HARBIN INSTITUTE OF TECHNOLOGY
NEWSLETTER 2021 ISSUE 1

HIT TIMES

ACADEMICIAN HAN JIECAI'S TEAM MADE A MAJOR SCIENTIFIC BREAKTHROUGH IN THE FIELD OF SINGLE CRYSTAL DIAMOND

CHINA SPACE DAY 2021

HIT TIMES

Harbin Institute of
Technology Newsletter
2021 ISSUE 1

HIT TIMES is a publication for alumni and friends of Harbin Institute of Technology, which is produced by the HIT Editorial Department of Journal.
If you have any suggestions, please do not hesitate to contact us.
We sincerely appreciate your wholehearted support.

Contents

Awards & Honors

Research & Academia

News & Events

AWARDS & HONORS

PROFESSOR TAN YIQIU WON THE HONORARY TITLE OF NATIONAL LABOUR DAY'S FEMALE MODEL

Recently, the National Commendation Conference for Advanced Female Workers (Collectives and Individuals) was held in the Great Hall of the People in Beijing. Professor Tan Yiqiu, from the School of Transportation Science and Engineering, was awarded the honorary title of National Labour Day's Female Model.

Professor Tan Yiqiu has been dedicated in the research of asphalt pavement basic theories and engineering applied technologies, achieving a series of original results on durability & integrated design of asphalt pavement materials and structure, traffic safety security technology of snow and ice regions and functional road of sustainable development. The main research areas are:

- Asphalt-based materials complex viscoelastic behavior and failure mechanism
- Asphalt pavement structural behavior simulation and monitoring techniques
- Initiative de-icing road and evaluation, restoration theories and methods of freeze-thaw damage
- Airport pavement structures and materials integrated design theory and methods ■

A GROUP AND A PROFESSOR FROM HIT WON "HEILONGJIANG YOUTH MAY FOURTH MEDAL"

Recently, the results of the 23rd "Heilongjiang Youth May Fourth Medal" were announced. The group of precision instruments from the School of Instrumentation Science and Engineering was awarded the "Heilongjiang Youth May Fourth Medal for Collective". Professor Quan Qiquan from the School of Mechatronics Engineering won the "Heilongjiang Youth May Fourth Medal."

Led by Academician Tan Jiubin and Professor Cui Junning, the group of precision instruments is oriented to broad fields related to the manufacturing of high-grade, precision and advanced equipment, large-scale scientific projects and precision medicine, and is pledged to the research and development of ultra-precision measurement methods and instrument technology, remote ultra-high-resolution laser measurement technology, label-free non-invasive microscopy methods and instrument technology, etc. It has developed a series of instruments based on new principles to solve key measured problems in the above-mentioned fields. In recent years, it has been awarded one 1st prize of National Technological Invention Award and three 2nd prizes of National Technological Invention Award.

Professor Tan Jiubin and his team

Professor Quan Qiquan and his students

Professor Quan Qiquan's current research interest is in-orbit & on-ground testing of the aerospace mechanism, including weak gravational asteroid anchoring & sampling and design and control of Mars UAV. He is a member of Institute of Electrical and Electronics Engineers (IEEE) and American Society of Mechanical Engineers (ASME). He served as an associate editor for the IEEE/RSJ International Conference on Intelligent Robots and Systems from 2017 to 2020. He served as the Registration Chairman of the 2016 IEEE International Conference on Robotics and Biomimetics which took place in Qingdao. He is the peer reviewer of International Journals, including *IEEE Robotics and Automation Magazine, Journal of Mechanism and Robotics, Journal of Mechanical Design, Journal of Vibration and Control, Mechatronics, Advanced Robotics,* and *Chinese Journal of Aeronautics.* He has authored or co-authored more than 100 papers and acquired more than 50 patents. ■

PROFESSOR DONG YONGKANG'S TEAM WON THE FIRST PRIZE OF THE TECHNOLOGICAL INVENTION AWARD OF CHINESE SOCIETY FOR OPTICAL ENGINEERING

In the final evaluation meeting of the 7th Chinese Society for Optical Engineering (CSOE) Technology Innovation Award held on May 16th, the project "High-Performance Distributed Brillouin Optical Fiber Sensing Technology, Instruments and Applications" was awarded the first prize in the category of technological invention. This project was led by Professor Dong Yongkang from the School of Astronautics, who is in charge of the National Key Scientific Instrument and Equipment Development Project of China.

The CSOE Technology Innovation Award is an important award in the field of optical engineering. It is selected once a year and focuses on recognizing outstanding contributions and achievements, especially in scientific and technological innovation, product research and development, and technological transformation in the field of optical engineering. In the 7th Innovation Award, there were two first prizes, four second prizes, and one third prize in the category of technological invention.

