

Nano Research

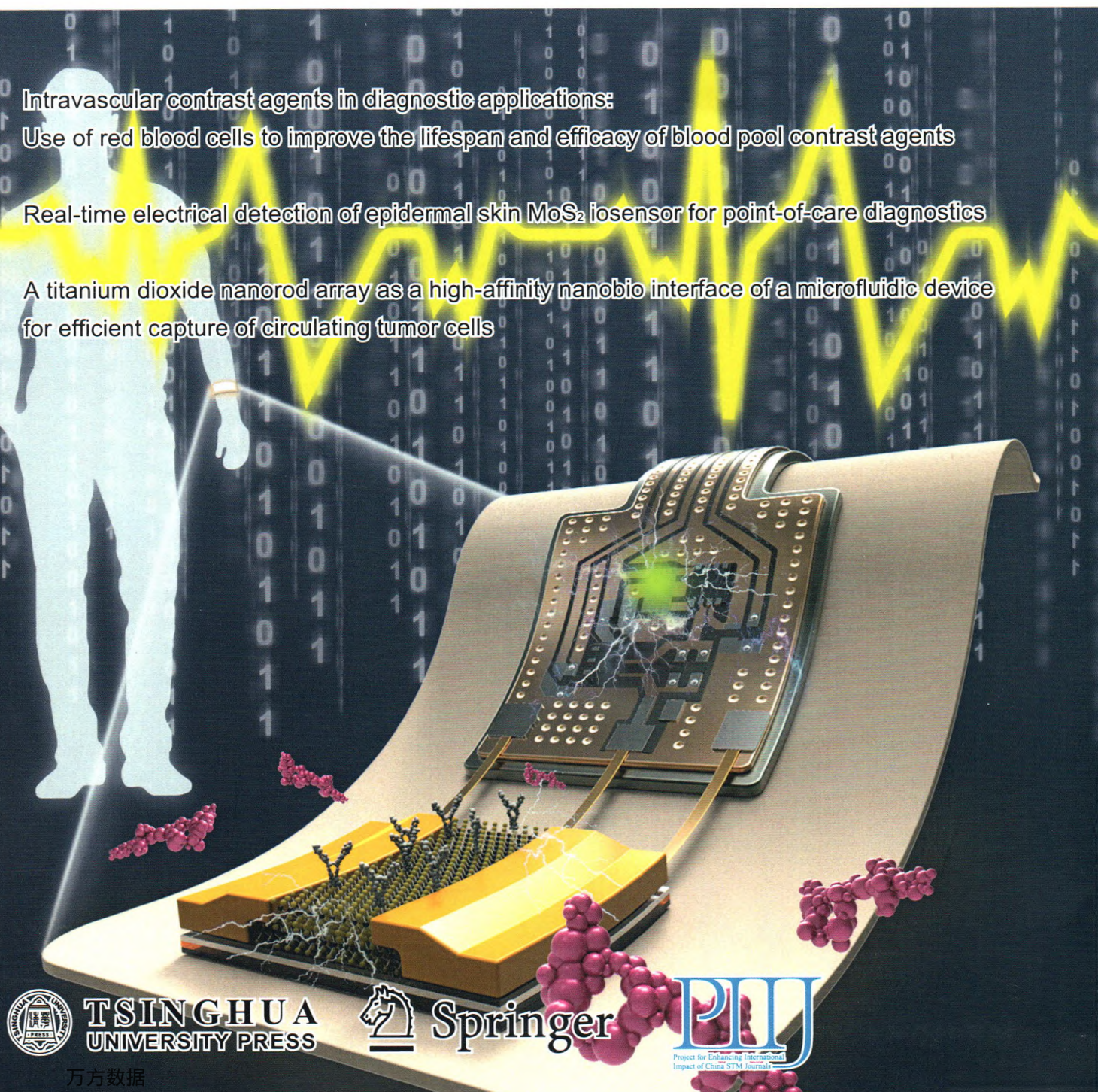
March · 2017
Volume 10 · Number 3

Intravascular contrast agents in diagnostic applications:

Use of red blood cells to improve the lifespan and efficacy of blood pool contrast agents

Real-time electrical detection of epidermal skin MoS_2 biosensor for point-of-care diagnostics

A titanium dioxide nanorod array as a high-affinity nanobio interface of a microfluidic device for efficient capture of circulating tumor cells



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Contents

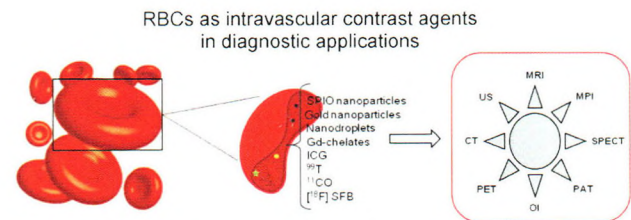
Review Article

**Intravascular contrast agents in diagnostic applications:
Use of red blood cells to improve the lifespan and efficacy
of blood pool contrast agents**

Antonella Antonelli*, Carla Sfara, and Mauro Magnani*

University of Urbino "Carlo Bo", Italy

731–766



Numerous imaging modalities have been developed for the visualization of tissue vascularization in cardiovascular diseases or during angiogenic and vasculogenic processes. Many scientists have contributed new contrast agents, and among these, red blood cells provide a scalable alternative to current procedures that allows adequate vascular imaging.

