Fabien Salaün, Université de Lille	Flexible, Biocompatible Electrodes for Wearable and Implantable Devices Junjie Wang, Hong Kong Polytechnic University	Moisture Management E- Textiles Jun Wan, Hong Kong Polytechnic University	AlN Ceramic Aerogels with Unprecedented Thermocapillary Properties for Thermal Cooling Shengnan Meng, Donghua University
5:15	Tannin-rich Fruit Epicarp Extract-treated Multifunctional Cellulosic Textiles: Valorization of Biowaste Sourav Banerjee, IIT-Delhi	Regenerated Cellulose Acetate Photonic Fibers- derived Aerogel Boards for On-demand Building Thermal Regulation and Carbon Reduction Shuangjiang Feng, Southeast University	Dynamic Radiative Thermal Management by Photothermal Conversion and Phase Change Danyuan Huang, Hong Kong Polytechnic University	Research on Material Innovation and the Development of Inclusive Fashion Products Hui Tao, Wuhan Textile University
5:30	Body Odour Management Performance of Different Fibers and Blends JinfengWang, Wuhan Textile University	Wearable Textile Sensors for Human-Computer Interaction and On-body Applications Ziqian Bai, Southern University of Science & Technology	Grapahene Fiber-based, High Thermal Conductivity Composite: Preparation and Application Exploration Yingjun Liu, Zhejiang University	Functional and Multicolor Super-resolution Nanoscopy of Subcellular Fibers Yang Zhang, NC State University
5:45	Controllable Fabrication and Applications of Cellulose-based Gels and Fibers Weiqing Kong, Donghua University	open	open	Biomechanical Modeling of Force Transfer and Deformation in Body-Garment Interactions Jun Zhang, Wuhan Textile University

6:00–8:30 Banquet and Awards Ceremony: Ju Yin House Seafood Restaurant, 4/F, Communal Building Banquet Speaker: Prof. Jintu Fan, The Hong Kong Polytechnic University

A Brief Account of the History and Prospects of Hong Kong Textile and Fashion Industry

Friday, May 23

8:00 Continental Breakfast, Jockey Club Innovation Tower (Block V, Third Floor)

Jockey Club Innovation Tower, V322

8:40 Plenary Lecture: Emmanuel Giannelis, Cornell University

Non-fluorinated Oil and Water Repellent Coarting for Fabrics and Textiles

9:20 **Plenary Lecture:** Xiaoming Tao, The Hong Kong Polytechnic University Fiber-based Sensory Emulation Mechanisms and Intelligent Wearable Technology

Moderator: Jintu Fan, The Hong Kong Polytechnic University

10:00–10-30 Break (Jockey Club Innovation Tower V, Third Floor)

Morning Sessions

	V312	V302	V303
	Session: AI, Robots, Metaverse, and Emerging Technologies Chair: Yurong Yan	Session: Modeling, Mechanics, and Fiber Testing Chair: Yingjun Liu	Session: Fibers for Comfort and Protection Chair: Yucan Peng
10:30 Keynote	open	open	Design of Micro/Nano Regulation Materials for Personal Thermal Management Yucan Peng, Peking University
10:50	Textile-based Circuits and Devices for Wearable Applications Qiao Li, Donghua University	Accurate Identification of Coating on Irregularly Shaped Fibrous Network Using Submicron Infrared Spectroscopy Michael Lo, Photothermal Spectroscopy Corp.	Coaxial Tubes Cooling System for Enhanced Personal Thermal Management Hongfei Yang, Hong Kong Polytechnic University
11:05	Versatile Soft Robots Enabled by Hierarchically Programmed Fabric Metasurfaces Fengxin Sun, Jiangnan University	Local Plastic Deformation in Warp- knitted Spacer Fabrics: Insights from Strain Redistribution Jing Huang, Donghua University	One-way Water Transport Denim Ziqi Wang, Hong Kong Polytechnic University
11:20	AI-enabled Real-Time Multimodal Physiological Analysis Jing Tao, Hong Kong Polytechnic University	Kinetics and Thermodynamic Modeling of Melt Spinning Hui Wang, Donghua University	Polymer UV-aging Resistance: Insights from Degradation Mechanisms and High-throughput Screening Yingwei Xie, Donghua University (on behalf of Jin Wen)

11:35 Close of Conference

Poster Session

Wednesday, May 21 Time: 4:00 p.m.—6:00 p.m. Fashion Gallery, V230

Title

Development of Velvet-like Textile Design Adoptable for Polyjet Additive Manufacturing

Session Chair: Xiangwu Zhang

Presenter

2. Sunhee Lee

Trescriter	
1. Pan Wu	Design and Properties Analysis of Highly Entangled Hydrogel Optical Fibers

Processes
 Chuhao Ma
 Dual-response Cholesteric Liquid Crystal Elastomer Sheath-Core Bicomponent Fiber

4. Jooyoun Kim

Direct Synthesis of MIL-88B(Fe) on Iron Wire for Gas Adsorption

5. Ruili Wang Surface Modifications of Short Quartz Fibers for Dental Composites

6. Yifan Liu Green Preparation of Bio-based Fibrous Membrance via Solution Blow Spinning

7. Yan Yu Structural Modulation of Melt-Spun Nanofiber-reinforced Silica Hybrid Aerogel Felts for

Thermal Insulation in Extreme Environments

8. Yuxi Wu Fibrovascular Structures Enhnaced Evaporative Cooling Fabric

9. Man Liu A Machine Learning-enabled Real-Time Temperature Response System Based on

Polymer-Filler Interactions for Conductive Network Assembly

10. Jiahao Lu Scalable Compliant Graphene Fiber-based Thermal Interface Material with Metal-level

Thermal Conductivity via Dual Field, Synergistic Alignment Engineering

11. Jiahao Zheng	Intergrated Dynamic Wet Spinning of Hydrogel Optical Fibers with Dual Core for Real- time Blood Oxygen Sensing in Vivo
12. D. Chowdhury	Analysis of 3D-printed Longitudinal Flat Foot Pads with Lattice Structures Using Various Microfoaming Filaments
13. Imjoo Jung	Analysis of Fully 3D-printed Shoes Prepared by Microfoaming Filament Based on Additive Manufacturing
14. Xulian Hu	An Expandabale Antigelation Spinning Method of Preparing Liquid Crystal Elastomer Fibers with High Orientation, Reliable Actuation for Biomimetic Devices
15. Wanying Luo	Texture Exploration and Design Practice of Traditional Tie-Dyeing Handicraft
16. Xinshuo Liang	A Non-enzymatic Flexible and Wearable Sensor Based on Thermal Transfer Printing Technology for Continuous Glucose Detection in Sweat
17. Songhan Shi	Highly Conductive Graphene Fiber Textile for Electromagnetic Interference Shielding
18. Taeryn Kim	Water-responsive Properties of Mushroom-derived Pulps
19. Gangfeng Cai	Ultrastiff and Highly Thermally Conductive Graphene Fibers
20. A. Jayakumar	Microbial Colour Using Textile Fibre Waste
21. Jaewon Lee	Hydration-driven Fibril Aggregation in Mushroom-derived Chitin Fiber
22. Qingqing Liu	Surface Wettability Modulation of Fibrous Membranes for Enhanced Performance via PDA-assisted Modification
23. Luning Yuan	Directional Liquid Transport Textiles via Embroidery: Softness and Stretchability Retained
24. Rong Yin	Scalable Embroidered Textile Pressure Sensors for Smart Wearables
25. Qixuan Zhu	Rigid-Flexible Coupling Poly(phenylene sulfide) Fiber Membrane: A Highly Stable Chemical and Thermal Material for Energy and Environmental Applications
26. Long Yu	Fiber Separator Materials for Metal-Ion Batteries
27. Fengfei Deng	A Numerical Model of Multimode Temperature-adaptive Thermoregulatory Fabrics
28. Yue Yu	Highly Thermally-conductive and Structurally Interfacial Stable Graphene Fiber/Carbide Composite Fiber Applied for Thermal Protection System
29. Qianqian Zhang	A Smart Soft Actuator Based on Graphene Aerogel Fiber and Liquid Crystal Elastomer
30. Seungsin Lee	Development and Evaluation of Multilayered Textile Systems for Enhanced Moisture Transport
31. Jeein Choi	Environmental Impacts of Viscose Rayon and Lyocell Production
32. Yingwei Xie	Molecular Dynamics Simulations of PA6T/6I Copolymer Properties: A Comparision of Machine Learning and Traditional Force Fields
33. Sai Yan	A Pro-angiogenic Wound Dressing Embedded with Natural Spider Silk Protein
34. Sohyun Park	Influence of Washing and Drying Conditions on the Surface Chemistry and Clothing Pressure of Smart Textiles
35. Somin Lee	Predicting Softness and Drapability via CNN

36. Binbin Fan	Multi-interfacial Interaction Engineered Underwater Superelastic Covalent Framework Aerogels for Photoinduced Uranium Extration
37. Yoojung Han	Quantitative Fabric Classification and Prediction Based on Drapability and Tactile Properties
38. Suhyun Lee	Comparision of Desorption and Re-adsorption of MIL-53(Fe)@cotton Fabric Under Various Dyes and Washing Conditions
39. Supun Mohotti	Blending Silkworm and Recombinant Spider Silk to Engineer Fibers with Customized Properties
40. Jingya Song	Mechanically and Conductively Robust Eutectogel Fiber Produced by Continuous Wet Spinning Enables Epidermanl and Implantable Electrophysiological Monitoring
41. Qihua Li	Eco-friendly Skin-inspired Micro-Nano Structured Cellulose Composite Fibers for Higly Efficient Daytime Radiative Cooling
42. Zhengwei You	Biomimetic Elastomers and Their 3D-printed Fibrous Devices for Biomedical Applications
43. Qingbao Guan	Chemistry and Rheological Behavior of Cross-linked Liquid Crystal Polyarylate with a Mixed End-capping Strategy
44. Fu Rui	Research on Safety Warning Design of Night Running Protective Gear Based on Triboelectricity
45. Su Hui	Degradable Microvascular Repair Cuff Tube
46. Bi Xu	Green Urethane Coating for Mechanically Durable Superhydrophobic Fabric
47. Jinli Piao	Trends in Critical Pressure Thresholds for Lower Limb Oedema Reduction Under Various Physiological Parameters and Dual Mode Compression Trial Effect
48. Shengyang Tang	Fast Uniform Fluid Distribution in Network-structured Wearable heat Transfer Panel
49. Li Xu	Ultralight and Superelastic Gd_2O_3/Bi_2O_3 Nanofibrous Aerogels Enables Efficient X-ray Absorption
50. Donghwi Kim	Development of Screen-printed Electrode Designs for EMG and Evaluation of Their Applicability to Clothing
51. Yen Truong	Development of Cell Lysis Fibrous Material for Continuous Manufacturing of Carotenoids from Recombinant Escherichia coli
52. Hyelim Kim	Study on Solid-State Polymerization and Melt Spinning for Mechanically Recycled PET
53. Byungil Hwang	MXene/CNT/ZnO-WO ₃ Ternary Composite: A Multifunctional Textile Platform for Wearable Applications
54. Bin Gu	Spectrally Selective Radiation Meta-fabric with Enhanced Thermo-moisture Management Performance
55. Yang Hong	Enhancing Heat Transfer in Pulsating Heat Pipes Using Fabric-like Structures

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We Gratefully Acknowledge Our Supporting Journal



Plenary Speakers

Fibrous Materials for Sustainable Energy

Guiyin Xu, Zexu Hu, Hengxue Xiang, Liping Zhu, Meifang Zhu

State Key Laboratoy of Advanced Fiber Materials, College of Materials Science and Engineering, Donghua University, Shanghai, China

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As the global energy structure transistions toward green, low-carbon, and sustainable development, fibrous materials, with their advantages of strong designability, multi-functional integration, and environmental friendliness, have demonstrated great potential in the fields of energy utilization and storage. The issue of resource scarcity is particularly prominent nowadays; sustainble energy is one of the important means to address this problem. From energy production to storage, fiber-based materials have provided breakthrough solutions for the high-efficiency, lightweight, and flexibility of sustainable energy. Fibrous materials, as a bridge connecting energy applications, are evolving from single-function to systematic and intergrated directions. Through interdisciplinary collaboration and in-depth integration of industry, academia, and research, fiber technology is expected to provide key material support for the carbon neutrality goal and to open a new chapter in the energy revolution. In this work, we will focus on high-thermal insulation fibers for the thermal insulation components of solar devices, on high-strength and ultra-lightweight fibers for the blades of wind turbines, and especially for battery separators for energy sotrage devices [1-3]. The traditional polyolefin separator has some problems, such as poor thermal stability and insufficient electrolyte wettability. To address this challenge, fiber-based separators play an important role in inducing the formation of a stable solid-state electrolyte interface, suppressing dendrite growth, and increasing battery life [4-5]. Moreover, the development of bio-based separators has further promoted the environmental friendliness of battery components, providing lightweight, highly safe, and sustainable key material support for the next generation, high-performance, energy storage systems.

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Challenges and Opportunities of Bicomponent Fibers

Rudolf Hufenus

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In the last 80 years, melt-spun fibers became by far the most important fibers for apparel, but even more so for technical textiles, where they spawned a myriad of novel applications. With bicomponent melt-spinning, several functionalities can be combined in one filament, thus expanding the array of possible fiber performance characteristics. In addition to the high controllability of cross-sectional configuration, the bicomponent approach also combines advantageous mechanical, physical or chemical properties of two materials in one fiber. The field has shown steady and continuous progress since its introduction in the 1960s; it is high time to summarize the technology from a contemporary point of view, with a strong focus on novel developments.

Liquid Metal Innovation: Development of Next-Gen Wearable Sensors

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We will delve into the innovative integration of liquid metal into wearable sensor technology, highlighting its transformative impact on human-interfaced electronic systems. Liquid metal, known for its outstanding conductivity and fluidity, paves the way for the development of flexible and stretchable electronics that far exceed the capabilities of traditional rigid conductors. This innovation opens up new horizons in the design and functionality of wearable devices, offering enhanced adaptability and performance.

First, we will cover an innovative wearable microtubular sensor, that features a liquid-state conductive core encapsulated within a soft silicone elastomer microtube, a design that grants it exceptional force sensitivity. This sensitivity is crucial for a variety of biomedical applications, including the precise tracking of physiological signals, facilitating refined human-machine interactions, and advancing the development of sensing gloves, which require nuanced feedback and responsiveness.

Second, we will introduce a bilayer liquid-solid conductor (b-LSC), a pivotal advancement in the field. The b-LSC serves as a seamless interface between rigid and elastomeric substrates, overcoming the traditional limitations of interfacing different materials. This innovation not only enhances connectivity with rigid electronics but also ensures ultra-high strain-insensitive conductivity and unparalleled stretchability. These properties are essential for creating durable and reliable wearable electronics that can endure the demands of real-world use without compromising performance.

The b-LSC's capabilities support a wide array of applications, including the development of sensor arrays capable of detailed environmental interaction, as well as interactive optoelectric electronic skins (E-skins), which offer new possibilities for touch-sensitive displays and interfaces. These advancements could benefit applications ranging from healthcare to human-machine interface, where responsive and adaptive electronics are increasingly critical.

These innovations have the potential to shape the future of wearable electronics through the groundbreaking use of liquid metal. This could unlock new possibilities and applications, driving the next wave of technological advancement in wearable devices and ushering in a new era of innovation and functionality.

Nanofiber Technology for Respiratory Personal Protection Equipment (PPE)

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MOTIVATION

Airborne transmission via aerosolized droplets is the major mode of transmission for many respiratory viruses, including SARS-CoV-2 (COVID-19). The global COVID-19 pandemic demonstrated the effectiveness of respiratory PPE (facemasks and filtering facepiece respirators, FFR) as a tool for mitigating the spread of viral disease. The N95 respirator and its international analogues such as the KN95 and FFFP2 were widely regarded as the gold standard in respiratory protection by first responders such as fire, police, and healthcare workers, as well as the general public. These respirators rely on an SMS filter assembly consisting of a tri-layer of spunbond, meltblown and spunbond polypropylene fibrous nonwovens, in which an electrostatically charged meltblown polypropylene is the active filtration layer. However, the pandemic also revealed certain deficiencies of these media, which include capital-intensive manufacturing processes, performance degradation in the presence of heat or humidity, limited shelf life, and a potentially large environmental footprint. To address these problems, we are motivated to develop alternative technologies that are more robust and can be scaled up quickly and reliably. Electrospinning is one such technology, suitable for manufacturing nonwoven filter media comprising submicron diameter fibers ("nanofibers") with controlled morphology that can be manufactured from a wide selection of materials. Electrospun nanofibers have found applications in tissue engineering, green energy, high performance materials, catalysis, and industrial filtration, to name a few. Previous experiments and modelling suggest that nanofiber media can have a much higher aerosol collection efficiency compared to microfibers for a comparable air resistance. Thus, electrospun fiber technology has the potential to open up new space for the design of respirators that satisfy international standards.

RESULTS

In this talk, we first discuss the design of electrospun polyacrylonitrile (PAN) aerosol filters for filtration applications and propose a simple graphical method that facilitates the design process, balancing filtration efficiency against pressure drop (or breathability). We also compare our experimental observations for a subset of materials to existing models for aerosol filtration and pressure drop and observe quantitative agreement with no adjustable parameters. We also consider issues related to the practical implementation of these materials into respirators. We demonstrate the fabrication and testing of FFRs that meet the N95 standard using a novel SNS filter assembly comprising a tri-layer of spunbond, *nanofiber* and spunbond fibrous non-wovens, an illustration

of which is shown in Figure 1. The nanofiber active layer can satisfy the N95 standard with or without electrostatic charging. We then demonstrate that the same or better performance can be realized using electrospun filtration media based on polycaprolactone (PCL), a commercially available, biodegradable polymer, as the active layer. PCL nanofiber media are then shown to degrade by a surface-mediated mechanism, with degradation kinetics that are orders of magnitude faster than conventional PCL particles, fibers, and films.

ACKNOWLEDGMENT

Financial support from the Massachusetts Emergency Response Team (M-ERT) and from the U.S. Army ARDEC (W15QKN-16-3-0001) and U.S. Department of Commerce (70NANB22H009) via Advanced Functional Fabrics of America (AFFOA) is gratefully acknowledged.

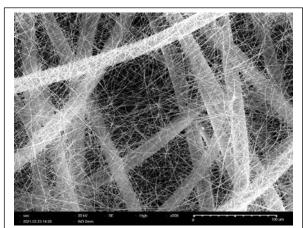


Figure 1. An illustration of electrospun PAN nanofibers (average diameter 213 ± 31 nm) deposited on a 23 gsm support of spunbond polypropylene (average fiber diameter of 23 ± 2 µm). The scale bar is 100 µm.

Non-fluorinated Oil and Water Repellent Coatings for Fabrics and Textiles

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Hydrophobic and oleophobic coatings are critical in several consumer products and industrial applications, including textile finishing, electronics protection, antifouling, and various household appliances. The active ingredients of these coatings are typically low-surface energy materials, with fluorine-based chemicals used most frequently. However, polyfluorinated compounds are resistant to degradation and persist in the environment. They also tend to bioaccumulate, and some of them have been linked to adverse health effects. As a result, the industry is under significant pressure to remove fluorine-containing compounds from their products. However, finding practical replacements with the same level of performance has proved challenging. In this talk, I will review our efforts to develop solvent- and water-based hydrophobic/oleophobic coatings built on alternative chemistries. Specifically, I will present a new coating technology based on silicone chemistry. The method involves coating a substrate with a solution or an emulsion of the polymer followed by an optional curing step to coalesce or crosslink the polymer. In some instances, the properties of the polymer coatings are enhanced by the presence of nanoparticles. Lastly, the performance of these coatings will be presented and discussed and an outlook for the technology will be provided.

Fiber-based Sensory Emulation Mechanisms and Intelligent Wearable Technology

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True human-like perception emulation technology aims to replicate human sensory experience. Although modern technology has solved the simulation of vision and hearing well, there are few wearable technologies for tactile and olfactory emulation based on scientific mechanisms. In this paper, we propose to explore and reveal the operating mechanisms of human mixed odor olfaction and multi-sensory tactile simulation by studying multimode sensory emulation wearable devices, and develop key technologies and their applications. This interdisciplinary research is based on and extends the team's past academic research foundation in flexible materials, sensors and actuators, wearable systems and biomedical applications, electronic fabrics, artificial intelligence, mathematics, acoustics, and signal processing. It also benefits from the team's long-term cultivation of solid engineering application and technology transfer capabilities, including the case that was rated as an internationally leading case by the Engineering Group and the Science Group in the Hong Kong Research Grants Council's social impact assessment. The research and development goals include human-like olfactory emulation technology that perceives and simulates mixed odors through artificial intelligence control; human-like fabric tactile simulators that can perceive and adjust interface forces and temperatures by changing hardness, size, surface morphology, and thermal properties; wearable fabric-based acoustic stethoscopes; and continuous detection of the location and intensity of sounds produced by internal organs of the human body with the help of machine learning models. This project opens up a new research direction and is expected to further enhance the level of scientific and technological innovation in the fields of healthcare. Internet of Things, smart cities, art technology, robotics, education, sports, personal protection, fashion, textiles, and entertainment.

ACKNOWLEDGMENT

The work has been supported by Theme-based Research Scheme, Research Grants Council, University Grant Council, Hong Kong (No. T42-513/24-R), the Research Institute for Intelligent Wearable Systems (No. 4-W03L) and Endowed Professor Fund (No. 847A) of The Hong Kong Polytechnic University.

New and Advanced Fibrous Materials

Structural Design and Functional Application of Novel Spiderweb-inspired Warp-knitted Meshes

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Mesh fabrics are widely used in various fields, such as aerospace, industrial protection, the marine industry, and agriculture, due to their advantages of being lightweight, high strength, soft, and breathable. Among them, protective meshes are an important category of mesh fabrics, mainly used for preventing personnel from falling, buffering dynamic impacts, and intercepting high-risk objects. In practical applications, protective meshes often face complex and harsh working conditions, which require high requirements for their mechanical properties. However, the current structural design of protective meshes is relatively conventional, and their mechanical properties are not fully sufficient to meet the complex needs of real-world tasks. In addition, the single-function design fails to meet the requirements of intelligent protection, lacking the ability to actively sense and respond to external loads. In response to the current shortcomings, our research is based on high-performance fibers, using spider web structures as biomimetic prototypes, and relying on textile technology to synergistically optimize and innovate the materials, structures, and functions of protective meshes, in order to enhance their overall mechanical performance and functional level. By integrating biomimetic principles with advanced textile technology, our research provides critical references for the development of next-generation intelligent protective meshes.

Molecular Mechanisms of Simultaneously High Strength and Toughness in Continuous Nanofibers

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Classical manufacturing techniques of advanced polymer fibers rely on a combination of high polymer crystallinity and a high degree of macromolecular alignment to achieve superior mechanical properties. As a consequence, high-performance fibers such as PPTA and UHMWPE possess high strength, but low strain to failure and toughness. Our mechanical and structural analysis of electrospun nanofibers (NFs) in the ultrafine (50-250 nm) diameter range showed extraordinary simultaneous improvements in strength, modulus, and toughness. The finest nanofilaments exhibited strength on par with that of advanced structural fibers, while exceeding their toughness by over an order of magnitude. This lecture will discuss supramolecular mechanisms of such an unusual mechanical behavior as well as review methods of processing and structural characterization of ultrafine continuous fibers. Prospects and impacts on wellbeing and sustainability of future textiles will be discussed.

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Ultra-strong Transparent Biomimetic Nanocomposite via Biomineralization

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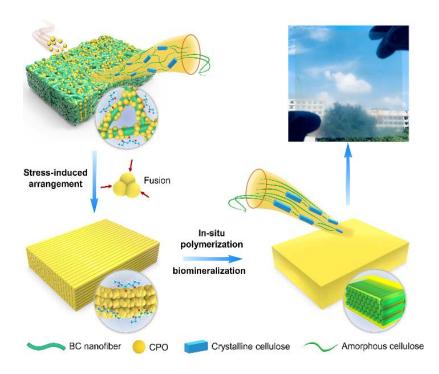
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The fascinating mechanical property of biomaterials in nature to support living organisms largely relys on their hierarchical and ordered structures. However, for the current biomimetic materials, their organic-inorganic heterostructures typically exhibit poor uniformity, weak interfacial bonding, and various defects, limiting the breakthrough in strength and toughness. Herein, we present an ultra-strong and transparent biomimetic nanocomposite by combining orientation effects and in-situ biomineralization to precisly engineer each level of the hierarchy. The orientation of nanofiber provides long-range and order matrix to remarkably eliminate defects, promote multi-scale interfacial bonding, and increase the crystalline degree and size of organic matrix, while the in-situ mineralization of amorphous inorganic oligomers firmly welds the organic-inorganic interface together to form a continuous and homogeneous monolithic structure. Due to the unique structural features, the nanocomposite exhibits a tensile strength of up to 1168.1 ± 10.2 MPa and a toughness of 34.1 ± 0.8 MJ m⁻³. Furthermore, the nanocomposite film is imparted with high transparency and anisotropic optical properties. This work is expected to provide insights into the design of high-performance, biomineralized materials from structural coupling to precisely controlling interfaces and microstructure.



Hollow Cholesteric Liquid Crystal Elastomer Fiber with Synergistically Enhanced Resilience and Mechanochromic Sensitivity

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Mechanochromic cholesteric liquid crystal elastomers (CLCE) are unique anisotropic rubbers with the programmable optical properties in response to external stimuli, bringing considerable interests in display, sensing, and smart textiles. However, creating mechanochromic CLCE fibers with high sensitivity, excellent resilience, and stable color-changing reversibility remains a challenge. This work describes mechanochromic CLCE symmetric hollow fibers with excellent radial helix alignment prepared by solvent evaporation-induced assembly and template assistance. The cylindrical symmetry renders the response identical in all directions perpendicular to fiber axis. The hollow fibers show mechanochromic ability in full visible spectrum: a large wavelength blueshift of 2.25 nm·%⁻¹ under low strain. Excellent mechanochromic reversibility of 100 cycles and resilience are both devoted by a cross-linking structure in the wall layer, which also contributes to reversible orientation recovery of liquid crystal units during stretching-recovery cycles. Numerical models and experimental measurements demonstrate that the hollow structure enables fibers to produce air pressure inside when being stretched. The fiber wall layer is subjected to greater stress compared to solid fibers, thus achieving high mechanochromic sensitivity. In addition, hollow fibers can still change color when subjected to the expansion stress inside the cavity, and programmable information displays in fabric prolongs its application in intelligent textiles.

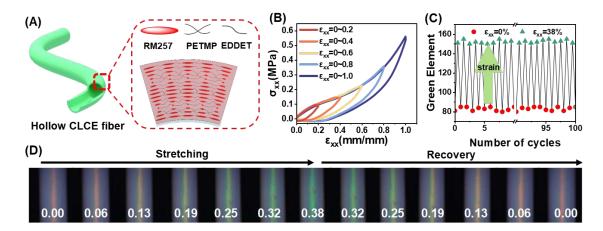


Figure 1 (A) The schematic illustration of hollow cholesteric liquid crystal elastomer fiber. (B) The stretching cycles of hollow cholesteric liquid crystal elastomer fiber. (C) Changes of green element in the CIE xy chromaticity diagram during 100 times stretching-recovery cycles under a length strain of 0.00 to 0.38. (D) Uniaxial stretching and recovery behavior of hollow CLCE mechanochromic fiber under length strain from 0.00 to 0.38.

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Cu2O/PLA Composite Fibers with Trace Coordination Bond Crosslinking Networks: Enhanced Mechanical Properties, Antibacterial Activity, and Recycling

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Public textiles demand high durability and safety, yet conventional materials such as cotton, linen, silk, and wool are prone to harboring pathogens and suffer from mechanical degradation due to microbial activity. The development of fibers with superior antimicrobial and mechanical properties for public textiles is crucial yet challenging. This study introduces a trace coordination bond cross-linking strategy to fabricate nano-Cu2O/polylactic acid (Cu2O/PLA) fibers that exhibit high antimicrobial activity, mechanical strength, and recyclability. The dynamic coordination bonds facilitate the uniform dispersion of nano-Cu2O within PLA, enhancing the molecular chain interface and resulting in exceptional mechanical properties, with a tensile fracture strength of 48.75 MPa. The antimicrobial efficacy of nano-Cu2O, combined with the weak acidity of PLA, provides outstanding antimicrobial activity against various pathogens (99.99%). This high performance endows Cu2O/PLA fibers with an ultra-long shelf life exceeding six months. Furthermore, the ease of breaking and regenerating coordination bonds imparts high recyclability to the Cu2O/PLA fibers. Consequently, this trace coordination bond cross-linking strategy offers a novel and feasible approach to producing nano-composite PLA fibers with excellent antimicrobial and mechanical properties, addressing the challenges faced by public textiles.

High-performance Liquid Crystalline Polyarylate and Its Composites

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With the development of the aerospace industry, the high performance of liquid crystalline polyarylate (LCP) has drawn much more interest. With the unique liquid crystalline state, LCP plays an important role in aerospace equipment, including space suits and stratospheric airships. However, due to the extreme conditions in space, it is still a great challenge to balance high performance (mechanical properties, heat resistance, and atomic oxygen resistance) and easy processability (low melting point and viscosity). Our group conducted a series of studies on the molecule structure, condensed-state structure, and interfacial interactions of LCP: (1) Terminating non-linear main-chain of LCP with mixed end-groups and achieving efficient preparation and fast curing of thermoset LCP^[1,2]; (2) development of in situ generated nanofiber reinforced materials with significant improvement of toughness and strength via tuning the structure and sequence of liquid crystalline mesogens^[3,4]; (3) constructing LCP nanocomposites and optimizing their processability for extreme environments via a "host-guest" synergy strategy^[5]. Our work systematically addressed the contradiction between high performance and processability of LCP, providing a novel design and modification strategy for the application of LCP and its composites in space.

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3D Self-folding All-weather Fabric

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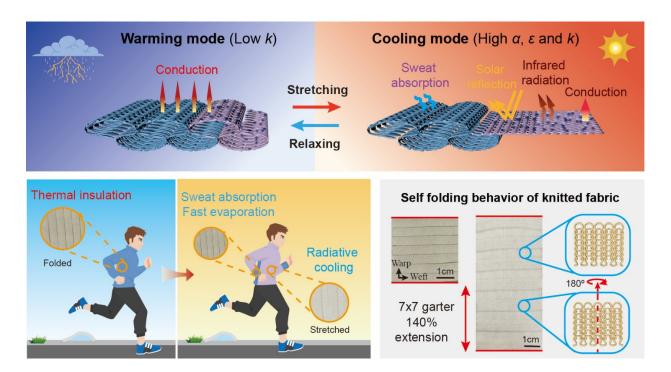
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In the era of global climate change, personal thermoregulation has become critical to addressing the growing demands for climate adaptability, comfort, health, and work efficiency in dynamic environments. Here, we introduce an innovative, three-dimensional (3D), self-folding knitted fabric that achieves dual thermal regulation modes through architectural reconfiguration. In the warming mode, the fabric maintains its natural 3D structure, trapping still air with extremely low thermal conductivity to provide high thermal resistance (0.06 m²K/W), effectively minimizing heat loss. In the cooling mode, the fabric transitions to a 2D flat state via stretching, with titanium dioxide (TiO₂) and polydimethylsiloxane (PDMS) coatings enhancing solar reflectivity (89.5%) and infrared emissivity (93.5%), achieving a cooling effect of 4.3°C under sunlight. The fabric demonstrates exceptional durability and washability, enduring over 1,000 folding cycles, and is manufactured using scalable and cost-effective knitting techniques. Beyond thermoregulation, it exhibits excellent breathability, sweat management, and flexibility, ensuring wear comfort and tactile feel under diverse conditions. This study presents an innovative solution for next-generation adaptive textiles, addressing the limitations of static thermal fabrics and advancing personal thermal management with wide applications for wearable technology, extreme environments, and sustainable fashion.



Stretchable Ceramic Aerogels with Binary Topology Network for Thermal Insulation

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Hypersonic aerospace vehicles, capable of traveling between the dense atmosphere, space, and orbital regions, necessitate thermal protection materials with thermo-mechanical synergy properties to withstand the intense aerodynamic heating produced during high-speed flight. As the forefront of advanced heat-insulating materials, the nanofiber-assembled elastic ceramic aerogels have exceptional potential to protect electronic devices of vehicles owing to their low density, excellent thermal resistance, and broad temperature adaptability. Despite their outstanding potential, the main application limitation associated with ceramic nanofibrous aerogels is the lack of stretch recovery capacity. Recent advancements in micro/nano-structural engineering, including crimped nanofibrous architecture and zig-zag configurations, have partially improved mechanical resilience. Nevertheless, the restricted rotational slip of curled nanofibers and limited elongation deformation freedom at the sub-micron scale result in a small tensile recovery deformation (<20%) and significant plastic deformation of ceramic aerogels. Herein, we elaborately engineer a programmable shape-morphing strategy for ceramic aerogels with a binary topology network through the paper-cut stacking method of ceramic nanofibrous membrane and subsequent nanofiber freeze-drying techniques. The special topology design, which includes kirigami lamellated aerogels (grid section) for bearing loading stress and randomly assembled aerogels (mesh section) for mechanical energy pre-storage to transfer tensile stress, effectively achieves mechanical tensile properties and thermal stability. The resulting ceramic aerogels demonstrate remarkable structural stability and topology network-derived mechanical tensile of up to 85% strain, excellent resilience to 500 cycles of 50% tensile strain, 1000 cycles of 60% buckling strain, and 500 cycles of 50% compressive strain, and temperature-invariant tensile recovery capability to 1100°C. Additionally, ceramic aerogels always exhibit a low thermal conductivity of 33.01 mW m⁻¹ K⁻¹ and exceptional high-temperature thermal insulation under both static and dynamic mechanical loading conditions, making their suitability as optimal thermal protection materials for aerospace applications.

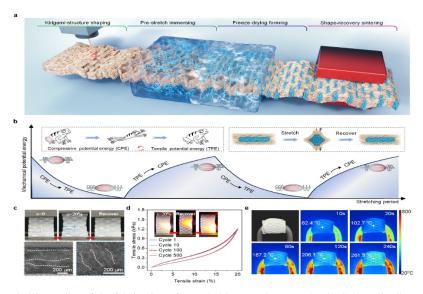


Figure 1. (a) Schematic illustration of the fabrication of stretchable ceramic aerogels. (b) Schematic diagram of the stretching deformation process of ceramic aerogels. (c) the stretching-recovery process of the ceramic aerogels and their microstructure images. (d) the 500-cycle tensile recovery curve of ceramic aerogels with a strain of 20% after heat treatment at 1100°C. (e) Optical and infrared images of the ceramic aerogels wrapped in a heat pipe.

Fiber Surface/Interface Modification: Functionalization and Advanced Applications in Multifunctional Fiber

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We have developed a robust and multifaceted system for fiber surface and interface engineering, underscoring the pivotal role of interfacial science in fiber functionalization. This system integrates several complementary approaches—chemical surface modification, polymer brush grafting, π -bond functionalization, and topological structuring of fiber interfaces—to precisely tailor interfacial properties. By systematically applying these techniques to a variety of fibers, we demonstrate the creation of catalytic fiber interfaces that enable electroless deposition of both metal ions and semiconductor nanoparticles. The resulting fibers exhibit a broad range of enhanced functionalities, including electrical conductivity, antibacterial properties, and ultraviolet resistance. In addition, the introduction of photocatalytic and electrocatalytic capabilities further expands their potential applications. Importantly, these functionalized fibers, when incorporated into polymer-based composites, not only impart desirable properties to the composite system but also open up new avenues in advanced textiles, biomedical materials, and energy-related devices. This work highlights a comprehensive and versatile modification strategy that advances the design and fabrication of high-performance, multifunctional fiber-based systems.

Synthetic Reversible Fibrous Network Hydrogels Based on a Double-Helical Polyelectrolyte

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The unique mechanical properties of fibrous networks in biological tissues have inspired the development of synthetic fibrous network hydrogels, yet few polymers can reversibly form such structures. Here, we report the first reversible fibrous network hydrogel composed of synthetic polyelectrolytes with extremely rigid conformation (persistence length is $\sim 1~\mu m$), made up of double-helical poly(2,2'-disulfonyl-4,4'-benzidine terephthalamide) (PBDT) and tetrabutylphosphonium bromide ([P₄₄₄₄]Br). The hydrogel exhibits a unique sol-gel transition, triggered by the hydrophobicity increase of [P₄₄₄₄]Br above lower critical solution temperature (LCST). This drives PBDT aggregation into fibrous bundles through electrostatic interactions. These bundles grow and branch into a continuous network, with the molecular rigidity of PBDT's double-helix conformation being key to gel formation. The hydrogel displays strain-stiffening mechanical responses akin to biological systems and shows a significant hysteresis (21°C) between heating and cooling cycles. Uniquely, the effects of salts on the transition temperature deviate from the Hofmeister series, highlighting coordination with sulfonate groups as the dominant factor. Leveraging its modulus change during gelation, the hydrogel was successfully applied as a spray coating on superhydrophobic vertical Teflon surfaces. This study broadens the scope of thermoreversible hydrogels introducing gelation mechanisms for rigid polyelectrolytes and demonstrates their potential in advanced coatings.

Effect of Electrospinning Environmental Conditions on the Morphology of Aramid Nanofibers

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INTRODUCTION

Firefighting has been listed as a possible carcinogenic risk by the World Health Organization since 2010. Over the last few years, researchers have revealed that smoke particulates and combustion-generated gaseous and vapor chemicals penetrate through firefighters' protective clothing. Nanofibers offer a great potential for better protective turnout gear due to their high surface area-to-volume ratio and low pore size, while preserving the garment breathability. They can also be easily manufactured by electrospinning. As the application targets fire protective clothing, the nanofiber material has to be inherently fire resistant. This communication describes the effect of the electrospinning environmental conditions on the morphology of the aramid nanofibers produced.

METHOD

The nanofibers were produced by needle-based electrospinning. It was performed in an enclosed chamber at a voltage of 19 kV, a distance of 20 cm, and a flow rate of 0.025 mL/h. The environmental conditions in the chamber were controlled using a local heating system situated inside. The electrospinning solution was prepared using meta-aramid fibers dissolved in dimethylacetamide (DMAc) in the presence of lithium chloride (LiCl). The formulation comprised 14% meta-aramid and 3% LiCl. It had been optimized to minimize the amount of salt as it negatively affects fiber strength while allowing full dissolution. The nanofiber morphology was characterized by scanning electron microscopy (SEM).

RESULTS

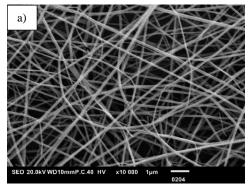
The environmental conditions in the chamber were observed to have a major impact on the outcome of the electrospinning process. At low relative humidity (RH)/high temperature conditions, a homogeneous mat with bead-free, straight nanofibers was obtained (Figure 1a). When electrospun at 27.5°C and 25% RH, the diameter of the fibers ranged between 70 and 140 nm. On the other hand, fiber bridging was observed at higher relative humidity/room temperature conditions. Observation by SEM revealed the formation of fiber bundles and semi-aligned structures (Figure 1b). It was attributed to the too slow evaporation of DMAc during electrospinning.

CONCLUSION

The results highlight the importance of controlling the environmental conditions during the electrospinning of aramid nanofibers. These membranes, which combine high filtration efficiency and breathability, will improve the protection offered to firefighters and other workers exposed to fire hazards by their protective clothing.

ACKNOWLEDGMENT

The authors thank Philippe Blondel of the University of Haute-Alsace for taking the SEM images.



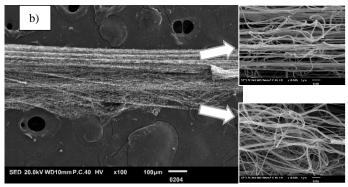


Figure 1. SEM images of the aramid nanofibers electrospun at (a) 27.5°C-25% RH and (b) 19.5°C-9% RH.

MXene Fibers for Future Textiles

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Since our initial report on MXene-coated fibers in 2017, the field has grown rapidly, with over 1500 publications exploring various aspects of fiber technology and the potential applications of MXene fibers. One critical area of research, as highlighted in the literature, is understanding the behavior of MXene in colloidal dispersions. While this understanding remains limited, the progress made so far has led to the development of innovative fabrication techniques, resulting in fibers with exceptional electrical conductivity and electrochemical properties. Many studies have demonstrated that MXene fibers hold significant promise across a broad range of applications, including energy storage, wearable electronics, motion and strain sensors, and electromagnetic interference shielding. As research advances, efforts continue to focus on enhancing the mechanical properties of MXenebased fibers and refining their fabrication methods to fully translate MXene's inherent properties into useful materials. Researchers worldwide are also exploring new applications and discovering novel MXene compositions with unique properties, further expanding the potential of these materials. This ongoing innovation is opening exciting new possibilities for functional fibers and textiles enabled by MXenes. This presentation aims to highlight the diverse applications of MXene fibers, with a particular emphasis on addressing fundamental knowledge gaps in our understanding of MXene's behavior in solutions and its effects on fiber formation. By addressing these gaps, we can unlock the full potential of solution-based processing to create MXene fibers for practical, real-world applications of these future textiles.

