

Nano Research

June · 2019

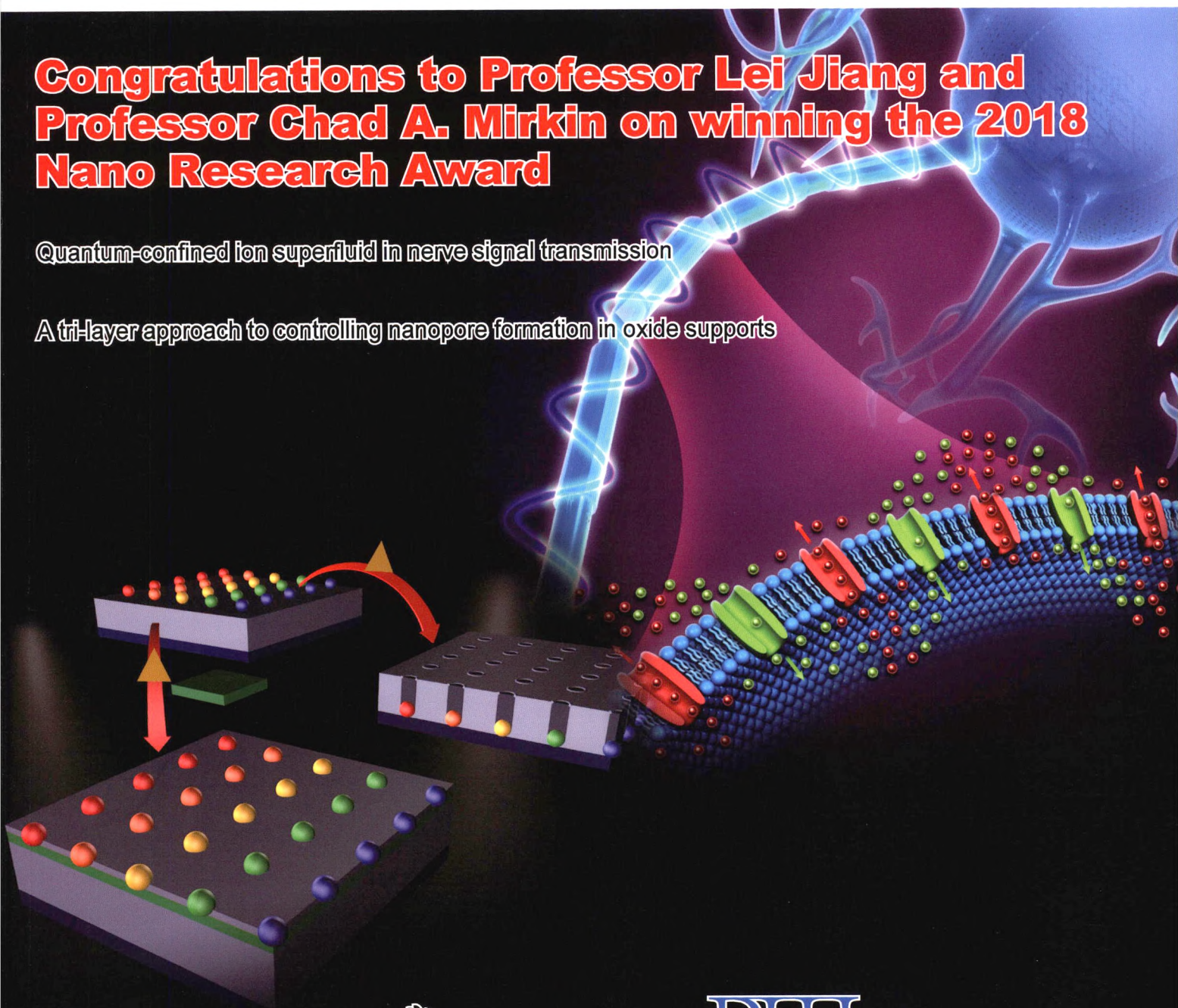
Volume 12 · Number 6



Congratulations to Professor Lei Jiang and Professor Chad A. Mirkin on winning the 2018 Nano Research Award

Quantum-confined ion superfluid in nerve signal transmission

A tri-layer approach to controlling nanopore formation in oxide supports



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Contents

Research Articles

Quantum-confined ion superfluid in nerve signal transmission

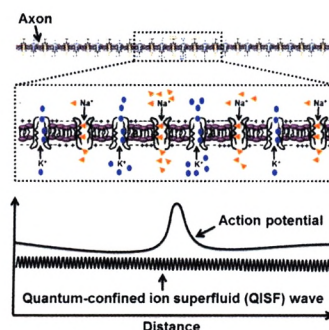
Xiqi Zhang¹ and Lei Jiang^{1,2,3,*}

¹ Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, China

² University of Chinese Academy of Sciences, China

³ Beihang University, China

1219–1221



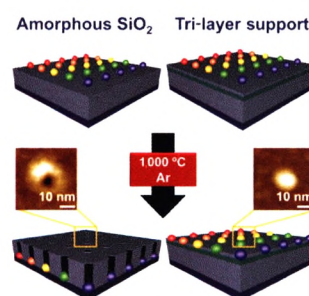
Ultrafast ions transportation through all sodium-potassium pump nanochannels simultaneously in the membrane leads to quantum-confined ion superfluid (QISF) wave along the neuronal axon, which acts as an information medium in the ultrafast nerve signal transmission.

A tri-layer approach to controlling nanopore formation in oxide supports

Abha A. Gosavi, James L. Hedrick, Peng-Cheng Chen, Justin M. Notestein*, and Chad A. Mirkin*

Northwestern University, USA

1223–1228



Metal nanoparticles, supported on amorphous SiO₂, form nanopores in the SiO₂ when heated above 1,000 °C. In this paper, we show that this behavior is general to a variety of metals (Au, Ag, Cu, Pd, and Pt) and demonstrate a way to control the extent of entrenchment. Further, we propose a mechanism and explain that this entrenchment occurs due to the glass-transition exhibited by amorphous SiO₂.

