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# Nano Research

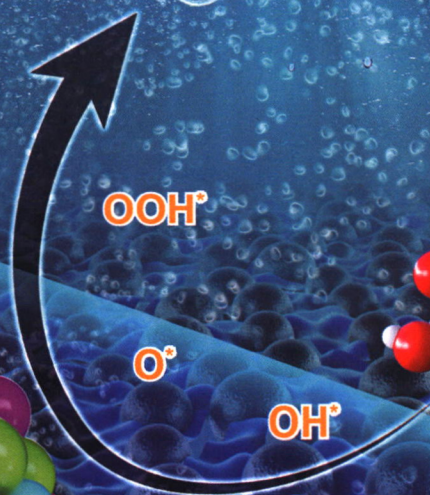
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Volume 15 · Number 10

Non-noble metal-based amorphous high-entropy oxides as efficient and reliable electrocatalysts for oxygen evolution reaction

A waterproof and breathable Cotton/rGO/CNT composite for constructing a layer-by-layer structured multifunctional flexible sensor

Highly-efficient thermoelectric-driven light-emitting diodes based on colloidal quantum dots



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# Contents

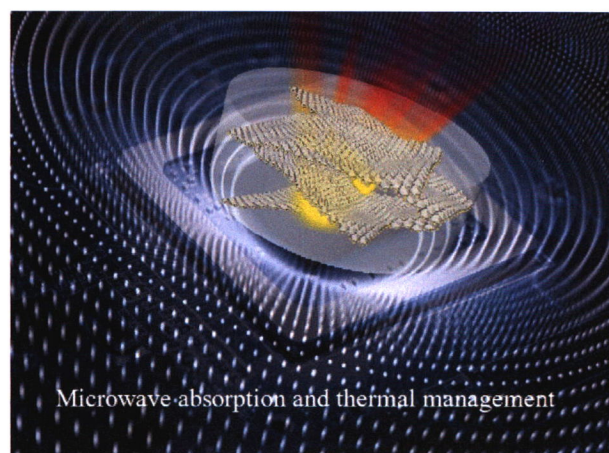
## Carbon

### Research Articles

#### Rationally tailoring interface characteristics of ZnO/amorphous carbon/graphene for heat-conduction microwave absorbers

Maofan Zhou, Xuefei Xu, Gengping Wan, Pengpeng Mou, Shengjie Teng, and Guizhen Wang\*

Hainan University, China



The highly uniform ZnO/amorphous carbon (ZnO/AC) hybrid films covered on the surface of graphene (ZnO/AC/Graphene) is innovatively reported to use as a heat-conduction microwave absorber. The uniform and controllable ZnO/AC coating synthesized with the auxiliary of atomic layer deposition technology can significantly improve the microwave absorption performance and thermal conduction properties of graphene.

8677–8687

#### Pomegranate micro/nano hierarchical plasma structure for superior microwave absorption

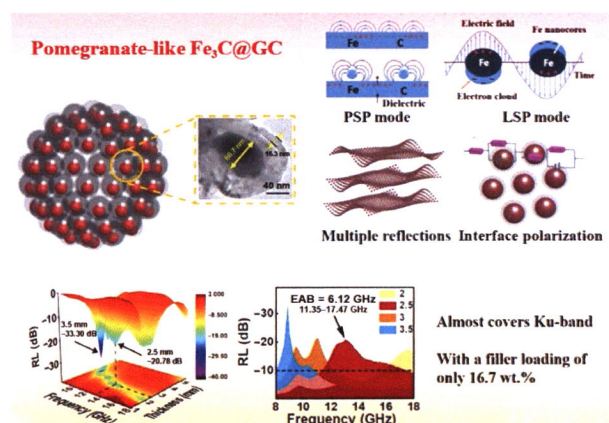
Chunyan Ding<sup>1,4</sup>, Tao Wu<sup>1,\*</sup>, Xinsen Hu<sup>1</sup>, Chengshuai Shao<sup>1</sup>, Zhipeng Xu<sup>1</sup>, Hui Fu<sup>1</sup>, Songsong Wu<sup>1,3,\*</sup>, Guangwu Wen<sup>1,3,4</sup>, and Xiaoxiao Huang<sup>2,\*</sup>

<sup>1</sup> Shandong University of Technology, China

<sup>2</sup> Harbin Institute of Technology, China

<sup>3</sup> Shandong Industrial Ceramics Research & Design Institute Co., Ltd., China

<sup>4</sup> Shandong Institute of Advanced Ceramic Co., Ltd., China



VSe<sub>2-x</sub> presents stronger adsorption towards lithium polysulfides due to selenium vacancies and shows the bidirectional catalysis towards the sulfur redox reactions.

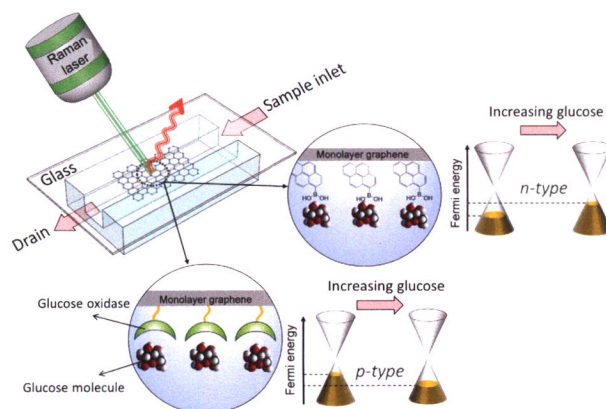
8688–8696



## Glucose measurement via Raman spectroscopy of graphene: Principles and operation

Alireza Ahmadianyazdi, Ngoc Hoang Lan Nguyen, Jie Xu, and Vikas Berry\*

University of Illinois at Chicago, USA



A graphene Raman spectroscopy-based sensor (GRS) is introduced to detect glucose molecules at the graphene's interface with a liquid medium. Upon increasing glucose concentration, Fermi energy of graphene functionalized with 1-pyrene boronic acid (PBA) increases, while it decreases when graphene is functionalized with glucose oxidase (GOx) enzymes.

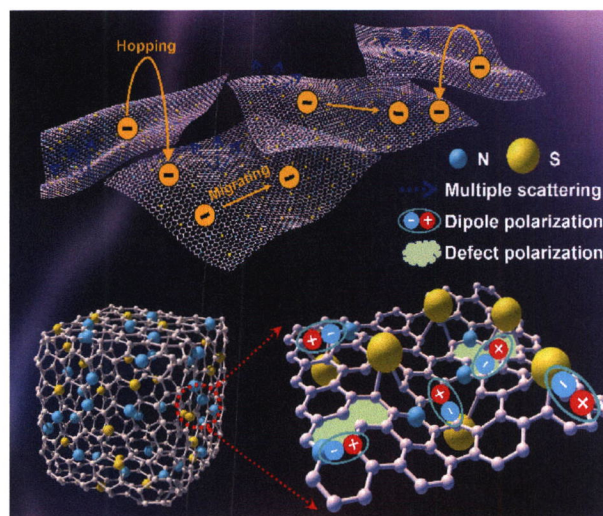
8697–8704

## Heteroatoms-doped carbon nanocages with enhanced dipolar and defective polarization toward light-weight microwave absorbers

Hanxiao Xu<sup>1</sup>, Guozheng Zhang<sup>1</sup>, Yi Wang<sup>1</sup>, Yiruo Wang<sup>1</sup>, Huanlei Wang<sup>2,\*</sup>, Ying Huang<sup>1</sup>, and Panbo Liu<sup>1,\*</sup>

<sup>1</sup> Northwestern Polytechnical University, China

<sup>2</sup> Ocean University of China, China



Hollow engineering decreases the complex permittivity and simultaneously promotes impedance characteristics, and doped heteroatoms generate additional dipole polarization, both of them result in superior microwave absorption.

8705–8713



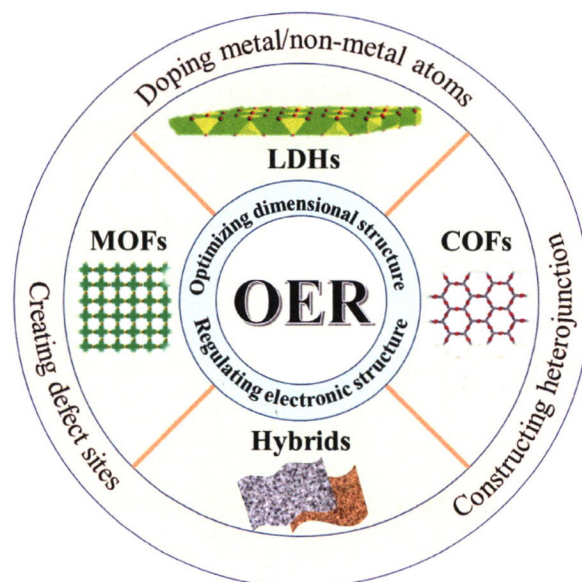
## Review Article

## Advances and challenges in two-dimensional materials for oxygen evolution

Tianmi Tang<sup>1</sup>, Saisai Li<sup>2</sup>, Jianrui Sun<sup>2</sup>, Zhenlu Wang<sup>1</sup>, and Jingqi Guan<sup>1,\*</sup>

<sup>1</sup> Jilin University, China

<sup>2</sup> Changchun University of Technology, China



This review introduces various synthesis methods of two-dimensional materials (including layered double hydroxides, metal-organic frameworks and their derivatives, covalent-organic frameworks, graphene, and black phosphorus), characterization techniques, and novel strategies (including metal/nonmetal doping, defect engineering, interface engineering, lattice strain, and fabrication of heterojunction) for improving the oxygen evolution reaction performance. Thereinto, the structure–function relationship is emphatically analyzed to gain deeper insight into the reaction mechanism and provide guidance for designing more efficient oxygen evolution reaction (OER) electrocatalysts.

8714–8750

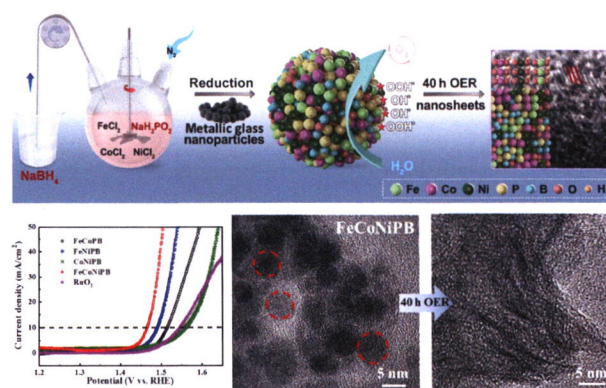
## Research Articles

## Non-noble metal-based amorphous high-entropy oxides as efficient and reliable electrocatalysts for oxygen evolution reaction

Qianqian Wang<sup>1,2</sup>, Jiaqi Li<sup>1</sup>, Yongjie Li<sup>1</sup>, Genmiao Shao<sup>1</sup>, Zhe Jia<sup>1</sup>, and Baolong Shen<sup>1,\*</sup>

<sup>1</sup> Southeast University, China

<sup>2</sup> Nanjing Institute of Technology, China



FeCoNiPB non-noble metal-based amorphous high-entropy oxides exhibit an outstanding oxygen evolution reaction (OER) catalytic performance. The superior OER electrocatalytic efficiency and stability of the FeCoNiPB oxides are primarily attributed to its unique amorphous high-entropy nanostructure, synergistic effects of the multiple components, and *in situ*-formed amorphous sheets with a thin (FeCoNi)OOH crystalline layer on the edge during long-term OER.

8751–8759



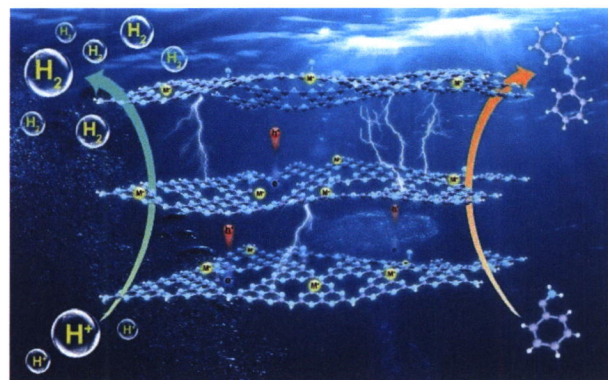
## Defect-rich ultrathin poly-heptazine-imide-framework nanosheets with alkali-ion doping for photocatalytic solar hydrogen and selective benzylamine oxidation

Chaofeng Zhu<sup>1</sup>, Xiao Luo<sup>1</sup>, Congyan Liu<sup>1</sup>, Yang Wang<sup>1,2</sup>, Xihai Chen<sup>1</sup>, Yan Wang<sup>1</sup>, Qing Hu<sup>1</sup>, Xiaojun Wu<sup>1,\*</sup>, and Bo Liu<sup>1,\*</sup>

<sup>1</sup> University of Science and Technology of China, China

<sup>2</sup> Max Planck Institute of Colloids and Interfaces, Germany

8760–8770



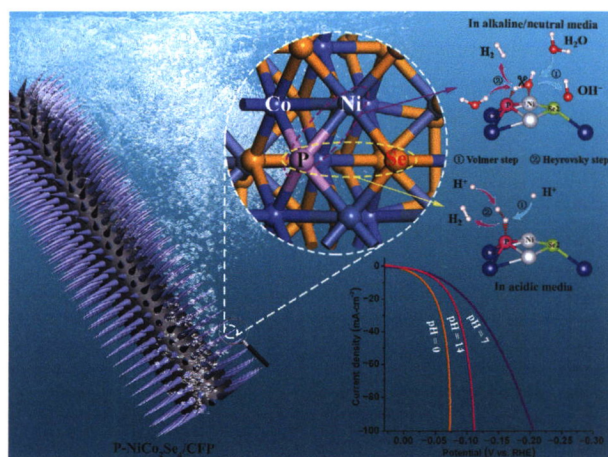
A facile salt template-assisted interfacial polymerization strategy is proposed for *in-situ* introducing defective sites and alkali ions in carbon nitride to promote charge separation and transportation. The obtained v-CN-KNa (CN = carbon nitride) not only shows superior photocatalytic hydrogen evolution reaction (HER) performance in real seawater, but also can simultaneously produce H<sub>2</sub> and N-benzylidenebenzylamine without using any sacrificial reagent.

## Phosphorus-induced electronic structure reformation of hollow NiCo<sub>2</sub>Se<sub>4</sub> nanoneedle arrays enabling highly efficient and durable hydrogen evolution in all-pH media

Guojing Wang, Yuzhuo Sun, Yidan Zhao, Yang Zhang, Xiaohong Li, Louzhen Fan, and Yunchao Li\*

Beijing Normal University, China

8771–8782



P<sub>8.71</sub>-NiCo<sub>2</sub>Se<sub>4</sub>/CFP hollow nanoneedle arrays grown on carbon fiber paper were first synthesized, which exhibit an outstanding hydrogen evolution reaction (HER) performance and good durability in all-pH media due to the optimized electronic structure and the increased active sites induced by the P doping.

## Ultrathin covalent organic framework nanosheet-based photoregulated metal-free oxidase-like nanozyme

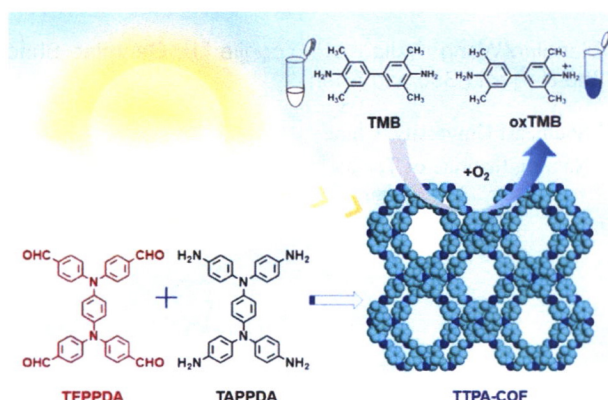
Yongwu Peng<sup>1,4</sup>, Minchu Huang<sup>1</sup>, Liangjun Chen<sup>1</sup>, Chengtao Gong<sup>1</sup>, Nanjun Li<sup>1</sup>, Ying Huang<sup>2,\*</sup>, and Changming Cheng<sup>3,\*</sup>

<sup>1</sup> Zhejiang University of Technology, China

<sup>2</sup> Southwest University of Science and Technology, China

<sup>3</sup> China Academy of Engineering Physics (CAEP), China

<sup>4</sup> Yancheng Teachers University, China



By using flexible photoactive building units, ultrathin covalent organic framework nanosheets are designed as novel photoregulated metal-free oxidase-like nanozyme, which can effectively catalyze the oxidation of 3,3',5,5'-tetramethylbenzidine (TMB) under light irradiation in the presence of O<sub>2</sub>.

8783–8790

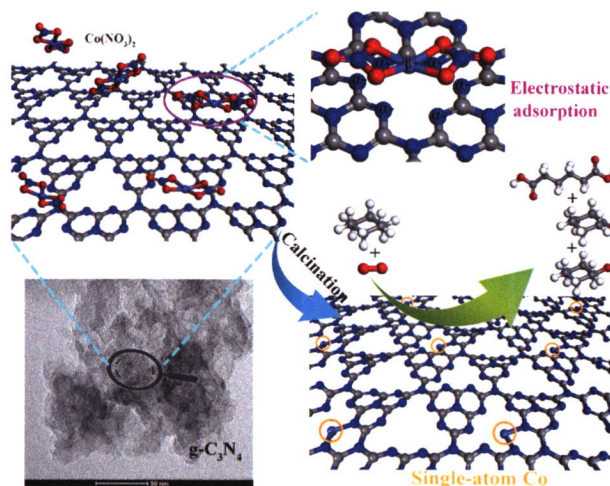


### Ultralow-loading single-atom cobalt on graphitic carbon nitrogen with robust Co-N pairs for aerobic cyclohexane oxidation

Enxian Yuan<sup>1,\*</sup>, Meixia Zhou<sup>1</sup>, Guojun Shi<sup>1</sup>, Panming Jian<sup>1</sup>, and Xu Hou<sup>2,\*</sup>

<sup>1</sup> Yangzhou University, China

<sup>2</sup> Changchun University of Technology, China



A series of single-atom Co/g-C<sub>3</sub>N<sub>4</sub>-w catalysts, possessing the ultralow Co loading of below 1.0 wt.%, were prepared by the adsorption method. Co/g-C<sub>3</sub>N<sub>4</sub>-0.9 exhibited the superior catalytic performance for the solvent-free cyclohexane oxidation with the 23.8% conversion, 95.6% selectivity, and excellent stability.

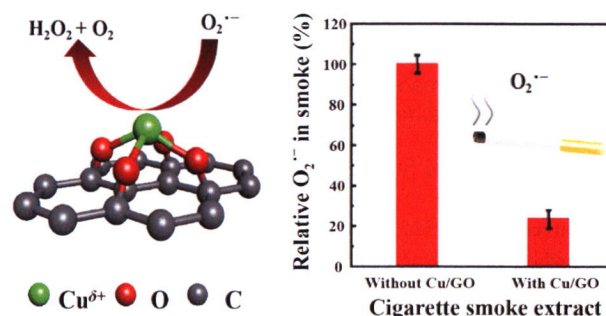
8791–8803

### Superoxide-like Cu/GO single-atom catalysts nanozyme with high specificity and activity for removing superoxide free radicals

Mingju Lu<sup>1</sup>, Jialu Wang<sup>1</sup>, Guoyuan Ren<sup>1</sup>, Fengjuan Qin<sup>2</sup>, Zhiqiang Zhao<sup>1</sup>, Kai Li<sup>1</sup>, Wenxing Chen<sup>2,\*</sup>, and Yuqing Lin<sup>1,\*</sup>

<sup>1</sup> Capital Normal University, China

<sup>2</sup> Beijing Institute of Technology, China



Inspired by the structure of natural superoxide dismutase (SOD), we synthesized graphene oxide-supported Cu single-atom catalysts (Cu/GO SACs, GO = graphene oxide) through the simple and easy-to-operate ultrasound method at room temperature. The Cu/GO SACs exhibit excellent SOD-like enzyme performance, but do not possess the properties of other common redox enzymes, and show even higher catalytic ability by 31% than natural enzymes.

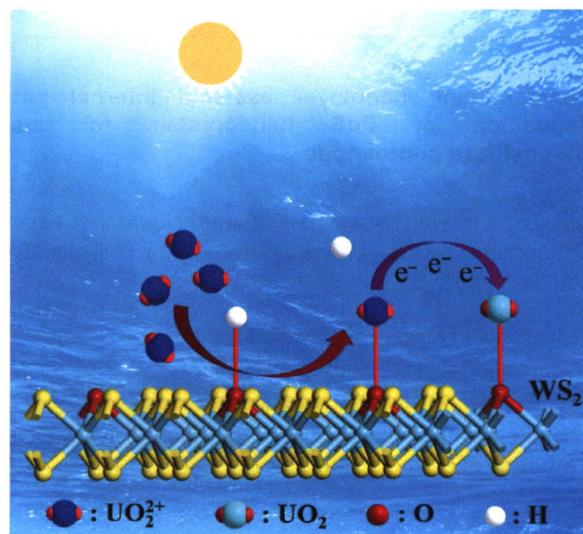
8804–8809

### In-situ oxidized tungsten disulfide nanosheets achieve ultrafast photocatalytic extraction of uranium through hydroxyl-mediated binding and reduction

Huanhuan Liu<sup>1</sup>, Jia Lei<sup>1</sup>, Changyao Gong<sup>1</sup>, Ye Li<sup>1</sup>, Huimei Chen<sup>2</sup>, Jiali Chen<sup>1</sup>, Fengchun Wen<sup>1</sup>, Dengjiang Fu<sup>1</sup>, Yan Liu<sup>2,\*</sup>, Wenkun Zhu<sup>1,\*</sup>, and Rong He<sup>1,\*</sup>

<sup>1</sup> Southwest University of Science and Technology, China

<sup>2</sup> Anhui Normal University, China



The oxidized surface tended to trap hydrogen atom and *in-situ* form hydroxyl groups in defect sites. The *in-situ* formed hydroxyl groups were participated in the uranium reduction, which dramatically enhanced uranium extraction kinetics and efficiency.