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Microfluidic Fiber Spinning Chemistry (FSC) and Beyond

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Microfluidic spinning technology is an ideal microreactor platform for the production of anisotropic ordered microfibers. In virtue of the precise and controllable shape, size and composition of fibers, as well as the high efficiency of mass and heat transfer and green reaction process, microfluidic spinning has attracted wide attention. Herein, we propose a new methodology for chemical synthesis based on microfluidic spinning, namely fibersspinning chemistry (FSC), which means utilizing spinning fibers as reactors to carry out chemical reactions. Online mixing, on-line assembly, and on-line in situ chemical reactions could be realized during the spinning process through the regulation of the microfluidics chip and external field. By connecting the microfluidic spinning techniques with chemical reaction, we break the limitations of pure physical fiber process in traditional spinning process, successfully constructing a series of advanced fiber materials and leading the development of spinning techniques. We realized the large-scale production of morpho-controllable, one-dimensional ordered nanofibers (array, Janus, bamboo), two-dimensional ordered photonic crystal films, and three-dimensional ordered Janus microbeads. In addition, by combining microfluidic spinning with microfluidic chips, multifunctional nanomaterials were constructed and their applications in artificial skin, microreactors, supercapacitors, and wearable devices were realized, laying a foundation for multifunctional micro-nano fibers via microfluidic spinning technology. Moreover, a series of living materials with biocatalytic function have been prepared by microfluidic 3D printing technology. This microfluidic 3D printing technology not only improves the specific surface area of living materials and mass transfer efficiency, but also enhances the biocatalytic effect of the whole living materials. Microfluidic 3D printing technology can regulate the distribution of cells in space, providing a powerful tool for the study of microbial symbiosis.

MXene-functionalized Textile Wastes and End-of-Life Garments for Wearable Electronics and Thermal Regulation

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Reusing discarded textile materials for manufacturing high value products (upcycling) presents a multi-faceted strategy for addressing the current environmental issues associated with the textile industry. In this study, we adopted a facile approach of upcycling waste textile fabrics through MXene functionalization. Specifically, we employed a simple method of dip coating fabrics into colloidal MXene dispersions, as a straightforward and versatile method of producing consistent coatings on a variety of natural and synthetic textile substrates (cotton, hemp, and nylon). Even at an imperceptible mass, the Mxene coating on these textile wastes provided adequate conductivity, and rapid temperature elevation (>60°C for cotton) within seconds of application of a small electric potential (~24 V), indicating their potential use as a Joule heater. The MXene coating also provided a discarded garment (cotton glove) sensitivity toward pressure and strain changes brought by the motion of its wearer. Increasing the number of coatings on the fabrics also enhanced their capability to block infrared (IR) radiation, suggesting their viability for thermal camouflage applications. We anticipate that the simple and scalable nature of this method will open avenues for the use of fabric off-cuts and end-of-life (EoL) garments toward the manufacturing of multi-functional textiles for smart wearable clothing and will potentially contribute to addressing the anticipated shortage of textile resources in the coming decades.

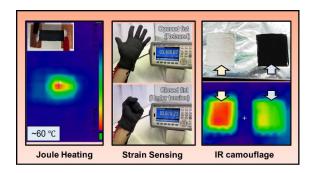


Figure 1. Demonstration on the use of MXene-coated textile off-cuts and end-of-life garments (cotton cloth and gloves) in a multitude of applications, such as Joule heating, strain sensing, and Infrared (IR) camouflage.

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Skin-like Sweating Simulator

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Perspiration is one of the most important functions of human skin, playing a crucial role in regulating sweat and temperature. Most sweating artificial skins use a liquid pump to generate sweat by thrust, but it lacks uniformity and precise control over a wide range. From a physiological perspective, the osmosis effect in eccrine induced by ion concentrations is the primary mechanism behind human sweating. Therefore, it is imperative to design a sweating artificial skin mimicking the osmosis effect, replicating the natural sweating process of human skin.

This research designed a conductive, textile-based artificial skin, utilizing an electro-driven method to mimic human perspiration. Carbon fibers were used as the anode and cathode; a low-voltage electric field was applied as the driving force for sweating. A layer of silicone was combined on the top of the artificial skin to simulate the skin texture and mechanical properties. Flexibility and conductivity are important criteria for choosing these materials.

The electric field gradient as a driving force is similar to the osmotic effect of human skin sweating. It is further reflected in the results: the sweating performance is uniform even at an extremely low sweating rate. Additionally, the sweating rate can be widely controlled by applying low voltages from 1.5 V~3.5 V, which corresponds to the real human sweating rate $(0.2~5~\mu L~min^{-1}~cm^{-2})$. No deformation was observed on the artificial skin, which is different from the situation of using liquid pump.

This sweating artificial skin has a promising application for providing human skin alternatives for clothing industry, health monitoring, robot technology, and medical rehabilitation. Unlike hiring people for tests, this artificial skin has a more uniform standard, more precise controllability, and lower cost. Most importantly, the artificial skin is designed from the principle of real human perspiration, which is a big step toward the bionic human body.

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Biomimetic Graphite-Aerogel Conductors with Interface-coherent Superlattices

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Carbon nanofibers, recognized as a cornerstone of high-performance materials, exhibit remarkable potential in energy storage, catalysis, and environmental remediation due to their low density, large surface area, excellent chemical stability, and exceptional electronic properties. By employing carbon nanofibers as building blocks and expanding their assembly into aerogels, it will be possible to deliver the extraordinary nanoscale characteristics into macroscopic bulk. However, the formation of interfaces barriers (1.42 Å < d < 5 Å) during the transition from the nanoscale to the macroscopic scale, which leads to significant restrictions in electrical conductivity (10⁻ ¹~10³ S⋅m⁻¹), impedes the efficiency of aerogels in energy storage and transmission. In nature, a novel nervous structure has been discovered in ctenophores, where multiple neurites extending from a single soma are selfstitched through anastomoses, forming a coherent syncytial nerve network with an interface distance of approximately 0 Å, as opposed to the traditional synaptic gap of over 200 Å. Notably, the coherent interface structure of this network enables rapid conduction of bioelectric signals, facilitating the coordination of sensory and motor functions across the organism. Herein, inspired by the syncytial nerve network of ctenophores, which achieves rapid conduction of bioelectric signals through coherent anastomotic interfaces, a "lattice self-stitching" strategy is proposed to synthesize graphite aerogel conductors with interface-coherent superlattices. The precisely engineered interfacial structure of aerogel, characterized by robust σ -bonds and extensive π -bonds, significantly reduces interfacial barriers (d~1.42 Å) and creates a biomimetic artificial "electron highway" with minimal resistance. The resulting graphite-aerogel conductors exhibit ultra-low band gap (0.00325 eV), high conductivity (1.36×10⁵ S⋅m⁻¹), thermal stability (-196~3000°C), and exceptional power density (1211 mW⋅cm⁻²) in proton exchange membrane fuel cells. Advancing ultra-fast electron transport in aerogel could offer a promising roadmap for next-generation energy storage and transmission, especially in harsh environments.

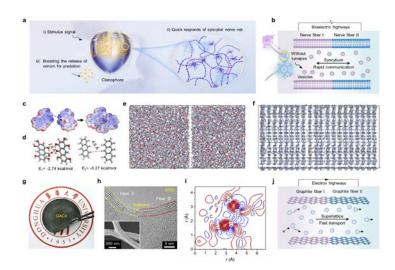


Figure 1. (a) Ctenophores with a distinctive syncytial neural network consisting of self-stitched nerve fibers. (b) Mechanism of rapid bioelectrical conduction in coherent cytomembranes. (c) ESP simulation for the formation of covalent bonds. (d) Theoretically optimized geometries and counterpoise-corrected interaction energies for carbon structural units with/without reactive sites. Simulating the evolution (e) before and (f) after the reactive site assisted carbon skeleton rearrangement reaction. (g) Photograph of flexible GACs. (h) SEM and TEM image of superlattice in the self-stitched junction. (i)The electron density difference isosurfaces in the interface-coherent superlattices. (j) Mechanism of fast electron transport in bionic coherent superlattices.

Hydrovoltextile

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Wearable electronics (e.g., smart watches, 3D glasses, and electronic textiles) have attracted increasing attention from academia and industry due to remarkable intelligence and portable characteristics, which are promising to be widely used in the fields of health monitoring, physical protection, drug delivery, and so on. To well-power the aforementioned wearable electronics, it is essential to develop a flexible and wearable energy supply system with a good match. Owing to abundant resource and easy fabrication, evaporation-induced electricity generators (EEGs) exhibit great potential as power sources for wearable devices and portable electronics. However, current EEGs generally lack sustainable electrical output under extreme conditions and comfortable wearability, which greatly restrict their practical applications in the fields of smart wearables. Herein, we put forward a novel hydrovoltextile with multifunctionality that not only realizes directional water transport but also generates continuous electricity. The newly-developed EEGs can maintain their electrical properties when fully wetted or immersed in water. Additionally, EEGs based on hydrovoltextile can be bent under different states. After bending, they cycle without performance decay, indicating outstanding flexibility and mechanical stability. In addition, large-scale integration of EEG units enhances the electric output by screen-printing and sewing techniques, which provides sufficient power for various commercial electric devices. The flexible EEGs with hydrovoltextile are promising candidates for use as power supplies for portable and wearable electronics.

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Biomimetic Bouligand Chiral Fibers Array Enables Strong and Superelastic Ceramic Aerogels

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Ceramic aerogels are often used when thermal insulation materials are desired; however, they are still plagued by their poor mechanical stability under thermal shock, such as large thermal gradients in deep-space and deep-earth. Recently, some improvements have been developed to strengthen ceramic aerogels focusing on introduction of continuous structural units (nanofibers or nanosheets) as building blocks and designing them with specific microstructures. However, the above existing ceramic aerogels still suffer from extremely low tensile strength (<10 kPa), resulting in limited applications in dynamic complex devices. Hence, it has been very challenging, if not impossible, to create ceramic aerogels that exhibit both superelasticity and high tensile strength property. Wood is light and strong; muscles are soft and tough; nacres are hard and resilient. The remarkable mechanical properties of natural materials have been the subject of extensive research in the field of materials science. Another particularly impressive example is the Bouligand (twisted plywood) chiral structure found in crustaceans (mantis shrimps, lobsters, beetles, etc.), which greatly enhances their strength. More importantly, the mechanical properties of these creatures can be finely tuned by modulating the spatial distribution and orientation of the nanofibrils. Herein, inspired by the dactyl clubs of mantis shrimp, we propose a compositional and structural engineering strategy by combining macro/nanoscale component control over building blocks with precise geometric freedom design in helix chiral fibers array to enable the synchronous fabrication of biomimetic Bouligand-chiral and fibrous structured ceramic aerogels (BcF-CAs). Benefiting from the stress dissipation, crack torsion and mechanical reinforcement of micro-/nano-scale Bouligand array, the tensile strength of BcF-CAs (170.38 MPa) is between two orders of magnitude greater than that of state-of-the-art nanofibrous aerogels; their elasticity is comparable to that of the best-performing thermal insulation aerogel materials. In addition, the BcF-CAs feature low density, low thermal conductivity (0.037W m⁻¹ K⁻¹), temperature-invariant superelastic and tensile properties (-196~1200°C), and robust compression fatigue tolerance up to 1000 cycles, making them ideal for thermal insulation applications. This proposed approach holds great promise for freely designing and assembling architectures while breaking the typical limitations of traditional fabrication technologies.

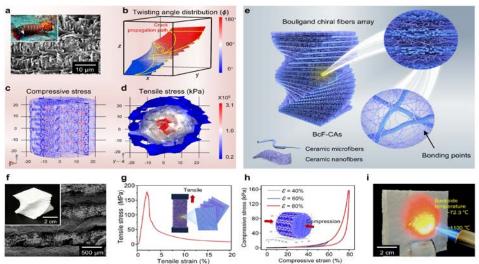


Figure 1. (a) Photo and SEM image of the dactyl club in mantis shrimp. (b) Structural features of typical Bouligand chiral array. In-plane isotropy of the mechanical properties in (c) compression and (d) tension modes. (e) Schematic illustration of BcF-CAs fabrication process. (f) Photos and SEM images showing the microscopic architecture of the BcF-CAs. (g) Tensile and (h) compressive stress-strain curve of the BcF-CAs. (i) The BcF-CAs exposed to a butane blowtorch, no damage was observed.

Intelligent Fibers and Wearable Technologies

All-Textile-Based Touch-Sensitive E-fabric via Contact Coupling Effect for Internet of Everything Smart Home Interaction

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Touch-sensing devices offer advantages such as immersive interaction, user-friendly operation, and rapid feedback, enabling comprehensive functions including panoramic display, industrial control, information query, and entertainment. However, most touch devices utilize rigid conductive materials (indium tin oxide, ITO) for touchscreens, which suffer from poor extensibility and fragility. To address this, we developed an all-textile-based touch-sensitive electronic fabric by preparing waterborne polyurethane/carboxylated multi-walled carbon nanotube (WPU@COOH-MWNTs) composite conductive ink through a self-emulsification method. A sizing process was subsequently employed to create conductive textiles with highly uniform resistance characteristics. Leveraging the non-Faradaic junction effect between the human body and conductive textiles, coupled capacitive microstructures were constructed at the contact interface to disrupt the uniform electrostatic field on the textile surface, achieving high tactile resolution recognition. Benefiting from the all-textile-based construction strategy, the touch-sensitive electronic fabric maintains stable tactile sensing performance under various extreme conditions (underwater, low temperature, high temperature). Integrated into sofa armrests, this fabric enables smart sofas with stepless backrest adjustment and gesture interaction capabilities. Furthermore, the developed tactile sensing technology has been extended from "all-textile substrates" to "non-textile substrates," achieving intelligent tactile upgrades for diverse daily materials such as paper, water, and wood panels.

Development and Performance Evaluation of Smart Clothing for Sleep Monitoring

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With the fast pace of modern life leading to widespread sleep problems, this study develops a smart garment integrating ECG and skin temperature sensors as a less intrusive alternative to polysomnography (PSG). We conducted 8-hour human sleep experiments collecting synchronized PSG-ECG data and transient skin surface temperature from four body sites (scapula, abdomen, forearm, and hand). Through statistical analysis of significant differences, four ECG parameters and eight skin temperature parameters were selected for model training. An XGBoost algorithm was employed to construct the sleep staging model, with Bayesian optimization applied for hyperparameter tuning. The optimized model achieved 78% accuracy in sleep stage classification, representing a 17% improvement over using ECG-only. The final garment prototype showed 73% agreement with PSG in sleep staging, with skin temperature monitoring maintained within $\pm 0.20^{\circ}$ C error range. The garment demonstrated good wearability with 0.226 clo thermal resistance (comparable to thermal underwear) and a subjective comfort rating of 3.67/5.

This study demonstrates that combining ECG and skin temperature monitoring enables sleep stage prediction (Wake/Light/REM/Deep). The system provides a comfortable and accurate solution for home sleep monitoring, effectively addressing the wearing inconvenience and sleep disturbance caused by conventional PSG devices.

Tough and Conductive Hydrogels for Human-Machine Interfaces

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We report a mechanically robust, highly conductive, and biocompatible hydrogel, reinforced by aramid nanofibers (ANFs), for advanced sensing applications. ANFs are uniformly dispersed within a polyvinyl alcohol (PVA) matrix via a vapor-assisted, freeze—thaw process, forming a physically crosslinked PA gel with dense hydrogen bonding and crystalline domains. The incorporation of ANFs not only enhances the structural integrity of the hydrogel but also promotes efficient infiltration and uniform polymerization of PEDOT:PSS. Subsequent thermal annealing facilitates PEDOT chain alignment and interfacial interaction, synergistically enhancing the hydrogel's mechanical and electrical properties.

As a result, the PAP hydrogel achieves an exceptional conductivity of 452.75 S/m, significantly outperforming state-of-the-art conductive hydrogels reported in recent literature, with a tensile strength of 10.72 MPa. This performance represents a 151293% increase in conductivity and a 31523.53% enhancement in strength over hydrogels without ANFs. The hydrogel also exhibits excellent flexibility, long-term stability, and cytocompatibility. These features enable its integration into multifunctional sensors for real-time monitoring of human motion, electroencephalogram (EEG), and electromyogram (EMG) signals. Furthermore, high-fidelity EMG signals enable accurate hand gesture recognition, demonstrating the material's promise in wearable electronics, healthcare monitoring, and human—machine interaction.

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Intelligent Tactile Oral Pad

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This study introduces a flexible oral pad designed as a tongue-controlled assistive "mouse" for individuals with severe motor disabilities. The device uses a conductive textile composite in a biocompatible polymer, achieving high sensitivity and low-latency response. It detects tongue pressure and movements, converting them into computer commands like cursor navigation. Tests with 10 participants showed a 92.3% recognition accuracy and no discomfort during extended use. The device proved adaptable for tasks like text input and web navigation, offering a non-invasive control solution. Future work will enhance tactile feedback and customization for smart wheelchair control and communication devices.

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Acoustic Fibers and Fabrics

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Acoustic fibers and fabrics represent a transformative approach to sound sensing and ultrasonic imaging, enabling seamless integration of acoustic functionality into flexible, wearable, and structural platforms. Constructed from piezoelectric materials, these fibers are capable of detecting sound waves across a broad frequency range, from audible signals to high-frequency ultrasound. Their unique combination of mechanical flexibility and acoustic sensitivity opens up diverse applications, including wearable devices for real-time physiological monitoring, high-resolution ultrasound imaging for healthcare diagnostics, and structural health monitoring in various environments. This talk will explore the fundamental principles of acoustic fiber design, the mechanisms of piezoelectric transduction in fiber-based systems, and recent advancements in scalable fabrication techniques. Additionally, we will discuss the challenges and future directions in optimizing acoustic performance, enhancing integration with existing electronic systems, and expanding their utility in next-generation smart textiles and biomedical technologies.

Intelligent Wearable Impact Protector with Core-Shell Fiber Technology

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Intelligent wearable devices featuring impact protection, high energy absorption, and multifunctional sensing capabilities have attracted significant interest. In this study, we developed an innovative shear thickening fluid (STF)-liquid metal core-shell fiber for wearable applications. This design incorporates liquid metal, silicone tubes, STF, and Kevlar fabric. The protective performance of the STF-liquid metal core-shell fiber showed an improvement of up to 36.8% compared to silicone tubes alone, due to the unique rheological properties of the STF. We analyzed the impact protection mechanism of the STF-liquid metal core-shell fiber, attributing its energy absorption capabilities to the formation and compression of a particle jamming zone during impact. Additionally, the wearable system demonstrates self-powered sensing abilities, capable of recognizing impact forces from various heights while simultaneously harvesting biomechanical energy. This system can capture mechanical energy from activities such as walking or hand patting to sustainably power wearable electronic devices. Furthermore, the wearable system has been successfully demonstrated as an impact monitoring system connected to a smartphone, providing alerts when subjected to strong impact forces.

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Elastic Smart Fibers and Integrated Wearable Smart Textile System for Human Motion and Physiological Monitoring

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In recent years, disruptive technologies, such as artificial intelligence and flexible electronics, have been continuously innovating. With this, the market demand for smart textiles and apparel continues to grow, especially in such areas as smart elderly care, chronic disease management, and sports and fitness. Here, specialized equipment and processes for one-step continuous production of elastic smart fibers/yarns have been developed. The prepared fibers exhibit high sensitivity, high linearity, wide detection range, and long-term stability under mechanical stimuli, such as stretching, bending, and compression. These fibers are also resistant to abrasion, washing, and perspiration. Further, the seamless integration technology of elastic smart fibers and textiles has been tackled. The sensing fibers and flexible wires are embedded into textiles (e.g., garments) through sewing or weaving strategies. A complete wearable smart textile system composed of smart textiles, multi-channel data acquisition unit, and intelligent terminals has been constructed. As shown in Figure 1, the smart sportswear and smart football socks developed based on this system have been applied to daily sportswear and professional training assistance. The smart sportswear is capable of multi-phase acquisition of the user's motion and physiological signals. The collected data is sent to the mobile phone APP via wireless Bluetooth technology, realizing real-time processing, display, and storage of heartbeat, respiration, and movement signals. The smart football socks are made by integrating elastic smart varns on a dedicated sock machine. They can be used to identify and evaluate the kicking actions of football players, including the running conditions, shooting and passing actions, and the movement paths of the triggered ball. It provides professional and scientific guidance for football players' training. The elastic smart fibers and wearable smart textile systems show application potential in the fields of sports science, smart healthcare, and human-computer interaction, and propose innovative solutions for the high-end, intelligent development of textiles.



Figure 1. The applications of elastic smart fibers and integrated wearable smart textile system.

Mechanical Assembly of Double Carbon Coupling Enhancement for Highly Stretchable, Flexible, and Smart Wearable Applications

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With the enhancement of the 21st-century daily lifestyle trend, the quest for functional materials has heightened in every part of society. The inclusion of functional materials into several wearable gadgets like smart watches, goggles, smartphones, clothing, shoes, etc., turned into an ordinary subject to supplement fascinating and lucrative appeal for the customers with distinct applications. As functional materials, several conductive polymers, like carbon-based conductive composites, are mostly employed owing to their viability of preparation and cost-effectiveness. However, these carbon-based conductive composites face challenges in maintaining the stability of the conductive network while continuously experiencing external load, stress-strain, or pressure. These challenges were overcome through the mechanical assembly of multiwalled carbon nanotubes (MWCNTs) and carbon black (CB), along with a Styrene Ethylene Butylene Styrene (SEBS) elastomer matrix for highly stretchable, flexible, and smart wearable applications. The mechanical performance of these double-conductive, carbon-based fillers with SEBS elastomer provides stretchability to ~450% strain, 2 MPa stress, and satisfactory conductivity, making this conductive composite a potential candidate for future smart functional materials.

Multilevel Feature Representation Learning for Wearable Sensor-based Gesture Recognition

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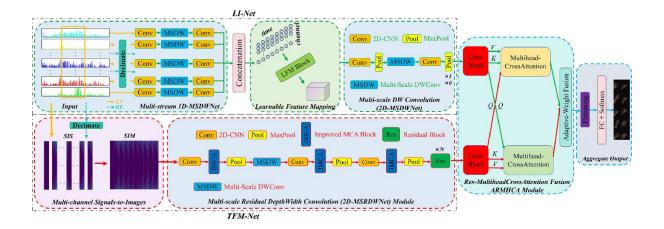
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Deep learning-based gesture recognition has garnered significant attention for its potential in wearable, textile, and fiber-based applications. Current approaches typically process a single modality of sensor signals separately, either limiting temporal feature extraction—failing to capture spatiotemporal dependencies—or relying on fixed time-frequency transformations—unable to adapt to dynamic signal characteristics. These limitations reduce generalization across varying sensor inputs and complex tasks. In this paper, we propose a novel hybrid network, LI-TFMNet, to explore multi-modal representations in signals from different perspectives. It integrates a cross-modal branch (LI-Net) and a cross-domain branch (TFM-Net). The cross-modal branch introduces four learnable, temporal, two-dimensionalization methods to model the relationship between temporal features and two-dimensional image representations. Simultaneously, the cross-domain branch employs a signal-to-image conversion approach, tailored for multi-channel time series data (including fiber-based sensors) to explore interactions among sequences. The effectiveness of the proposed architecture is then extensively evaluated on four gesture recognition datasets, which incorporate various heterogeneous wearable device sensor combinations.



AI-driven Multimodal Sensors for Object Recognition

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Bio-inspired pneumatic soft actuators (PSAs), fabricated from flexible materials such as silicone rubber, inherently exhibit compliance and dexterity. Their simple structure, ease of fabrication, rapid response, and high force output make them ideal for handling delicate and irregular objects. However, a gap persists in the field of intelligent soft grasping systems capable of recognizing and flexibly grasping various objects. To bridge this gap, we introduce a novel grasping system that overcomes the limitations of existing models by integrating PSAs, textile-based, self-powered tactile sensors, stretchable strain sensors, and a sophisticated, multi-channel signal processing algorithm.

The textile-based tactile sensor demonstrates exceptional mechanical compliance, allowing it to bend and twist without impeding the deformation of the PSA. Additionally, the sensor's simplistic design enhances its robustness against unpredictable conditions, such as impacts from a hammer, and ensures consistency in the fabrication process. Furthermore, the sensor is self-powered, thereby offering a prolonged operational lifespan without the need for a battery. Crucially, this sensor is capable of providing precise information regarding contact area, location, and material properties in various applications. The strain sensor demonstrates exceptional extension capabilities. Its notable stretchability and sensitivity in monitoring strain deformation indicate its potential for effectively tracking the bending status of the PSA.

Deep Learning (DL) algorithm has been validated as an efficient method for handling time-series signals, capable of extracting subtle but significant information from raw data for classification. For the analysis of temporal data acquired from the TENGs, a one-dimensional, convolutional neural network (1D-CNN) is utilized, achieving an impressive accuracy rate of 97.1% in discerning among twenty-seven distinct objects. Remarkably, this system is adept at differentiating between objects of analogous materials but disparate sizes, and conversely. By integrating feedback control, we have successfully developed an intelligent gripper system that achieves real-time object recognition and adaptive grasping capabilities. We anticipate the intelligent gripper system to tackle practical challenges in diverse domains such as flexible manufacturing, automated agriculture, human-machine interaction, and prosthetic hands.

ACKNOWLEDGMENT

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Healthcare and Biomedical Applications

Electrospun Fibers in Healthcare: Advancing Sensors, Thermal Management, and Biomedical Applications

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Electrospinning has emerged as a versatile technique for fabricating nanofibrous materials with unique properties, presenting transformative potential in healthcare applications. This presentation highlights recent advancements in electrospun fibers for sensors, thermal management, and biomedical applications. In sensor technology, electrospun fibers create highly sensitive, flexible, and biocompatible platforms for real-time monitoring of physiological parameters, such as glucose levels, pH, and biomechanical signals, paving the way for innovations in wearable diagnostics. For thermal management, electrospun nanofibers with tailored porosity and thermal conductivity offer innovative solutions for wound dressings and smart textiles, ensuring optimal temperature regulation for patient comfort and tissue healing. In biomedical applications, electrospun scaffolds effectively mimic the extracellular matrix, promoting cell adhesion, proliferation, and differentiation in tissue engineering and regenerative medicine. Additionally, drug-loaded electrospun fibers facilitate controlled release, enhancing therapeutic outcomes in wound healing and infection control. By integrating multifunctional properties, such as antimicrobial activity and mechanical flexibility, electrospun fibers are set to address critical healthcare challenges. This presentation will discuss fabrication strategies, material innovations, and emerging applications, emphasizing the pivotal role of electrospinning in shaping the future of personalized and precision medicine.

Translational Potential of a Braided Electrospun Polycaprolactone Graft for Anterior Cruciate Ligament Reconstruction

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BACKGROUND AND OBJECTIVES

Anterior cruciate ligament (ACL) injuries are highly prevalent and often require surgical reconstruction. While autografts remain the gold standard, they are associated with donor site morbidity, long recovery times, and high re-tear rates. Synthetic grafts have failed to achieve widespread adoption due to issues with biointegration, immunogenicity, and poor mechanical adaptation. We developed a braided electrospun scaffold made of polycaprolactone (PCL), designed to replicate the hierarchical structure and mechanical function of native ligament tissue while enhancing biointegration.

METHODS

The braided cord was fabricated from aligned electrospun polycaprolactone (PCL) yarns and assembled into braided multiscale constructs mimicking native ligament architecture. Scanning electron microscopy (SEM) was used to characterize the microstructure. The degradation profile of the scaffold was assessed under physiological conditions. Biocompatibility and cell infiltration were evaluated using patient-derived ACL explants and GFP-expressing mesenchymal stem cells (MSCs) cultured in a soft bioreactor. Mechanical properties were evaluated through anterior drawer, pull-out, tensile, and stress relaxation tests in sheep cadaveric knees. A 10-week in vivo study was conducted using an ovine ACL reconstruction model. Post-mortem MRI and CT imaging were performed to assess graft positioning, bone tunnel morphology, and structural integration. Histological analysis included H&E staining to assess cell infiltration and graft-to-bone healing.

RESULTS

SEM showed aligned fibres with ECM-like nanostructures. In vitro, the electrospun device supported high MSC viability and progressive cell infiltration. In cadaveric tests, it demonstrated anterior drawer displacement of 1.4 mm, pull-out strength of 376 N, and stiffness of 22.8 N/mm, comparable to autografts and above the physiological threshold for ovine ACL loads. In vivo, sheep exhibited normal gait at 10 weeks. The graft was covered by synovium with visible neovascularization. MRI and CT confirmed graft continuity and bone tunnel integration. Histology showed fibrous tissue ingrowth, ECM deposition, and early tendon-bone healing. Tensile integrity was maintained with pull-out failure occurring at the tibial fixation site.

CONCLUSION AND SIGNIFICANCE

The electrospun graft mimics the mechanical and structural properties of native ACL while supporting tissue integration. It demonstrates strong potential as a bioresorbable synthetic graft for ACL reconstruction, particularly in combination with bioreactor-based preconditioning.

ACKNOWLEDGMENT

This work was supported by the Norman Collisson Foundation, UK Versus Arthritis and the UK Research and Innovation (UKRI) Medical Research Council. The authors thank the Oxford Musculoskeletal Biobank and the Royal Veterinary College for their support in tissue procurement and animal studies.

Multifunctional Artificial Skin for Accelerating Wound Healing

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The skin serves as the body's first line of defense, and its damage poses significant health risks and economic burdens. To address this challenge, our research focuses on developing artificial skin and advanced wound dressings that promote healing through both structural and functional innovations. We specifically mimic the dual-layer architecture of natural skin—the epidermis and dermis—by utilizing nanofibers to create a dense yet breathable protective epidermal layer. Meanwhile, freeze-drying or gel cross-linking techniques are employed to form a porous, scaffold-like dermal layer that supports cell growth, resulting in artificial skin that not only protects the wound but also guides tissue regeneration. Furthermore, we enhance the biological functionality of polymers through organic-inorganic hybridization and bioactive functional group/bioprotein modifications. Our studies have shown that grafting gallic acid onto gelatin significantly improves its antioxidant properties, while incorporating spider silk protein into synthetic polymers enhances angiogenesis, promoting blood vessel formation in wounds. These bioactive enhancements, including anti-inflammatory, antioxidant, and proangiogenic properties, accelerate wound healing, offering a promising approach for next-generation wound care solutions.

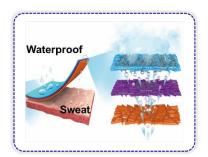
Smart, Personal, Microclimate Health Management Textiles

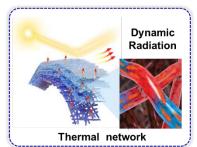
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As global warming trends intensify and heavily polluted weather frequently occurs, people's physical health and lives have been severely impacted. Concurrently, the increasing demand for comfortable and healthy textiles has propelled smart personal microclimate health management textiles to become a research hotspot. These textiles play a crucial role in regulating the moisture, heat, and air exchange between the human body and the external environment. This report systematically describes the research progress of smart personal microclimate health management textiles in three aspects: moisturizing textiles, thermal management textiles, and textiles for air filtration. By investigating the synergistic effect of fine structure and interfacial wettability of textiles on vapor/liquid transport, we have developed multi-functional humidity management textiles that are waterproof and breathable, moisture-conducting, intelligent temperature-controlled, etc. Through the study of efficient coupled particle-fiber-fabric multiscale thermal management mechanisms, we have prepared various smart thermal management textiles that can be used for indoors and outdoors. By constructing the "bellows effect" through-hole structure and high-density, deep well charge on fibrous materials, high-efficiency and low-resistance masks were obtained. On this basis, we have analyzed the current challenges and future directions in smart personal microclimate health management textiles, aiming to provide theoretical support for related research fields.





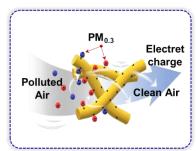


Figure 1: Smart Moisture-Heat-Air Personal Microclimate Health Management Textiles.

Biomimetic Dry Spinning of Tough and Bioactive Protein Fibers

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Protein-based biomaterials play a critical role in biomedical applications, such as tissue engineering, regenerative medicine, and drug delivery. However, developing protein-based biomaterials combining satisfied mechanical properties and tailored biofunction still face great challenges. Here, inspired by natural silk spinning adopted by spiders and silkworms, a biomimetic dry spinning approach for producing tough protein fibers with designed bioactivities is demonstrated. In the approach, an engineered protein-based spinning dope with similar structural and physical properties to the native silkworm gland is prepared. Upon dry spinning and post-stretching treatment, the regenerated protein fibers exhibit a toughness of up to $191.6 \pm 36.4 \text{ MJ/m}^3$, superior to natural spider silks (135 MJ/m³). Multiscale structural characterizations indicate the regenerated protein fibers possess hierarchical structures composed of nanofibrils enriched with β -sheet nanocrystalline domains, similar to natural silks. The crystallinity, size of the nanocrystalline, and orientation factor are 34%, $4.28 \times 3.99 \times 5.08$ nm, and 0.941, respectively, leading to high toughness. Furthermore, bioactive molecules (e.g., DOX, collagen, bFGF) can be doped to the engineered spinning dope to prepare tough and bioactive protein fibers for tissue engineering. Also, this study demonstrates a scalable approach for producing artificial tough protein fibers by mimicking natural silk spinning and provides a pathway to fabricate protein-based materials with tailored biofunctions.

Thermal Transfer, Printed, Flexible, and Wearable Bionic Skin with Bilayer Nanofiber for Comfortable, Multimodal Health Management

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Existing bionic skin technologies face several limitations, including complex and expensive manufacturing processes, low wearing comfort, and challenges in achieving comfortable real-time health monitoring. These shortcomings hinder the widespread adoption and practical utility of bionic skin in various applications. The bionic skin invention presented in this article addresses these issues by introducing a novel thermal transfer manufacturing process that is low-cost and easy to operate. This method is particularly suitable for the small-scale mass production required for bionic skin applications. Additionally, the innovative bilayer unidirectional moisture transport nanomembrane incorporated into the bionic skin offers high extensibility and breathability. This feature enhances the ability of the skin to absorb sweat, thereby facilitating comfortable real-time health monitoring. The specially designed bionic skin sensor embedded within this system can monitor various biomarkers in sweat, including glucose, lactic acid, uric acid, pH, temperature, and skin impedance. When combined with the CARE(Continuous Analyte Monitoring with Real-time Engagement) system, it enables real-time data transmission and processing, offering a comprehensive approach to health monitoring that is both comfortable and reliable.

INTRODUCTION

In light of these developments and challenges, this paper introduces a specially designed bionic skin sweat sensor. By addressing the current limitations in bionic skin sweat sensor technology, this innovative design represents a significant step forward in wearable health monitoring, offering potential applications across various fields of health and wellness.

RESULTS AND CONCLUSION

This paper presents the development of a bionic skin sweat sensor, an innovative device designed to emulate human skin's sensory capabilities for non-invasive health monitoring. By analyzing sweat for key biomarkers, such as glucose, lactate, and electrolytes, the sensor offers real-time insights into the wearer's health status. Fabricated using thermal transfer method and supported by an electrospun nanomembrane with moisture-wicking properties, the sensor ensures comfort and efficiency in small-batch production. The integration of multiple electrodes for comprehensive health analysis, alongside a custom-engineered circuit board featuring wireless connectivity, enhances the user experience by facilitating continuous, real-time monitoring. Experimental results demonstrate the sensor's high sensitivity and accuracy in biomarker detection, validating its effectiveness in continuous in situ monitoring of physiological changes.

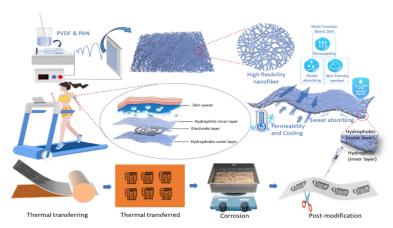


Figure 1. The schematic diagram of proposed bionic skin.

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Design, Fabrication, and Characterization of Fibrous Acoustic Sensing Membranes for Biomedical Applications

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With the widespread application of wearable technology, acoustic sensors are rapidly evolving toward being lightweight, integrated, and miniaturized, presenting new challenges for traditional acoustic sensors. In the field of biomedicine, applications such as biocompatible artificial cochleae and electronic stethoscopes for real-time health monitoring are continuously developing and expanding. Compared to other types of acoustic sensors, piezoelectric-based acoustic sensors (PAS) are easy to fabricate into thin films or fabrics, enabling them to offer multiple benefits, such as self-powering, tunable resonant frequencies, and stability in environment. Therefore, flexible piezoelectric sensors based on biomedical applications warrant further in-depth research and exploration. Common piezoelectric thin-film acoustic sensors usually employ micro-cone structures to more effectively absorb sound wave energy. However, most of the current thin-film piezoelectric acoustic sensors have not fully considered the transverse piezoelectric coefficient in vibration modes, nor have they deeply explored the performance of piezoelectric sensors when simultaneously coupling two working modes.

To address the problems mentioned, a highly oriented piezoelectric fiber film, fabricated through electrospinning, has been developed for use as acoustic sensor. The fibrous membranes with uniaxial stretching of fibers have high content of all-trans crystalline phase with the content of β phase reaching over 88%. The output performance of aligned-samples in bending mode can reach 220-280 mV, which is four times higher than that of non-oriented films. When considering the acoustic-electrical conversion property, the sensitivity of PVDF-TER@BaTiO₃ fibrous membrane is 26 mV/Pa at fixed sound source without any outside vibration amplification, comparable with other similar works. This work provides the potential for fabricating flexible piezoelectric acoustic sensors for biomedical applications using oriented fiber films.

Construction of Self-reinforced Networks with High-crystallinity Silk Nanofibrils for Ultrafine and Biodegradable Recycled Regenerated Silk Fibroin Monofilament Sutures

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Superfine recycled regenerated silk fibroin (RRSF) monofilament sutures are designed to minimize surgical incisions, prevent scar formation, and facilitate precise suturing in cosmetic and plastic surgeries. However, balancing fineness and strength remains a challenge because the RRSF extraction process disrupts the hierarchical structure of natural silk fibers, leading to suboptimal mechanical properties. This study employed mechanical peeling and grinding to exfoliate β-sheets-rich silk fibroin nanofibrils (SFNF), which served as homologous reinforcing materials uniformly dispersed in the RRSF spinning system. Water-soluble, biocompatible polyvinyl alcohol (PVA) was introduced to enhance ductility. The SFNF/RRSF/PVA (SRP) fiber underwent extensive water immersion stretching to produce ultrafine fibers and foster a highly oriented internal self-reinforcing SFNF network structure. Monofilament surgical sutures were successfully fabricated following surface coating with chitosan. As shown in Figure 1, with 0.1 wt% SFNF (SRP-0.1) and a stretching multiplier of 2.5, the tensile strength of the fibers increased by 33% compared to those without SFNF (SRP-0.0). Fluorescence staining confirmed the presence of highly oriented SFNF networks within the fibers. Mechanical simulations validated the pronounced reinforcement effect of this network structure. The sutures, measuring 39.38 µm in diameter and exhibiting a tensile strength of 0.31 N, met USP standards for 9-0 surgical sutures, making them suitable for microsurgery. Additionally, they demonstrated antibacterial properties, biocompatibility, and degraded at a rate of 43.09% within 30 days. In animal trials, the sutures facilitated wound closure, reduced inflammatory responses, and minimized scar formation.

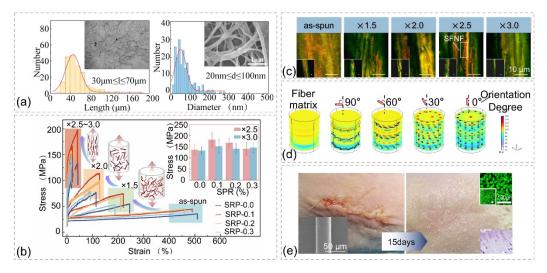


Figure 1. (a) Frequency distribution of SFNF length and diameter; (b) effect of water immersion stretching on the mechanical properties of SRP fibers; (c) dispersion of SFNF in SRP fibers under different water immersion stretching conditions (green fluorescence representing RRSF while red fluorescence representing SFNF); (d) mechanical simulation results of orientation degree on the mechanical enhancement of SFNF-reinforced networks; and (e) the feasibility of the application of surgical sutures.

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Bionic Micro-nanofibers and Sustainable Materials

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Electrospinning, a crucial technology for producing micro-nanofibers, has gained significant attention for its applications in catalysis, flexible sensing, and biomedical engineering. Despite its potential, challenges remain in performance, consistent with the electrospinning process, multi-level fiber structure design, use of bio-based polymers, and functional membrane construction. Addressing these challenges, we have developed an in situ biomimetic nano-welding technology, designed a high-performance biomimetic skin structure membrane, and demonstrated its applications in waterproof and breathable materials, biomedicine, and health. The specific advancements include: (1) Established the relationship between the electrospinning process, fiber morphology, and performance. This involves linking high-voltage electric fields to polymer molecular orientation, addressing the issue of weak mechanical strength in electrospun fiber membranes through solvent-assisted in situ welding technology, and transitioning from needle electrospinning to industrial-scale needle-free electrospinning; (2) designed biomimetic, comfortable nanofiber membranes that integrate flexible sensing and artificial intelligence for advanced sensor research. This enables the monitoring of physiological signals, such as breathing, pulse, and sweat for health management, and the development of advanced wound dressings; (3) developed functional materials from cellulose, chitin, and polylactic acid (PLA), studying the response of molecular chains to solvents and temperature, achieving the industrialization of polylactic acid polyols, and expanding their applications in textiles, wound repair, and vascular stents. This research is grounded in sustainable material application, multilevel micromorphology control, and biomimetic structure design, advancing the development and high-value applications of electrospinning technology and sustainable materials.