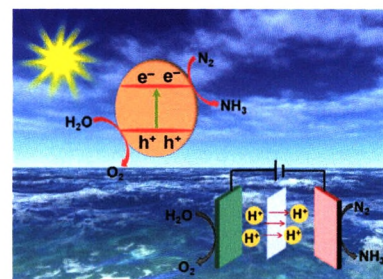
Review Articles

Review on photocatalytic and electrocatalytic artificial nitrogen fixation for ammonia synthesis at mild conditions: Advances, challenges and perspectives

Xiaolan Xue, Renpeng Chen, Changzeng Yan, Peiyang Zhao, Yi Hu, Wenjun Zhang, Songyuan Yang, and Zhong Jin*

Nanjing University, China

1229–1249



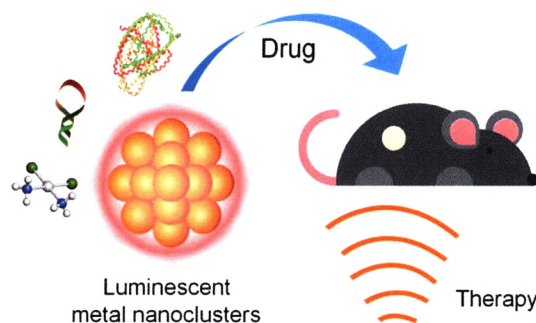
This review presents the research progresses on the design of photo(electro)catalysts and electrocatalysts for N₂ reduction reaction towards ammonia synthesis in aqueous solutions under ambient conditions and discusses the challenges and prospects of artificial nitrogen fixation.

Luminescent metal nanoclusters for biomedical applications

Yu Su¹, Tiantian Xue¹, Yuxin Liu¹, Jinxia Qi¹, Rongchao Jin^{2,*}, and Zhenkun Lin^{1,*}

¹ The Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University, China

² Carnegie Mellon University, USA



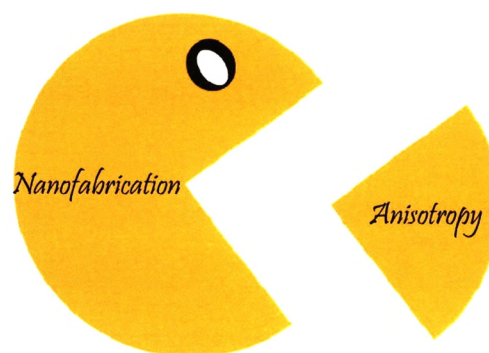
Luminescent metal nanoclusters possess unique properties and hold promise in biomedical applications, including diagnosis and treatment of diseases, especially for tumors and cancers.

1251–1265

Recent advances in the synthesis and applications of anisotropic carbon and silica-based nanoparticles

Chunhong Chen, Lei Xie, and Yong Wang*

Zhejiang University, China



Nature creates abundant organisms with not only isotropic but also anisotropic structures, as is the same with nanofabrication of materials. In this minireview, we summarize the latest synthesis methodologies of anisotropic carbon and silica-based nanoparticles.

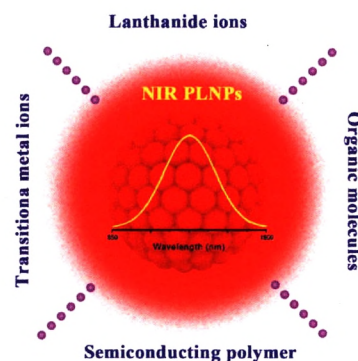
1267–1278

Recent progress in engineering near-infrared persistent luminescence nanoprobe for time-resolved biosensing/bioimaging

Ling Liang¹, Na Chen¹, Yiyi Jia¹, Qinqin Ma², Jie Wang², Quan Yuan^{1,2,*}, and Weihong Tan¹

¹ Hunan University, China

² Wuhan University, China



This review is organized around the engineering of different type of long-lived near-infrared persistent luminescence nanoprobe (NIR PLNPs) for time-resolved biosensing/bioimaging, such as transition metal ions-doped NIR PLNPs, lanthanide ions-doped NIR PLNPs, organic molecules-based NIR PLNPs, and semiconducting polymer self-assembled NIR PLNPs.

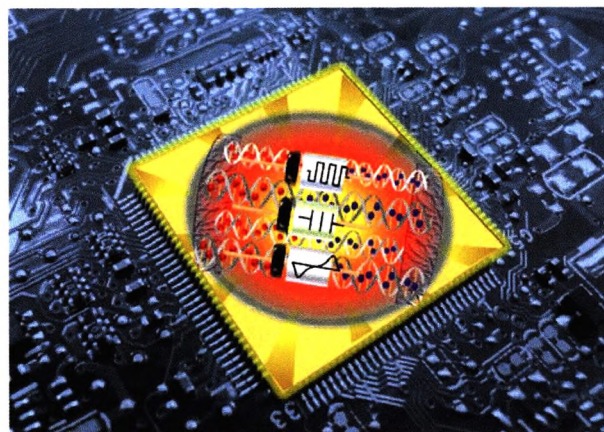
1279–1292

The fabrication and application of Ni-DNA nanowire-based nanoelectronic devices

Pang-Chia Chang¹, Chia-Yu Chang¹, Wen-Bin Jian^{1,*}, Chiun-Jye Yuan¹, Yu-Chang Chen¹, and Chia-Ching Chang^{1,2,*}

¹“National Chiao Tung University”, Taiwan, China

²“Academia Sinica”, Taiwan, China



DNA-guided nickel ion chain (Ni-DNA) nanowire device is a novel memelement exhibiting multiple functions, including memresistor, memcapacitor and redox-based negative differential resistance (NDR) effect. These unique characteristics make Ni-DNA-based nanoelectronic device the potential core components for the future memcomputing.

1293–1300

Research Articles

Synthesis of MoX_2 ($\text{X} = \text{Se}$ or S) monolayers with high-concentration 1T' phase on 4H/fcc-Au nanorods for hydrogen evolution

Zhengqing Liu^{1,2}, Xiao Zhang², Yue Gong^{3,4}, Qipeng Lu², Zhicheng Zhang², Hongfei Cheng², Qinglang Ma², Junze Chen², Meiting Zhao², Bo Chen², Ye Chen², Xue-Jun Wu², Pengfei Yin², Lin Gu^{3,4,5,*}, Yaping Du^{1,*}, and Hua Zhang^{2,*}

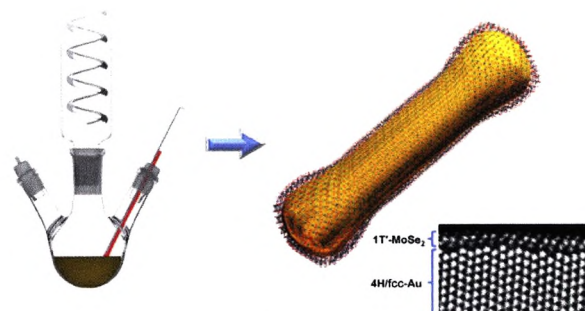
¹ Nankai University, China

² Nanyang Technological University, Singapore

³ Institute of Physics, Chinese Academy of Sciences, China

⁴ University of Chinese Academy of Sciences, China

⁵ Collaborative Innovation Center of Quantum Matter, China



Colloidal synthesis

4H/fcc-Au@ MoX_2 ($\text{X} = \text{Se}$ or S)

MoX_2 ($\text{X} = \text{Se}$ or S) monolayers with high-concentration 1T' phase were synthesized through the colloidal synthesis strategy by using 4H/fcc-Au nanorods as templates to form 4H/fcc-Au@ MoX_2 nanocomposites, which exhibited excellent electrocatalytic performance for hydrogen evolution reaction in acid medium.

