浙江大学
Zhejiang University

生物分析、生物医学工程与纳米技术国际会议
International Symposium on Bioanalysis, Biomedical Engineering and Nanotechnology

Biomimetic inter-connecting of graphene on fibrin fiber to prepare conductive multi-functional composites for biosensing

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May 25, 2018


Contents

- Food safety
- Our researches
- The fibrin-graphene composites case
- Conclusions

Some facts and data about food safety

Foodborne diseases encompass a wide spectrum of illnesses and are a growing public health problem worldwide (WHO, October 2017).

- Over 200 diseases are caused by unsafe food
- 1 in 10 people fall ill every year from eating contaminated food
- 420 000 people die each year as a result
- Children u… ith some 125 000 y… y year.

Detection!

USDA: U.S. Foodborne Illnesses Cost More Than $15.6 Billion Annually

Poses major economic risks, especially in a globalized world.

Germany's 2011 E.coli outbreak: US$ 1.3 billion in losses for farmers and industries; US$ 236 million in emergency aid payments to 22 European Union Member States.

Our biosensing researches

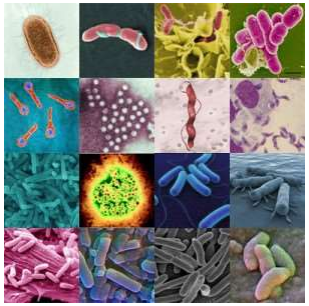
Immobilization

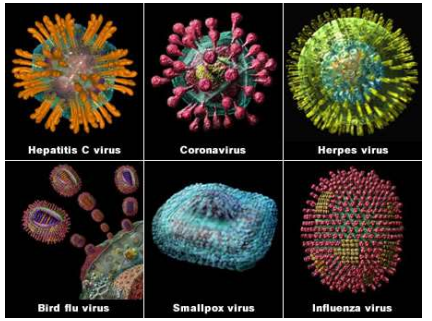
Biosensing

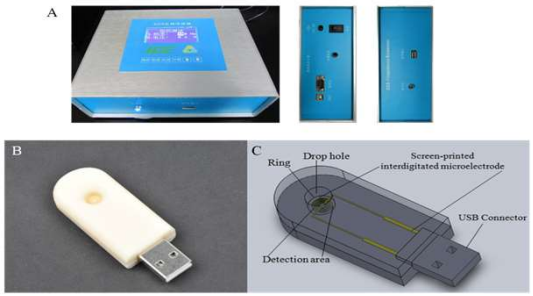
Technologies

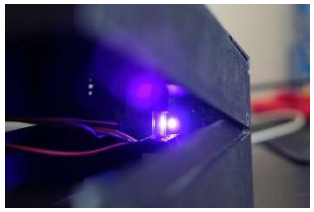
Instruments

J. Mater. Chem. A, 2018, 6, 3402;
J. Food Sci., 2018, 83, 756;
Anal. Chem., 2017, 89, 12145;
J. Phys. Chem. C, 2017, 121, 6229;
Electrochem. Commun., 2017, 79, 18;
Anal. Chem., 2016, 88, 8542;
Food Control, 2015, 56, 135;
Sci. Rep., 2015, 5;
Biosens. Bioelectron., 2014, 54, 64;
Anal. Chem., 2014, 86, 1965;
Adv. Funct. Mater. 2014, 24, 5011;
Chem. Eur. J., 2014, 20, 2623;
…





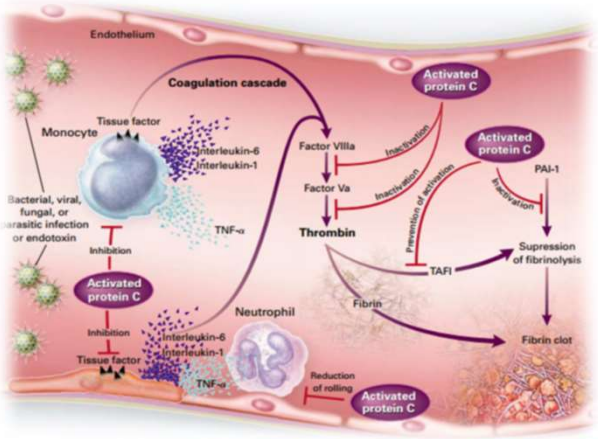




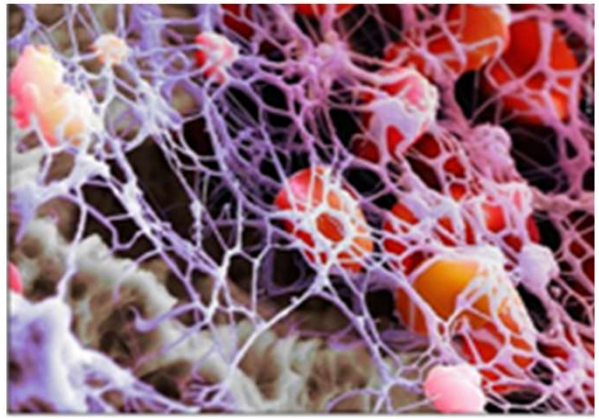
Biomimetics: inspiration of functional materials