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Versatile Dynamic Poly(oxime-urethane)s Enabling Covalently Crosslinked Fibers

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Dynamic polymers have shown great promise in many fields. Recently, we have developed a series of multifunctional dynamic polymers and composites based on emerging dynamic oxime-urethane bond [1]. The trade-off between the mobility and stability of dynamic crosslinked polymers is a key challenge in the field. We have developed several approaches to overcome it. We constructed a Cu(II)-dimethylglyoxime-urethanecomplex-based poly(oxime-urethane) elastomer (Cu-DOU-CPU) with synergetic hydrogen bonds/coordination bonds/dynamic covalent bonds. We demonstrated the dual mechanism of coordinated metal ions including strengthening elastomers and catalyzing the dynamic oxime urethane bond reorganization to solve the contradiction between self-healing ability and high mechanical strength, and provided a general molecular design principle for biomimetic soft, strong, tough, and self-healing elastomers [2]. We utilized highly dynamic fourarm crosslinking units with an internal, catalytic oxime-carbamate group to fabricate a polymer network with high crosslinking density yet reduced thermal processing temperature [3]. This approach enabled the resulting ionogel to exhibit both high self-healing efficiency at room temperature and superior mechanical properties [4]. We proposed a bone-inspired stress-gaining concept of converting typically destructive stress into a favorable factor to substantially enhance the mechanical properties of elastomers by orders of magnitude [5]. The resultant dynamic polymers also exhibited excellent processibility. Accordingly, for the first time, covalently crosslinked fibers have been continuously produced by molten spinning [6] and significantly improved the creep resistance and elasticity of linear counterpart fibers. This type of adaptable covalently crosslinked fibers may emerge as a new family of fibers. Furthermore, we explored diverse applications of poly(oxime-urethane)s. A new concept of fabricating a medical device via in situ self-healing assembly at the lesions in vivo has been proposed to efficiently treat aortic aneurysms, nerve coaptation, and bone immobilization in rat model [7]. Fiber-based multifunctional ionotronics with the integration of several desirable functionalities, including sensor, triboelectric nanogenerator, and electroluminescent display, have been fabricated [8]. Overall, our work demonstrates the significant potential of utilizing the synergistic electronic, spatial, and topological effects as a new design strategy for developing highperformance materials. We expect versatile oxime-urethane will create more functional smart materials and enable more novel applications in the future.

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Theranostic Wound Dressings: Four Strategies for Enhancing Sensitivity and Accuracy in Detecting Bacterial Infections Without False Positives

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BACKGROUND AND PURPOSE

Traditional antibacterial dressings continuously elute biocides, even in the absence of bacteria. This unnecessary release can lead to bacterial resistance, cause cytotoxicity to skin cells, and delay healing. Simultaneous monitoring and treatment of wound infection are of great importance in the biomedical field. The present work describes the development of a theranostic wound dressing (TH-WD) that can simultaneously monitor and inhibit wound infection, along with four different strategies used to enhance the detection of wound bacterial infection.

METHODS

Using the electrospinning technique, we fabricated a polyurethane nanofibrous membrane (TH-WD) loaded with a ciprofloxacin-based prodrug (Pro-Cip) and a chromogenic probe (H-Cy). We adopted four strategies to further boost detection sensitivity and speed: 1. Enrich the chromogenic probe in the shell of core-shell structured nanofibers; 2. add a polymeric dopant (polyvinyl pyrrolidone, PVP) in the shell; 3. achieve cross-alignment of nanofibers; and 4. incorporate a surfactant into the biosensor.

CONCLUSIONS

In vitro studies have shown that TH-WD is effective in reducing *Pseudomonas aeruginosa* (ATCC 27853) by 100 \pm 4% within 4 hours of contact. Additionally, it provides a simple visual indication of wound infection through a color change from yellow to green to red. TH-WD is highly selective, only releasing the active drug (ciprofloxacin) in the presence of certain lipase-secreting pathogenic bacteria. When incubated with no- or low-lipase-producing bacteria (such as *E. coli* TOP 10) or skin cell fibroblasts, no color change or cytotoxicity was observed. This helps to minimize the emergence of bacterial resistance associated with the overuse of antibiotics and avoid unnecessary cytotoxicity to skin cells. All four adopted strategies improve detection sensitivity, enabling the detection of pathogenic bacteria at clinically relevant concentrations (<1.0E+5.0 CFU/cm²).

ACKNOWLEDGMENT

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Assessment of Wearable Cooling and Dehumidifying System Used Under Personal Protective Clothing Through Human Subject Testing

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Healthcare professionals wearing personal protective equipment (PPE) during outbreaks often experience heat strain and discomfort, which can negatively impact their work performance and well-being. This study aimed to evaluate the physiological and psychological effects of a newly designed wearable cooling and dehumidifying system (WCDS) on healthcare workers wearing PPE through a 60-minute treadmill walking test. Core temperature, mean skin temperature, heart rate, and subjective assessments of thermal sensation, wetness sensation, and thermal comfort were measured throughout the test. Additionally, ratings of wearing comfort and movement comfort were recorded during a wearing trial. The results showed that the WCDS significantly reduced core temperature, improved thermal sensation, and reduced wetness sensation compared to the non-cooling condition. The microclimatic temperature within the PPE was significantly lower in the cooling condition, indicating the WCDS's ability to reduce heat build-up. The wearing trial results demonstrated general satisfaction with the wearability and comfort of the WCDS across various postures. These findings contribute to the development of enhanced PPE designs and the improvement of working conditions for healthcare professionals on the frontlines during outbreaks.

Wound Dressing with Janus Fabric

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Medical dressings with asymmetrical design of the micro-nano surface structures can achieve effective biofluids management for chronic wounds, which can prevent surgical site infections and death in severe areas. Asymmetric dressing exhibits different wettability characteristics on each side, integrates advances in novel biomaterials, and dynamic control of biofluids, provide biofluid drainage strategies to cope with complex chronic wound scenarios. The composition and design of Janus wound dressings and on-demand treatment strategies for chronic wounds are analyzed. This paper provides a new option for achieving biofluid management and high-performance, one-way biofluid drainage dressing, which has great potential for surgical operations applications.

Conventional dressings often retain wound exudate, creating a moist environment conducive to bacterial proliferation and impeding tissue regeneration. Unidirectional, self-pumping dressings utilize asymmetric wettability gradients or microstructural designs (e.g., Janus membranes) to actively transport exudate from the wound surface to the outer absorbent layer. This unidirectional fluid transport prevents reverse contamination while maintaining an optimally moist microenvironment, accelerating angiogenesis and epithelialization.

Employing biomaterials such as silk fibroin or cellulose, the dressing conforms and adheres to dynamic wound contours during movement. This mechanocompatibility minimizes shear stress-induced secondary damage while ensuring consistent fluid transport efficiency across curved anatomical regions. The self-pumping mechanism reduces dressing replacement frequency compared to passive absorbent materials. Furthermore, polymer substrates align with circular economy principles, addressing the environmental burden of chronic wound care waste.

The one-way, self-pumping dressing uses asymmetric wettability gradients and biomimetic microstructures to construct Janus textiles, which can actively drain wound exudate while preventing exudate reflux and maintaining optimal "water balance." This dressing is made of compatible biomaterials and can seamlessly fit the dynamic wound contour. The autonomous fluid delivery system does not require dressing changes, thereby eliminating secondary injuries and improving patient compliance, thus redefining chronic wound management through material science and microfluidic engineering and achieving coordinated "drainage-adaptability-sustainability" precision care.

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Fibrous Materials for Medical Implants: Durability Issues

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STATEMENT OF PURPOSE: Textile materials have been largely used as medical implants (vascular graft, stent grafts, hernia meshes...) over the last decades. However, the long-term success of these implants relies on their ability to interact with the surrounding biological tissues. In this context, non-woven fibrous constructions made from small fibers and large pores are expected to limit fibrotic tissue development, but they lack strength. The purpose of this work is to investigate various strategies to increase the strength of non-woven mats: (1) reinforcement by embroidery; (2) assembling with a woven or knitted fibrous construction layer.

METHODS: Two approaches were considered. First, non-woven samples were produced from both melt-blowing (MB) and electro-spinning (ES) techniques, reinforced with a stitching yarn and tested regarding strength. Various stitching patterns were considered (X or L). In a second approach, non-woven mats were combined with a woven fibrous layer using needle punching in order to obtain a hybrid material.

RESULTS: Regarding the embroidery reinforced non-woven mats, results show that the burst strength can be increased by up to 100% for the ES material and 50% for the MB material (Figure 1). However, it turns out that after cyclic loading, the strength of both materials goes down due to the cycling interaction between the reinforcement yarn and the non-woven mats. However, the remaining strength values after cycling remains above control sample values.

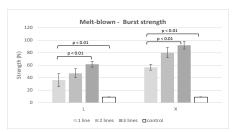


Figure 1. Burst strength vs stitching pattern.

Regarding the assembling of the non-woven mat with a woven layer, it turns out that the needle punch assembling process allows strong entanglement of the fibres between the layers (Figure 2). Finally, the hybrid construction combines the advantages of both materials. The obtained construction is stronger than the non-woven mat alone, which itself helps to limit cell proliferation by offering a more appropriate topography.

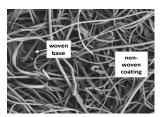


Figure 2. Hybrid textile construction.

CONCLUSION: These preliminary results confirm that it is possible to enhance and control the strength of non-woven mats for biomaterial applications with either embroidery reinforcement or needle punching.

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Rational Design of Micro- and Nano-fibrous Spheres for Efficient Stem Cell Delivery and Tissue Repair

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Stem cells represent a promising source of cells for tissue engineering due to their capacity for self-renewal and multi-directional differentiation¹. Biomaterial scaffolds are imperative in the regulation of stem cell activity and promotion of tissue repair. However, the fabrication of three-dimensional scaffolds and injectable biomaterials poses significant challenges, thereby constraining their clinical applications. Micro- or nano-fibers, with their high specific surface area, high porosity, large aspect ratio, and tunable properties, offer new opportunities for biomedical applications². To advance these strategies toward clinical use, it is essential to optimize scaffold properties and enhance cell-material interactions. Herein, we designed and fabricated a series of micro- and nanofibrous spheres for the delivery of stem cells and bioactive factors by combining electrospinning and electrospray techniques. These fibrous spheres have been shown to regulate stem cell differentiation and effectively promote the repair of damaged nerves, bones, and wounds. As shown in Figure 1, a series of injectable fibrous microspheres made of polycaprolactone or poly(lactic-co-glycolic acid) were developed for efficient delivery of stem cells and/or nerve growth factors. Such class of microspheres with a 3D network structure can facilitate stem cell adhesion and growth by simulating the complex native tissues. The controlled release of bioactive factors together with the structure will simultaneously induce neural differentiation and formation of myelin sheaths. The bioactive glass incorporated organic-inorganic complex fibrous spheres have been specifically designed to deliver bone marrow mesenchymal stem cells and facilitate osteogenic differentiation and angiogenesis during the regeneration of bulk bone defects. We have also developed polycaprolactone/magnesium hydroxide nanofibrous spheres with excellent antibacterial properties for the treatment of infected wounds. Taken together, the advanced research on micro- and nanofibrous spheres shows great promise for stem delivery and traumatic tissue repair. The diverse fibrous spheres also have considerable value in high-throughput drug screening, organoid construction, and personalized medicine research, providing innovative solutions to advance biomedical applications.

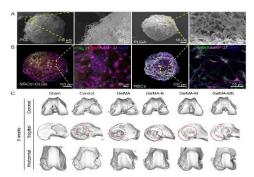


Figure 1. (A) SEM images showing the morphologies of the fibrous spheres; (B) fluorescence micrographs showing the adhesion and differentiation of neural stem cells on the nanofibers spheres; (C) efficient bone tissue repair using injectable organic-inorganic complex fibrous spheres with the delivery of bone marrow mesenchymal stem cells.

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ACKNOWLEDGMENT: This work was supported by National Natural Science Foundation of China (82001970), Natural Science Foundation of Shandong Province (ZR2021YQ17), and Young Elite Scientists Sponsorship Program by CAST (No. YESS20200097).

AlN Ceramic Aerogels with Unprecedented Thermocapillary Properties for Thermal Cooling

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Aluminum nitride (AlN) nanofiber materials, as the forefront of emerging fibrous materials, have attracted considerable attention for their broad implications, ranging from industrial to aerospace applications, due to their integrated advantages of high-temperature resistance, corrosion resistance, and intrinsic high thermal conductivity. Despite their immense potential, critical challenges remain, primarily due to their short rod-like polycrystalline morphology and mechanically fragile architectures, which limit their practical deployment. Recent advances in monocrystalline nanofiber aerogels via direct vapor-assisted rotational stacking growth may offer a pathway to address these challenges. However, the synthesis of such aerogels with structurally sophisticated features remains extremely challenging. Here, we propose a novel strategy to fabricate AlN monocrystalline nanofiber aerogels (ANAs), featuring vertically aligned channels and ultra-long monocrystalline nanofibers by combining tandem catalytic nanoengineering and freeze-shaping technique. Through tandem catalytic vapor deposition, our AlN nanofibers achieved monocrystalline hexagonal structure with elongated morphology, which enables near-perfect phonon conduction with thermal conductivity exceeding 100 W m⁻¹ K⁻¹. Driven by the capillary action of vertically aligned channels, the ANAs exhibit an excellent water transport rate of up to 8.3 mm s⁻¹. These aerogels achieve ultrafast cooling capabilities, reducing the surface temperature from 1100°C to ~100 °C at a rate of approximately 150°C s⁻¹, due to the efficient heat exchange between the nanofibers and coolant. The ANAs exhibit an integrated coupling effect that combines phonon-conduction thermal transfer, unrestricted liquid propulsion, and unimpeded vapor diffusion to achieve a breakthrough in sustainable thermal protection systems. These unique properties position ANAs as ideal candidates for advanced thermal management applications, particularly in hypersonic aerospace vehicles.

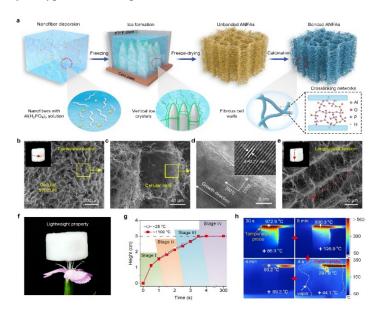


Figure 1. Structural design and aligned architectures of ANAs. (a) Illustration of the preparation process of ANAs. (b, c) Transverse sectional SEM images of ANAs at various magnifications. (d) HRTEM characterization of the AlN nanofiber. (e) Longitudinal sectional SEM images of ANAs. (f) Optical image of ANAs self-standing at the tip of flower. (g) Capillary flow curves of ANAs. (h) Thermographic images over time under extreme temperature conditions, with and without water.

Research on Material Innovation and the Development of Inclusive Fashion Products

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Amidst the rapidly evolving consumer demands and the global shift toward sustainable development, inclusive fashion products face multidimensional challenges throughout their design and development phases. The critical question lies in how emerging materials can empower the creation of truly inclusive products. Through analysis of existing consumer data and case studies, this research explores the empowerment mechanisms and future trajectories of novel materials in inclusive fashion product design, offering strategic insights for material innovation applications. Key findings reveal three primary dimensions: (1) Technologically enabled smart materials (e.g., shape-memory alloys) are redefining performance boundaries through adaptive capabilities. Their dynamic adjustments significantly enhance accommodation of diverse physiological needs and usage scenarios across user demographics; (2) Bio-derived materials present sustainable solutions through recyclability and circular lifecycle management. These eco-conscious materials enable advancement of inclusive products while maintaining environmental responsibility; (3) Future research should prioritize systematic material property analysis combined with interdisciplinary collaborative innovation. Special attention must be given to addressing the specific needs of vulnerable groups, particularly individuals with physical disabilities and the elderly, through human-centered design approaches. This study demonstrates that leveraging material innovation can unlock inclusive fashion's potential to create products that harmonize technical functionality with socially sustainability values.

INTRODUCTION

In the face of new consumer demands, fashion products must be reimagined, redefined, and restructured, with product innovation emerging across three key areas: materials, design, and product development. Among these, materials serve as the "second skin" for the human body, playing a crucial role in the relationship between people and product innovation. Meanwhile, the Chinese textile fabric trend highlights that materials should make fashion more warm, diverse, inclusive, and fun, indicating that material innovation aligns with the direction of inclusive fashion products. Currently, most scholars, such as Ni Jiapian and Wang Wei, have focused on explaining the concept of inclusive fashion and design methods, without exploring the impact of new materials on the development of inclusive fashion. Therefore, this paper takes inclusive fashion products as its entry point, exploring how materials empower fashion products in terms of appearance, functionality, and perception. It examines the needs of the elderly population, a key focus of inclusive design, and, through prior analysis, outlines how material innovation can respond to the needs of elderly-inclusive fashion products. This not only guides the application of new materials in elderly clothing but also promotes the synergistic development of materials and inclusive fashion products.

METHODS

This paper employs literature review, survey, and case study methods to ensure a rigorous and reliable review of existing research, thereby exploring the latest developments in material innovation and inclusive fashion products. To identify relevant studies, we developed a comprehensive search strategy, retrieving research from CNKI, Wanfang, Web of Science, and other databases over the past five years. According to CNKI literature searches, there were approximately 33 entries for "elderly smart clothing," 22 for "elderly functional clothing," 5 for "disability functional clothing," and 20 for "smart children's clothing." Additionally, existing new materials on the market and clothing cases incorporating inclusive design concepts were selected for in-depth analysis. Through comparisons across time and space, the advantages and limitations of materials in terms of appearance,

performance, and adaptability were examined. Finally, with older people as the research focus, the paper explores pathways for the synergistic development of material innovation and inclusive products, with a particular emphasis on the critical role that material functionality plays in this process.

RESULTS

The application of new materials in fashion products has driven multi-dimensional transformations, enhancing product form, functionality, sensory interaction, and social responsibility. In terms of form, these materials enable dynamic shapes and colour adaptability, shifting from static designs to interactive, environmentally responsive structures. Functionally, they enhance protective properties such as insect repellent and health monitoring, while introducing active sensing capabilities to enable real-time user feedback. Advancements in sensory technology, through temperature regulation, comfort enhancement, and emotional response mechanisms, have fostered empathetic connections with users, thereby optimising the wearing experience. Ultimately, the emergence of new materials has heightened public and educational awareness of sustainability, driving the fashion industry toward ethical consumption and environmental protection.

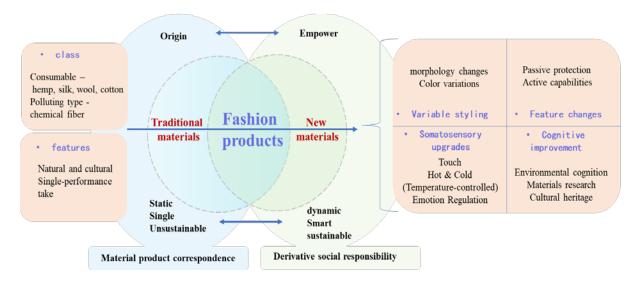


Figure 1. The relationship between materials and fashion products.

Given the transformative role of new materials in the fashion industry, this study focuses its analysis on the elderly consumer demographic. The unique physiological, safety, and emotional needs of this group are driving an urgent demand for inclusive product development. Demand analysis reveals a significant increase in consumers' prioritisation of comfort, protective functionality, and mental well-being. Data indicate that consumers exhibit a high interest in fabrics capable of alleviating skin sensitivity, preventing falls, and reducing feelings of loneliness. Material innovation addresses these needs through three key dimensions: motion-based monitoring and protection, achieved through sensor-embedded textiles for real-time health tracking and impact absorption; daily performance upgrades, using advanced fibres to provide superior breathability, temperature regulation, and antimicrobial properties to enhance comfort and health; and psychological and emotional care, achieved through interactive materials that simulate hugs and AI-driven companionship features to alleviate feelings of isolation. These innovations collectively pave the way for collaborative development, driving the realisation of inclusive fashion by customising material functions to meet the specific needs of older people, thereby promoting dignity and sustainability in home-based elderly care. This targeted strategy not only reinforces a user-centric design philosophy but also highlights the broader societal trend of the fashion industry shifting toward ethically driven, health-focused innovation.

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Functional and Multicolor Super-resolution Nanoscopy of Subcellular Fibers

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Super-resolution fluorescence microscopy has revolutionized our ability to visualize subcellular structures beyond the diffraction limit, offering unprecedented insights into cellular organization and function. Here, we present a functional and multi-color spectroscopic, single-molecule localization microscopy (sSMLM) approach to investigate the nanoscale architecture and dynamic properties of subcellular fibers of tubulin, actin, and DNA fibers. By integrating tailored fluorophore labeling strategies with optimized imaging conditions, we achieve precise molecular localization and spectral separation of distinct fiber populations. Our method enables high-resolution mapping of cytoskeletal and nuclear components, revealing intricate structural details and interactions that govern cellular mechanics. Furthermore, we incorporate functional imaging to probe local nanoscale fiber properties, including chemical polarity and molecular diffusion, shedding light on their roles in cellular processes. This approach provides a powerful framework for studying fiber-based cellular architectures with nanometer precision and multiplexed molecular specificity, advancing our understanding of subcellular organization and its implications in health and disease.

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ACKNOWLEDGMENT

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Biomechanical Modeling of Force Transfer and Deformation in Body-Garment Interactions

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BACKGROUND

With the increasing application of compression apparel and medical compression garments in sports, as well as health maintenance and chronic disease management, the influence of their mechanical properties on human physiological responses has received significant attention. Traditional design methods based on empirical knowledge or simplified mechanical assumptions do not fully account for the inherent heterogeneity and nonlinear characteristics of human tissue. Since compression garments are in direct contact with the human body, their functionality and comfort are largely determined by the appropriateness and uniformity of the pressure distribution. This limitation hampers the accurate quantification of dynamic mechanical interactions between biological tissues and compression garments, often resulting in inconsistent therapeutic efficacy or reduced comfort.

METHODOLOGY

To overcome these challenges, this study introduces a biomechanics-driven multiscale coupling framework that integrates human tissue mechanical models with micro- to macro-scale garment mechanics. This framework combines material characterization techniques, advanced imaging modalities, and computational modeling to systematically investigate stress transfer mechanisms and coupled deformation behaviors at the tissue-garment interface. Specifically, 3D body scanning and tissue indentation testing were employed to quantify the region-specific mechanical properties of human tissues under varying compressive loads, establishing correlations between localized pressure and tissue deformation. Subsequently, dynamic multidimensional tissue deformations under garment pressure were characterized via 3D body scanning. Finally, a finite element (FE) contact model was developed to simulate the interactions between the human body and garments.

INNOVATION AND APPLICATIONS

FE simulations clarified the mechanical coupling mechanisms between human tissues and garments, revealing nonlinear pressure transmission through subcutaneous structures and shear-induced sliding effects that regulate pressure distribution at the interface. This study advances the fundamental understanding of coupled deformation mechanisms, and represents a paradigm shift from rigid-body approximations to multiscale, tissue-specific, biomechanical modeling. The proposed framework enables the way for designing personalized compression garments with spatially graded mechanical properties. Moreover, the derived biomechanical datasets and simulation protocols offer robust support for virtual fitting systems and digital human modeling in healthcare. This integrative approach bridges the gap between biomechanical theory and functional garment engineering, providing the transformative potential for precision medicine and performance optimization in compression therapy.

ACKNOWLEDGMENT

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Fibers for Comfort and Protection

Study on Preparation and Industrialization of Smart Thermo-moisture Regulatory Fibers

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Comfort and aesthetics are among the most important functions of textiles. This study invented smart fibers with thermo-moisture responsiveness through innovative structural design. This study utilized the reversible deformation of fibers under thermo-moisture stimuli to dynamically alter yarn compactness, thereby achieving intelligent regulation of the fabric's pore structure. As a result, when the wearer perspires, the fabric pores expand to enhance heat dissipation, whereas they contract in dry and cold conditions to improve thermal insulation. This work has made a significant advancement in the bidirectional intelligent regulation of thermal and moisture comfort fabrics, successfully realizing the industrial-scale production of smart thermo-moisture regulatory fibers and broadening the scope of smart fiber applications in textiles.

Permanent Antibacterial and Odor-absorbing Nylon Through Extrusion Chemistry

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Permanent antibacterial properties in yarn and fabric are highly desirable for a wide range of applications, from sporting goods to medical textiles. However, when considering mass-market applications, several challenges must be addressed. In addition to exhibiting robust and durable antibacterial activity, the material must be safe for human use, widely available, and compatible with accessible manufacturing technologies. Furthermore, minimizing the number of technological steps is essential to prevent cost escalation.

Our research initially focused on the incorporation of essential oils into polypropylene yarn via high-speed mixing of pellets and oils before the spinning process. Some essential oils demonstrated the ability to withstand extrusion, thereby imparting antibacterial properties to the resulting fabric. Concurrently, we explored the modification of polyacrylonitrile (PAN) yarn with diamines, resulting in an impressive array of functional enhancements.

Inspired by the successful direct extrusion of antibacterial additives with polypropylene and keeping in mind the functional surface of modified PAN, we aimed to develop antibacterial and odor-absorbing nylon using a similar approach. The first series of experiments involved incorporating 12 distinct antibacterial additives into nylon. The selection criteria included availability, human safety, and high thermal stability. Initially, films containing 5 wt% of each additive were produced to evaluate their compatibility with nylon during extrusion. Eight additives demonstrated strong antibacterial efficacy, maintained even after 15 washing cycles. Notably, some additives exhibited chemical interaction with nylon, while others formed simple blends. Some additives were dramatically transformed during extrusion process.

Following the preliminary screening, the most promising additive candidates were incorporated at 2 wt% into nylon, and yarn spinning was performed under semi-industrial conditions. Three additives successfully imparted robust antibacterial properties to the yarn.

Subsequently, the fabrics were dyed under industrial conditions to assess the stability of antibacterial properties post-processing. One of the three fabrics retained its antibacterial effectiveness after 15 washing cycles. Furthermore, the addition of melamine to nylon yielded superior odor-absorbing performance, while benzalkonium chloride conferred the most potent antibacterial properties.

Nanocellulose-assisted Fabrication of Functional Materials for Electromagnetic Pollution Elimination

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Electromagnetic Functional Materials (EFMs) that could eliminate electromagnetic pollution effectively are becoming increasingly vital in contemporary society, both for safeguarding public health and maintaining the optimal function of precision instruments. Nanocellulose possesses a large aspect ratio and abundant functional groups, facilitating its effective interaction with nanomaterials, such as carbon nanotube, graphene, transition metal carbides/nitrides (MXenes). The efficient interactions enabled a great potential of nanocellulose for assisting fabrication of high-performance EFMs. This talk will discuss the nanocellulose-assisted preparation of composite films and aerogels for electromagnetic pollution elimination. In particular, we will discuss (1) the fabrication of flexible and highly conductive nanocellulose composite film for electromagnetic wave shielding application; and (2) the development of lightweight nanocellulose-based aerogel for electromagnetic absorption.

High-performance Waterproof and Breathable Nanofibrous Membranes

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Functional membranes with protection and thermal-wet comfort are highly demanded in various fields. Nevertheless, the existing membranes suffer from a tradeoff dilemma of liquid resistance and moisture permeability, as well as poor thermoregulating ability. This presentation reports recent progress in the formation and structural regulation of ultrafine nanofibrous membranes and their waterproof and breathability properties. The key points are summarized as follows: (1) The superhydrophobic nanofibrous membranes with perdurable liquid repellency and robust breathability were achieved via combining humidity-induced electrospinning with coat-crosslinking technology; (2) A novel strategy was developed based on manipulating the equilibrium of stretch deformation and phase separation of electrospun jets to develop true nanoscale fibers for high-performance waterproof and breathable applications; (3) Antisymmetric wetting nanoarchitectured meshwork, consisting of hydrophobic ferroelectric nanofiber/meshes and hydrophilic nanofiber/meshes, were constructed for personal thermal-wet comfort management based on the electromeshing technique, and the nanofiber/meshes formation mechanism of ejection, deformation, and phase separation of charged droplets was revealed; (4) The dual-network structured nanofiber/mesh for high-performance waterproof, breathable, and radiative cooling membranes was obtained by proposing a new strategy based on the synchronous occurrence of humidity-induced electrospinning and electromeshing. The successful creation of high-performance waterproof and breathable membranes opens a new avenue for developing advanced functional textiles.

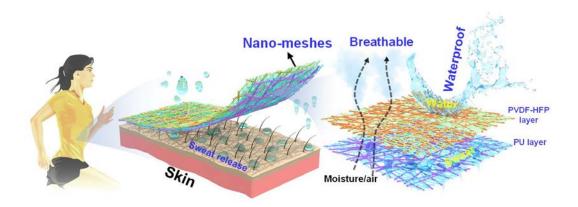


Figure 1. Schematic demonstrating waterproofness, breathability, and sweat release of the nano-meshes fabrics[1].

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Diapers with Next-to-Skin Moisture-adaptive Embossment for Improved Comfort

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Diapers are essential living consumables for infants and elderly. Thermal and tactile comfort of diapers are critical to the well-being of those who use them daily. Prolonged contact with moisture and fecal matter has been identified as a primary factor contributing to diaper dermatitis. The embossing patterns on the diaper's next-to-skin surface can reduce the contact area and decrease the risk of dermatitis. Current surface embossing designs of baby diapers have limitations in addressing issues related to prolonged usage, lack of support under body pressure, and insufficient reduction of skin contact with the surface layer. This paper reports on the development of a novel moisture-adaptive embossed surface layer through the embedment of a moisture absorbing hydrogel [viz. acrylic acid-co-sodium acrylate (AA-co-SA)] in the embossing structure. The incorporation of tailored AA-co-SA hydrogel dots within the diaper's inner surface layer resulted in superior thermal and moisture comfort in comparison with existing commercial products. The designed embossments proved effective in reducing the contact area and maintaining an air gap between the skin and the diaper under heavy compression.

Figure 1



Flexible Radiative Cooling Fiber Meta-fabric with Prolonged Phase-change Thermal Storage Properties

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In response to the overheating effects on the human body caused by sudden high temperatures, it is necessary to develop a new strategy with temperature regulation capabilities. This strategy aims to maintain a relatively stable personal microenvironment to combat heat stress. In fact, phase-change textiles can achieve temperature regulation under variable weather conditions. Currently, most reported phase-change textiles incorporate large amounts of phase-change materials to enhance thermal storage performance. However, due to encapsulation issues, leakage occurs. Moreover, conventional phase-change textiles exhibit poor mechanical properties and washing durability, which can even affect the wearer's comfort. Therefore, the technique of incorporating large amounts of phase-change materials into textiles still faces a significant challenge. In this work, we proposed a novel and effective technique for incorporating a large amount of phase-change microcapsules into nanofiber textile through electrospinning. Notably, the phase-change microcapsules showed no signs of rupture after electrospinning. Simultaneously, the phase-change microcapsules were tightly wrapped by nanofibers, enhancing their stability. Furthermore, we integrated phase-change thermal storage and radiative cooling functionalities to fabricate hierarchical structure nanofiber textile. The results indicated that incorporating 60 wt% of phase-change microcapsules into nanofiber textile not only preserved the spectral properties of the radiative cooling layer but also significantly compensated for its shortcomings. Meanwhile, due to the phase-change microcapsules having a phase-change temperature close to skin temperature, along with their strong thermal storage and high heat capacity, the nanofiber textile can buffer sudden temperature changes effectively, thereby maintaining prolonged thermal comfort. Outdoor testing results demonstrated that the nanofiber textile was 6.5°C cooler than the subambient temperature. Compared to textile without phase-change microcapsules and cotton, the nanofiber textile can achieve temperature drops of 3.7°C and 14.8°C, respectively. Significantly, the cooling performance of the nanofiber textile is obviously higher than that of other previously reported phase-change fabrics. Furthermore, after 300 wash cycles, the quality of the nanofiber textile remained essentially unchanged, with its phase-change performance also showing minimal alteration. In addition, the nanofiber textile exhibited excellent flexibility, tear resistance, UV resistance, thermal stability, washability, breathability, and moisture permeability. These qualities provide a new solution for manufacturing the next generation of advanced phase-change textiles.

Development of Flexible Aerogel Blanket for Thermal Insulation

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BACKGROUND

Aerogels, characterized by their combination of high porosity and nanoporous structure, have the lowest bulk density of any known material, the highest specific surface area of any monolithic material (up to 1200 m²/g), and very low thermal conductivity <30 mw/mK, thus offering a lightweight solution when compared to contemporary insulating materials. Despite the excellent characteristics that aerogels display, their poor mechanical properties and brittle nature limit their applicability in a textile where flexibility is a serious concern. Sustainable insulation presents a critical challenge to the requirements of modern industry, consumer demands, and environmental concerns. Use of biopolymers in aerogel fabrication is gaining importance in many areas to tackle challenges of mechanical properties and sustainability. This research primarily focuses on the development of a sustainable flexible aerogel system for textile integration.

METHODS

In this study we prepared biobased aerogels with the help of polysaccharide extracted from algae as a 3D network forming material and Micro-crystalline Cellulose (MCC) as a reinforcing agent. The aerogels were crosslinked to enhance the dimensional stability and microporous structure. The addition of MCC delivered a multifold enhancement of the mechanical properties and stability of the polysaccharide skeleton. The aerogels were able to withstand 1500x of their own weight without crumbling. Silylation was carried out to prevent the biobased aerogel from absorbing moisture and impart hydrophobicity to the material. The inherent flexibility of nonwoven fibrous matrix offers numerous benefits for aerogel integration and widens the application potential of the materials. Polysaccharide and MCC composite precursors are coated onto the nonwoven blanket to prepare flexible thermal insulation barriers. The bio-based aerogel composite fibers displayed low thermal conductivities <25 mW/mK and enhanced mechanical properties. The bio-composite structure prevents aerogels from collapsing during compression of nonwovens, which is essential for effective insulation.

The findings of the study highlight the potential of polysaccharide aerogels as high-performance, sustainable materials with potential for applications in high-performance, thermal insulation for textiles.

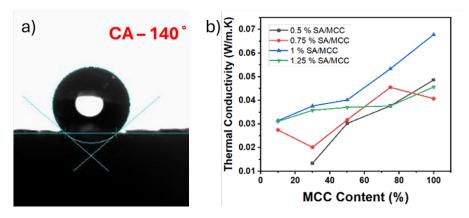


Figure 1: (a) Water contact angle of the aerogel after silylation; (b) thermal conductivity of aerogels.

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Bioinspired Multilayered Knitted Fabric with Directional Water Transport and Collection for Personal Sweat Management

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Effective sweat management fabric for sportswear facilitates the sweat removal from the body skin and elevates the comfort for human. However, when the human body is in a strong hot and humid environment or after strenuous exercise, the sweat management fabric will be totally wetted and saturated quickly. As a result, the excess sweat cannot be absorbed effectively by the garment, which creates obvious stickiness and heaviness to humans. In this paper, a directional water transport and collection multi-layered knitted fabric (DWTCF) is prepared by the low-temperature plasma pre-treatment technology and screen coating. The tree-like water transport network inspired from nature is designed in order to drive the liquid flow along the channels. By surface modification, branched hydrophilic flow paths are fabricated, and other regions are hydrophobic. As a demonstration, DWTCF has been injected with water to observe the liquid transport behavior. During the experiment, the 76.7% liquid is collected by DWTCF. However, there is just 0.06% collected by ordinary knitted fabric, while the weight increase of ordinary fabric is 555.4% larger than that of DWTCF. Specifically, DWTCF utilizes the wetting and pressure gradient-induced interfacial tension as well as gravitational effect to facilitate the fluid motion along the hydrophilic channel, in addition to the capillarity effect present in the fabric structure. This study provides a new idea for developing a directional water transport and collection fabric to solve the moisture absorption saturation problem of the fabric, especially for conditions with intense sweating.

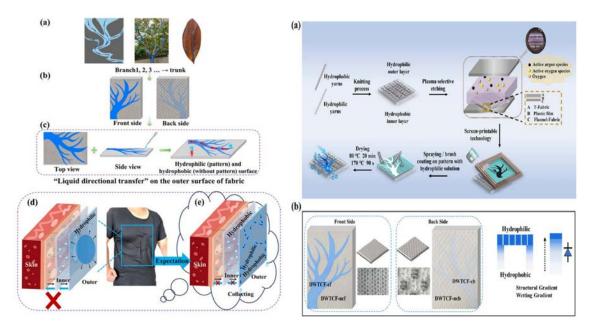


Figure 1. Design concept of the DWTCF.

Figure 2. Preparation process.

ACKNOWLEDGMENT

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Thermal Responsive Hydrogels with Programmable Shape Memory Properties Enabled by Phase Separation for Personal Protective Equipment

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Soft materials like hydrogels with great biocompatibility, softness, and flexibility have shown great potential in emerging technologies, including soft robotics, medical devices, health monitoring, and aerospace applications. With the in-depth study of hydrogels, stimuli-responsive hydrogels have received extensive attention. They not only possess the flexibility and good biocompatibility of hydrogels but also possess the transformation of physical or chemical properties under certain specific conditions, which are highly similar to human tissues (e.g., muscle tissues). Among them, thermo-responsive hydrogels are the most widely studied because the thermo-responsive mechanism has very unique advantages. However, most of the reported thermal-responsive hydrogels are too soft to resist higher external impact. The traditional anti-impact shields are normally made of stiff and hard materials and therefore are deficient in flexibility, exhibiting great limitations in personal protective equipment with complex geometries or significant deformability. Traditional thermal-responsive hydrogels usually rely on heat transportation, which is uncontrollable and inefficient. To address the inherent conflict between flexibility and impact resistance in traditional anti-impact shields and the dependence on external stimulus, in this study, a shape memory hydrogel composed of polyacrylic acid, which can reversibly change from soft to hard state via phase separation donated by internal mass diffusion, was devised. This hydrogel can remember specific shapes and return to its original state under natural ambient temperature with a recovery onset control. At room temperature, the prepared hydrogel shows softness, flexibility, and skin compatibility to those of ordinary hydrogels. With increasing temperature, the gel becomes hard, rigid, and self-supporting. The modulus of hydrogel increased from 0.21 MPa to 321.33 MPa, showing excellent mechano-adaptability and impact resistance owing to the synergistic effect between hydrophobic interactions and ionic bonding. Through hydrophobic and ionic interactions, the hydrogel skin transitions from a rubbery state to a glassy state at high temperatures, resulting in a transient increase in the modulus to achieve impact resistance. Further, the phase transition caused by the change in temperature absorbs heat, which lowers the temperature and protects the human body from scalding. These specific characteristics of hydrogel have a high potential for application in personal protective equipment and thermal protective clothing.

Smart Thermoregulating Fabric: Passive Radiative Cooling with Comfortable Breathability

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Reducing energy consumption is crucial for advancing global sustainable development. A significant portion of energy is currently expended on temperature regulation for human comfort, primarily through air conditioning. Researchers have focused on passive thermal management technologies to reduce energy consumption. However, achieving dual-mode thermal management—enabling both efficient cooling and adaptive temperature regulation in a single material system without external energy input—remains a challenge.

In this study, we report a passive radiative cooling multilayer fabric with phase-change material to enhance the property, which synergistically combines radiative cooling, evaporative cooling, and phase-change thermoregulation into a single platform. The obtained fabric shows high-performance for adaptive thermal and humidity management.

Figure 1 shows that the smart thermoregulating fabric demonstrated exceptional spectral selectivity, achieving 97% sunlight reflectivity and 94% selective infrared emissivity. In outdoor cooling experiments under a solar intensity of 72.5 mW/cm² at midday, the thermoregulating fabric exhibited an average temperature reduction of 14.4°C. Leveraging its interlayer wettability gradient, this fabric achieved a high water-vapor transmission rate of 0.35 g cm⁻¹ day⁻¹, enabling rapid sweat evaporation and enhanced evaporative cooling. Furthermore, the integration of phase-change material endowed this thermoregulating fabric with adaptive thermoregulation, maintaining stable performance under extreme temperatures (60°C and 7°C). With scalable production capabilities and superior functionality, this thermoregulating fabric presents a promising solution for next-generation smart textiles in adaptive thermal regulation, moisture management, and sustainable energy-efficient applications.

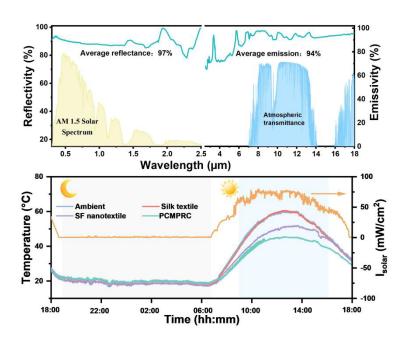


Figure 1. Sunlight reflectivity and infrared emissivity of the obtained fabric, and its cooling performance.

Shock-resistant Triboelectric Generator for Intelligent Firefighting Suit

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Self-powered sensor devices utilizing shear-thickening gels (STGs) are prone to damage and degraded protective performance under severe mechanical and thermal shocks, significantly limiting the advancement of smart wearable devices. Given the extreme external impact environments, particularly the detrimental effect of thermal shocks on the protective performance of STGs, developing multifunctional protective liquid metal-based triboelectric generators (TENGs) becomes imperative. In this work, we construct a dual-layer protective structure combining phase-change paraffin (PCM) and STG. The core layer features a coaxial tubular structure composed of liquid metal and metallic heating wires, serving as both a triboelectric generator and a Joule heater. The PCM layer absorbs heat from thermal shocks first, preventing excessive temperature rise in the STG layer that would otherwise degrade its protective performance. Based on the electrostatic induction effect, the liquid metal-based generator enables energy harvesting. Simultaneously, the heating wires exhibit exceptional electrothermal performance, enabling dynamic regulation of the PCM's molten state and providing heat release for warmth in cold environments. The device has been comprehensively investigated for applications in smart firefighting suits, demonstrating capabilities in thermal shock protection, mechanical impact resistance, self-powered sensing, and joule heating. This work provides critical guidance for developing multifunctional smart wearable electronics and safety protection systems.