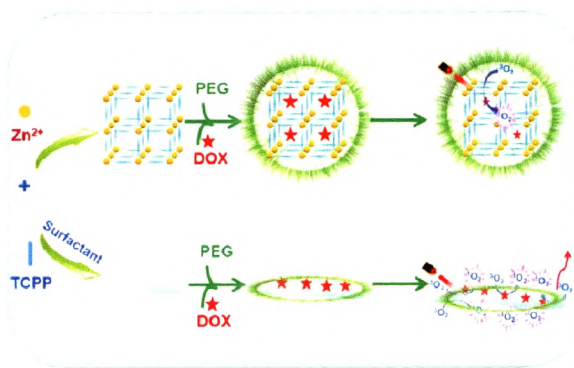
1301–1305

Two-dimensional metal-organic-framework as a unique theranostic nano-platform for nuclear imaging and chemo-photodynamic cancer therap

Wenjun Zhu¹, Yu Yang², Qitong Jin¹, Yu Chao¹, Longlong Tian¹, Jingjing Liu¹, Ziliang Dong¹, and Zhuang Liu^{1,*}

¹ Soochow University, China

² University of Macau, Macau, China



Two-dimensional nanoscale metal organic frameworks (2D NMOFs) composed of Zn^{2+} and tetrakis(4-carboxyphenyl) porphyrin (TCPP) are fabricated and functionalized with polyethylene glycol (PEG). Compared to their particulate counterpart, such 2D NMOFs show greatly increased drug loading capacity and enhanced light-triggered singlet oxygen production, promising for chemotherapy and photodynamic therapy (PDT) with efficient biodegradation and rapid renal clearance.

1307–1312

Shape-controlled synthesis of liquid metal nanodroplets for photothermal therapy

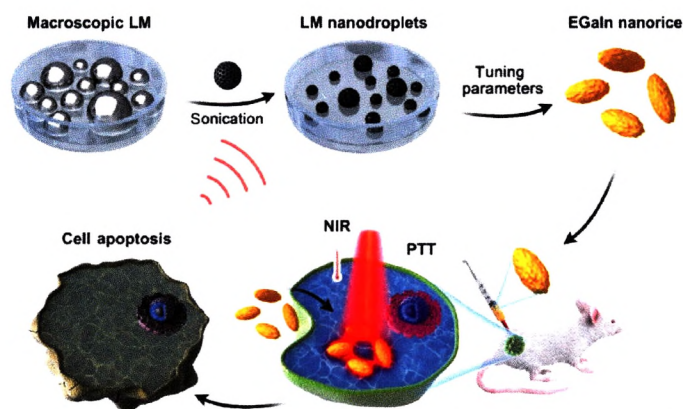
Junjie Yan^{1,2,3}, Xudong Zhang^{1,3}, Yang Liu⁴, Yanqi Ye^{1,3}, Jicheng Yu^{1,3}, Qian Chen^{1,3}, Jinqiang Wang^{1,3}, Yuqi Zhang^{1,3}, Quanyin Hu^{1,3}, Yang Kang^{1,3}, Min Yang^{2,*}, and Zhen Gu^{1,3,*}

¹ University of North Carolina at Chapel Hill and North Carolina State University, USA

² Jiangsu Institute of Nuclear Medicine, China

³ University of California, Los Angeles, USA

⁴ North Carolina State University, USA



Utilization of ultrasmall water-soluble melanin nanoparticles (MNPs) as a ligand not only can achieve excellent stability in aqueous solutions, but also can realize the shape-controlled synthesis of liquid metal (LM) nanodroplets. Among various shapes, LM nanorices presented the best photothermal conversion efficiency and performed as a new kind of photothermal ablation agents.

1313–1320

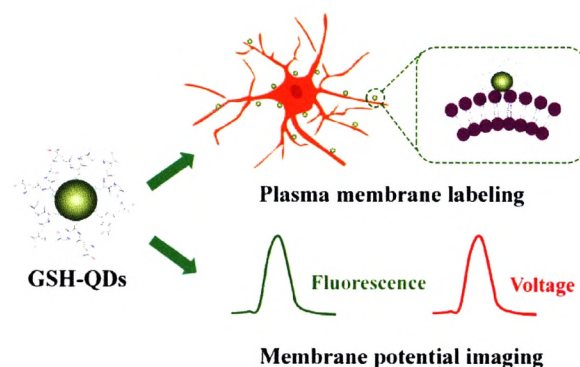
Glutathione-capped quantum dots for plasma membrane labeling and membrane potential imaging

Guangcun Chen^{1,2,*}, Yejun Zhang^{1,2}, Zhao Peng^{1,2}, Dehua Huang^{1,2}, Chunyan Li^{1,2}, and Qiangbin Wang^{1,2,3,*}

¹ Suzhou Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, China

² University of Science and Technology of China, China

³ University of Chinese Academy of Sciences, China



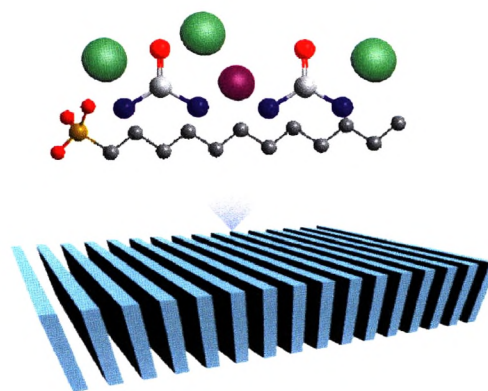
Glutathione-capped quantum dots were prepared by a facile ligand exchange method and used for plasma membrane labeling and membrane potential imaging.