Professor Dong Yongkang's team has been focusing on the research work of high-performance distributed Brillouin optical fiber sensing technology for more than ten years. They have made a solid path from basic research to industrial application and successfully achieved systematic and high-level research results. The team has always insisted that "technology should not be limited in the laboratory". With the support of the National Key Scientific Instrument and Equipment Development Project of China "Distributed Optical Fiber Strain Monitor", the team has developed a series of high-performance distributed Brillouin optical fiber sensing analyzer with independent intellectual property rights. The instrument has reached centimeter-level spatial resolution, megahertz-level measurement speed, 100-km-level measurement distance and other performance indicators of the international leading position. Also, it has played a significant role in petrochemical, electric power, civil, transportation, and other key areas of national economy and people's livelihood, which has been widely praised by the China Aerospace Science and Industry Corporation Limited, China Electronics Technology Group Corporation, China National Petroleum Corporation, State Grid Corporation of China, CCCC Highway Consultants, CRRC Corporation Limited, and other leading enterprises in the industry.

Professor Hu Pengcheng (the third one from the right)

PROFESSOR HU PENGCHENG WON THE FIRST PRIZE OF SCIENCE AND TECHNOLOGY PROGRESS AWARD OF CHINESE SOCIETY FOR MEASUREMENT

Awards & Honors
HIT TIMES 2021

Recently, the award ceremony of the Science and Technology Progress Award of Chinese Society for Measurement was held in Beijing. A project, led by Professor Hu Pengcheng from the School of Instrumentation Science and Engineering, won 1st prize in the category of Basic Research.

Under the guidance and continuous support of Academician Tan Jiubin, Professor Hu Pengcheng's group has been focused on the ultra-precision laser interferometry technology research for many years. His research fields include: ultra-precision heterodyne interferometric techniques and instrumentation, ultra-precision homodyne interferometric techniques and instrumentation, and high precision temperature/displacement sensors. The research group has cooperated with several enterprises and developed a series of ultra precision laser interferometer products. The four core indicators have reached the top or performed better than those of international top-level instruments of the same kind, and more than 90 invention patents have been granted at home and abroad.

The "Science and Technology Progress Award of Chinese Society for Measurement" is an important award in the field of measurement and testing in China. In 2013, it was approved by the Ministry of Science and Technology of the People's Republic of China and the National Office for Science & Technology Awards. It is selected once a year and has been held eight times so far.

PHD STUDENT HE YING WON THE WANG DAHENG'S OPTICAL AWARD FOR STUDENTS

On April 17th, 2021, the list of the 17th Wang Daheng Optical Awards was announced. There were two Wang Daheng Optical Awards for Young and Middle-Aged Scientists and Researchers. Thirty students won the Wang Daheng Optical Award for Students. PhD student He Ying from the School of Astronautics was on the list.

In 1996, the Wang Daheng Optical Award was set up to commend and encourage outstanding contribution in optical science and technology. In 24 years, 27 people have won the Wang Daheng Optical Award for Young and Middle-Aged Scientists and Researchers, and 291 people have won the Wang Daheng Optical Award for Students. ■

HIT STUDENTS WON THE FIRST PRIZE OF THE 12TH NATIONAL MATHEMATICS COMPETITION FOR COLLEGE STUDENTS (NON-MATHEMATICS MAJOR GROUP)

From May the 14th to the 16th, the 12th National Mathematics Competition for College Students was held in Jilin University. In non-mathematics major group, Li Xing from the School of Astronautics and three other HIT students won the 1st prizes; four HIT students won the 2nd prizes, and two HIT students won the 3rd prizes. This has been our best achievement in the national subject competition in recent years.

The National Mathematics Competition for College Students was sponsored by the Chinese Mathematical Society. Since 2009, it has become one of the most influential national high-level discipline competitions for undergraduates. It aims to improve the quality of talent training in colleges and universities, promote the construction of mathematics courses and teaching reform in universities, and provide a stage for students to show their basic skills and comprehension of mathematics. In 2021, the competition was divided into the preliminary competition and the final competition. There were 206,921 applicants from 897 universities in the preliminary competition. In the end, more than 600 students entered the national finals. ■