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An Oriented Layered Nano-CaCO3 with Enhanced Fire Resistance and Acoustic Insulation Performance

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Modern architectural insulation systems face a critical challenge in reconciling the inherent trade-offs between organic and inorganic materials—where polymeric substances offer superior thermal resistance ($\lambda \approx 0.03~W \cdot m^{-1} \cdot K^{-1}$) and sound attenuation capabilities but suffer from flammability risks (LOI < 22%), while mineral-based alternatives exhibit fire resistance at the expense of acoustic and mechanical performance. To address this dilemma, we developed a coordination-driven nanoarchitectured composite through Ca^{2+} -mediated assembly of chitosan lamellae with in situ precipitated nano-CaCO3 (50-80 nm). The resulting Flame-retardant Nano-CaCO₃/Chitosan Lamellar Composite (FNCLC) demonstrates multimodal functionality: Its hierarchically ordered layers with 3.2 nm interlamellar spacing create air-entrapped microdomains (75-85% porosity) that suppress thermal conduction ($\lambda = 0.096~W \cdot m^{-1} \cdot K^{-1}$, ASTM C518), while the periodic inorganic-organic interfaces induce acoustic impedance mismatch, achieving 42.3 dB sound transmission loss at 1 kHz (ISO 10140). Remarkably, the nano-CaCO3 phase simultaneously enhances structural integrity (12.8 MPa compressive strength) and provides combustion energy absorption through endothermic decomposition ($\Delta H = 1789~J \cdot g^{-1}$), yielding unprecedented flame retardancy with a 99.12% limiting oxygen index (UL-94 V-0 rating). This bioinspired coordination strategy establishes a paradigm for next-generation insulation materials that transcend conventional performance ceilings.

Design of Micro/Nano Thermal Regulation Materials for Personal Thermal Management

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Optimizing thermal regulation design not only enhances the thermal management capabilities of objects but also improves the efficiency of energy and resource utilization, playing a crucial role in energy saving, emission reduction, and sustainable development. In this presentation, I will introduce some of my recent works in the design of micro/nano thermal regulation materials for personal thermal management. First, I will talk about novel fibers and fabrics, which were designed and fabricated for human body radiative cooling. Nanoporous polyethylene (PE) was proposed as an infrared (IR)-transparent, visibly opaque material for maximizing the human body's IR radiation meanwhile offering concealing function [1]. NanoPE fiber extrusion process was developed to embed nanopores of 50–1000 nm, strongly scattering visible light into an intrinsically IR-transparent PE matrix. The large-scale continuous NanoPE fiber production is the prerequisite for making NanoPE fabrics via industrial weaving/knitting techniques. The as-prepared NanoPE fabric demonstrates ~ 80% mid-IR transmittance, 90% visible opacity, and ~ 2.3°C skin cooling effect [2]. In addition to NanoPE, we also developed colored PE-based radiative cooling fibers/fabrics and ZnO-NanoPE composite for outdoor radiative cooling, which increased practicality and expanded application scope [3-4]. Also, we designed a bifunctional asymmetric fabric with tailored thermal conduction and radiation for personal cooling and warming [5]. In the second section of my talk, I will mainly discuss some insights for personal moisture management and sweat evaporation, as well as the integrated cooling (i-Cool) textile combining design of thermal conduction and directional sweat transportation for human body evaporative heat dissipation [6]. i-Cool exhibits enhanced evaporation ability and high sweat evaporative cooling efficiency, not merely liquid sweat wicking function. In the steady-state evaporation test, compared to cotton, up to over 100% reduction in water mass gain ratio and 3 times higher skin power density increment for every unit of sweat evaporation are demonstrated. i-Cool shows about 3°C cooling effect with greatly reduced sweat consumption than cotton in the artificial sweating skin test. I will also introduce an integrated 3D hydrophilicity/hydrophobicity design for artificial sweating skin (i-TRANS), which provides a facile and low-cost solution for mimicking human skin perspiration [7].

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Coaxial Tubes Cooling System for Enhanced Personal Thermal Management

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Effective personal thermal management is essential for ensuring comfort, safety, and performance in high-heat environments, particularly for military, medical, and industrial personnel. Rising global temperatures and prolonged exposure to extreme conditions necessitate innovative solutions to mitigate overheating and heat-related health risks. Traditional cooling systems often struggle to balance portability, efficiency, and sustained performance. This study introduces a coaxial tube cooling system (CTCS@PCM/HTF) that synergistically integrates phase change material (PCM) and heat transfer fluid (HTF) (Figure 1a–c). Mimicking the dynamic balance of complementary forces, the system employs a multi-lumen coaxial design to simultaneously enable passive latent heat absorption (via PCM) and active convective cooling (via HTF circulation), addressing both transient and steady-state thermal loads.

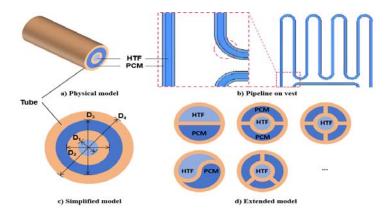


Figure 1. Schematic illustration of the coaxial tubes cooling system (CTCS@PCM/HTF). (a) Physical model of CTCS; (b) pipeline arrangement on thermal management vest; (c) simplified model CTCS; (d) extended multi-lumen model of CTCS, including double-lumen, Taiji double-lumen, triple-lumen tube, quadra-lumen, penta-lumen, and multi-lumen.

Key innovations include double-lumen and multi-lumen configurations (Figure 1d), which significantly improve thermal uniformity and heat dissipation efficiency. The hybrid system's prolonged cooling performance compares to standalone PCM or HTF systems, maintaining stable skin-contact temperature gradients under simulated physiological heat loads. Parametric studies reveal that optimizing PCM properties and HTF flow dynamics achieve a balanced interplay between energy-efficient stabilization and responsive thermal control. The lightweight, flexible design enables seamless integration into wearable thermal vests (Figure 1b), providing personalized cooling for high-heat scenarios. By unifying passive and active cooling principles, CTCS@PCM/HTF offers a versatile and sustainable solution to modern thermal challenges, prioritizing user comfort and operational reliability.

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One-way Water Transport Denim

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Based on the wearer's need for clothing functionality in different living and working environments, textiles with different functions have evolved. Denim, as a classic fabric, has the advantages of abrasion resistance, stiffness, and versatility. However, those dominances come with thickness, which reduces the comfort of the wearer in a hot and stuffy environment. In this paper, a denim finishing process for one-way water transport is proposed and tested to alleviate the problem of stifling discomfort of traditional denim fabrics in hot and humid environments.

In the experiment, polyester-polyether copolymer was used as the hydrophilic finishing agent. Polyester-polyether, thickening agent, and water were proportionally formulated into a paste solution, which was printed on the skin-friendly side of the denim fabric using screen blank printing technology. The sample was then preheated and shaped in an oven to complete the finishing process. Subsequently, a hydrophobic paste made of perfluoroacrylate, thickener, and water was printed on the outer side of the fabric in a dot screen pattern and heat set. The experimental results showed that the fabric can achieve one-way moisture transfer from the inside to the outside: moisture is absorbed by the hydrophilic surface and transferred to the outer layer through the dot structure. In contrast, the hydrophobic property of the outer side prevented the seepage of moisture back from the outside, thus enhancing the wearer's dryness and comfort. Water droplets were observed to spread on the hydrophilic side, while the hydrophobic side repelled water. In addition, the process was washable and abrasion-resistant.

In future research, the study plans to use non-fluorinated finishing agents to further reduce the environmental burden and promote the development of green textiles. This study provides a new idea for the comfort enhancement of functional denim fabrics and lays the experimental foundation for the sustainable development of multifunctional fabrics.

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Polymer UV-aging Resistance: Insights from Degradation Mechanisms and High-throughput Screening

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Photodegradation severely limits the utility of high-performance fibers in aerospace and heat-resistant applications, especially under acidic photo-irradiation conditions. Poly(*p*-phenylene benzobisoxazole) (PBO) is a prime example, exhibiting significant degradation under UV exposure, particularly in acidic environments. To address this challenge, we propose a machine learning framework for high-throughput screening of UV-resistant functional groups to enhance PBO's photostability. First, density functional theory (DFT) calculations elucidate the degradation mechanism, revealing that phosphoric acid catalysis significantly lowers the reaction barriers for oxazole ring opening. Subsequently, molecular dynamics (MD) simulations using a reactive force field (ReaxFF) demonstrate that mechanical performance declines when degraded repeating units exceed a critical threshold of 2.50%. Leveraging these mechanistic insights, we developed a transformer-based spectral prediction model to screen UV-resistant candidates. This model identified three optimal functional groups that preserve PBO's intrinsic mechanical properties without compromising its performance. This integrated computational approach—combining DFT, ReaxFF-MD, and machine learning—provides a scalable strategy for designing UV-resistant polymers. Our findings offer a promising pathway for enhancing the photostability of high-performance fibers and have broader applicability to advanced material systems.

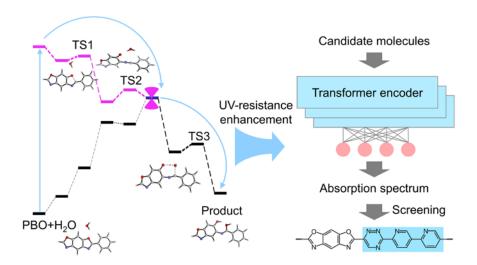


Figure 1. The photodegradation process of PBO (left) and the high-throughput selection of UV-resistant functional groups using a transformer-based model (right).

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Sustainable Fibers and Textiles

Development of Reusable, Biodegradable, and Biocidal Fibrous Filtering Materials for Facemasks

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The popular uses of facemasks prevent the transmission of respiratory diseases among people, but also lead to generations of large amounts of used facemask materials, primarily made of polypropylene (PP) or other non-renewable polymers, which have become an environmental concern. Biobased and biodegradable materials for new facemasks are highly demanded. Poly(lactic acid) (PLA) as a biobased and biodegradable thermoplastic polymer has great potential to become an alternative for these synthetic polymers and has gained a lot of attention from researchers. However, some drawbacks in properties of PLA fibers, including fiber rigidity, slow biodegradability, and low storage stability, have inhibited the applications in textiles and facemasks. This research focuses on improving the mechanical and biodegradable properties of PLA by mixing with biobased plasticizers during melt extrusion processes. Results indicate that the PLA films and fibers plasticized with the biobased triesters present improve flexibility, toughness, and enzymatic degradation rates of the products. Addition of a novel photo-active agent into the plasticized polymer fibers could achieve effective and reusable antibacterial function under daylight irradiation and still retain the desired improvements in mechanical and biodegradable performances. The presentation will provide a detailed discussion on these improvements.

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3D Printing Flexible Textile Using Polyester-Textile-Recycled Filaments

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To investigate the effect of textile structures on mechanical performance, the KES-F system was used to evaluate the textiles at different infill densities, rotation angles, and intersection angles, which affect the flexibility and rigidity of 3D-printed textiles produced by recycled polyester (rPET) filament and led to the anisotropy of mechanical properties in warp and weft directions. The low infill density enhanced tensile, shear, bending, and compressive properties due to the fewer lines in the textiles. The 45° rotation angles increased the flexibility in the tension and shear due to the increase in deformation of the minimum repeat unit with less strain on lines and high yielding with out-of-plane deformation. The low intersection angle at 30° greatly enhanced flexibility in the weft direction and significantly increased the rigidity in the warp direction, resulting in the anisotropy of the flexibility of textiles in two directions. In the weft direction, the diagonal was shortened to increase the number of units with the decreasing intersection angle, indicating that the textile deformation was allocated into smaller deformations for each unit to reduce the strain of lines and materials to resist lower loading. The low infill density, rotation angle, and low intersection angle enhanced the flexibility of rPET 3D-printed textiles. The flexibility enhancement would promote the efficiency and effectiveness of the circular economy approach from waste textiles to 3D-printed textiles by closing the polyester recycling loop. It might further stimulate waste polyester textile recycling to reduce the environmental loading for disposal.

Cellulose Dissolution for Sustainable Fibers: Can Machines Aid Our Learning?

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Cellulose dissolution is a prerequisite for producing commercial Man-Made Cellulosic Fibers (MMCFs), as well as for the development of "green" alternatives to these fibers. Cellulose fibers under development in the literature involve solvents such as ionic liquids, non-aqueous salt solutions, alkaline/urea solutions and mixtures of acids. The cellulose being dissolved in these solvents can differ in origin from wood and cotton to bacteria; cellulosic waste streams, such as waste cotton textiles, are increasingly being utilized. Given the diversity in solvents and cellulose sources, it is no wonder the mechanisms of cellulose dissolution are still not well understood. Here, we discuss our results in developing sustainable wet spun cellulosic fibers from waste cotton using ionic liquid as the solvent. Possible dissolution mechanisms acting in ionic liquid-cellulose solutions are discussed and we give a broader overview of cellulose (in)solubility in literature. We highlight some of the inconsistencies in experimental solubility studies that may offer insights and lead to a better understanding of dissolution. The development of next-generation cellulosic fibers will rely on the successful combination of the appropriate solvent with a cellulosic material having compatible properties. It is our plan to use artificial intelligence (AI) in the form of machine learning (ML) models to better understand the mechanisms of cellulose dissolution and provide information on which solvent and cellulose properties require attention. We will discuss promising ML models that may be applied to cellulose processing and dissolution research and other similar research areas.

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Nanofibrous Aerogels: Progress in Materials, Properties, and Applications

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Electrospun nanofibers, as the forefront of advanced fibrous materials, hold extraordinary potential applications, ranging from environmental to energy to biology, owing to their integrated advantages of fine diameter, extremely high aspect ratio, and ease of scalable synthesis from various materials. Despite their outstanding potential, the major problem associated with electrospun nanofibers is their anisotropic lamellar deposition character, which leads to bottlenecks in further improving the thickness and porosity of current electrospun nanofibrous materials. Alternatively, three-dimensional (3D) nanofibrous aerogels (NFAs) with both high porosity and excellent compressive resilient might open up the possibility of solving the problem and expanding the applications of electrospun nanofibers; however, creating such NFAs has proven extremely difficult. Herein, we demonstrate a novel strategy to create fibrous, isotropically-bonded elastic reconstructed (FIBER) NFAs with a hierarchical cellular structure and superelasticity by combining electrospun nanofibers and the fibrous freeze-shaping technique. Our approach causes the intrinsically lamellar deposited electrospun nanofibers to assemble into elastic bulk aerogels with tunable densities and desirable shapes. We have carried out a systematic study toward the controllable fabrication, hierarchical structure regulation, and structure-activity relationships to achieve the enhancement of performance in terms of various applications. 3D multifunctional electrospun ceramic and polymeric nanofibrous aerogels (NFAs) with high porosity, tunable densities, and desirable shapes were successfully fabricated, the resulting FIBER NFAs exhibit densities of > 0.12 mg cm⁻³, rapid recovery from deformation, slight plastic deformation with 14.5% after 1000th cyclic compression at a large ε of 60%, efficient energy absorption, and multifunctionality in terms of the combination of thermal insulation, sound absorption, warmth retention, emulsion separation, and elasticity-responsive electric conduction. Additionally, the newly developed ceramic nanofibrous aerogels possess low thermal conductivity (~0.025W m⁻¹ K⁻¹) and intriguing temperature-invariant superelasticity to 1100°C. The successful synthesis of such fascinating FIBER NFAs provides a new insight into the design and development of multifunctional NFAs for various applications.

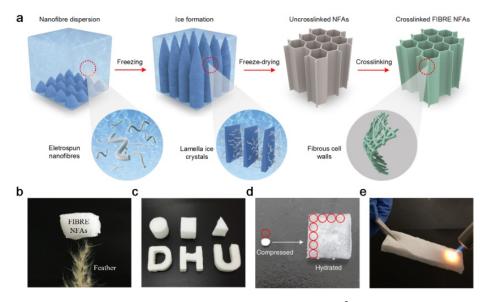


Figure 1. (a) Schematic illustration of the fabrication of FIBRE NFAs. (b) A $20~\rm cm^3$ FIBER NFA ($\rho=0.12~\rm mg~cm^{-3}$) stands on the tip of feathers. (c) FIBRE NFAs with diverse shapes. (d) The water retention capacity of the nanofibrous hydrogels (NFH). A sample of squashed and dried NFH of ~10 mg could hold ~5 g of water. (e) Ceramic nanofibrous aerogels heated by a butane blowtorch without any damage.

A Novel Method for Producing High-quality Yarn and Fabric from Recycled Fibers (Cotton/Polyester) at High Speeds

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Recycled fibers are generally shorter in length and exhibit poor uniformity, which presents challenges when spinning them into yarn. Even when successfully spun, the resulting yarn often demonstrates suboptimal performance. This paper explores the blending of recycled cotton and recycled polyester fibers with three common staple fibers—raw cotton, rayon, and polyester—to ensure enhanced yarn performance and quality. In this study, polyester, acetate, and rayon filaments of varying proportions and fineness are utilized in the rotor spinning method (OE – all staple fibes & OEX – staple fibers and filaments) to create filament/staple fiber composite yarns. These filaments can significantly improve the properties of recycled yarns. The effectiveness of these filaments in enhancing the strength of recycled yarn is ranked as follows: polyester ranks highest, followed by rayon, and then acetate. Filament/staple fiber composite yarns exhibit superior evenness compared to staple-fiber-blended yarns. There is minimal difference observed between the performances of polyester and acetate filaments; however, rayon filaments demonstrate inferior results. The hairiness index for filament/staple fiber composite yarns is considerably lower than that for blended yarns, with no significant differences noted among various filament/staple fiber composite combinations. Furthermore, these filaments enhance both the physical performance and fast-drying properties of fabrics while having a negligible impact on moisture permeability; there is only a slight increase in wicking ability and sweat volatility performance. Additionally, both rayon and polyester fibers markedly improve perspiration management and wicking capacity within fabrics—rayon exhibiting superior perspiration control while polyester excels in wicking performance. In comparison to OE yarn, OEX demonstrates superior abrasion resistance. This paper provides an effective approach to waste textile recycling through an investigation into the properties of yarns and fabrics made from recycled cotton and recycled polyester fibers.

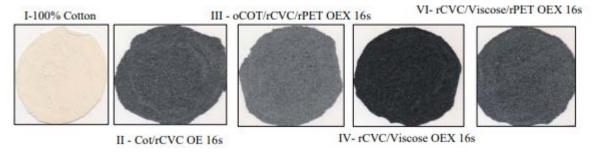


Figure 1. Pilling performance of fabrics.

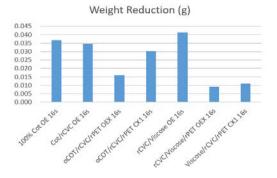


Figure 2. Weight reduction of fabrics after abrasion test.

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The Eco-friendly Choice of R-PET: Which is the Best Way?

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The issue of recycling of PET is becoming in increasingly specific hot topic within increasing pressure for control of carbon emissions. LCA analysis was carried out on R-PET staple fibers from R-PET bottles or R-PET fabrics, respectivley, to compare their environmental impacts. Combined with cost analysis, the environmental impacts and economic costs of R-PET staple fibers from R-PET fabrics were lower than those of R-PET bottles. It is more environmental-friendly and energy-saving to produce R-PET staple fibers with modified R-PET fabrics. Comparing the environmental impact of different treatment routes, we found that successfully separating different parts or different types of PET bottles at the beginning can reduce carbon emissions by 10.05%. Energy consumption can be reduced by 8.53% and carbon emissions by 5.41% with the optimized water bottles post-process, such as reducing unnecessary washing and drying processes. By optimizing the energy structure, replacing hybrid power with green power or replacing coal with natural gas can reduce carbon emissions by 2.34% to 15.27%. In addition, the LCA analysis of the R-PET black recycled polyester staple fibers production shows that adding a certain proportion of R-PET foam can reduce the environmental impacts.

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Protein Paper from Microfibrillated Silk

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Silk fibers possess a hierarchical micro/nano structure, with protein chains organising into 15-20 nm nanofibrils, which, in turn pack, together into the 10-15 μm fibre. By applying top-down exfoliation methods, these nanofibril bundles can be opened into fibrillar suspensions known as Microfibrillated Silk (MFS). The processing of MFS can be tailored using different chemical, mechanical, or combined strategies. These MFS suspensions can then be processed into "protein papers," which are analogous to cellulosic papers.

This study compared two approaches, casting and vacuum filtration, to produce MFS papers and explored the impact of MFS processing conditions on paper properties. MFS suspensions were prepared using three different processing levels: (1) shear homogenization alone, (2) acid treatment followed by shear homogenization, and (3) a combination of acid treatment, shear homogenization, and high-pressure homogenization. The choice of fabrication method and level of processing played a critical role in defining surface and mechanical properties, which impact the overall material performance. Shear homogenization alone led to papers with a tensile index of 23.94 ± 1.51 Nm/g and 23.63 ± 1.23 Nm/g for casting and vacuum filtration, respectively. Acid treatment resulted in a significant drop in tensile index, but this step was necessary to facilitate high pressure homogenization. Acid treated, shear homogenized, and high pressure homogenized papers had a tensile index close to the untreated papers because of the greater degree of fibrillation, leading to greater inter-fibrillar interactions and entanglement.

Casting resulted in a pronounced difference in roughness between the top ($Sa=6.87\pm0.79~\mu m$) and bottom ($Sa=1.3\pm0.29~\mu m$) surfaces in the shear homogenized samples, an effect that diminishes with increased fiber processing. In contrast, vacuum filtration produced papers with uniform roughness on both sides in all processing levels. The ability to control surface roughness is particularly useful for biomedical applications, since rougher surfaces have shown to enhance cell adhesion and proliferation in the cell culture studies performed. By strategically controlling MFS processing and assembly techniques, this approach enables the design of silk-based materials tailored for various biomedical applications, including guided bone regeneration membranes and wound healing dressings.

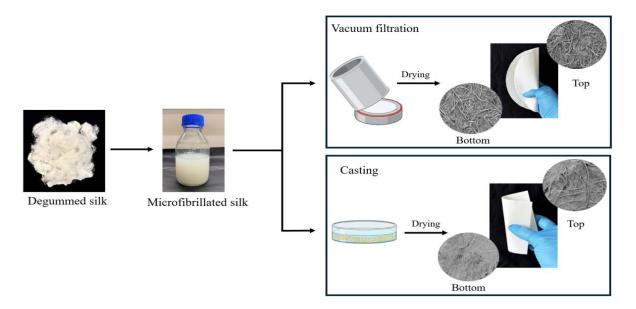


Figure 1: Fabrication of protein paper from silk.

Green Fabrication of Chitosan Fibrous Membrane via Organic-Inorganic Hybrid Strategy for Anti-adhesion Applications

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Tendon adhesion remains a significant clinical challenge following surgical repair or trauma, leading to impaired tendon gliding, persistent pain, and restricted joint mobility. Despite advancements in anti-adhesion biomaterials, limitations in mechanical strength, degradation kinetics, and biocompatibility continue to hinder their clinical translation. Here, we propose a green and efficient strategy for fabricating high-performance, chitosan-based, organic-inorganic, hybrid fibrous membranes via solution blow spinning (SBS). Inspired by marine mussels, catechol-modified chitosan (CS-C) and catechol-functionalized hydroxyapatite (C-Hap) were synthesized to enhance hydrophilicity and interfacial interactions. The use of a water-ethanol solvent system enabled an environmentally friendly fabrication process, while the organic-inorganic hybrid strategy endowed the resulting membrane with excellent mechanical strength (17.45 MPa), tunable dry-to-hydrogel phase transition properties, controlled degradation profiles, and robust biocompatibility. In vitro and in vivo evaluations demonstrated their efficacy in suppressing fibroblast activation, attenuating inflammatory responses, and preventing exogenous fibroblast infiltration. Mechanistically, these membranes inhibited myofibroblast differentiation by modulating the Wnt5a-driven signaling pathway. Notably, the green fabrication process eliminated toxic solvents, addressing critical biosafety concerns. This study presents a safe and effective strategy for developing high-performance anti-adhesion membranes, offering a promising approach for the clinical prevention and treatment of tissue fibrosis.

Functional Synergy Mechanism and Textile Application Innovation of Biobased PLA and Wool Blended Materials

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Polyactic acid (PLA) fibers, in addition to their bio-based origin and biodegradable safety and environmental protection characteristics, have three major functions in the textile and apparel industry: skin care, antibacterial deodorization, and moisture-wicking quick-drying applications. However, pure PLA fibers have high rigidity, which can affect the feel of the fabric. Wool, on the other hand, has a soft feel, and its natural crimp structure provides the fabric with loft and warmth. The blend of PLA fibers and wool combines the advantages of both, not only improving the performance shortcomings of traditional wool fabrics but also imparting more comprehensive functionality and environmental sustainability to textiles. Previous researchers have attempted this type of blended process, but were limited by: (1) compatibility issues between the two dyeing processes; and (2) strength loss during PLA dyeing, which prevented widespread application. Recently, Esun has addressed the compatibility issues in wool dyeing and strength loss during PLA dyeing by modifying the PLA raw material and optimizing the production process. This article focuses on introducing the key technical issues, complementary advantages, and application prospects of the blend.

Fibrillation of Bacterial Cellulose: Its Characterisation and Applications

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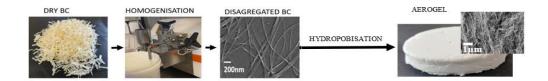
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Bacterial cellulose (BC) has the potential to replace petroleum-based materials and plant-derived cellulose for a range of applications. It has potential applications in the formation of hydrophobic aerogels for thermal insulation. This work focused on surface modification of BC to obtain the required level of hydrophobicity suitable for production of water repelling, mechanically stable, and thermally insulating aerogels. Initial experiments focused on dispersion of dry BC in aqueous solution and fibrillation/disaggregation using high-pressure homogenisation (HPH). Scanning Electron Microscope and Atomic Force Microscope showed a decrease in agglomeration of BC, as the number of HPH cycles increased. Furthermore, this study explored the development of water repellent BC aerogels by acetylation. Moisture stability was confirmed by the dynamic vapour sorption analysis and the chemical structure characterised by the Fourier-transform infrared spectroscopy and Nuclear Magnetic Resonance. Scanning Electron Microscope image analysis revealed highly interconnected aerogel structures exhibiting both meso and micropores. Hydrophobicity was confirmed by a water contact angle ranging from of 120° to 140°. The thermal conductivity of BC aerogels was measured to be ~ 42 ±1 mW m⁻¹K⁻¹, with no obvious effects of chemical modification. The specific surface area of treated BC aerogels ranged from 157 m²g⁻¹ to 226 m²g⁻¹. This study paves the way for the development of future moisture stable, sustainable, scalable, and market-ready cellulose insulation materials.

ACKNOWLEDGMENT

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Figure 1. Schematic representation of processing of BC for preparation of aerogels.



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A Green Strategy to Recycle Waste PP Meltblown Materials: From 2D to 3D Construction

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INTRODUCTION

The COVID-19 pandemic has led to a surge in polypropylene (PP) melt-blown materials, resulting in significant environmental challenges due to inadequate waste management. Traditional disposal methods like landfill and incineration are unsustainable, prompting the need for innovative recycling solutions. This study presents a green method to transform waste PP melt-blown materials into 3D porous sponges for oil spill remediation.

METHODS

Waste PP melt-blown materials and skin-core type polyester fibers (CO-PET/LPET) were processed using freeze-drying and thermal treatment. The fibers were dispersed in a water/tert-butanol mixture, freeze-dried, and heated to form sponges. The sponges were characterized for morphology, thermal stability, mechanical properties, hydrophobicity, and oil absorption capacity.

RESULTS AND DISCUSSION

The resulting PP sponges exhibited a low density (>0.014 g/cm³), high porosity (<98.77%), and excellent hydrophobicity (water contact angle: 130.4–139.9°). Their compressive modulus (33.59–201.21 kPa) surpassed most fiber-based porous materials, ensuring durability. The sponges demonstrated high oil absorption capacity (<47.61 g/g) and selective oil-water separation, with minimal performance degradation over 10 reuse cycles.

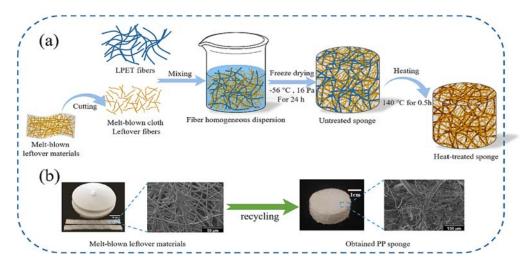


Figure 1. (a) The preparation process of the PP sponges; (b) photograph and SEM of waste PP melt-blown materials; and (c) PP sponge.

CONCLUSIONS

This study offers a sustainable, scalable solution for recycling PP waste into high-value, oil-absorbing sponges. The method addresses environmental pollution while providing a practical application for waste management. Future work could explore industrial-scale production and broader environmental applications.

ACKNOWLEDGMENT

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Mimicking the Hierarchical Structure of Spider Silk: PseudoproteinNanofiber Yarns with Unprecedented Toughness

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Preparing high-performance artificial spider silk with hierarchical structures using purely chemical synthesis methods is challenging, albeit promising. In this study, a high-molecular-weight pseudoprotein material (CPPUU) was synthesized by introducing polypeptide fragments (poly(N6-Cbz-L-Lysine), PZLY) and cystine dimethyl ester (CDE) into a polyurethane/urea macromolecular chain. The PZLY fragments, with a controlled degree of polymerization (\sim 11), were designed to mimic the α -helix and β -sheet of natural spider silk, while CDE enhanced urea bonding density to improve strength.

Nanofiber yarns (NFYs) were fabricated using an optimized electrospinning process. After 100% pre-stretching, the β -sheet content increased from 28.65% to 57.75%, and the β -sheet nanocrystal size reduced from 3.97 nm to 3.39 nm, as confirmed by Fourier-transform infrared spectroscopy (FTIR) and wide-angle X-ray diffraction (WAXD). These structural modifications resulted in unprecedented mechanical properties: a tensile strength of 286.0±47.1 MPa and toughness of 925.4±116.1 MJ/m³, surpassing that of both natural and synthetic fibers reported to date (Figure 1a–b). The yarns demonstrated exceptional load-bearing capacity, lifting 100,000× their mass (0.0019 g lifting 200 g), and absorbing impact energy from a 50 g free-falling weight (25,000× their mass) in modified rope tests (Figure 1c).

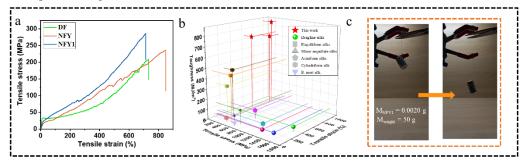


Figure 1 (a) Stress-strain curve of the fibers. (b) Ashby plot of the toughness versus tensile strength of the fibers prepared in this work compared with that of natural spider silks and B. mori silk. (c) Photos of modified rope impact resistance test.

Structural analysis revealed hierarchical features, including random coils, α -helices, β -sheets, and newly identified β -turns in pseudoprotein materials. The stress-strain curve and β -sheet transition during stretching suggested a self-toughening mechanism: under stress, random coils and α -helices reorganized into β -sheets, dissipating energy through hydrogen-bonded networks, while interfacial friction between nanofibers further enhanced energy absorption. This biomimetic fishnet-like structure replicated spider silk's natural toughening process.

Overall, this study advances the design of biomimetic fibers and demonstrates a scalable approach for producing artificial spider silk with superior mechanical properties. These findings offer promising insights for future applications in high-performance materials, ranging from textiles to aerospace.

ACKNOWLEDGMENT

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Recycling Post-consumer Cotton Waste for Lightweight Foams

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Apparel consumption has been rapidly increasing in recent years, significantly contributing to the growing volume of post-consumer textile waste. In the U.S., approximately 13 million tons of textile waste are generated annually, while the European Union discards around 10 million tons, most of which end up in landfills or incinerators due to low recycling rates. As a major cellulose fiber, cotton accounts for more than 95% of fibers used in apparel and home textiles. With rising cotton product consumption, the amount of post-consumer cotton waste continues to accelerate, driving the urgent need for environmentally friendly and economically viable recycling technologies.

To address this need and promote sustainability and circularity, we developed a recycling technology that converts post-consumer cotton waste into lightweight, biodegradable foams with great potential to replace petroleum-based synthetic foams in various applications. Using an eco-friendly, alkali-urea solvent mixture, cotton waste was dissolved into a viscous solution and solvent cast into foams. The resulting foams exhibited an open-pore structure, low density, excellent compression strength, and superior thermal insulation that were comparable to commercial polyurethane and polystyrene-based foams used in packaging and thermal insulation. The properties and functionalities of these foams could be tailored by adjusting cotton concentration, processing conditions, and incorporating functional fillers, such as cellulose nanofibers, flame retardants, and water-repellency agents. Additionally, this technology demonstrated its viability in recycling cotton-synthetic fiber blends, further expanding its potential for sustainable textile waste management.

Applicability of Asian Urticaceae Fibre Isolation Protocol to European Species

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This research adapts common Asian fibre isolation procedure to European *Urticaceae* species, aiming to test the (a) applicability and (b) to improve processes to enable the usability of the fibre. The comparative setting was selected based on previous studies on European nettle (*Urtica dioica*) fibre extraction, as well as registered patents and current commercial protocols on Asian nettle species, mainly *Boehmeria nivea*, but also utilizing studies on *Giardinia diversifolia*, when appropriate.

The fibre isolation was conducted in a quasi-experimental setting where both fresh and dry biomass was processed. The protocols were tested on both native Finnish nettles as well as *Boehmeria nivea* biomass originating from a botanical garden (Brera Botanical Garden, Milano, Italy). The Asian process separates fibre containing bark (secondary phloem) from the inner core (xylem) on fresh stems prior starting the actual fibre isolation protocols, in contrast to European methods, which work on pre-retted, dried stems in a ramming manner, mainly following common flax processing protocols.

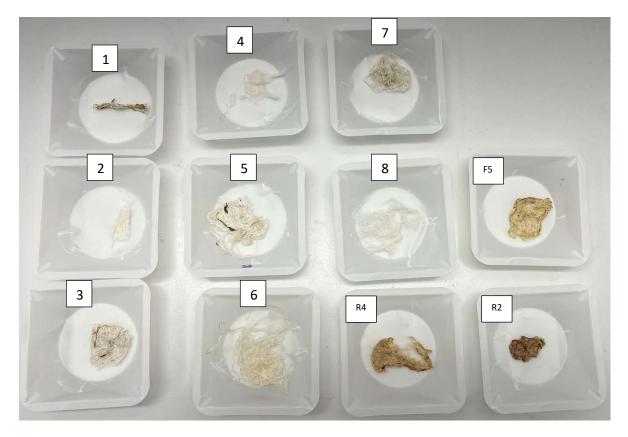
Stem retting as a pre-treatment is a standard procedure and can be conducted in natural waters, in a controlled environment, or in the field after harvesting, utilizing environmental humidity. Retting initiates the natural decomposition of stem biomass, allowing phloic fibres to detach from inner xylem, easing the further fibre extraction processes.

The barks in this study were separated from core stems immediately after harvest and water retted in controlled conditions for one week, after which the process was terminated. A post-treatment followed immediately to clean the fibres. The post-treatment was selected on a "least invasive possible" basis, adapting the results from the previous studies on *Urticaceae* fibre extraction. Regular tap water, dilute (1%) sodium hydroxide, and standard detergent (AATCC 4%) were used; samples were washed in their respective solutions in closed, slightly pressurized 200 ml steel containers (Linitest) at 100°C for approximately an hour. A comparative setting was produced for dried, commercially sourced Finnish nettle stems as well as ramie, in order to investigate the processing logic's efficiency and potential differences among nettle species.

RESULTS

Based on our studies, the Asian process works well on European nettle species. The Asian processing logic on European nettle allows water retting, a common bast fibre processing method to be performed directly on barks, making it accessible for creating workable fibres with a native biological retting process and finer fibre output with minimal chemical intervention.

In this setting, solely water retted nettle fibres from fresh biomass were bright in colour when post-treated with either dilute sodium hydroxide or standard detergent. For comparative samples of dry nettle stems the dilute 1% 200 ml sodium hydroxide solution proved less sufficient.



Picture 1: Freshly treated Finnish nettle samples (1-8) with comparative fresh ramie samples (R2, R4) and dry nettle sample (F5).

The fresh processing on the Finnish nettle resulted in bright white fibres with both AATCC (samples 1, 3, 5 and 7) as well as dilute sodium hydroxide treatment (samples 2, 4, 6 and 8), respectively. For the comparative samples, sodium hydroxide treated fresh ramie (R2, R4) and similarly treated Finnish commercially sourced dried nettle stems (F5), the processing was not as efficient, as seen in Picture 1. Multiple samples were produced to cover different growth stages of the plant. Samples 1-8 stem lengths ranged between 32 and 93 cm, whereas for ramie sample R2, it was 26 cm (a younger specimen); for sample R4, which was from a more mature plant, the stem length was 66 cm. Sample F5, Finnish, commercially obtained stem material, was received dried and processed with phloic that corresponded to the volume of other tested samples.

CONCLUSIONS

The selected treatments were not sufficient to create clean fibres from ramie samples, highlighting the difference in plant physiology among the *Urticaceae* plant family, despite relatively similar natural appearance as plants and uniformity on their usage in textiles applications. This experiment highlighted the difference between processing fresh phloic nettle material in comparison to dried. All freshly treated nettle samples resulted naturally light in colour, suggesting potential to discard additional bleaching with minor further process development.

Even with differences in plant anatomy between these *Urticaceae* species, an adapted Asian processing, with the equipment developed for the local species, could be used widely for the European species, potentially with less chemical inputs, in comparison to Asian local species.

ACKNOWLEDGMENT

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Rc-TPA-based MOF from PET Fiber for Dye Removal

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Metal-organic frameworks (MOFs) are a promising class of crystalline porous materials that combine metal nodes with organic ligands, demonstrating significant potential for applications such as dye removal. A standard synthesis method involves a solvothermal process, where precursors—typically a metal salt and an organic ligand—are mixed in a solvent and heated. One widely used ligand is terephthalic acid (TPA), often sourced from commercial products, but also obtainable through the chemical recycling of polyethylene terephthalate (PET). Given the environmental challenges textile waste poses, recycling PET presents a valuable strategy for sustainably producing TPA. In this research, the authors successfully implemented alkaline hydrolysis on PET extracted from PET/cotton fabric to yield chemically recycled terephthalic acid (Rc-TPA), which was purified and employed in the synthesis of an iron-based MOF, referred to as Rc- MIL- 101 (Fe). The synthesized framework was characterized using Fourier-transform infrared spectroscopy (FTIR), revealing characteristic peaks that indicate the successful incorporation of iron and the presence of functional groups associated with the organic ligand. Notably, the TPA-derived framework exhibited peaks corresponding to carboxyl and aromatic structures, along with iron-oxygen stretching vibrations, confirming the practical synthesis. Additionally, the thermogravimetric analysis revealed that Rc- MIL- 101 (Fe) had a weight loss profile similar to that of MOFs constructed with commercial TPA, indicating comparable thermal stability. The performance of Rc- MIL- 101 (Fe) in adsorbing Reactive Blue 4 (RB 4) dye was evaluated, achieving a maximum capacity of 227 mg/g. Adsorption data fit well with the Langmuir isotherm model, suggesting homogeneous adsorption sites and a monolayer adsorption process. Kinetic studies implied a chemical adsorption mechanism, while thermodynamic evaluations indicated that the adsorption is both endothermic and spontaneous. Overall, the findings establish that Rc-TPA can serve as a viable alternative for MOF synthesis in reactive dye removal applications, showcasing its potential for supporting sustainable practices in the textile industry (Figure 1).

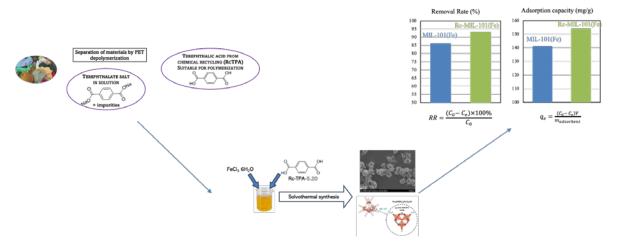


Figure 1. Chemically recycled terephthalic acid (Rc-TPA) derived from polyethylene terephthalate (PET) can be effectively used to synthesize an iron-based metal-organic framework (Rc-MIL-101(Fe)) for the effective removal of Reactive Blue 4 dye, achieving comparable performance to that of commercially sourced TPA.

ACKNOWLEDGMENT

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Tannin-rich Fruit Epicarp Extract-treated Multifunctional Cellulosic Textiles: Valorization of Biowaste

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The shift toward greener practices is gaining momentum, with growing research focused on minimizing the devastating effects of waste through prevention, reduction, recycling, and reuse. Every day, large quantities of bio-waste are generated, much of which ends up in landfills or is used as fuel, contributing to ecological harm and increasing the carbon footprint. In response, researchers around the world are seeking innovative ways to recycle waste for the benefit of the environment.

