Construction and Application of MOF-Reinforced Casein-Based Hydrogel Self-Powered Leather for Wearable Electronics

XiaoyuXu, QunnaXu*, JianzhongMa*, Guanjie Huang

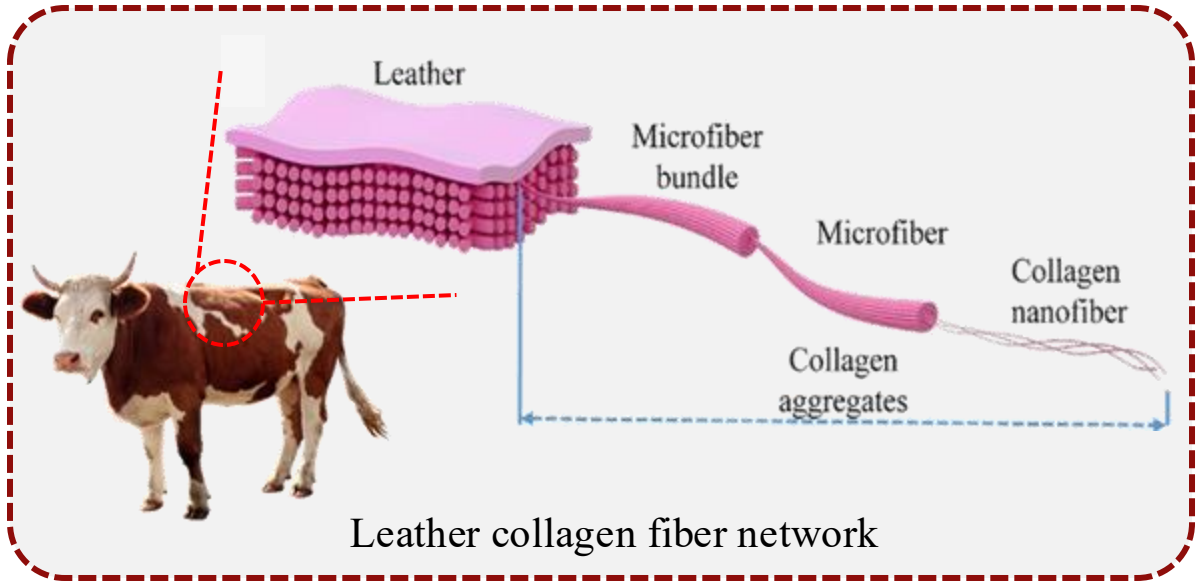
Shaanxi University of Science & Technology

September 10th, 2025

CONTENTS

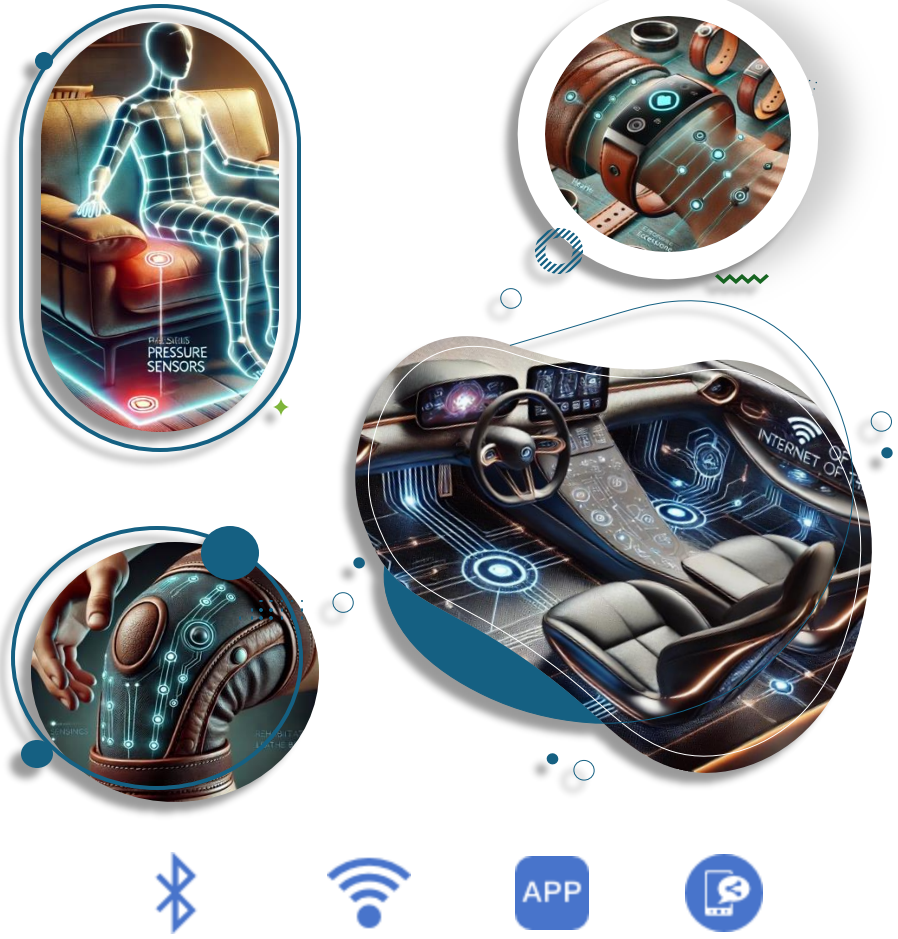
1. BACKGROUND

- ***The natural multi-level structure of leather makes it an ideal substrate for wearable electronic products.***



Leather collagen fiber network

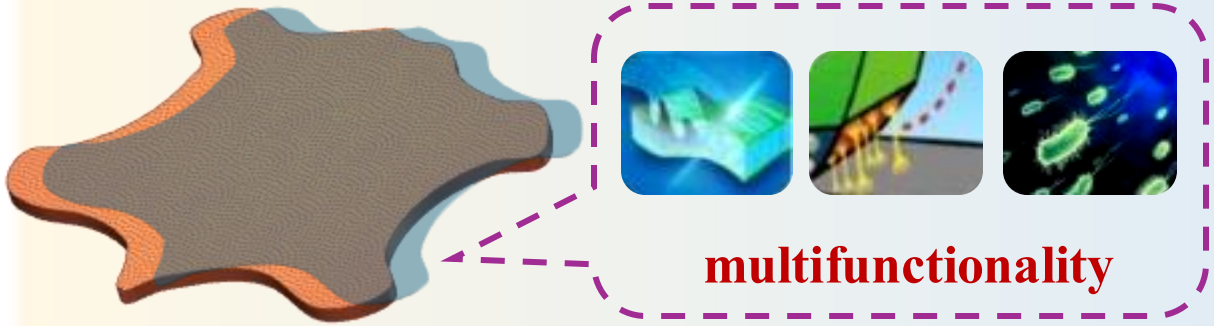
- **Flexibility & Mechanical**
- **Stability Biocompatibility & Breathability**
- **Environmental adaptability & Durability**



1. BACKGROUND

◆ ***Surface coating** is an efficient strategy for comfortable E-leather preparation*

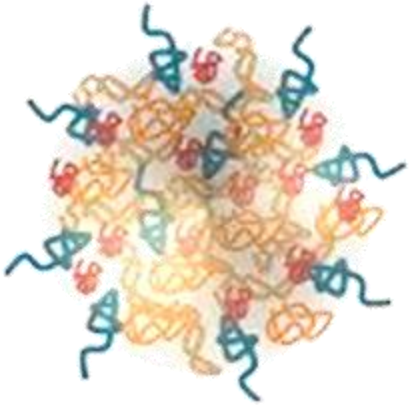
VS



- **Highly targeted functions**
- **Flexible feature combination**
- **Material naturalness preservation**
- **High process controllability**

1. BACKGROUND

***Casein** is a good candidate for leather surface treating due to its film-forming properties*



Casein Micells

- **Biodegradability**
- **Air permeability**
- **Strong adhesion**
- **Vapor permeability**
- **Film-forming behavior**