8810–8818



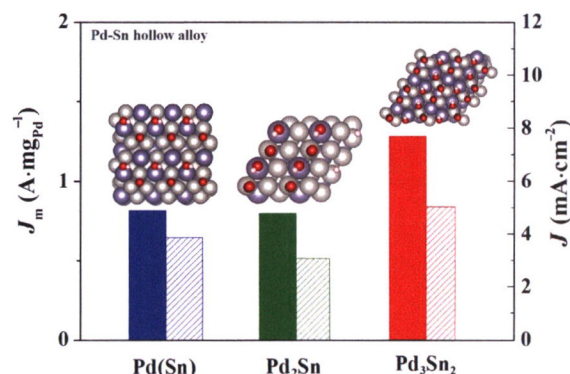
## Pd-Sn alloy nanoparticles for electrocatalytic methanol oxidation: Phase evolution from solid solution to intermetallic compounds

Jinna Xue<sup>1</sup>, Zheng Hu<sup>1,\*</sup>, Hui Li<sup>1,2</sup>, Yu Zhang<sup>1,2</sup>, Chang Liu<sup>1</sup>, Min Li<sup>1</sup>, Qiuhua Yang<sup>1,\*</sup>, and Shi Hu<sup>1,2,\*</sup>

<sup>1</sup> Tianjin University, China

<sup>2</sup> Hefei Comprehensive National Science Center, China

8819–8825



The Pd-Sn alloy realizes the phase transition from solid solution to intermetallic compound, in which Pd<sub>3</sub>Sn<sub>2</sub> exhibits excellent methanol oxidation reaction (MOR) performance. And then density functional theory (DFT) calculations show that the surface structure has a great influence on the performance.

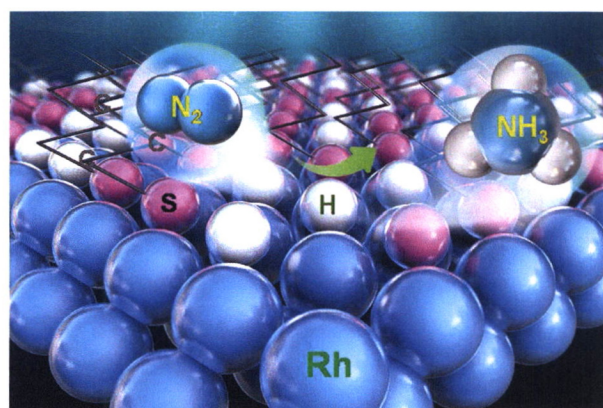
## Interfacial engineering of metallic rhodium by thiol modification approach for ambient electrosynthesis of ammonia

Meng Jin<sup>1,2</sup>, Xinyuan Zhang<sup>1,2</sup>, Xian Zhang<sup>1,2,\*</sup>, Hongjian Zhou<sup>1,2</sup>, Miaomiao Han<sup>3</sup>, Yunxia Zhang<sup>1,2</sup>, Guozhong Wang<sup>1,2</sup>, and Haimin Zhang<sup>1,2,\*</sup>

<sup>1</sup> Institute of Solid State Physics, HFIPS, Chinese Academy of Sciences, China

<sup>2</sup> University of Science and Technology of China, China

<sup>3</sup> Huzhou University, China



A comprehensive understanding of controlling the surface environment toward nitrogen reduction reaction performance combined with experimental and theoretical studies over different dodecanethiol coverages Rh catalysts, revealed the synthetical effect of metal–organic interface and H\* coverage on the electrochemical NRR activity.

8826–8835

## Polydopamine nanolayer assisted internal photo-deposition of CdS nanocrystals for stable cosensitized photoanode

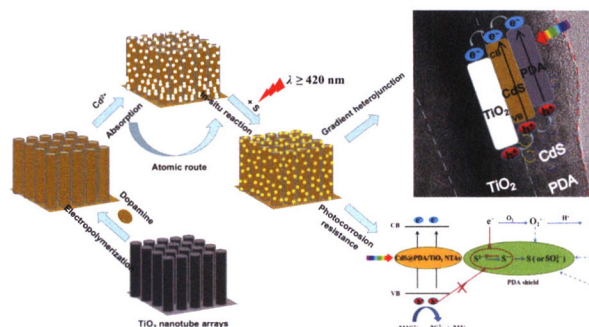
Na Li<sup>1</sup>, Lu Han<sup>1,\*</sup>, Hainan Zhang<sup>1</sup>, Juntong Huang<sup>2</sup>, Xudong Luo<sup>1</sup>, Xibao Li<sup>2,\*</sup>, Yuanhao Wang<sup>3,\*</sup>, Weiqi Qian<sup>4</sup>, and Ya Yang<sup>4,\*</sup>

<sup>1</sup> University of Science and Technology Liaoning, China

<sup>2</sup> Nanchang Hangkong University, China

<sup>3</sup> Southern University of Science and Technology, China

<sup>4</sup> Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences, China



Sandwich structured CdS@PDA/TiO<sub>2</sub> nanotube arrays (NTAs) synthesized via an ingenious four-step synthesis process exhibit enhanced and stable photo-electro-chemical (PEC) performance under light irradiation, which can be attributed to co-photosensitization, optimized photogenerated charge transfer, transport route arising from CdS embedding, and inhibition of CdS photocorrosion covered by polydopamine (PDA) shelter. This advance bodes well for the development of PEC field founded on multifunctional PDA.

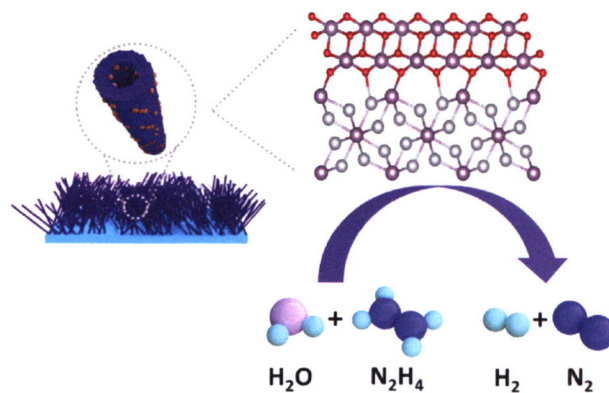
8836–8845



### Reduction-induced interface reconstruction to fabricate MoNi<sub>4</sub>-based hollow nanorods for hydrazine oxidation assisted energy-saving hydrogen production in seawater

Lili Guo, Qingping Yu, Xuejun Zhai, Jingqi Chi\*, Tong Cui, Yu Zhang, Jianping Lai, and Lei Wang\*

Qingdao University of Science and Technology, China



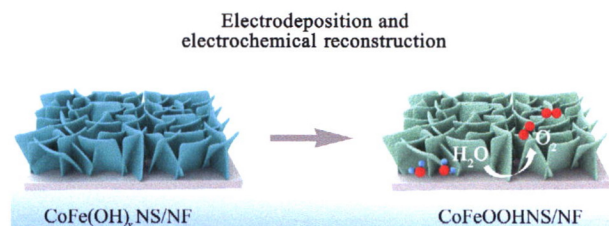
The MoNi alloys supported on MoO<sub>2</sub> nanorods with enlarged hollow diameter on Ni foam (MoNi@NF) are synthesized, which is constructed by limiting the outward diffusion of Ni via annealing and thermal reduction of NiMoO<sub>4</sub> nanorods. When coupling hydrazine oxidation reaction (HzOR) and hydrogen evolution reaction (HER) by employing MoNi@NF as both anode and cathode in a two-electrode seawater system, a low cell voltage of 0.54 V is required to achieve 1,000 mA·cm<sup>-2</sup>, with long-term durability for 100 h to keep above 100 mA·cm<sup>-2</sup> and nearly 100% Faradaic efficiency.

8846–8856

### Synergizing high valence metal sites and amorphous/crystalline interfaces in electrochemical reconstructed CoFeOOH heterostructure enables efficient oxygen evolution reaction

Xiangjian Liu, Rui Liu, Jinming Wang, Yarong Liu, Liuhua Li, Wenxiu Yang\*, Xiao Feng, and Bo Wang\*

Beijing Institute of Technology, China



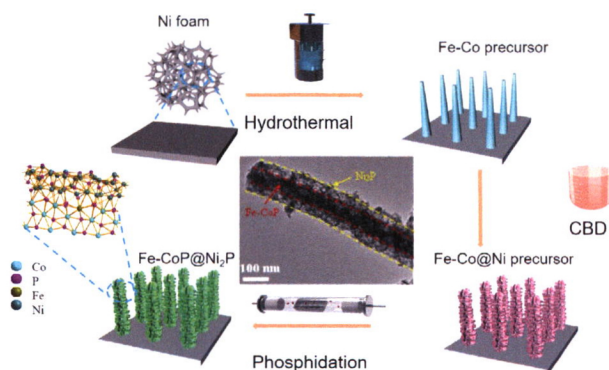
The CoFeOOH nanosheet/Ni foam (CoFeOOHNS/NF) with abundant high valence metal and amorphous/crystalline heterostructure interfaces was prepared by an electrochemical reconstructed method. The resulting CoFeOOHNS/NF electrode exhibited excellent oxygen evolution reaction (OER) performance and comparable water splitting activity in alkaline solution.

8857–8864

### Bifunctional Fe-doped CoP@Ni<sub>2</sub>P heteroarchitectures for high-efficient water electrocatalysis

Zhongxin Duan, Depeng Zhao, Yuchen Sun, Xiaojie Tan, and Xiang Wu\*

Shenyang University of Technology, China



In this work, we have prepared a high-efficient electrocatalyst by constructing a heterogeneous structure and cation doping.

8865–8871

## Confined interface engineering of self-supported Cu@N-doped graphene for electrocatalytic CO<sub>2</sub> reduction with enhanced selectivity towards ethanol

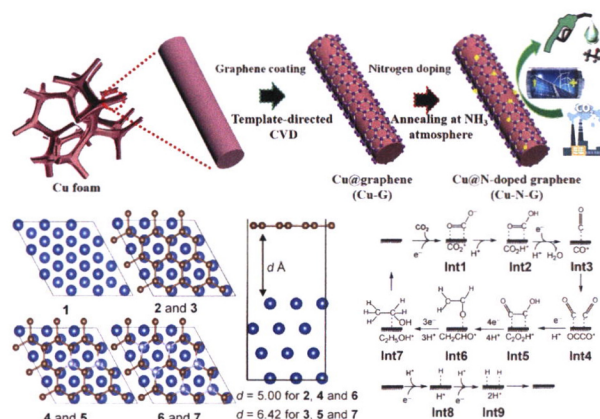
Dejin Zang<sup>1,\*</sup>, Xuejiao J. Gao<sup>3</sup>, Leyun Li<sup>3</sup>, Yongge Wei<sup>4</sup>, and Haiqing Wang<sup>2,\*</sup>

<sup>1</sup> Shandong First Medical University & Shandong Academy of Medical Sciences, China

<sup>2</sup> University of Jinan, China

<sup>3</sup> Jiangxi Normal University, China

<sup>4</sup> Tsinghua University, China



Self-supported Cu@N-doped graphene framework was prepared through template-directed chemical vapour deposition (CVD). Confined interface engineering was proved to be effective in promoting C<sub>2</sub>-ethanol selectivity in CO<sub>2</sub> reduction reaction (CO<sub>2</sub>RR).

8872–8879

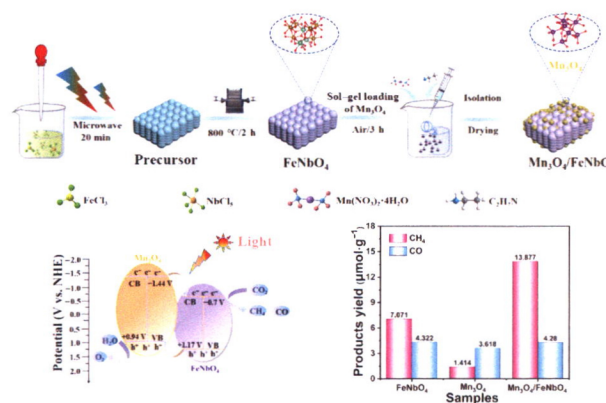
## A core-satellite structured type II heterojunction photocatalyst with enhanced CO<sub>2</sub> reduction under visible light

Yuanyuan Cheng<sup>1</sup>, Yixian Liu<sup>1</sup>, Yunliang Liu<sup>1</sup>, Yaxi Li<sup>1</sup>, Ruqiang Wu<sup>1</sup>, Yongchao Du<sup>1</sup>, Najmeh Askari<sup>1</sup>, Naiyun Liu<sup>1</sup>, Fen Qiao<sup>1</sup>, Chenghua Sun<sup>2,\*</sup>, Zhenhui Kang<sup>3,\*</sup>, and Haitao Li<sup>1,\*</sup>

<sup>1</sup> Jiangsu University, China

<sup>2</sup> Swinburne University of Technology, Australia

<sup>3</sup> Soochow University, China



A facile microwave-related synthesis method of Mn<sub>3</sub>O<sub>4</sub>/FeNbO<sub>4</sub> type II heterojunction photocatalyst with a core-satellite structure was developed. The prepared Mn<sub>3</sub>O<sub>4</sub>/FeNbO<sub>4</sub> type II photocatalyst exhibits obvious enhanced catalytic properties in the photocatalytic CO<sub>2</sub> reduction reaction, where the CH<sub>4</sub> yielding rate is 1.96 and 9.81 times those of FeNbO<sub>4</sub> and Mn<sub>3</sub>O<sub>4</sub>, respectively. This work provides a promising strategy for designing an efficient photocatalyst applied for CO<sub>2</sub> reduction reaction.

8880–8889



### MoC nanocrystals confined in N-doped carbon nanosheets toward highly selective electrocatalytic nitric oxide reduction to ammonia

Ge Meng<sup>1,\*</sup>, Mengmeng Jin<sup>2</sup>, Tianran Wei<sup>3</sup>, Qian Liu<sup>4</sup>, Shusheng Zhang<sup>5</sup>, Xianyun Peng<sup>6,\*</sup>, Jun Luo<sup>2</sup>, and Xijun Liu<sup>3,\*</sup>

<sup>1</sup> Wenzhou University, China

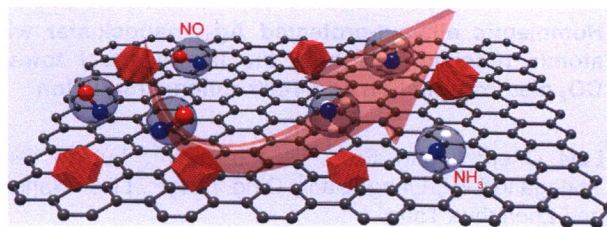
<sup>2</sup> Tianjin University of Technology, China

<sup>3</sup> Guangxi University, China

<sup>4</sup> Chengdu University, China

<sup>5</sup> Zhengzhou University, China

<sup>6</sup> Institute of Zhejiang University–Quzhou, China



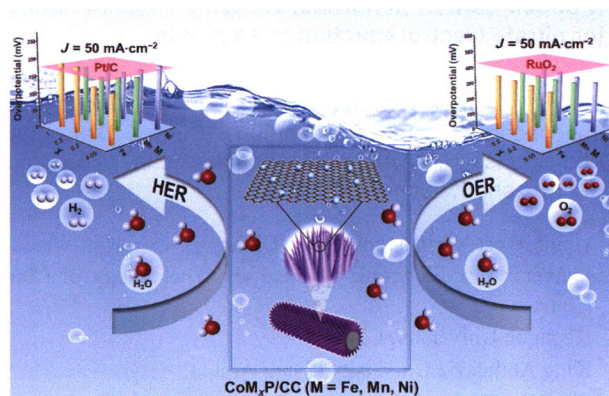
Electrochemical nitric oxide reduction reaction (NORR) to produce ammonia (NH<sub>3</sub>) under ambient conditions is a promising alternative to the energy and carbon-intensive Haber–Bosch approach, but its performance is still improved. Herein, molybdenum carbides (MoC) nanocrystals confined by nitrogen-doped carbon nanosheets are first designed as an efficient and durable electrocatalyst for catalyzing the reduction of NO to NH<sub>3</sub> with maximal Faradaic efficiency of 89% ± 2% and a yield rate of 1,350 ± 15 μg·h<sup>-1</sup>·cm<sup>-2</sup> at the applied potential of -0.8 V vs. reversible hydrogen electrode (RHE) as well as high stable activity with negligible current density and NH<sub>3</sub> yield rate decays over a 30 h continue the test. Moreover, as a proof-of-concept of Zn–NO battery, it achieves a peak power density of 1.8 mW·cm<sup>-2</sup> and a large NH<sub>3</sub> yield rate of 782 ± 10 μg·h<sup>-1</sup>·cm<sup>-2</sup>, which are comparable to the best-reported results. Theoretical calculations reveal that the MoC(111) has a strong electronic interaction with NO molecules, thus lowering the energy barrier of the potential-determining step and suppressing hydrogen evolution kinetics. This work suggests that Mo-based materials are a powerful platform providing great opportunities to explore highly selective and active catalysts for NH<sub>3</sub> production.

8890–8896

### DFT-assisted rational design of CoM<sub>x</sub>P/CC (M = Fe, Mn, and Ni) as efficient electrocatalyst for wide pH range hydrogen evolution and oxygen evolution

Xiangrui Zhang, Chunyan Sun, Shusheng Xu\*, Mengru Huang, Yi Wen, and Xue-Rong Shi\*

Shanghai University of Engineering Science, China



A joint density-functional theory-experiment rational design strategy is employed. The prepared bimetallic phosphides, especially CoFe<sub>0.05</sub>P with the zero-dimensional (0D)/two-dimensional (2D) structure, delivered excellent hydrogen evolution reaction (HER) performances in four kinds of electrolytes and oxygen evolution reaction (OER) in two kinds of electrolytes.

8897–8907

## Homoleptic alkynyl-protected Ag<sub>32</sub> nanocluster with atomic precision: Probing the ligand effect toward CO<sub>2</sub> electroreduction and 4-nitrophenol reduction

Leyi Chen<sup>1</sup>, Fang Sun<sup>2</sup>, Quanli Shen<sup>1</sup>, Lubing Qin<sup>1</sup>, Yonggang Liu<sup>1</sup>, Liang Qiao<sup>3</sup>, Qing Tang<sup>2,\*</sup>, Likai Wang<sup>4,\*</sup>, and Zhenghua Tang<sup>1,5,\*</sup>

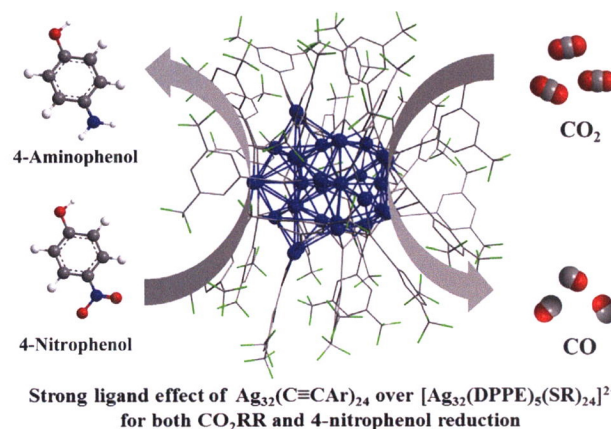
<sup>1</sup> South China University of Technology, China

<sup>2</sup> Chongqing University, China

<sup>3</sup> PetroChina Company Limited, China

<sup>4</sup> Shandong University of Technology, China

<sup>5</sup> Jinan University, China



A novel homoleptic alkynyl-protected Ag<sub>32</sub> nanocluster was first-time synthesized, and it exhibited superior catalytic performance toward both CO<sub>2</sub> electroreduction and 4-nitrophenol reduction than the thiolate and phosphine ligands co-protected Ag<sub>32</sub> counterpart. Density functional theory (DFT) calculations revealed that, one ligand stripping off exposed undercoordinated metal atom is the active site for both clusters, and alkynyl-protected Ag<sub>32</sub> nanocluster favors the formation of the key \*COOH intermediate and the adsorption of 4-nitrophenol.

8908–8913

## CeO<sub>2</sub> nanoparticles with oxygen vacancies decorated N-doped carbon nanorods: A highly efficient catalyst for nitrate electroreduction to ammonia

Zerong Li<sup>1</sup>, Zhiqin Deng<sup>2</sup>, Ling Ouyang<sup>2</sup>, Xiaoya Fan<sup>2</sup>, Longcheng Zhang<sup>2</sup>, Shengjun Sun<sup>2</sup>, Qian Liu<sup>3</sup>, Abdulmohsen Ali Alshehri<sup>4</sup>, Yonglan Luo<sup>1,\*</sup>, Qingquan Kong<sup>3,\*</sup>, and Xuping Sun<sup>2,5,\*</sup>

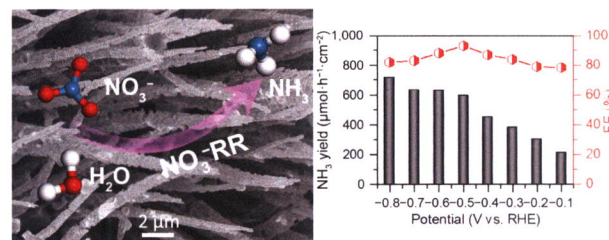
<sup>1</sup> China West Normal University, China

<sup>2</sup> University of Electronic Science and Technology of China, China

<sup>3</sup> Chengdu University, China

<sup>4</sup> King Abdulaziz University, Saudi Arabia

<sup>5</sup> Shandong Normal University, China



CeO<sub>2</sub> nanoparticles with oxygen vacancies (VO) decorated N-doped carbon nanorods on graphite paper (CeO<sub>2-x</sub>@NC/GP) perform efficiently and stably for nitrate reduction electrocatalysis, achieving a remarkably high Faradic efficiency of 92.93% and a large ammonia yield of 712.75 μmol·h<sup>-1</sup>·cm<sup>-2</sup> in 0.1 M NaOH with 0.1 M NO<sub>3</sub><sup>-</sup>.