1321–1326

Fabrication of NiFe layered double hydroxide with well-defined laminar superstructure as highly efficient oxygen evolution electrocatalysts

Hao Zhang, Haoyi Li, Bilal Akram, and Xun Wang*

Tsinghua University, China



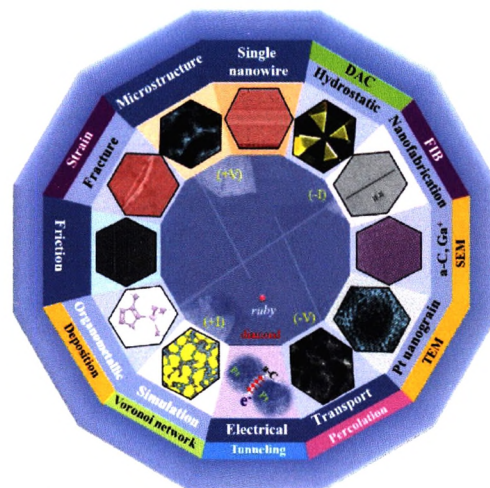
The layered double hydroxide-based laminar superstructure was fabricated by a one-step hydrothermal process, and exhibited an excellent catalytic activity on electrochemical oxygen evolution reaction.

1327–1331

High-pressure triggered quantum tunneling tuning through classical percolation in a single nanowire of a binary composite

Sudeshna Samanta^{1,2}, Mokwon Lee², Deok-Soo Kim², Jaeyong Kim², and Lin Wang^{1,*}

¹ Center for High Pressure Science & Technology Advanced Research, China

² Hanyang University, Republic of Korea

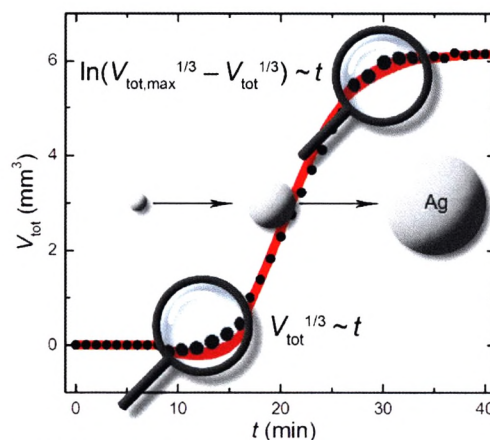
We studied the fabrication of a single metal-carbon composite nanowire device inside a diamond-anvil-cell to explore its electrical transport properties under external hydrostatic pressure. The pressure-induced shape reconstruction of metallic grains and associated modification of inter-grain interactions successfully explained the observed electrical transport behavior.

1333–1338

An extreme-condition model for quantifying growth kinetics of colloidal metal nanoparticles

Siyu Wu and Yugang Sun*

Temple University, USA



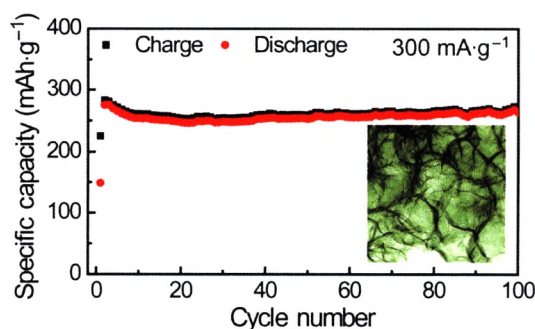
A strategy has been developed for quantitatively analyzing growth kinetics of colloidal metal nanoparticles by focusing on the time-dependent evolution of total nanoparticle volume at both the very early and the very late growth stages, resulting in the determination of intrinsic kinetics parameters involving in the growth of colloidal silver nanoparticles.

1339–1345

Inverse opal manganese dioxide constructed by few-layered ultrathin nanosheets as high-performance cathodes for aqueous zinc-ion batteries

Hao Ren, Jin Zhao, Lan Yang, Qinghua Liang, Srinivasan Madhavi*,
and Qingyu Yan*

Nanyang Technological University, Singapore



Inverse opal structured birnessite MnO_2 composed of ultrathin nanosheets shows promising performance as cathode material for aqueous zinc-ion batteries, benefiting from the ultrathin few-layered nanosheets and the stable unique structure favoring the charge carrier diffusion.

1347–1353

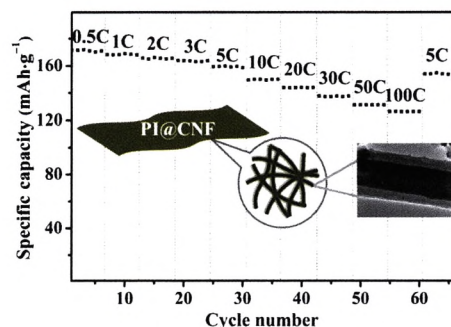
A polyimide cathode with superior stability and rate capability for lithium-ion batteries

Jianghui Zhao^{1,2}, Tuo Kang², Yanli Chu^{1,2}, Peng Chen², Feng Jin^{1,2}, Yanbin Shen^{1,2,*}, and Liwei Chen^{2,3,*}

¹ University of Science and Technology of China, China

² Suzhou Institute of Nano-Tech and Nano-Bionics, Chinese Academy of Sciences, China

³ Shanghai Jiaotong University, China



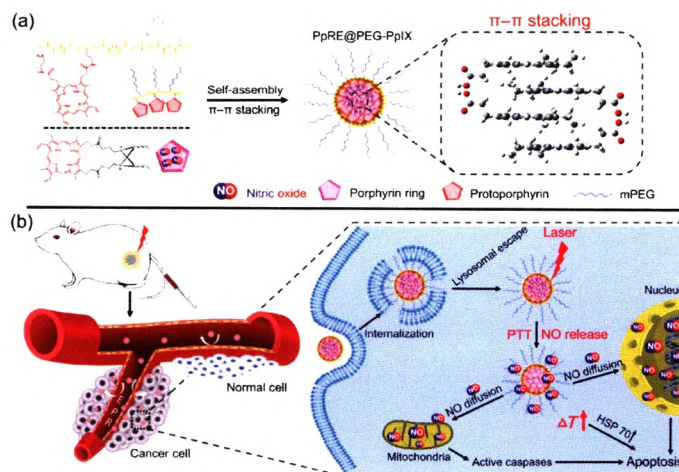
A binder-free self-supporting organic electrode with excellent redox kinetics is demonstrated via *in situ* polymerization of a uniform thin polyimide (PI) layer on a porous and highly conductive carbonized nanofiber (CNF) framework.