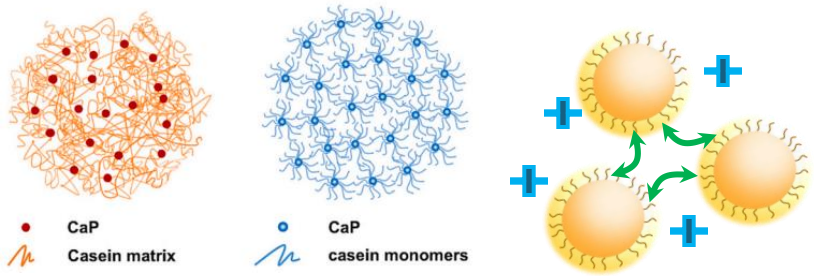
Modification

Casein coating material

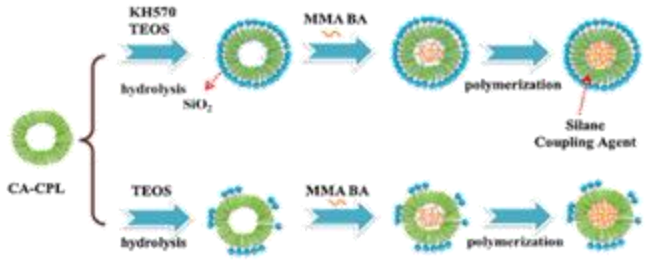
Widely used in the leather industry since the 1820s

1. BACKGROUND

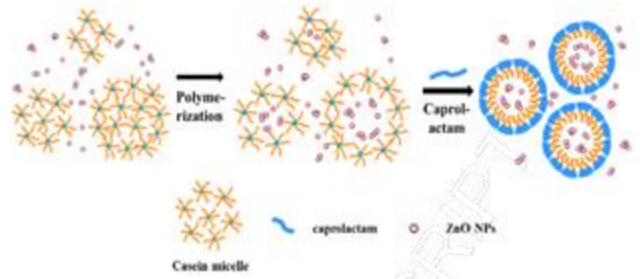
- ***Casein modification has been conducted to be endowed with functionality***



Functional monomers

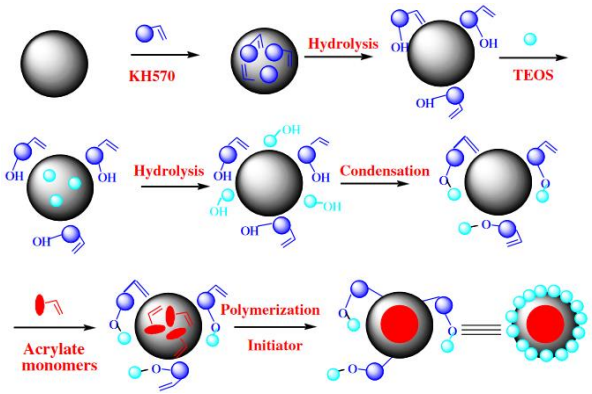


Progress in Organic Coatings, 2015, 88: 1–7.

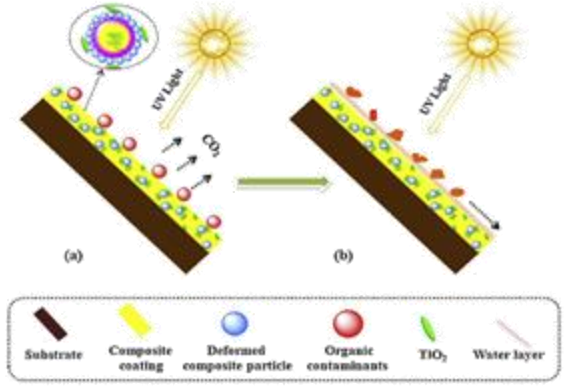


Materials & Design, 2017, 113: 240–245.

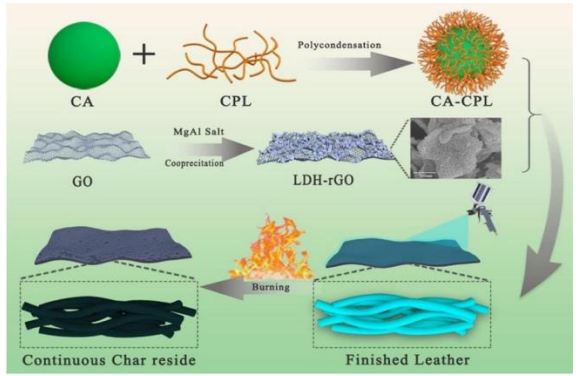
Modification **Functionalization**



Chemical Engineering Journal, 2013, 228: 281–289.



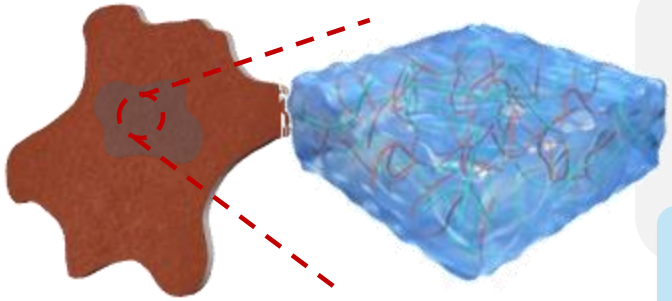
Progress in Organic Coatings, 2016, 99: 223–229.



Applied Surface Science, 2022, 575: 151767.

1. BACKGROUND

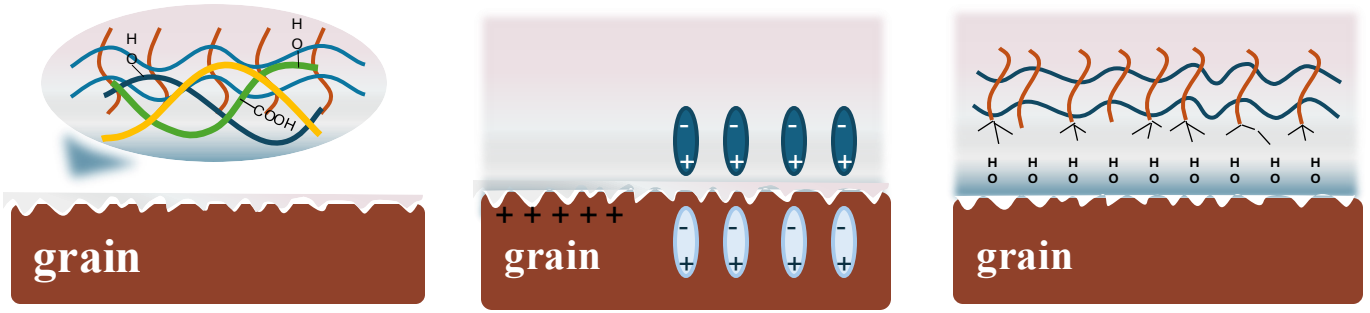
◆ ***Hydrogel coating shows great application potential in surface treating***



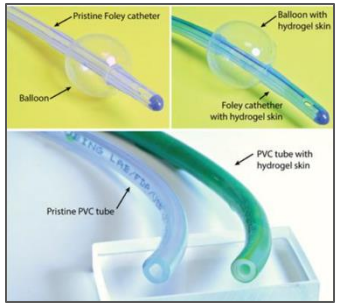
Hydrogel —— **Water-soluble polymer system with a three-dimensional network structure**

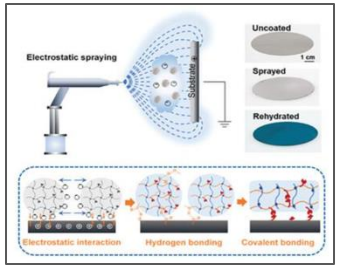
High flexibility | Adjustable mechanical | Flexible conductivity