8914–8921



### N, O-doped carbon foam as metal-free electrocatalyst for efficient hydrogen production from seawater

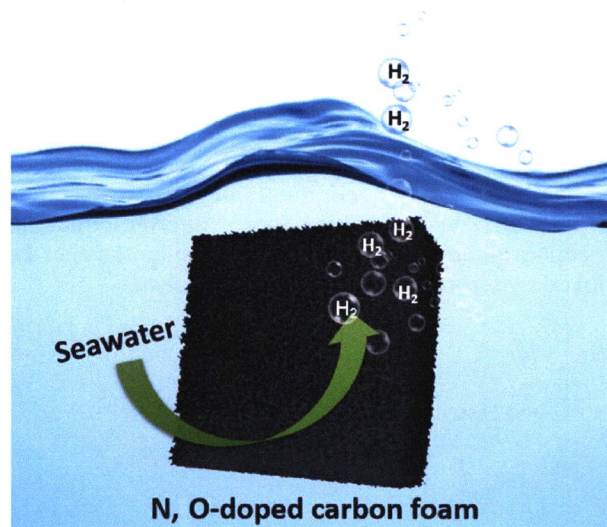
Qian Liu<sup>1</sup>, Shengjun Sun<sup>2</sup>, Longcheng Zhang<sup>2</sup>, Yongsong Luo<sup>2</sup>, Qin Yang<sup>2</sup>, Kai Dong<sup>2</sup>, Xiaodong Fang<sup>1</sup>, Dongdong Zheng<sup>2</sup>, Abdulmohsen Ali Alshehri<sup>3</sup>, and Xuping Sun<sup>2,4,\*</sup>

<sup>1</sup> Chengdu University, China

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N, O-doped carbon foam derived from commercial melamine foam is a high-efficiency metal-free electrocatalyst for hydrogen production from acidic seawater, requiring small overpotential of 161 mV to drive 10 mA·cm<sup>-2</sup> with a low Tafel slop of 97.5 mV·dec<sup>-1</sup>.

8922–8927

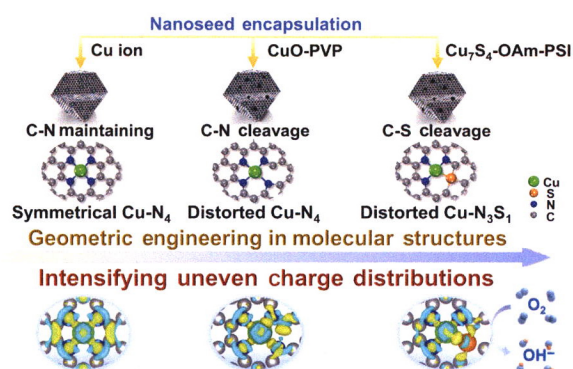
### Intensifying uneven charge distribution via geometric distortion engineering in atomically dispersed M-N<sub>x</sub>/S sites for efficient oxygen electroreduction

Zhuting Zhang<sup>1</sup>, Simin Yang<sup>1</sup>, Rui Jiang<sup>1</sup>, Tian Sheng<sup>2,\*</sup>, Chunfeng Shi<sup>3,\*</sup>, Yueguang Chen<sup>1,\*</sup>, and Leyu Wang<sup>1,\*</sup>

<sup>1</sup> Beijing University of Chemical Technology, China

<sup>2</sup> Anhui Normal University, China

<sup>3</sup> SINOPEC, China



A novel seed encapsulation–decomposition strategy was proposed for the geometric engineering and thermal atomization of a series of Cu-N<sub>x</sub>/S sites by peripheral C–S or C–N bond cleavage. The increased distortion degree of the Cu-N<sub>x</sub>/S molecular structure intensified charge redistribution, changed the rate-determining step and substantially decreased the overall oxygen reduction reaction (ORR) energy barriers for Zn-air batteries.

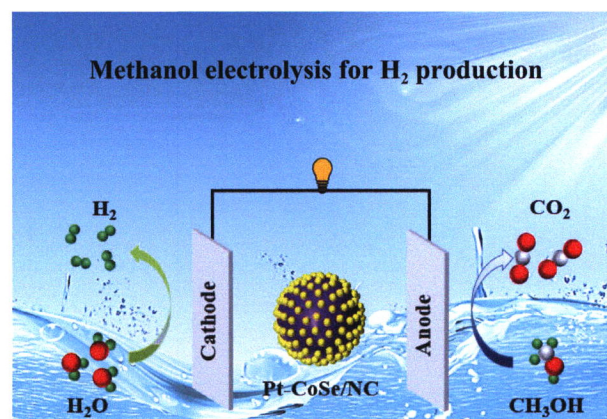
8928–8935

### Efficient bifunctional catalysts of CoSe/N-doped carbon nanospheres supported Pt nanoparticles for methanol electrolysis of hydrogen generation

Yang Zhou<sup>1</sup>, Qiaowei Wang<sup>1</sup>, Xinlong Tian<sup>2</sup>, and Ligang Feng<sup>1,\*</sup>

<sup>1</sup> Yangzhou University, China

<sup>2</sup> Hainan University, China



The increased charge density of Pt induced by CoSe/NC support has a bifunctional ability for optimizing H<sup>+</sup> adsorption energy in hydrogen evolution reaction and weakening the CO adsorption energy for methanol oxidation reaction.

8936–8945

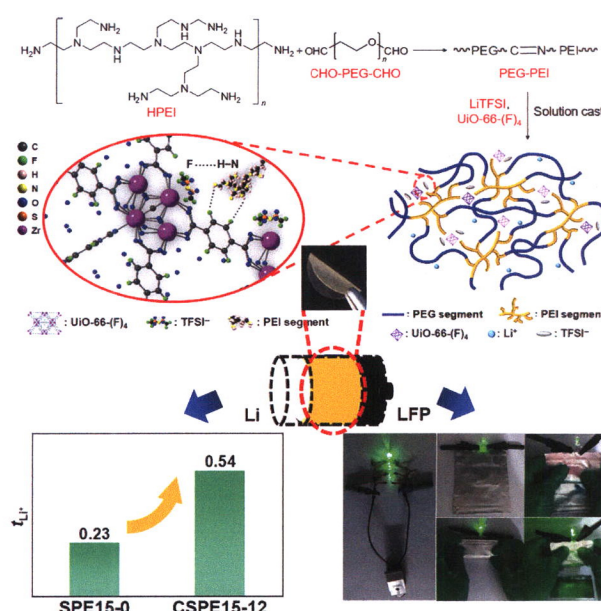
## Research Articles

# Enhancing Li-ion conduction and mechanical properties via addition of fluorine-containing metal-organic frameworks in all-solid-state cross-linked hyperbranched polymer electrolytes

Wen Wen<sup>1,2</sup>, Qinghui Zeng<sup>1</sup>, Pingping Chen<sup>1</sup>, Xin Wen<sup>1</sup>, Zhenfeng Li<sup>1</sup>, Yu Liu<sup>1</sup>, Jiazhu Guan<sup>1</sup>, Anqi Chen<sup>1</sup>, Wei Liu<sup>1,\*</sup>, and Liaoyun Zhang<sup>1,\*</sup>

<sup>1</sup> University of Chinese Academy of Sciences, China

<sup>2</sup> PetroChina, China



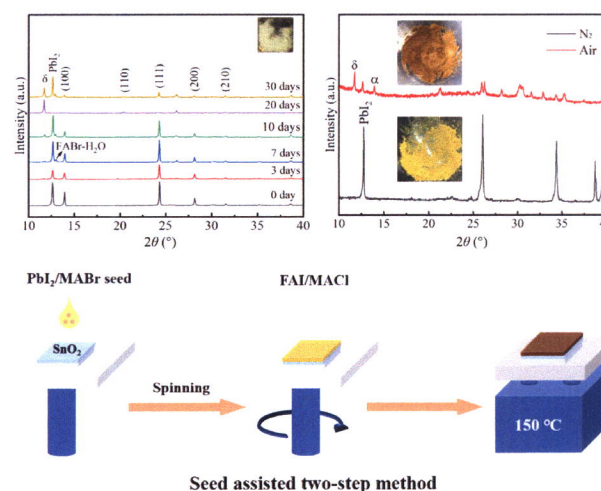
A novel composite solid polymer electrolyte (CSPE) with high Li<sup>+</sup> transference number for Li-metal batteries containing metal-organic framework (MOF) fillers UiO-66-(F)<sub>4</sub> and hyperbranched polyether-based polymer matrix is prepared via a quick method. The coin and pouch cells assembled with the CSPEs can light up the light emitting diode (LED) lamps.

8946–8954

# Degradation mechanism and stability improvement of formamidine-based perovskite solar cells under high humidity conditions

Fengren Cao, Peng Zhang, Haoxuan Sun, Meng Wang, and Liang Li<sup>\*</sup>

Soochow University, China



Through X-ray diffraction and scanning electron microscopy characterization of different perovskite systems in a high humidity environment, the degradation process and corresponding mechanism of commonly used formamidine-based perovskite films under high humidity were presented. On this basis, a seed solution strategy in a two-step preparation process was adopted to enhance the performance and stability of formamidine-based perovskite solar cells.

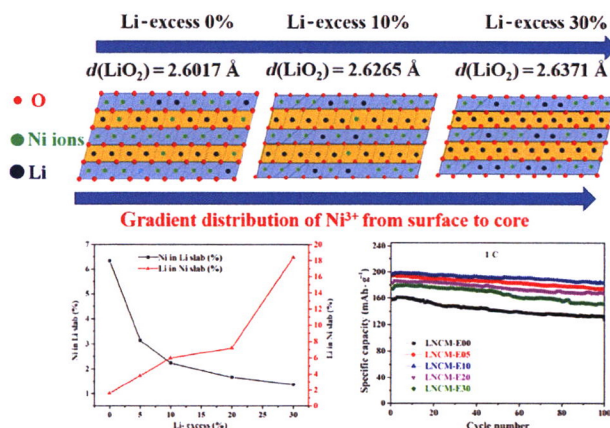
8955–8961



## Tuning Li-excess to optimize Ni/Li exchange and improve stability of structure in $\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$ cathode material for lithium-ion batteries

Fangya Guo, Yongfan Xie, and Youxiang Zhang\*

Wuhan University, China



Electrochemical performance of  $\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$  was optimized by adjusting the ratio of Li-excess during the calcination. Moderate Li-excess contributes to larger Li slab space and optimizes the Ni/Li exchange.

8962–8971

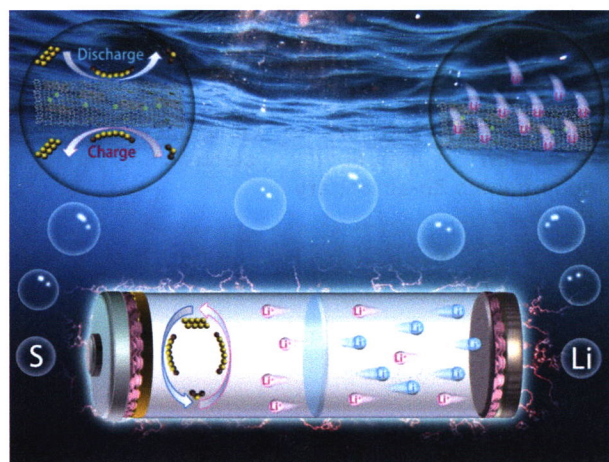
## *In-situ* embedding CoTe catalyst into 1D-2D nitrogen-doped carbon to didirectionally regulate lithium-sulfur batteries

Bin Li<sup>1</sup>, Peng Wang<sup>1</sup>, Baojuan Xi<sup>1,\*</sup>, Ning Song<sup>1</sup>, Xuguang An<sup>2</sup>, Weihua Chen<sup>3</sup>, Jinkui Feng<sup>1</sup>, and Shenglin Xiong<sup>1,\*</sup>

<sup>1</sup> Shandong University, China

<sup>2</sup> Chengdu University, China

<sup>3</sup> Zhengzhou University, China



Two-dimensional (2D) graphene with a laminar structure and one-dimensional (1D) carbon nanotubes were constructed to serve as support for highly conductive CoTe nanoparticles (CoTe@NCGs) via the *in-situ* embedding. The established optimization strategy renders CoTe@NCGs with both lithiophilic and sulfiphilic properties, targeting high-performance Li-S batteries.

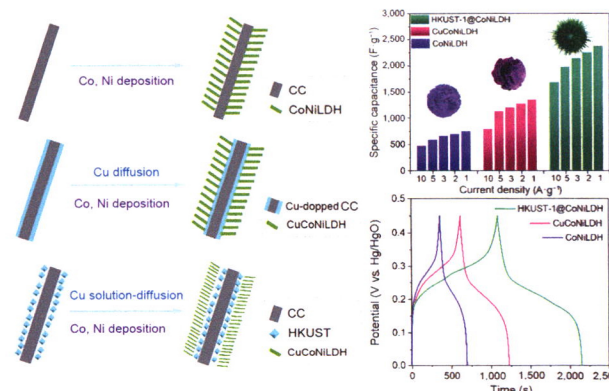
8972–8982

## Enhanced ionic diffusion interface in hierarchical metal-organic framework@layered double hydroxide for high-performance hybrid supercapacitors

Yanan Zhang<sup>1</sup>, Junlei Chen<sup>1</sup>, Chenyang Su<sup>1</sup>, Keyao Chen<sup>1</sup>, Huabin Zhang<sup>2</sup>, Yuhao Yang<sup>1</sup>, and Wenhuan Huang<sup>1,\*</sup>

<sup>1</sup> Shaanxi University of Science and Technology, China

<sup>2</sup> King Abdullah University of Science and Technology, Kingdom of Saudi Arabia



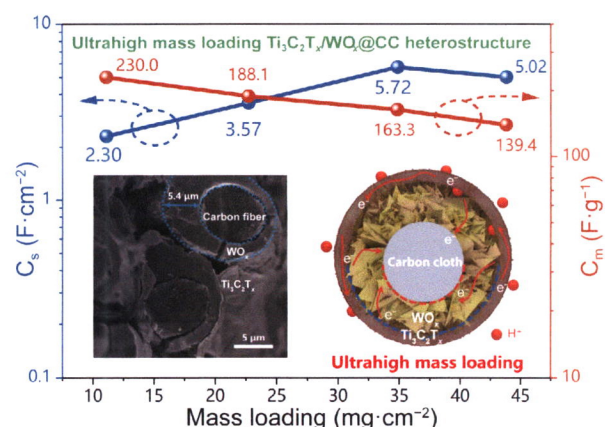
An enhanced ionic diffusion HKUST-1/CoNi layered double hydroxide (LDH) interface in hybrid supercapacitor (HSC) electrode delivers high energy density of 39.8 Wh.kg<sup>-1</sup> at a power density of 799.9 W.kg<sup>-1</sup> with an outstanding capacitance retention of 90% after 5,000 charge-discharge cycles.

8983–8990

## Construction of $\text{Ti}_3\text{C}_2\text{T}_x/\text{WO}_x$ heterostructures on carbon cloth for ultrahigh-mass loading flexible supercapacitor

Zhihu Pan, Chenghao Yang\*, Zhiwu Chen, and Xiaohong Ji\*

South China University of Technology, China



The  $\text{Ti}_3\text{C}_2\text{T}_x/\text{WO}_x$  composites have been grown directly on the flexible carbon cloth ( $\text{Ti}_3\text{C}_2\text{T}_x/\text{WO}_x@\text{CC}$ ) by a facile electrochemical deposition method. The existence of  $\text{Ti}_3\text{C}_2\text{T}_x/\text{WO}_x$  heterointerface plays a key role in achieving high and stable performance by promoting electrons and  $\text{H}^+$  ions diffusion mobility and preventing the peeling off  $\text{WO}_x$ . The  $\text{Ti}_3\text{C}_2\text{T}_x/\text{WO}_x@\text{CC}$  flexible electrode with an ultrahigh mass loading of  $34.9 \text{ mg}\cdot\text{cm}^{-2}$  exhibits a high areal capacitance of  $5.73 \text{ F}\cdot\text{cm}^{-2}$  at  $5 \text{ mA}\cdot\text{cm}^{-2}$  and excellent rate capability.

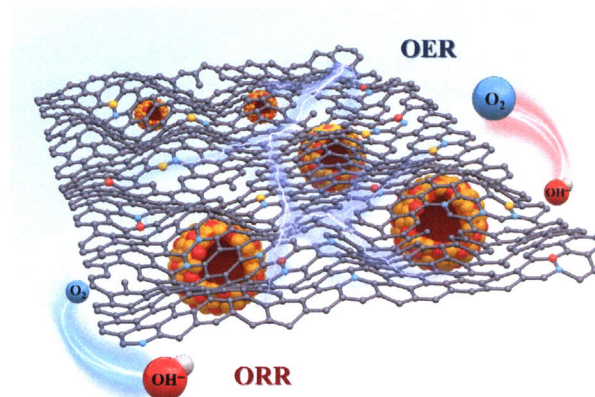
8991–8999

## Confinement synthesis of bimetallic MOF-derived defect-rich nanofiber electrocatalysts for rechargeable Zn-air battery

Xing Chen<sup>1</sup>, Jie Pu<sup>2</sup>, Xuhui Hu<sup>1</sup>, Le An<sup>1</sup>, Jianjun Jiang<sup>1,\*</sup>, and Yujun Li<sup>1,\*</sup>

<sup>1</sup> Northwestern Polytechnical University, China

<sup>2</sup> Wuhan University, China



Three-dimensional (3D) defect-rich nanofiber electrodes with excellent bifunctional electrocatalytic performance were synthesized. The synergistic effect from the irregular hollow CoFe nanospheres and defect-rich carbon boosts the bifunctional electrocatalytic activity, endowing Zn-air battery with high power density and energy density.

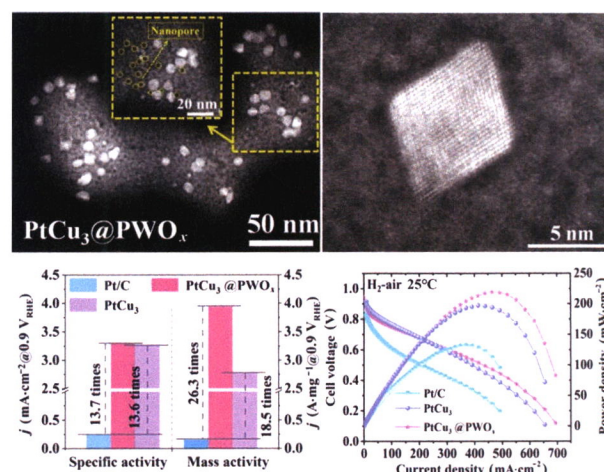
9000–9009

## PtCu<sub>3</sub> nanoalloy@porous PWO<sub>x</sub> composites with oxygen container function as efficient ORR electrocatalysts advance the power density of room-temperature hydrogen-air fuel cells

Rui Chen<sup>1</sup>, Tie Shu<sup>2</sup>, Fengling Zhao<sup>1</sup>, Yongfei Li<sup>2</sup>, Xiaotong Yang<sup>1</sup>, Jingwei Li<sup>2</sup>, Daliang Zhang<sup>2</sup>, Li-Yong Gan<sup>2,\*</sup>, Ke Xin Yao<sup>2,\*</sup>, and Qiang Yuan<sup>1,\*</sup>

<sup>1</sup> Guizhou University, China

<sup>2</sup> Chongqing University, China



Porous  $\text{PtCu}_3$  nanoalloy@ $\text{PWO}_x$  composites are employed as efficient oxygen-storing oxygen reduction reaction (ORR) electrocatalysts for practical room-temperature  $\text{H}_2$ -air fuel cells.

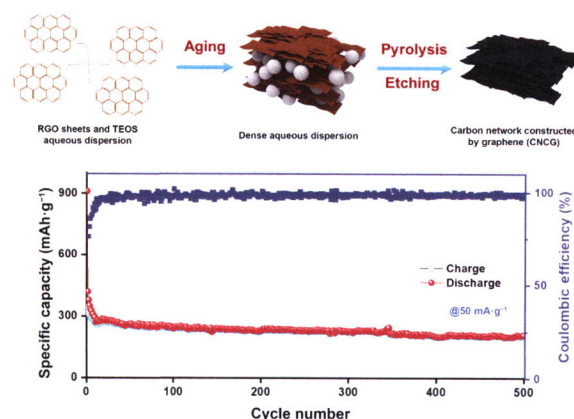
9010–9018



## Chemical cross-linking and mechanically reinforced carbon network constructed by graphene boosts potassium ion storage

Chenxu Wang, Ruohan Yu, Wen Luo\*, Wencong Feng, Yuanhao Shen, Nuo Xu, and Liqiang Mai

Wuhan University of Technology, China



A new synthetic strategy by sol-gel with acid etching for chemical cross-linking of graphene sheets was proposed. The obtained carbon network constructed by graphene (CNCG) exhibits remarkable electrical conductivity and mechanical enhancement as high-performance potassium ion battery anode.