Mussel adhesion

Blood coagulation

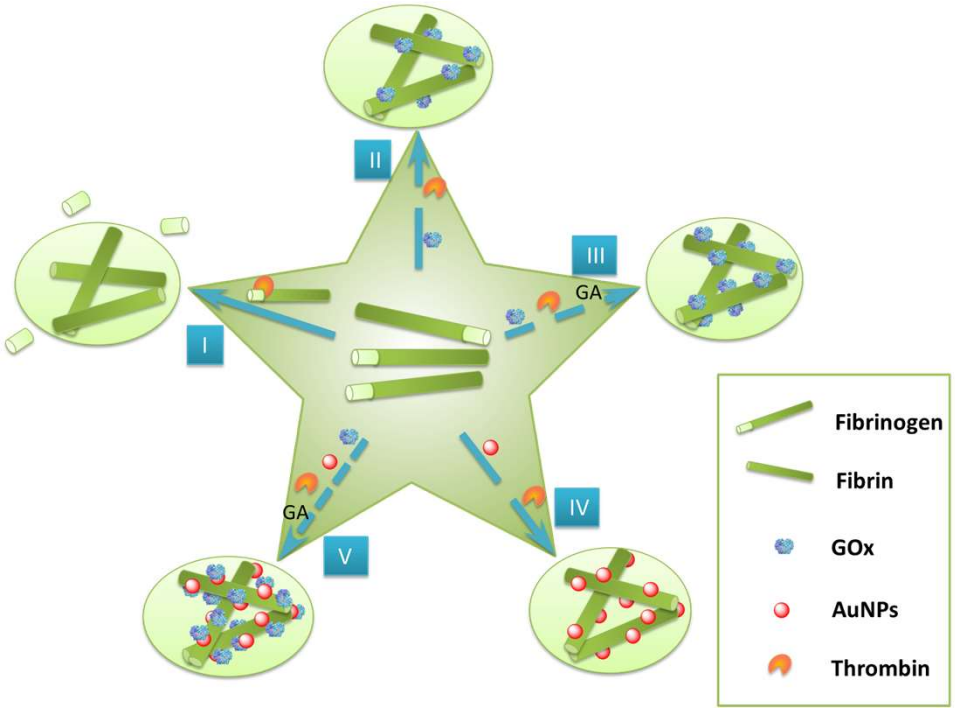


Biomineralization

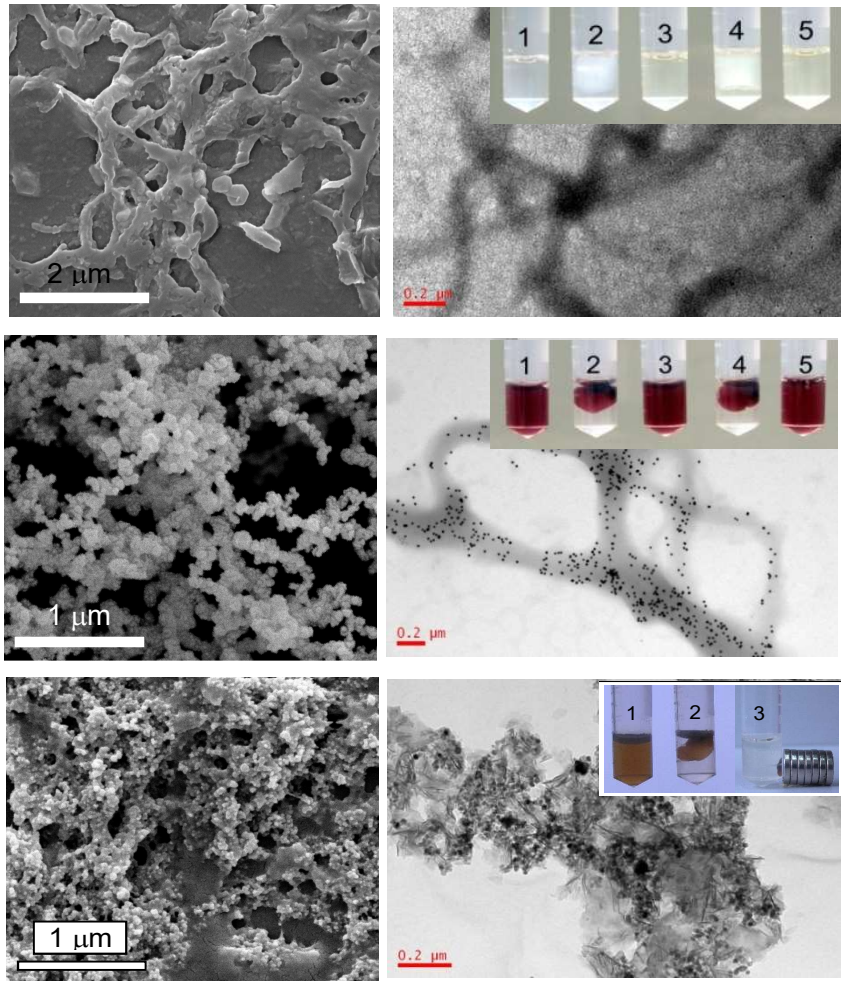


Adhesive 3-D fibrin fiber network

Blood coagulation-inspired immobilization matrices with high efficiency

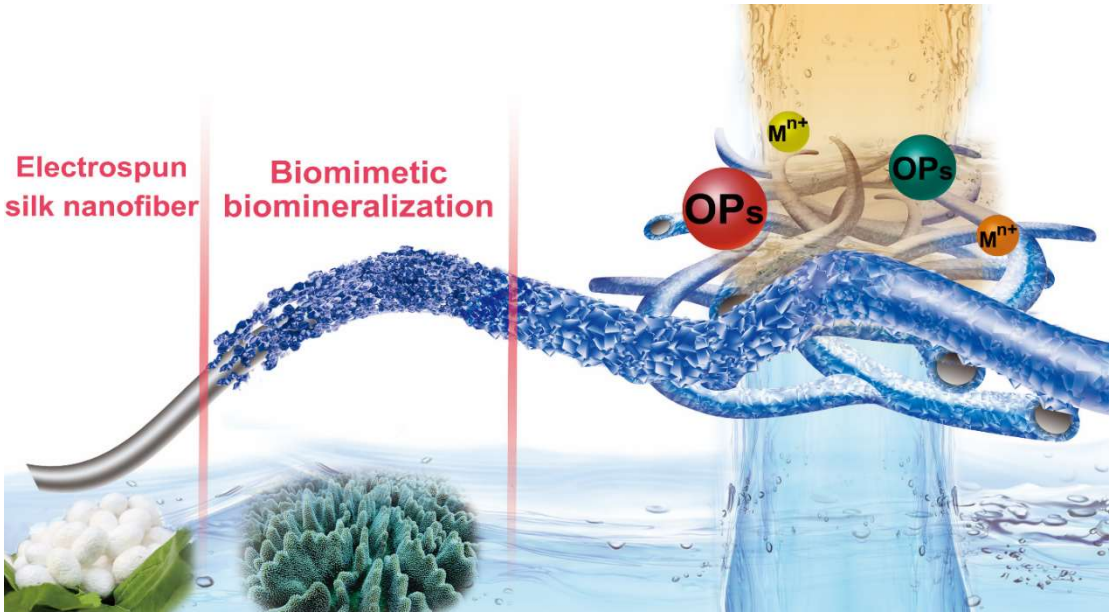


Loading rates:
Enzyme: 57%
Nanoparticles: 99%

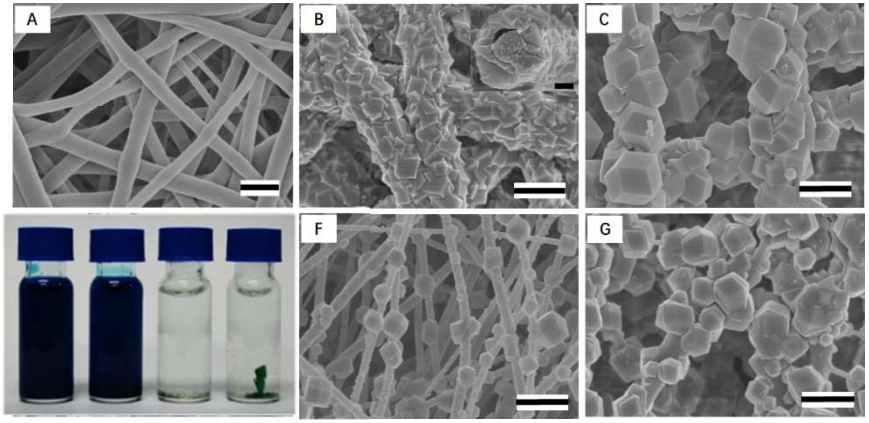


Adv. Funct. Mater. 2014, 24, 5011

Biomineralization-mimetic growth of metal-organic frameworks (MOFs) on silk nanofibers



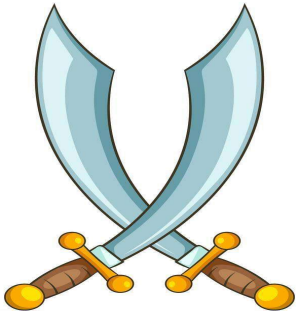
- **Loading rate of MOFs: 38%**
- **Adsorption rate of dye and heavy metal ions: 99%**



J. Mater. Chem. A, 2018, 6, 3402 (Front cover paper)

Protein-loaded conductive composites?