Awards & Honors
HIT TIMES 2021

RESEARCH & ACADEMIA

ACADEMICIAN HAN JIECAI'S TEAM MADE A MAJOR SCIENTIFIC BREAKTHROUGH IN THE FIELD OF SINGLE CRYSTAL DIAMOND

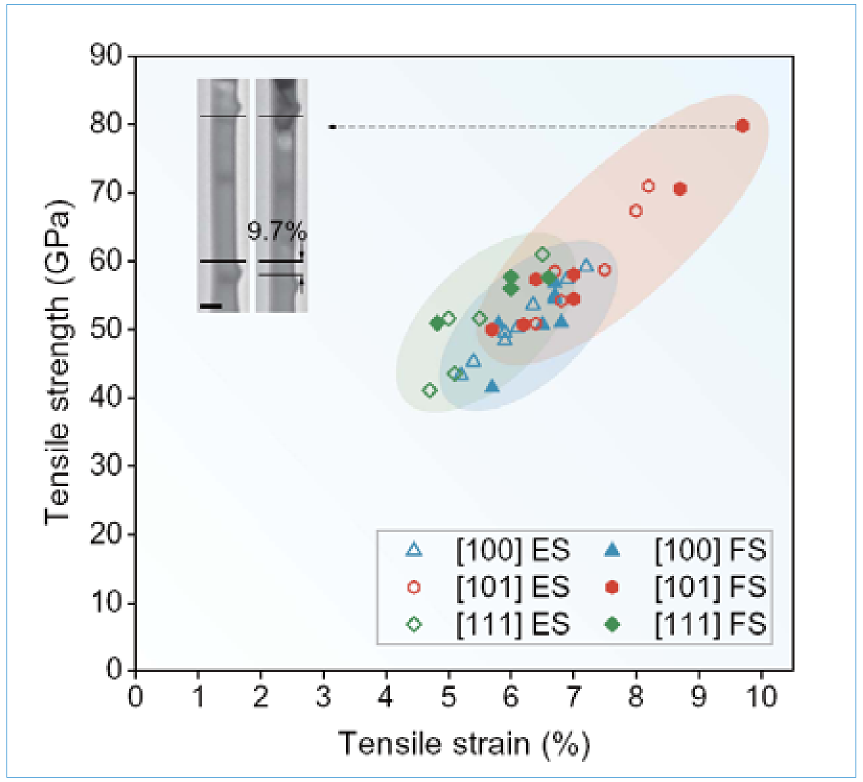
The uniform deep elastic strain of microcrystalline diamond arrays was demonstrated for the first time through nanomechanics by HIT, in cooperation with City University of Hong Kong and MIT. This work highlighted the huge application potential of deep elastic strain engineering in photonics, electronics and quantum information technology. The results of this research were published on *Science Online* with the title of "Achieving Large Uniform Tensile Elasticity in Microfabricated Diamond." Professor Zhu Jiaqi and young teacher Dai Bing from Academician Han Jiecai's team, are co-corresponding authors (Lu Yang, Li Ju, Zhu Jiaqi, Alice Hu) and co-first authors (Dang Chaoqun, Jyh-Pin Chou, Dai Bing, Chang Ti Chou), respectively. HIT is the unit of co-corresponding author and co-first author.

Due to its high hardness, ultra wide band gap, outstanding carrier mobility, and excellent thermal conductivity, diamond is one of the basic materials to realize electronic, optoelectronic and quantum chips in the "post Moore" era. At present, the biggest technical obstacle lies in the effective modulation of band gap. However, owing to the compact structure of diamond, the progress of conventional n-type doping is slow. But this study found that the band structure of diamond can be fundamentally changed through the large elastic strain control, which provides a basic and subversive solution for elastic strain engineering and the application of single crystal diamond devices.

Nano diamond needle has been proved to have super large elastic deformation, and the local tensile elastic strain reaches more than 9%, which indicates that deep elastic strain engineering (ESE) produces very high (> 5%) tensile and shear elastic strains in diamond. However, the strain attempts above are often limited to small sample volume bending, resulting in uneven strain distribution and high strain field will be highly localized. In order to make full use of deep elastic strain engineering for large-scale integrated machining of diamond devices, there will need to be more academic and engineering significance to realize large uniform elastic strain in wafer level and micron scale samples.

In this study, the single crystal diamond bridge structure with a length of about 1 μm and a width of about 100 nm was fabricated along [100], [101], and [111] directions at room temperature, and the uniform elastic strain in the sample range was obtained under uniaxial tensile load. The band gap of single crystal diamond can be reduced up to 2eV by calculation.

The research group led by Academician Han Jiecai and Professor Zhu Jiaqi has been engaged in the research and development of large-size single crystal diamond, advanced devices and equipment for a long time. With the support of the National Key Research and Development Program and the National Natural Science Foundation, they have made great achievements in inch-grade single crystal diamond, diamond enhanced thermal conductivity devices, solar blind UV detection, nuclide battery, etc., which effectively support the improvement of HIT basic research and major engineering research capabilities.



Statistical tensile results of [100]-, [101]-, and [111]-oriented diamonds.