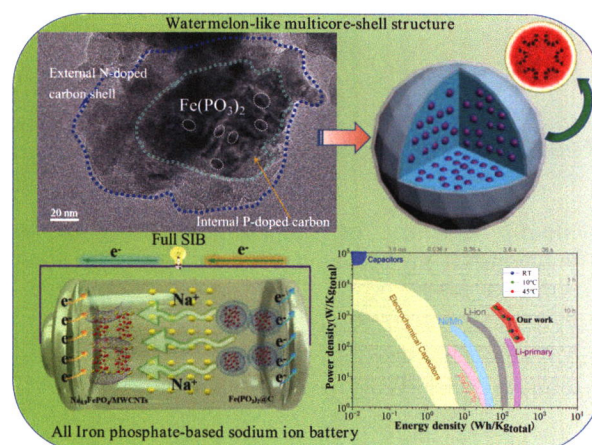
9019–9025

## Watermelon-like multicore-shell $\text{Fe}(\text{PO}_3)_2$ @carbon nanocapsule anode to construct an all iron phosphate-based sodium ion battery

Lu Yue<sup>1</sup>, Jingyu Zhang<sup>1</sup>, Meng Kong<sup>1</sup>, Kai Li<sup>1</sup>, Wenhui Zhang<sup>1,\*</sup>, Xiaotian Guo<sup>2</sup>, Mengmeng Xiao<sup>1</sup>, Feng Zhang<sup>1</sup>, and Huan Pang<sup>2,\*</sup>

<sup>1</sup> Yancheng Institute of Technology, China

<sup>2</sup> Yangzhou University, China



A new type of all iron-based phosphate sodium ion battery (SIB) full battery is constructed by combining watermelon-like multicore-shell  $\text{Fe}(\text{PO}_3)_2$ @C nanocapsule anode with  $\text{FePO}_4$ /MWCNTs as cathode materials, which can output a high power and energy density from 10 to 45 °C.

9026–9037

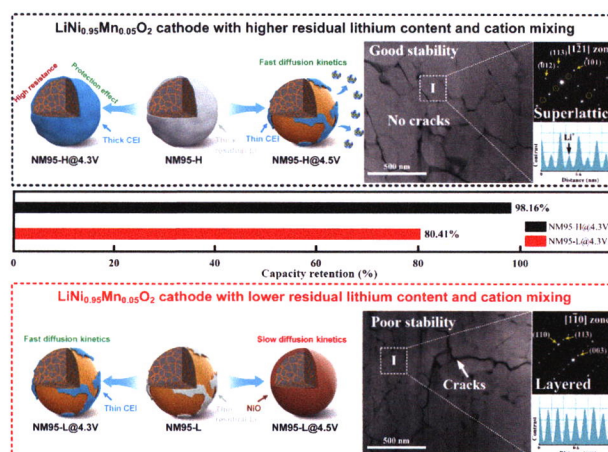
## Unveiling the impact of residual Li conversion and cation ordering on electrochemical performance of Co-free Ni-rich cathodes

Chu Wang<sup>1</sup>, Lei Tan<sup>1</sup>, Hongling Yi<sup>1</sup>, Zixiang Zhao<sup>1</sup>, Xiaoli Yi<sup>2</sup>, Youyuan Zhou<sup>3</sup>, Junchao Zheng<sup>2</sup>, Jiexi Wang<sup>2</sup>, and Lingjun Li<sup>1,\*</sup>

<sup>1</sup> Changsha University of Science and Technology, China

<sup>2</sup> Central South University, China

<sup>3</sup> Hunan Changyuan Lico Co., Ltd., China



The residual Li can protect cathodes from electrolyte attack by converting to cathode electrolyte interphase (CEI) below 4.3 V and the cation ordering structure impedes lattice collapse at a highly charged state.

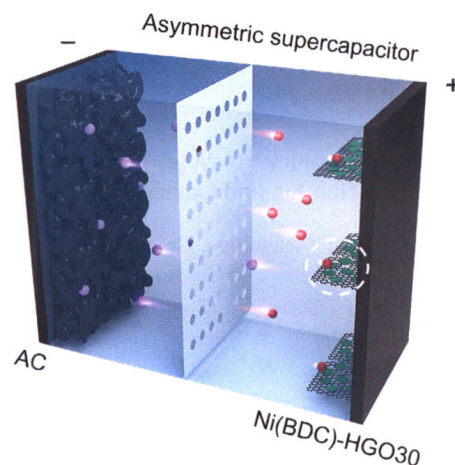
9038–9046

## Holey graphene oxide-templated construction of nano nickel-based metal–organic framework for highly efficient asymmetric supercapacitor

Hang Wang<sup>1,\*</sup>, Pengfei Zhao<sup>1</sup>, Xingmao Zhang<sup>1</sup>, Su Zhang<sup>1</sup>, Xiaolong Lu<sup>1</sup>, Zhipeng Qiu<sup>1</sup>, Kang Ren<sup>1</sup>, Zheng Xu<sup>1</sup>, Ruxin Yao<sup>2</sup>, Tong Wei<sup>1,\*</sup>, and Zhuangjun Fan<sup>1,\*</sup>

<sup>1</sup> China University of Petroleum, China

<sup>2</sup> Shanxi Normal University, China



The designed nano structure of two-dimensional (2D) Ni(BDC) on holey graphene oxide enables rapid mass/charge transport and the obtained Ni(BDC)-HGO30 is favorable for asymmetric supercapacitor application.

9047–9056

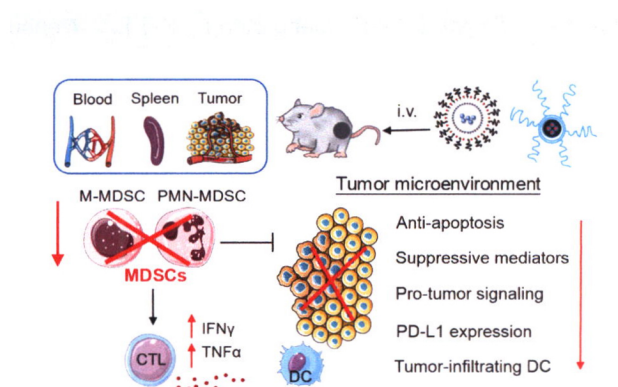
## Nano biology

### Research Articles

#### Systemic delivery of gemcitabine analogue and STAT3 siRNA promotes antitumor immunity against melanoma

Huan Yan, Zhanyan Liu, Guibin Lin, Fei Gu, Yan Liu, Yuxiao Xu, Xueli Kuang, and Yuan Zhang

South China University of Technology, China



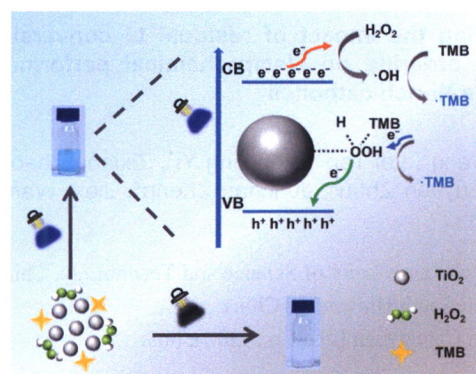
Gemcitabine analogue and STAT3 siRNA (siSTAT3) nanoparticles could alleviate myeloid cell-mediated immune suppression and enhance endogenous T-cell mediated antitumor immunity.

9057–9072

#### A photonanozyme with light-empowered specific peroxidase-mimicking activity

Sili Lin, Wenlong Tan, Pengfei Han, Xu Li, Jinzhao Li, Zhou Nie, and Kun Li

Hunan University, China



Light as a direct energy source driving photonanozymatic reactions with  $\text{H}_2\text{O}_2$  enables  $\text{TiO}_2$  photonanozymes to have the peroxidase-like specificity exclusively under illumination. Photogenerated hot charge carriers and the accompanied reactive oxygen species are responsible for light-empowered photonanozymatic activity, while co-substrates are conducive to the formation of the photo-reactive peroxo-oxygen bridge bond between  $\text{TiO}_2$  and  $\text{H}_2\text{O}_2$  that specifically allows the peroxidase-like activity.

9073–9081



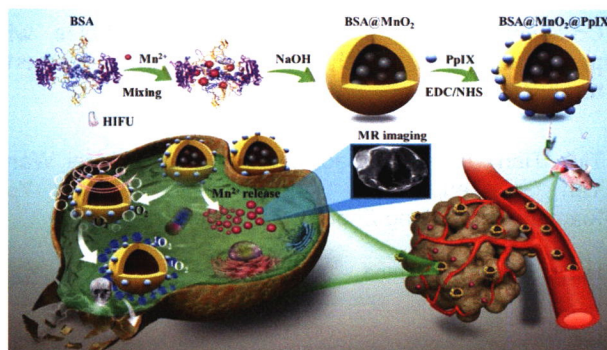
## Versatile nanocomposite augments high-intensity focused ultrasound for high-efficacy sonodynamic therapy of glioma

Yingyan Zheng<sup>1,2</sup>, Dejun She<sup>1,2</sup>, Huihui Huang<sup>3</sup>, Lin Lin<sup>2</sup>, Sunhui Chen<sup>2</sup>, Yiping Lu<sup>2</sup>, Li Liu<sup>2,\*</sup>, Zhiqing Pang<sup>2,\*</sup>, and Bo Yin<sup>2,\*</sup>

<sup>1</sup> First Affiliated Hospital of Fujian Medical University, China

<sup>2</sup> Fudan University, China

<sup>3</sup> Fujian Medical University, China



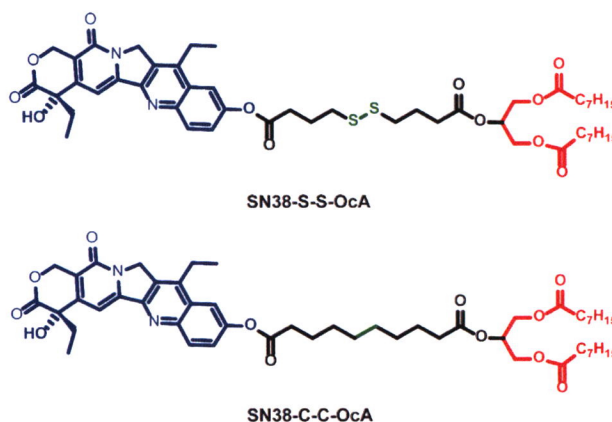
The high reduction of  $\text{MnO}_2$  under the presence of  $\text{H}_2\text{O}_2$  contributes to tumor microenvironment (TME)-responsive  $T_1$ -weighted magnetic resonance imaging (MRI). Under high-intensity focused ultrasound (HIFU) irradiation with MRI guidance,  $\text{PpIX@MnO}_2\text{@BSA}$  (BMP, PpIX = Protoporphyrin IX and BSA = bovine serum albumin) alleviates hypoxic environment by releasing  $\text{O}_2$ , and further facilitates the generation of toxic reactive oxygen species (ROS) to enhance the suppression of glioma growth, thereby realizing the high-efficacy sonodynamic therapy (SDT).

9082–9091

## Boosting SN38-based oral chemotherapy to combine reduction-bioactivated structured lipid-mimetic prodrug with ascorbic acid

Helin Wang, Qi Lu, Yifan Miao, Jiaxuan Song, Mingyang Zhang, Zixuan Wang, Haotian Zhang, Zhonggui He, Chutong Tian\*, and Jin Sun\*

Shenyang Pharmaceutical University, China



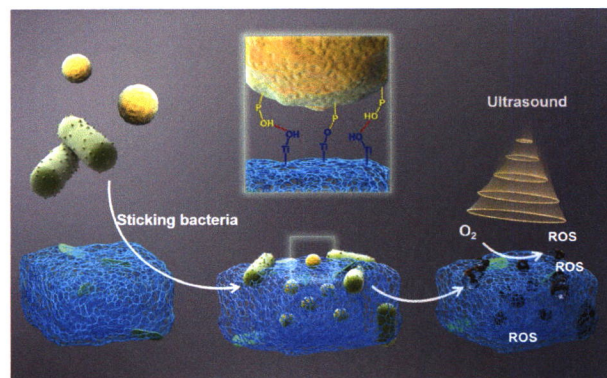
A structured lipid-mimetic SN38 prodrug for smart cancer therapy by combination of the high hydrophobic structured lipid-mimetic prodrug structure and disulfide bond was designed. And ascorbic acid (ASC) was co-administrated to further promote the efficient release of SN38 from the prodrug. The combination of structured lipid-mimetic prodrug along with ASC is firstly demonstrated to boost the oral chemotherapy effect of the difficult-for-oral chemotherapeutics.

9092–9104

## Sticking-bacteria gel enhancing anti-multidrug-resistant microbial therapy under ultrasound

Ya-Qi Zhu, Wei-Qiang Huang, Guang Chen, Lei Xia, Ye-Zi You\*, and Yue Yu\*

University of Science and Technology of China, China



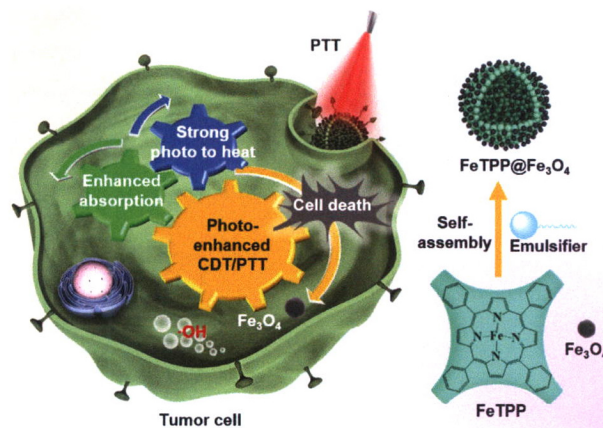
Inspired by that the mucus in respiratory mucosa could trap bacteria to kill them, here, a new gel that could stick bacteria and inhibit their invasion into normal cell is developed for effectively killing bacteria under ultrasound.

9105–9113

### Co-assembly of FeTPP@Fe<sub>3</sub>O<sub>4</sub> nanoparticles with photo-enhanced catalytic activity for synergistic tumor therapy

Tian Tian, Jianshuai Bao, Jinghan Wang, Jiefei Wang, Yan Ge, Zengyin Li, Shanqing Gao, Zhongqi You, Xiaoyan Yang, Yong Zhong\*, and Feng Bai\*

Henan University, China



Iron(III) tetraphenylporphyrin (FeTPP) and magnetic (Fe<sub>3</sub>O<sub>4</sub>) composite nanoparticles (FeTPP@Fe<sub>3</sub>O<sub>4</sub> NPs) possessing magnetic resonance imaging (MRI) functions were prepared through a one-step microemulsion-assisted co-assembly method. The introduction of Fe<sub>3</sub>O<sub>4</sub> nanocrystals (NCs) enhances the disorganized amorphous aggregation of FeTPP monomers, then increases the aggregation-caused quenching (ACQ) of porphyrins, which endowed FeTPP@Fe<sub>3</sub>O<sub>4</sub> NPs high photothermal performance and photo-enhanced the Fenton reaction for amplified chemodynamic therapy (CDT).

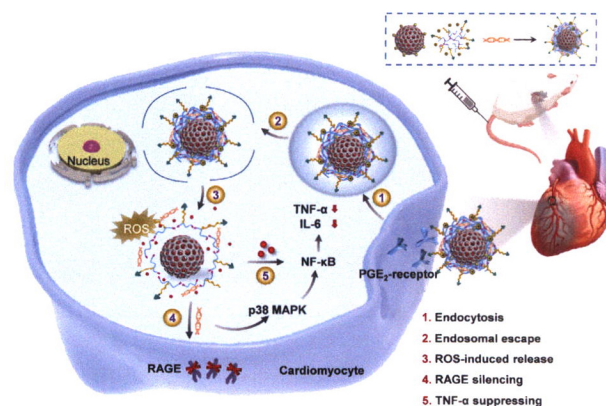
9114–9124

### Cardiomyocyte-targeted anti-inflammatory nanotherapeutics against myocardial ischemia reperfusion (IR) injury

Min Lan<sup>1</sup>, Mengying Hou<sup>1</sup>, Jing Yan<sup>1,\*</sup>, Qiurong Deng<sup>1</sup>, Ziyin Zhao<sup>1</sup>, Shixian Lv<sup>1</sup>, Juanjuan Dang<sup>1</sup>, Mengyuan Yin<sup>1</sup>, Yong Ji<sup>2,\*</sup>, and Lichen Yin<sup>1,\*</sup>

<sup>1</sup> Soochow University, China

<sup>2</sup> Wuxi People's Hospital Affiliated to Nanjing Medical University, China



Cardiomyocyte-targeting and reactive oxygen species (ROS)-ultrasensitive nanocomplexes (NCs) based on mesoporous silica nanoparticles gated with a ROS-degradable polycation (PPTP) were prepared for the co-delivery of siRAGE and Dex toward the anti-inflammatory treatment against myocardial ischemia reperfusion (IR) injury. The NCs efficiently entered cardiomyocytes, and PPTP was sensitively degraded by the over-produced ROS, releasing the siRAGE and Dex to mediate RAGE silencing and cooperative anti-inflammatory effect.

9125–9134

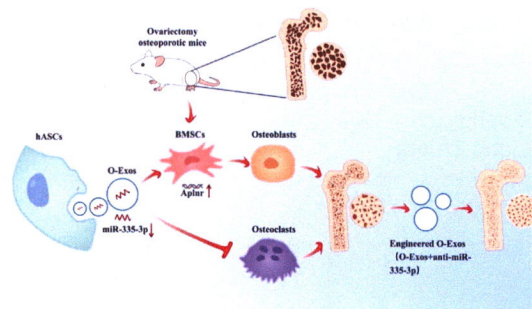


## Exosomes derived from human adipose-derived stem cells ameliorate osteoporosis through miR-335-3p/Aplnr axis

Chunhui Sheng<sup>1</sup>, Xiaodong Guo<sup>1</sup>, Zhuqing Wan<sup>1</sup>, Xiaoqiang Bai<sup>1</sup>, Hao Liu<sup>1</sup>, Xiao Zhang<sup>1</sup>, Ping Zhang<sup>1</sup>, Yunsong Liu<sup>1</sup>, Wenyue Li<sup>2\*</sup>, Yongsheng Zhou<sup>1\*</sup>, and Longwei Lv<sup>1\*</sup>

<sup>1</sup> Peking University School and Hospital of Stomatology, China

<sup>2</sup> Capital Medical University, China



Exosomes derived from human adipose-derived stem cells (hASCs) cultured in osteogenic induction medium (O-Exos) enhanced the osteogenic differentiation of bone marrow-derived stem cells (BMSCs) from ovariectomy osteoporotic mice and inhibited osteoclastogenesis which resulted in the amelioration of the osteoporotic conditions, and the engineered O-Exos constructed by transfection of miR-335-3p inhibitor into the exosomes showed a better effect. The findings indicated that the ASC-exosome-based therapy brings new possibilities for osteoporosis treatment.

9135–9148

## Novel gold nanoparticles targeting somatostatin receptor subtype two with near-infrared light for neuroendocrine tumour therapy

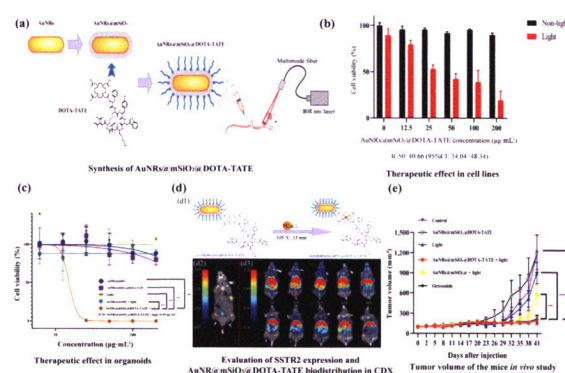
Qichen Chen<sup>1</sup>, Zilin Li<sup>2</sup>, Jiangyuan Yu<sup>3</sup>, Qing Xie<sup>3</sup>, Haizhen Lu<sup>1</sup>, Yiqiao Deng<sup>1</sup>, Jinghua Chen<sup>1</sup>, Wenjia Zhu<sup>1</sup>, Li Huo<sup>1</sup>, Yizhou Zhang<sup>1</sup>, Wei Song<sup>1</sup>, Jianqiang Lan<sup>4</sup>, Jianqiang Cai<sup>1\*</sup>, Zhen Huang<sup>1\*</sup>, Zixi Wang<sup>2\*</sup>, and Hong Zhao<sup>1\*</sup>

<sup>1</sup> Chinese Academy of Medical Sciences and Peking Union Medical College, China

<sup>2</sup> Tsinghua University, China

<sup>3</sup> Peking University Cancer Hospital & Institute, China

<sup>4</sup> Accurate International Biotechnology Co. Ltd., China



This study presented a feasible strategy to construct AuNRs@mSiO<sub>2</sub>@DOTA-TATE with excellent physiological stability, somatostatin receptor 2 (SSTR2)-targeting ability, and biocompatibility. Both *in vitro* and *in vivo*, AuNRs@mSiO<sub>2</sub>@DOTA-TATE was very effective in killing tumours under low-power laser irradiation. In addition, AuNRs@mSiO<sub>2</sub>@DOTA-TATE showed little systemic toxicity and no long-term side effects, warranting further explorations of multifunctional nanocomposites for applications in neuroendocrine tumours therapy.