Protein: insulating
Bio-/chem-functions

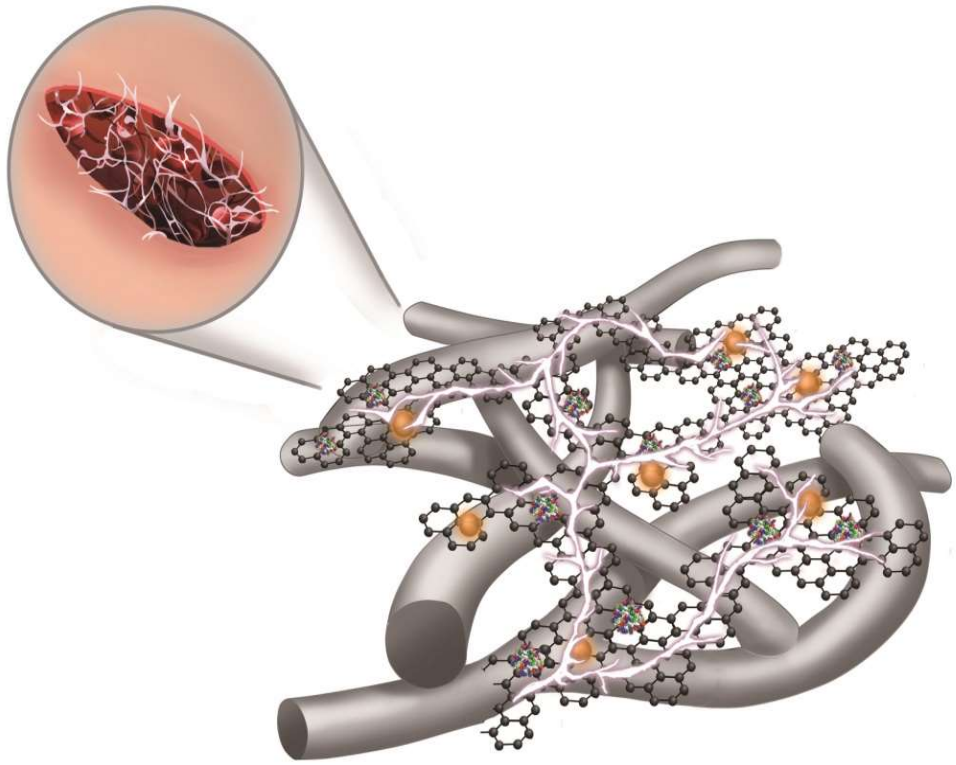


Conductivity:
Electrochemistry

Conductive composites

To be conductive → Linking of enough conductive materials
→ high loading rate + organized (assembled)

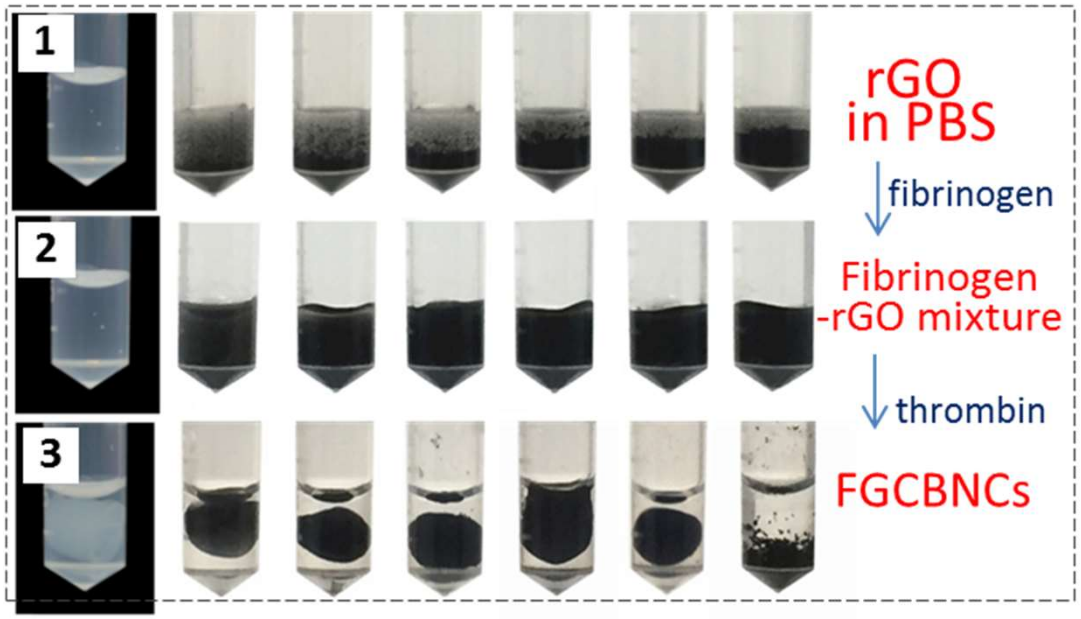
Blood coagulation-inspired inter-connecting of graphene on fibrin fiber to prepare conductive multi-functional composites