Research Articles

**Real-time electrical detection of epidermal skin MoS₂
iosensor for point-of-care diagnostics**

Geonwook Yoo¹, Heekyeong Park², Minjung Kim²,
Won Geun Song², Seokhwan Jeong², Min Hyung Kim³,
Hyungbeen Lee³, Sang Woo Lee³, Young Ki Hong²,
Min Goo Lee⁴, Sungho Lee^{4,*}, and Sunkook Kim^{2,*}

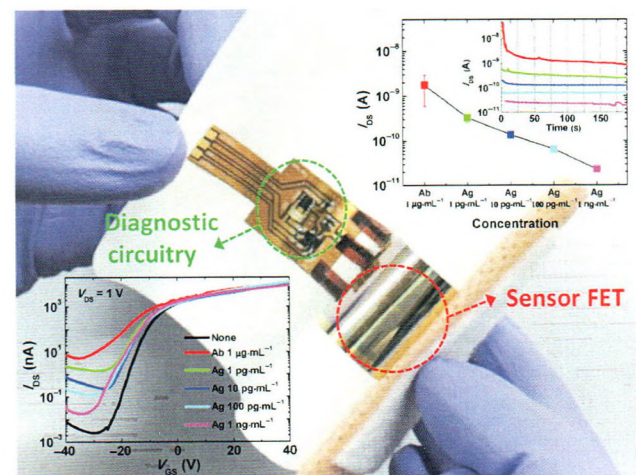
¹ Soongsil University, Republic of Korea

² Kyung Hee University, Republic of Korea

³ Yonsei University, Republic of Korea

⁴ Korea Electronics Technology Institute, Republic of Korea

767–775



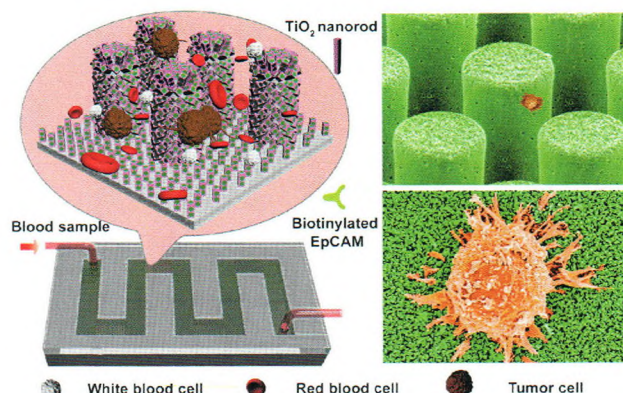
A highly sensitive point-of-care epidermal skin-type diagnostic device is demonstrated with system-level integration of a flexible MoS₂-field-effect transistor (FET) biosensor, read-out circuits, and light indicator that enable real-time electrical detection of the prostate cancer biomarker.

A titanium dioxide nanorod array as a high-affinity nano-bio interface of a microfluidic device for efficient capture of circulating tumor cells

Jichuan Qiu^{1,2}, Kun Zhao¹, Linlin Li¹, Xin Yu¹, Weibo Guo¹, Shu Wang¹, Xiaodi Zhang¹, Caofeng Pan^{1,*}, Zhong Lin Wang^{1,*}, and Hong Liu^{2,*}

¹ Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences; National Center for Nanoscience and Technology (NCNST), China

² Shandong University, China



A novel micro-nano three-dimensional (3D) hierarchically structured microfluidic device consisting of hexagonally patterned Si pillars in channels with a TiO_2 nanorod array as a sensitive nano-bio interface was constructed and showed efficient capture of circulating tumor cells ($76.7\% \pm 7.1\%$) in an artificial whole-blood sample.

776–784

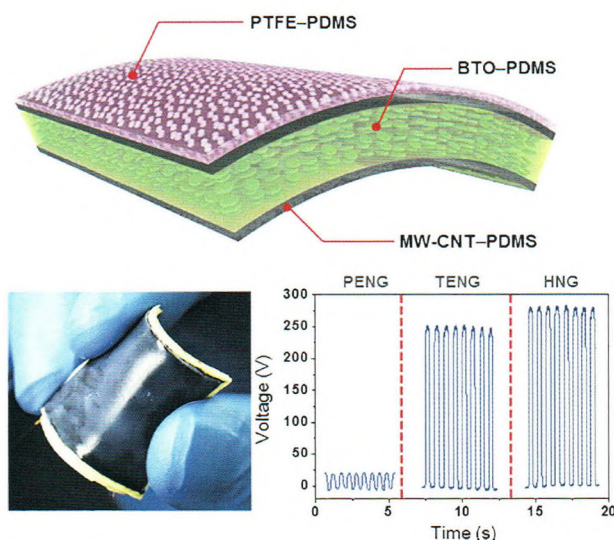
Multilayered flexible nanocomposite for hybrid nano-generator enabled by conjunction of piezoelectricity and triboelectricity

Huayang Li¹, Li Su¹, Shuangyang Kuang¹, Youjun Fan¹, Ying Wu², Zhong Lin Wang^{1,3,*}, and Guang Zhu^{1,*}

¹ Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences; National Center for Nanoscience and Technology (NCNST), China

² Chongqing University of Science and Technology, China

³ Georgia Institute of Technology, USA



Utilizing polytetrafluoroethylene nanoparticles, multi-walled carbon nanotubes, $\text{Bi}_4\text{Ti}_3\text{O}_{12}$ nanoplates, and a polydimethylsiloxane matrix, we fabricate a hybrid nanogenerator (HNG), based on multilayered nanocomposite materials, which integrates a piezoelectric nanogenerator and a triboelectric nanogenerator into a single structure with only two electrodes. The HNG can be excited by mechanical stimuli in different forms, such as pressing and bending, which can be used to harvest different types of biomechanical energy.

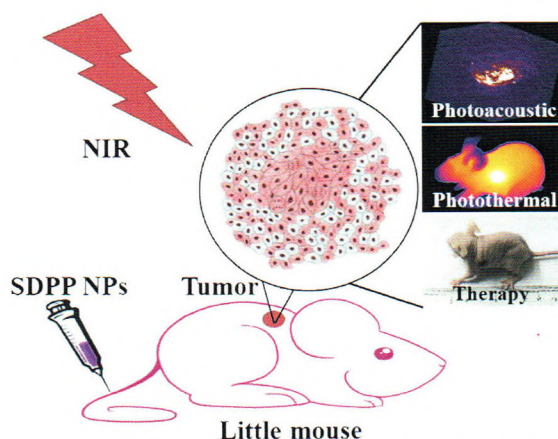
785–793

Small-molecule diketopyrrolopyrrole-based therapeutic nanoparticles for photoacoustic imaging-guided photothermal therapy

Yu Cai¹, Weili Si¹, Qianyun Tang¹, Pingping Liang¹, Chengwu Zhang¹, Peng Chen², Qi Zhang^{1,*}, Wei Huang^{1,*}, and Xiaochen Dong^{1,*}

¹ Nanjing Tech University (NanjingTech), China

² Nanyang Technological University, Singapore



Donor-acceptor-donor (D-A-D) structured organic nanoparticles based on the small molecule diketopyrrolopyrrole (SDPP NPs) were prepared using a reprecipitation approach. These SDPP NPs can be employed as an excellent therapeutic agent for highly efficient and noninvasive photoacoustic imaging-guided photothermal therapy.