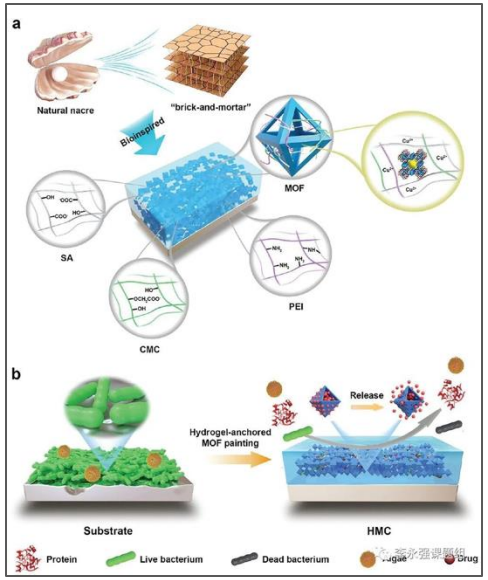
Construction method



Interface interpenetration | physical penetration | non-covalent bond





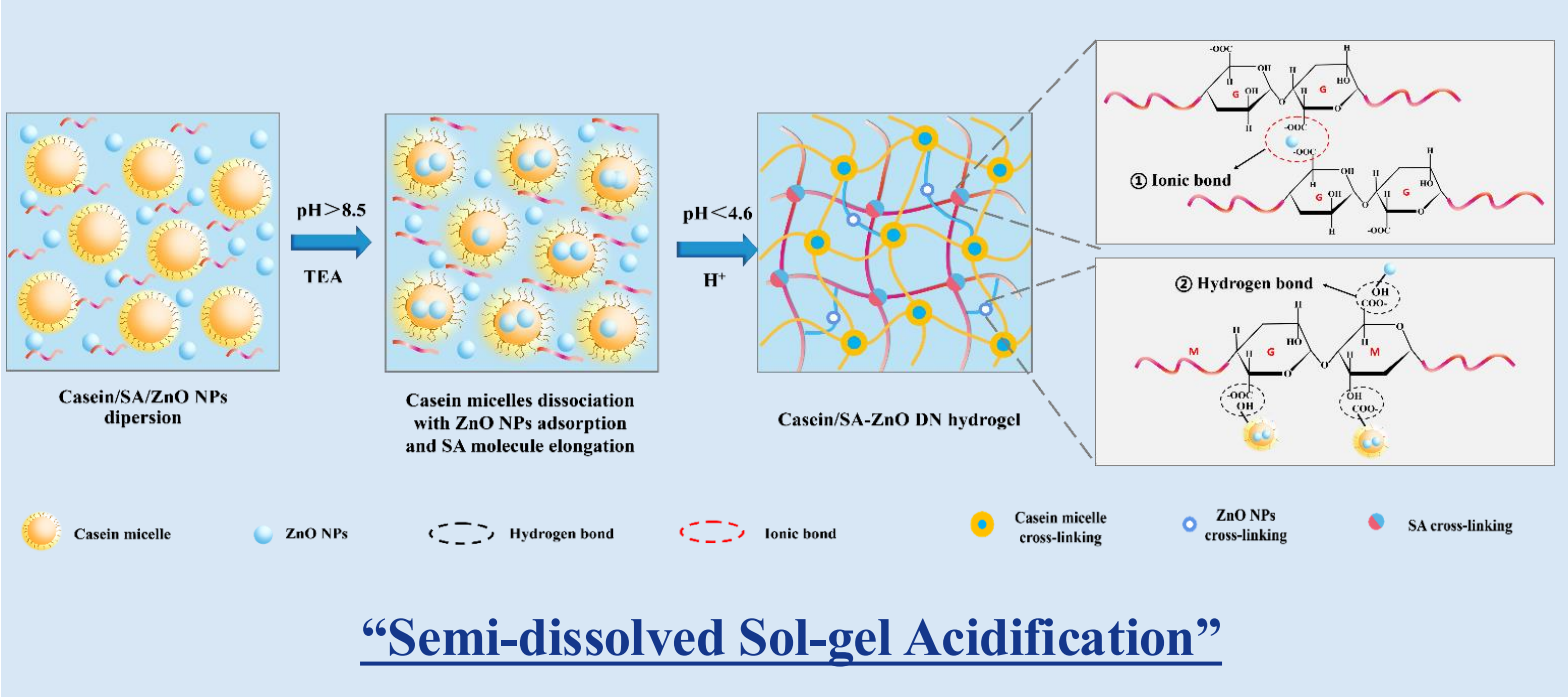


Yu Y, Yuk H, Parada G A, et al. Adv. Mate. 2019, 31(7): 1807101.

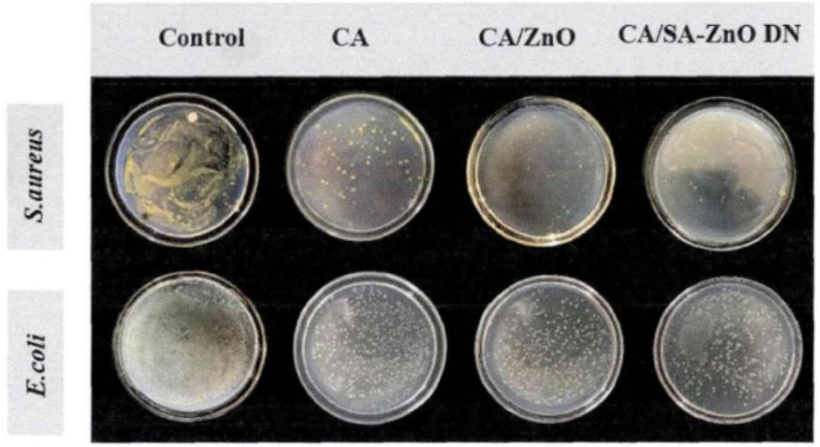
CONTENTS

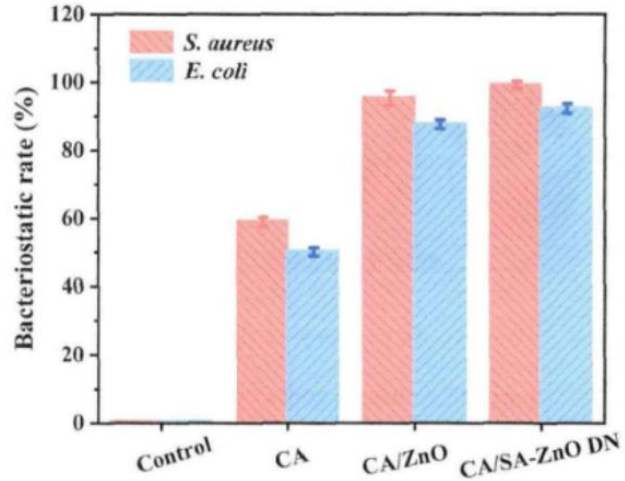
2. PREVIOUS WORK

◆ *2.1 Antibacterial Casein-Based Hydrogel*



"Semi-dissolved Sol-gel Acidification"