1355–1360

Stimuli-responsive nitric oxide generator for light-triggered synergistic cancer photothermal/gas therapy

Xuehui Huang, Funeng Xu, Huabo Hou, Jianwen Hou, Yi Wang*, and Shaobing Zhou*

Southwest Jiaotong University, China



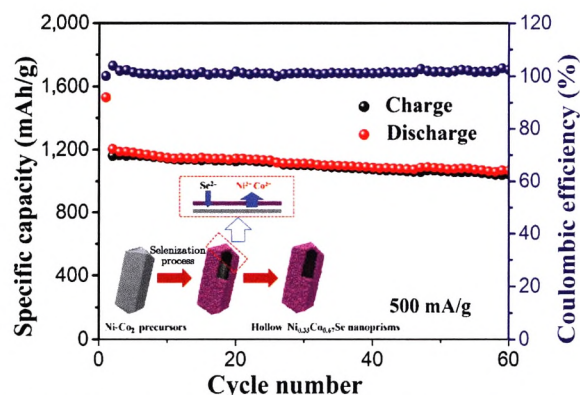
A novel intelligent protoporphyrin-based polymer nanoplatform is developed for synergistic enhancement of cancer treatment through combined photothermal therapy (PTT) and nitric oxide (NO) therapy.

1361–1370

Novel hollow $\text{Ni}_{0.33}\text{Co}_{0.67}\text{Se}$ nanoprisms for high capacity lithium storage

Shaohua Zhu, Cheng Chen, Pan He, Shuangshuang Tan, Fangyu Xiong, Ziang Liu, Zhuo Peng, Qinyou An*, and Liqiang Mai*

Wuhan University of Technology, China



Uniform $\text{Ni}_{0.33}\text{Co}_{0.67}\text{Se}$ hollow nanoprisms have been prepared successfully, and they exhibit superior electrochemical performance as anode materials for lithium-ion batteries.

1371–1374

Vacuum-tuned-atmosphere induced assembly of Au@Ag core/shell nanocubes into multi-dimensional superstructures and the ultrasensitive IAPP proteins SERS detection

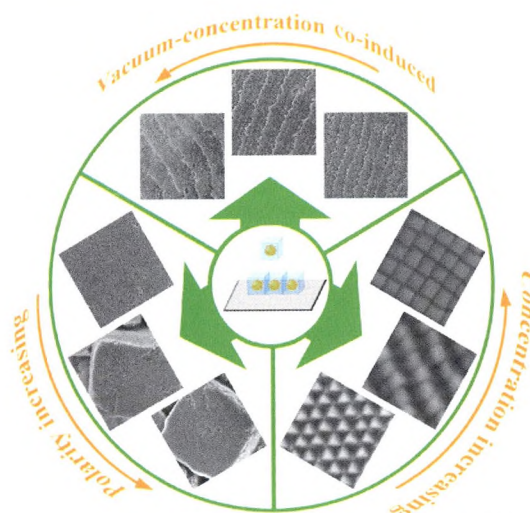
Meng Xu¹, Guopeng Tu¹, Muwei Ji^{2,3}, Xiaodong Wan¹, Jiajia Liu¹, Jia Liu¹, Hongpan Rong¹, Yanlian Yang⁴, Chen Wang⁴, and Jiatao Zhang^{1,*}

¹ Beijing Institute of Technology, China

² Shenzhen University, China

³ Tsinghua University, China

⁴ National Center for Nanoscience and Technology (NCNST), Chinese Academy of Sciences, China



Coordinated modulating the vacuum degree, colloid concentration and evaporation atmosphere, Au@Ag core/shell nanocubes (NCs) can controllably assemble into diverse multi-dimensional superstructures.

1375–1379

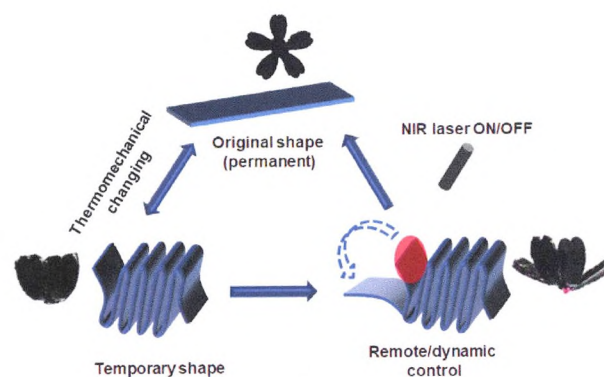
A novel near-infrared light responsive 4D printed nanoarchitecture with dynamically and remotely controllable transformation

Haitao Cui¹, Shida Miao¹, Timothy Esworthy¹, Se-jun Lee¹, Xuan Zhou¹, Sung Yun Hann¹, Thomas J. Webster², Brent T. Harris³, and Lijie Grace Zhang^{1,*}

¹ The George Washington University, USA

² Northeastern University, USA

³ Georgetown University, USA



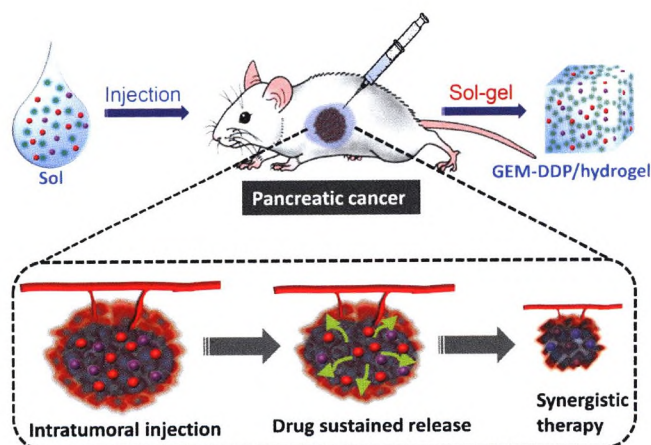
A near-infrared light (NIR) responsive four-dimensional (4D) printing technique is presented, capable of achieving a dynamically and remotely controllable transformation in a spatiotemporal manner.

1381–1388

Sustained co-delivery of gemcitabine and cis-platinum via biodegradable thermo-sensitive hydrogel for synergistic combination therapy of pancreatic cancer

Kun Shi, Bingxin Xue, Yanpeng Jia, Liping Yuan, Ruxia Han, Fan Yang, Jinrong Peng, and Zhiyong Qian*

Sichuan University and Collaborative Innovation Center, China



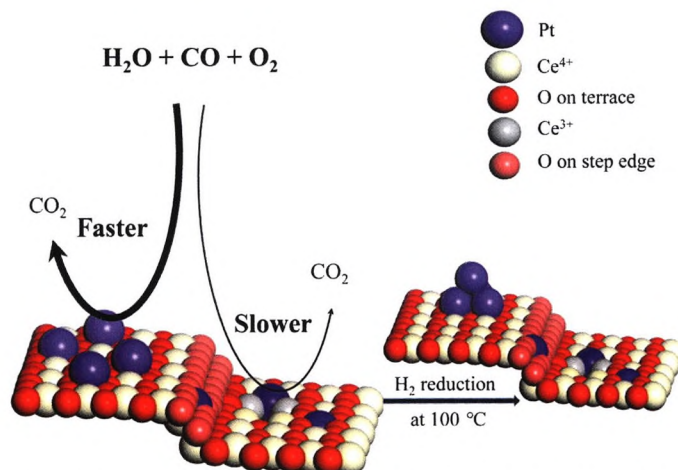
A dual-drug delivery system was designed that employed an injectable thermo-sensitive copolymer hydrogel for the local delivery of gemcitabine (GEM) and cis-platinum (DDP) to promote the synergistic combination therapy of pancreatic cancer.