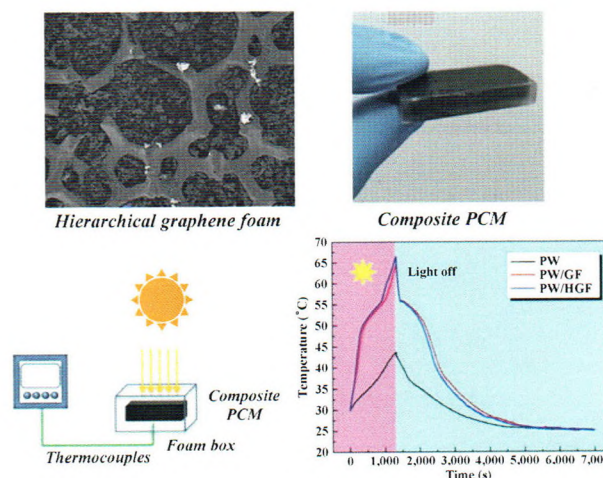
794–801

Hierarchical graphene foam-based phase change materials with enhanced thermal conductivity and shape stability for efficient solar-to-thermal energy conversion and storage

Guoqiang Qi^{1,2}, Jie Yang², Ruiying Bao², Dongyun Xia¹, Min Cao¹, Wei Yang^{2,*}, Mingbo Yang², and Dacheng Wei^{1,*}

¹ Fudan University, China

² Sichuan University, China



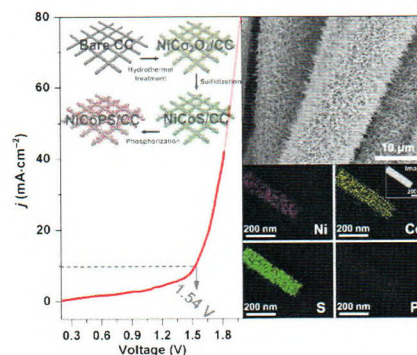
A novel three-dimensional (3D) hierarchical graphene foam (HGF) is obtained by filling the pores of graphene foam with hollow graphene networks. The HGF is then used to prepare a paraffin wax (PW)-based light-driven composite phase-change material (PCM). The PW/HGF composite PCM exhibits enhanced thermal conductivity and shape stability, a high thermal energy storage density, good thermal reliability, and efficient solar-to-thermal energy conversion.

802–813

Quaternary pyrite-structured nickel/cobalt phosphosulfide nanowires on carbon cloth as efficient and robust electrodes for water electrolysis

Jiayuan Li, Zhaoming Xia, Xuemei Zhou, Yuanbin Qin, Yuanyuan Ma, and Yongquan Qu*

Xi'an Jiaotong University, China



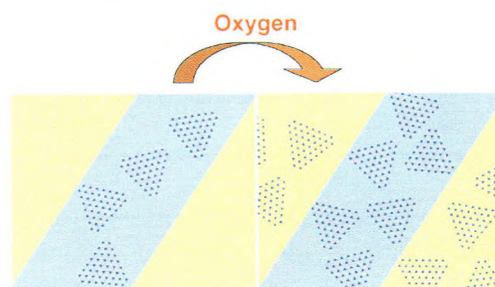
Quaternary pyrite-structured nickel/cobalt phosphosulfide (NiCoPS) nanowires on carbon cloth exhibited efficient and robust electrocatalytic activity toward the hydrogen and oxygen evolution reactions. Ni/P co-doping regulates the electronic structures of the active sites and accelerates charge transfer. The oxygen evolution reaction (OER) activity of the composites can be attributed to *in situ* formation of surface Ni–Co oxo/hydroxy species as active sites. The nickel/cobalt phosphosulfide nanowires on conductive carbon cloth (NiCoPS/CC) electrodes gave rise to a catalytic current density of $10 \text{ mA} \cdot \text{cm}^{-2}$ for overall water splitting at potentials as low as 1.54 V during operation over 100 h in 1.0 M KOH.

814–825

Oxygen-suppressed selective growth of monolayer hexagonal boron nitride on copper twin crystals

Xuemei Li, Yao Li, Qin Wang, Jun Yin, Jidong Li, Jin Yu, and Wanlin Guo*

Nanjing University of Aeronautics and Astronautics, China



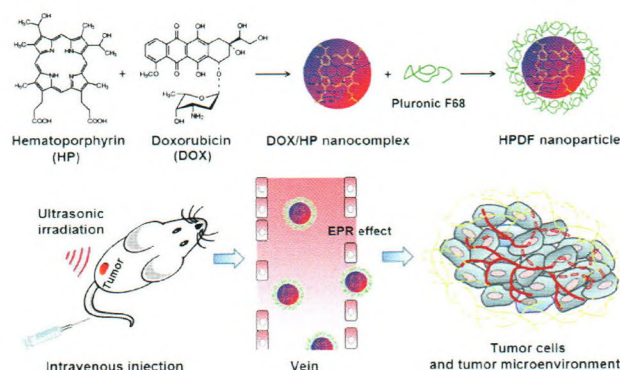
The selective growth of monolayer hexagonal boron nitride (h-BN) on Cu twin crystals can be significantly suppressed by introducing oxygen during chemical vapor deposition. This oxygen acts as an efficient knob for switching the h-BN growth behavior between selective and uniform growths.