REFERENCE

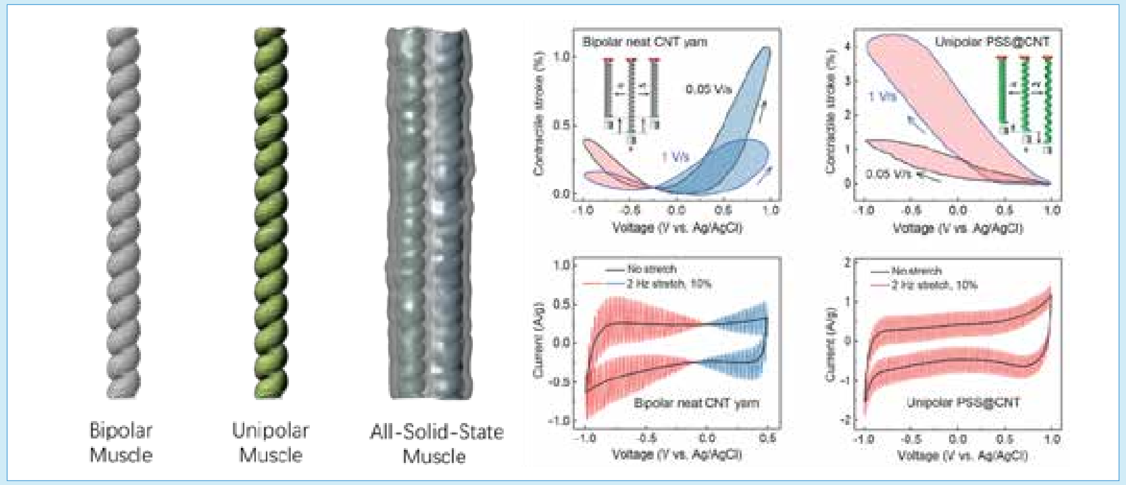
Chaoqun Dang, Jyh-Pin Chou, Bing Dai, et al. Achieving large uniform tensile elasticity in microfabricated diamond. Science, 2021, 371 (6524), 76-78. DOI: 10.1126/science.abc4174

UNIPOLAR-STROKE, ELECTROOSMOTIC-PUMP CARBON NANOTUBE YARN MUSCLES

On January 29th, 2021, Professor Leng Jinsong from the Center of Composite Materials and Structures, Harbin Institute of Technology, in collaboration with Professor Ray H Baughman from University of Texas at Dallas, Professor Ding Jianning from Jiangsu University, et al., published a paper titled "Unipolar-Stroke, Electroosmotic-Pump Carbon Nanotube Yarn Muscles" in *Science*.

For the past seven years, Professor Leng's group and his collaborators have focused on the a fundamental research of artificial muscle smart material. In this research, unipolar actuating behavior was found for electrochemical carbon nanotube yarn muscles *via* a polyelectrolyte functionalization strategy in place of bipolar actuating behavior of traditional electrochemical carbon nanotube yarn muscles. The unipolar muscles provide the unique property of increasing stroke with increasing potential scan rate, which is called scan rate enhanced stroke (SRES).

Further investigations revealed that the unipolar is caused by a polyelectrolyte-induced shift of the potential of zero charge outside the electrolyte's electrochemical window. Moreover, the effective ion size of electrolyte grows with increasing potential scan rate because of electroosmotic pumping of solvent, which induces the SRES effect. This effective ion size includes the ion hydration observed at low scan rates as well as the water dragged by the hydrated ion at high scan rates.



Schematic diagrams of Bipolar Muscle, Unipolar Muscle and All-solid-state Muscle. Contractile stroke measurements and piezoelectrochemical spectroscopy for a neat yarn muscle and a 30 wt % PSS@CNT yarn muscle.

The breakthrough research solves the capacitance-dependent issue of the performance of electrochemical carbon nanotube yarn muscles and provides a new theoretical basis for the design of high-performance actuators with non-toxic and low actuating voltages.

Professor Leng Jinsong, Professor Ding Jianning and Professor Ray H Baughman are the corresponding authors. Professor Leng Jinsong's Ph.D. student Dr. Chu Hetao, together with Hu Xinghao, Wang Zhong, Mu Jiuke, are the co-first-authors. ■

REFERENCE

Hetao Chu, Xinghao Hu, Zhong Wang, Jiuke Mu, et al. Unipolar stroke, electroosmotic pump carbon nanotube yarn muscles. Science, 2021, 371, 494–498. DOI: 10.1126/science.abc4538