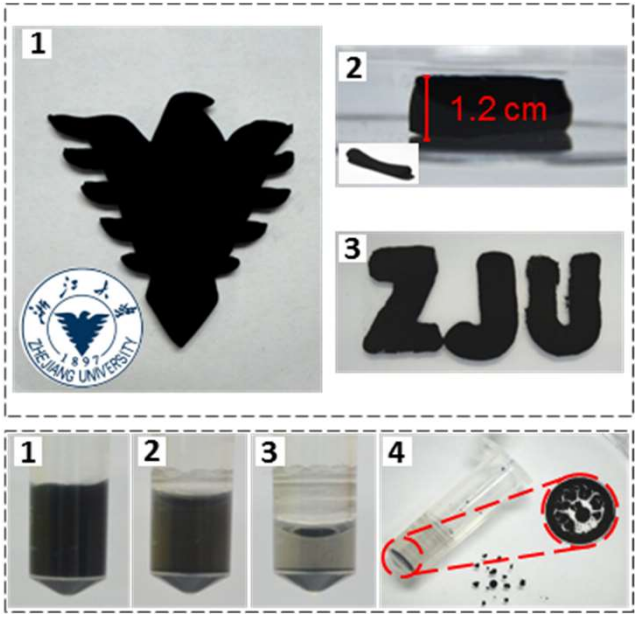


Loading + inter-connecting

Unpublished work

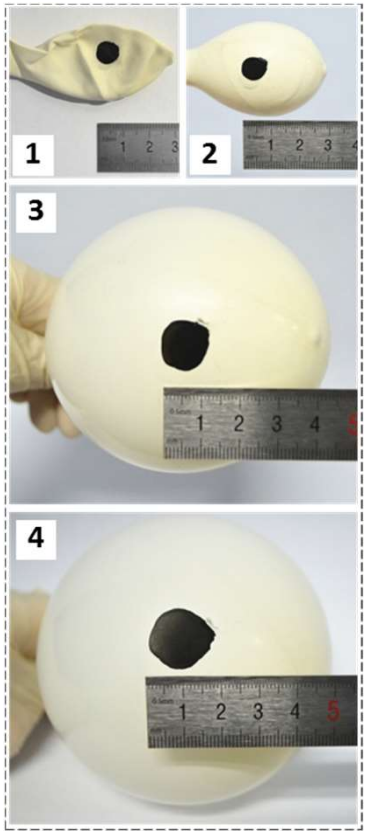
Preparation

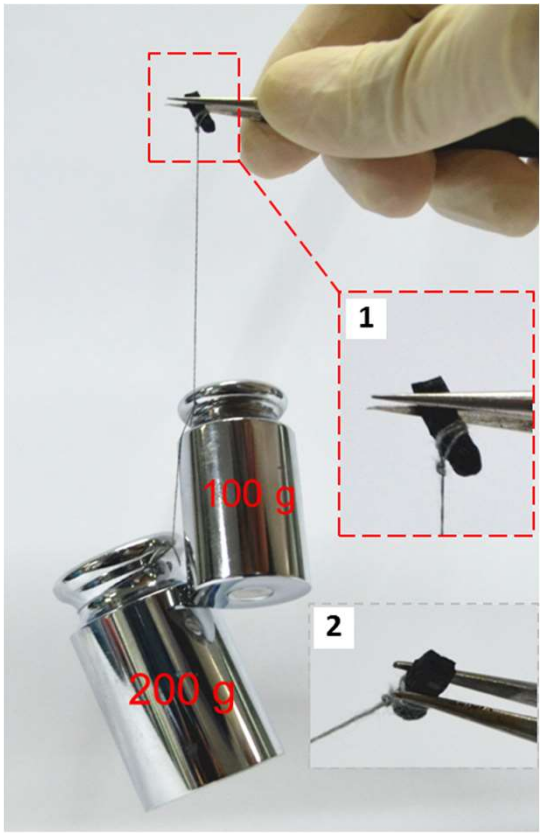


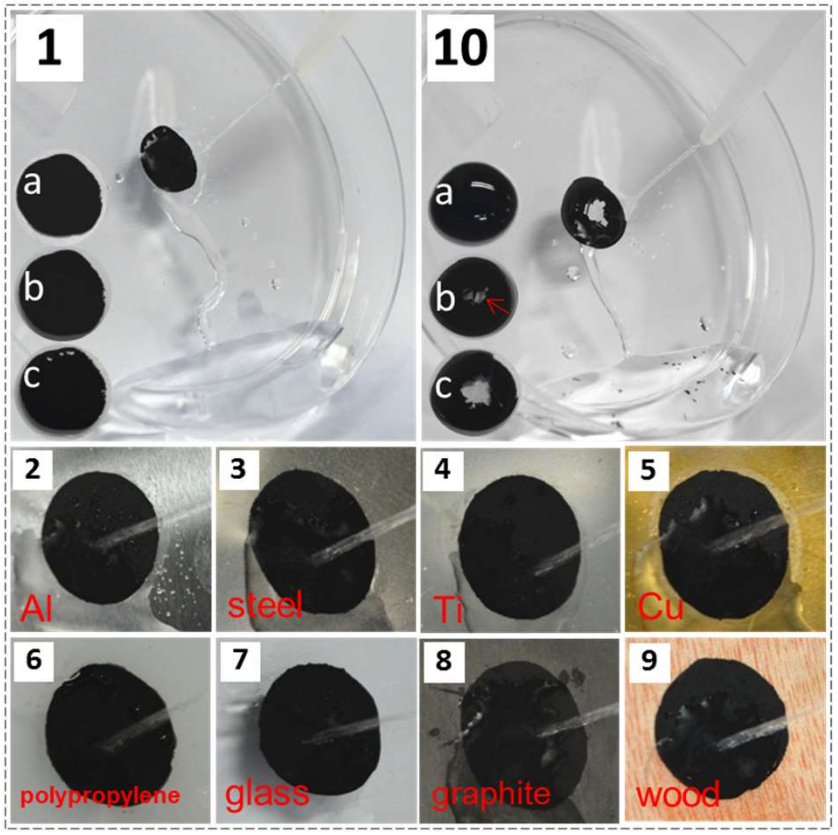


- Gel-like composites
- High-load of Graphene