826–833

A multifunctional nanoparticle system combines sonodynamic therapy and chemotherapy to treat hepatocellular carcinoma

Yang Liu, Guoyun Wan, Hua Guo, Yuanyuan Liu, Ping Zhou, Hemei Wang, Dan Wang, Sipei Zhang, Yinsong Wang*, and Ning Zhang*

Tianjin Medical University, China



HPDF nanoparticles, containing doxorubicin/hematoporphyrin (DOX/HP) nanocomplex core and Pluronic F68 shell, display excellent targeting capability for hepatocellular carcinoma and can significantly inhibit tumor growth both *in vitro* and *in vivo* by combining sonodynamic therapy and chemotherapy.

834–855

Paclitaxel-loaded hollow-poly(4-vinylpyridine) nanoparticles enhance drug chemotherapeutic efficacy in lung and breast cancer cell lines

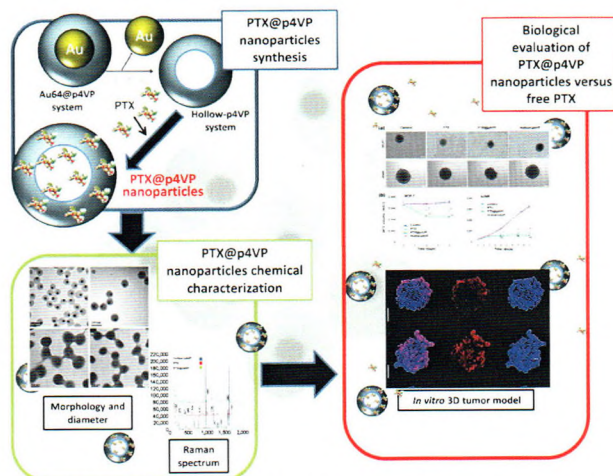
Rafael Contreras-Cáceres¹, María C. Leiva^{2,3}, Raúl Ortiz^{2,4}, Amelia Díaz¹, Gloria Perazzoli², Miguel A. Casado-Rodríguez¹, Consolación Melguizo^{2,3,*}, Jose M. Baeyens², Juan M. López-Romero¹, and Jose Prados^{2,3}

¹ University of Málaga, Spain

² University of Granada, Spain

³ SAS-Universidad de Granada, Spain

⁴ University of Jaén, Spain



This paper describes the synthesis and characterization of hollow-poly(4-vinylpyridine) (hollow-p4VP) nanoparticles loaded with paclitaxel, including a comprehensive study of their biological activity against breast and lung cancer models.

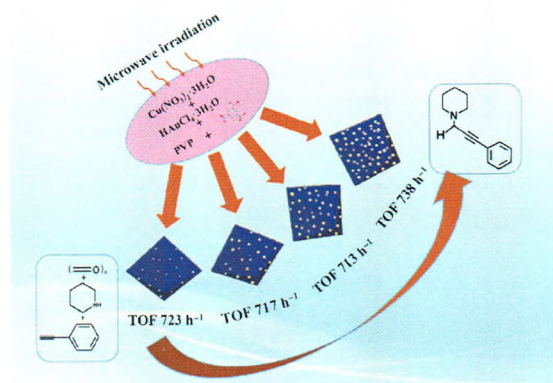
856–875

Microwave-assisted synthesis of ultrafine Au nanoparticles immobilized on MOF-199 in high loading as efficient catalysts for a three-component coupling reaction

Yan Jiang¹, Xin Zhang^{1,*}, Xiaoping Dai¹, Wen Zhang¹, Qiang Sheng¹, Hongying Zhuo¹, Yun Xiao¹, and Hai Wang²

¹ China University of Petroleum, China

² National Institute of Metrology, China



Ultrafine Au nanoparticles with different loadings were immobilized on MOF-199 using microwave irradiation and exhibited high activity and similar turnover frequencies (TOFs) for the A³-coupling reaction.

876–889

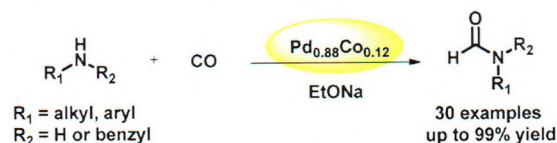
Bimetallic PdCo catalyst for selective direct formylation of amines by carbon monoxide

Yifeng Chen¹, Junjie Mao¹, Rongan Shen¹, Dingsheng Wang¹, Qing Peng¹, Zhixin Yu², Huifang Guo^{1,†,*}, and Wei He^{1,*}

¹ Tsinghua University, China

² University of Stavanger, Norway

[†] Present address: Chinese Academy of Medical Sciences & Peking Union Medical College, China



A highly efficient and selective bimetallic Pd_{0.88}Co_{0.12} nanoparticle catalyst was developed for the direct N-formylation of amines by carbon monoxide. This catalyst is compatible with a wide range of substrates, affording synthetically useful N-formyl amines under practical and mild reaction conditions.

890–896

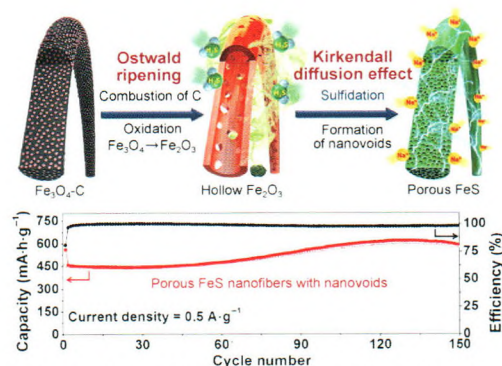
Porous FeS nanofibers with numerous nanovoids obtained by Kirkendall diffusion effect for use as anode materials for sodium-ion batteries

Jung Sang Cho^{1,2}, Jin-Sung Park¹, and Yun Chan Kang^{1,*}

¹ Korea University, Republic of Korea

² Chungbuk National University, Republic of Korea

897–907



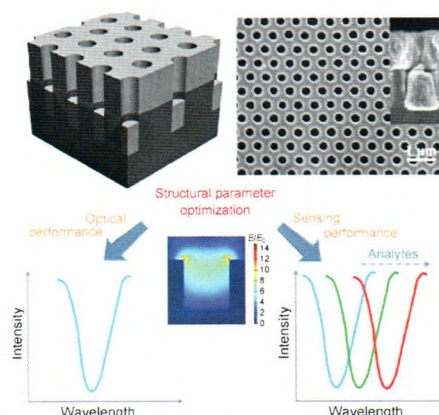
Porous FeS nanofibers with numerous nanovoids prepared by a simple two-step process were studied as anode materials for sodium-ion batteries. The Fe_2O_3 hollow nanofibers were transformed into porous FeS nanofibers, and the formation of porosity in the FeS nanofibers was driven by the nanoscale Kirkendall diffusion effect.