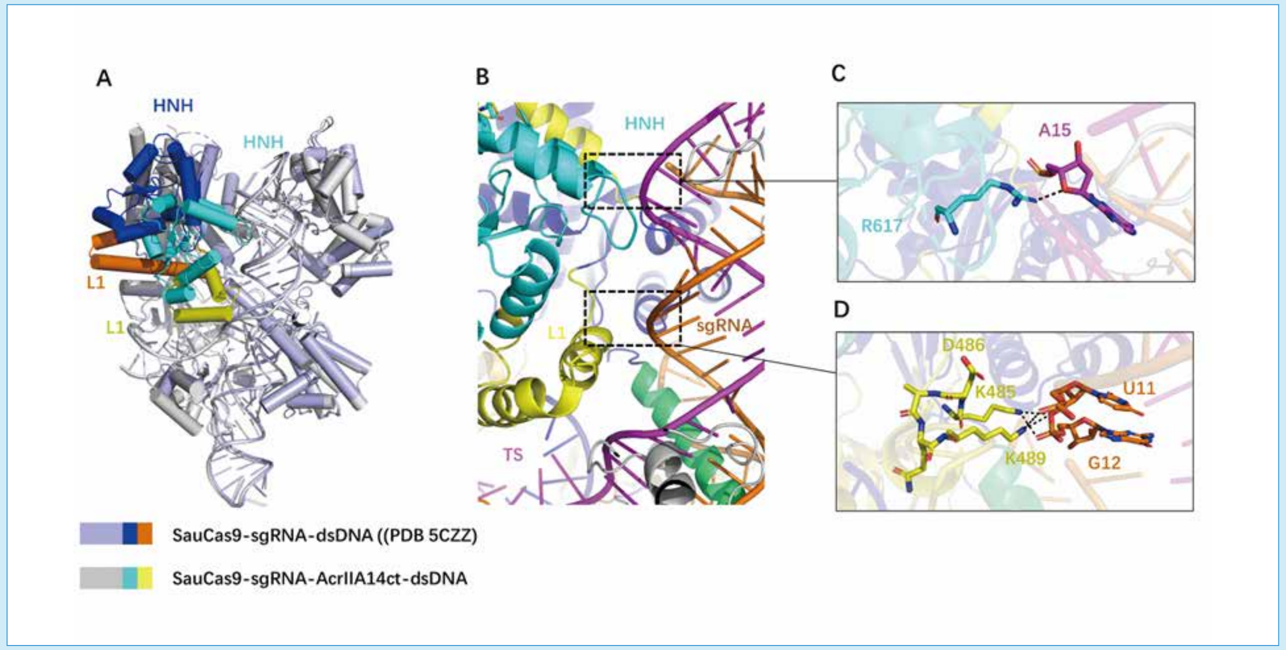
STRUCTURAL BASIS OF STAPHYLOCOCCUS AUREUS Cas9 INHIBITION BY AcrIIA14

On June 9th, 2021, the laboratory of Professor Huang Zhiwei, from the School of Life Science and Technology at HIT, published a research paper titled "Structural Basis of Staphylococcus Aureus Cas9 Inhibition by AcrIIA14" in the journal of *Nucleic Acids Research*. The research team reported the crystal structure of a quaternary complex of AcrIIA14 bound SauCas9-sgRNA-dsDNA at 2.22 Å resolution, revealing the molecular basis for AcrIIA14 recognition and inhibition. This study expands the understanding of the regulation of CRISPR-Cas system activity by Anti-CRISPR proteins and provides additional clues for the rational use of the CRISPR-Cas system in genome editing and gene regulation.

CRISPR-Cas systems have become the most widely used gene editing tool due to their convenient operability and high editing efficiency. However, there are still many urgent problems to be solved, and one of which is the off-target effect of gene editing due to uncontrollable cleavage activity. How to break the gene editing system and control its editing activity has been an important and urgent problem in this field.

CRISPR-Cas system is an adaptive immune system that bacteria and archaea use to resist the invasion of phages, and in the face of the evolutionary pressure of CRISPR-Cas in bacteria, phages have evolved corresponding antagonistic mechanisms. The proteins involved in this process are called anti-CRISPR proteins. In previous studies, it was found that anti-CRISPR protein AcrIIA14 was able to inhibit the activity of SauCas9, but its specific inhibitory mechanism is still unclear.

In order to elucidate the mechanism of SauCas9 inhibition by AcrIIA14, the team first purified and assembled the stable AcrIIA14-bound SauCas9-sgRNA-dsDNA quaternary complex protein *in vitro*, and then solved the crystal structure of the complex using X-ray crystallography. By analyzing



Binding of AcrIIA14 to the HNH domain induces SauCas9 allostery

this complex structure, the AcrIIA14 protein was found to interact with the HNH domain of the SauCas9 protein at a 1:1 stoichiometry. This binding sterically prevents the movement of the HNH domain toward the scissile phosphodiester linkage in the target DNA strand. At the same time, it induces HNH domain and L1 linker to approach the target-guide heteroduplex. As a result, two new intramolecular interactions are formed inside the SauCas9 protein complex, further improving its inhibitory ability.