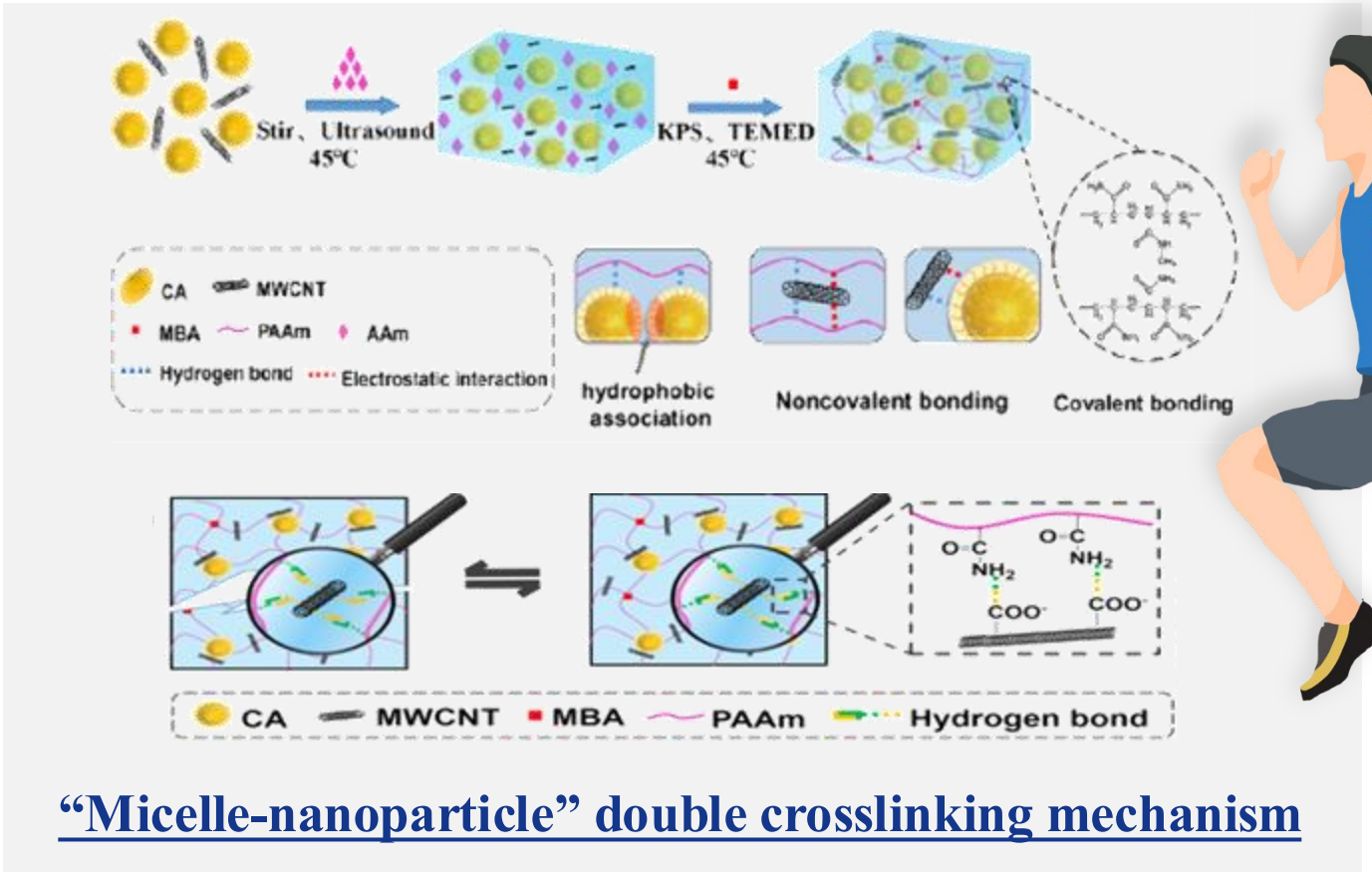


- ✓ **Casein and Sodium Alginate were employed as dual networks**
- ✓ **Nano-ZnO endows the hydrogel with excellent antibacterial properties.**

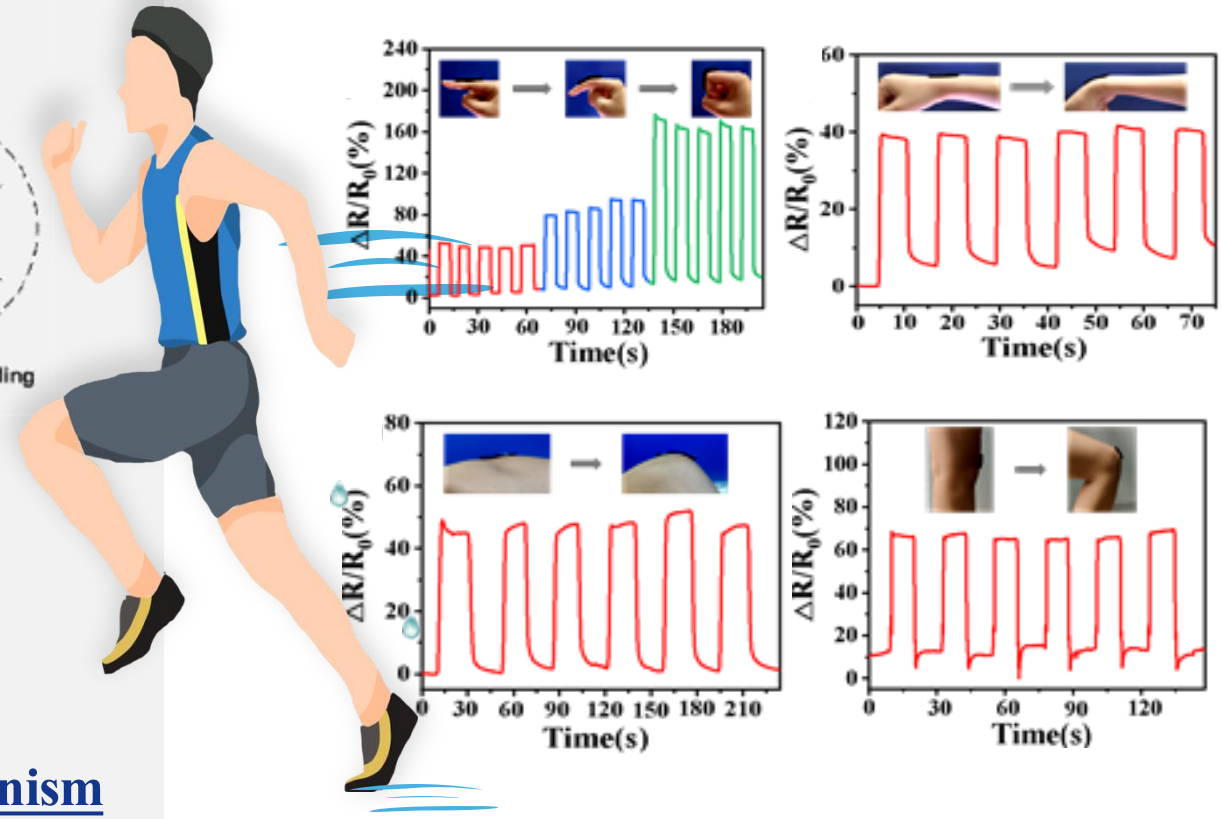
➢ *QN.Xu*, JZ Ma*, et al. Fine Chemicals (2022)*

2. PREVIOUS WORK

◆ *2.2 Conductive Casein-Based Hydrogel*



"Micelle-nanoparticle" double crosslinking mechanism



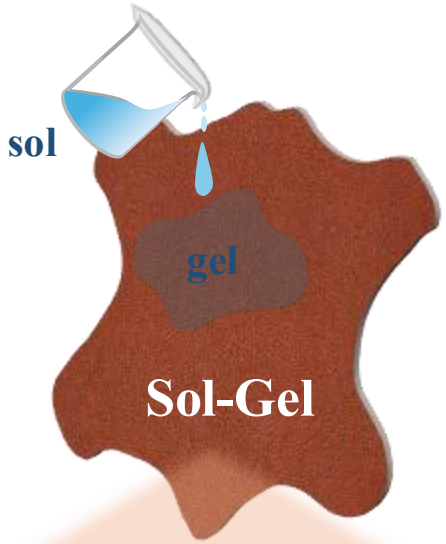
- ✓ **Smart casein-based MWCNT hybrid hydrogel was prepared successfully**
- ✓ **The hydrogel is used as an intelligent sensor for motion monitoring.**

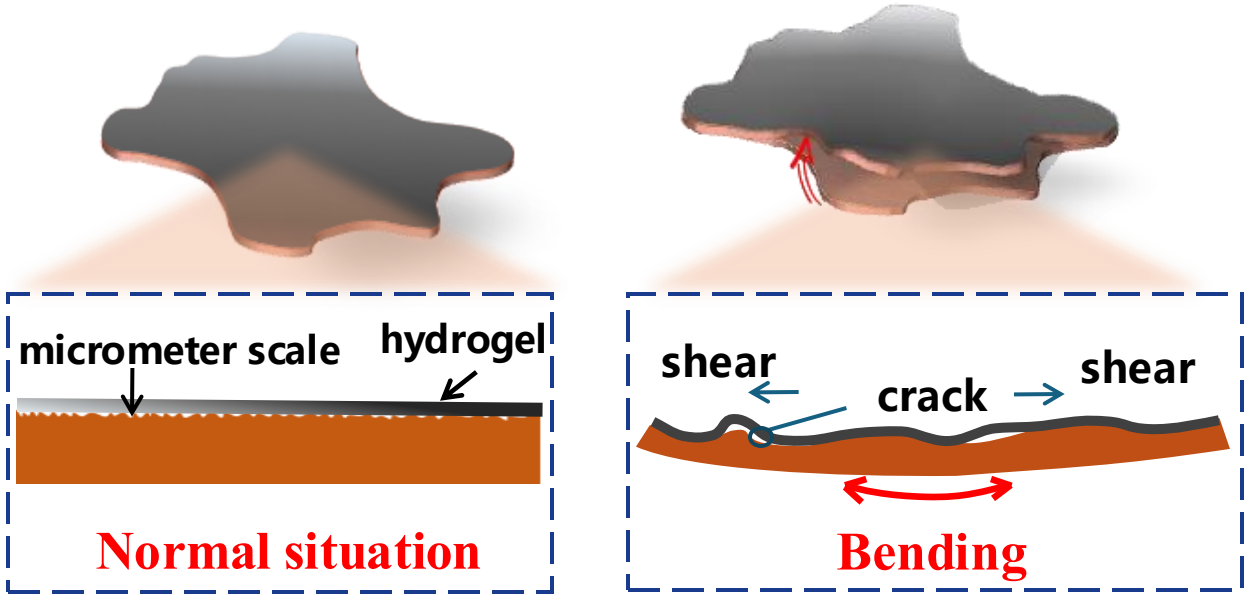
➢ *QN.Xu*, JZ Ma*, et al. Int. J. Biol. Macromol.(2023)*