1389–1399

Insight of the stability and activity of platinum single atoms on ceria

Xuxu Ye, Hengwei Wang, Yue Lin, Xinyu Liu, Lina Cao, Jian Gu, and Junling Lu*

University of Science and Technology of China, China



Here we show that CeO₂ surface defect sites, Pt–O–Ce bond interactions, electronic properties of Pt₁ single atoms all play critical roles in the catalytic activity of Pt₁/CeO₂ single-atom catalysts (SACs).

1401–1409

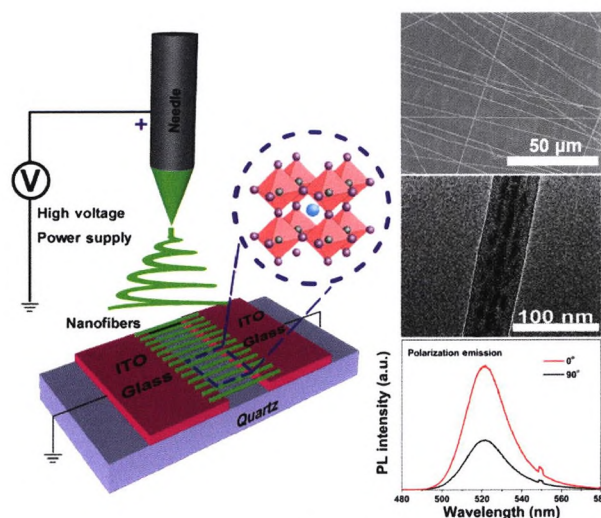
In-situ fabricated anisotropic halide perovskite nanocrystals in polyvinylalcohol nanofibers: Shape tuning and polarized emission

Linghai Meng¹, Changgang Yang², Jingjia Meng¹, Yongzhi Wang¹, Yong Ge¹, Ziqiang Shao^{1,*}, Guofeng Zhang², Andrey L. Rogach³, and Haizheng Zhong^{1,*}

¹ Beijing Institute of Technology, China

² Shanxi University, China

³ City University of Hong Kong, Hong Kong, China



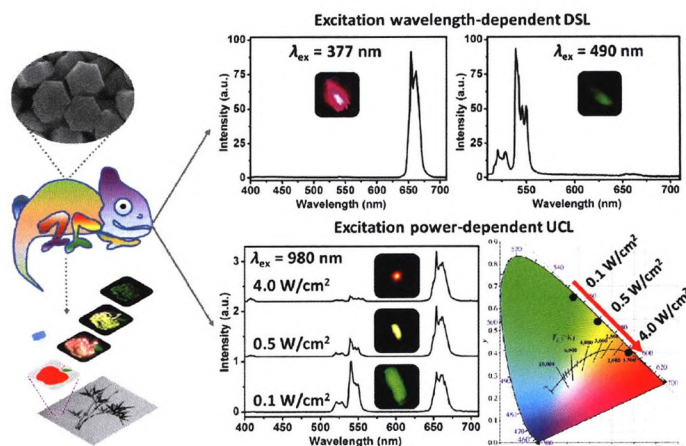
This paper demonstrates that the shape of lead halide perovskite nanocrystals inside polyvinylalcohol nanofibers can be manipulated through tuning the precursor content, and reveals the influence of the aspect ratios of these anisotropic nanoparticles on the polarized emission.

1411–1416

“Chameleon-like” optical behavior of lanthanide-doped fluoride nanoplates for multilevel anti-counterfeiting applications

Wenwu You, Datao Tu*, Renfu Li, Wei Zheng, and Xueyuan Chen*

Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, China



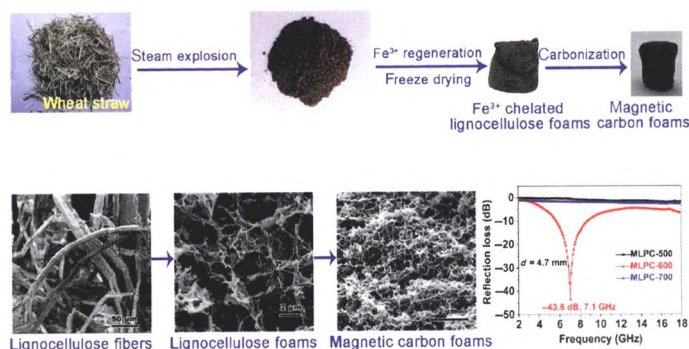
The “chameleon-like” lanthanide-doped fluoride nanoplates exhibiting unique excitation wavelength-dependent downshifting single-band emissions and sensitive excitation power-dependent upconversion multicolor emissions were explored as multilevel anti-counterfeiting materials.

1417–1422

Wheat straw-derived magnetic carbon foams: *In-situ* preparation and tunable high-performance microwave absorption

Guangjun Gou, Fanbin Meng*, Huagao Wang, Man Jiang, Wei Wei, and Zuowan Zhou*

Southwest Jiaotong University, China



Fe^{3+} chelated wheat straw can be directly transformed into magnetic carbon foams, which exhibit tunable high-performance microwave absorption.