One promising solution is the extraction of polyphenolic secondary metabolites from bio-waste to create functional textiles from ordinary cellulosic fabrics. Fruit peels, either used alone or combined with safer crosslinkers, are emerging as a sustainable alternative to synthetic agents, metal oxides, and nanoparticles in textile treatments. This study focuses on extracting tannins from fruit waste, adhering to green chemistry principles, and applying them to cotton fabrics in an economical and eco-friendly manner. The result is a textile with excellent ultraviolet protection (50+ rating) and over 95% antimicrobial activity against both gram-positive and gram-negative bacteria, all while maintaining the fabric's physical and aesthetic qualities. This innovation opens significant potential for these textiles in the international market.

ACKNOWLEDGMENT

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Body Odour Management Performance of Different Fibers and Blends

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Various strategies have been employed by the textile industries to control odour development within textiles. The most common method is to apply biocides to impart antimicrobial properties to the fibres and fabrics. Depending on fibre type, these biocides can be used either as finishing agents or incorporated into the fibres during melt extrusion. The imparting of antimicrobial properties on fibre or fabric could inhibit the growth of odour-causing bacteria, which could prevent odour build up within the textiles. Other methods for controlling body odour include finishing the textile materials with fragrance oils to mask the odour, and also finishing the textile material with cyclodextrins and active carbons to absorb odour.

This study compared the odour retention performance of three commonly used fibre types (polyester, cotton and wool), and also evaluated how wool percentage in polyester/wool blends affects the odour intensity of a garment after active wear. The sorption/emission performance of four model body odour compounds was quantitatively evaluated by both the developed odour detection system and by standard sensory testing. The body odour retention on the optimized wool blend and polyester fabric was also compared in a wear trial. The wool blend fabric proved to be an effective and natural way to minimize body odour in active wear.

Figure 1 illustrates that the selected fibres showed great difference in their NH₃ odour sorption capacity, with wool being the highest at 93.7%, followed by cotton at 78.6%, and polyester at 57.1%. After reaching their sorption saturation, the odour emission or desorption from these fibers was also investigated. The emitted odour intensity from the saturated fibres followed the order of polyester>cotton>wool. Wool's high odour sorption but low emission makes it suitable for fibre-based body odour management in active sportswear. Because of the excellent natural odour resistance of wool, this study also evaluated how the wool percentage in polyester/wool blends affects the odour intensity of a garment after active wear.

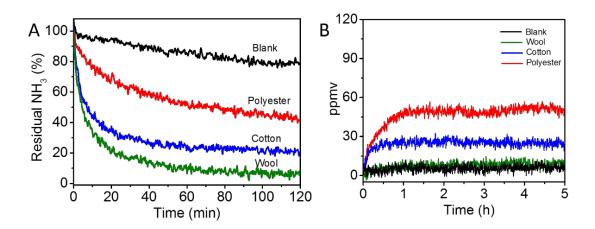


Figure 1. (A) Time-dependent NH₃ absorption by different fiber types. (B) Time-dependent gas desorption from different fiber types.

Controllable Fabrication and Applications of Cellulose-based Gels and Fibers

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Hydrogels are a class of soft, wet materials with a three-dimensional crosslinked network structure, which hold significant application potential in various fields, including tissue engineering, disease diagnosis and treatment, and flexible electronics. However, the limited mechanical properties, lack of specific functionalities, and processing difficulties of traditional hydrogels restrict their broader application. In our work, we developed a series of performance-tunable multifunctional hydrogels and fibers through molecular design and microstructure regulation. By utilizing the anisotropic structure and high tensile strength of natural wood, we prepared highstrength, highly conductive wood-based hydrogels, which hold promise for applications in tissue engineering and nanofluidic systems. Moreover, by employing strategies such as dynamic crosslinking and double-network design, we constructed anisotropic dynamic hydrogels with excellent biocompatibility and osteogenic properties. Through solid-liquid, dual-continuous, and wet-spinning strategies, we achieved the efficient, continuous preparation of gel fibers with tunable structure and performance, exploring their applications in in vivo and in vitro signal monitoring. Additionally, hydrogels are inherently prone to dehydration and freezing, severely limiting their range of use. To address these limitations, we developed ion gels using low eutectic solvents as dispersing media, which are stable across a wide temperature range, and constructed corresponding fiber-based devices. These ion gels and fibers have potential applications in wearable electronics, biomedical fields, and human-machine interaction.

Fiber-based Sensors, Actuators, and Batteries

Electroactive Fibrous Materials and Textile Structures

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Smart electronic textiles have become an essential part of wearable electronics. However, the majority of currently available electronic textiles are based on simple physical integration of rigid silicon-based microelectronics onto conventional textile fabrics, which severely constrains the application performance at large strain levels, as well as wear comfort and product durability. In addition to the rapid evolution of 2D flexible electronic materials, the future development of smart electronic textiles can benefit from various types of electroactive fibers. Electroactive fibers with different functions, such as conducting, sensing, color changing, temperature regulating, energy harvesting, or storage, can make significant contributions to the future of smart electronic textiles. At the same time, the mature processing industry of fiber and textile engineering offers great opportunity in designing and fabricating smart textile structures. In this talk, our recent work on using electroactive fibers for piezoelectric/triboelectric energy harvesting, flexible sensing, and aqueous energy storage will be introduced.

Benefiting from in-situ mechanical stretching and electrical poling, electrospun nanofibers prepared using piezoelectric polymers possess ideal piezoelectricity for mechanical energy harvesting and flexible sensing, especially when integrated with conventional textiles. In addition, a nanofibrous structure is an ideal substrate for electrochemistry electrodes. By using simultaneous electrospinning and electrospraying, an ultra-flexible nanofibrous electrode with a thickness of only 88 µm was obtained with dual gradients of porosity and electric conductivity, demonstrating excellent dendrite-free Zinc deposition behavior and Zinc-ion battery performance. Through conventional spinning and braiding processes, composite textile structures are able to detect human motions and provide extra heating or protecting functions. It is hoped that future smart textiles will avoid the use of rigid microelectronic devices, replaced by flexible, fibrous materials and structures to realize highly sensitive, user-friendly, durable, and comfortable smart textiles for effectively integrated personal protection, health monitoring, and human-machine interface.

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Developing Bicomponent Conductive Fibers for Smart Wearables via Experimental and Simulative Approaches

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With material innovation and functionalization becoming an important trend in the textile industry, smart wearables have drawn growing attention. Among various efforts, developing functional fibers remains a significant research focus. Responding to this need, this study aims to develop conductive fibers for sensing applications in a variety of smart wearable products. Traditional functional fibers are typically produced by mixing functional fillers with a polymer to achieve a homogeneous blend. The key challenge lies in balancing the filler load for functionality and the mechanical properties of the blend fibers, as fillers often compromise fiber strength.

In this work, we investigated the production of composite fibers with a heterostructure via wet spinning, employing side-by-side spinning nozzles. This dual-solution approach introduced two polymer solutions simultaneously, but separately, to form a side-by-side fiber, where each side retained its individual properties, enabling unique functions in the unified composite fiber. Solutions with various rheological properties were prepared to study how solution characteristics influenced fiber formation and performance. Using polyaniline as the functional material, we produced conductive side-by-side fibers and demonstrated the advantages of this structure in enhancing both fiber mechanical strength and sensor functionality for diverse applications.

To complement the experimental work, computational fluid dynamics (CFD) simulation was used to model the flow behavior of the dual solutions within the nozzle. The simulation offered insights into velocity profiles, mixing patterns, and interface stability under varying flow rates and viscosities. This combined experimental-simulation approach provides a foundation for future innovations in wet spinning and the development of advanced composite materials for functional fibers.

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Metallic Yarn Coating as a New Lithium-ion Battery Electrode Configuration: Formulation and Implementation of Filled Polymer Blends

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The booming demand for the miniaturization of electronic devices and the growing need of consumers for energy storage devices with free-form geometries that meet performance challenges (long cycle-life, high-specific energy...) are driving the global market toward the next generation of lithium-ion batteries with customized flexible structures suitable for a variety of applications (e.g., aerospace electronics, micro-electromechanical systems, etc.). Conventional power systems cannot meet smart textiles purposes. This work aims to create a textile Li-ion battery using yarns coated with active material-based composites as electrodes—a blend based on lithium iron phosphate (LiFePO4) and lithium titanate (Li4Ti5O12) for the positive and negative electrodes, respectively. These are associated with (1) immiscible non-polar (polypropylene-PP) and polar (polycaprolactone-PCL) thermoplastic polymers with a small amount of thermoplastic elastomer for flexibility, and (2) carbon nanofibers (CNF) that are coated on a metallic multifilament (current collector) to ensure electrical conductivity [1]. Obtaining a morphology of this immiscible polymers blend with selective localization through the various processing steps is a real challenge. The first challenge is to fully cover the metallic yarn while keeping the coating as thin as possible, by playing on the formulation and extrusion parameters of the coating process. The coated multifilaments are then 3D-weaved and dived in liquid electrolyte to ensure a three-dimensional diffusion of the ions, achieving optimal capacity performances. The weaving challenge lies in avoiding contacts between the electrodes inside the structure, highlighting the importance of the cotton separative varn and varn diameters. A semi-continuous weaving structure should eliminate these issues by using two yarns per electrode, diminishing the number of loops and predicting their trajectories.

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A Novel Gold, Nanoparticle-modified, Laser-induced Graphene Electrochemical Sensor with a Multistage Pore Structure for Dinotefuran Pesticide Detection

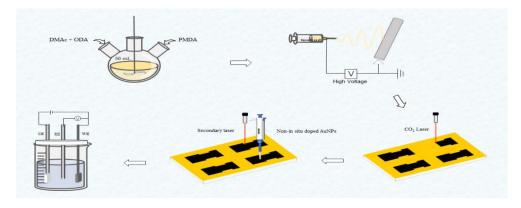
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Neonicotinoids are the most widely used insecticides in the past two decades, representing a quarter of the global insecticide market. Dinotefuran (DNF) acts as an agonist to insect nicotinic acetylcholine receptors and plays an important role in synaptic transmission in the central nervous system, providing broad-spectrum insecticidal activity. However, the excessive and uncontrolled application of pesticides, including DNF, has led to pesticide residues in water, soils, grains, fruits, and vegetables, which could enter the food chain and cause a serious risk to the health and safety of consumers. Accordingly, it is necessary to develop an accurate and simple method for evaluation and monitoring trace levels of DNF residue in food and environment.

In this study, we integrated electrospinning and laser-direct writing technologies to fabricate a gold nanoparticlemodified, laser-induced graphene (LIG@AuNPs) electrode featuring a multistage pore structure for field detection of neonicotinoid pesticide residues. The morphology, structure, molecular composition, conductivity, and hydrophilicity of the LIG@AuNPs probes were characterized using SEM-EDS, Raman spectroscopy, XRD, FTIR spectroscopy, and static contact angle tests. Initially, the fiber diameter and porosity of the polyacrylic acid (PAA) precursor were controlled through electrospinning technology to establish the desired multistage pore structure. Subsequently, a conductive graphene substrate was prepared via laser-induced pyrolysis of a polyimide porous fiber film, which was synthesized by the imide reaction of PAA. Finally, gold nanoparticles were incorporated into the surface and internal pores of the porous LIG using a secondary laser reduction method. This modification increased the defects and carbon content of LIG, significantly enhancing its hydrophilicity, electrical conductivity, and electrochemical properties. Under optimal conditions, the fabricated LIG@AuNPs sensor demonstrated excellent electrochemical sensing performance for DNF, achieving a low detection limit of 0.061 μM within a linear concentration range of 0.061 μM to 50 μM and exhibiting a high sensitivity of 21.53 $\mu A \cdot \mu M^{-1} \cdot cm^{-2}$. Additionally, the LIG@AuNPs sensor displayed reproducibility (RSD = 5.80%), stability, and high selectivity toward DNF. Furthermore, an investigation of real samples in rice, with recoveries ranging from 93.3% to 108%, suggests the promising application potential of LIG@AuNPs in DNF monitoring.



Scheme 1. illustrates the synthesis of LIG@AuNPs sensor.

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Fiber-shaped Organic Electrochemical Transistors and Proactive Healthcare Applications

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Organic electrochemical transistors (OECTs) exhibit mixed ionic-electronic conduction characteristics, making them highly promising for bioelectronics, embodied intelligence, wearable devices, and beyond. Fiber-based OECTs integrate the functionality of semiconductor devices with the inherent weavability of fiber materials. However, challenges persist in condensed-state regulation of the semiconductor layer, device interface engineering, and the integration into woven systems. This presentation focuses on spatially ordered design of semiconductor functional units, the optimization of interface engineering for fiber devices, and the system-level design of woven circuits, while also demonstrating applications in fields, including motion intervention, sleep health, and textile logic circuits.

The Design of Fiber-based Bacterial Sensors

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Bacteria contamination is the main factor implicated in diseases, characterized by low dose and high infectivity. It is very important to develop rapid, cheap, and simple methods for pathogen detection. Fibers are the ideal material for making bacterial test papers. There are two key issues for detecting bacteria with ultra-low concentrations: (1) The detection signal of ultra-low concentration pathogen is extremely weak, resulting in a tedious detection time; (2) test results are prone to false positives, because bacteria is easy to miss when the bacterial concentration is too low.

In order to detect the bacteria with ultra-low concentration, we proposed three effective strategies: (1) Ultra-thin bacterial response layer and ultrafine particles can significantly accelerate bacterial response rate; (2) the cascade signal amplification method is an effective strategy, stimulated by characteristic secretion of pathogenic bacteria; (3) efficient separation and enrichment of bacteria in the sample could eliminate false positives, resulting in better detection performance. Based on these strategies, we could detect bacterial concentrations as low as 0.1 CFU/mL within 14 h. Its ability to identify ultra-low concentration pathogenic bacteria was proven by detecting pathogenic bacteria in food (e.g., water and milk).

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High-performance Fiber Strain Sensors for Wearable Healthcare

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Fiber electronics have attracted considerable attention due to their high flexibility, light weight, and miniaturization, which could be seamlessly integrated with clothes for wearable application. We report high-performance, stretchable, fiber strain sensors based on the formation of anchoring sensing materials in situ. The ultra-mechanically sensitive sensing layer greatly improved the sensitivity. The resulting stretchable fiber sensors simultaneously possessed an ultra-low strain detection limit of 0.05%, a high stretchability of 100%, and a high gauge factor of 433.6. Such flexible and lightweight fibers were attached to skin or woven into clothes for recording physiological signals. A fiber sensor-based wearable and smart healthcare system was designed to monitor asthma, transmitting health status remotely for timely intervention.

Fiber Bragg Grating Sensors for Precise Monitoring of the Next Generation Secondary Batteries

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Fiber Bragg Grating (FBG) sensors are a type of optical fiber sensor widely used for measuring strain, temperature, pressure, and other physical parameters. They are based on fiber optics technology and are known for their high sensitivity, immunity to electromagnetic interference, and suitability for harsh environments. FBG is created by inscribing a periodic variation in the refractive index along the core of an optical fiber using ultraviolet (UV) light. This structure acts as a wavelength-specific mirror; when broadband light is transmitted through the fiber, the grating reflects a narrow band of wavelengths known as the Bragg wavelength. This reflected wavelength is highly sensitive to changes in strain and temperature. As the fiber experiences mechanical deformation or thermal expansion, the spacing of the grating and the refractive index change, causing a shift in the Bragg wavelength. By measuring this shift, one can accurately determine the amount of strain or temperature change the fiber has undergone.

FBG sensors offer several advantages over traditional electrical sensors. They are lightweight, passive (requiring no electrical power at the sensing point), and can be multiplexed—meaning multiple FBGs can be written along a single fiber and interrogated simultaneously. This makes them ideal for distributed sensing in large structures such as bridges, aircraft, wind turbines, and pipelines.

Recently, FBG sensors have also attracted interest for battery monitoring applications. Their ability to deliver precise, real-time measurements over extended distances with minimal signal degradation presents significant advantages for the next-generation battery industry. In this study, we applied FBG sensors to monitor strain and temperature changes in coin-cell-type zinc-ion batteries. Through cyclic charge/discharge tests, FBG sensors successfully captured mechanical and thermal responses of the battery, offering valuable insights into electrode behavior and stability. Our findings demonstrate the potential of FBG sensors for accurate and non-invasive characterization of zinc-ion coin cells.

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Smart Liquid Crystal Elastomer Fibers: From Actuators to Soft Robots

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Liquid crystal elastomers (LCEs), consisting of liquid crystal mesogens coupled with polymeric chains to form a cross-linked network, exhibit anisotropic optical and mechanical properties due to their phase transitions under external stimuli, such as light, electricity, magnetic field, and heat [1]. LCE fibers, owing to their high aspect ratios, superior responsive properties, and one-dimensional material geometry, have emerged as outstanding candidates for constructing soft actuators in recent years [2].

This talk will first introduce the fabrication of LCE fibers, including dry spinning, melt spinning, template method, and rotational 3D printing. It will also explicate how to obtain solid and hollow fibers, control their size, structure, component, and liquid crystal orientation. Finally, soft actuators based on LCE fibers, responsive to heat, electricity, and air pressure, will be demonstrated, highlighting their diverse functionalities.

Some examples include: (1) LCE fibers can simulate pumping function of heart muscles [3], lifting heavy objects akin to biceps brachii [4], and achieving rapid ball throwing similar to triceps brachii [5]; (2) LCE fibers with programmed alignment enriched responsive modes of LCE actuators and achieved not only common shrinkage and bending deformations but also developed complex deformations such as elongation, torsion, and rotation [6,7]; (3) incorporating liquid metal into LCE fibers can integrate sensing and actuating in a single fiber with a simple design [8,9]; (4) additive manufacturing of LCE actuators based on knitting technology can bring about advanced geometry, integrated multi-functions, and efficient recyclability [10]; the porous structure and soft elasticity of LCE knitted actuators facilitate the development of ergonomic and comfortable wearable devices. Knitted LCE actuators incorporated with other functional fibers and smart textiles can act as a deformable, multifunctional platform. The above works provide new design concepts for constructing a new type of simple, intelligent, and miniaturized soft actuators.

LCE actuators based on fiber structure are expected to be applied in fields such as wearable devices, including motion assistance and human computer interactions.

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Enabling All-Solid-State Lithium-Sulfur Batteries with Functional Fibers and Nanofibers

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Advancements in fiber science research have extended far beyond traditional applications, opening new frontiers in energy storage technologies. Among these, all-solid-state lithium-sulfur (Li-S) batteries have emerged as a promising alternative due to their high theoretical energy density, cost-effectiveness, and enhanced safety. Functional fibers and nanofibers with tailored properties offer a unique opportunity to optimize surface reactions and charge transport within Li-S batteries, significantly improving performance and reliability. This presentation will explore the design, development, and evolution of fiber- and nanofiber-based materials for all-solid-state Li-S batteries, highlighting their potential in advancing next-generation energy storage solutions for a more sustainable future.

Dual-responsive Yarn-based Artificial Muscles

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Smart textiles have gained widespread attention from both industry and academia due to their capabilities of sensing, actuating, communicating, energy harvesting, interconnecting, etc. Notably, stimuli-responsive materials provide opportunities and challenges for adaptive actuation, in response to environmentak changes. Moisture-responsive artificial muscles have attracted tremendous interest since they can generate external power by ubiquitous water molecules. However, most current moisture muscles suffer from a critical issue of fast actuation-induced ,long recovery time, leading to low output power density. Therefore, efficient power density is urgently required for practical applications.

We propose a dual-responsive, hybrid, yarn-based artificial muscle (HYAM) reinforced by Mxene based on viscose fibers, which is easy to process and provides exceptional stability and high-power density. The HYAM is simply prepared using a droplet stretching method to form a Ti₃C₂T_x Mxene sheath and viscose core. Larger rotation stroke and speed during moisture actuation are provided by the HYAM, reinforced by Mxene sheath, compared with the pristine one. Meanwhile, HYAM achieves a faster electrothermal recovery with the function of the conductive sheath, showing a much higher power density than the control. The reversible actuation recovery cycle can be stably conducted at least fifty times. These soft yarn-based artificial muscles have huge application potential in smart textiles and wearable devices, such as self-adaptive textiles, soft robotics, and energy-generating devices.

HIGHLIGHTS

- 1. A novel, dual-responsive, yarn-based artificial muscle has been developed.
- 2. This muscle is easy to process and demonstrates exceptional stability and high-actuation performance.

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Nanocellulose and Two-dimensional, Flexible, Conductive Composite Materials

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The strong van der Waals force between carbon nanotubes (CNTs) makes them prone to aggregation or entanglement, hindering their development in the field of flexible electronic sensing. Nanocellulose is considered an ideal CNT dispersant due to its one-dimensional nanoscale and controllable surface-active groups. However, the efficient preparation of CNF and its dispersion mechanism for CNTs are still unclear. This work explored an efficient method for preparing CNF by using potassium permanganate (KMnO₄) as an oxidant. The CNF acted as a green dispersant; a stable dispersion of CNF/CNT conductive slurry was obtained by utilizing size matching between the two and the abundant carboxyl structure on the surface of CNF. It can be assembled into thin films with excellent conductivity and mechanical properties through wet-forming as papermaking. Patterned flexible electrode construction can be achieved on different flexible substrates, laying a good foundation for the development and application of flexible sensors.

Results showed that CNF can complete self-assembly and form thin films with excellent mechanical strength (tensile strength up to 75 MPa). The film has high haze (>90%) characteristics due to the excellent nanoscale (diameter 3-7 nm, length 0.32-1.10 μ m) and small particle size dispersion of CNF, as well as the difference in refractive index between the crystalline region, amorphous region, and internal air within the CNF structure, demonstrating its potential for application in flexible devices. The introduction of a small amount of CNF can effectively disperse CNTs, with a CNT dispersion concentration of up to 80%. The resulting CNF/CNT slurry has a low Zeta potential (below -60 mV) with good stability, and can maintain stable dispersion for more than three months in a static state. The parental structure of CNF and the electrostatic repulsion between surface carboxyl groups played a good dispersing role in the CNF/CNT system. When the CNF/CNT conductive slurry was filtered into a film, its tensile strength reached 152.87 MPa.

Van der Waals Fibers for Flexible and Stretchable Electronics

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Flexible and stretchable electronics have garnered significant attention due to their potential applications in wearable devices and advanced technologies. Two-dimensional (2D) materials with van der Waals (vdW) structures exhibit remarkable mechanical and electrical properties, making them promising candidates for such applications. However, current fabrication methods for vdW 2D materials often rely on solvents or binders, leading to environmental concerns and residual contamination that compromise their performance. In this study, we propose an innovative solvent-free and binder-free coating technique for the fabrication of vdW graphene fibers. This eco-friendly method ensures a clean coating process, resulting in fibers with excellent mechanical and electrical properties. The vdW graphene fibers demonstrate a conductivity of $160~\Omega/cm$ and maintain 16.7 times their initial conductivity even when stretched to 200% elongation. Furthermore, the unique material structure endows the fibers with outstanding stability and recovery capabilities. The proposed approach is versatile and can be extended to various 2D materials, including graphene, MXene, and MoS2. The resultant vdW fibers show great potential for applications in sensing, stretchable electrodes, and other flexible electronic devices. This work not only advances the fabrication of high-performance vdW fibers but also contributes to the development of sustainable and efficient materials for next-generation electronics.

Chiral Origami Impact Protector and Sensor

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This study presents a revolutionary, chiral, origami-structured triboelectric nanogenerator with integrated load localization, addressing critical limitations in conventional protective materials and energy-harvesting systems. Traditional energy-absorbing architectures, such as honeycomb or foam-based designs, often exhibit rigid deformation patterns, limited energy recovery capabilities, and poor spatial awareness. Similarly, existing triboelectric nanogenerators face challenges in balancing mechanical compliance with efficient energy conversion, particularly under dynamic impact conditions. Inspired by the hierarchical deformation mechanicals of beetle elytra—a natural system optimized for impact resistance and structural adaptability—the proposed design leverages bio-inspired, hyperbolic lattice geometry to achieve geometrically nonlinear energy dissipation. By integrating torsion-enhanced mechanisms into a 3D reconfigurable chiral origami framework, the system overcomes the trade-off between structural flexibility and loading bearing capacity inherent to conventional designs.

The 3D reconfigurable architecture, fabricated via nylon-based 3D printing, achieves a 737.96% improvement in energy absorption density compared to conventional designs, maintaining structural stability under 15% strain cyclic compression. By embedding conductive silver layers into chiral origami surface and sandwiching them with fabric/silicone panels, the system enables tri-model functionality: (1) Superior cushioning via multi-stage deformation (elastic torsion ->plastic buckling -> plateau phase), reducing peak compressive loads to 195.12 \pm 10.33 N; (2) self-powered energy generation; (3) position-sensitive triboelectric mapping across a 100×100 mm² active area. Dynamic testing demonstrated 58.61% peak impact force reduction (475.62 N \rightarrow 196.84 N) and 1050% extended energy dissipation duration (2.8 ms \rightarrow 32.2 ms). Upon application of impact loads, instantaneous signal variation was detected, confirming the systems' ability to perceive dynamic forces and initiate rapid mechanical responses synchronously. Human trials confirmed practical viability, with protectors exhibiting body-conforming flexibility and millisecond-level impact detection for active hazard response. This geometrically nonlinear design bridges energy harvesting, intelligent protection, and potential positioning mapping, showing transformative potential for robotics, smart logistics, and industrial automation.

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Flexible, Biocompatible Electrodes for Wearable and Implantable Devices

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Biopotential electrodes are pioneering new frontiers in precise diagnosis and treatment of brain diseases by enabling continuous electrophysiological monitoring. However, these electrodes usually lack the ability for signal monitoring and tissue repairment at the same time, which makes them unusable for special application scenarios. To address these issues, a totally flexible electrode has been developed by embedding an array of poly (3,4-ethylenedioxythiophene)-poly (styrenesulfonate) onto the electro-spun styrene ethylene butylene styrene/cellulose acetate (SEBS/CA) substrate. The mesh structure of the stretchable SEBS/CA substrate and hydrogen bond between CA and PEDOT: PSS allows stable contact. The electrode performance for monitoring electrocorticography (ECoG) was evaluated in vivo animal experiments using rats. The fabricated SEBS/CA-based electrode had the ability to conform to the curved, grooved surface of the brain just by being placed. Most importantly, the fabricated electrode exhibited good biocompatibility, causing less immune reaction and less damage to brain tissue during implantation. Additionally, the electro-spun SEBS/CA electrode could also be used in vitro as wearable product, and its conductivity could be enhanced by body fluid. It also manifested the ability for in vitro electrophysiological signal monitoring and gesture identification, combined with machine learning techniques.

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Regenerated Cellulose Acetate Photonic Fibers-derived Aerogel Boards for On-demand Building Thermal Regulation and Carbon Reduction

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Cellulose fibers play significant roles in passive radiative thermal management due to their structure diversity, low thermal conductivity, and high abundance. However, the fixed micro-structure and abundant hydrophilic groups limit the regulatability of their optical and thermal properties. This work explores the solvent selectivity of cellulose acetate (CA) and mechanically-assisted solvent extraction strategy for possibly regenerating CA as photonic fibers. The regenerated fibers allow for extensive doping of photonic media and phase-change materials to alter their spectral selectivity and thermal properties. The derived radiative cooling board (PRC) is lighter than traditional building materials and exhibits high solar reflectance (~94%) and thermal emission (~96%), thus achieving ~11°C daytime and 6°C nighttime radiative cooling effects. The phase-change heating board integrates solar absorption (A_{solar}~96%), thermal insulation (T_{shielding}~30°C), and storage functions (t_{release}>1200 s), which can maintain heat building at ~12°C under I_{solar}~1000 W/m². According to evaluation, the cellulose fibers-derived units can save over 45% of energy, rrepresent 1.042 \$/m² cost savings, and report a 4.978 kg/(m²·y) CO₂ emission level in Nanjing annually. It is believed that the results have positive effects for clarifying the structure-effect relationship between fiber micro-structure and radiative heat transfer, forwarding the commercialization of building thermal management materials.

Wearable Textile Sensors for Human-Computer Interaction and On-body Applications

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Textile-based sensors demonstrate superior wearability and comfort compared to conventional rigid wearable devices. Enabled by artificial intelligence (AI) advancements, wearable textile systems have progressed beyond basic physiological and postural monitoring to incorporate programmability, interactive capabilities, and closed-loop feedback mechanisms—features particularly crucial for specialized populations and extreme environments. These AI-integrated textile systems, combining inherent mobility, autonomy, and user-friendliness, represent promising adjunct tools for healthcare providers. However, practical implementation faces challenges, including limited decision-making accuracy and reduced robustness, primarily due to complex human physiological variability and significant inter-individual differences.

This study examines AI's potential to enhance smart wearable technologies and explores their implementation across various applications. We present case studies from the authors' research group, highlighting contributions to both wearable sensor development and human-computer interaction (HCI) domains.

Fibers for Energy and Environment

Photothermal Fabrics for Solar-driven Seawater Desalination

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Solar-driven seawater desalination has attracted widespread attention for its potential to address global freshwater and energy challenges. The key to this technology relies on efficient solar absorbers and well-designed evaporators. Among these absorbers, photothermal fabrics stand out for their abundant availability, low cost, large surface area, versatility, tunable structure, and excellent flexibility. We have developed three types of photothermal fabrics and evaporators. The first type is washable photothermal fabrics and reversible evaporator for salt dissolution. This strategy primarily removes crystallized salt particles through simple hand-washing or by flipping the evaporation surface into seawater, allowing the salts to be dissolved. To prevent salt crystallization, we developed the second type of salt-resistant hanging evaporators. Using surface modification and electrospinning techniques, a series of photothermal fabrics (such as cotton-CsxWO₃ membrane, PAN@CuS membrane, breathable membrane with three-layered structure) have been fabricated and suspended between water tanks. Under sunlight, seawater is drawn to the fabric edge and flows along the hanging fabric via capillary action, where solar energy is converted into heat to drive evaporation. The resulting concentrated brine drips into a lower collection tank, effectively preventing internal salt accumulation. To achieve all day efficient seawater evaporation, we have developed the third type of photo/electrothermal fabrics, including honeycomb CNTgraphene composite PET fabric, CF@graphene oxide-PVA fabric, and CF/TiO₂@PPy fabric. These membranes are built into hanging evaporators, showing excellent photothermal, electrothermal, and photo/electro-thermal synergistic properties. The above research primarily focuses on preparing photothermal fabrics and designing novel evaporation models, as well as exploring methods to address the primary challenges in solar seawater evaporation.

Multifunctional MXene@CNT Coaxial Fiber for Balanced Mechanical Properties, Electrical Conductivity, and Specific Capacitance

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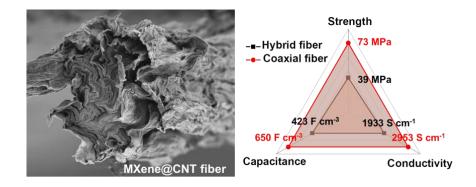
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The discovery of liquid crystalline (LC) phases in dispersions of two-dimensional (2D) materials has enabled the development of macroscopically aligned three-dimensional (3D) macrostructures. Previously, we reported the experimental observation of self-assembled LC phases in aqueous $T_{i3}C_2T_x$ MXene without using LC additives, binders, or stabilizing agents. We showed that the transition concentration from the isotropic to nematic phase is influenced by the aspect ratio of MXene flakes. The formation of the nematic LC phase made it possible to produce fibers from MXenes using a wet-spinning method. The wet-spun $T_{i3}C_2T_x$ fibers showed a high electrical conductivity of ~7750 S cm⁻¹, surpassing existing nanomaterial-based fibers. A high volumetric capacitance of ~1265 F cm⁻³ makes $T_{i3}C_2T_x$ fibers promising for fiber-shaped supercapacitor devices. However, the mechanical strength of pure MXene fiber is very low 40 MPa, seriously hindering its practical application.

In the last few years, various preparation methods for MXene-based composite fibers have been widely studied and reported. However, balancing mechanical strength, electrical conductivity, and specific capacitance of MXene-based composite fibers remains a critical challenge for promoting their practical application in fiber-shaped supercapacitors (FSCs). In this study, we introduce a scalable wet-spinning strategy for the rapid and continuous production of MXene@CNT coaxial fibers. We provide a detailed analysis of the structural and property differences between MXene@CNT coaxial fibers and MXene/CNT hybrid fibers. Thanks to the optimized composite material and fiber structure, MXene@CNT coaxial fibers achieve a perfect balance of mechanical properties, electrical conductivity, and specific capacitance. Specifically, the MXene@CNT coaxial fiber exhibits a tensile strength of 73.75±6.51 MPa, an outstanding electrical conductivity of 2953.93±108.15 S cm⁻¹, and a high specific capacitance of up to 650 F cm⁻³ at a current density of 1 A cm⁻³. When assembled into fiber-shaped supercapacitors, these fibers demonstrate an impressive energy density of ~11.61 Wh kg⁻¹ and a power density of ~6007.14 W kg⁻¹. This research offers a novel perspective on structural engineering for the large-scale production of high-performance MXene-based composite fibers.



High-safety, Fiber-based Battery Separators

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Lithium-ion batteries have achieved remarkable advancements in recent decades, making substantial contributions to portable electronics, electric vehicles, and large-scale energy storage systems. However, frequent battery accidents have imposed heightened safety requirements on separator materials. As critical electronic insulators and ion transport media between electrodes, conventional polyolefin separators face critical limitations in thermal stability that constrain battery safety. Fiber-based materials emerge as promising candidates for constructing high-safety separators, due to high porosity interconnection, tunable three-dimensional network, and superior thermo-mechanical properties.

Our team focuses on the research of organic-inorganic composite fiber separators to improve battery performance, and prepares new high-safety composite separator with high lithium-ion conductivity, superior temperature resistance, excellent mechanical properties, and fast thermal conductivity. Through in-situ/ex-situ characterization methods, we deeply elucidate the structural evolution mechanism of the separator during the cycling, and reveal the structure-property relationship between material microstructure, surface/interface characteristics, and electrochemical performance. This presentation will focus on the application of fiber-based separator materials in energy, as well as the prospects, challenges, and recycling directions of fiber separators in this field.

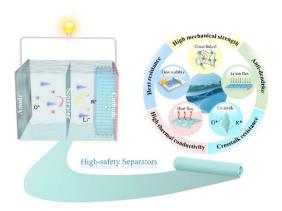


Figure 1. Design of High Safety Separator for Lithium Battery.

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Assessing the Energy Harvesting Performance of Electrospun Nylon 11/Glycine Nanocomposite: Unique Soft Material for Piezoelectric Applications

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The textile industry is well acquainted with the technical and conventional applications of nylons. The latest discovery of nylons as an energy material has added a new edge to the technical aspect of this polymer. Nylons have the unique ability to convert mechanical energy into its electrical counterpart, through the mechanism of piezoelectricity. This property is exclusively observed in the case of odd-numbered nylons. The anti-parallel arrangement of dipoles in even-numbered nylons imparts a non-polar nature, depriving it of piezoelectric characteristics. Nylon 11, a bio-based polyamide, has emerged as a promising piezoelectric polymer. The -CO and NH groups constitute the dipole pair in the case of nylons. Nylon 11 exists in different crystal phases, depending upon its processing technique. The tightly hydrogen-bonded a phase of nylon 11 impedes dipole movement on application of stimuli, making it piezoelectrically inert. On the other hand, the loosely hydrogenbonded δ ' phase of this polymer is desired for piezoelectric applications. Glycine is an amino acid that has reported appreciable piezoelectric activity. This biocompatible amino acid is being used in composites to form high-performance materials. In this study, electrospun nanocomposites of nylon 11/glycine were explored in order to study the influence of glycine in stabilizing the electroactive phase of nylon 11 and assess its energy performance. It was found that a combination of 80/20 nylon 11/glycine showed superior piezoelectric performance compared to pristine nylon 11. Glycine introduced disorderliness in the ordered structure of nylon 11, facilitating the formation of δ ' phase of nylon 11. The open-circuit voltage of 80/20 nylon 11/glycine was found to be 11.2V under 1.3N force at 4Hz frequency. The piezoelectric coefficient of this combination was 7.1pm/V, which was significantly higher than 3.31pm/V for pristine nylon 11. Further, the cyclic stability of its performance manifests its long-term usage. The ability of this material to harvest energy from mechanical movements indicates its capacity for integration into wearables and textiles in the form of sensors. Such flexible substrates that can scavenge wasted mechanical energy and convert it into usable electrical form are emerging in the era of smart wearables.

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Nature-inspired Strategies for High-performance Fibrous Aerogels

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We report a unified framework of nature-inspired design principles for the development of next-generation fibrous aerogels with exceptional thermal, mechanical, and structural properties. Guided by geological processes, biological architectures, and fluid dynamic phenomena, we establish three distinct yet synergistic strategies that enable precise structural control across multiple length scales. By emulating volcanic crystallization, reindeer guard hair morphology, and hydrodynamic instabilities, we demonstrate how disparate natural paradigms can be harnessed and integrated to engineer fibrous aerogels with tailored anisotropy, hierarchical porosity, and extreme environmental resilience. This convergence of geophysical, biological, and physicochemical insights opens new avenues for the rational design of multifunctional aerogels in demanding applications ranging from thermal insulation and wearable electronics to aerospace and energy systems.

Volcanic-inspired Crystallization of Cristobalite Silica Fibers

Emulating natural volcanic processes, we demonstrate alkali-ion-induced crystallization of amorphous silica into highly crystalline β -cristobalite fibrous aerogels. Using airflow-assisted rotary spinning and alkali hydroxide doping, the crystallization onset temperature is reduced from >1400°C to ~1000°C; alkali-ion facilitates optimal spinnability and phase transformation. HRTEM and XRD reveal a nucleation-driven mechanism with sharp amorphous–crystalline interfaces, enabling reversible α - β transitions near 220°C. These aerogels exhibit thermal stability up to 1500°C, thermal conductivities as low as 0.026-0.028 W·m⁻¹·K⁻¹, and robust structural resilience, making them ideal for aerospace and fireproof applications.

Biomimetic PBO Aerogel Fibers with Core-Shell Architecture

Inspired by the hierarchical structure of reindeer guard hairs, we report the fabrication of ultralight, tough, and thermally insulating poly (p-phenylene benzobisoxazole) (PBO) aerogel fibers with a coaxial core-shell architecture. Using a wet-spinning strategy and tunable phase separation, the fibers exhibit a porous core for thermal insulation and a wrinkled shell for mechanical robustness. By adjusting solvent ratios and coagulation temperatures, we achieve precise control over porosity, shell morphology, and interfacial dynamics. The resulting aerogel fibers demonstrate an exceptional combination of properties, including >140% elongation at break, a toughness of 9 MJ/m³, and a specific surface area exceeding 450 m²/g. These fibers maintain integrity under flame exposure (1150°C, 8 minutes) and outperform conventional aerogel materials in both mechanical resilience and thermal regulation, establishing a promising platform for wearable insulation, multifunctional composites, and extreme-environment textiles.

Multiscale Alignment and Porosity in Aerogel Fibers via Waterfall Coagulation

We report a rotary jet wet spinning strategy to fabricate ultralight, aligned PBO aerogel fibers with hierarchical porosity and enhanced mechanical and thermal properties. The spinning system integrates rapid solvent exchange and shear-induced alignment via a continuous "waterfall" coagulation bath. The resulting fibers exhibit a tensile strength up to ~100 MPa and an ultralow thermal conductivity of ~0.03 W m⁻¹ K⁻¹, surpassing those of conventional polymer aerogels. Multiscale structural control, including nanofiber orientation and Kelvin Helmholtz instability-induced wrinkling, yields a dual porosity network that enables high strength, low density (~2.8 mg/cm³), and efficient thermal insulation. These findings offer a scalable route to anisotropic aerogel fibers for advanced thermal management, structural composites, and wearable applications.

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Wearable PEDOT:PSS/DVS-coated Yarn-type, Transpiration-driven Electrokinetic Power Generator with High-power Efficiency and Water Stability

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Hydroelectric nanogenerators, which generate electricity using small quantities of water, are attracting increasing interest as sustainable power sources for next-generation wearable electronics. However, conventional HENGs face limitations in terms of power density and long-term operational stability, restricting their practical application. In this study, we present a transpiration-driven electrokinetic power generator (TEPG) based on silk yarn coated with poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) and divinyl sulfone (DVS), designed to function as wearable hydroelectric nanogenerators with superior power generation efficiency and water stability.

Silk yarn was chosen as the substrate due to its inherent hydrophilicity, high aspect ratio, and mechanical durability, making it highly suitable for wearable and yarn-based systems. This structure allows for high spatial efficiency and improved volumetric power density. To further enhance the long-term performance of the device, DVS was incorporated as a covalent crosslinker, which stabilizes the PEDOT:PSS layer and maintains its electrochemical performance under continuous operation.

The developed yarn-type TEPG demonstrated a maximum power output of $112~\mu W~cm^{-3}$ using a 0.051~M NaCl solution, which mimics the ion concentration of human sweat. Leveraging the flexibility and sewability of the yarn, an array of 25 yarn-type TEPGs was assembled in a series–parallel configuration to validate the scalability of the system. The successful integration and performance of the array highlight the strong potential of this approach for powering wearable devices. Overall, this work provides a promising strategy for realizing efficient, durable, and flexible hydroelectric nanogenerators suitable for wearable energy harvesting applications.