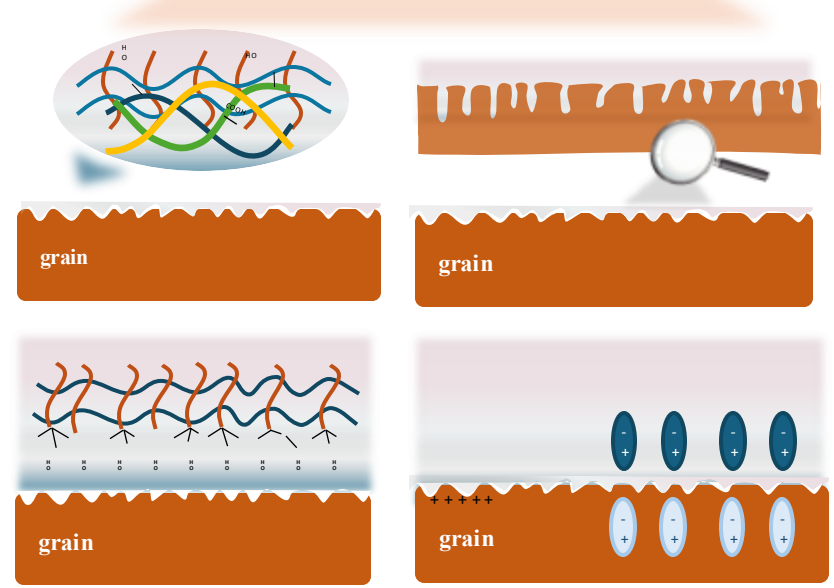
2. PREVIOUS WORK

Existing Problems :

- Poor controllability and uniformity of coating thickness
- Poor adhesion between functional layer and leather substrate
- Poor functional synergistic effect