- Easily modulated shapes

Characterizations: mechanical properties



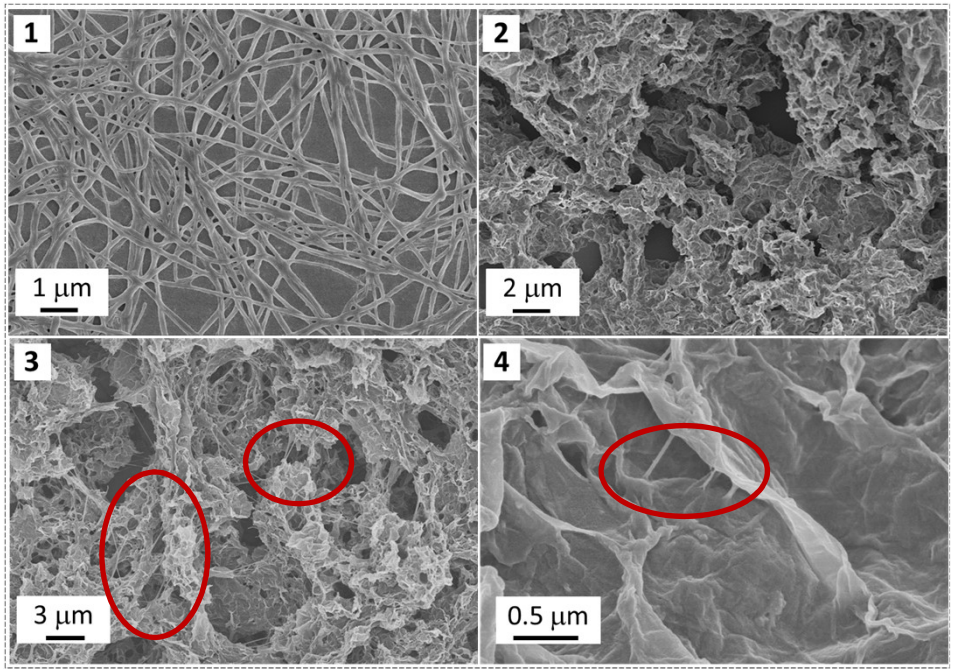


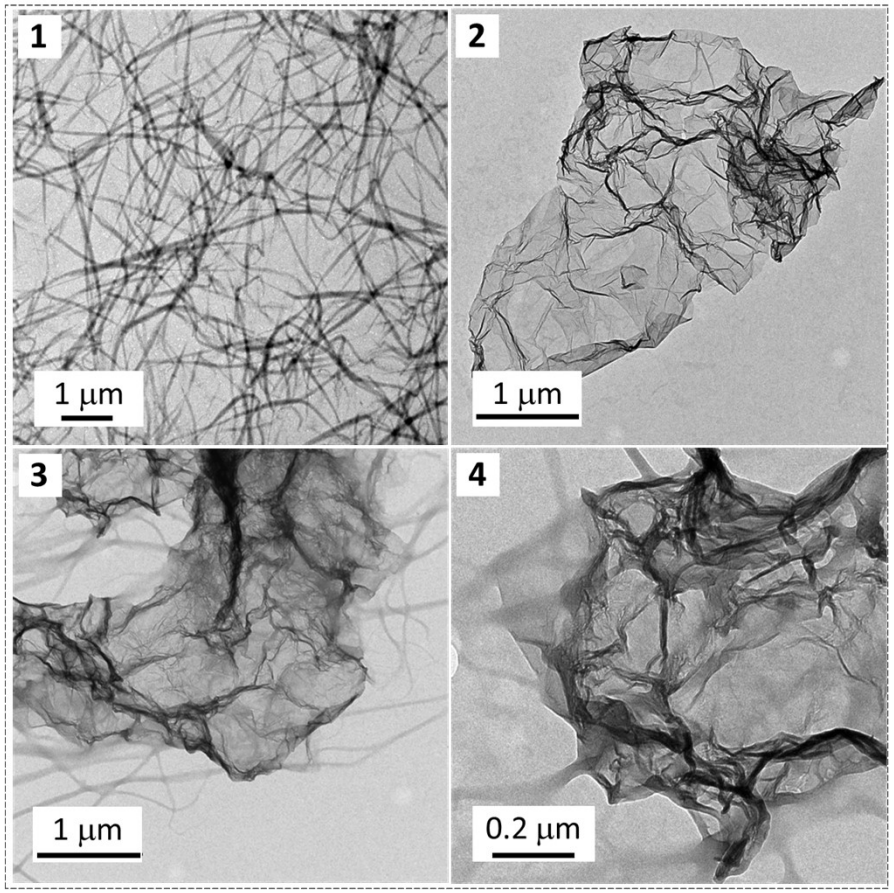


- Flexible in wet state
- Good mechanical strength in dry state
- High adhesion on various surfaces