9149–9159

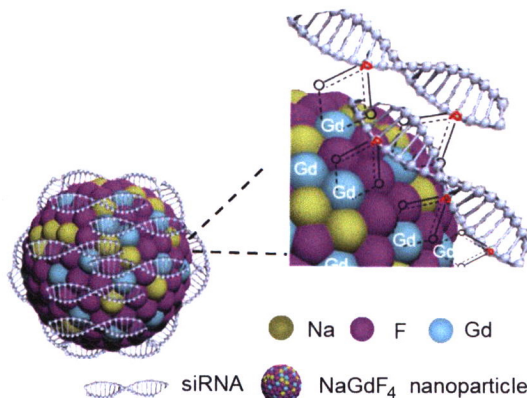
## siRNA-functionalized lanthanide nanoparticle enables efficient endosomal escape and cancer treatment

Chanchan Yu<sup>1,2</sup>, Kun Li<sup>1</sup>, Lin Xu<sup>1</sup>, Bo Li<sup>1</sup>, Chunhui Li<sup>1</sup>, Shuai Guo<sup>1</sup>, Ziyue Li<sup>1</sup>, Yuquan Zhang<sup>1</sup>, Abid Hussain<sup>1</sup>, Hong Tan<sup>3</sup>, Mengyu Zhang<sup>3</sup>, Yongxiang Zhao<sup>3\*</sup>, Yuanyu Huang<sup>1\*</sup>, and Xing-Jie Liang<sup>2\*</sup>

<sup>1</sup> Beijing Institute of Technology, China

<sup>2</sup> National Center for Nanoscience and Technology of China, China

<sup>3</sup> Guangxi Medical University, China



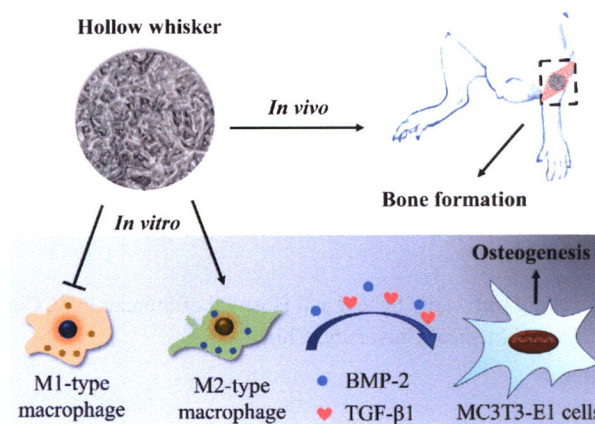
In this work, we explored the basic interaction of the double-stranded small interfering RNA (siRNA) with lanthanide NaGdF<sub>4</sub> nanoparticles (NPs) and discovered that an efficient encapsulation and rapid endosomal escape of siRNA from the endosome/lysosome were achieved by utilizing the dual capacity of siRNA loading and endosomal escape of NaGdF<sub>4</sub> NPs.

9160–9168

## Whisker of biphasic calcium phosphate ceramics: Osteo-immunomodulatory behaviors

Jinjie Wu, Cong Feng, Menglu Wang, Hongfeng Wu, Xiangdong Zhu, Xiangfeng Li\*, Xuening Chen\*, and Xingdong Zhang

Sichuan University, China



Biphasic calcium phosphate (BCP)-HW ceramics induced the M2 polarization of macrophages, showing better promoting effect on the osteogenesis of MC3T3-E1 cells through the paracrine pathway and new bone formation *in vitro*.

9169–9182

## NIR-II fluorescence/photoacoustic imaging of ovarian cancer and peritoneal metastasis

Siyu Lu<sup>1,2</sup>, Liru Xue<sup>1</sup>, Meng Yang<sup>3</sup>, Jingjing Wang<sup>2</sup>, Yang Li<sup>2</sup>, Yuxin Jiang<sup>3</sup>, Xuechuan Hong<sup>1,2,4</sup>, Mingfu Wu<sup>1,\*</sup>, and Yuling Xiao<sup>2,5,\*</sup>

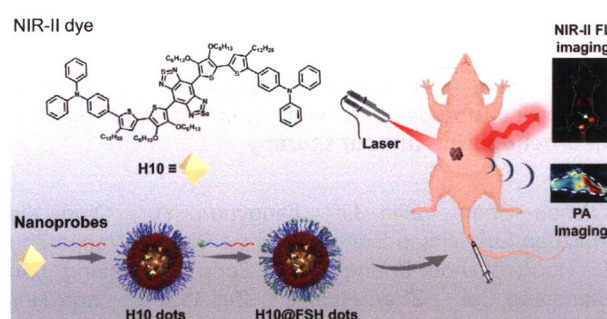
<sup>1</sup> Huazhong University of Science and Technology, China

<sup>2</sup> Wuhan University, China

<sup>3</sup> Chinese Academy of Medical Science and Peking Union Medical College, China

<sup>4</sup> Tibet University, China

<sup>5</sup> Shenzhen Institute of Wuhan University, China



H10@follicle-stimulating hormone (FSH) dots have been developed for near-infrared II (NIR-II, 1,000–1,700 nm) fluorescence/photoacoustic imaging of ovarian cancer and peritoneal metastasis.

9183–9191

## Biological composite fibers with extraordinary mechanical strength and toughness mediated by multiple intermolecular interacting networks

Sikang Wan<sup>1,2</sup>, Wenhao Cheng<sup>1,2</sup>, Jingjing Li<sup>1</sup>, Fan Wang<sup>1</sup>, Xiwen Xing<sup>3,\*</sup>, Jing Sun<sup>4,\*</sup>, Hongjie Zhang<sup>1,2,5</sup>, and Kai Liu<sup>1,2,5,\*</sup>

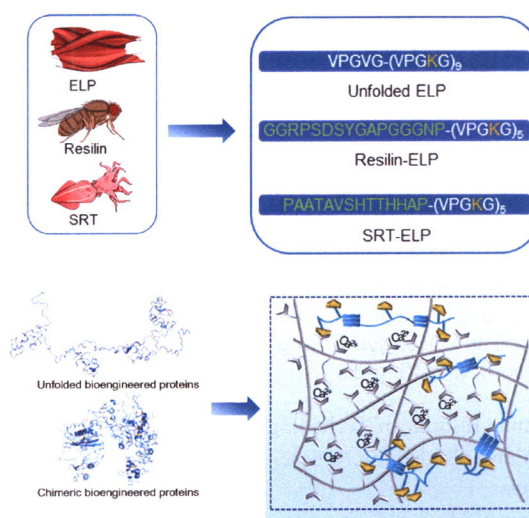
<sup>1</sup> Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, China

<sup>2</sup> University of Science and Technology of China, China

<sup>3</sup> Jinan University, China

<sup>4</sup> Ulm University, Germany

<sup>5</sup> Tsinghua University, China



A versatile molecular engineering strategy is employed to develop robust biosynthetic protein-saccharide composite fibers by internal multiple networks. In stark contrast to the conventional saccharide-based fibers, the lysine-rich biosynthetic proteins significantly enhance saccharide-protein composite fiber's overall mechanical properties due to their internal multiple networks, offering potential applications for next-generation renewable high-performance bio-composite fibers.

9192–9198

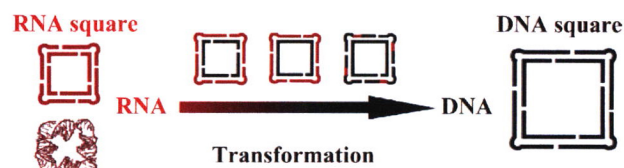


## RNA nanostructure transformation into DNA ones

Jiazhen Lyu<sup>1</sup>, Shiyu Ma<sup>1</sup>, Chong Zhang<sup>2</sup>, and Zhen Huang<sup>1,2,\*</sup>

<sup>1</sup> Sichuan University, China

<sup>2</sup> SeNA Research Institute, China



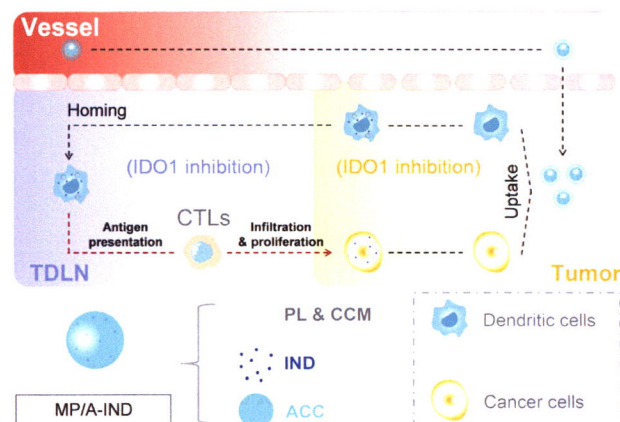
RNA nanostructure can be transformed into DNA ones, by designing and increasing ionic strengths and duplex lengths. Our research strategy opens a new avenue for exploring the structure connection between RNAs and DNAs.

9199–9203

## Tumor and dendritic cell dual-targeting nanocarriers maximize the therapeutic potential of IDO1 inhibitor *in vivo*

Tong Yu, Xiangyu Jin, Fangying Yu, Xiqin Yang, Yingping Zeng, Tingting Meng, Hong Yuan, and Fuqiang Hu\*

Zhejiang University, China



Nanoscale amorphous calcium carbonate (ACC) encapsulating indoximod (IND) was coated with phospholipid (PL) and modified with cancer cell membrane (CCM) (MP/A-IND). By fully utilizing the homologous adhesion proteins and antigenic motifs on CCM, MP/A-IND is capable of infiltrating tumors and actively accumulating in cancer cells and dendritic cells (DCs), as well as hitching a ride on DCs to tumor-draining lymph nodes (TDLNs). Ultimately, through increasing the density of indoleamine-2,3-dioxygenase-1 (IDO1) inhibitors in both tumors and TDLNs, the efficacy of IND is greatly enhanced without the aid of chemotherapeutic drugs, achieving substantial control of tumor growth.

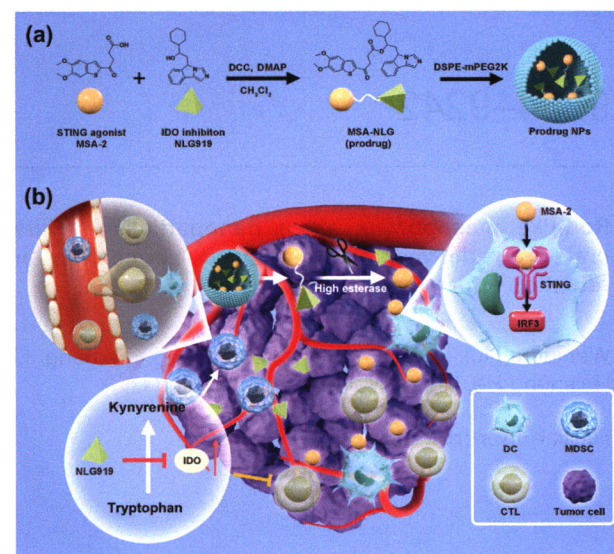
9204–9214

## A prodrug nanoplatform via esterification of STING agonist and IDO inhibitor for synergistic cancer immunotherapy

Madiha Zahra Syeda<sup>1,2</sup>, Tu Hong<sup>1</sup>, Min Zhang<sup>2</sup>, Yanfei Han<sup>1</sup>, Xiaoling Zhu<sup>1</sup>, Songmin Ying<sup>1,2,\*</sup>, and Longguang Tang<sup>1,\*</sup>

<sup>1</sup> The Fourth Affiliated Hospital of Zhejiang University School of Medicine, China

<sup>2</sup> Zhejiang University School of Medicine, China



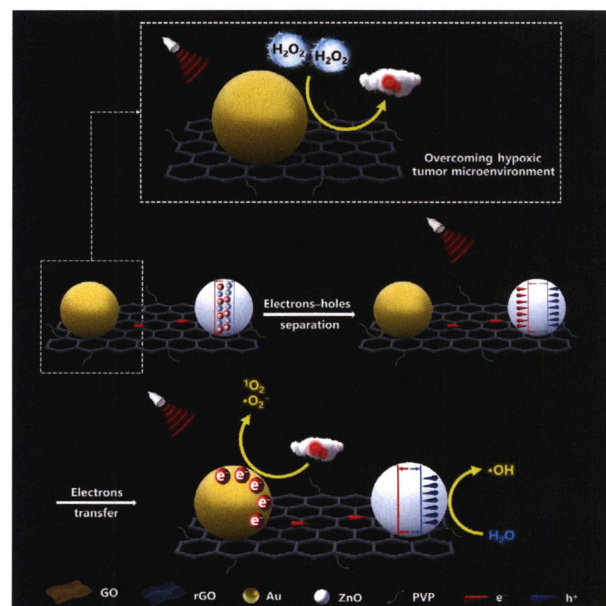
Prodrug (MSA-NLG) was synthesized and encapsulated with 1,2-distearoyl-sn-glycero-3-phosphoethanolamine-N-[methoxy (polyethylene glycol)-2000] (DSPE-mPEG2K) to attain prodrug nanoparticles (prodrug NPs) (a), for synergistic cancer immunotherapy (b).

9215–9222

## Integrating Au and ZnO nanoparticles onto graphene nanosheet for enhanced sonodynamic therapy

Fei Wang, Boyu Wang, Wei You, Guang Chen\*, and Ye-Zi You\*

University of Science and Technology of China, China



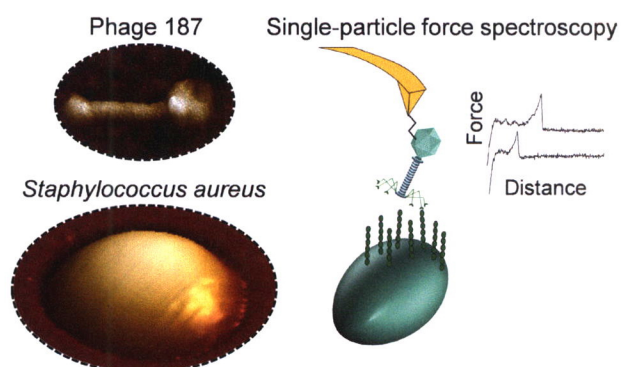
Au-rGO-ZnO@PVP, a promising sonosensitizer, could generate oxygen to mitigate the hypoxic tumor microenvironment and reactive oxygen species (ROS) to kill tumor cell under ultrasound irradiation.

9223–9233

## Deciphering the role of monosaccharides during phage infection of *Staphylococcus aureus*

Baptiste Arbez, Marion Gardette, Christophe Gantzer, Neus Vilà, Isabelle Bertrand, and Sofiane El-Kirat-Chatel\*

Université de Lorraine, France



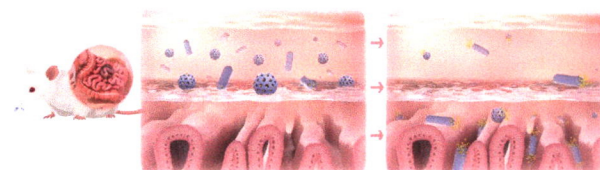
*Staphylococcus aureus* cell wall was deciphered using a phage-decorated atomic force spectroscopy tip in order to identify major receptors involved in phage adhesion and infection of host cell.

9234–9242

## Rod-like mesoporous silica nanoparticles facilitate oral drug delivery via enhanced permeation and retention effect in mucus

Wenjuan Liu, Luyu Zhang, Zirong Dong, Kaiheng Liu, Haisheng He, Yi Lu, Wei Wu, and Jianping Qi\*

Fudan University, China



Oral absorption could be improved by the enhanced permeation and retention effect in mucus caused by rod-like nanoparticles.

9243–9252



### Electrically controlled mRNA delivery using a polypyrrole-graphene oxide hybrid film to promote osteogenic differentiation of human mesenchymal stem cells

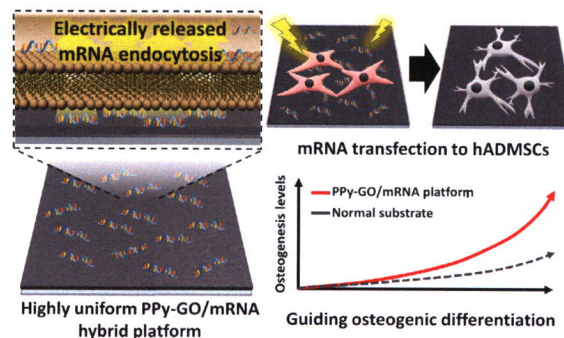
Huijung Kim<sup>1</sup>, Kübra Solak<sup>2</sup>, Yoojoong Han<sup>1</sup>, Yeon-Woo Cho<sup>1</sup>, Kyeong-Mo Koo<sup>1</sup>, Chang-Dae Kim<sup>1</sup>, Zhengtang Luo<sup>3</sup>, Hyungbin Son<sup>1</sup>, Hyung-Ryong Kim<sup>4,\*</sup>, Ahmet Mavi<sup>2,\*</sup>, and Tae-Hyung Kim<sup>1,\*</sup>

<sup>1</sup> Chung-Ang University, Republic of Korea

<sup>2</sup> Atatürk University, Turkey

<sup>3</sup> Hong Kong University of Science and Technology, Hong Kong, China

<sup>4</sup> Jeonbuk National University, Republic of Korea



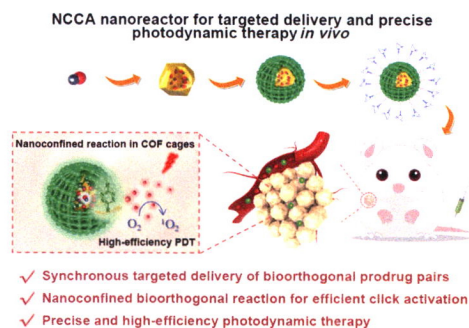
An mRNA-loaded polypyrrole-graphene oxide composite was electrochemically fabricated on the indium tin oxide substrate. Under electrical stimulation, total mRNAs isolated from osteoblasts were delivered into the mesenchymal stem cells and enhanced osteogenic differentiation.

9253–9263

### Nanovoid-confinement and click-activated nanoreactor for synchronous delivery of prodrug pairs and precise photodynamic therapy

Peng Wang, Fang Zhou, Xia Yin\*, Qingji Xie, Guosheng Song\*, and Xiao-Bing Zhang

Hunan University, China



The nanovoid-confinement and click-activated (NCCA) nanoreactor is de novo developed for overcoming the space-time dislocation of bioorthogonal reagents. The NCCA nanoreactor utilized the nanoconfined bioorthogonal reactions in defined tetrazine-based covalent organic framework (COF) cages to boost the collision probability of bioorthogonal prodrug with tetrazine triggers, resulting in higher-efficiency photodynamic therapy (PDT) *in vivo*.

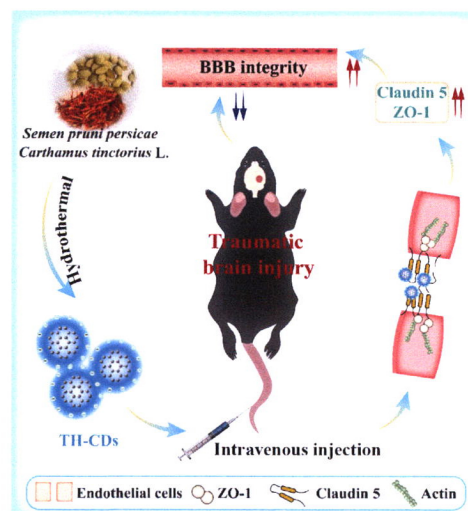
9264–9273

### Green functional carbon dots derived from herbal medicine ameliorate blood–brain barrier permeability following traumatic brain injury

Weikang Luo<sup>1</sup>, Lianglin Zhang<sup>1</sup>, Xuexuan Li<sup>1</sup>, Jun Zheng<sup>1</sup>, Quan Chen<sup>1</sup>, Zhaoyu Yang<sup>1</sup>, Menghan Cheng<sup>1</sup>, Yao Chen<sup>1</sup>, Yao Wu<sup>1</sup>, Wei Zhang<sup>2</sup>, Tao Tang<sup>1</sup>, and Yang Wang<sup>1,\*</sup>

<sup>1</sup> Central South University, China

<sup>2</sup> Hunan University of Chinese Medicine, China



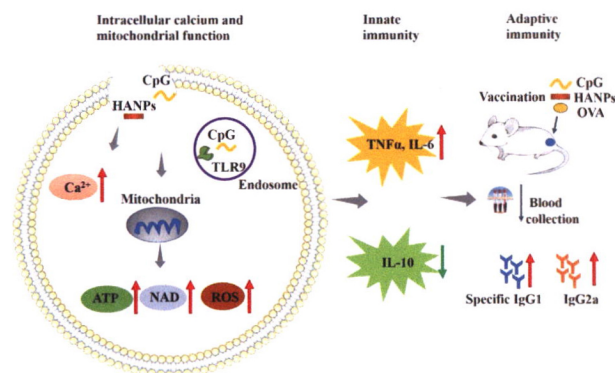
Green functional carbon dots derived from herbal medicine (TH-CDs) were synthesized. TH-CDs can ameliorate blood–brain barrier permeability following traumatic brain injury, which may be due to the electrostatic interaction between TH-CDs and claudin 5.

9274–9285

## Hydroxyapatite nanoparticles drive the potency of Toll-like receptor 9 agonist for amplified innate and adaptive immune response

Qin Zeng<sup>\*</sup>, Ruiqi Wang, Yuchen Hua, Hongfeng Wu, Xuening Chen, You-cai Xiao, Qiang Ao, Xiangdong Zhu<sup>\*</sup>, and Xingdong Zhang

Sichuan University, China



Hydroxyapatite nanoparticles (HANPs) modulate the intracellular calcium level, mitochondrial function in support of the synthesis of adenosine triphosphate (ATP), the production of nicotinamide adenine dinucleotide (NAD), and reactive oxygen species (ROS) in the presence or absence of CpG, a TLR9 agonist. Further, HANPs enhance the secretion of immunostimulatory cytokines (TNF $\alpha$  or IL-6) while reducing the production of immunosuppressive cytokine (IL-10) in macrophages in response to CpG. In vaccinated mice model, vaccination with a mixture of CpG, HANPs, and OVA, a model antigen, allowed the development of a long-lasting balanced humoral immunity in mice.