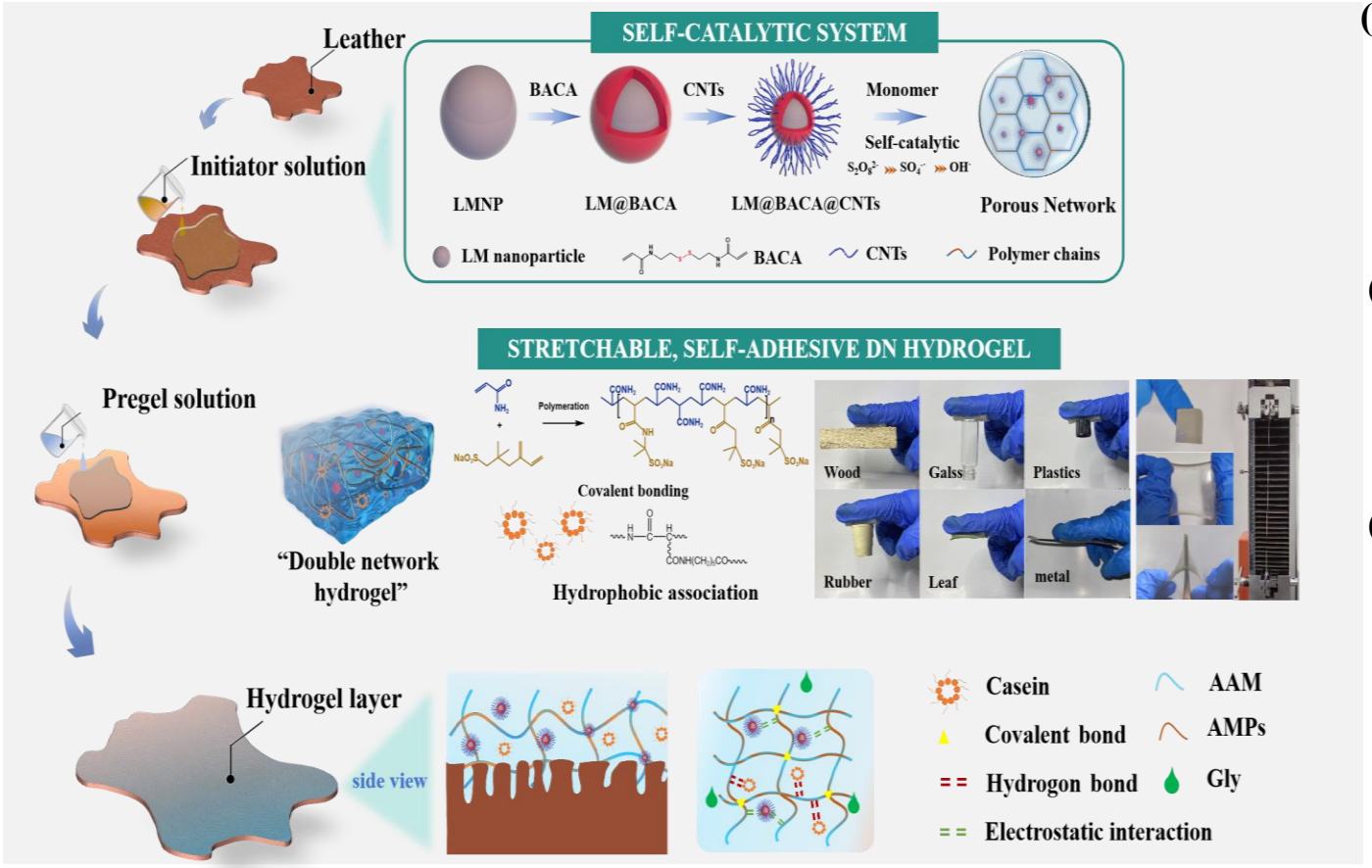


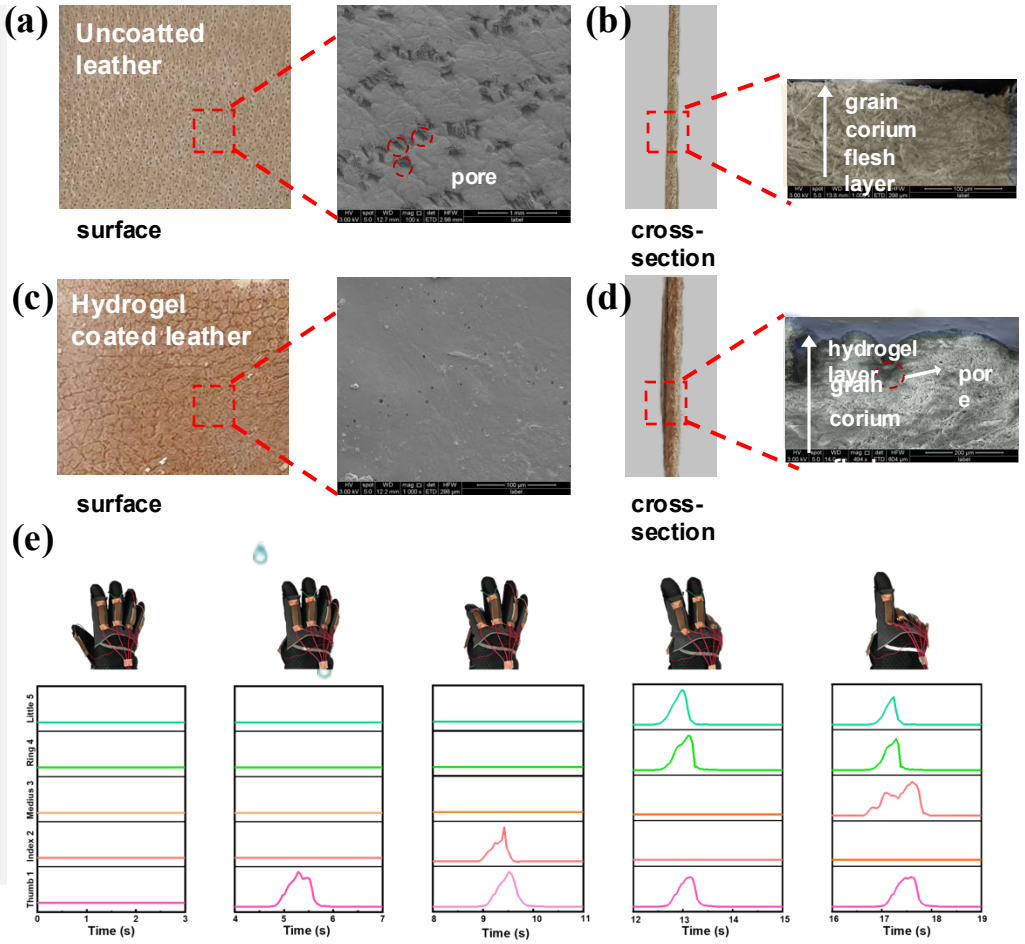




2. PREVIOUS WORK

◆ *2.3 Casein-Based Conductive Hydrogel Leather Coating via a One-Step Method*





"in situ polymerization"

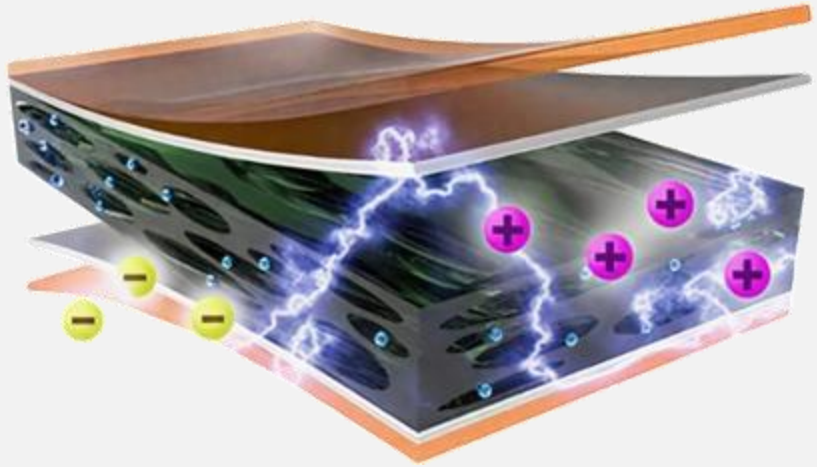
➢ *QN.Xu*, JZ Ma*, et al. . Chem.Eng.J. (2024)*

CONTENTS

3. RECENT WORK

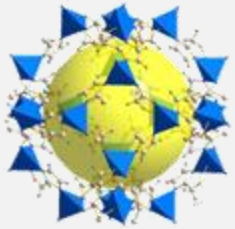
◆ *How to promote the improvement of the portability of smart leather electronic devices?*

Self-powered device

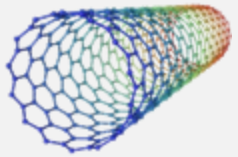


- **Does not rely on external power sources**
- **The natural high triboelectric properties of leather**

MOF-Enhanced TENG



- Increase surface charge density
- Increase the effective contact area



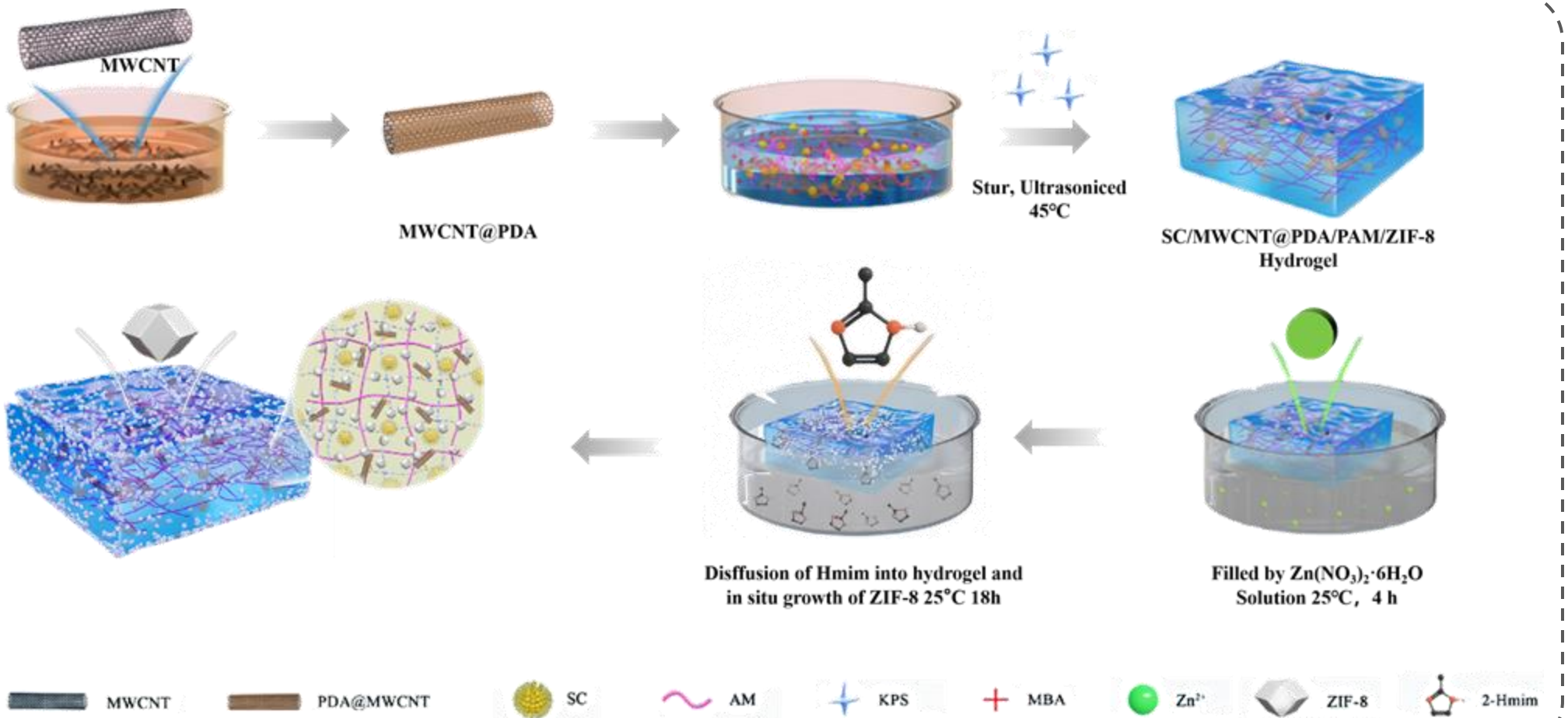
- impart electrical conductivity
- light-to-heat conversion capability

Disintegration

"Chemical Antibacterial" Synergy with "Physical Antibacterial"