In contrast to AcrIIC1 and AcrIIC3, AcrIIA14ct binds to a novel non-conserved region of the HNH domain, which results in AcrIIA14ct inhibition being specific to SauCas9. The fact that diverse Acr proteins can target different surfaces of the HNH domain suggests that HNH allostery is very important during Cas9 protein activation. Additionally, it may be a mechanism used by phages to evade bacterial anti-anti-CRISPR strategies in this ongoing arms race. In conclusion, this paper widens the understanding of the diverse anti-CRISPR inhibitory mechanisms and supports the use of SauCas9 as a gene editing tool.

Professor Huang Zhiwei is the corresponding author of this research paper; PhD student Liu Hongnan and associate researcher Zhu Yuwei are the co-first authors. Postgraduate Lu Zebin made important contributions to this study. X-ray diffraction data was collected at Shanghai Synchrotron Radiation Facility (SSRF). This research was financially supported by the National Natural Science Foundation of China. ■

REFERENCE

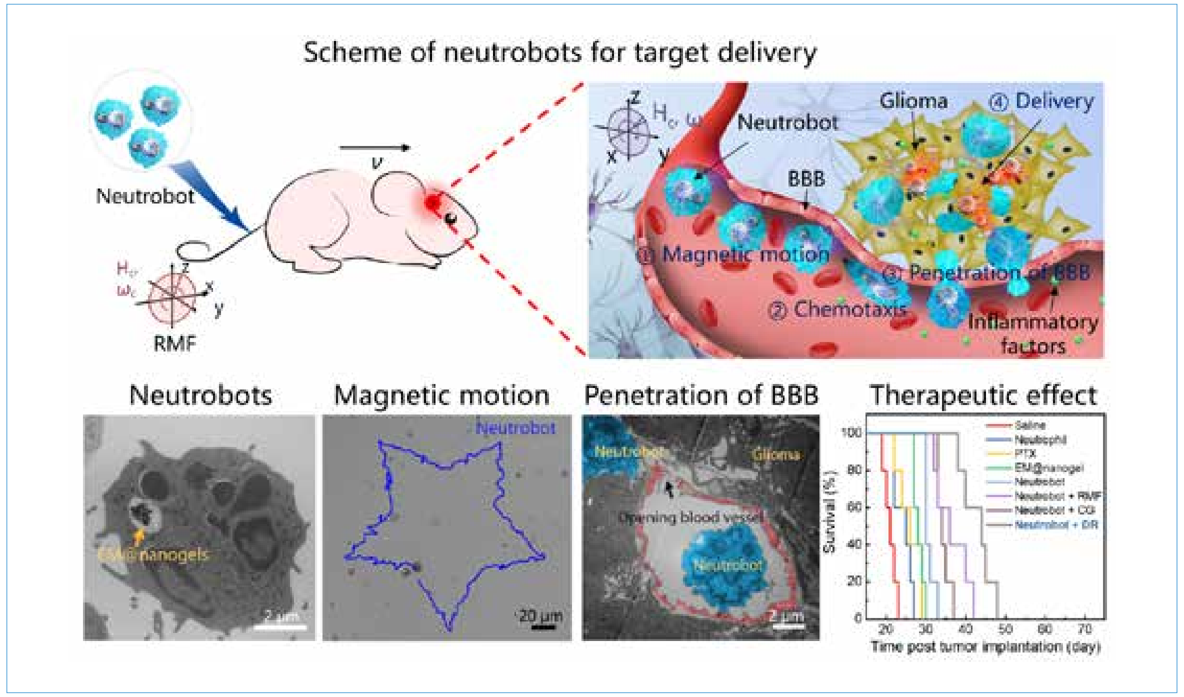
Hongnan Liu, Yuwei Zhu, Zebin Lu, Zhiwei Huang. Structural basis of Staphylococcus aureus Cas9 inhibition by AcrIIA14. Nucleic Acids Research, 2021, 49, 11, 6587–6595. https://doi.org/10.1093/nar/gkab487

ACTIVE TARGETED THERAPY TOWARD GLIOMA USING NEUTROPHIL - HYBRID SWIMMING MICROROBOTS

Professor He Qiang and Professor Wu Zhiguang, from the Key Laboratory of Micro-Systems and Micro-Structures Manufacturing, Ministry of Education, recently published a paper titled "Dual-Responsive Biohybrid Neutrobots for Active Target Delivery" in the top journal, *Science Robotics*. The first author is Zhang Hongyue.

Glioblastoma represents one of the toughest cancers to be effectively cured. China ranks number one in patients and deaths worldwide. The lack of precise treatment is one of the most important reasons. Moreover, blood-brain barrier and blood-tumor barrier limit the treatment strategies for the delivery of medicine to the intracranial tumor. The breakage of the blood-brain barrier, with the expectation of accomplishment of active targeted delivery of drugs and improvement of the curative effect of drugs on glioma, has become a bottleneck issue in the field of glioma medicine for a long time.