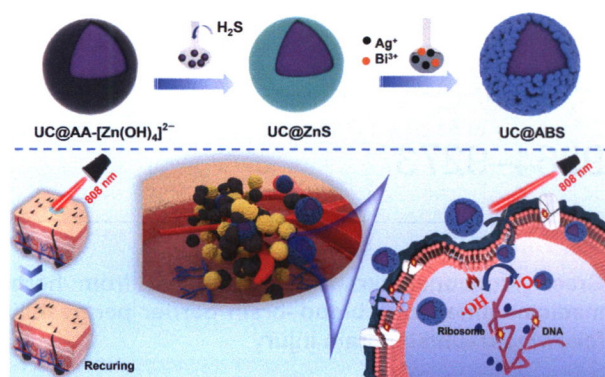
9286–9297

## Antibacterial mechanism and transcriptomic analysis of a near-infrared triggered upconversion nanoparticles@AgBiS<sub>2</sub> for synergetic bacteria-infected therapy

Shi Chen<sup>1</sup>, Zhaoyou Chu<sup>2</sup>, Limian Cao<sup>1</sup>, Lingling Xu<sup>2,\*</sup>, Qianqian Jin<sup>2</sup>, Nian Liu<sup>1</sup>, Benjin Chen<sup>2</sup>, Ming Fang<sup>1</sup>, Wannan Wang<sup>2</sup>, Haisheng Qian<sup>2,\*</sup>, and Min Shao<sup>1,\*</sup>

<sup>1</sup> The First Affiliated Hospital of Anhui Medical University, China

<sup>2</sup> Anhui Medical University, China



Upconversion nanoparticles@AgBiS<sub>2</sub> were successfully prepared, which showed enhanced photothermal conversion performance and good reactive oxygen species production ability for combined photothermal–photodynamic therapy of methicillin-resistant *Staphylococcus aureus* (MRSA) infection.

9298–9308



## Nano detection

### Research Articles

#### Ion compaction effect in hollow FePt nanochains with ultrathin shell under low energy ion irradiation

Jialong Liu<sup>1,\*</sup>, Jianguo Wu<sup>2,3</sup>, Long Cheng<sup>4</sup>, Suyun Niu<sup>5</sup>, Zhiqiang Wang<sup>6</sup>, Mengyuan Zhu<sup>7</sup>, Jingyan Zhang<sup>7</sup>, Shouguo Wang<sup>7,\*</sup>, and Wei Wang<sup>1,\*</sup>

<sup>1</sup> Beijing University of Chemical Technology, China

<sup>2</sup> Institute of Geology and Geophysics, Chinese Academy of Sciences, China

<sup>3</sup> Innovation Academy for Earth Science, Chinese Academy of Sciences, China

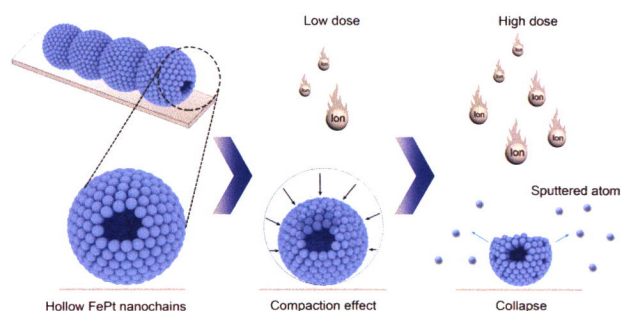
<sup>4</sup> Beihang University, China

<sup>5</sup> Beijing Hangxing Machinery Manufacturing Co., Ltd., China

<sup>6</sup> Beijing Smart-chip Microelectronics Technology Co., Ltd., China

<sup>7</sup> University of Science and Technology Beijing, China

9309–9318



The compaction effect has been observed in hollow FePt nanochains under low energy ions irradiation. The volume and microstructure of hollow architecture can be manipulated by ions.

#### *In situ* decorating the surface and interlayer of montmorillonite with $\text{Co}_{0.5}\text{Ni}_{0.5}\text{Fe}_2\text{O}_4$ nanoparticles: A sustainable, biocompatible colorimetric platform for $\text{H}_2\text{O}_2$ and acetylcholine

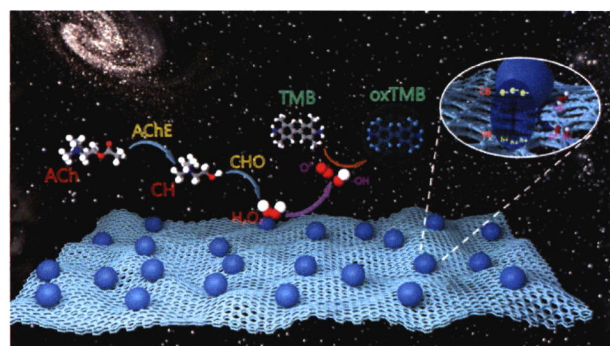
Xixi Zhu<sup>1</sup>, Hongyu Li<sup>1</sup>, Tao Wu<sup>1</sup>, Hui Zhao<sup>1</sup>, Kaili Wu<sup>2</sup>, Wenjing Xu<sup>3</sup>, Fengjuan Qin<sup>3</sup>, Wenxing Chen<sup>3,\*</sup>, Jinlong Zheng<sup>2,\*</sup>, and Qingyun Liu<sup>1,\*</sup>

<sup>1</sup> Shandong University of Science and Technology, China

<sup>2</sup> University of Science and Technology Beijing, China

<sup>3</sup> Beijing Institute of Technology, China

9319–9326



A facile and efficient biosensor for acetylcholine (ACh) was established based on the peroxidase-like activity of  $\text{Co}_{0.5}\text{Ni}_{0.5}\text{Fe}_2\text{O}_4$ -MMT originated from its catalytic decomposition of  $\text{H}_2\text{O}_2$  into  $\cdot\text{OH}$  and  $\text{O}_2^-$ .

#### Natural interface-mediated self-assembly of graphene-isolated-nanocrystals for plasmonic arrays construction and personalized information acquisition

Shen Wang<sup>1</sup>, Tianhuan Peng<sup>1</sup>, Shengkai Li<sup>1</sup>, Linlin Wang<sup>1</sup>, Liang Zhang<sup>1</sup>, Zhiwei Yin<sup>1</sup>, Xin Xia<sup>1</sup>, Xinqi Cai<sup>1</sup>, Xiaoxu Cao<sup>1</sup>, Long Chen<sup>2</sup>, Zhuo Chen<sup>1,\*</sup>, and Weihong Tan<sup>1,3,4</sup>

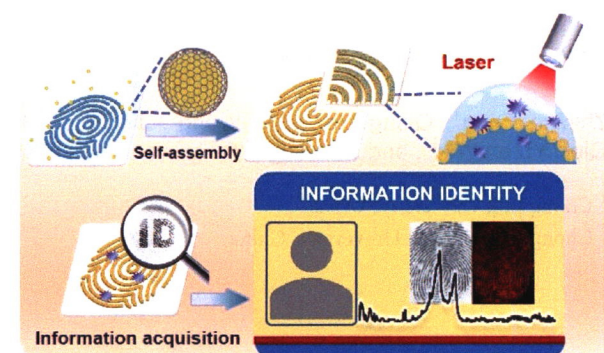
<sup>1</sup> Hunan University, China

<sup>2</sup> University of Macau, Macau, China

<sup>3</sup> Hangzhou Institute of Medicine (HIM), Chinese Academy of Sciences, China

<sup>4</sup> Shanghai Jiao Tong University, China

9327–9333



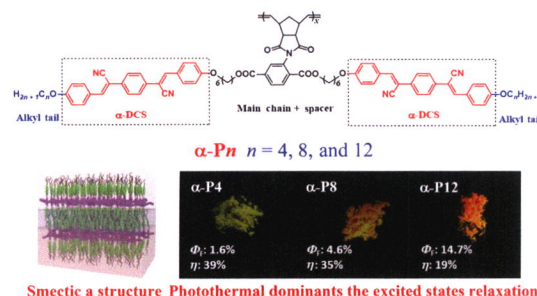
The naturally accessible interface of latent fingerprints (LFPs) offers a platform for localized self-assembly of graphene isolated Au nanocrystals (GIANs). The densely packed GIANs arrays on the fingerprint ridge are further used for personalized information acquisition, including high resolution imaging-mediated identification, as well as label-free, non-invasive acquisition of molecular information about residues in LFPs.

## AlEgen containing side-chain liquid crystalline polymers: Photoluminescence or photothermal, which dominate?

Lei Tao<sup>1</sup>, He-Lou Xie<sup>2,\*</sup>, Xin Qi<sup>1</sup>, Jun Song<sup>1</sup>, Hong Xin<sup>1,\*</sup>, and Zhen-Qiang Yu<sup>1,\*</sup>

<sup>1</sup> Shenzhen University, China

<sup>2</sup> Xiangtan University, China



Smectic a structure Photothermal dominates the excited states relaxation

A series of  $\alpha$ -dicyanodistyrylbenzene (a-DCS) containing luminescent liquid crystalline polymers (LLCPs) with polynorbornene as main chain are successfully prepared via ring-opening metathesis polymerization to reveal the relationship between photoluminescence (PL) and photothermal behavior. The liquid crystal (LC) phase structure, molecular packing model, photoluminescence behavior, lifetime, and photothermal effect of the resultant polymers are strongly dependent on the alkyl tail length and the photothermal effect plays a dominant role during the excited states energy decay.

9334–9340

## Nano device

### Research Articles

#### A waterproof and breathable Cotton/rGO/CNT composite for constructing a layer-by-layer structured multifunctional flexible sensor

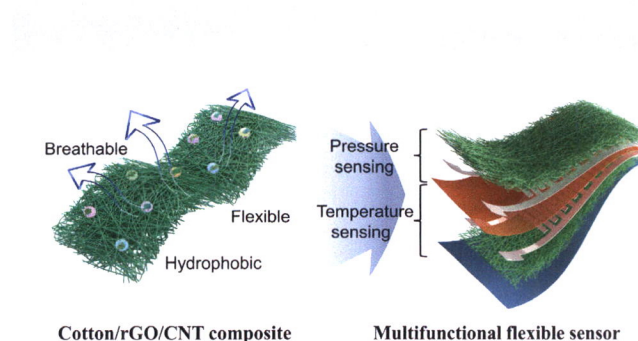
Feifei Yin<sup>1</sup>, Yunjian Guo<sup>1</sup>, Hao Li<sup>1</sup>, Wenjing Yue<sup>1</sup>, Chunwei Zhang<sup>1</sup>, Duo Chen<sup>3</sup>, Wei Geng<sup>4</sup>, Yang Li<sup>1,\*</sup>, Song Gao<sup>1,\*</sup>, and Guozhen Shen<sup>2,\*</sup>

<sup>1</sup> University of Jinan, China

<sup>2</sup> Beijing Institute of Technology, China

<sup>3</sup> Qilu University of Technology (Shandong Academy of Science), China

<sup>4</sup> Shandong Provincial Maternal and Child Health Care Hospital, China



A waterproof and breathable Cotton/reduced graphene oxide (rGO)/carbon nanotube (CNT) composite is proposed and reported to achieve a layer-by-layer structured multifunctional flexible sensor, enabling the high-sensitivity detection of pressure and temperature stimulus. In light of the superior pressure and temperature sensing capability, an array consisting of multifunctional flexible sensors further demonstrates the feasibility in perceiving and mapping pressure and temperature information of contact objects.

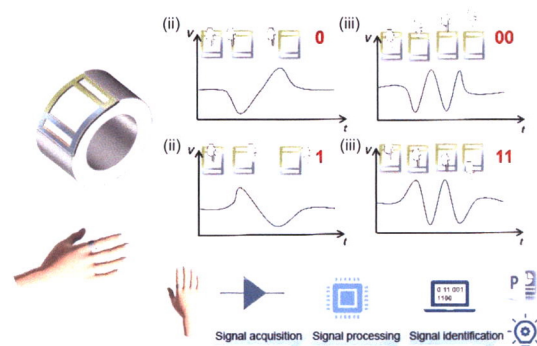
9341–9351

#### Multimode human-machine interface using a single-channel and patterned triboelectric sensor

Zhiping Feng<sup>1</sup>, Qiang He<sup>1</sup>, Xue Wang<sup>1</sup>, Jing Liu<sup>1</sup>, Jing Qiu<sup>1</sup>, Yufen Wu<sup>2,\*</sup>, and Jin Yang<sup>1,\*</sup>

<sup>1</sup> Chongqing University, China

<sup>2</sup> Chongqing Normal University, China



Human-machine interfaces play a crucial role in artificial intelligence. Here, a triboelectric interface by encoding voltage signals of opposite polarities is proposed for human-machine interfaces (HMIs). Combining the polarity and number of voltage output peak as coding information, it greatly reduces the size of the device and provides a new coding strategy. The interface attached to the ring successfully realizes intelligent control.

9352–9358

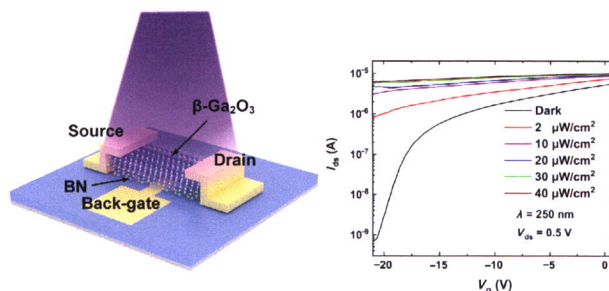


## Highly sensitive and stable $\beta$ -Ga<sub>2</sub>O<sub>3</sub> DUV phototransistor with local back-gate structure and its neuromorphic application

Xiao-Xi Li<sup>1</sup>, Guang Zeng<sup>1</sup>, Yu-Chun Li<sup>1</sup>, Qiu-Jun Yu<sup>1</sup>, Meng-Yang Liu<sup>1</sup>, Li-Yuan Zhu<sup>1</sup>, Wenjun Liu<sup>1,\*</sup>, Ying-Guo Yang<sup>1,2,\*</sup>, David Wei Zhang<sup>1</sup>, and Hong-Liang Lu<sup>1,\*</sup>

<sup>1</sup> Fudan University, China

<sup>2</sup> Shanghai Advanced Research Institute & Shanghai Institute of Applied Physics, Chinese Academy of Sciences, China



The fabricated  $\beta$ -Ga<sub>2</sub>O<sub>3</sub> phototransistor with local back-gate structure exhibits a high responsivity of  $1.01 \times 10^7$  A/W. The first-principles calculations reveal the decent stability of  $\beta$ -Ga<sub>2</sub>O<sub>3</sub> nanosheet against oxidation and humidity without significant performance degradations.

9359–9367

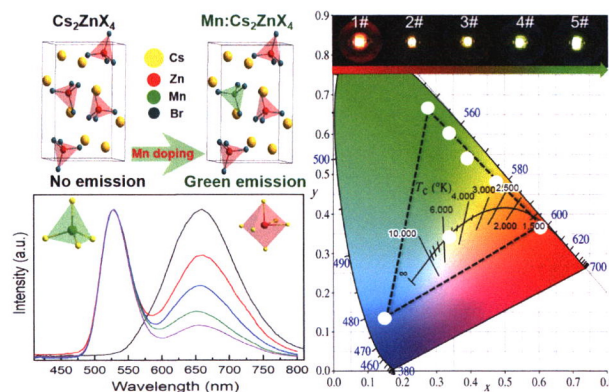
## Ultra-stable and color-tunable manganese ions doped lead-free cesium zinc halides nanocrystals in glasses for light-emitting applications

Kai Li<sup>1</sup>, Ying Ye<sup>1</sup>, Wenchao Zhang<sup>1</sup>, Yao Zhou<sup>1</sup>, Yudong Zhang<sup>1</sup>, Shisheng Lin<sup>2,3</sup>, Hang Lin<sup>2,3</sup>, Jian Ruan<sup>1</sup>, and Chao Liu<sup>1,\*</sup>

<sup>1</sup> Wuhan University of Technology, China

<sup>2</sup> Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, China

<sup>3</sup> Fujian Science & Technology Innovation Laboratory for Optoelectronic Information of China, China



Lead-free  $\text{Mn}^{2+}:\text{Cs}_2\text{ZnX}_4$  nanocrystals with tunable photoluminescence are precipitated in glasses. These  $\text{Mn}^{2+}:\text{Cs}_2\text{ZnX}_4$  nanocrystals embedded glasses show good thermal, chemical, and photo-stabilities, promising for applications in light-emitting devices.

9368–9376

## Highly anisotropic thermal conductivity of few-layer CrOCl for efficient heat dissipation in graphene device

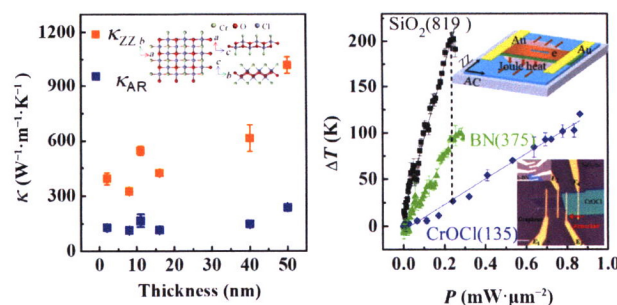
Xiaoming Zheng<sup>1,4</sup>, Yuehua Wei<sup>2</sup>, Zhenhua Wei<sup>2</sup>, Wei Luo<sup>2</sup>, Xiao Guo<sup>3</sup>, Xiangzhe Zhang<sup>2</sup>, Jinxin Liu<sup>1</sup>, Yangbo Chen<sup>1</sup>, Gang Peng<sup>2</sup>, Weiwei Cai<sup>1,4</sup>, Shiqiao Qin<sup>2</sup>, Han Huang<sup>3,\*</sup>, Chuyun Deng<sup>2,\*</sup>, and Xueao Zhang<sup>1,4,\*</sup>

<sup>1</sup> Xiamen University, China

<sup>2</sup> National University of Defense Technology, China

<sup>3</sup> Central South University, China

<sup>4</sup> Jiujiang Research Institute of Xiamen University, China



The layered CrOCl with anisotropic thermal conductivity can function as a heat sink for directional thermal dissipation in nanodevices.

9377–9385

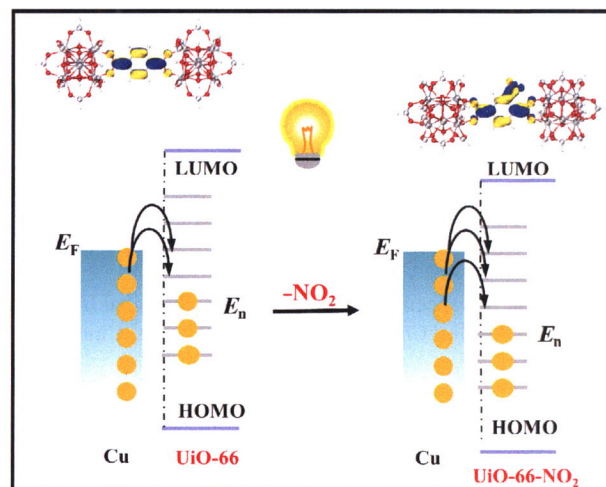
## Controllable design of high-efficiency triboelectric materials by functionalized metal–organic frameworks with a large electron-withdrawing functional group

Rongmei Wen<sup>1,\*</sup>, Rui Feng<sup>3</sup>, Bo Zhao<sup>1</sup>, Jiangfeng Song<sup>1</sup>, Liming Fan<sup>1,\*</sup>, and Junyi Zhai<sup>2,\*</sup>

<sup>1</sup> North University of China, China

<sup>2</sup> Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences, China

<sup>3</sup> Nankai University, China



Isostructural UiO-66-X (X = H, NH<sub>2</sub>, NO<sub>2</sub>, and Br) films are chosen as triboelectric materials to investigate the underlying relationships between different functional groups and the triboelectric performance of triboelectric nanogenerator (TENG). This work guides us on how to choose and design high-efficiency triboelectric material metal–organic frameworks to enhance the output performance of TENG.

9386–9391

## Ultrathin layered double hydroxide nanosheets prepared by original precursor method for photoelectrochemical photodetectors

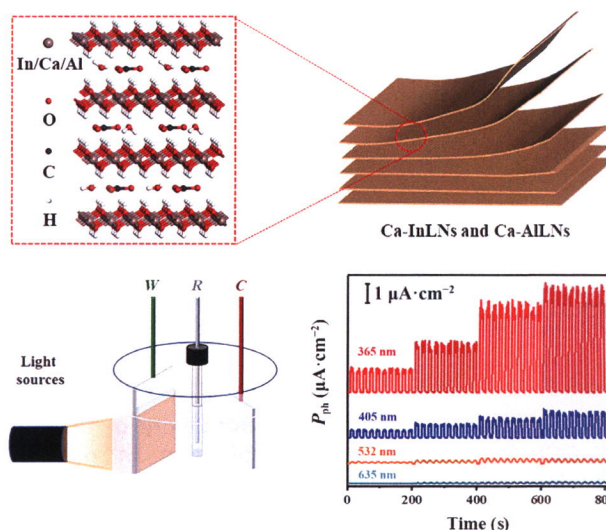
Yu Wang<sup>1</sup>, Fulai Zhao<sup>1</sup>, Yiyu Feng<sup>1,2,3,4</sup>, and Wei Feng<sup>1,2,3,\*</sup>

<sup>1</sup> Tianjin University, China

<sup>2</sup> Tianjin Key Laboratory of Composite and Functional Materials, China

<sup>3</sup> Key Laboratory of Advanced Ceramics and Machining Technology, Ministry of Education, China

<sup>4</sup> Zhengzhou University, China



Two novel ultrathin layered double hydroxides (LDHs, Ca-In and Ca-Al LDH) nanosheets are prepared through the original precursor method, and demonstrate a uniform thickness distribution, micron-level lateral sizes, and moderate bandgap, broad light absorption range, hydrophilicity and stability, thus, Ca-In and Ca-Al LDH nanosheets are applied for the first time in photoelectrochemical photodetectors, realizing a wide range of light detection from ultraviolet to visible light. Moreover, the fabricated photodetectors exhibit excellent cycle stability, and the average photocurrent density shows no reduction after 70 days.