3. RECENT WORK

◆ *3.1 MOF-Reinforced Casein-Based Hydrogel Self-Powered Leather*



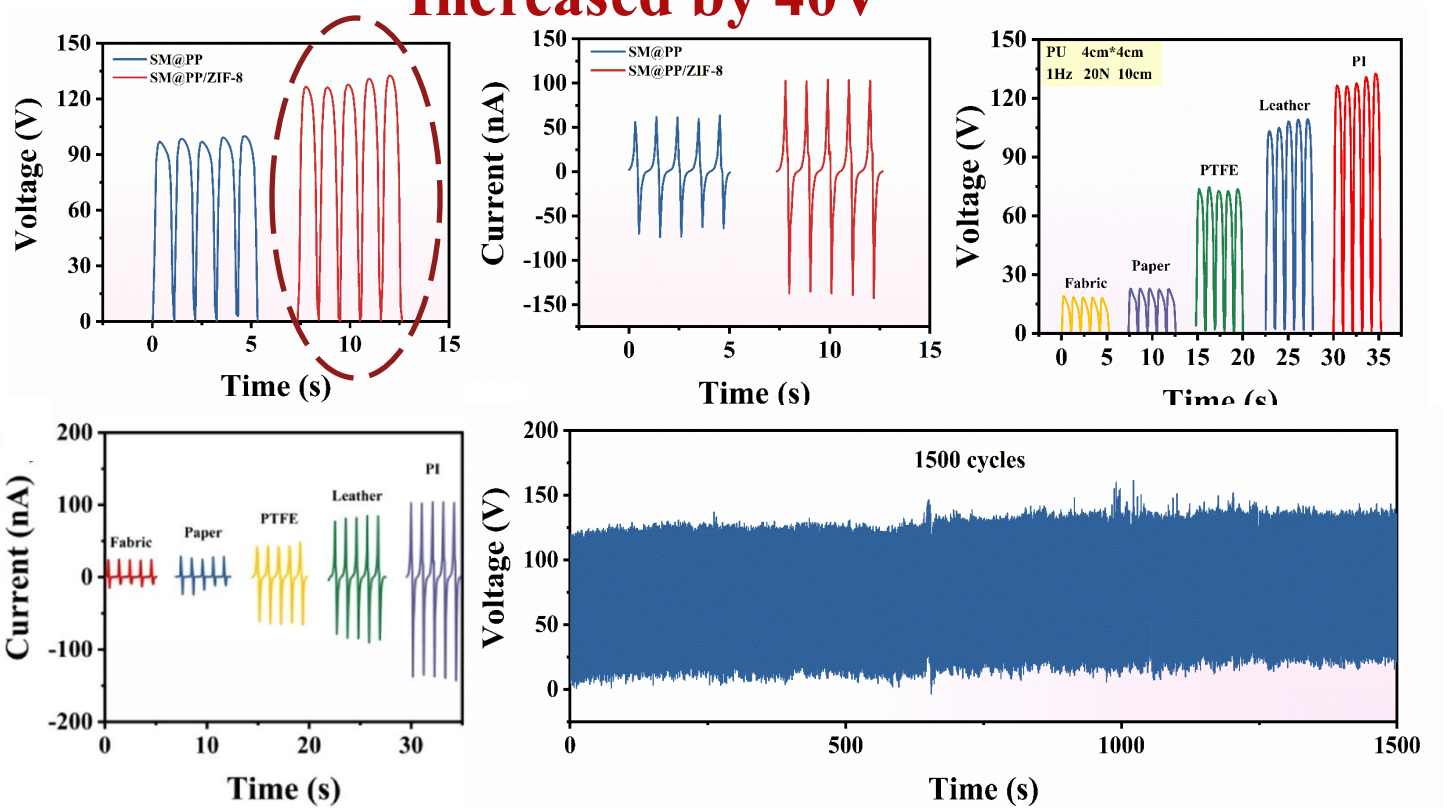
In-Situ Polymerization

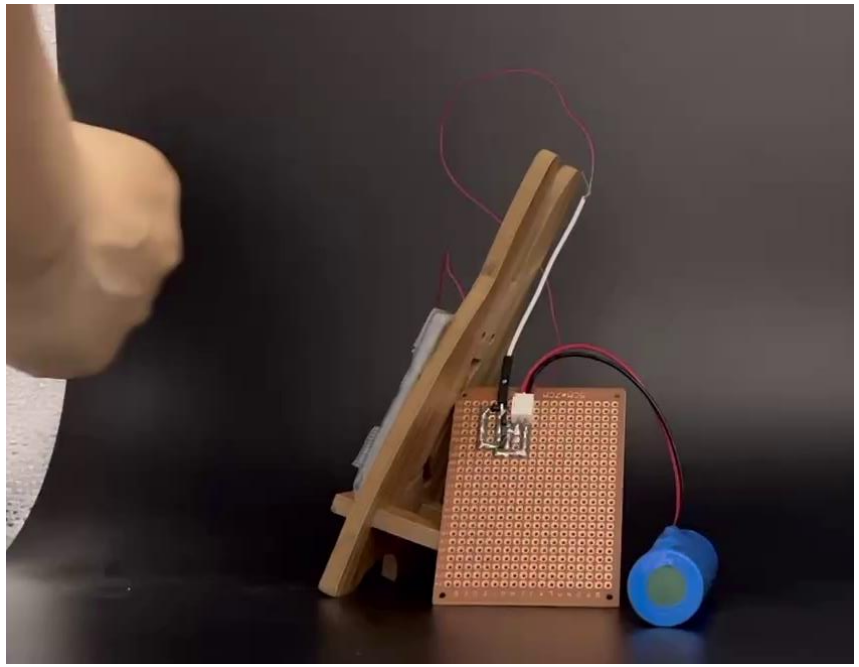
Stepwise Immersion

3. RECENT WORK

◆ *3.2 Triboelectric Output Performance*

Increased by 40V



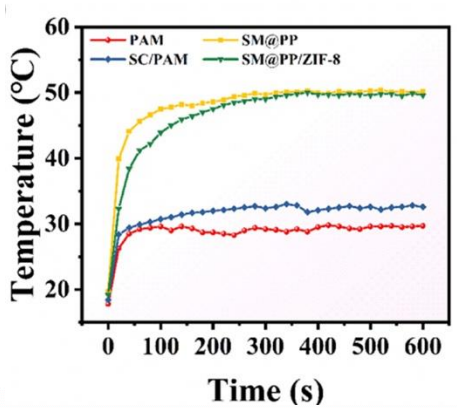


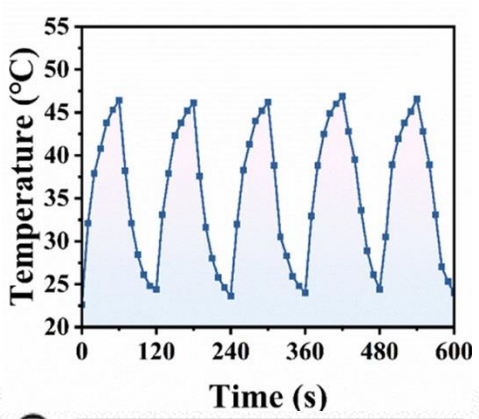
Non-Contact Type!

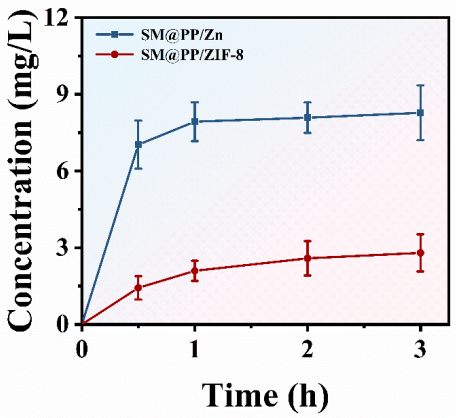
◆ *MOFs induce a solid-liquid biphasic triboelectric effect, significantly increasing the output voltage (131 V).*