Coating and modification

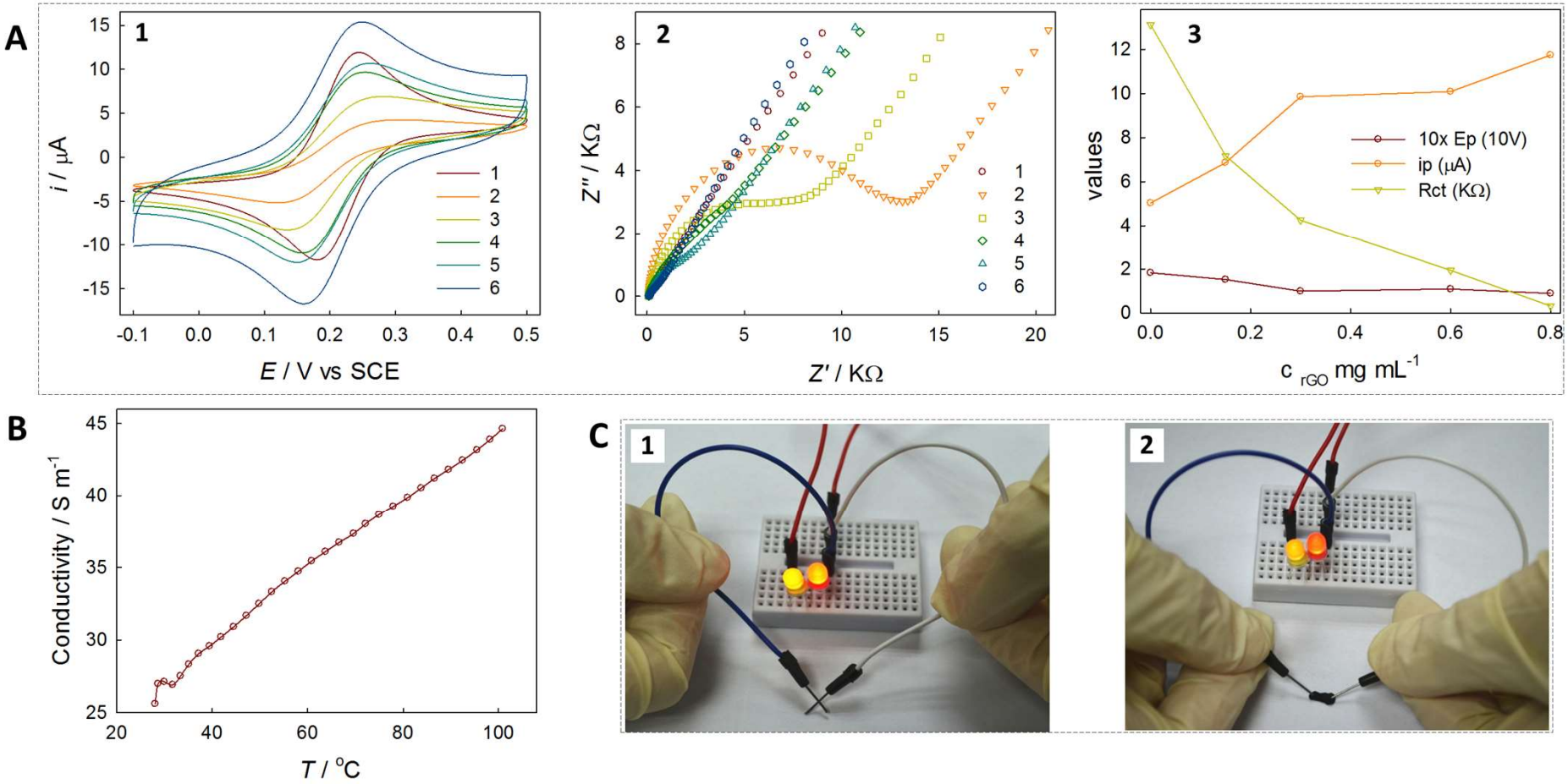
Characterizations: SEM and TEM





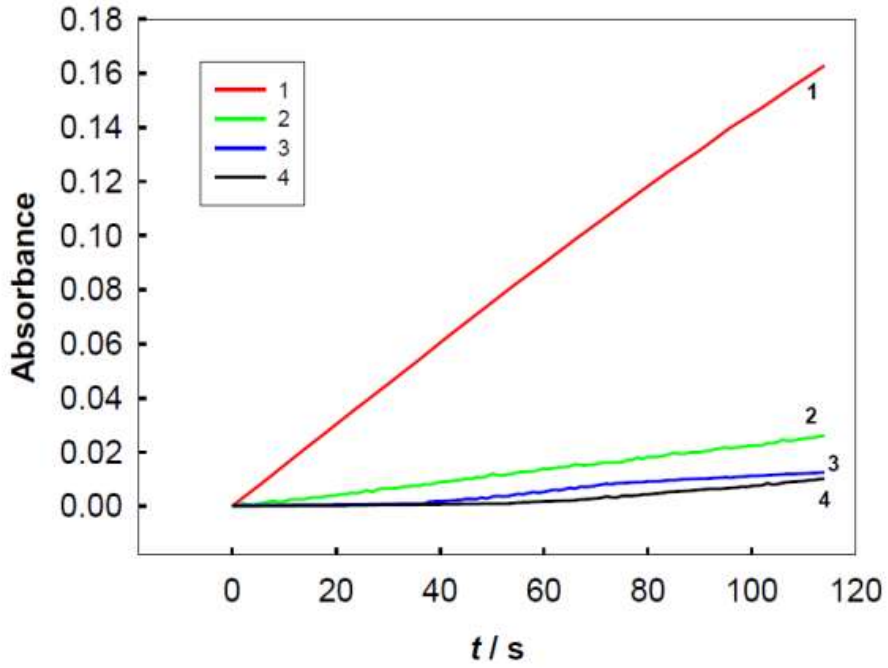
Loading + inter-connecting

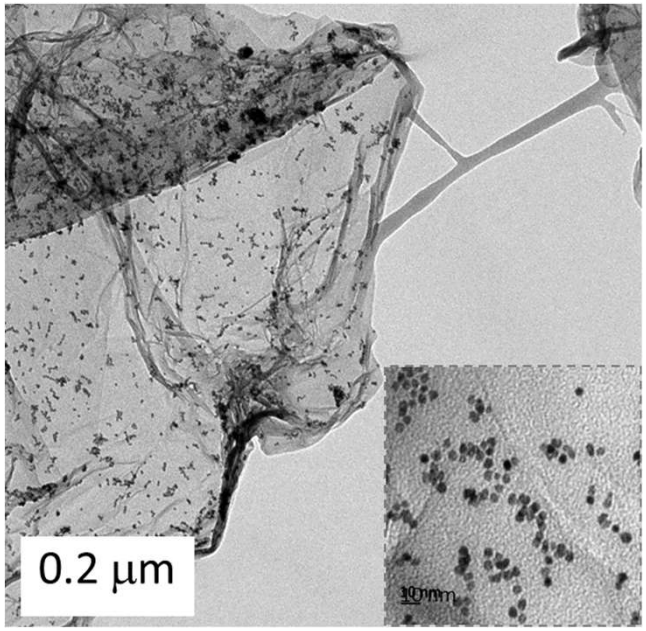
Characterizations: Conductivity



- Electrochemical activity comparable to that of bare electrode
- 27 S m^{-1} (close to protein-free conductive composites)