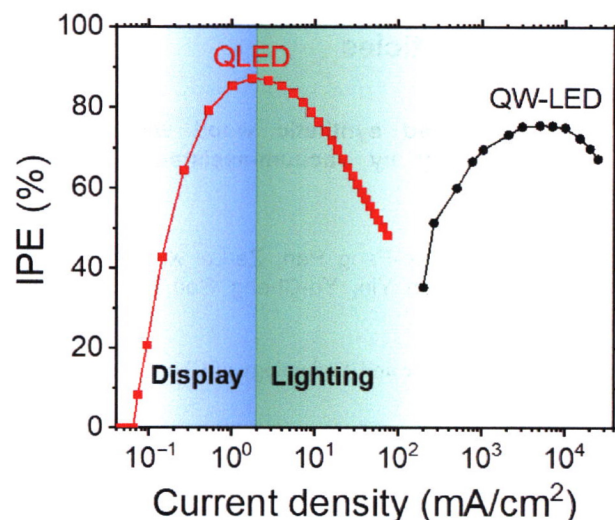
9392–9401



## Highly-efficient thermoelectric-driven light-emitting diodes based on colloidal quantum dots

Xing Lin, Xingliang Dai, Zikang Ye, Yufei Shu, Zixuan Song, and Xiaogang Peng

Zhejiang University, China



Efficient thermal-electrical driven light-emitting diodes can be constructed based on solution-processed colloidal quantum dots (QLEDs). The device can achieve its peak internal power conversion efficiency (IPE ~ 90%) and remain high level within the current density range of 0.5–100 mA/cm<sup>2</sup> which matches the demand of display and lighting applications. Micro-LEDs based on epitaxially grown quantum well (QW-LEDs) exhibit very limited power conversion efficiency in the same current density range due to leakage current and/or Shockley–Read–Hall (SRH) nonradiative recombination.

9402–9409

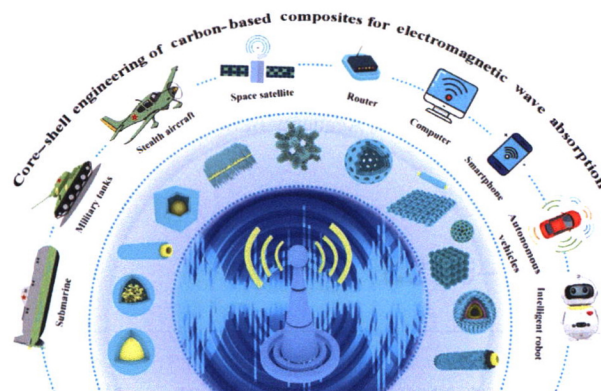
## Nano unit

### Review Article

## Advances in core-shell engineering of carbon-based composites for electromagnetic wave absorption

Lixue Gai, Honghong Zhao, Fengyuan Wang, Pan Wang, Yonglei Liu, Xijiang Han\*, and Yunchen Du\*

Harbin Institute of Technology, China



Herein, the research progress in core-shell carbon-based electromagnetic wave absorption materials is reviewed, with a special focus on the advances of built-in carbon cores with diverse morphologies, as well as built-out carbon shells with positively protective effect. Furthermore, the future challenge and perspectives on the development of core-shell carbon-based composites in electromagnetic absorption field are also discussed and predicted.

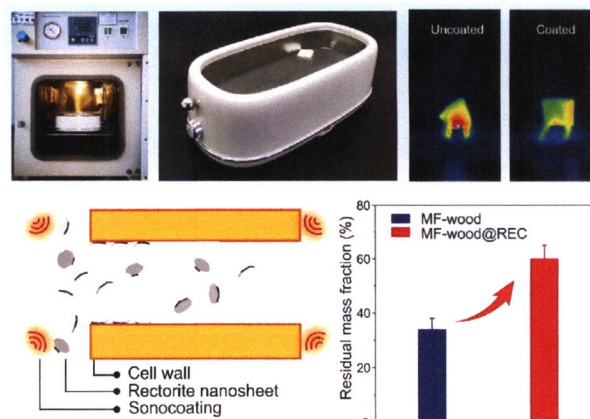
9410–9439

## Research Articles

### Nanosheet-coated synthetic wood with enhanced flame-retardancy by vacuum-assisted sonocoating technique

Zhi-Yuan Ma, Xiao-Feng Pan, Ze-Lai Xu, Zhi-Long Yu, Bing Qin, Yi-Chen Yin, Yu-Cheng Gao, and Shu-Hong Yu\*

University of Science and Technology of China, China



A vacuum-assisted sonocoating approach has been proposed to modify the artificial wood with a rectorite nano-coating on every internal channel wall. The nanosheets can go much deeper into the channels with the help of vacuum and sonication, which promote the infiltration of nanosheets solution into the channels. The nanosheet coating enables the formation of a thick ash layer and a char layer to endure the fire erosion for at least 10 min without any structural collapse.

9440–9446

### Chirally assembled plasmonic metamolecules from intrinsically chiral nanoparticles

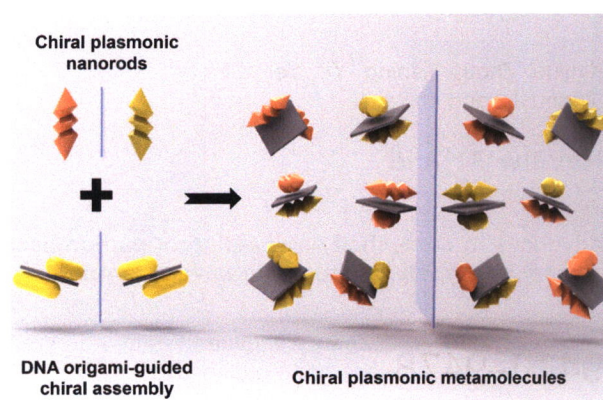
Jiahao Pan<sup>1,2</sup>, Xiaoyao Wang<sup>1,2</sup>, Jinjin Zhang<sup>1,2</sup>, Qin Zhang<sup>2,3</sup>, Qiangbin Wang<sup>1,2,4</sup>, and Chao Zhou<sup>1,2,\*</sup>

<sup>1</sup> University of Science and Technology of China, China

<sup>2</sup> Suzhou Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, China

<sup>3</sup> Soochow University, China

<sup>4</sup> University of Chinese Academy of Sciences, China



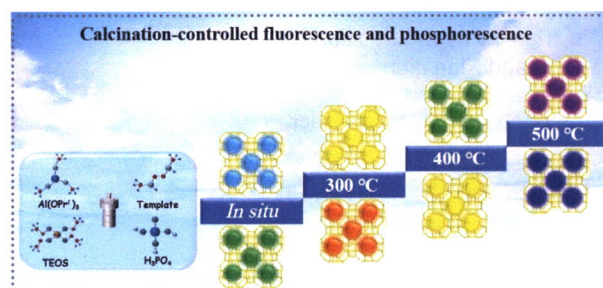
Plasmonic nanorods with intrinsic chirality are chirally assembled into dimeric plasmonic metamolecules with intriguing plasmonic circular dichroism.

9447–9453

### Calcination-controlled fabrication of carbon dots@zeolite composites with multicolor fluorescence and phosphorescence

Siyu Zong, Bolun Wang, Xin Yin, Wenyan Ma, Jiani Zhang, and Jiyang Li\*

Jilin University, China



A universal calcination strategy based on the *in-situ* hydrothermal synthesis is presented to prepare multicolor carbon dots (CDs)-based composites.

9454–9460



## Toroidal dipole-modulated dipole-dipole double-resonance in colloidal gold rod-cup nanocrystals for improved SERS and second-harmonic generation

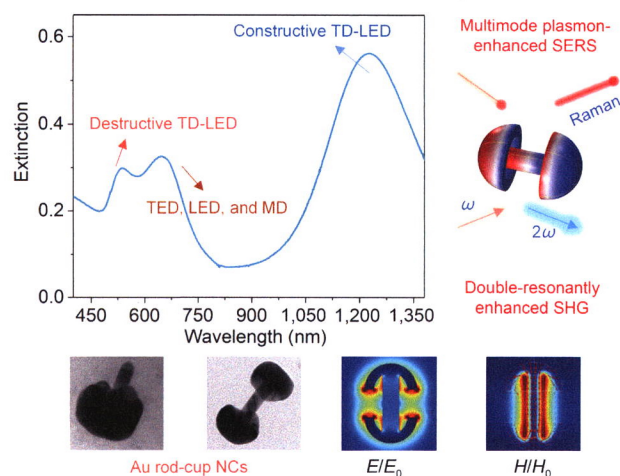
Hao-Sen Kang<sup>1</sup>, Wen-Qin Zhao<sup>1</sup>, Tao Zhou<sup>2</sup>, Liang Ma<sup>1,\*</sup>, Da-Jie Yang<sup>3</sup>, Xiang-Bai Chen<sup>1</sup>, Si-Jing Ding<sup>2</sup>, and Qu-Quan Wang<sup>4,\*</sup>

<sup>1</sup> Wuhan Institute of Technology, China

<sup>2</sup> China University of Geosciences (Wuhan), China

<sup>3</sup> North China Electric Power University, China

<sup>4</sup> Southern University of Science and Technology, China



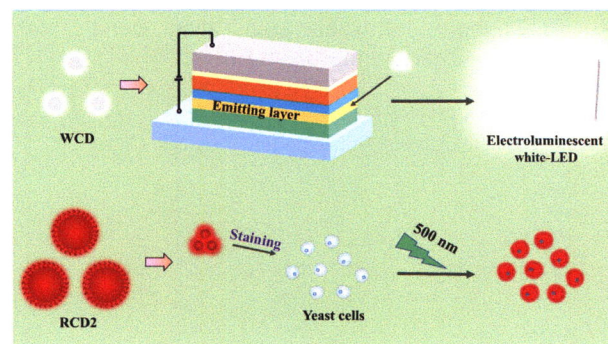
High-yield, stable, and monodisperse Au rod-cup nanocrystals in which Au nanocups are embedded on one or two ends of Au nanorods are successfully prepared for the first time. The Au rod-cup nanocrystals possess transverse and longitudinal electric dipole, magnetic dipole, toroidal dipole modulated longitudinal electric dipole resonances, largely-improved surface-enhanced Raman spectroscopy (SERS), and double-resonantly enhanced second-harmonic generation.

9461–9469

## A novel method for the synthesis of carbon dots assisted by free radicals

Xinyue Zhou, Keping Yi, Yeling Yang, Guohua Xie\*, Xinghu Ji\*, and Zhike He\*

Wuhan University, China



Free radicals assisted synthesis of carbon dots for white electroluminescence (white carbon dots (WCD)) and cell staining (red CDs (RCD2)).

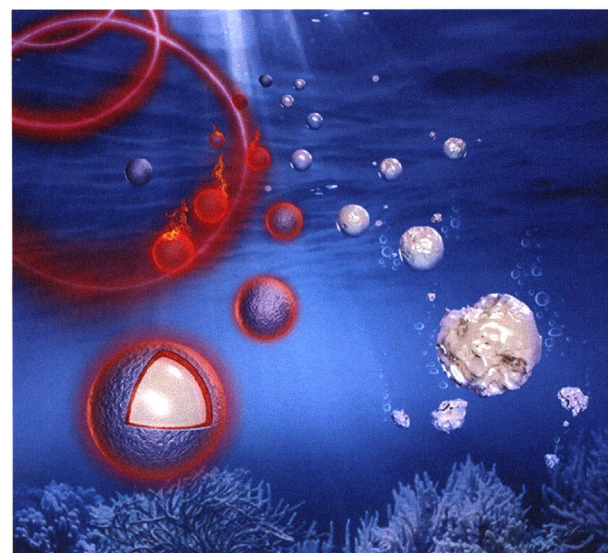
9470–9478

## Large-scale synthesis of fluorine-free carbonyl iron-organic silicon hydrophobic absorbers with long term corrosion protection property

Wei Tian<sup>1</sup>, Jinyao Li<sup>1</sup>, Yifan Liu<sup>1</sup>, Longjiang Deng<sup>1,\*</sup>, Yang Guo<sup>2,\*</sup>, and Xian Jian<sup>1,\*</sup>

<sup>1</sup> University of Electronic Science and Technology of China, China

<sup>2</sup> Panzhihua University, China



Carbonyl iron (CI)@SiO<sub>2</sub>/1,1,1,3,3,3-hexamethyl disilazane (HMDS) hybrid exhibits excellent microwave absorption and long-term corrosion protection properties, largely due to the extraordinary wave-transparent and shielding ability of hydrophobic protective layer.

9479–9491

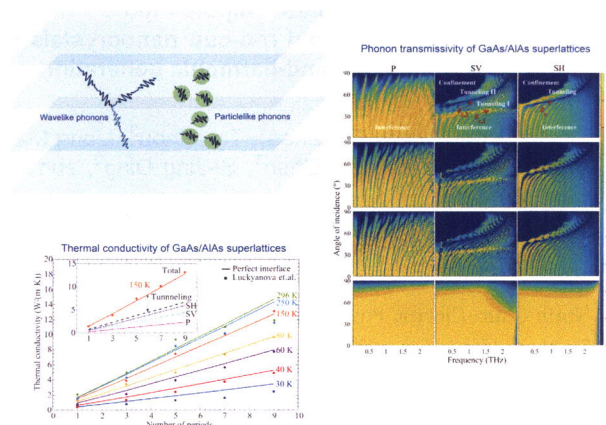
## Heat conduction of multilayer nanostructures with consideration of coherent and incoherent phonon transport

Bin Liu<sup>1</sup>, Yangyu Guo<sup>2</sup>, Vladimir I. Khvesyuk<sup>1</sup>, Alexander A. Barinov<sup>1</sup>, and Moran Wang<sup>3,\*</sup>

<sup>1</sup> Bauman Moscow State Technical University, Russia

<sup>2</sup> Université de Lyon, France

<sup>3</sup> Tsinghua University, China



Coherent thermal transport in multilayer structures is investigated within the framework of the continuum model. By further introducing the incoherence of phonons, the classical minimum thermal conductivity is reproduced.

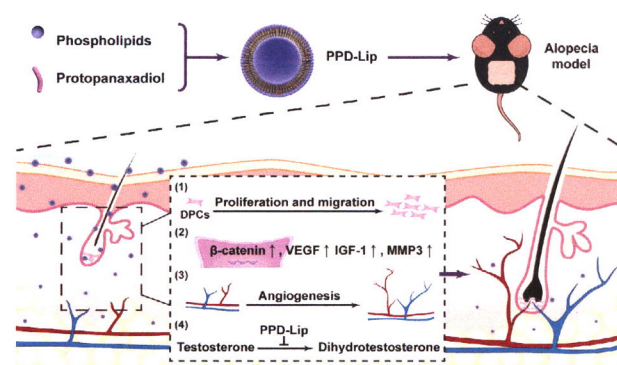
9492–9497

## A multifunctional cholesterol-free liposomal platform based on protopanaxadiol for alopecia therapy

Xuefei Zhang<sup>1,2</sup>, Shuxuan Li<sup>1</sup>, Yating Dong<sup>1</sup>, Hehui Rong<sup>1</sup>, Junke Zhao<sup>1</sup>, and Haiyan Hu<sup>1,\*</sup>

<sup>1</sup> Sun Yat-sen University, China

<sup>2</sup> West Yunnan University of Applied Sciences, China



Multifunctional cholesterol-free liposomes were prepared using protopanaxadiol (PPD) as fluidity buffer instead of cholesterol to avoid the potential biosynthesis of testosterone which may potentiate hair loss. The protopanaxadiol-based liposomes (PPD-Lip) could accelerate hair regeneration *in vitro* and *in vivo* by promoting proliferation, migration, gene expression of dermal papilla cells, and angiogenesis.

9498–9510

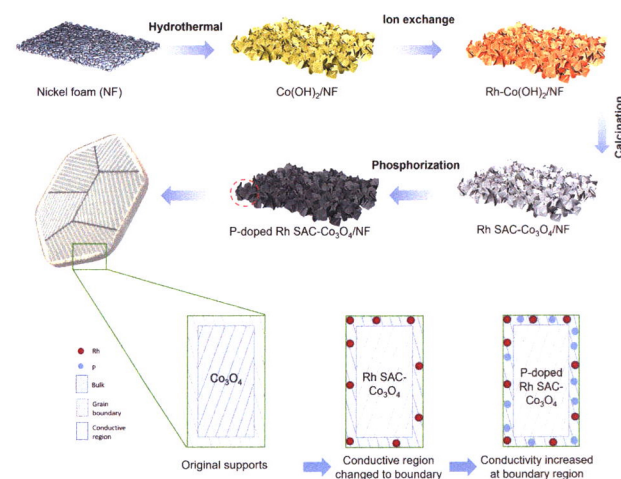
## Enhancing electrical conductivity of single-atom doped Co<sub>3</sub>O<sub>4</sub> nanosheet arrays at grain boundary by phosphor doping strategy for efficient water splitting

Yaohang Gu<sup>1</sup>, Xuanyu Wang<sup>1</sup>, Ateer Bao<sup>1</sup>, Liang Dong<sup>3</sup>, Xiaoyan Zhang<sup>1,3</sup>, Haijun Pan<sup>3,\*</sup>, Wenquan Cui<sup>2,\*</sup>, and Xiwei Qi<sup>2,\*</sup>

<sup>1</sup> Northeastern University, China

<sup>2</sup> North China of Science and Technology, China

<sup>3</sup> Northeastern University at Qinhuangdao, China



A phosphor doped single atom with Co<sub>3</sub>O<sub>4</sub> supported bifunctional electrocatalyst was fabricated (P-doped Rh SAC-Co<sub>3</sub>O<sub>4</sub>). P-doped Rh SAC-Co<sub>3</sub>O<sub>4</sub> requires only 1.77 V to reach the current density of 50 mA·cm<sup>-2</sup> for overall water splitting. The phosphor doping strategy increased the electrical conductivity with almost 2 orders of magnitude. The grain boundary is the main conductive area for P-doped Rh SAC-Co<sub>3</sub>O<sub>4</sub> where the elevated conductivity originates.

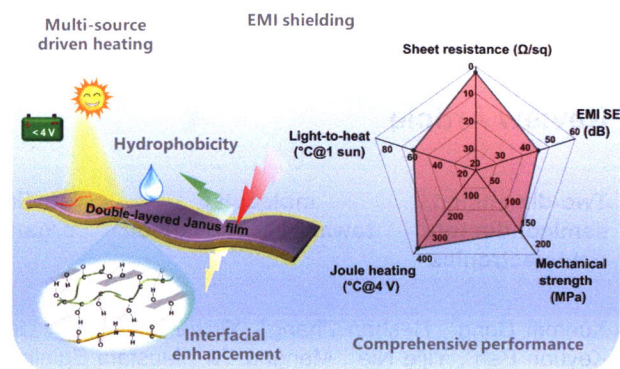
9511–9519



## Robust double-layered ANF/MXene-PEDOT:PSS Janus films with excellent multi-source driven heating and electromagnetic interference shielding properties

Bing Zhou, Jianzhou Song, Bo Wang, Yuezhan Feng\*, Chuntai Liu\*, and Changyu Shen

Zhengzhou University, China



Multifunctional aramid nanofiber (ANF)/MXene-poly(3,4-ethylenedioxy-thiophene):poly(styrenesulfonate) (PEDOT:PSS) films with double-layered Janus structure exhibited excellent comprehensive properties, including hydrophobicity, electrical conductivity, electromagnetic interference (EMI) shielding, and mechanical and multi-source driven heating properties, which should be useful for preparing advanced electronic components in future.

9520–9530

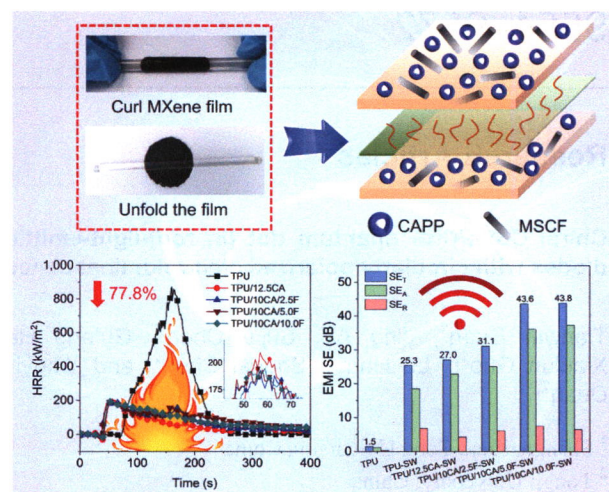
## Multi-hierarchical flexible composites towards superior fire safety and electromagnetic interference shielding

Kexin Chen<sup>1</sup>, Miao Liu<sup>1</sup>, Yongqian Shi<sup>1,\*</sup>, Hengrui Wang<sup>1</sup>, Libi Fu<sup>1</sup>, Yuezhan Feng<sup>2</sup>, and Pingan Song<sup>3</sup>

<sup>1</sup> Fuzhou University, China

<sup>2</sup> Zhengzhou University, China

<sup>3</sup> University of Southern Queensland, Australia



Multi-hierarchical flexible thermoplastic polyurethane (TPU)/CAPP/MSCF/MXene systems were successfully fabricated by a novel air-assisted thermocompression. The obtained TPU composites integrate superior fire safety and electromagnetic interference (EMI) shielding properties.

9531–9543

## In-situ doping nickel single atoms in two-dimensional MXenes analogue support for room temperature NO<sub>2</sub> sensing

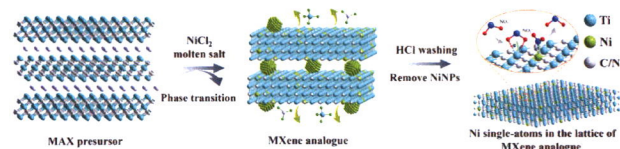
Weiming Chen<sup>1,2</sup>, Peipei Li<sup>1,2</sup>, Jia Yu<sup>1,2</sup>, Peixin Cui<sup>3</sup>, Xiaohu Yu<sup>4,\*</sup>, Weiguo Song<sup>1,2,\*</sup>, and Changyan Cao<sup>1,2,\*</sup>

<sup>1</sup> Institute of Chemistry, Chinese Academy of Sciences, China

<sup>2</sup> University of Chinese Academy of Sciences, China

<sup>3</sup> Institute of Soil Science, Chinese Academy of Sciences, China

<sup>4</sup> Shaanxi University of Technology, China



Through a  $\text{NiCl}_2$  molten salt etching method, Ni single atoms could be *in-situ* doped in the lattice of MXenes analogue support, resulting in much larger charge transfer from Ni atoms to adjacent Ti atoms, and thus increasing the electronic density of these Ti atoms for  $\text{NO}_2$  sensing at room temperature.