1423–1429

An electrodeposition approach to metal/metal oxide heterostructures for active hydrogen evolution catalysts in near-neutral electrolytes

Michael J. Kenney¹, Jianan Erick Huang¹, Yong Zhu², Yongtao Meng^{1,3}, Mingquan Xu², Guanzhou Zhu¹, Wei-Hsuan Hung^{1,4}, Yun Kuang^{1,5}, Mengchang Lin³, Xiaoming Sun⁵, Wu Zhou², and Hongjie Dai^{1,*}

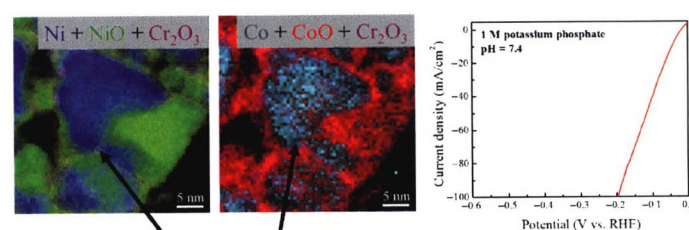
¹ Stanford University, USA

² University of Chinese Academy of Sciences, China

³ Shandong University of Science and Technology, China

⁴ Feng Chia University, Taiwan, China

⁵ Beijing University of Chemical Technology, China



Nanoscale interfaces

Metal–metal oxide nano interfaces in a Ni-Co-Cr catalyst exhibit impressive hydrogen evolution activity in near-neutral electrolytes.

1431–1435

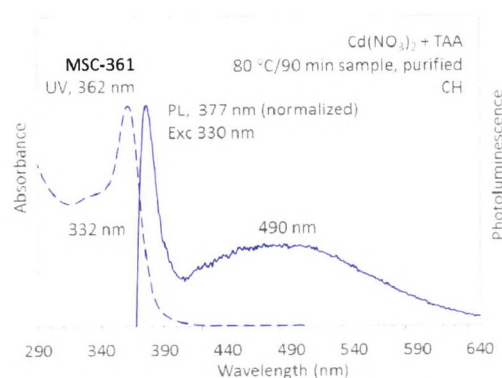
CdS magic-size clusters exhibiting one sharp ultraviolet absorption singlet peaking at 361 nm

Junbin Tang¹, Juan Hui¹, Meng Zhang¹, Hongsong Fan¹, Nelson Rowell², Wen Huang¹, Yingnan Jiang³, Xiaoqin Chen^{1,*}, and Kui Yu^{1,*}

¹ Sichuan University, China

² National Research Council of Canada, Canada

³ Changchun University of Chinese Medicine, China



The synthesis of CdS magic-size clusters (MSCs), which exhibit a single sharp absorption peaking at ~ 361 nm, along with sharp band edge photoemission at ~ 377 nm and broad trap emission peaking at ~ 490 nm, is reported for the first time. We label them as MSC-361. For reaction products displaying two absorption peaks at 361 and 322 nm, we demonstrate that they do not evolve synchronously. Thus, the 322 nm peak is not a higher order electronic transition of MSC-361, but due to the presence of another ensemble, namely MSC-322.

1437–1444

Nanotrap-enabled quantification of KRAS-induced peptide hydroxylation in blood for cancer early detection

Zaian Deng^{1,2}, Zhen Zhao³, Bo Ning⁴, Jeffery Basilio⁵, Karen Mann⁶, Jie Fu⁷, Yajun Gu⁸, Yuanqing Ye⁷, Xifeng Wu⁷, Jia Fan⁴, Paul Chiao⁷, and Tony Hu^{4,*}

¹ Shenzhen Technology University, China

² Houston Methodist Research Institute, USA

³ Weill Cornell Medical College, USA

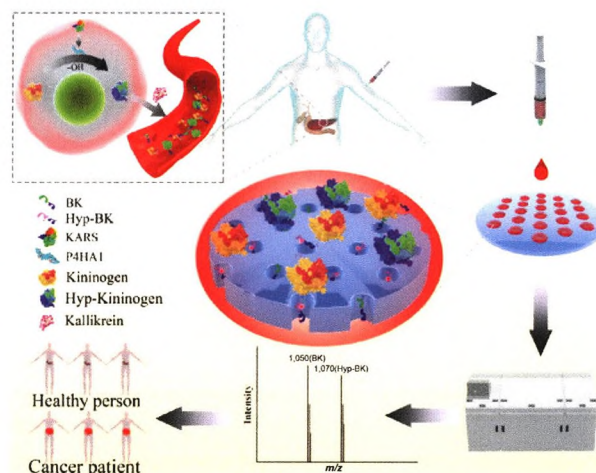
⁴ Arizona State University, USA

⁵ National Institutes of Health, USA

⁶ H. Lee Moffitt Cancer Center, USA

⁷ The University of Texas MD Anderson Cancer Center, USA

⁸ Tianjin Medical University, China



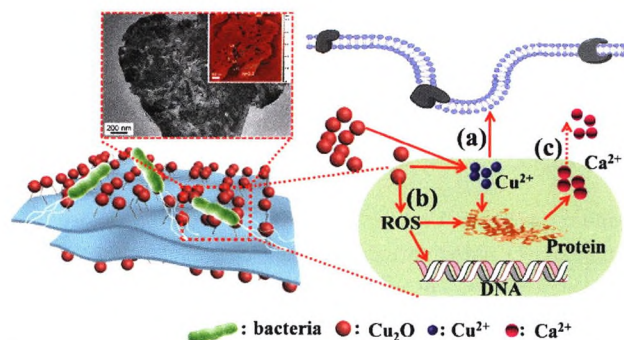
The hydroxylation level of bradykinin (BK) may reflect the prolyl-4-hydroxylase alpha-1 (P4HA1) expression level regulated by oncogenic KRAS in pancreatic ductal adenocarcinoma (PDAC). BK and hydroxylated bradykinin (Hyp-BK) can be captured by nanotrap and detected by mass spectrometry (MS) and the ratio of their peak area can serve as a potential biomarker for PDAC diagnosis.

1445–1452

Intriguing anti-superbug Cu₂O@ZrP hybrid nanosheet with enhanced antibacterial performance and weak cytotoxicity

Jialiang Zhou, Hengxue Xiang, Fatemeh Zabihi, Senlong Yu, Bin Sun, and Meifang Zhu*

Donghua University, China



Cu₂O@ZrP nanosheets with excellent dispersibility and antibacterial traits are fabricated by a facile method. Meanwhile, Cu₂O@ZrP nanosheets have extraordinary antibacterial activity against superbugs with more than 99% microbial reduction.