To overcome this issue, the research group developed a swimming microrobot (Neutrobot), which is based on neutrophils. Such neutrobots were constructed through phagocytosis of *Escherichia coli* membrane-enveloped, drug-loaded magnetic nanogels by natural neutrophils. The neutrobots facilitate the stable and efficient encapsulation



of various antitumor drugs such as paclitaxel , navigating toward brain using self-made control system before finally precisely releasing paclitaxel of the diseased area, resulting in the enhancement of efficient of drug. These results demonstrate the potential promises of precise therapy toward glioblastoma employing immune cells-based swimming microrobots.

Professor He Qiang developed the first swimming micro/nanorobots research group in the Key Lab for Microsystems and Microstructure Manufacturing at Harbin Institute of Technology since 2010. Professor Wu Zhiguang obtained a doctoral degree in 2015, and he was selected for MIT's technology review "Innovators Under 35 in China".

This work was financially supported by the National Natural Science Foundation of China. *Science Robotics* has also published a focus article to introduce this paper. ■

REFERENCE

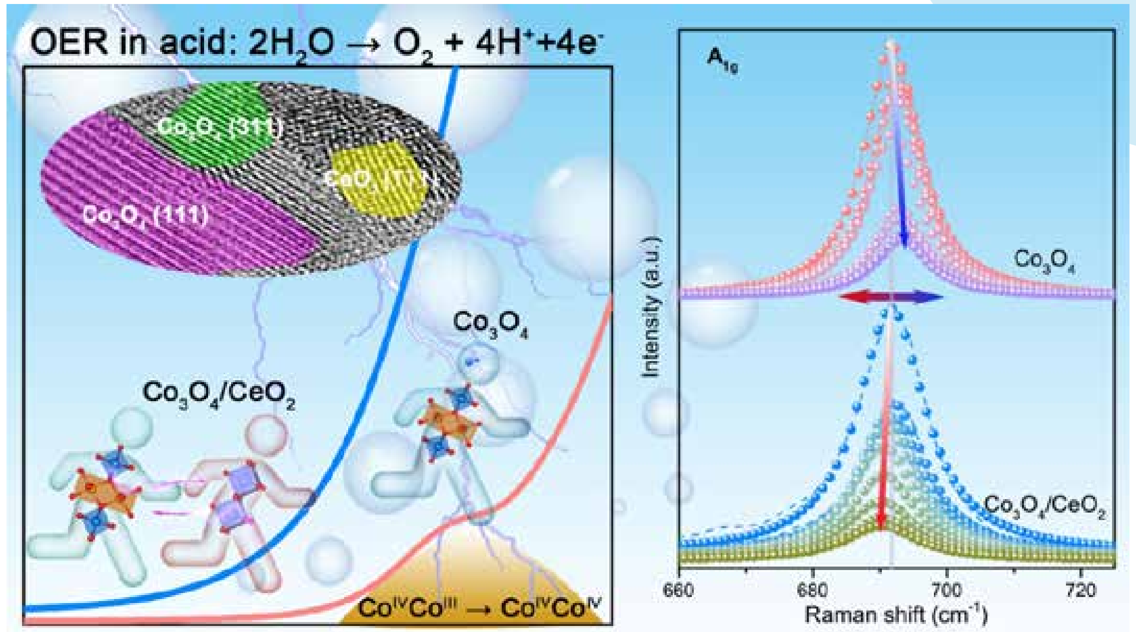
Hongyue Zhang, Zesheng Li, Changyong Gao, Xinjian Fan, Yuxin Pang, Tianlong Li, Zhiguang Wu, Hui Xie, Qiang He. Dual-responsive biohybrid neutrobots for active target delivery. Science Robotics, 2021, 6, eaaz9519.

NANOCOMPOSITE ELECTROCATALYST FOR ACIDIC OXYGEN EVOLUTION REACTION

Recently, Professor Song Bo and his collaborators from the Center for Composite Materials and Structures reported the progress on developing earth-abundance nanocomposite electrocatalyst for efficient acidic oxygen evolution reaction (OER). The article, titled "Modifying Redox Properties and Local Bonding of Co_3O_4 by CeO_2 Enhances Oxygen Evolution Catalysis in Acid", was published in *Nature Communications*.

The splitting of electrocatalytic has been considered a promising approach to generating hydrogen as a clean and renewable energy carrier. Proton exchange membrane (PEM) electrolyzers operated in acidic media have shown great promises for large-scale applications. However, the development of high-performance yet cost-effective electrocatalysts for the sluggish four-electron oxygen evolution reaction (OER) is challenging, especially in acidic media, which contributes to a major energy loss in the overall water splitting process and is a bottleneck for realizing practical PEM electrolyzers.