9544–9553

## Semiconductor

## Review Article

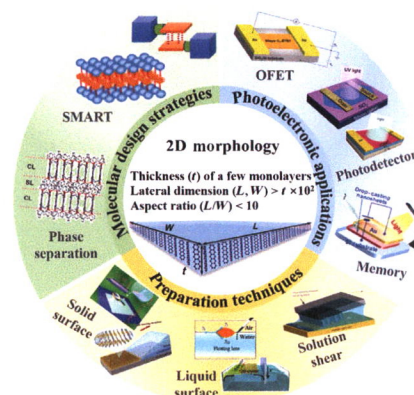
## Two-dimensional molecular crystalline semiconductors towards advanced organic optoelectronics

Xuemei Dong<sup>1</sup>, Heshan Zhang<sup>1</sup>, Yinxiang Li<sup>1,\*</sup>, Bin Liu<sup>1</sup>, Keyuan Pan<sup>1</sup>, Yijie Nie<sup>1</sup>, Mengna Yu<sup>2</sup>, Mustafa Eginligil<sup>1</sup>, Juqing Liu<sup>1,\*</sup>, and Wei Huang<sup>1,2,3,\*</sup>

<sup>1</sup> Nanjing Tech University (Nanjing Tech), China

<sup>2</sup> Nanjing University of Posts & Telecommunications, China

<sup>3</sup> Northwestern Polytechnical University, China



This review focuses on molecular building block design, preparation technology as well as their recent advances in optoelectronic devices of two-dimensional molecular crystalline semiconductors (2D-MCSs).

9554–9572

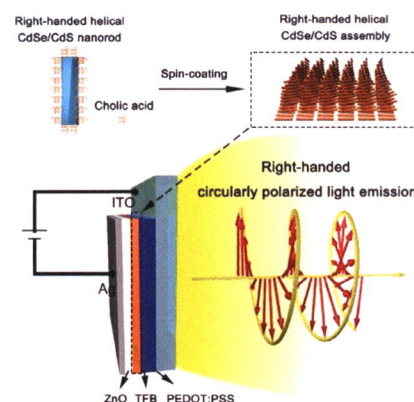
## Research Articles

## Chiral CdSe/CdS quantum dot (in rod)-light-emitting diodes with circularly polarized electroluminescence

Tianwei Duan<sup>1</sup>, Jing Ai<sup>2</sup>, Sujie Chen<sup>1</sup>, Gufeng He<sup>1</sup>, Xiaojun Guo<sup>1,\*</sup>, Lu Han<sup>2,\*</sup>, Shunai Che<sup>1,2</sup>, and Yingying Duan<sup>2,\*</sup>

<sup>1</sup> Shanghai Jiao Tong University, China

<sup>2</sup> Tongji University, China



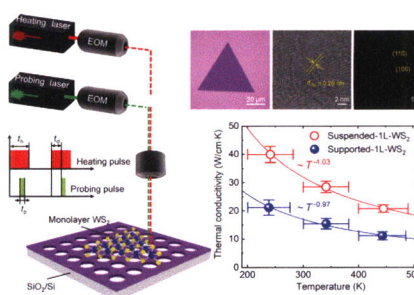
The chiral quantum dot (in rod)-light-emitting diodes were fabricated through spin-coating evaporation of chiral CdSe/CdS quantum rods as an emitting layer, exhibiting right-handed circularly polarized light emission at 600 nm due to the filtration effects as a result of the circular Bragg resonance by quasi-photonic crystal structures.

9573–9577

Reduction in thermal conductivity of monolayer WS<sub>2</sub> caused by substrate effect

Yufeng Zhang, Qian Lv, Aoran Fan, Lingxiao Yu, Haidong Wang, Weigang Ma, Ruitao Lv\*, and Xing Zhang\*

Tsinghua University, China



A significant reduction in thermal conductivity was observed in supported monolayer WS<sub>2</sub> at 200–400 K by dual-wavelength flash Raman method. The molecular dynamics simulation and Raman study mutually demonstrated the suppression of acoustic phonons and the peculiar behavior of optical phonons induced by substrate effect.

9578–9587



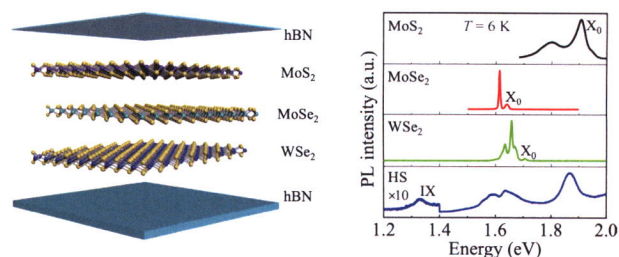
## Observation of interlayer excitons in trilayer type-II transition metal dichalcogenide heterostructures

Biao Wu<sup>1</sup>, Haihong Zheng<sup>1</sup>, Junnan Ding<sup>1</sup>, Yunpeng Wang<sup>1</sup>, Zongwen Liu<sup>2</sup>, and Yanping Liu<sup>1,3,\*</sup>

<sup>1</sup> Central South University, China

<sup>2</sup> The University of Sydney, Australia

<sup>3</sup> Shenzhen Research Institute of Central South University, China



We successfully observed the interlayer excitons in the trilayer type-II heterostructure and confirmed the source of the interlayer excitons.

9588–9594

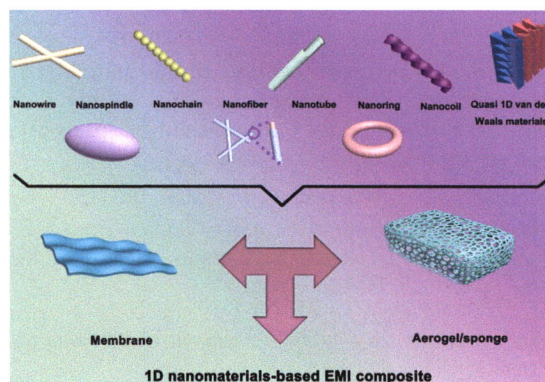
## Synthesis

### Review Articles

## One-dimensional metallic, magnetic, and dielectric nanomaterials-based composites for electromagnetic wave interference shielding

Ya Cheng, Wendong Zhu, Xiaofeng Lu\*, and Ce Wang\*

Jilin University, China



In this review, we focus on the electromagnetic wave interference (EMI) shielding membrane- or aerogel/sponge-like composite, including one-dimensional (1D) metallic, magnetic, and dielectric nanomaterials as EMI fillers. Correspondingly, the fabricated routes, shielding performance, and attenuated mechanism of 1D metallic, magnetic, and dielectric filler-based composites are summarized.

9595–9613

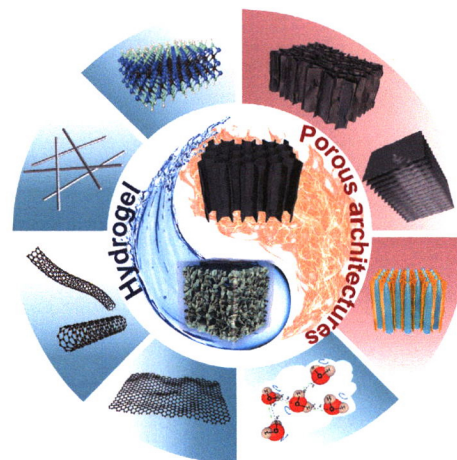
## Hydrogel-based composites beyond the porous architectures for electromagnetic interference shielding

Yunfei Yang<sup>1</sup>, Mingrui Han<sup>1</sup>, Wei Liu<sup>1,2</sup>, Na Wu<sup>3,\*</sup>, and Jiurong Liu<sup>1,\*</sup>

<sup>1</sup> Shandong University, China

<sup>2</sup> Shenzhen research institute of Shandong University, China

<sup>3</sup> ETH Zurich, Switzerland



In this review, we summarized the hydrogel-based composites for electromagnetic interference (EMI) shielding. The preparation process, research progress, as well as the multifunctionalities of the hydrogel-based EMI shields were introduced. The importance of pore structure design and preparation process of biomimetic aligned porous architectures were also emphasized to provide a reference for hydrogel-based EMI shields.

9614–9630

## Research Articles

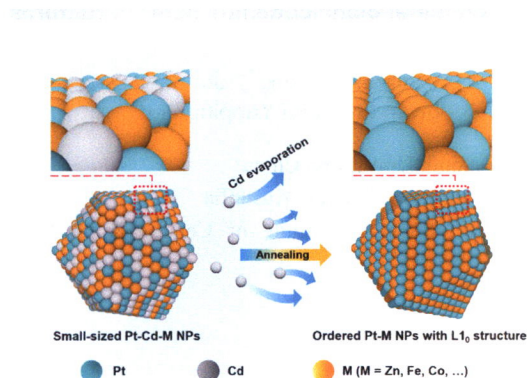
### A top-down strategy to realize the synthesis of small-sized L<sub>10</sub>-platinum-based intermetallic compounds for selective hydrogenation

Yu Jin<sup>1</sup>, Guomian Ren<sup>2</sup>, Yonggang Feng<sup>3</sup>, Shize Geng<sup>3</sup>, Ling Li<sup>1</sup>, Xing Zhu<sup>1</sup>, Jun Guo<sup>1</sup>, Qi Shao<sup>1</sup>, Yong Xu<sup>2,\*</sup>, Xiaoqing Huang<sup>3,\*</sup>, and Jianmei Lu<sup>1,\*</sup>

<sup>1</sup> Soochow University, China

<sup>2</sup> Guangdong University of Technology, China

<sup>3</sup> Xiamen University, China



We have demonstrated a facile top-down strategy for synthesizing small-sized L<sub>10</sub>-PtM intermetallic compounds (IMCs), which has been validated by the generations of various binary, ternary, quaternary, quinary, and senary Pt-based IMCs with L<sub>10</sub> structure. The obtained IMCs exhibit high stability against to high temperature (700 °C) and excellent selectivity towards 4-nitrophenylacetylene hydrogenation.

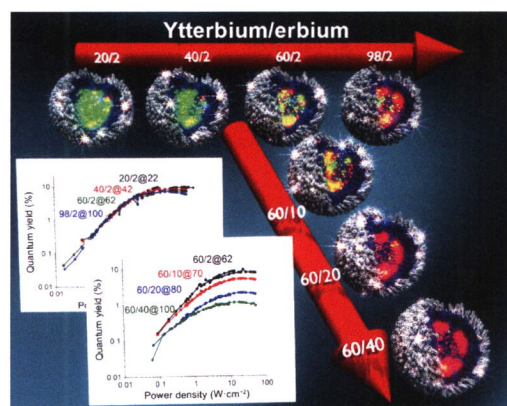
9631–9638

### Yb- and Er concentration dependence of the upconversion luminescence of highly doped NaYF<sub>4</sub>:Yb,Er/NaYF<sub>4</sub>:Lu core/shell nanocrystals prepared by a water-free synthesis

Christian Würth<sup>1</sup>, Bettina Grauel<sup>1</sup>, Monika Pons<sup>1</sup>, Florian Frenzel<sup>1</sup>, Philipp Rissiek<sup>2</sup>, Kerstin Rücker<sup>1</sup>, Markus Haase<sup>1,\*</sup>, and Ute Resch-Genger<sup>1,\*</sup>

<sup>1</sup> Federal Institute for Materials Research and Testing (BAM), Germany

<sup>2</sup> Universität Osnabrück, Germany



Absolute upconversion luminescence (UCL) measurements of highly doped NaYF<sub>4</sub>:Yb,Er/NaYF<sub>4</sub>:Lu core/shell nanocrystals prepared by an elaborate water-free synthesis reveal that high Yb<sup>3+</sup> concentrations of up to 98% barely reduce the record quantum yield of ~ 9% for an Er<sup>3+</sup> concentration of 2% and present a very effective tool to boost particle brightness. Increasing the Er<sup>3+</sup> concentration to 40% leads to a 7-fold decrease in UCL for heavily Yb<sup>3+</sup>-doped nanocrystals, yet this reduction in UCL can be compensated by high excitation power densities.

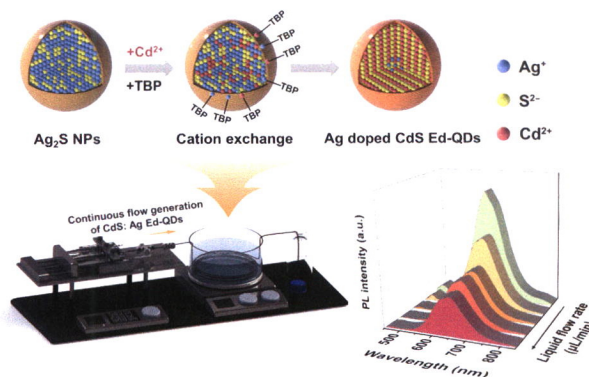
9639–9646

### Microreactor platform for continuous synthesis of electronic doped quantum dots

Yuxi Li<sup>1</sup>, Yanbin Li<sup>2</sup>, Xinyuan Li<sup>1,\*</sup>, Tailai Hou<sup>1</sup>, Chen Qiao<sup>1</sup>, Yunpeng Tai<sup>1</sup>, Xiaole Gu<sup>1</sup>, Di Zhao<sup>1</sup>, Le Sang<sup>1,\*</sup>, and Jiatao Zhang<sup>1,\*</sup>

<sup>1</sup> Beijing Institute of Technology, China

<sup>2</sup> Beijing University of Chemical Technology, China



Electronic doped quantum dots were continuously synthesized using microreactor platform by cation exchange reaction. The kinetics of reactions were mediated by varying liquid flow rates, achieving quantum dots with enhanced optoelectronic properties.

9647–9653

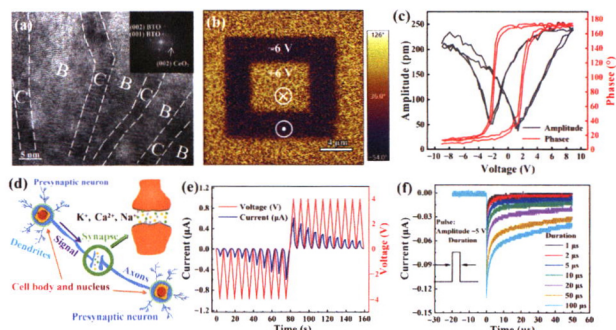


## Silicon-based epitaxial ferroelectric memristor for high temperature operation in self-assembled vertically aligned BaTiO<sub>3</sub>-CeO<sub>2</sub> films

Xiaobing Yan<sup>1,\*</sup>, Hongwei Yan<sup>1</sup>, Gongjie Liu<sup>1</sup>, Jianhui Zhao<sup>1,\*</sup>, Zhen Zhao<sup>1</sup>, Hong Wang<sup>1</sup>, Haidong He<sup>1</sup>, Mengmeng Hao<sup>1</sup>, Zhaohua Li<sup>1</sup>, Lei Wang<sup>1</sup>, Wei Wang<sup>1</sup>, Zixuan Jian<sup>1</sup>, Jiaxin Li<sup>1</sup>, and Jingsheng Chen<sup>2,\*</sup>

<sup>1</sup> Hebei University, China

<sup>2</sup> National University of Singapore, Singapore



The ferroelectric memristors based self-assembled vertically aligned nano-composites BaTiO<sub>3</sub>-CeO<sub>2</sub> on silicon could increase the Curie temperatures to stabilize the performance of ferroelectric memristor due to higher in-plane compressive strain. In addition, this device not only mimics the artificial synaptic function, but also has up to 86.78% digits recognition ability in a single-layer perceptron model.

9654–9662

## Theory

### Research Articles

## Single-atom catalysts modified by molecular groups for electrochemical nitrogen reduction

Zengxi Wei<sup>1</sup>, Yuchang Liu<sup>1</sup>, Hongjie Liu<sup>1</sup>, Shaopeng Wang<sup>1,2,3</sup>, Minchen Hou<sup>4</sup>, Liwei Wang<sup>1,2,3,\*</sup>, Dong Zhai<sup>5</sup>, Shuangliang Zhao<sup>1</sup>, Kefu Yu<sup>1,3</sup>, and Shaolong Zhang<sup>4,\*</sup>

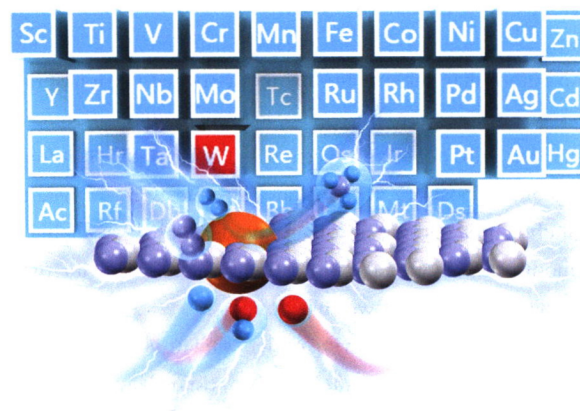
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We have screened a series of transition metals single atom catalysts (SACs) in the substrate of g-C<sub>3</sub>N<sub>4</sub> for electrochemical nitrogen reduction reaction (eNRR). The theoretical results exhibited that the W-based SACs can be as a candidate for eNRR.

9663–9669

## Dry reforming of methane on doped Ni nanoparticles: Feature-assisted optimizations and ranking of doping metals for direct activations of CH<sub>4</sub> and CO<sub>2</sub>

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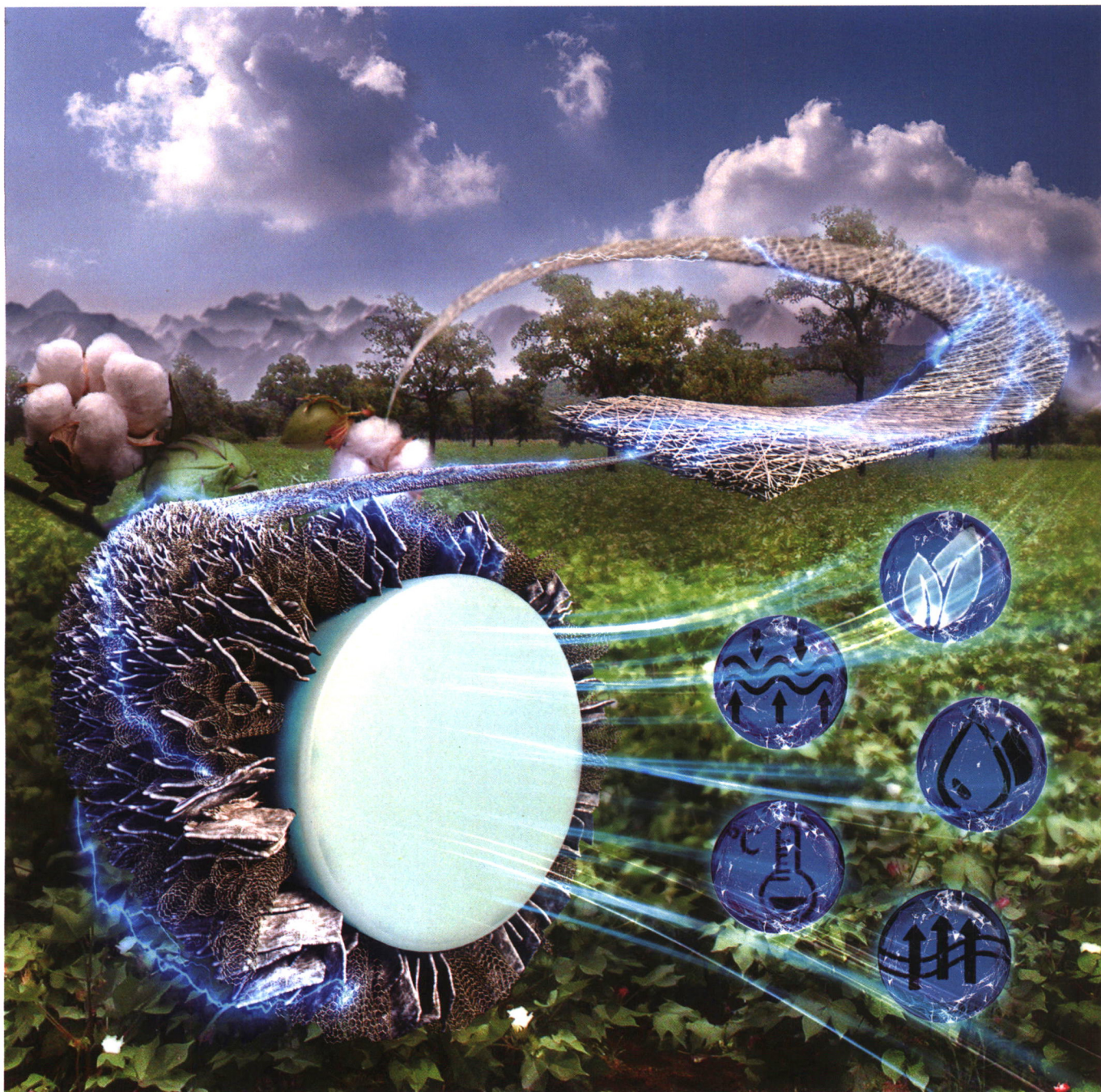
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We developed both a regression model and a ranking model for the prediction of optimal Ni-based bimetallic catalysts for dry reforming of methane (DRM), based on first-principle mechanistic investigations on direct CH<sub>4</sub> and CO<sub>2</sub> activations as well as coke formation.

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