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Turning Waste into Treasure: One-way Fluidic Janus Evaporator from Discarded Fabrics for Efficient Solar Desalination

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Solar interfacial desalination is recognized as an innovative and efficient strategy to address the freshwater crisis with minimized carbon footprint. However, its further application is limited by the high-cost of raw materials and the trade-off between thermal localization and salt resistance. Herein, a discarded fabric-derived hanging-slope Janus evaporator with one-way fluidic structure is proposed to surmount the long-standing dilemma, thereby achieving stable and high-rate solar desalination. Converting discarded fabrics into high value-added energy materials not only maintains 3E (economy-energy-environment) nexus but also helps solve the freshwater shortages. Benefiting from flow-driven salt migration, the possibility of salt deposition on the evaporator surface is completely eliminated. The synergistic effect of Janus structure and double-surface evaporation design maximizes the thermal localization of the evaporation interface. More notably, the mass transfer fabric at the end of the evaporator not only fully recovers the conductive heat carried by the operating fluid but also captures ambient energy to enhance evaporation. With the rational design employed, an evaporation rate of 3.25 kg m⁻² h⁻¹ on average without salt accumulation, even in 10 wt% brine for continuous 8 hours, is achieved under one sun illumination. Based on those findings, an in-situ self-cultivation system is developed using seawater, which can effectively cultivate a variety of crops. This work not only demonstrates a facile yet efficient strategy for high-performance solar desalination but also provides innovative insights into self-sufficient future ocean cultivation.

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Research on Bio-inspired Nanofibrous Electrocatalyst with Confined Channels for Enhanced ORR/OER Performance

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The development of efficient and durable electrocatalysts for oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) is crucial for advancing energy conversion technologies, such as fuel cells and metal-air batteries. At present, noble metal-based materials are the most efficient ORR/OER electrocatalysts. However, their disadvantages, including high cost, poor operation durability, and poor tolerance to cross effect, seriously hinder the further development and commercialization of energy conversion technologies. It is of great significance to design active, durable, and low-cost, non-noble metal bifunctional ORR/OER catalysts to mitigate reliance on noble catalysts.

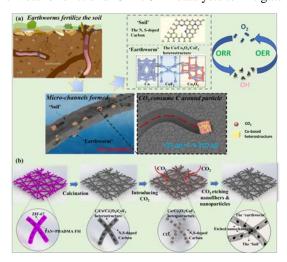


Figure 1. Schematic illustrations of (a) the formation of the unique architecture of the nanofibrous electrocatalyst mimics the process of earthworms fertilizing the soil, and (b) the corresponding synthesis route of $Co/Co_3O_4/CoF_2@NSC$.

This study presents a novel earthworm-inspired nanofibrous electrocatalyst, Co/Co₃O₄/CoF₂@NSC, designed with confined channels to enhance catalytic performance. The formation of a unique architecture mimics the process of earthworms fertilizing soil, facilitating efficient mass transport and electron transfer (Figure 1a). The synthesis involves a facile electrospinning technique followed by controlled thermal treatment, resulting in a composite of cobalt, cobalt oxide, and cobalt fluoride embedded in nitrogen-doped carbon (NSC) nanofibers (Figure 1b). The confined channels within the nanofibers are engineered to optimize the exposure of active sites and improve the accessibility of reactants, thereby enhancing the ORR and OER activities. Electrochemical evaluations reveal that the Co/Co₃O₄/CoF₂@NSC electrocatalyst exhibits superior bifunctional catalytic performance, with a high onset potential and low overpotential for both ORR and OER. The catalyst also demonstrates remarkable stability and durability under prolonged operational conditions, attributed to the robust nanofibrous structure and the synergistic effect of the multi-component system. The earthworm-inspired design not only provides structural advantages but also promotes a favorable electronic environment for catalytic reactions. Density functional theory (DFT) calculations further elucidate the electronic interactions and charge distribution within the composite, supporting the experimental findings.

This work underscores the potential of bio-inspired designs in developing advanced electrocatalysts and offers a promising strategy for enhancing the efficiency of energy conversion systems. The insights gained from this study could pave the way for future innovations in catalyst design, contributing to the sustainable development of clean energy technologies.

Influence of Nonwoven Manufacturing Methodologies on the Energy Harvesting Performance of Nonwoven-based Triboelectric Nanogenerators

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Transformation of wasted mechanical energies into electrical outputs has great potential to alleviate the present problem of energy crisis. Triboelectric nanogenerator has emerged as an effective device, which can generate electrical outputs from frictional motions. Nonwovens, a unique class of textile materials, are utilized both in proximity to the human body as well as in various technical applications. Involvement of such demanding textile structures as triboelectric layer may widen the scope of harvesting wasted mechanical energies linked to various application fields. Needle punching is a mechanical bonding technique for providing structural integrity within a fibrous web. This technique is well known for its easy processability and is an economically viable route. The other highlights of this technology are flexibility in raw material selection and robust output products. In this work, acrylic needle punched nonwoven has been utilized as a triboelectric layer. A detailed experimental analysis has been performed to uncover the effect of structural parameters of needle punched nonwoven in determining its triboelectric energy harvesting performance. The triboelectric energy harvesting performance has been found to be influenced by the fibre fineness and fibre packing density of the nonwoven. Additionally, energy harvesting performance of thermal bonded nonwoven structures is also compared to the same of needle punched structures. Finally, electronic applications of needle punched nonwoven samples are captured in this work.

Beyond Powder Catalysts: Fiber-immobilized ZIS and CZS Photocatalysts with Electron-mediated and Piezoelectric Synergy for Scalable Hydrogen Generation

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Electrospun nanofibrous membranes are gaining attention as advanced engineering platforms for photocatalyst immobilization, offering such advantages as high surface area, controllable porosity, mechanical flexibility, and ease of recycling. Compared to traditional powder catalysts, these composite membranes effectively alleviate issues of particle aggregation, poor dispersibility, and difficult recovery, thereby enhancing photocatalytic activity and enabling practical application and scale-up. In this work, two distinct systems were constructed by combining solvothermal synthesis with blend electrospinning to prepare high-performance composite membranes for visiblelight-driven photocatalytic hydrogen evolution. In the ZnIn2S4 (ZIS)-based system, 3D flower-like ZIS powders were synthesized via a solvothermal method and incorporated into polyacrylonitrile (PAN) fibers through electrospinning to fabricate ZIS/PAN nanofibrous membranes. The optimal membrane with 5 wt% ZIS loading achieved a hydrogen evolution rate of 1836 µmol/(g·h), which is 3.7 times higher than that of pristine ZIS powder (494 µmol/(g·h)). This enhancement originates from the improved dispersion and immobilization of ZIS particles within the nanofiber matrix, as well as chemical interactions between ZIS and the PAN substrate. The cyano groups (-CN) in PAN act as electron-withdrawing moieties that attract and stabilize photogenerated electrons, thereby effectively suppressing electron-hole recombination and prolonging the photocatalytic activity. In the Cd0.3Zn0.7S (CZS)-based system, 3D cauliflower-like CZS nanoparticles were synthesized through solvothermal processing and embedded into TiO2/PVDF/PAN fibers via electrospinning to form CTPP membranes. The 7.5-CTPP membrane exhibited a hydrogen evolution rate of 27.1 mmol/(g·h), which is 1.74 times that of pure CZS powder (15.6 mmol/(g·h)), demonstrating the advantage of fibrous loading. Upon UV etching, which exploits the band structure of TiO2 to generate hydroxyl radicals(·OH) that etch fiber surfaces, the exposure of active sites was improved and the hydrogen evolution performance increased to 33.5 mmol/(g·h). The integration of piezoelectric PVDF introduced an internal electric field under mechanical agitation, which facilitated charge carrier separation. Photocatalytic tests under stirring conditions showed a hydrogen evolution rate of 27.1 mmol/(g·h), compared to 18.3 mmol/(g·h) under static conditions, indicating that the piezoelectricphotocatalytic synergy enhanced performance by 1.48 times.

Fiber Composites and Industrial Textiles

Continuous Fiber Composite 3D Printing

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Continuous carbon fiber composites offer exceptional strength-to-weight ratios, making them ideal for lightweight structural applications. However, traditional composite manufacturing methods face limitations in achieving controlled fiber orientation, forming complex 3D geometries, and utilizing material efficiently. In this study, we present an innovative 3D Fiber Tethering (3DFiT) manufacturing technique that enables the spatial placement of continuous single-tow fiber along principal load bearing 3D paths, ensuring precise fiber orientation and fabrication of complex 3D geometries with enhanced material and process efficiency. This study leverages topology optimization to design a lightweight bracket structure tailored for the 3DFiT process, enabling efficient material distribution and aligned fiber placement while preserving structural integrity. Through 3DFiT technique, we demonstrate fabrication of the optimized 3D continuous fiber thermoset composite bracket, achieving a 93.5% reduction in mass, which highlights the effectiveness of 3DFiT manufacturing in translating optimized designs into high-performance composite structures. 3DFiT offers strong potential for the rapid and scalable fabrication of topology-optimized 3D composite structures, featuring superior material efficiency, mechanical performance, and geometric freedom in advanced composites fabrication.

Mechanical Property Analysis of Wool Fiber-reinforced Composite Materials

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The increasing demand for sustainable materials in industries such as automotive, aviation, and construction has driven significant interest in natural fiber-reinforced composites (NFRCs). These composites offer several advantages over traditional, inorganic, fiber-reinforced composites, including lower environmental impact, costeffectiveness, and renewable sources, coupled with satisfactory mechanical properties. However, one of the primary challenges limiting the broader application of NFRCs is their inherent flammability, which poses safety concerns in high-risk environments. In order to address this issue, researchers have explored various flameretardant strategies to enhance the fire resistance of NFRCs. In this study, we introduced the innovative approach of incorporating wool fabric, known for its inherent fire resistance, as a reinforcement material in a PLA matrix to create environmentally friendly composites with enhanced mechanical properties. The preparation of these composites involved selecting and blending wool and PLA fibres in various proportions. The nonwoven fabrics were produced with proportions of 60% wool and 40% PLA and 40% wool and 60% PLA. The composites were prepared with different thicknesses from nonwoven fabrics using a compression molding technique. The composite samples produced were subjected to various experimental investigations, including tensile strength, three-point flexural bending, interlaminar shear strength, impact test, Limiting Oxygen Index (LOI), UL-94 vertical burning, and Thermal Gravimetric Analysis (TGA) tests. The results obtained from the experimental investigation were thoroughly analyzed to determine the possibility of using wool-PLA-based composite materials in various sectors. The research finding revealed that the wool-PLA nonwoven fabric reinforced composites had shown good fire resistance for the composites produced from a high proportion of wool fibers (60% wool and 40% PLA) in the nonwoven fabric composition. In addition, this variant showed adequate mechanical properties in comparison with many other natural fibers-based composite materials. The result obtained is promising for tackling the issue of NFRCs' inherent flammability.

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Experimental and Numerical Analysis of the Impact Performance of Wool/PLA Composites

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Natural fiber-reinforced composites are gaining increasing attention as sustainable alternatives to conventional synthetic fiber composites. Polylactic acid (PLA), due to its biodegradability and favorable mechanical properties, is widely used as a matrix in bio-based composites. However, its intrinsic brittleness and low-impact resistance limit its use in dynamically loaded structures. To address these limitations, this study investigates the mechanical and impact behavior of wool/PLA composites using both experimental and numerical approaches.

The experimental phase involved fabricating composite samples with different wool-to-PLA ratios and evaluating their mechanical properties through tensile, flexural, and interlaminar shear strength tests. These tests provided critical input parameters for numerical modeling. The impact performance of the composites was assessed using Charpy impact tests with an impact energy of 4J, allowing for the identification of key failure mechanisms, such as delamination, fiber pullout, and matrix cracking.

For the numerical analysis, the finite element method (FEM) was applied using LS-DYNA, implementing the MAT_COMPOSITE_DAMAGE_54/55 material model. The model parameters were calibrated based on the experimentally obtained material properties. Validation of the numerical model was conducted through direct comparison between simulation results and experimental findings from the impact tests. The results demonstrated that the numerical model effectively captures the energy absorption characteristics and failure mechanisms observed during physical testing. The predicted damage patterns and impact resistance closely matched the experimental outcomes, confirming the reliability of the computational model.

The findings of this study suggest that wool-reinforced PLA composites exhibit promising impact resistance, making them potential candidates for low-velocity impact applications, such as protective gear, automotive components, and lightweight structural materials. Furthermore, the validated LS-DYNA model provides a valuable predictive tool for assessing the behavior of bio-based composites under dynamic loading conditions. Future research will focus on enhancing fiber-matrix adhesion and optimizing fiber orientation to further improve the mechanical performance and energy absorption capacity of wool/PLA composites.

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Fabrication and Optimization of Continuous, Fiber-reinforced, Suspended Architecture by Self-supporting Suspension Printing

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Continuous fiber-reinforced polymer additive manufacturing (CFRP-AM) offers great potential for fabricating unattainable suspension features in fused deposition modeling (FDM) by taking advantage of continuous fiber. While existing studies predominantly focus on simple overhangs, fabrication of complex suspension patterns remains challenging due to gravitational effects and fiber-tension induced deviation. This study proposes a bioinspired fabrication strategy along with a process optimization method for the self-supporting suspension printing (SSSP) of geometrically accurate and mechanically robust architecture over a large span. Mimicking spider-web architecture, the fabrication process is decoupled into the primary skeleton (e.g., frame struts) and secondary elements fabrication (e.g., bracing struts). The geometric accuracy and mechanical performance of those suspension elements with different printing features were systematically investigated. To precisely construct intricate suspension patterns, a physics-informed, few-shot learning (PI-FSL) and genetic algorithm (GA)-based approach was presented to guide the inverse design of the printing path for target structural patterns. A novel slip transmission mechanism was introduced in the inverse design framework to quantify the time-dependent influence of preceding path slippage on the stability of subsequent continuous paths. The proposed approach demonstrated high efficiency and accuracy for the given target pattern with a geometric deviation below 1.0 mm at all trajectory points with desirable path uniformity. The method was further adapted to create two-and-a-half dimensional (2.5D), fiber-reinforced battery enclosures with improved mechanical and heat dissipation performance and extended to 3D skeleton fabrication via robotic-assisted CFRP-AM (e.g., drone protective shields). This method offers an efficient tool for designing various suspension features in CFRP-AM.

Machine Learning-based Method of Damage Detection in Fiber-reinforced Plates

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Recent advancements in structural engineering have seen the widespread implementation of fiber-reinforced thin-walled structures across various sectors. While such configurations are engineered to withstand loads within predefined safety margins, damages induced can compromise the structural integrity, resulting in defects. Additionally, cyclic loading can precipitate fatigue damage, leading to the propagation of cracks within metallic components. Consequently, there is an increasing demand for the development of advanced and reliable damage detection methods for these structures. In response, recent research has shifted toward the integration of data-driven approaches, particularly those utilizing machine learning techniques, as an alternative to traditional diagnostic methods. By utilizing the vibrational data of the structures, machine learning algorithms such as Convolutional Neural Network (CNN) are trained to search for patterns that can indicate damage location and severity. These algorithms work faster at detecting damages than conventional visual structural health monitoring, which is suitable for maintenance in a fast-paced environment.

In this study, Convolutional Neural Network (CNN) modified from GoogLeNet, forming an ensemble network, was tested on two plate structures: isotropic and orthotropic. Damage localization in isotropic plates was efficiently determined using a modified regression network, while quantification was achieved through an ensemble network to enhance accuracy. In the case of composite orthotropic plates, the model identified the specific layer where the damage occured by incorporating an additional output parameter. This necessitated the development of a separate localization network, which was then integrated with the ensemble network to handle general cases. The accuracy of the results obtained from the ensemble network significantly surpassed those derived from individual networks with RMSE 0.0139. Experiments were also conducted to validate the method in real structure showing two damage cases in Figure 1. The CFRP (Carbon Fiber Reinforces Polymer) plates were placed in front of a laser scanning measuring device that captured deflections at multiple points in a grid. This input signal was fed into the algorithm, which successfully predicted damage in both cases. It was shown that both the localization and quantification processes delivered results with high accuracy for the plate structures.

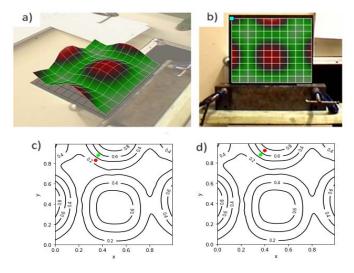


Figure 1. Experiment results and validation for the orthotopic case CNN model (a) 3D representation of plate mode shape, (b) front view of the plate mode shape, (c) prediction result under low severity, (d) prediction result under high severity (green dot: real location, red dot: model prediction; values of x, y, and z are normalized with respect to the plate size).

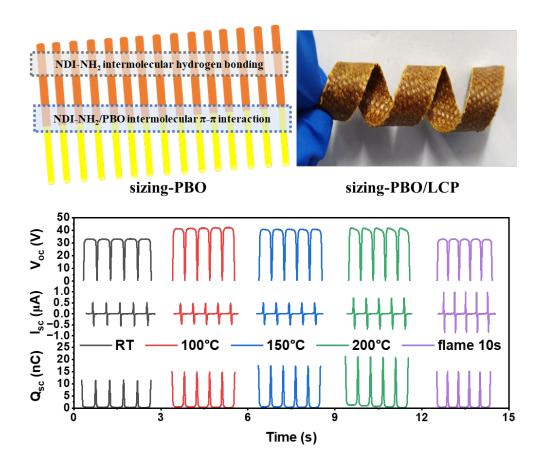
Robust PBO/Liquid Crystal Polymer Composites for Flexible Triboelectric Nanogenerators in Harsh Environment

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Achieving power supply for electronic devices in harsh environment has been a long-standing challenge. The discovery of triboelectric nanogenerators (TENGs) provides a safer method for collecting green energy and converting it into electricity. However, due to the failure of materials in high temperatures or combustion environments, electrical output performances of TENGs rapidly deteriorate or even fail. To address the problem, here we strategically constructed TENGs by using high-performance, PBO fiber fabric, and thermoplastic liquid crystal polyarylester (LCP) composites, which exhibit excellent high-temperature resistance and electrical stability in combustion environments. The PBO fibers were modified by aminated naphthalimide (NDI-NH₂) sizing to improve the thermodynamic properties of the PBO/LCP composites. Besides good flexibility and high heat resistance index of 303.9°C, sizing-PBO/LCP possessed high tensile strength of 409.3 MPa and storage modulus of 577.5 MPa at 250°C, which were increased by 54.7% and 664%, compared to that of pristine PBO/LCP composites, respectively. More importantly, the dielectric constant (ε=3.11~3.86@10⁶Hz) and dielectric loss tangent (tanδ=0.004~0.009@@10⁶Hz) were relatively stable in a wide temperature range of RT~200°C. The sizing PBO/LCP-based TENGs showed enhanced electrical performance as the ambient temperature increased. At 200°C, the open circuit voltage (Voc), short-circuit current (Isc), and short-circuit charge (Q_{sc}) reached to 42 V, 0.7 μA, and 20.7 nC, respectively, which were 30.0%, 42.8%, and 81.6% higher than the values at room temperature. Even after burning on the flame for 10 seconds, the V_{oc} was almost 100% retained. This work provides a novel approach for self-powering wearable devices in extreme environments.



Moisture Management E-Textiles

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Wearable electronic textiles (e-textiles) that are flexibile, lightweight, and compatibile with the human body have attracted widespread interest, particularly in fields such as healthcare, sports and fitness, and medical treatment. The combination of fibrous structure and multifunction gives e-textiles not only softness, stretchability, and breathability but also conductivity. Along with a fibrous textile substrate, the long-term moisture comfort and conductivity after mechanical deformation remain big challenges. Here, a novel e-textile with moisture management and extraordinary sweat (MMET)-enhanced conductivity is reported. Moisture management is made by a wetting gradient, which can unidirectionally expel surplus perspiration, ensuring a dry and comfortable microclimate for users. The developed printable and stretchable circuit exhibits excellent conductivity by using silver flakes-based ink where the conductivity can be enhanced by human sweat, facilitating the restoration of the high conductivity performance. This design provides textile-integrated electronics comfort and durability as well as effectively long-term health monitoring, especially during high-intensity outdoor activities where moisture is a prominent challenge to conventional e-textiles.

ACKNOWLEDGMENT

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Dynamic Radiative Thermal Management by Photothermal Conversion and Phase Change

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Maintaining optimal thermal comfort in outdoor apparel, especially under extreme conditions, remains a challenge. In this study, we developed a novel composite fabric with a multilayered structure that balances radiative cooling and photothermal conversion. This design offers improved thermal regulation, enhancing wearer comfort and adaptability in fluctuating temperatures.

The fabric consists of three layers arranged in a sandwich-like structure. The top layer integrates radiative cooling materials, allowing it to switch between black and white, depending on temperature, thereby maximizing solar absorption in cold weather and promoting heat dissipation when it is hot. The middle layer, made of pure textile, provides mechanical support and breathability. The bottom layer contains a composite phase-change material (PCM) that stabilizes temperature variations by storing and releasing heat as required.

This research presents three key innovations. First, the dynamic coordination of radiative cooling and photothermal conversion enables an adaptive thermal regulation system, reducing dependence on external energy sources. Second, the multifunctional sandwich-inspired structure enhances mechanical strength, flexibility, and air permeability. Third, the use of biomass-based, green manufacturing processes makes the fabric environmentally sustainable without compromising performance.

Experimental findings confirm that the fabric effectively adjusts temperature through phase transitions and radiative effects. Under different thermal conditions, it modulates heat exchange dynamically, significantly improving wearer comfort. Compared to traditional textiles, our fabric design lowers heat stress in high temperatures and minimizes heat loss in colder environments. These advantages make it particularly suitable for outdoor clothing, sportswear, and protective gear.

Our work contributes to the development of smart textiles and next-generation thermal management solutions. By integrating sustainable materials with innovative structural designs, we propose a viable approach to creating eco-friendly, high-performance textiles. Future efforts will focus on optimizing material composition and refining large-scale manufacturing techniques to enhance durability and efficiency.

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Graphene Fiber-based, High Thermal Conductivity Composite: Preparation and Application Exploration

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Graphene fibers, constructed by the ordered assembly of graphene as the primary structural building block, represent a research frontier in the field of macroscopic graphene-based materials. These fibers exhibit exceptional properties, including high strength, high modulus, high thermal conductivity, and high electrical conductivity, making them promising candidates for applications in smart textiles, wearable devices, and high-performance composites. Prof. Gao Chao's team at Zhejiang University has conducted over a decade of foundational research on graphene fiber preparation methodologies, performance enhancement mechanisms, and application development. This presentation focuses on the team's recent advances in graphene fiber-based composite materials, particularly highlighting flexible composites and thermal interface materials for thermal management in high-power electronic devices. The unique advantages of graphene fibers as a novel carbon fiber material will be systematically demonstrated through these application cases.

AI, Robots, Metaverse, and Emerging Technologies

Textile-based Circuits and Devices for Wearable Applications

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Electronic textile devices are of great importance in wearable applications, enabling seamless integration of electrically active functions like health detection or power supply into garments. They provide comfort, mechanical flexibility, and real-time monitoring, revolutionizing personalized healthcare and human-machine interaction.

This report focuses on continuous production of stretchable conductive yarns and uses of electrical wires in textile circuits and devices for wearable applications. Stretchable conductive yarns were continuously manufactured with yarn spinning technology. Via a single-factor control method and orthogonal experimental design, various single-layer/double-layer coated conductive yarns were achieved with enhanced mechanical stretchability and electrical stability. To demonstrate their uses in wearable areas, a knitted circuit was first designed for data transmission of mobile phones. The connection between the knitted circuit and the terminals was established to fabricate the electrical cable, followed by characterization of electric-charging performance. The knitted data cable exhibited high fatigue resistance, excellent elastic recovery, and enhanced durability against breakage and oxidation. Moreover, its compatibility with textiles provided valuable insights for the advancement of flexible electronics and wearable technology. A gesture-recognition smart glove was also fabricated. Electrical wires were seamlessly incorporated into the glove through fully-fashioned knitting techniques, thereby eliminating the issue of disorganized wiring in conventional smart gloves. The integration of an external Type-C interface enabled detachable sensor functionality, addressing challenges related to sensor maintenance and customization.

Versatile Soft Robots Enabled by Hierarchically Programmed Fabric Metasurfaces

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Soft robots with inherent flexibility, adaptivity, and safeness have drawn increasing attention in fields such as healthcare wearables, soft manipulation, and human-robot interaction. However, the current development of soft pneumatic actuators and robots faces limitations, including low volumetric efficiency, complex control systems requiring high operation pressures, limited design flexibility, slow and costly production, and weak environmental adaptability. To overcome these challenges, we propose a novel, caterpillar-inspired soft actuator system that integrates hierarchical textile architecture with a stitch-by-stitch programmable knitting strategy. Unlike existing methods, our approach utilizes boucle fancy yarns and a trilayer-knit topology to fabricate monolithic elastomer shells without assembly, enabling scalable and cost-effective production.

Through in-depth analysis of the correlation between stitch topology and mechanical performance, we reveal the mutual influence between knitting structure and yarn consumption, offering a theoretical basis for the design of composite mechanical properties of knit sleeves for fabric-based soft robots. The resulting robots/actuators exhibit outstanding performance, featuring rapid actuation (1100° s⁻¹), large bending strain (1080° m⁻¹), high power density (272 W m⁻³), dual-stiffness behavior, and human-friendly tactile comfort. Furthermore, we demonstrate programmable multi-dimensional curvature deformation and smooth Gaussian morphing, which enable the development of functional soft robots for crawling, sensing, and bioinspired movement.

This integrated and programmable textile-based approach opens a new paradigm for the design of adaptive, scalable, and multifunctional soft robots, with broad potential in medical rehabilitation, physiotherapy, wearable devices, and next-generation intelligent systems.

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AI-enabled Real-Time Multimodal Physiological Analysis

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An increasing number of smart wearable devices are being used to monitor human physiological signals, which opens up a plethora of opportunities for real-time applications in areas such as health management, emotion recognition, and human-computer interaction. Wearable devices sense an individual's physical and emotional state in real time by capturing a large amount of data, including heart rate, electrical skin activity, body temperature, and movement, leading to instant, actionable insights that promote health and well-being. Since multiple sensors are used to capture different types of physiological signals, data from each modality provide different aspects of information that must be effectively combined to gain a comprehensive understanding of an individual's state. These multiple modalities are not only heterogeneous but also highly temporally correlated, with each signal evolving over time in a dynamic and interdependent manner. Since changes in physiological states tend to be gradual and follow certain temporal patterns, these patterns must be captured in order to make accurate analyses. With the growing need for more personalized and adaptive health monitoring systems, the need for real-time computation, high accuracy, and modeling is becoming increasingly important. Existing methods still face great challenges in efficiently dealing with such intricate time dependencies and inter-variable correlations.

This study proposes CADF (Causality-Aware Dual-Dimensional Fusion), a new framework for real-time analysis of multimodal physiological signals. First, a parallel matrix storage unit effectively captures the long-term time dependence while preserving the structural causality of the original signals. Then a multivariate correlation spatial mask is extracted on a 2D scale to enhance the representation of shared information of multimodal signals; Finally, a streamlined multi-head STA mechanism is designed to facilitate the fusion of 2D features. Extensive experiments on DSADS, WESAD, and CAP datasets show that CADF achieves up to 98% accuracy, which is consistently and significantly better than the SOTA method. Additionally, ablation studies and efficiency analyses confirm the contribution of key components to the overall model performance and highlight its computational efficiency. These results underscore CADF's potential in advancing multimodal physiological signal analysis, with promising applications in health monitoring, emotion recognition, and human-computer interaction. Despite these advances, some limitations remain. Future work will be organized around the following two aspects: (1) Integrating CADF with additional sensing modalities to further enhance its predictive capabilities, and (2) developing interpretability techniques to provide deeper insights into the decision-making process of the model, particularly for healthcare applications where explainability is crucial.

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Modeling, Mechanics, and Fiber Testing

Accurate Identification of Coating on Irregularly Shaped Fibrous Network Using Submicron Infrared Spectroscopy

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Accurate chemical knowledge in surface modification of fiber networks enables material performance assessment and failure mode analyses. In modern fiber analysis, conventional Fourier-transform infrared (FTIR) spectroscopy and Raman analysis represent a ubiquitous combination for identifying nearly all fibrous elements. Unfortunately, conventional FT-IR could only yield satisfactory results when the round fibers could be sufficiently flattened either by a roller or by using the attenuated total reflectance (ATR) accessory of the FT-IR instrument. In either case, the sample compression causes irreparable harm to the fiber and would be detrimental to future analysis in the case of a unique specimen. FT-IR could be operated in a non-contact manner in reflection mode (r-FTIR); but the irregular shape of the fiber leads to scattering artifacts that would distort infrared bands, which would lead to misidentification of material. Raman spectroscopy is a non-contact technique that measures bands complementary to the infrared bands. This method works best for colorless and aliphatic-containing fibers, but poorly for colored and aromatic variants due to autofluorescence baseline. Specimen may also be damaged by the excitation laser due to excessive laser illumination. Recently, a novel non-contact instrumentation based on measuring of mirage affect has been developed to record infrared spectral profiles at submicron spatial resolution, but with little to no influence from the fiber's surface topography [1, 2]. This new instrumentation method could overcome these challenges in ATR-FTIR, r-FTIR and Raman spectroscopies and would be better equipped to effectively and accurately characterize fibrous materials. Although we have previously reported the use of O-PTIR for analyzing standard fibrous material with good agreement to their identity [3], analysis of coatings applied to irregularly shaped fibrous network have not been reported. In this contribution, we will first briefly describe the submicron O-PTIR technique and then illustrate the effective process for identifying the components of a complex coated fiber specimen.

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Local Plastic Deformation in Warp-knitted Spacer Fabrics: Insights from Strain Redistribution

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Warp-knitted spacer fabric features a sandwich structure with high production efficiency and excellent air permeability, making it ideal for cushioning applications. However, compression resilience inevitably degrades during long-term use, primarily due to plastic deformation of monofilaments. Experimentally identifying local plastic deformation in a single monofilament is challenging. This study employs finite element simulation based on micro-X-ray computed tomography reconstruction to analyze monofilament plastic deformation. Two typical monofilament configurations, vertical and inclined, are examined concerning radial and longitudinal strain distribution.

Radially, tensile and compressive strain are unevenly distributed due to the combined effects of bending and axial compression. The compressive area occupies a larger portion than the tensile area, making it more susceptible to failure. Numerical simulation reveals that the vertical spacer monofilament exhibits pronounced fluctuations in the distribution of neutral axis deviation along its length, characterized by two symmetric peaks. In contrast, the inclined monofilament maintains a relatively steady distribution with no distinct peaks. As compression increases, the neutral axis deviation decreases, reducing the compressive region. For the vertical monofilament, the peak compressive area declines from 78.65% to 66.56% and 56.26%, eventually disappearing when the fabric is compressed to 1 mm, 3 mm, 5 mm, and 8 mm, respectively. In contrast, the compressive region in inclined monofilament remains relatively stable, with only a slight decrease from 51.5% to 50.3%.

Longitudinally, numerical simulation indicates that the maximum strain distribution fluctuates along monofilament's length, with the vertical monofilament experiencing higher strain than the inclined one. Notably, in the vertical monofilament, the region where the neutral axis continuously migrates during compression remains within the instantaneous recovery zone of material. This is possibly due to the strain redistribution preventing the material from entering the plastic zone. The middle and end sections fall within the delayed recovery zone, while the remaining section enters the plastic zone. In contrast, for the inclined monofilament, when the fabric is compressed to 3 mm, the entire length remains in the delayed recovery zone. An in-depth understanding of the resilience degradation patterns in different monofilament configurations is essential for predicting the long-term performance and durability of spacer fabrics.

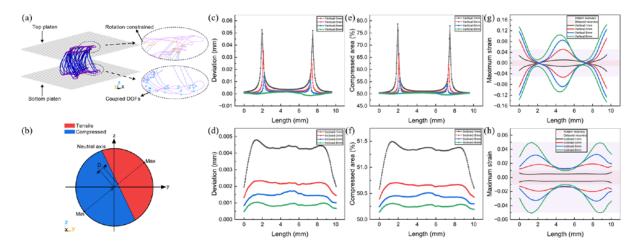


Figure 1. (a) Finite element model; (b) definition of neutral axis deviation and compressed area; (c) neutral axis deviation distribution in vertical monofilament and (d) inclined monofilament; (e) compressed area distribution in vertical monofilament and (f) inclined monofilament; (g) maximum strain distribution in vertical monofilament and (h) inclined monofilament.

Kinetics and Thermodynamic Modeling of Melt Spinning

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Polyarylate fibers are of critical importance in national security, aerospace, and cutting-edge technologies, with strong strategic demand. Their quality is determined by melt spinning technology, yet the production of high-performance polyarylate fibers in China remains constrained by foreign technologies. The melt spinning process involves complex non-Newtonian fluid rheology, interfacial wave instability, and heat and mass transfer at phase change interfaces. Investigating these mechanisms is highly challenging and represents a core scientific issue for improving fiber quality. This study independently developed a high-temperature melt spinning intelligent experimental system capable of online monitoring of fiber diameter, temperature, and solidification points along the spinning path. This report details the construction of the experimental system and progress in experimental research on the nonlinear rheology of spinning polymers. By establishing targeted viscoelastic fluid constitutive models and combining numerical simulations, such as the enthalpy-based solidification model, a kinetic model of melt spinning was developed to elucidate the influence of process parameters and equipment structure on fiber structure and performance. This research aims to identify effective methods for efficient, stable, and high-quality fiber production, providing robust support for domestic innovation in high-performance fiber manufacturing technology and equipment. It also extends multiphase flow thermophysical science into polymer processing.

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Posters

Design and Properties Analysis of Highly Entangled Hydrogel Optical Fibers

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Hydrogel optical fibers (HOFs) have emerged as a new direction in biomedical optical technology due to their high biocompatibility, mechanical compatibility, and environmental responsiveness, but their high optical propagation loss and insufficient mechanical stability remain critical challenges to be addressed. In this study, HOFs featuring a hybrid double-network core layer and a physical single-network sheath layer were successfully fabricated. The core layer of the HOF was formed by the physical entangling and ion crosslinking, whereas the sheath layer was formed exclusively via ionic crosslinking. Specifically, the physical entanglement was achieved through the interweaving of polyacrylamide molecular chains, while the ion crosslinking was realized by coordination interaction between metal cations and the carboxyl groups of poly(acrylamide-co-acrylic acid) copolymer. Comparative analysis revealed that the tensile strength of the HOF was significantly enhanced by the incorporation of a high-entanglement network. Furthermore, the introduction of the sheath layer effectively reduced the optical propagation loss of the HOF to 0.357 dB/cm. Additionally, the integration of metal ions not only optimized the fiber dimensions but also improved its electrical conductivity. This work expands the design possibilities of HOFs for health management applications, demonstrating potential for practical implementation in strain sensing and optical medical therapy.

Development of Velvet-like Textile Design Adoptable for Polyjet Additive Manufacturing Processes

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The purpose of this study is to verify the manufacturing process of velvet-like 3D printing textile design using an additive manufacturing machine. Under the theme of "velvet-like 3D printing textile design," flower and bird patterns were designed, and velvet-like 3D printing textile was designed using polyjet printing. In other words, 2D SketchUp was performed using the Illustrator program to obtain a png file, and then 3D modeling work was performed using a 2D to 3D program. Using the 2D to 3D program, 3D modeling files were obtained by setting the height to 2.5 mm and 5 mm for 1 mm-sized circles, triangles, and hexagons, and setting five different patterns for the protruding parts to create a velvet effect. Next, the GrabCaD program was used to convert the 3D object (.obj) file into a 3D printable G-code file, and then five fabrics of 560 mm x 460 mm, including tulle, nobang, sochang, 15's sheeting, and 14's sheeting, were used as back fabrics and printed using polyjet additive processing machine (J850TM Prime 3D, Stratasys). By applying the polyjet additive manufacturing process, the possibility of producing a velvet-like fabric with a more three-dimensional visual effect was confirmed by giving a velvet-like material feel to the images of plant and bird patterns.

Dual-response Cholesteric Liquid Crystal Elastomer Sheath-Core Bicomponent Fiber

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Cholesteric liquid crystal elastomers (CLCE) can respond with thermal, chemical, electric, and mechanical stress to achieve the change of structural color due to the change of molecular pitch inside cholesteric liquid crystals. However, the tendency of cholesteric liquid crystal phase destruction inside the blending with other polymers will worsen the highly sensitive response of color when a multifunctional system is prepared. In this study, a simple template method was designed to prepare cholesteric liquid crystal elastomer sheath-core bicomponent fiber (PIL-CLCEF) using CLCE and 1-(2-hydroxyethyl)-3-imidazole bromide salt as raw materials. The cholesteric liquid crystal layer of the sheath-core fibers is preserved intact and possesses both force-color and force-electricity response properties. PIL-CLCEF has a high sensitivity force-color response (mechanically induced color change sensitivity) of -1.94 nm %-1. The fiber was sensed and detected over a strain vary from 0% to 80%, showing a relative resistance change from 0% to 280% with a strain sensitivity of 1.15, providing an excellent force-electric response. This work provides an effective strategy for the preparation of CLCE-based functional fiber, which offers a new possibility for the application of smart textiles and display application.

Direct Synthesis of MIL-88B(Fe) on Iron Wire for Gas Adsorption

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This research introduces an innovative method for directly growing metal-organic frameworks (MOFs) on a Fe wire, utilizing the wire both as a substrate and an iron source for synthesizing MIL-88B(Fe) and MIL-88B(Fe)-NH₂. This straightforward in-situ approach requires only the addition of a ligand precursor to initiate MOF formation, eliminating the need for an external metal precursor and providing an eco-friendly strategy for repurposing Fe wire waste. The adsorption capabilities of the resulting MOF-grown wire are assessed for polar formaldehyde gas and nonpolar cyclohexane vapor. The findings emphasize the crucial role of functional compatibility between gas/vapor (GV) and MOF in determining mesoporous GV diffusion into MOF pores (< 20 nm) and overall adsorption efficiency, as confirmed by experimental observations and theoretical calculations. In contrast, diffusion through larger interparticle pores (> 20 nm) remains hardly affected by the functional compatibility, highlighting the distinct impact of nanoscale interactions. Density functional theory simulations further validate these results, demonstrating stronger interactions and increased adsorption sites for well-matched GV-MOF pairs. This study presents a sustainable approach to developing advanced GV filtration systems, emphasizing the significance of microporous diffusion in optimizing adsorption performance.

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Surface Modifications of Short Quartz Fibers for Dental Composites

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Quartz fibers (QFs) are considered as the ideal candidate reinforcing material in dentistry, due to their superior mechanical strength, high purity, and good photoconductive properties. However, the relatively inert surfaces limit their further applications [1]. Therefore, the aim of this study is to modify the fiber surface properties to improve the interfacial interactions with polymeric resins. In this study, we systematically introduced four different surface modification strategies onto short quartz fibers (SQFs) for the preparation of dental composites (Figure 1) [2]. Particularly, acid etching was a facile way to create mechanical interlocking structures. In addition, the silanization process, the sol-gel treatment, and the polymer grafting were further proposed to increase surface roughness and reactive sites. The effect of surface modifications on the fiber surface morphological changes, mechanical properties, water stability, and in vitro cell viability of dental composites were investigated. The results showed that among all surface-modified SQFs, SQFs-POSS (SQFs modified with methacrylate-POSS) exhibited the roughest surface morphology and highest grafting rates compared with other three materials. Furthermore, all these SQFs were applied as reinforcements to make dimethacrylate-based dental resin composites. Of all fillers, SQFs-POSS demonstrated the best reinforcing effect, providing significantly higher improvements of 55.7%, 114.3%, and 164.7% for flexural strength, flexural modulus, and breaking energy, respectively, over those of SQFs-filled composite. The related reinforcing mechanism was further investigated. This work provided valuable insights into the optimization of filler-matrix interaction through fiber surface modifications.

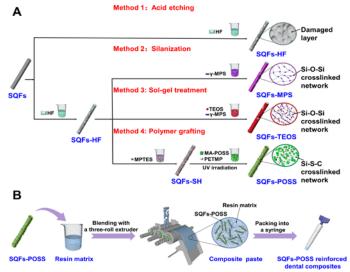


Figure 1: Schematic illustration of four different surface modifications on SQFs (A) and the representative scheme of the fabrication of SQFs-POSS-filled dental composites (B).

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Green Preparation of Bio-based Fibrous Membranes via Solution Blow Spinning

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Bio-based fibrous membranes have attracted considerable attention in the biomedical field due to their environmentally friendly nature and resource-efficient characteristics. However, conventional fabrication processes of bio-based fibers often rely on organic solvents, which can pose cytotoxic risks and trigger immune rejection reactions, thereby limiting their clinical applicability. To overcome these challenges, we developed a fully green spinning system utilizing water and ethanol as solvents and successfully fabricated high-performance chitosan fibers via solution blow spinning (SBS). Specifically, we synthesized catechol-chitosan (CS-C) with enhanced water solubility and systematically optimized the water-to-ethanol ratio to establish the feasibility of this green solvent system. Additionally, we conducted a comprehensive analysis of the rheological properties of the spinning solution and elucidated their impact on fibrous membranes formation and morphology. The resulting fibrous membranes exhibited excellent biocompatibility, remarkable antibacterial activity, and favorable mechanical properties, underscoring their potential for tissue engineering and other biomedical applications. This study presents a novel and sustainable approach for the green fabrication of bio-based fibers, contributing to their broader adoption in biomedical engineering.