Highly sensitive deep-silver-nanowell arrays (d-AgNWAs) for refractometric sensing

Xueyao Liu, Wendong Liu, Liping Fang, Shunsheng Ye, Huaizhong Shen, and Bai Yang*

Jilin University, China

908–921



Large-area deep-silver-nanowell arrays (d-AgNWAs) were fabricated by combining colloidal lithography with metal deposition. Considering the optical and sensing performance, the structural parameters were gradually optimized to obtain the best sensing for d-AgNWAs, whose sensitivity was as high as $933 \text{ nm} \cdot \text{RIU}^{-1}$, which is substantially higher than those of most thin metallic hole arrays.

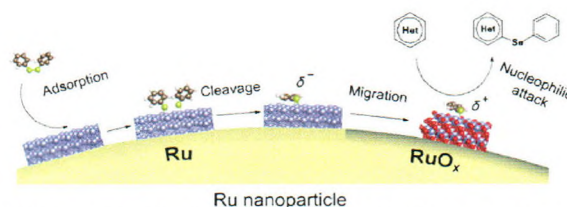
Heterogeneous synergistic catalysis by Ru-RuO_x nanoparticles for Se–Se bond activation

Mu Lin¹, Liqun Kang¹, Jun Gu¹, Linxiu Dai¹, Shengbo Tang¹, Tao Zhang¹, Yuhao Wang¹, Lindong Li¹, Xiaoyu Zheng¹, Wei Zhu¹, Rui Si², Xuefeng Fu¹, Lingdong Sun^{1,*}, Yawen Zhang^{1,*}, and Chunhua Yan^{1,*}

¹ Peking University, China

² Shanghai Institute of Applied Physics, Chinese Academy of Sciences, China

922–932



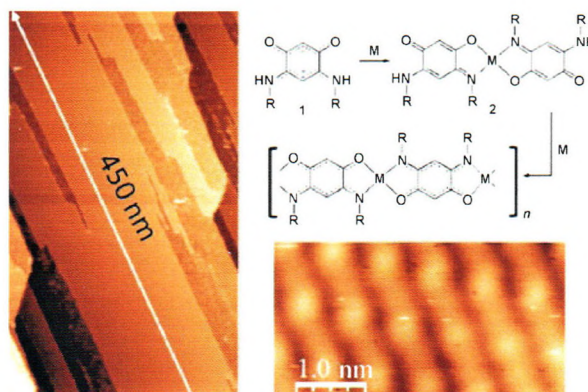
Hydrothermally synthesized ruthenium nanoparticles showed variable performance in the Se–Se bond activation, exhibiting a volcano-shaped relationship between catalytic activity and composition. Moreover, a synergistic effect was observed for Ru-RuO_x nanocatalysts.

On-surface synthesis of covalent coordination polymers on micrometer scale

Mathieu Koudia, Elena Nardi¹, Olivier Siri*, and Mathieu Abel*

CNRS, France

933–940



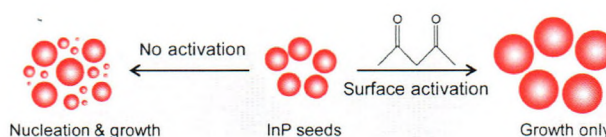
Co-deposition of quinoid zwitterion molecules with iron atoms on a Ag(111) surface allows the formation of micrometer-sized single domains based on covalent coordination bonds.

Surface activation of colloidal indium phosphide nanocrystals

Yang Li, Chaodan Pu, and Xiaogang Peng*

Zhejiang University, China

941–958



The growth bottleneck of InP quantum dots was removed via surface activation by small fatty acids and acetylacetone. In particular, acetylacetone activation allowed the full growth of generic precursors on existing InP nanocrystals without additional nucleation.

Fabrication of nanozyme@DNA hydrogel and its application in biomedical analysis

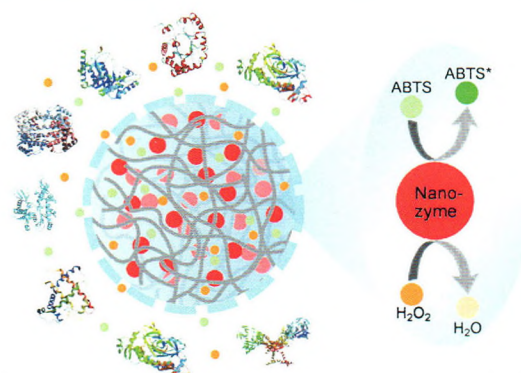
Xiaoli Zhu¹, Xiaoxia Mao^{1,2}, Zihan Wang¹, Chang Feng³, Guifang Chen^{1,*}, and Genxi Li^{1,3,*}

¹ Shanghai University, China

² Anqing Normal University, China

³ Nanjing University, China

959–970



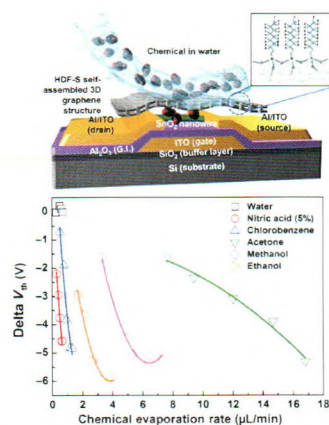
Artificial nanozymes are apt to passivate and consequently damage the catalytic capability in complex physiological samples. To conquer this problem, we fabricated novel nanozyme@DNA hydrogel architecture. It can retain the catalytic capability of nanozymes, thereby allowing the detection of hydrogen peroxide and glucose in physiological samples.