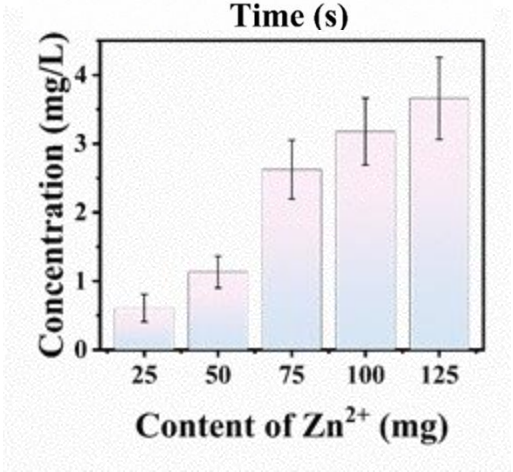
3. RECENT WORK

◆ *3.3 Photothermal Conversion Performance & Antibacterial Performance*

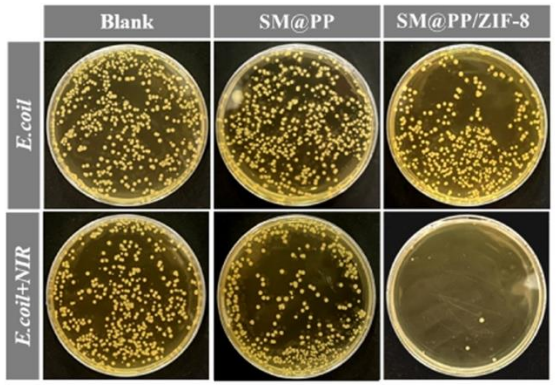


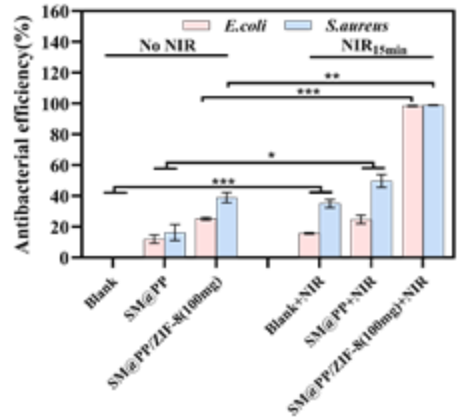


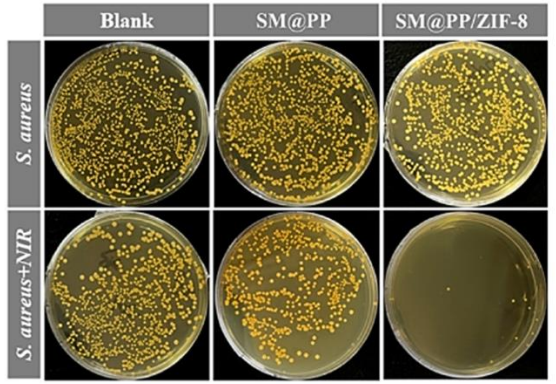


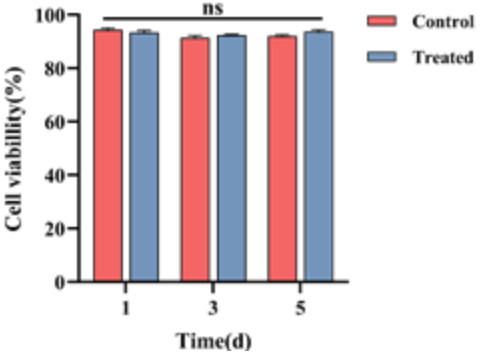


➢ *The photothermal conversion efficiency reaches 52.19%.*









➢ *The antibacterial rate ≥ 99%.*

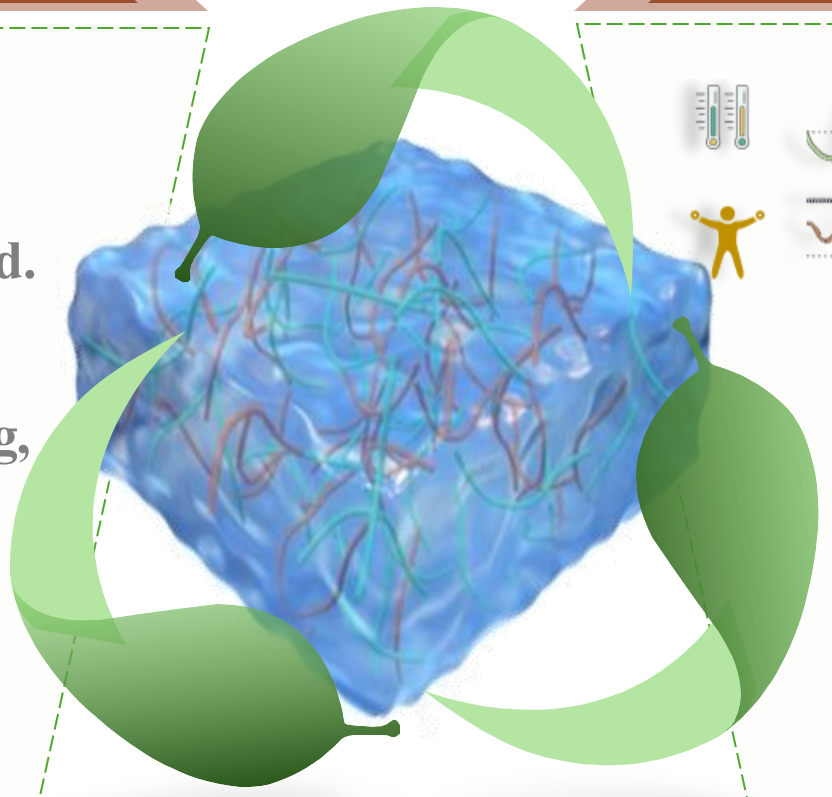
➢ *The excellent biocompatibility*

CONTENTS

3. SUMMARY & OUTLOOK

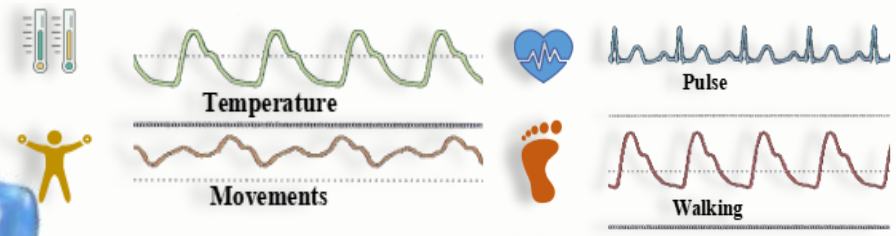
SUMMARY

- A ZIF-8-enhanced solid-liquid biphasic leather-based hydrogel TENG was successfully prepared.
- The Integration of Self-Powering, Antibacterial Property and Photothermal Effect
- Significantly enhance the high-end attributes of leather



Smart Leather

OUTLOOK



Multimodal Sensor

Energy Harvesting

Acknowledgements

- National Natural Science Foundation of China (22278258);
- National Natural Science Foundation of China (22078185)
- THE XXXVIII IULTCS CONGRESS

Jianzhong Ma

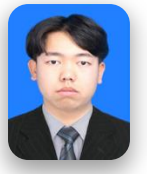
Quanna Xu

Xiaoyu Xu

Jiaqi Lu

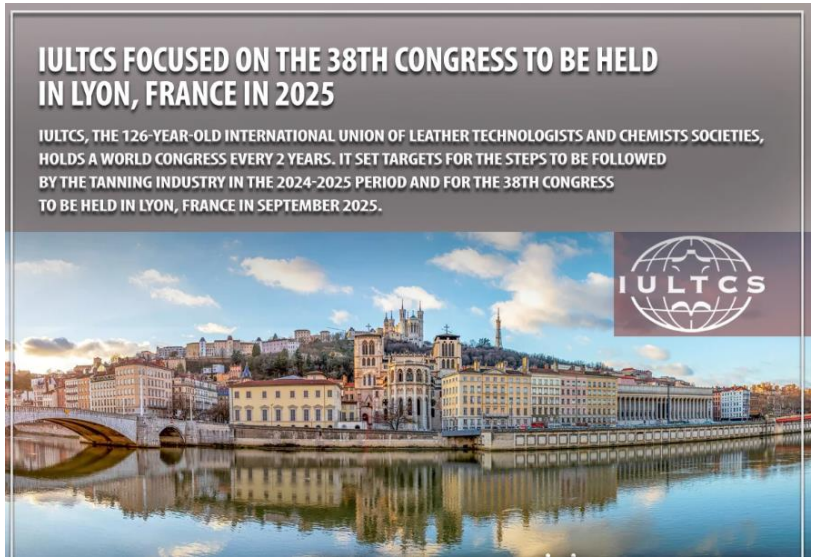
Yanting Deng

Yao Pu



Zhenyang Li

Yuan Zhao



Thanks

E-MAIL : xxy1229_sust@163.com

xxqqnn870304@163.com

TEL : 17349447565/1 5291486817