Structural Modulation of Melt-Spun Nanofiber-reinforced Silica Hybrid Aerogel Felts for Thermal Insulation in Extreme Environments

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Aerogels are most attractive for thermal clothing. However, mechanical fragility and structural instability restrict their practical applications. These issues are overcome by developing industrial scale sea-island melt-spun ultrafine fibers with large and uniform length-to-diameter as building blocks, which are assembled into aerogel felts with corrugated lamellar structure through freeze-shaping technology. These aerogels possess excellent mechanical properties to meet fabric elasticity and comfort needs, including super-flexibility (25% tensile strain, 95% compression, 180° bending performance) and fatigue resistance of over 10,000 cycles. The aerogels are also self-cleaning, waterproof, breathable, and flame-retardant, making them suitable for application requirements in extreme environments. Moreover, the obtained aerogel felt clothing exhibits excellent thermal insulation properties close to that of dry air, and is only one-third as thick as down clothing with similar insulating properties. Expanding sea-island melt-spun fiber to construct aerogel in this strategy provides scalable potential for developing multifunctional insulating aerogel clothing.

Fibrovascular Structures Enhanced Evaporative Cooling Fabric

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To alleviate heat stress in hot environments, many personal cooling garments have been developed to enhance thermal comfort. Among these, evaporative cooling garments have drawn much attention, but they often lead to a feeling of stuffiness when the fabric becomes fully saturated. Inspired by the high evaporation efficiency of leaf stomata, which achieve significant evaporation with minimal wetting, we propose a novel fabric with vascular structures that mimic leaf veins to distribute water (viz., vascular cool fabric). This vascular structure benefits from the extended contour, which achieves enhanced evaporation by disrupting interactions between the interfacial water, and facilitating the edge effect to effectively reduce vapor concentration. In our study, the vascular cool fabric was fabricated and optimized for human thermal management. Experimental results showed that even with a relatively low proportion of hydrophilic area (62%-63%), the initial evaporation rate of the vascular cool fabric exceeded 11% of pristine PET fabric and the drying rate increased by 50%, compared to the pristine cotton fabric. Human wear trials with PET sportswear in hot environments (30°C, RH 65%) revealed that wearing a vascular cool T-shirt significantly lowered skin temperature (maximum 0.39°C; average 0.26°C during running) and skin humidity (maximum 5%; average 2.6% throughout the experiments). Most importantly, less than 16% sweat accumulated in the vascular-cooled fabric and showed better sensation ratings (wetness improved by 5.9%; stickiness improved by 11.4%; stuffiness improved by 20.4%; and thermal sensation improved by 16.3%: overall comfort increased by 19.3%), providing a drier, less sticky, less stuffy, and more comfortable experience. The intensive evaporation facilitated by the vascular pattern with a small wetting area enhances thermal comfort during heavy perspiration, marking a significant advancement in the development of the sweat management fabric.

A Machine Learning-enabled Real-Time Temperature Response System Based on Polymer-Filler Interactions for Conductive Network Assembly

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Temperature sensing is essential for the human body's interaction with the environment, and electronic skin mimicking human perception is crucial for developing smart wearable devices. Wearable sensors based on conductive polymer composites (CPCs) possess large sensitive, simple, and low-cost preparation characteristics. However, establishing the conductive networks necessitates sufficient filler doping, posing processability and cost control challenges. Herein, we report a susceptible thermo-sensor (TS) that utilizes the secondary polymer TPU to connect carbon black (CB) particles, facilitating the assembly of a conductive network at low concentrations, thereby improving their electrical conductivity. The TS can defect temperatures in the range of 15–45°C with a sensitivity of 1200%, a PTC intensity of approximately 5, and a respond time of less than 10 seconds. By machine learning to identify the output signal of TS, the recognition accuracy reaches 99.8%, then the real-time temperature display can be successfully realized. This approach provides a simple preparation method for personalized medicine and soft robotics.

Scalable Compliant Graphene Fiber-based Thermal Interface Material with Metal-level Thermal Conductivity via Dual Field, Synergistic Alignment Engineering

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The rapid increase of heat flux in integrated circuits has posed a threat to the reliability and service life of highpower electronic devices. Thermal interface materials (TIMs) with high through-plane thermal conductivity and low contact thermal resistance are urgently needed to remove excess heat by filling the micro gap between the heating elements and the heat sink. However, the inherent trade-off conflict between achieving high thermal conductivity and excellent compliance of filler-enhanced TIMs results in unsatisfied interfacial heat transfer efficiency of existing TIM solutions. Here we report the graphene fiber (GF) based elastic TIM with metal-level thermal conductivity via mechanical-electric dual-field synergistic alignment engineering. Compared with the state-of-the-art carbon fiber (CF), GF features both high thermal conductivity of ~1200 W m⁻¹ K⁻¹ and outstanding flexibility. Under the dual-field synergistic alignment regulation, GFs are vertically aligned with an excellent orientation (0.88) and high array density (33.5 mg cm⁻²), forming continuous thermally conductive pathways. Even at a low filler content of ~17 wt%, GF-based TIM demonstrates extraordinarily high through-plane thermal conductivity up to 82.4 W m⁻¹ K⁻¹, exceeding most CF-based TIMs, and even comparable to commonly used soft indium foil. Benefited from the low stiffness of GF, GF-based TIM shows lower compressive modulus down to 0.57 MPa, excellent resilience rate of 95% after compressive cycles, and diminished contact thermal resistance as low as 7.4 K mm² W⁻¹. Our results provide a novel paradigm for directed assembly of thermally conductive and flexible GFs to achieve scalable and high-performance TIMs, overcoming the long-standing bottleneck of mechanical-thermal mismatch in TIM design.

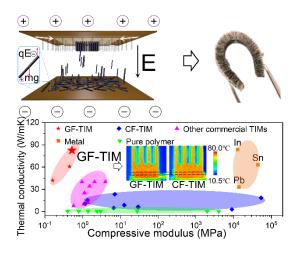


Figure 1. Dual-field synergistic alignment engineering diagram and the performance of this work.

Intergrated Dynamic Wet Spinning of Hydrogel Optical Fibers with Dual Core for Real-time Blood Oxygen Sensing in Vivo

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Compared with traditional polymer optical fiber materials, hydrogel optical fibers have garnered extensive attention in the field of photomedicine due to their tissue-like modulus and high biocompatibility. Currently, by constructing a core/sheath structure with different refractive indices ($n_{core} > n_{sheath}$), hydrogel optical fibers with excellent light-guiding properties within tissues have been successfully fabricated. However, the challenge of collecting light signals in deep tissues remains significant, specifically regarding how to effectively extract the light signal after it has been introduced and utilized for sensing. To address this issue, we developed a dual-core structured hydrogel optical fiber for the integrated input and collection of optical signals in deep tissues. First, by designing the structure of the spinning needle tip and introducing mutually independent core-layer fluid channels, combined with rheological regulation of the spinning solution parameters, we successfully fabricated a dual-channel hydrogel optical fiber with independent core layers. This enables independent transmission of optical signals in each channel, achieving an optimal light attenuation of 0.65 ± 0.02 dB/cm. Subsequently, a coupling head for integrated signal input and collection was designed, enabling the construction of a platform for simultaneous optical signal input and collection. In the mouse blood oxygen model test, the information collection platform could promptly reflect the real-time levels of oxygenated hemoglobin (HbO₂) and deoxygenated hemoglobin (HbO) within the mouse, demonstrating its potential applications in biosensing and tissue imaging.

Analysis of 3D-printed Longitudinal Flat Foot Pads with Lattice Structures Using Various Microfoaming Filaments

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This study evaluates the compressive properties of 3D-printed longitudinal flat foot pads to identify the optimal microfoaming filament and lattice structure for developing improved flat foot pads. Three filaments were used: thermoplastic polyurethane (TPU, eflex, Esun, China), lightweight thermoplastic polyurethane (LW-TPU, varioshore TPU, colorFabb, Netherlands), and lightweight polylactic acid (LW-PLA, colorFabb, Netherlands), with 1.75 mm diameters, densities of 1.12 g/cm³ for TPU and LW-PLA, and 1.25 g/cm³ for LW-TPU. The thermal properties of the filaments were analyzed using differential scanning calorimetry (DSC) to find the optimal temperature for printing. Solid (SL) and five lattice structures were fabricated: voronoi (VOR), tetrahedral (TET-H), kagome (KGM), rhombic (RHM) and icosahedral (ICO-H), with dimensions of 59.03 × 86.64 × 7.06 mm³. FDM 3D printer was used, with 10% infill density, zigzag pattern, 0.4 mm nozzle size, nozzle temperatures were set at 230°C for TPU and LW-PLA and 240°C for LW-TPU, with the bed at room temperature for TPU and LW-TPU and a bed temperature of 65°C for LW-PLA, and a 60 mm/sec printing speed. The lattice structures were designed using the carbon design engine and saved as *.stl files, which were sliced with Cubicreator4 V4.4.0. Compressive properties were evaluated using a universal testing machine. The DSC analysis revealed that LW-PLA had the lowest glass transition temperature (Tg) at 60 °C, while LW-TPU and TPU had Tg values of 76.29 °C and 82.33°C, respectively. LW-PLA also had a lower melting temperature (T_m) at 150°C compared to 166.93°C for LW-TPU and 170.73°C for TPU. In compression tests, LW-PLA showed higher compressive values than TPU and LW-TPU. ICO-H LW-PLA had the highest initial modulus of 4.28 ± 0.69 MPa compared to TPU at $0.16 \pm$ 0.00 MPa and LW-TPU at 0.23 ± 0.05 MPa. It also had the highest stress at 15% strain of 4.02 ± 0.69 kN. Thus, LW-PLA exhibited superior compressive properties, with the ICO-H structure achieving the highest strength. The resultant 3D printed flat foot pads with various lattice designs and foaming materials can aid individuals with metatarsalgia due to poor weight distribution, providing specialized metatarsal support through additive manufacturing.

ACKNOWLEDGMENT

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Analysis of Fully 3D-printed Shoes Prepared by Microfoaming Filament Based on Additive Manufacturing

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Microfoaming material contains a chemical foaming agent that expands into a foam structure when heated. This foam-like structure offers key advantages, including low density for lightweight properties, excellent impact absorption, and superior mechanical performance, making it ideal for footwear requiring cushioning and shock absorption. This study aims to develop fully 3D printed shoes using microfoaming materials, and examine plantar pressure characteristics to determine optimal materials and manufacturing conditions. The shoe samples were produced using a dual-nozzle FDM 3D printer (Ultimaker S5 Pro Bundle, Ultimaker B.V., Netherlands), allowing customized and sustainable footwear production through diverse material combinations. The shoes were printed using thermoplastic polyurethane (TPU, Ultimaker B.V., Netherlands), lightweight TPU (LW-TPU, ColorFabb B.V., Netherlands), polylactic acid (PLA, Ultimaker B.V., Netherlands), and lightweight PLA(LW-PLA, ColorFabb B.V., Netherlands). The shoes and their supports used TPU/LW-PLA, LW-PLA/PLA, and LW-TPU/PLA combinations. First, each filament was analyzed using differential scanning calorimetry (DSC 25, TA instrument, USA) to confirm the foaming property. Second, the plantar pressure experiments were conducted on the 3D printed shoes using a plantar pressure analyzer (Materialise, Belgium) and a foot scanner (Alchemaker, US). As results of DSC, the glass transition and crystallization temperatures of LW-TPU and LW-PLA were consistent with the characteristics of standard TPU and PLA. On the other hand, the dual melting temperatures were observed, which indicated the porous polymer properties of LW-TPU and LW-PLA. The plantar pressure results showed that wearing the 3D printed shoes indicated that shoes reduced peak pressure in the area compared to the barefoot condition, effectively distributing force. Shoes LW-PLA was too hard to wear. In particular, compared to barefoot, there was a decreasing trend in the zones located in the metatarsal and heel areas. The contact area showed an increasing trend in all zones when wearing 3D printed shoes compared to barefoot, indicating that the load could be distributed. In particular, Shoes LW-TPU exhibited a larger contact area. Therefore, wearing fully 3D printed shoes can reduce peak pressure, enhancing comfort and support.

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An Expandable Antigelation Spinning Method of Preparing Liquid Crystal Elastomer Fibers with High Orientation, Reliable Actuation for Biomimetic Devices

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Liquid crystal elastomer fibers (LCEFs) have been noticed and consistently reported as a reliable driving smart material for smart fabrics, smart wound dressings, and energy conversion materials. Gelation process is an evident negative factor for the preparation of LCEFs. To address these challenges, an antigelation spinning method was reported and used to prepare LCEFs for this paper. A bifunctional small molecule (DMS) was used to both regulate the intermolecular force for the antigelation of high concentration spinning solutions (HCSS) and enhance the mechanical strength for LCEFs using RM257 liquid crystal and monomers with sulfhydryl as raw materials. The order parameter of liquid crystal unit inside LCEF was up to 0.63 using HCSS with high concentration as high as 60 wt% and DMS ratio of 5 wt%. Also, the obtained filament showed an actuation strain of 15% after lifting a weight 1,000 times its own weight for biomimetic devices. More importantly, this antigelation spinning method possessed a great expandable capability (except DMS, alkenes such as acrylic acid and vinyl ethers can be used for the preparation of LCEFs).

Texture Exploration and Design Practice of Traditional Tie-Dyeing Handicraft

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As a traditional handicraft with thousands of years of history, tie-dye art, enriching people's spiritual and cultural life, has formed rich and diverse artistic expressions with distinct regional characteristics in the world. Continual research and innovative practices are the important ways to inherit and promote this valuable cultural heritage. In this research, tie-dye craftsmanship was studied as the core of modern fashion design language and was incorporated with the historical and cultural perspective. Through in-depth analysis of design cases of brands such as Yuima Nakazato and Juana Martin, it explores the application of tie-dyeing techniques in contemporary women's clothing, and conducts in-depth research on the specific design elements of tie-dyeing techniques in modern women's clothing. The results indicate that different tying techniques provide the way to create three-dimensional textures with distinct stylistic characteristic and give the way to cleverly combine multi-element textures to enhance the possibilities of their application in clothing fabrics. The relevant research and practice results are presented in the form of a series of designed clothing styles, which enrich the application scenarios of traditional tie-dyeing craftsmanship in the fashion field and provide new ideas and methods for modern women's clothing design.

A Non-enzymatic Flexible and Wearable Sensor Based on Thermal Transfer Printing Technology for Continuous Glucose Detection in Sweat

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This paper presents a non-enzymatic, flexible, and wearable glucose sensor for sweat detection, made using thermal transfer printing. The novel sensor operates in an alkaline environment facilitated by a NaOH/Nafion/PEO blend film and uses CuO and CaTiO3 for accurate, stable glucose monitoring. This research contributes to the development of flexible and wearable sensors for non-invasive sweat diagnostics, enabling continuous glucose monitoring for various applications in healthcare and wellness.

INTRODUCTION

This paper presents a non-enzymatic flexible and wearable glucose sensor for continuous sweat monitoring. The sensor utilizes a CuO-CaTiO3 composite and a NaOH/Nafion/PEO blend film to create an alkaline environment for CuO electrochemical reactions. A novel thermal transfer printing method is introduced for cost-effective, small-batch production of flexible sensors. The proposed sensor demonstrates high sensitivity, good selectivity, biocompatibility, stability, reproducibility, and flexibility for sweat glucose detection in wearable applications.

METHODS

A flexible, wearable glucose sensor was created using CuO/CaTiO₃/Nafion-modified electrodes and a NaOH/Nafion/PEO blend film that adjusts pH and enhances conductivity for direct sweat glucose detection without pretreatment. Fabricated via thermal transfer on PI copper film, the thin sensor can be attached to the body. It comprises modified working, counter, and reference electrodes, enabling non-invasive real-time glucose monitoring.

RESULTS

The as-prepared flexible and wearable senor exhibits superior performance toward glucose monitoring. A series of excellent properties displayed under the electrochemical evaluation, such as high sensitivity of $487.3\mu A$ mM-1 cm-2, while the limit of detection (LOD) is estimated about $0.75\mu M$, wide dynamic linear range from $0.1\mu M$ to $2\mu M$, and fast response time of less than 0.1 second. What's more, the proposed sensor also exhibited excellent selectivity, reproducibility, and flexibility, as well as good stability with about 88% of its initial activity after five weeks' storage. In addition, the sensor can be successfully applied for the detection of glucose concentration in human sweat in real samples.

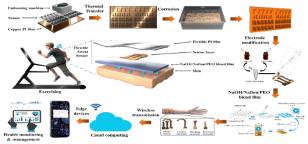


Figure 1. The schematic diagram of proposed wearable and flexible glucose sensor.

DISCUSSION AND CONCLUSION

In summary, the researchers have successfully developed a flexible and wearable electrochemical non-enzymatic sensor based on CaTiO3/CuO. The sensor exhibits excellent performance for glucose monitoring, including high sensitivity, wide dynamic range, fast response, good selectivity, reproducibility, flexibility, and stability. The integration of CuO and CaTiO3 materials, along with the thermal transfer printing technology, provides a promising solution for accurate and stable glucose monitoring in human sweat.

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Highly Conductive Graphene Fiber Textile for Electromagnetic Interference Shielding

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Textiles with excellent electromagnetic interference (EMI) shielding properties are highly desirable to prevent interference between electronic devices and to ensure their stable service in this era of serious electromagnetic radiation. However, the prevalent method to prepare EMI shielding textiles focused on decorating conductive nanomaterials onto insulative textile, limiting the performance of textiles. Here, we directly weave highly conductive graphene fiber (GF) tows to obtain a GF textile with high EMI shielding performance. The electrical conductivity of GFs is improved by the restored conjugate structure and optimized crystallinity through efficient thermal annealing. An X-band EMI shielding effectiveness (SE) for GF textile of more than 90 dB is achieved owing to the high electrical conductivity of 8.5×10⁵ S m⁻¹ of GF. Overlapping two layers of textile weaved by GF yields an SE of more than 120 dB. Moreover, the woven GF textiles exhibit excellent durability of bending and pressing. Combined with the outstanding EMI shielding performance, the GF textiles show great potential for applications in wearable devices, communication, defense, and the Internet of Things.

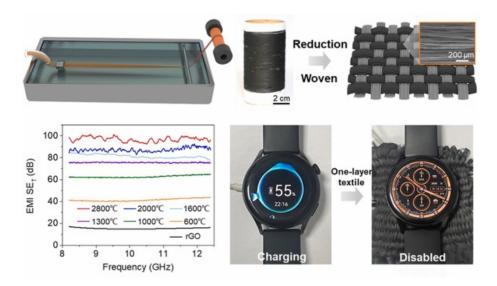


Figure 1. Preparation, electromagnetic interference shielding performances, practical applications of grapheme fiber textiles.

Water-responsive Properties of Mushroom-derived Pulps

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This study investigates the water-responsive properties of mushroom-derived pulps and their potential applications. Upon exposure to moisture changes in the environment, mushroom pulps swell and deswell, leading to physical entanglements of mushroom pulps, thereby forming various 3-dimensional shapes. The moisture-induced swelling properties of mushroom pulps were confirmed through Atomic Force Microscopy (AFM) and Dynamic Vapor Sorption (DVS) analysis under controlled relative humidity (RH) conditions. When assembled in a larger quantity, the mushroom pulps form paper-like materials that show reversible and repeatable water-responsive adhesion, opening up possibilities for the use of mushroom pulps in advanced adhesives and sustainable engineering.

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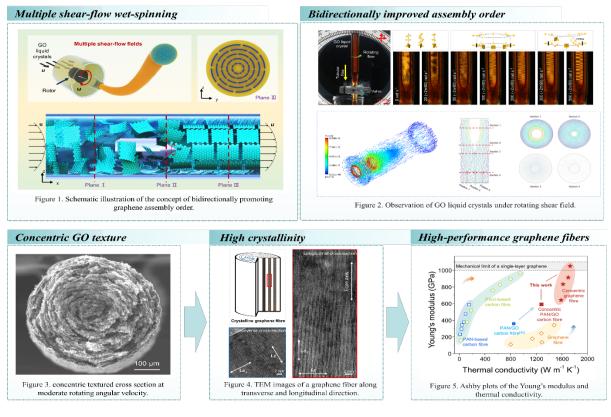
Ultrastiff and Highly Thermally Conductive Graphene Fibers

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Graphene fibers assembled from 2D nanosheets are new and impressing types of fiber materials. Previous works have highlighted the importance of improving the axial alignment of graphene sheets to enhance the mechanical and transport properties of graphene fibers, analogy to aligning linear chains in 1D polymer fibers. Here, we report a multiple shear-flow assisted wet-spinning to bidirectionally promote the assembly order of graphene fibers, which brings significant improvement in both ultra-high modulus (901 GPa) and thermal conductivity (1660 W m⁻¹ K⁻¹).



CONCLUSIONS

- ◆ Multiple shear-flow assisted wet-spinning was reported to bidirectionally promote the assembly order of graphene fibers.
- ◆ Concentric graphene fibers exhibited significant improvements in assembly order, density, and crystalline size. The thermal conductivity of graphene fibers reaches 1660 W/mK and the modulus was as high as 901 GPa.
- ◆ Concentric model can be applied as a template to high thermal conductivity and high modulus polyacrylonitrile (PAN)/graphene composite carbon fibers. The modulus of this composite carbon fiber reached 663 GPa and the thermal conductivity reached 1254 W/mK.

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"Bidirectionally promoting assembly order for ultrastiff and highly thermally conductive graphene fibers." *Nat. Commun.*, 15, 2024: 409.

Microbial Colour Using Textile Fibre Waste

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The textile industry significantly contributes to pollution with synthetic dyes, chemicals, and non-renewable resources. The dyes generate toxic byproducts and contribute to health problems. The exploration of sustainable alternatives, including microbial pigments such as prodigiosin, focuses on their vibrant coloration, antimicrobial properties, and potential applications in textiles, food, and pharmaceuticals. This research investigates the sustainable utilization of microbial pigments, particularly prodigiosin from Serratia marcescens, for dyeing textile fibre waste (silk, cotton, wool) converted into fine particles. The study addresses the environmental challenges posed by synthetic dyes and organic solvent-based pigment extraction by proposing a solvent-free method where fibre particles serve as both pigment adsorbents and nutrient substrates for microbial growth. Key findings demonstrate that introducing silk, cotton, or wool particles into microbial culture media at the end of fermentation enables efficient pigment absorption, yielding brightly coloured particles with excellent wash and light fastness. Notably, silk particles exhibited superior dye uptake due to their proteinaceous structure, while early introduction of particles hindered microbial growth, suggesting optimal timing is critical. Solid-state fermentation (SSF) and submerged fermentation (SmF) were explored, with fibre particles enhancing pigment yield in SSF by providing a high-surface-area, nutrient-rich substrate. Particle size analysis confirmed uniform dye distribution (e.g., silk particles: $Dv(50\%) = 6.70 \mu m$), ensuring stability for textile applications. The research aligns with circular economy principles by valorising textile waste, eliminating hazardous solvents, and offering scalable, eco-friendly dyeing alternatives. Future work will optimize fermentation parameters, characterize pigment-fibre interactions, and explore applications of dyed particles in functional textiles. This approach not only reduces the textile industry's environmental footprint but also pioneers a closed-loop system for waste-toresource conversion.

ACKNOWLEDGMENT

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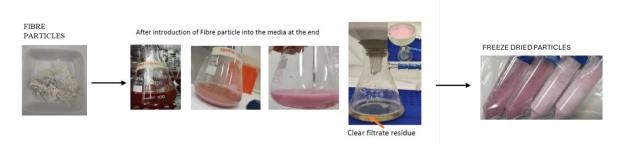


Figure 1. Schematic representation of dyeing of fibre particles.

Hydration-driven Fibril Aggregation in Mushroom-derived Chitin Fibers

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This study investigated the role of water-induced chitinous fibril aggregation in the self-repairability of mushroom-derived fibers. Fibers composed of long, thin chitinous fibrils demonstrated the ability to re-adhere, likely due to fibrillar reaggregation upon water exposure. In contrast, fibers with particulate matrix morphologies lacked both swellability and self-repairability. Neutron scattering imaging, combined with XRD, SEM, and FTIR analyses, revealed that distinct chitin morphologies govern water distribution within fibrillar networks. By systematically correlating processing-induced structural variations with macroscopic repair efficiency, this research provided fundamental insights into bio-sourced material design, while addressing challenges in scalability and environmental sustainability.

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Surface Wettability Modulation of Fibrous Membranes for Enhanced Performance via PDA-assisted Modification

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Fibrous membranes with hierarchical architectures, good mechanical properties, and ease of functionalization have garnered significant attention in different application fields. Tailoring surface wettability via interfacial engineering is imperative to improving performance on apparel, separation, and other application fields. Advancing stimuli-responsive architectures enables adaptive performance in dynamic environments, addressing industrial demands for sustainable purification systems. In this study, surfaces with tunable wettability were constructed by coating fibrous membranes with polydopamine (PDA) and functional polymers. By coating one side of hydrophobic HDPE fibrous membranes with PDA and a superhydrophilic polyelectrolyte, the Janus HDPE fibrous membrane exhibited distinct hydrophobicity/hydrophilicity. It demonstrated an excellent water transmission rate (577.61 \pm 72.66 g m⁻² h⁻¹), water vapor transmission rate (131.62 \pm 24.34 g m⁻² h⁻¹), and gas permeability $(17,496 \pm 235 \text{ m}^3 \text{ m}^{-2} \text{ h}^{-1} \text{ bar}^{-1})$, which are much better than those commercial membranes (Tyvek with water transmission rate 518.93 g m⁻² h⁻¹, water vapor transmission rate 53.09 g m⁻² h⁻¹, and gas permeability 2,871 m3 m⁻² h⁻¹ bar⁻¹). Further, the Janus HDPE fibrous membranes kept outstanding mechanical strength (17.00 \pm 4.26 MPa of tensile strength, 45.49 \pm 8.75% of strain at break), and exhibited an asymmetric wettability on each side, which was demonstrated by the separation experiments with various oil-water mixtures. Furthermore, surface with under-liquid amphiphobicity and stimuli-responsiveness can also be fabricated with this strategy by anchoring block polymers onto a PDA coated filter paper (FP). Compared with original FP, the modified surface exhibited a water contact angle (CA) of 115.5° in air, and the water CA in oil and oil CA in water were 157.5° and 151.2°, respectively. In addition, the zeta potential, WCAs, UOWCAs decreased and UWOCAs increased with pH increases. This work not only offered the potential of fibrous membranes for versatile applications in oilwater separation and apparel applications but also offered a scalable and environmentally friendly approach to addressing challenges in liquid-iquid separation systems and other industrial applications.

Directional Liquid Transport Textiles via Embroidery: Softness and Stretchability Retained

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Fabrics with directional liquid transport properties have received much attention in scientific and industrial communities in recent years and various methods has been introduced to develop such kind of moisture management textiles. However, the route of embroidery (which is a scalable method of creating a variety of new fashion and functional applications due to the unique opportunity of creating three-dimensional lightweight structures and laying threads on the base material in all directions) has not been investigated for moisture management fabrics. We aim to fill this gap by studying embroidery designs and influencing factors. The work focused on creating embroidery patterns to improved moisture management properties of fabrics endowed with enhanced one-way water transport capacity thorough embroidery and its attributes, including substrate, interlining fabrics, threads, structure, and finishing treatments. The developed fabrics showed improved accumulative one-way transport properties while maintaining the desired feel, softness, and stretchability chiefly desired for wearable applications. The work offers a scalable and promising approach of developing moisture management functional embroidery fabrics for a variety of potential applications in sportswear, medical textiles, and industrial textiles.

Scalable Embroidered Textile Pressure Sensors for Smart Wearables

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This work focuses on the development of programmable and scalable textile-based pressure sensors using machine embroidery, aiming to address key challenges in wearable sensor design, including fabrication scalability, seamless integration, and functional customization. Conformable and breathable textiles offer an ideal platform for wearable sensing; however, practical implementation has been limited by complex manufacturing processes and rigid components [1]. In this study, we present a cost-effective and fully textile approach to fabricating pressure sensors using commercial embroidery techniques, allowing for easy incorporation into garments and smart wearable systems [2].

Two embroidered sensor configurations were developed. The first was a single-layer satin block stitched with conductive yarn, which demonstrated high piezoresistive sensitivity, a rapid response time of 35 ms, fast recovery at 16 ms, and long-term durability over 5,000 press—release cycles. This design proved effective in monitoring biomechanical movements such as plantar pressure and muscle contractions, highlighting its utility for personalized health and fitness tracking.

The second design featured a double-layer structure incorporating a conductive embroidered path and two parallel spacer threads anchored beneath a satin block. This configuration supported scalable integration with minimal wiring and was demonstrated through a 3×3 sensor array. When coupled with a convolutional neural network (CNN) machine learning model, the system successfully recognized handwritten digits (0–9) with 98.5% accuracy, indicating strong potential for applications in user authentication, gesture recognition, and soft-interface passcode entry.

Together, these results showcase the versatility of machine embroidery as a platform for creating high-performance, customizable, and aesthetically compatible pressure sensors for smart textiles. The ability to tailor sensor design, response characteristics, and integration strategies directly into fabric structures opens new possibilities for wearable technologies across health monitoring, human–machine interaction, and security-focused applications.

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Rigid-Flexible Coupling Poly(phenylene sulfide) Fiber Membrane: A Highly Stable Chemical and Thermal Material for Energy and Environmental Applications

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The poly(phenylene sulfide) (PPS) fiber membrane is composed of interwoven fibers, with a three-dimensional porous structure. The three-dimensional porous structure makes PPS fiber membranes have high porosity and large specific surface area, which stands out in the field of membrane separation. PPS fiber is a high-performance fiber with excellent chemical and thermal stability. These characteristics allow PPS fiber membranes to be used in harsh membrane separation environments, such as strong acids, alkalis, and high temperatures. However, the corrosion resistance and high-temperature stability of PPS fibers also make the preparation of PPS fibers and their membranes challenging. In this paper, the preparation method is summarized, including two direct methods to make a PPS fiber membrane (melt-blown spinning and melt electrostatic spinning), and two indirect methods (wet papermaking and weaving). Additionally, the applications of PPS fiber membranes are summarized in detail in energy and environmental fields, such as lithium-ion batteries, alkaline water electrolysis, air filtrations, chemical catalyst substrates, and oil-water separations. This paper provides an insightful understanding of PPS fiber membrane preparation methods and the interconnections between these preparation methods and specific applications, thus laying a solid foundation for further advancing the range of PPS fiber membrane applications.

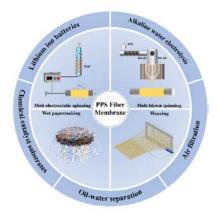


Figure 1. Preparation methods and application of PPS fiber membrane.

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Fiber Separator Materials for Metal-Ion Batteries

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In energy storage systems, metal-ion batteries (lithium-, sodium-, and zinc-ion batteries) have attracted wide attention due to their high energy density and excellent cycle stability. However, commercial separators for these batteries face critical challenges, including inadequate thermal stability, dendrite penetration risks, and interfacial side reactions. Current polyolefin separators often exhibit low mechanical strength and non-optimized pore architecture, failing to address safety issues, such as thermal shrinkage from internal temperature spikes, mechanical breakdown under external impacts, and uncontrolled dendrite growth. Additionally, poor electrolyte-separator compatibility exacerbates side reactions (e.g., hydrogen evolution and metal corrosion), severely limiting cycle life. Fiber-based separators offer a promising solution by effectively facilitating the formation of a stable solid electrolyte interphase (SEI), suppressing dendrite propagation, and extending battery lifespan. Therefore, developing high-safety fiber separators with dendrite resistance and thermal tolerance is critical for advancing battery safety. In this work, we focus on design strategies for functional fiber separators aiming to achieve synergistic properties including high-temperature stability, dendrite suppression capability, and enhanced ionic conductivity. We systematically investigate their applications in energy storage and provide a comprehensive analysis of future prospects, technical challenges, and sustainable recycling strategies for next-generation battery systems.



Figure 1. Performance requirements for high-safety metal-ion battery separators.

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A Numerical Model of Multimode Temperature-adaptive Thermoregulatory Fabrics

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This study develops a numerical simulation model to investigate heat and mass transfer in temperature-adaptive thermoregulatory fabrics with temperature-responsive material properties. The model incorporates multi-physics processes, including natural convection between skin and fabric, evaporative cooling from sweat diffusion through fabric layers, dynamic radiative absorptivity of the fabric, thermal conductivity variations in fibers with temperature, and density changes in phase change material (PCM) capsules during phase transitions. Additionally, the synergistic effects of fabric porosity and thickness on heat and mass transfer are systematically analyzed. The model is validated against experimental data, demonstrating strong agreement.

Key applications of the model include: Optimizing PCM selection by systematically evaluating phase change temperature, latent heat capacity, and density variability during transitions; quantifying the influence of radiative absorptivity on radiative heat flux to guide material design; determining the dynamics of vapor diffusion driven by thermal convection and their interaction with fabric permeability; evaluating adaptive performance under diverse environmental conditions to align thermoregulatory behavior with human comfort requirements.

This work establishes a predictive framework for designing next-generation smart textiles through targeted optimization of composition, permeability, and radiative properties, advancing applications in adaptive clothing and personalized thermal management systems.

Highly Thermally-conductive and Structurally Interfacial Stable Graphene Fiber/Carbide Composite Fiber Applied for Thermal Protection System

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The escalating demands for thermal protection materials (TPMs) in hypersonic vehicles, re-entry spacecraft, and rocket propulsion necessitate materials that achieve exceptional ablation resistance under extreme thermomechanical-oxidative environments. In conventional TPMs, carbon-based fiber makes a significant difference to the ablation resistance performance and structural stability. However, their intrinsic limitations have hindered the further development of the TPMs. On one hand, their moderate thermal conductivity (k) results in severe localized heat accumulation, inducing an inevitable oxidative degradation and significantly shortening the lifespan of TPMs. On the other hand, their inert surface always exhibits an interfacial mismatch with functional coatings, especially when they undergo an extreme temperature fluctuation, leading to a coating spallation and further compromising ablation performance.

Graphene fiber (GF) has garnered significant attention due to its ultrahigh k. Additionally, the wrinkled surface morphology and exceptional flexibility of GF have been demonstrated to enhance interfacial stability and enable precise structural engineering in composite materials, positioning them as superior candidates for TPM. But in spite of these developments, no reports have included GF in TPMs, mostly due to the difficulty in obtaining high-quality GF in bulk. Recently, our group successfully realized the large-scale industrial fabrication of GF filaments with a high k of 1204 W/m·K. It puts a pavement for the application of GF-based composites under extreme high-temperature oxygen-containing environments.

Herein, we propose a GF/titanium carbide (TiC) composite fiber (GTF) with well-defined core/shell structure via molten salt synthesis, leveraging the synergistic merits of GF's ultrahigh thermal conductivity and TiC's oxidation barrier functionality. The wrinkled surface topology and highly graphitized lattice of GF are strategically exploited to promote TiC growth and foster a strong full-scale interlocking interface. The optimized composite fiber exhibits an exceptional k of 916 W/m·K. The woven consisted with GTF exhibited excellent ablation resistance ability. During ablation testing at 2200°C, the mass ablation rate was as low as 0.3 mg/s after 210 seconds exposure, outperforming conventional carbon-based composites. It highlights the potential of GF/ceramic composite materials as next-generation thermal protection systems for hypersonic vehicles and re-entry spacecraft, meeting simultaneous demands for extreme heat flux management and structural integrity.

A Smart Soft Actuator Based on Graphene Aerogel Fiber and Liquid Crystal Elastomer

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Soft actuators hold great potential for next-generation soft robotics, smart clothing, and implantable medical reinforcements, among other applications. Moreover, compared to traditional actuating modes, near-infrared (NIR) actuating has emerged as a research hotspot in smart materials due to its advantages, including non-contact operation, rapid response, precise control, biocompatibility, and environmental adaptability. However, constructing a soft actuator that optimally combines actuation parameters, including strain, stress, and high mechanical strength, remains a significant challenge in practical applications. Herein, a highly porous graphene aerogel fiber (GAF), through a synergistic combination of 3D printing, the hydrothermal method, and directional freeze-drying, was developed. Simultaneously, a liquid crystal elastomer (LCE), capable of undergoing significant and reversible deformation under photothermal stimulation, was synthesized via the Michael addition reaction, serving as the filling material for the fabrication of smart fibers (LCE-GAF). This approach enabled the formation of a continuous graphene structure with oriented alignment and high porosity, providing ample space and favorable binding sites. Notably, as an exceptional photothermal converter, graphene enables the composite smart fiber to rapidly heat up under NIR laser irradiation ($\lambda = 808$ nm), which is crucial for achieving large actuation. Upon alignment of LCE-GAF via stretching, the resulting smart fiber demonstrates remarkable properties, including enhanced mechanical strength (increasing from 13.6 kPa to 1.48 MPa) and improved actuation performance. A single LCE-GAF fiber (about 1.5 mg) exhibited 667-fold mass lifting capacity, successfully lifting a 1 g weight due to synergistic enhancement of mechanical strength and large actuation. Notably, the photothermal mechanism enables rapid actuation under NIR laser on-off switching, achieving up to 40% contraction and demonstrating its suitability for a soft actuator. This study presents a soft actuating material with rapid response and easily controllable actuation, offering a promising smart fiber that could benefit the development of intelligent wearable devices, artificial muscle, and other applications.

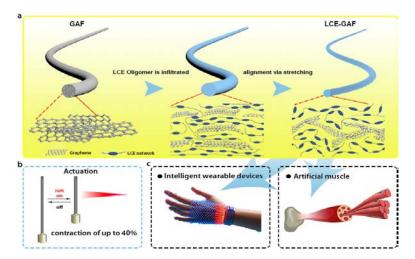


Figure 1. (a) Evolution process of the smart fiber; (b) photothermal actuation of LCE-GAF; (c) future applications of the smart fiber.

Development and Evaluation of Multilayered Textile Systems for Enhanced Moisture Transport

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There is a growing demand for high-performance sportswear that quickly absorbs and dries perspiration produced by the body in harsh conditions. In this regard, this study focused on developing multilayered textile systems for enhanced moisture transport. The proposed trilayered structure includes a hydrophobic polyester (PET) tricot layer, a weakly hydrophobic polyurethane/poly(ethylene glycol) diacrylate (PU/PEGDA) nanofibrous membrane layer, and a PET woven layer with a hydrophilic surface modification. The moisture transport properties of the multilayered textile systems were examined and compared against commercially available sportswear materials, including a PET knit consisting of fibers with channeled cross-section structure and a PET mesh, through evaluation at both the textile and garment levels. In the initial phase, where physical analysis of textiles was conducted, we assessed the moisture transport properties such as vertical wicking, drying rate, liquid moisture management, and evaporative resistance using the hot plate method for the three samples. Following this, the nanofibrous membrane, which is the middle layer of the multilayered textile system, was produced using horizontal electrospinning with a multi-nozzle and a roll-to-roll collector; experimental garments were fabricated from each sample. At the garment level, we evaluated evaporative resistance of the experimental garments using a thermal manikin. Finally, wear trials were conducted with human subjects under hot, humid conditions to examine sweat evaporation rate, garment weight change, skin temperature and humidity inside the garment, and subjective comfort. The multilayered textile systems exhibited excellent moisture-wicking performance with superior drying rate and liquid moisture management properties compared to the control samples. Large-area nanofibrous membranes were successfully produced using a horizontal electrospinning process with a multinozzle and a roll-to-roll collector and integrated into garments. Measurements of evaporative resistance using the hot plate method and thermal manikin revealed substantial differences, implying the importance of evaluating evaporative resistance at both textile samples and complete garments. Wear trials indicated that the garment made of multilayered textile systems considerably reduced back temperature, confirming its moisture-wicking efficacy at the garment level. This study provides foundational information for assessing the moisture comfort of moisturewicking textiles at both textile and garment levels, as well as guidance for future sportswear development.

Environmental Impacts of Viscose Rayon and Lyocell Production

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INTRODUCTION

Industrial processes depend on raw materials and non-renewable energy, causing environmental harm. Regenerated cellulosic fibers, such as viscose rayon and lyocell, offer alternatives to natural fibers, but have trade-offs. Both exhibit similar traits: viscose rayon consumes more water and produces non-recyclable waste, while lyocell requires high energy due to NMMO use. This study compared their environmental impacts during production.

RESEARCH METHOD

Following ISO 14040:2006, this study evaluated the environmental impacts of producing 1 t of viscose rayon and lyocell fiber. Inputs and outputs were assessed across six impact categories: Global Warming Potential (GWP), Eutrophication (ET), Acidification (AP), Abiotic Depletion Potential (ADP), Water Use (WU), and Primary Energy Demand (PED), using data from the past decade.

RESULT AND DISCUSSION

To produce 1 t of viscose rayon fiber, 1.04 t of pulp, 0.48 t NaOH, 60.02 t water, 129.37 t CS₂, 840 kWh electricity, 0.78 t H₂SO₄, 1.91 t ZnSO₃, 7.03 t steam, and 2.5 kg oil were required, yielding 1 t fiber, 61 t wastewater, 0.2 t steam, 18.93 t CS₂(g), and 5.02 t H₂S(g). For lyocell, 1.17 t pulp, 32.46 t water, 4.02 t NMMO, 1800 kWh electricity, 0.135 t H₂SO₄, 10 t steam, and 3 kg oil were used, with outputs of 1 t fiber, 27.34 t wastewater, and 0.5 t steam.

Impacts were calculated with the inputs and outputs. For viscose rayon, impacts included 3065.46 kg CO₂ eq (GWP), 2454.26 CTUe (ET), 13.53 kg Sb eq (ADP), 52,509.87 kg (WU), 381.18 kg SO₂ eq (AP), and 125,484.24 MJ (PED). For lyocell, the impacts included 8443.55 kg CO₂ eq, 2391.40 CTUe, 2050.02 kg Sb eq, 44,218.38 kg, 62.99 kg SO₂ eq, and 304,815.40 MJ. Lyocell showed lower acidification and eutrophication due to its closed-loop process and reduced emissions. However, its energy use was high because of NMMO recovery. Both fibers had trade-offs, so the selection depended on prioritized impact.