Detection of chemicals in water using a three-dimensional graphene porous structure as liquid–vapor separation filter

Taekyung Lim, Jaejun Lee, Jonghun Lee, and Sanghyun Ju*

Kyonggi University, Republic of Korea

971–979



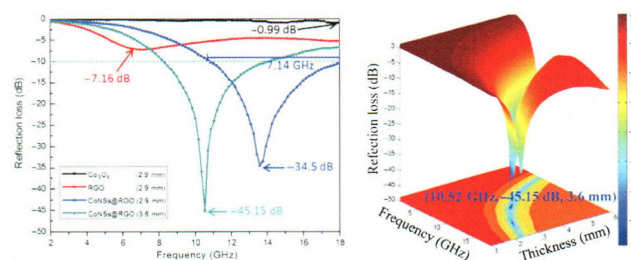
The concentration of chemical agents in water can be consistently detected by observing the shift in the threshold voltage of an oxide nanowire transistor covered by a (heptadecafluoro-1,1,2,2-tetrahydrodecyl)trichlorosilane (HDF-S) self-assembled three-dimensional (3D) graphene structure.

Investigation on the broadband electromagnetic wave absorption properties and mechanism of Co₃O₄-nanosheets/reduced-graphene-oxide composite

Yi Ding, Zheng Zhang, Baohe Luo, Qingliang Liao*, Shuo Liu, Yichong Liu, and Yue Zhang*

University of Science and Technology Beijing, China

980–990



The nanocomposite of cobalt-oxide-nanosheets/reduced-graphene-oxide (CoNSs@RGO) was successfully prepared by chemical hydrothermal growth as a lightweight and highly efficient absorbing material for the production and application in high frequency band.

Specific distribution of orientated C70-fullerene triggered by solvent-tuned macrocycle adlayer

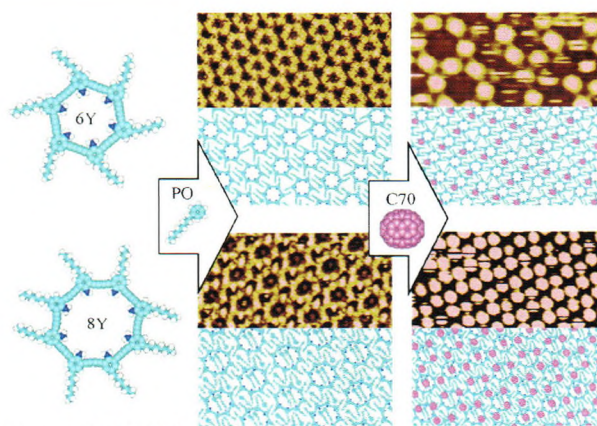
Yanfang Geng¹, Ping Li¹, Jindong Xue¹, Dapeng Luo², Junyong Zhang³, Lijin Shu^{2,*}, Ke Deng^{1,*}, Jingli Xie^{3,*}, and Qingdao Zeng^{1,*}

¹ National Center for Nanoscience and Technology (NCNST), China

² Hangzhou Normal University, China

³ Jiaying University, China

991–1000



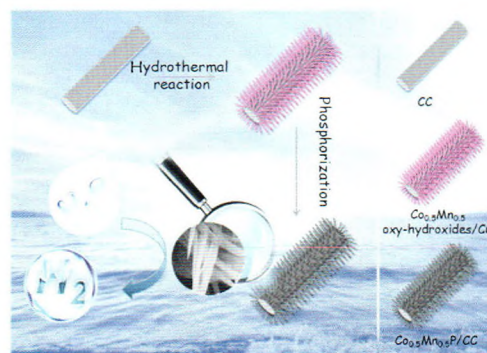
Orientated C70-fullerene molecules were selectively localized on the supramolecular structures of macrocycles (6Y and 8Y) through specific interaction sites in the presence of 1-phenyloctane molecules.

Self-supported ternary $\text{Co}_{0.5}\text{Mn}_{0.5}\text{P}$ /carbon cloth (CC) as a high-performance hydrogen evolution electrocatalyst

Xiaoyan Zhang^{1,2}, Wenling Gu^{1,2}, and Erkang Wang^{1,2,*}

¹ Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, China

² University of Chinese Academy of Sciences, China



Self-supported ternary $\text{Co}_{0.5}\text{Mn}_{0.5}\text{P}$ /carbon cloth (CC) nanomaterial was prepared through hydrothermal reaction and phosphorization process. The excellent hydrogen evolution reaction (HER) performance may derive from the synergistic effect between Co and Mn atoms and the special relative atom ratio of 1:1 from Co:Mn.

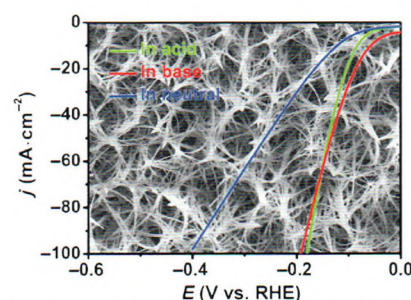
1001–1009

Flexible cobalt phosphide network electrocatalyst for hydrogen evolution at all pH values

Jianwen Huang^{1,2}, Yanrong Li¹, Yufei Xia², Juntong Zhu², Qinghua Yi², Hao Wang², Jie Xiong^{1,*}, Yinghui Sun^{2,*}, and Guifu Zou^{2,*}

¹ University of Electronic Science and Technology of China, China

² Soochow University, China



Efficient hydrogen evolution at all pH values was observed for a flexible nanocrystalline cobalt-phosphide (CoP) network cathode. The system exhibited a superior electrocatalytic property during hundreds of cycles of bending/extending from 100° to 250°. Significant catalytic stability was maintained after 100 h of continuous electrolysis at a high current density of $60 \text{ mA} \cdot \text{cm}^{-2}$ even in neutral media.