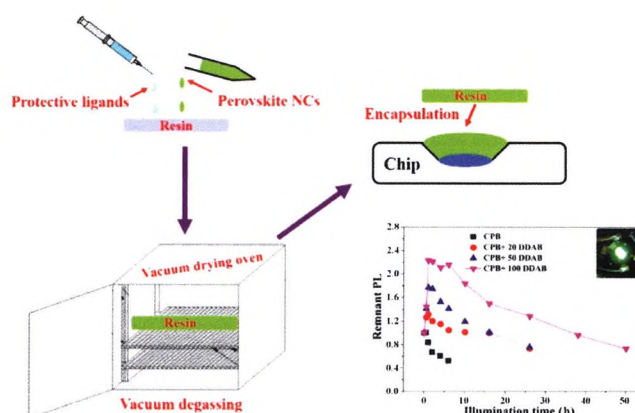
1453–1460

Stabilizing perovskite nanocrystals by controlling protective surface ligands density

Weilin Zheng¹, Zhichun Li¹, Congyang Zhang¹, Bo Wang¹, Qinggang Zhang¹, Qun Wan¹, Long Kong^{1,*}, and Liang Li^{1,2,*}

¹ Shanghai Jiao Tong University, China

² Shanghai Institute of Pollution Control and Ecological Security, China



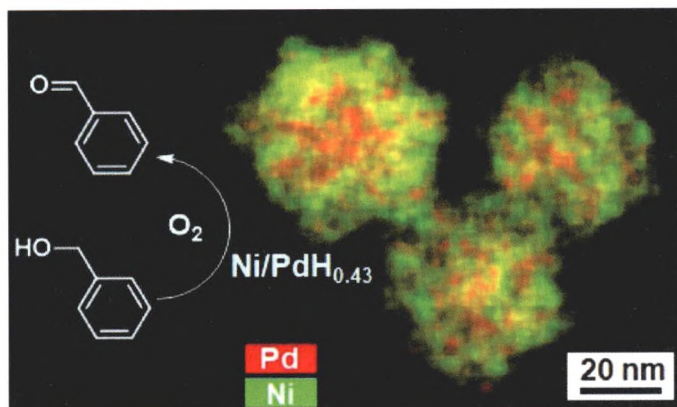
We proposed a new strategy to stabilize perovskite nanocrystals (NCs) in the resin film from the view of packaging process: adding protective ligands into the perovskite NCs resin composite, then encapsulating them on blue light emitting diodes (LED) chips. Surprisingly, by this way the LED devices (20 mA, 2.7 V) can keep 80% of the initial photoluminescence (PL) intensity for more than 50 h, while the devices without adding protective ligands dropped to 50% of the initial PL intensity within 6 h.

1461–1465

Synthesis of surface controlled nickel/palladium hydride nanodendrites with high performance in benzyl alcohol oxidation

Zipeng Zhao, Michelle M. Flores Espinosa, Jihan Zhou, Wang Xue, Xiangfeng Duan, Jianwei Miao, and Yu Huang*

University of California, Los Angeles, USA



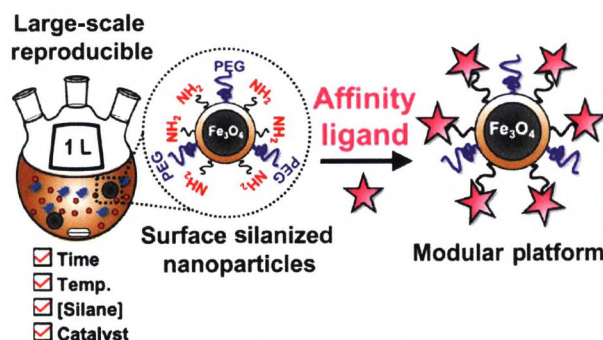
The controllable synthesis of nickel palladium hydride nanodendrites enables high stability and enhanced catalytic activity for benzyl alcohol oxidation reaction.

1467–1472

Reproducible large-scale synthesis of surface silanized nanoparticles as an enabling nanoproteomics platform: Enrichment of the human heart phosphoproteome

David S. Roberts, Bifan Chen, Timothy N. Tiambeng, Zhijie Wu, Ying Ge*, and Song Jin*

University of Wisconsin-Madison, USA



A reproducible and scalable nanomaterials platform for enabling proteomics applications is described. When coupled with a suitable affinity ligand, this nanomaterials platform allows for the capture, enrichment, and analysis of low abundance proteins in general.

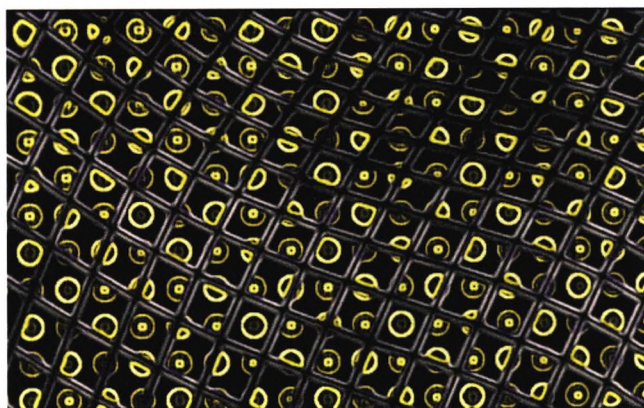
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Mass-production of flexible and transparent Te-Au nylon SERS substrate with excellent mechanical stability

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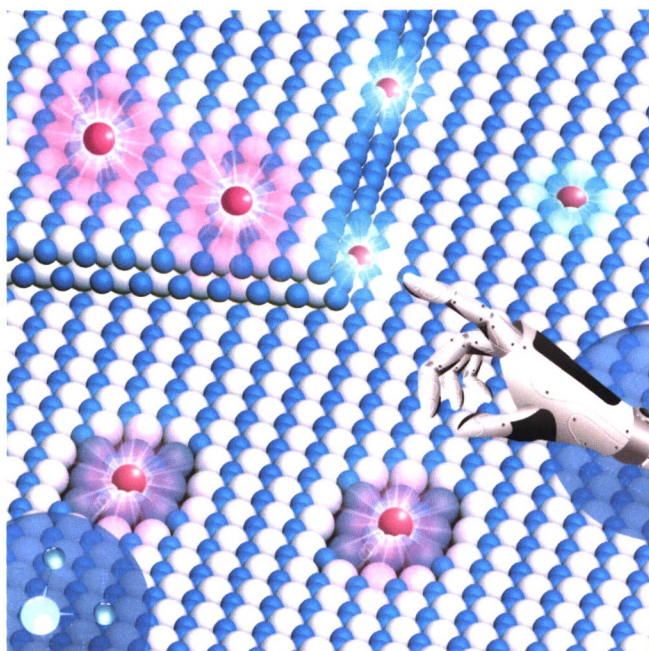


A 7.5 m² of Te-Au nylon surface-enhanced Raman scattering (SERS) substrate can be fabricated by simple dip coating process using the nylon skeleton with low cost, showing the best enhancement factor (EF) of 9.17×10^{10} and the detection limit of 3,3'-diethylthiatricarbocyanine iodide (DTTCl) molecules is lower than 10^{-14} M.

1483–1488

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