Characterizations: Loading rates

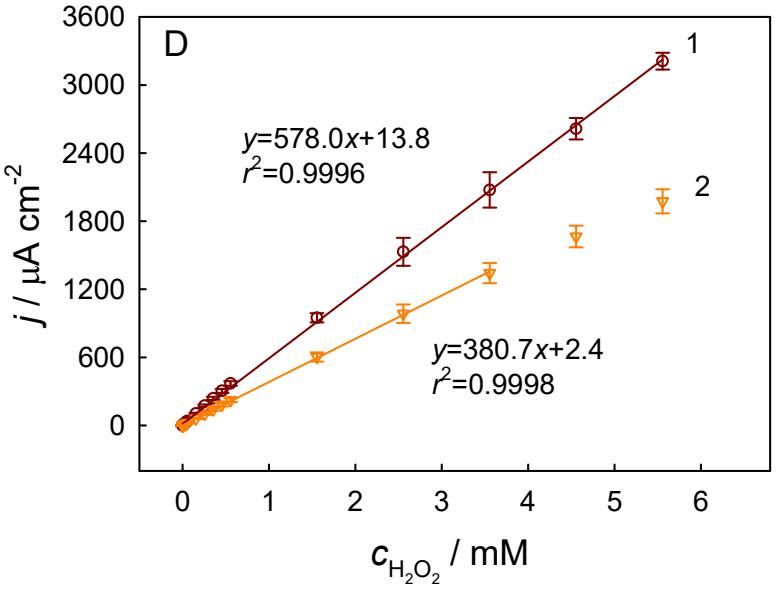


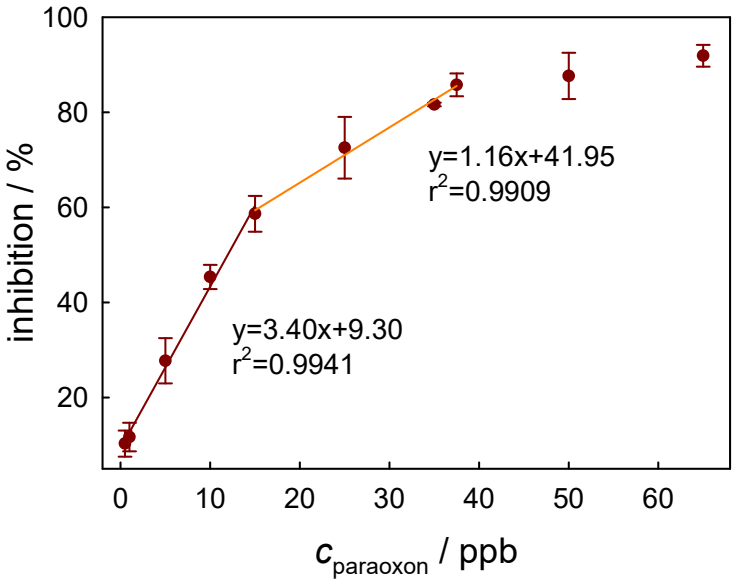


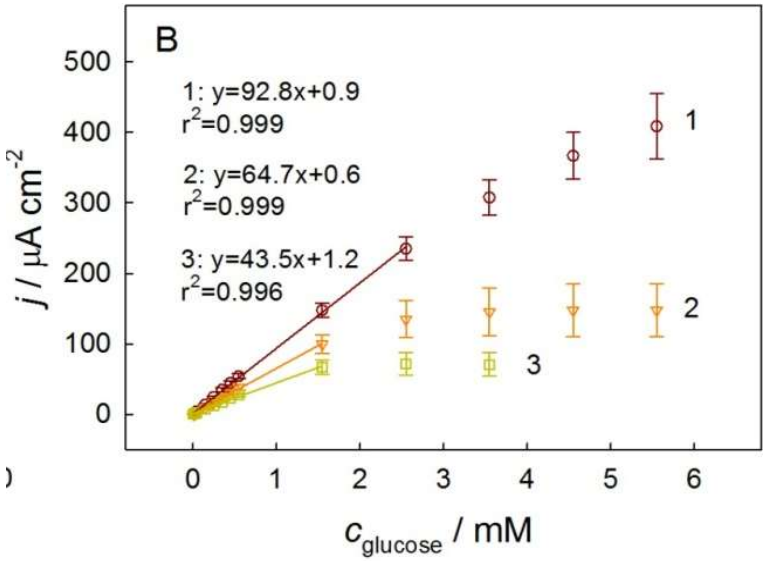
- Graphene: 100% (0.8 mg mL^{-1})
- Enzyme: 94% (1 mg mL^{-1})
- Pt nanoparticles: 90% (ten-fold concentrated)

All in the best range

Detection performance







Detection limits of H_2O_2, glucose and paraoxon are better than most analogues

Conclusions

- Biomimetics offers a great way to innovate multi-functional materials

- High loading and organization of conductive materials on protein fibers could be promising to develop conductive and multi-functional composites for electrochemical applications

Thanks to

Collaborators

Prof. Yibin Ying
Prof. Yanbin Li
Prof. Shouzhou Yao
Prof. Qingji Xie
Prof. Jianping Wang
…

Funders

中华人民共和国科学技术部
Ministry of Science and Technology of the People´s Republic of China

NSFC

Walmart Foundation

湖南大学 化学生物传感与计量学国家重点实验室
State Key Laboratory of Chemo/Biosensing and Chemometrics, Hunan University

Thank you