1010–1020

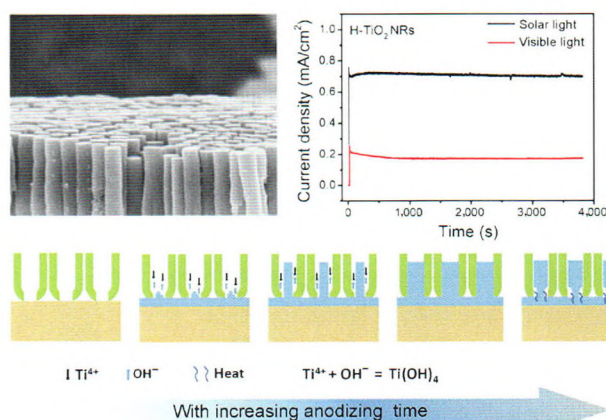
In situ growth of single-crystal TiO_2 nanorod arrays on Ti substrate: Controllable synthesis and photoelectrochemical water splitting

Tingting Zhang^{1,2}, Zia Ur Rahman¹, Ning Wei³, Yupeng Liu¹, Jun Liang¹, and Daoai Wang^{1,3,*}

¹ Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, China

² University of Chinese Academy of Sciences, China

³ Qingdao Center for Resource Chemistry and New Materials, China



A feasible method to fabricate vertical TiO_2 nanorod arrays (NRs) on Ti substrates by using through-mask anodization process is reported. After hydrogenation, the hydrogenated TiO_2 (H- TiO_2) NRs showed higher photocurrent density under simulated sunlight illumination, which suggests potential applications in photoelectrochemical water splitting, photocatalysis, solar cells, and sensors.

1021–1032

Synthesis of $\text{Cu}_{3.8}\text{Ni}/\text{CoO}$ and $\text{Cu}_{3.8}\text{Ni}/\text{MnO}$ nanoparticles for advanced lithium-ion battery anode materials

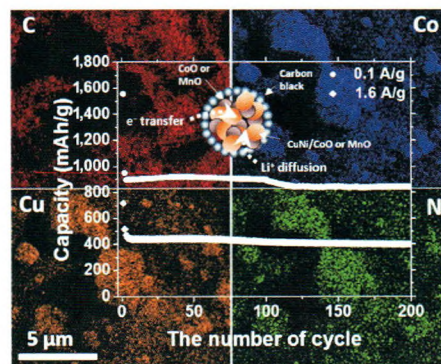
Jaewon Lee³, Huazhang Zhu², Wei Deng¹, and Yue Wu^{1,2,*}

¹ Shanghai Institute of Technology, China

² Iowa State University, USA

³ Purdue University, USA

1033–1043



$\text{Cu}_{3.8}\text{Ni}/\text{CoO}$ and $\text{Cu}_{3.8}\text{Ni}/\text{MnO}$ nanoparticles have been synthesized by an easy and scalable solution reaction approach. Electrons can be transferred via metallic $\text{Cu}_{3.8}\text{Ni}$, which will not react with lithium ions. The heterogeneous structures of $\text{Cu}_{3.8}\text{Ni}/\text{CoO}$ and $\text{Cu}_{3.8}\text{Ni}/\text{MnO}$ nanoparticles are believed to enhance the lithium ion mobility and improve the life cycle, and these materials are therefore promising candidates for use as advanced anode materials for lithium-ion batteries.

Synthesis of Co/SiO_2 hybrid nanocatalyst via twisted $\text{Co}_3\text{Si}_2\text{O}_5(\text{OH})_4$ nanosheets for high-temperature Fischer-Tropsch reaction

Ji Chan Park^{1,2,*}, Shin Wook Kang¹, Jeong-Chul Kim³, Jae In Kwon¹, Sanha Jang¹, Geun Bae Rhim¹, Mijong Kim⁴, Dong Hyun Chun^{1,2}, Ho-Tae Lee¹, Heon Jung¹, Hyunjoon Song^{4,*}, and Jung-Il Yang^{1,*}

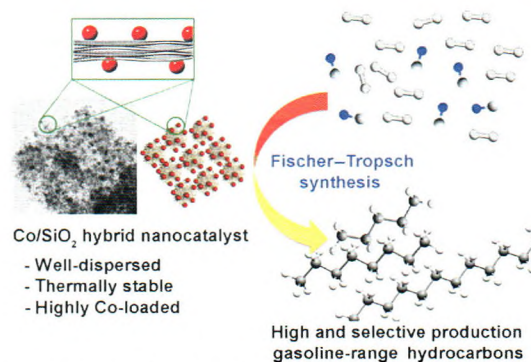
¹ Korea Institute of Energy Research, Republic of Korea

² University of Science and Technology, Republic of Korea

³ Institute for Basic Science, Republic of Korea

⁴ Korea Advanced Institute of Science and Technology, Republic of Korea

1044–1055



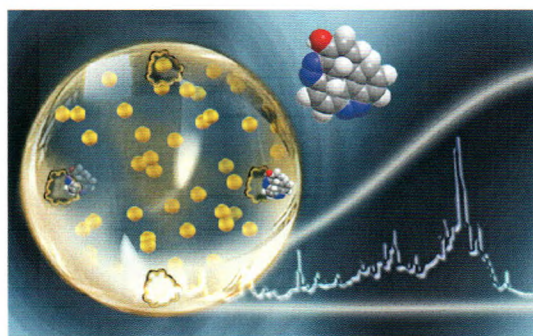
A new type of cobalt-silica hybrid nanocatalyst shows high CO conversion and good selectivity for gasoline-range hydrocarbons in the high-temperature Fischer-Tropsch synthesis reaction.

Nanosphere molecularly imprinted polymers doped with gold nanoparticles for high selectivity molecular sensors

Tehila Shahar, Tama Sicron, and Daniel Mandler*

The Hebrew University of Jerusalem, Israel

1056–1063



Nanostructured molecularly imprinted polymers were doped with gold nanoparticles, which generate surface enhanced Raman scattering (SERS) bands of the templated molecules with high selectivity.