CONCLUSION

Neither fiber was environmentally superior in all categories. Lyocell performed better in acidification and water impacts, while viscose rayon had lower energy demand and global warming potential. Further studies should consider the use and disposal phases, where laundering, wearing, and degradation vary by fiber type.

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Molecular Dynamics Simulations of PA6T/6I Copolymer Properties: A Comparison of Machine Learning and Traditional Force Fields

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This study employed molecular dynamics (MD) simulations based on a machine learning force field (MACE-OFF) and a conventional force field (PCFF) to predict the properties of poly(terephthalamide-co-hexamethylene isophthalamide) (PA6T-6I) copolymers, in comparison with the experimental data. The aim was to evaluate the reliability of these two approaches in predicting the thermal properties of PA6T/6I copolymers.

We conducted force field calibration for the PA6T/6I homopolymer. The results demonstrated that the MACE-OFF, based on the M06 functional, exhibited comparable accuracy in modeling π - π interactions and hydrogen bonding. The dynamic MD simulation results indicated that the MACE-OFF method provided more stable thermal properties, such as the simulation of the glass transition temperature (Tg) and density for copolymer systems with varying PA6T content, which are in good agreement with experimental data. Additionally, a systematic analysis of factors, such as mean squared displacement, number of hydrogen bonds, and free volume in the PA6T/6I copolymer, was conducted to elucidate the mechanisms behind the temperature-dependent variations in Tg and density observed during the simulation process.

This study demonstrated that the MACE-OFF force field exhibited higher accuracy in simulating the PA6T/6I copolymer system, providing a reliable approach for predicting the properties of the PA6T/6I system at the molecular level.

A Pro-angiogenic Wound Dressing Embedded with Natural Spider Silk Protein

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Angiogenesis plays a key role in wound healing by supplying nutrients and oxygen to the tissue. Current clinical strategies, however, face persistent challenges in addressing wounds characterized by compromised vascular networks. In this work, by incorporating natural spider silk proteins (SSP) with poly(L-lactic acid) (PLLA) nanofiber, we developed a pro-angiogenic wound dressing. The addition of SSP reduces fiber diameter, creating a hierarchical structure that promotes cellular adhesion and spreading. Moreover, the combined effects of these biophysical and SSP-derived biochemical cues synergistically enhanced vascular regeneration, resulting in significant improvements in three key angiogenic parameters compared to pure PLLA controls: a 16.3% increase in blood vessel count, a 118.6% increase in vascular branching, and a 32.8% increase in total vessel length. In vivo experiments showed a 29% improvement in the wound healing rate compared to the control group. This dual-mechanism strategy, synergizing structural biomimicry with bioactive cues, establishes a multifunctional platform to address complex wound healing challenges, particularly in ischemic and chronic wounds.

ACKNOWLEDGMENT

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Influence of Washing and Drying Conditions on the Surface Chemistry and Clothing Pressure of Smart Textiles

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Smart textiles, which are textile-integrated conductive materials, serve as key components in wearable devices and garments for monitoring and transmitting physiological signals. For their practical application in daily wear, it is essential not only to ensure electrical durability under repeated washing but also to account for structural changes in the fabric that may affect the reliability of physiological signal acquisition. This study investigated the effects of washing and drying conditions on surface chemical changes and clothing pressure variations in silvercoated knitted smart fabrics, aiming to understand how care processes influence functional performance and wear comfort.

A commercial silver-coated nylon knit fabric was subjected to five washing cycles under varied detergent type (alkaline, neutral, and none) and temperature(15°C, 40°C, 60°C), followed by air or machine drying. Surface morphology was observed using FE-SEM, and chemical changes were analyzed through X-ray Photoelectron Spectroscopy(XPS), and clothing pressure was simulated using CLO 3D software with physical fabric data.

XPS revealed that washing led to degradation of the silicone layer protecting the silver coating, exposing silver to oxidation. Neutral detergents resulted in the greatest silver loss due to deeper micellar penetration and hydrogen bonding interactions, while alkaline detergents showed moderate degradation. Despite some changes, overall hand value remained within acceptable limits. Clothing pressure, simulated through 3D fitting, increased significantly—up to 147% in the chest area—under alkaline detergent and high-temperature conditions, due to fabric shrinkage and reduced elasticity. This increased tightness can hinder stable skin contact of sensing elements, potentially affecting signal accuracy.

These results highlight that washing conditions critically influence the structural and chemical integrity of smart textiles. Damage to conductive layers and dimensional changes can alter the fabric's fit, which in turn affects its functional performance. Therefore, washing guidelines for wearable smart fabrics should consider not only electrical stability but also material responses, such as surface degradation and pressure distribution.

Predicting Softness and Drapability via CNN

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INTRODUCTION

In recent years, online fashion platforms have become increasingly active, and consumers are more frequently purchasing textile materials through indirect visual experiences. However, in the online environment, emotional characteristics of textiles, such as softness and drapability, are not accurately conveyed. This study aims to develop a model using artificial intelligence technology to classify and predict these emotional characteristics, with the goal of intuitively delivering such information to consumers.

RESEARCH METHOD

Clustering analysis was conducted based on subjective evaluations of the softness and drapability of fabrics, and correlations between the visual characteristics of each cluster and their emotional properties were derived. High-resolution images of textiles were captured using the Vizoo 3D scanner and the Fabric Scan Device. A Convolutional Neural Network (CNN) was applied for image analysis, allowing automatic learning of visual patterns, and enabling classification and prediction of emotional characteristics.

RESULT AND DISCUSSION

Image analysis

In the comparison between the Vizoo 3D scanner and the Fabric Scan Device, the Fabric Scan Device, which provides front-light-based imaging conditions, was found to more clearly visualize tactile qualities. Subsequently, this device was used to capture samples for CNN model training.

CNN Learning

CNN training was designed to compare scratch learning and transfer learning, with transfer learning demonstrating more stable prediction performance. The trained model classified images based on subjective evaluations and predicted emotional levels for new images, enabling the identification of the most suitable image acquisition conditions for emotional characteristic prediction.

Similarity between the trained model and subjective evaluations

A comparison of the CNN model's predictions and the previously collected subjective evaluation values showed high correlation coefficients for both softness and drapability. This result indicates that the model's predictions align with the emotional characteristics perceived subjectively based on visual information.

CONCLUSION

The trained CNN model showed high correlation with subjective evaluations of softness and drapability based on image data, demonstrating its validity. Therefore, the proposed prediction model is expected to be utilized in online textile platforms to intuitively deliver emotional information and expand into various applications, such as personalized fabric recommendation systems, 3D virtual fitting, and digital textile content creation.

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Multi-interfacial Interaction Engineered Underwater Superelastic Covalent Organic Framework Aerogels for Photoinduced Uranium Extraction

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Uranium (U) extraction from seawater by novel porous materials, such as covalent organic frameworks (COFs), holds great promise for developing nuclear energy. Currently, most COFs deployed for U extraction from seawater are devoid of macro-continuity, thus hindering their practical application. Here, we report a facile method of constructing photosensitive COFs into a superelastic aerogel structure based on size rearrangement and multi-interfacial interaction engineering with bacterial cellulose nanofibers (BCNs). The resulting photosensitive COF aerogels (PCAs) exhibit a record-high AZO-3 loading (~90%), hierarchical porosity, high surface area (188.27 m²/g), and superior underwater stability and elasticity over 500 compressions. Eventually, the PCAs show excellent photoinduced U extraction performances with 838.70% improved U extraction capacity than in a dark condition, good recyclability, and superior adsorption selectivity (selectivity coefficient up to 26.99). The successful design of PCAs offers attractive perspectives on the development of next-generation adsorbents for U extraction from seawater. This work is also expected to inspire the design of other typical porous adsorbents into a macro-continuous matrix with improved mass transfer properties and stability.

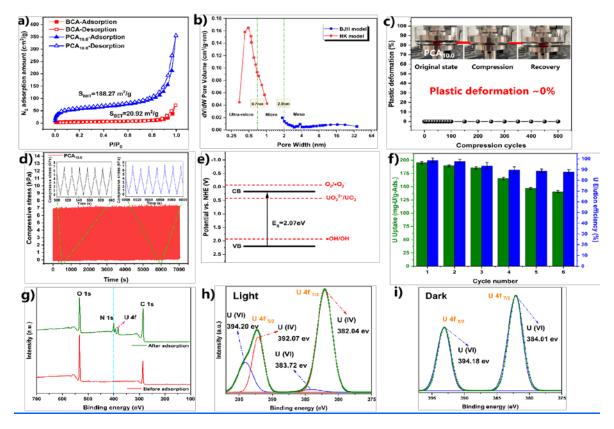


Figure 1. (a) N_2 sorption isotherms of BCA and $PCA_{10.0}$ at 77 K. (b) The pore size distribution of $PCA_{10.0}$ based on BJH and HK models. (c) Plastic deformation, and (d) σ -t curves, the compressive stress of $PCA_{10.0}$ during 500 compression cycles in water. (e) Schematic illustration of the mechanism of photocatalytic reduction of UO_2^{2+} to UO_2 by PCAs. (f) U extraction amount (U initial concentration = 10 ppm) and elution efficiency in 6 successive adsorption-desorption cycles under daylight irradiation. (g) XPS spectra of $PCA_{10.0}$ before and after uranium adsorption under light irradiation. (h-i) High resolution U 4f XPS spectra of $PCA_{10.0}$ after uranium adsorption under light irradiation and dark.

Quantitative Fabric Classification and Prediction Based on Drapability and Tactile Properties

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INTRODUCTION

As key affective characteristics of fabrics, drapability and tactile properties have a significant impact on wear comfort and product selection. However, the absence of clear, objective, and quantitative indicators for these sensory characteristics often leads to miscommunication between consumers and manufacturers, causing confusion in product selection. This study aims to address this issue by proposing an objective and quantitative classification system based on the drapability and tactile properties of fabrics.

MATERIALS AND METHODS

A total of 1,020 fabric samples were evaluated for drape coefficient and tactile properties. The collected data were analyzed using Fuzzy C-Means (FCM) clustering to group the fabrics. Additionally, expert subjective evaluations were conducted to validate the practical applicability of the proposed classification system. Furthermore, to predict the drapability and tactile properties groups based on mechanical properties, an artificial neural network (ANN) model was developed. The ANN was trained on the dataset of 777 samples and tested with an independent validation set of 243 samples to evaluate its prediction accuracy.

RESULTS AND DISCUSSION

The study found that the cluster classification quantitatively derived through Fuzzy C-Means (FCM) clustering for fabric drapability and tactile properties showed a significant correlation with the subjective evaluations of expert panels. The consistency between the objectively quantified classification system and the subjective judgments made in real-world settings was verified through inter-cluster difference testing and correlation analysis. Moreover, the developed ANN model successfully classified 202 out of the 243 validation samples, achieving a high prediction accuracy of 83.5%. These results demonstrate that affective properties such as drapability and tactile properties can be effectively predicted using only mechanical property data.

CONCLUSION

This study developed and validated an objective and quantitative classification system for fabrics based on drapability and tactile properties. Supported by FCM clustering and expert evaluations, the system has strong potential for practical application in fabric assessment. Additionally, the high accuracy of the ANN prediction model suggests that this approach could contribute effectively to enhancing communication clarity and improving user experience in online shopping and virtual try-on technologies by providing objective representations of fabric characteristics.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (RS-2025-00517052).

Comparison of Desorption and Re-adsorption of MIL-53(Fe)@cotton Fabric Under Various Dyes and Washing Conditions

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This study examines the use of washing methods with surfactants to remove pollutants from metal-organic framework (MOF)-based fabrics, specifically MIL-53(Fe)@cotton, while maintaining their structural stability and reusability. Cationic rhodamine B (RhB) and anionic methyl orange (MO) dyes were used to evaluate the absorption properties based on the electrostatic interactions with the MOF surface. Three washing methods, including launder-o-meter, mechanical agitation, and ultrasonic washing, as well as various surfactant types, were tested to analyze their influence on dye removal and re-adsorption behaviors of MIL-53(Fe)@cotton.

The results showed that the re-adsorption rate for RhB remained similar to the initial adsorption after washing, while MO exhibited a significant decrease in re-adsorption. This indicated that RhB primarily adsorbed on the external surface of MIL-53(Fe), allowing for easier detachment during washing, whereas MO either penetrated the MOF's inner structure or formed stronger chemical bonds with MIL-53(Fe). Additionally, the washing methods had varying effects on re-adsorption, with ultrasonic washing achieving the highest re-adsorption, followed by agitation washing and launder-o-meter. Regarding surfactant types, anionic surfactants proved most effective for RhB removal through strong electrostatic attraction, while nonionic and zwitterionic surfactants showed similar re-adsorption rates to the control group without surfactants. For MO, the efficiency of dye removal varied depending on the surfactant type, with anionic surfactants showing the best performance due to their ability to form micelles and enhance dispersion in the solution.

Overall, the study demonstrates that dye type, cleaning method, and surfactant properties all play significant roles in the removal and re-adsorption of pollutants from MOF-based fabrics. These findings contribute to the development of more efficient cleaning and management strategies for protective clothing and functional textiles, enhancing the practical application of MOF-based fabrics in real-world scenarios.

ACKNOWLEDGMENT

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (Grant Nos. RS-2024-00405333; RS-2025-00523094).

Blending Silkworm and Recombinant Spider Silk to Engineer Fibers with Customized Properties

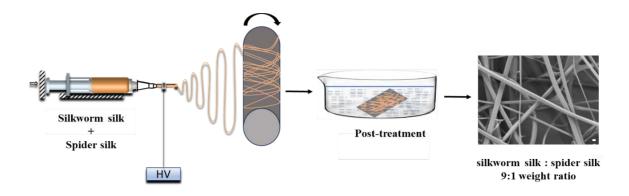
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Silkworm and spider silk are both promising protein-based fibers, each with unique advantages and limitations. Silkworm silk is readily available in large quantities through silkworm farming and is cost-effective. However, it requires degumming for extraction of the underlying silk proteins, leading to a broad molecular weight distribution and an uncontrollable sequence, which limits its ability to be functionalized or modified for specific properties. Recombinant production of spider silk proteins enables their production in sufficient quantity and purity, making them suitable for material development for biomedical and engineering applications. Spider silk is no longer just a natural fiber; spider silk is now used in applications such as tissue-engineered scaffolds, medical device coatings, and drug delivery systems. The ability to produce specific types of spider silk through recombinant technology has further expanded its potential uses.

Future work will aim to understand the mixing of the two proteins in solution and distribution of the silk varieties in the electrospun fibres to better understand their interactions. Also, focus will be given to electrospinning specialized spider silk variants with silkworm silk, incorporating specific functionalities into silkworm silk, and investigating potential applications for these hybrid fibres.



Mechanically and Conductively Robust Eutectogel Fiber Produced by Continuous Wet Spinning Enables Epidermal and Implantable Electrophysiological Monitoring

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In recent years, the collection and monitoring of human physiological signals have garnered increasing attention due to their wide-ranging applications in healthcare, human–machine interaction, sports, and other fields. However, the continuous fabrication of flexible gel fiber electrodes with high mechanical performance, high conductivity, and durability for extreme environments using a simple, efficient, and universal strategy remains challenging for physiological signal acquisition. Here, we have employed a strategy of solvent replacement and multi-level hydrogen bond enhancement to construct eutectogel fibers with continuous solid–liquid structure, achieving continuous production of fibers with high strength, high conductivity, and low-temperature resistance. In the fiber, PVA serves as the solid-state elastic phase, DES as the liquid ionic conductive phase, and CNF as the reinforcement phase. The resulting eutectogel fibers exhibit excellent tensile strength (37.3 MPa), good elongation (>700%), high electrical conductivity (0.543 S/m), and resistance to extreme dry and -60°C low-temperature environments. Furthermore, these eutectogel fibers demonstrate high sensitivity for monitoring joint movements and effectively detecting in vitro and in vivo signals, showcasing their potential for wearable strain sensors and monitoring physiological signals.

Eco-friendly Skin-inspired Micro-Nano Structured Cellulose Composite Fibers for Highly Efficient Daytime Radiative Cooling

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Passive radiative cooling fabrics offer a sustainable pathway to reduce energy consumption in thermal management, yet their reliance on petroleum-derived materials and complex coating processes compromises both environmental compatibility and wearability. To address these challenges, we propose a bio-inspired, coating-free strategy by designing regenerated cellulose/SiO₂ nanoparticles fibers (RCSF) via wet-spinning. Mimicking the micro-nano structure of human skin (surface protrusion height $\approx 2~\mu m$), the RCSF achieves simultaneous high solar reflectivity (93.7% at 0.4-1 μm) and infrared emissivity (0.98 at 8-13 μm) through intrinsic material properties rather than external coatings. The hierarchical porous structure enhances specific surface area while maintaining air permeability (75% improvement vs. pristine cellulose fabrics) and moisture-wicking performance. Under 800 W m⁻² solar irradiation, RCSF exhibits a net cooling power of 100.1 W m⁻², translating to 5°C temperature reduction in summer environments. Crucially, this one-step fabrication method eliminates toxic paints and energy-intensive post-treatments, offering a cost-effective alternative to conventional coated fabrics. By integrating renewable cellulose with skin-like structural design, our work establishes a paradigm for ecoefficient radiative cooling materials that balance optical performance, wearer comfort, and scalable manufacturing.

Biomimetic Elastomers and Their 3D-printed Fibrous Devices for Biomedical Applications

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Owing to their potential for biomimetic mechanical properties, elastomers have been extensively used and have become more and more important in biomedical fields, such as medical implants, regenerative medicine, and bioelectronics. In addition to further enhancing the common properties of elastomers, it is highly desired to endow elastomers with such functionalities as reprocessability, biomimetic mechanical properties, self-healing ability, bioactivity, and electrical conductivity, which will significantly broaden their applications. The covalent or noncovalent cross-linked structure is the essential factor for the elasticity of elastomers. Traditional elastomers are usually composed of a single type of cross-linked molecular network, which is difficult for modulating the properties and for introducing functionalities. Inspired by the simultaneous existence of multiple cross-linked structures in proteins, we have employed a hybrid cross-linking strategy to construct elastomers. Various noncovalent interactions (e.g., hydrogen bonds [1], cation- π interaction [2], and coordination bonds [3]) and dynamic covalent bonds (e.g., oxime-urethane bonds [4], urea bonds [5], and disulfide bonds [6]) have been integrated into elastomers. Accordingly, the properties and functionalities of elastomers can be tuned by regulating the types, ratios, and distributions of cross-links. The hybrid cross-linking strategy provides a versatile and effective way to construct diverse functional elastomers for broad applications [4,7]. In this talk, we present our recent progress on functional elastomers constructed by hybrid cross-linking strategy, including their design, preparation, properties, 3D-printed fibrous devices, and their diverse biomedical applications, including bioelectronics [8], tissue regeneration[9,10], and treatment of cardiovascular diseases [11,12].

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Chemistry and Rheological Behavior of Cross-linked Liquid Crystal Polyarylate with a Mixed End-capping Strategy

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Liquid crystalline polyarylate (LCP), as a class of high-performance polymer, has attracted increasing attention in the fields of aerospace and electronics industry. However, when it comes to the fabrication of thermoplastic composite materials, the high melt viscosity of thermoplastic LCP leads to unavoidable interface incompatibility between matrix and fiber reinforcement, resulting in the interface defects of composites. The development of crosslinkable liquid crystalline polyarylate thermosets (LCTs) provided a promising approach for composites with excellent interface bonding. Nevertheless, subject to the poor reactivity of end-groups, the existing LCTs end-capped with phenylethynyl group exhibit high curing temperature (370 °C) and long curing time (>1 h), thereby restricting the fabrication and application of LCT-based composites. Recently, our group proposed a mixed end-capping strategy for molecular structure design based on the influence of end-groups on the curing behavior. In our work, the relationship between reactive sites of end-groups and curing behavior of LCTs was investigated. Furthermore, a class of 4-maleimidophenol end-group as well as corresponding LCTs was developed. Benefiting from the introduction of reactive end-groups, the curing parameters of relevant LCTs were effectively optimized (300°C of temperature, 1 minute of curing time), therefore providing an innovative structure design strategy for high-performance polymers.

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Research on Safety Warning Design of Night Running Protective Gear Based on Triboelectricity

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With the acceleration of modern life's pace, night running has become a choice for many people. However, due to dim lighting in cities at night, night runners are difficult to see, leading to frequent accidents. The existing protective gear on the market has deficiencies in terms of warning functions, such as inconvenient operation and poor adhesion. This study aims to develop a self-driven, comfortable, and sensitive night running protective gear to enhance the safety of night running. This research is based on the Triboelectric Nanogenerator (TENG), designing and developing a night running protective gear that collects the mechanical energy of the human body during running, converts it into electrical energy, and continuously powers the protective gear's warning system. This type of protective gear is not only environmentally friendly but also aligns with the concept of sustainable economic development. The research content includes the analysis and meshing division of leg morphology, selection and performance optimization of TENG materials, design of energy storage systems, and the challenges of integrating TENG with knee pads in terms of craftsmanship and design.

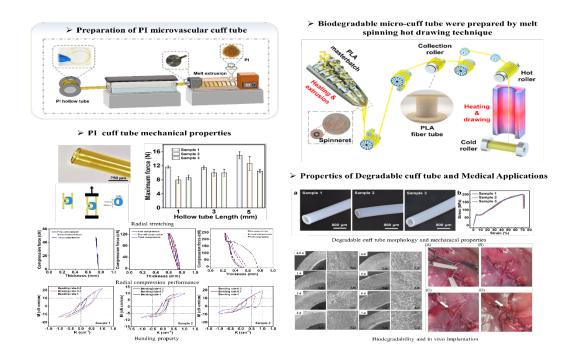
Degradable Microvascular Repair Cuff Tube

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Our team has been long committed to research on the molding and processing of polymer materials. In recent years, with the rapid development of minimally invasive interventional medical technology and the increasing demand for medical interventional catheters, the extrusion molding technology of polymer microtubes has received growing attention. However, due to the small size of microtubes, there are differences in mold design, mold manufacturing, extrusion process, etc., compared with traditional extrusion molding. Especially, medical microtubes have higher requirements for geometric accuracy, which puts forward higher demands on the extrusion molding of microtubes. Therefore, the extrusion technology of polymer microtubes has become the research focus of scholars. In the early stage, synthetic polymers that are easy to process routinely (such as PP, TPU, etc.) were used as materials, and artificial blood vessels were prepared through the microtube extrusion process. However, whilethese materials have good fluidity and viscoelasticity, their low strength and tolerance limit their further use in the body. Our research group used special high-performance materials (such as PI, etc.) and biodegradable materials (such as PLA, etc.) as implant materials. Through precise customization of the spinning equipment and improved processing methods, artificial blood vessels with various inner diameters were prepared to meet the anastomosis of blood vessels in various parts of the body. The super environmental tolerance and strength of the PI tube enabled it to remain stable during the long-term recovery process of blood vessels; the excellent rigidity and bioabsorbability of the PLA tube enabled it to degrade in the body by itself after the blood vessels heal, eliminating the need for surgical removal and the possibility of secondary trauma to the blood vessels. In conclusion, the artificial blood vessels we prepared can be customized according to actual needs to meet the strength, thickness, degradation cycle, etc., of the implant materials required for blood vessels in various different parts. The feasibility and effectiveness of the proposed method have been verified through implantation experiments.



Green Urethane Coating for Mechanically Durable Superhydrophobic Fabric

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Developing fluorine-free, bio-based, and mechanically robust water repellent coating is attractive for the textile industry, yet remains challenging. In this work, we reported a bio-based urethane prepared in one step by utilizing the nucleophilic addition reaction between sorbitan tristearate and isophorone diisocyanate. The obtained urethane was subsequently emulsified and applied onto three types of fabrics—cotton, polyester pongee, and nylon taffeta—through a simple dip-pad-cure process, to produce durable superhydrophobic coatings. Both the resulting cotton fabrics and polyester fabrics exhibit static water contact angles above 150° and a grade of 5 in the water spray test, while the nylon fabrics own a water contact angle of 147° and a grade of 4 in the water spray test. All the fabrics maintained excellent air permeability. Additionally, the treated fabrics maintained hydrophobicity after harsh durability tests, including 3000 cycles of friction, 400 cycles of sandpaper abrasion, and 70 hours of chemical corrosion. Overall, the findings presented in this study offer valuable insights into the development of non-fluorine, durable bio-based water repellents, highlighting their potential for diverse industrial applications.

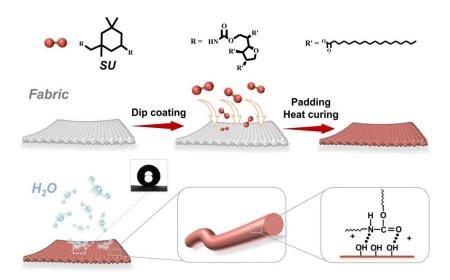


Figure 1: Schematic illustration of SU coating and its application on cotton fabric.

ACKNOWLEDGMENT

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Trends in Critical Pressure Thresholds for Lower Limb Oedema Reduction Under Various Physiological Parameters and Dual Mode Compression Trial Effect

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Lower limb oedema requires lifelong management. It arises from fluid accumulation due to disruptions in fluid exchange within the capillary bed unit. While medication and surgical interventions pose risks and inconveniences, compression therapy emerges as a favorable method for sustained oedema management. Additionally, skeletal muscle movement offers an alternative by exerting pressure on blood and lymphatic vessels, aiding in oedema prevention and reduction. Despite advancements in understanding the physiological mechanisms of lower limb oedema, predicting the required compression pressure for varying physiological parameters remains complex. This study employs a two-dimensional numerical model of capillary-blood-tissue interactions to determine the critical compression pressure threshold necessary for oedema reduction under diverse physiological conditions through computational fluid dynamics (CFD) methods. Numerical simulations reveal the influence of physiological parameters such as tissue and capillary porosities, blood viscosity, inlet heart rate on oedema reduction. Results indicate that capillary and tissue porosity, as well as inlet velocity, significantly impact oedema reduction under constant compression pressure, while blood viscosity has a minor effect. Additionally, harmonic compression pressure demonstrates similar efficacy to constant pressure in oedema reduction. Trial tests conducted on young and elderly subjects with mild oedema show that combining lowpressure medical compression stockings with movement significantly reduces lower limb oedema. Dynamic mean pressures during movement exceed the critical pressure identified in simulations, suggesting effective compression application. This study emphasizes the potential of wearable low-pressure compression devices combined with movement in effectively managing and relieving lower limb oedema, providing insights into optimizing treatment strategies based on individual physiological parameters.

ACKNOWLEDGMENT

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Fast Uniform Fluid Distribution in Network-structured Wearable Heat Transfer Panel

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As society evolves, activities in extreme environments, such as firefighting, industrial operations, and space exploration, have increased, necessitating advanced personal wearable thermal management systems. These systems manage the body's microclimate and often utilize fluid as a medium, with applications that include airconditioned clothing and spacesuits. This work introduces innovative fluidic fabric heat transfer panels designed for wearable thermal management, pain relief, and sports recovery. Traditional panels with single tubes face challenges, like high energy loss and low heat transfer efficiency. However, the proposed network-structured panels address these issues by enabling self-adjustment and homogenized flow through engineered designs. These panels can switch temperatures within approximately 10 seconds, achieving fast fluid flow and uniform surface temperature distribution.

The study innovatively redesigns guide vanes to streamline fluid channels and minimize resistance. Reinforcement dots create a network structure tailored for distinct functional areas, optimizing flow rates and enhancing heat distribution. The successful application of these panels for lower limbs in rapid contrast therapy—switching temperatures from 5°C to 40°C—demonstrates their potential for supporting athletic recovery.

Computational fluid dynamics simulations and flow visualization experiments reveal three flow regimes within the network: pure laminar, transitional, and turbulent transitional flow. A four-step mass transfer mechanism is proposed, explaining the flow field homogenization and temperature uniformity achieved by the panels. Power loss computations clarify pressure drops due to inertial and viscous forces, revealing that different flow regimes significantly influence power loss characteristics.

Overall, this research advances the engineering design and optimization of network-structured fluidic fabric heat transfer panels. With rapid temperature switching and improved thermal management, these panels effectively support various thermal management needs in extreme conditions, showcasing their potential in enhancing performance in demanding environments.

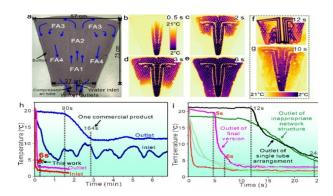


Figure 1. Rapid and uniform thermal performance of full leg network-structured heat transfer panels.

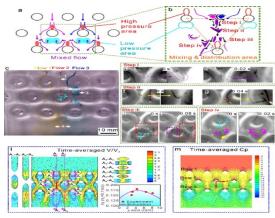


Figure 2. Instantaneous and time-averaged flow behavior reveals the 4-step mass mixing mechanism and flow field inside network-structured fluidic fabric.

Ultralight and Superelastic Gd₂O₃/Bi₂O₃ Nanofibrous Aerogels Enables Efficient X-ray Absorption

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The widespread use of X-rays has prompted a surge in demand for effective and wearable shielding materials. However, the Pb-containing materials currently used to shield X-rays are commonly bulky, hard, and biotoxic, severely limiting their applications in wearable scenarios. Inspired by the nacre, we report on ultralight, superelastic, and nontoxic X-ray shielding nanofibrous aerogels with microarch-engineered brick/mortar structure by combining polyurethane/Bi₂O₃ nanofibers (brick) and Gd₂O₃ nanosheets (mortar). The synergistic attenuation effect toward X-rays from the reflection of microarches and absorption of Bi/Gd elements significantly enhances the shielding efficiency of aerogels, and microarches/robust nanofibrous networks endow the materials with superelasticity (Figure 1). The resultant materials exhibit integrated properties of superior X-ray shielding efficiency (91%–100%), ultralow density (52 mg cm⁻³), large stretchability of 800% reversible elongation, and high-water vapor permeability (8.8 kg m⁻² day⁻¹). The fabrication of such novel aerogels paves the way for developing next-generation effective and wearable X-ray shielding materials.

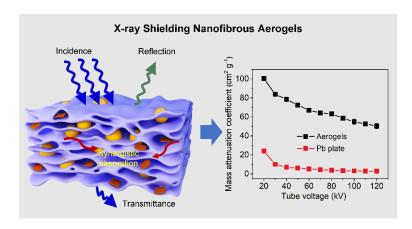


Figure 1. Schematic illustration of the X-ray shielding mechanism and mass attenuation coefficients of aerogels and Pb plate.

Development of Screen-printed Electrode Designs for EMG and Evaluation of Their Applicability to Clothing

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Smart clothing incorporating electromyogram (EMG) electrodes is gaining traction due to its potential in exercise health monitoring, rehabilitation, and sports science. Current research focuses on developing EMG-measuring clothing using conductive yarn in embroidery and knitting, as well as screen-printed electrodes with conductive materials. Studies on embroidered and knitted electrodes primarily aim to enhance EMG signal acquisition by modifying electrode and fabric structures. In contrast, research on screen-printed electrodes mainly explores their feasibility, with limited investigation into the impact of printing conditions or electrode design variations on signal acquisition. This study aims to develop optimal electrode designs by screen-printing various designs onto single jersey fabric. Furthermore, we propose EMG-measuring smart clothing that integrates the developed electrode design to measure biceps brachii muscle activity.

To achieve this, first, electrode fabrication conditions were optimized by adjusting ink amount, printing direction, printing cycles, and electrode shape. Second, optimal designs were developed based on size, design, and reduction rate, which is the downsizing of the original electrode within the same size. Third, the feasibility of EMG signal detection from the biceps brachii was evaluated. Fourth, clothing durability was tested against washing, wear, and elongation. Fifth, the electrodes were applied to stretchable armband- and T-shirt-type clothing. Finally, their applicability to other muscles was assessed to confirm suitability for EMG-measuring clothing. The feasibility of the developed design for use in EMG-measuring clothing was confirmed.

The results showed that the EMG-measuring electrodes developed in this study stably acquired EMG signals, exhibiting signal quality superior to conventional Ag/AgCl wet electrodes. We also created EMG-measuring clothing that can monitor real-time biceps brachii muscle movement, demonstrating stable acquisition of EMG signals. Durability assessments revealed that the electrodes retained 83.4% of their initial performance after 10 wear cycles and 80.6% after 10 wash cycles, indicating effective signal acquisition and electrode performance even after repeated wear and washing. They also exhibited durability up to 100% elongation. When applied to different stretchable fabrics, the electrodes performed similarly to conventional Ag/AgCl wet electrodes; they were also able to collect EMG signals from muscles other than the biceps brachii.

In conclusion, the EMG clothing with the optimized electrode design effectively captures EMG signals corresponding to muscle activity and exhibits excellent stretchability and crack resistance, ensuring durability during wear and washing. These findings provide valuable insights for future smart textile development.

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Development of Cell Lysis Fibrous Material for Continuous Manufacturing of Carotenoids from Recombinant *Escherichia coli*

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In this collaborative project, material scientists from the CSIRO Manufacturing research unit partnered with the Singapore Institute of Food and Biotechnology's Strain Engineers to explore the potential for continuous manufacturing of carotenoids using recombinant *Escherichia coli*.

Carotenoids are vital as natural colorants and health promoters due to their antioxidant properties and role as precursors to vitamin A. They hold a significant market share among food additives, with an expected annual growth rate of 4.2%, according to a recent market report [1].

While continuous fermentation has been successfully employed for large-scale production of various chemicals, such as ethanol, acetone-butanol-ethanol, lactic acid, succinic acid, and PH [2], the biopharmaceutical industry predominantly relies on traditional batch and fed-batch processing for producing active pharmaceutical ingredients and fine chemicals. Traditional batch fermentation has several drawbacks, including high operational costs, inconsistent product quality, and supply chain disruptions. With advancing technology, there is growing interest in continuous manufacturing processes.

While upstream processing involves the initial steps required to prepare and grow the microorganisms or cells that will produce the desired product, downstream processing involves the recovery and purification of the product from the fermentation broth. One of the steps in downstream processing is cell lysis or cell disruption to open the cells to release the intracellular product.

In this study, hybrid fibrous materials were fabricated, characterized, and tested for cell lysis efficacy, with the aim of using them continuously in a packed column. The characterization of these fibrous hybrid materials and preliminary cell lysis results will be presented.

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Study on Solid-State Polymerization and Melt Spinning for Mechanically Recycled PET

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INTRODUCTION

Recently, as awareness of environmental issues has expanded, there has been an increasing movement toward the development and use of environmentally friendly recycled fibers. PET is one of the most consumed polymers in the world due to its advantages of high performance, light weight, and low cost, and attempts to recycle and reuse it are constantly being made. Mechanically recycled PET chip(mr-PET) is obtained by collecting—sorting—crushing—washing used PET bottles, removing impurities, and manufacturing the regenerated raw material into flakes or pellets without chemical change. In this study, solid-state polymerization conditions for mr-PET were optimized, followed by melt spinning to obtain filament fibers. The possibility of manufacturing recycled PET fibers using mr-PET was examined through the analysis of mechanical properties.

EXPERIMENTAL

In this study, v-PET for bottle grade and mr-PET from bottles with an intrinsic viscosity of 0.7 dL/g and 0.8 dL/g were used, respectively. Solid-state polymerization was performed in four steps, using a lab-scale solid-state polymerization reactor: Step 1, vacuum; Step 2, crystallization; Step 3, solid-state polymerization; and Step 4, cooling. Step 2 was performed at 140°C for 3 hours for crystallization. Step 3 was performed at 230°C for 6 hours. The obtained solid-state polymerized chips were used for melt spinning using lab-scale melt spinning equipment under the conditions shown in Table 1. The free drop samples were analyzed for intrinsic viscosity (IV) and gel permeation chromatography (GPC). The fibers obtained by changing the take-up speed were analyzed for S-S curve, tenacity, and elongation through a single fiber tensile test.

Table 1. Conditions of melt spinning process.

Nozzle	Spinning Temp.	Throughput rate	Take-up speed (m/min)	
type	(°C)	(g/min hole)	v-PET	mr-PET
Single, ø 0.5-2.0L	285	2.5	1,000~5,000	500~4,000

RESULTS AND DISCUSSION

The IV values of v-PET and mr-PET before/after solid-state polymerization were 0.689/0.776 dL/g and 0.637/0.857 dL/g, respectively, confirming that the viscosity increased after solid-state polymerization. In particular, mr-PET was confirmed to have higher viscosity than v-PET after solid-state polymerization. This was confirmed to be correlated with IV through the Mark-Houwink Equation since the Mw of v-PET and mr-PET were 42,450 and 54,020, respectively, in the GPC analysis results. The mechanical property results of the samples obtained by changing the take-up speed showed that the tenacity increased and the elongation decreased as the take-up speed increased both before and after solid-state polymerization. It is confirmed that the polymer chains within the fiber were oriented due to the drawing process. In addition, the fibers wound up to 3,000 rpm after solid-state polymerization showed higher tenacity than the samples before solid-state polymerization. At this time, v-PET and mr-PET showed similar values of 4.43 g/den and 4.40 g/den, respectively. As a results of the above, the possibility of manufacturing PET fiber with similar strength to v-PET by applying mr-PET through solid-state polymerization was confirmed.

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MXene/CNT/ZnO-WO₃ Ternary Composite: A Multifunctional Textile Platform for Wearable Applications

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The convergence of materials science, nanotechnology, and advanced fiber fabrication has paved the way for multifunctional textiles that integrate diverse functionalities within a single fabric. In this study, we present a novel ternary composite system comprising MXene, carbon nanotubes (CNTs), and ZnO nanorods (NRs) doped with WO₃, designed to address critical challenges in the development of next-generation wearable textiles. The integration of MXene and CNTs provides exceptional electrical conductivity, EMI shielding, and mechanical flexibility, while the incorporation of ZnO NRs enhances mechanical—electrical coupling, dielectric polarization, and piezoelectric response. WO₃ doping further improves carrier mobility and thermal response, enabling efficient Joule heating and uniform heat distribution.

Despite significant progress in MXene-based textile systems, issues such as environmental stability, oxidation, and poor interfacial compatibility, prominent challenges remain. The proposed ternary composite addresses these limitations by leveraging the high aspect ratio of ZnO NRs for efficient stress transfer and the conductive pathways formed by MXene-CNT networks. The resulting architecture exhibits enhanced strain-sensing capabilities, electromagnetic wave attenuation, and thermal management under dynamic conditions, making it a promising candidate for industrial safety monitoring and wearable electronics.

This work underscores the potential of MXene/CNT/ZnO-WO₃ composites in multifunctional textile platforms, providing a pathway toward sustainable and reliable smart textile applications. The developed system demonstrates significant advancements in mechanical robustness, environmental stability, and multifunctionality, positioning it as a transformative solution for next-generation wearable systems.

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Spectrally Selective Radiation Meta-fabric with Enhanced Thermo-moisture Management Performance

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With the progressive intensification of the urban heat island effect, the rising temperatures of buildings and ground surfaces have impaired the cooling performance of broadband infrared radiative fabrics, thereby significantly compromising human thermal comfort in outdoor environments. Recently, mid-infrared spectrally selective fabrics have been proven to effectively minimize the absorption of thermal radiation from the surroundings. However, in high-temperature environments, excessive sweating seriously impacts on the spectrally selective radiative capability of the fabric. Therefore, enhancing the sweat-wicking performance of spectrally selective fabrics is both urgently needed and highly challenging. Herein, we have ingeniously designed a multiband, spectrally selective fibrous metafabric featuring a directionally guided and hierarchical sweat-wicking structure. The metafabric possessed high reflectance in the solar band, high emissivity within the atmospheric window band, and low emissivity in the mid-infrared non-atmospheric window band, minimizing the net heat gain affects from solar and surroundings, while maximizing heat dissipation to outer space. More significantly, this metafabric can rapidly transport sweat to outer surface, where it drips off, effectively maintaining its spectrally selective radiative cooling performance, thereby enhancing human thermo-moisture regulation under urban heat island conditions. Experimental results showed that the multiband spectrally selective fibrous metafabric achieved temperature reductions of 3.5°C and 8.6°C, compared to broadband emissive fabric and cotton, respectively, demonstrating excellent cooling performance. The design of this spectrally selective fibrous metafabric with coupled thermal and moisture transfer holds great application potential for human thermo-moisture regulation in high-temperature, urban environments.

Enhancing Heat Transfer in Pulsating Heat Pipes Using Fabric-like Structures

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Pulsating heat pipes (PHPs) are capable of achieving high heat transfer performance without the necessity of wicking layers; however, their operational stability is compromised, particularly at low heating temperatures, which significantly restricts their applicability. The structural configuration of PHPs has been identified as a critical factor influencing their flow dynamics and thermal efficiency. This study introduces a novel fabric-like structure for PHPs, utilizing R134a as the working fluid, to augment heat transfer performance under low thermal loads. The investigation encompassed an experimental analysis of the effects of R134a filling ratios and the inclination angles of the heat pipes. The results demonstrate that the fabric-like structure PHP exhibits superior thermal performance, characterized by unidirectional fluid flow and enhanced operational stability. The thermal conductivity of this structure was found to be up to 3.54 times greater than that of a conventional PHP. Infrared thermal imaging further substantiated the fabric-like structure's role in promoting uniform temperature distribution. Moreover, the cross-bonding structure PHP also exhibited improved heat transfer performance and stability relative to the traditional design. These improvements are attributed to the flow resistance imbalance and the heat regeneration from backflow liquid within the horizontal tubes. The findings offer significant insights for the design of PHPs, particularly for applications in electronics cooling and low-temperature heat recovery systems.

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