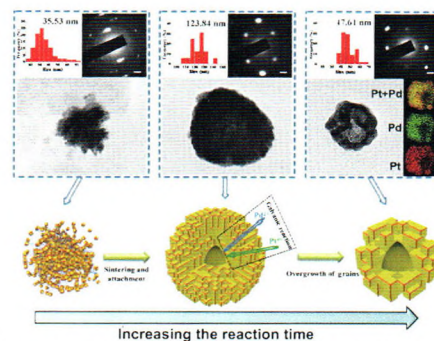
Halide ion-induced formation of single crystalline mesoporous PtPd bimetallic nanoparticles with hollow interiors for electrochemical methanol and ethanol oxidation reaction

Pengtao Qiu¹, Shaomin Lian¹, Guang Yang¹, and Shengchun Yang^{1,2,*}

¹ Xi'an Jiaotong University, China

² Suzhou Academy of Xi'an Jiaotong University, China

1064–1077



The coexistence of Br^- and I^- ions induced the formation of mesoporous single crystalline PtPd bimetallic nanoparticles with hollow interiors due to the oriented attachment (OA) growth mechanism and galvanic reactions.

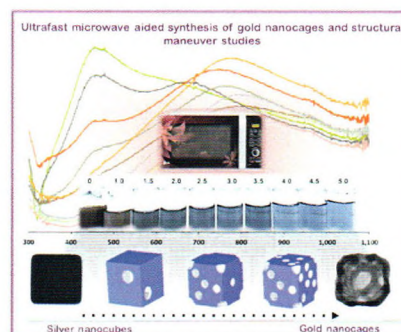
Ultra-fast microwave aided synthesis of gold nanocages and structural maneuver studies

Sreejith Raveendran¹, Anindito Sen², Toru Maekawa¹, and D. Sakthi Kumar^{1,*}

¹ Toyo University, Japan

² JEOL Ltd., Japan

1078–1091



A novel, ultra-fast, simple, and highly convenient method for large scale production of the gold nanocages using microwave heating is demonstrated. Structural maneuver and atomic dislocation studies were demonstrated using electron microscopy.

Interface engineering of high efficiency perovskite solar cells based on ZnO nanorods using atomic layer deposition

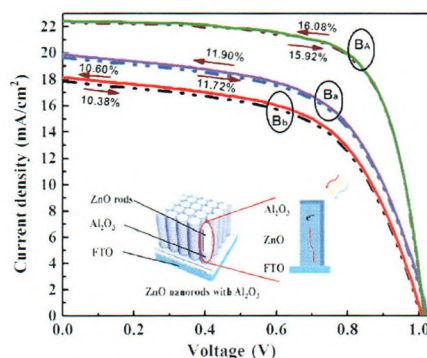
Shibin Li^{1,*}, Peng Zhang¹, Yafei Wang¹, Hojjatollah Sarvari², Detao Liu¹, Jiang Wu³, Yajie Yang¹, Zhiming Wang¹, and Zhi David Chen^{1,2,*}

¹ University of Electronic Science and Technology of China, China

² University of Kentucky, USA

³ University College London, UK

1092–1103



The surface defects of ZnO nanorods were suppressed by atomic layer deposition of Al_2O_3 monolayers. The average efficiency of ZnO nanorods-based perovskite solar cells was increased from 10.33% to 15.06%, and the highest efficiency attained was 16.08%.

Erratum to: Gold nanoflowers for 3D volumetric molecular imaging of tumors by photoacoustic tomography (DOI 10.1007/s12274-014-0688-4)

1104

Erratum to: Real-time electrical detection of epidermal skin MoS_2 biosensor for point-of-care diagnostics (DOI 10.1007/s12274-016-1289-1)

1105

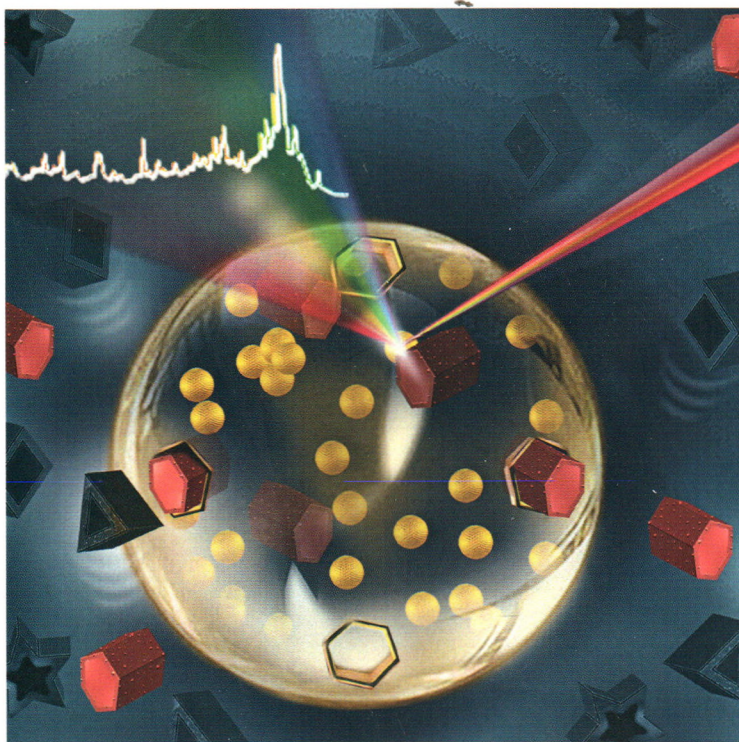
ISSN 1998-0124

CN 11-5974/O4

Nano Research

Volume 10 · Number 3 · March 2017

(Monthly, started in 2008)



纳米研究 (英文版) (月刊, 2008年创刊) 第10卷 第3期 2017年3月出版

Editors-in-Chief Hongjie Dai, Yadong Li

Sponsored by Tsinghua University & Chinese Chemical Society

Edited by Nano Research Editorial Office

Published by Tsinghua University Press

Address Xueyan Building,
Tsinghua University,
Beijing 100084, China

Website www.theNanoResearch.com & www.springer.com/journal/12274

Online Manuscript Submission, Review and Tracking System www.editorialmanager.com/nare

主管单位 中华人民共和国教育部

主办单位 清华大学

中国化学会

主 编 戴宏杰 李亚栋

编 辑 《纳米研究》编辑部

出版发行 清华大学出版社有限公司

印刷单位 北京中献拓方科技发展有限公司

ISSN 1998-0124



万方数据