Most OER catalysts show inferior activities in acidic media compared to in alkaline media and require higher overpotentials to achieve comparable catalytic current densities. Furthermore, the often-observed tradeoff between activity and stability in acidic OER catalysts complicates the catalyst design. As a result, there have been severely limited choices of earth-abundant OER catalysts that are both active and stable in acidic media. In this work, the intrinsic catalytic activity of Co_3O_4 is enhanced by introducing nanocrystalline CeO_2 to form a heterogeneous Co_3O_4/CeO_2 nanocomposite and establish Co_3O_4/CeO_2 nanocomposite as an active acidic OER catalyst. The overpotentials required for Co_3O_4/CeO_2 to achieve a geometric catalytic current density of 10 mA cm^{-2} on FTO, and carbon paper electrodes are~423 and 347 mV respectively, making it an efficient earth-



abundant electrocatalysts for acidic OER.

In-depth electrochemical characterizations using the kinetic isotope effect, pH- and temperature-dependence analyses, together with *in situ* Raman and *ex situ* X-ray adsorption spectroscopy structural characterizations of the Co_3O_4/CeO_2 catalyst before and after OER testing, consistently reveal the microstructural states of the catalysts and their changes through the OER processes. The introduction of nanocrystalline CeO_2 modifies the electronic structures and creates a more favorable local bonding environment in Co_3O_4 that allows the Co^{III} surface species to be easily oxidized into OER-active Co^{IV} species and suppresses the charge accumulation of Co_3O_4 under electrochemical conditions, which are the keys to bypassing the potential-determining redox step in Co_3O_4 that result in substantial surface reconstruction and thus enhancing the acidic OER activity. Interestingly, Co_3O_4/CeO_2 also breaks the activity/stability tradeoff by featuring enhanced activity but comparable acidic OER stability and better open circuit stability in comparison with Co_3O_4.

This work not only establishes an active earth-abundant nanocomposite catalyst (Co_3O_4/CeO_2) for OER in acidic media, but also stimulates mechanistic understandings and provides an effective strategy to design more efficient and stable nanocomposite electrocatalysts for acidic OER or other reactions in the future. ■

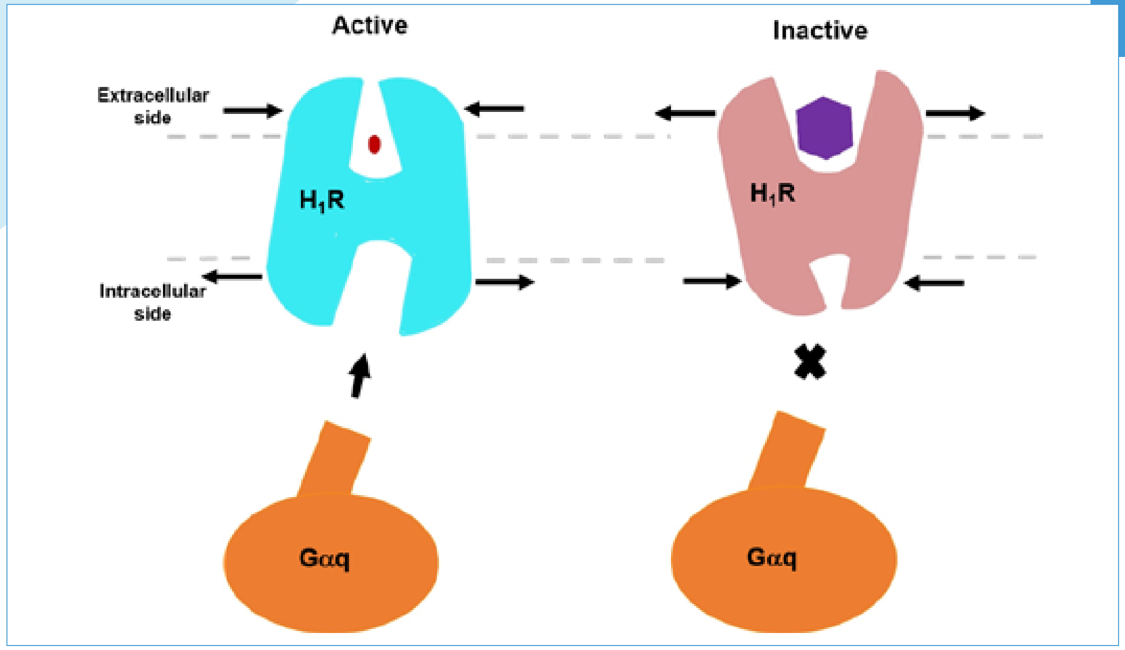
REFERENCE

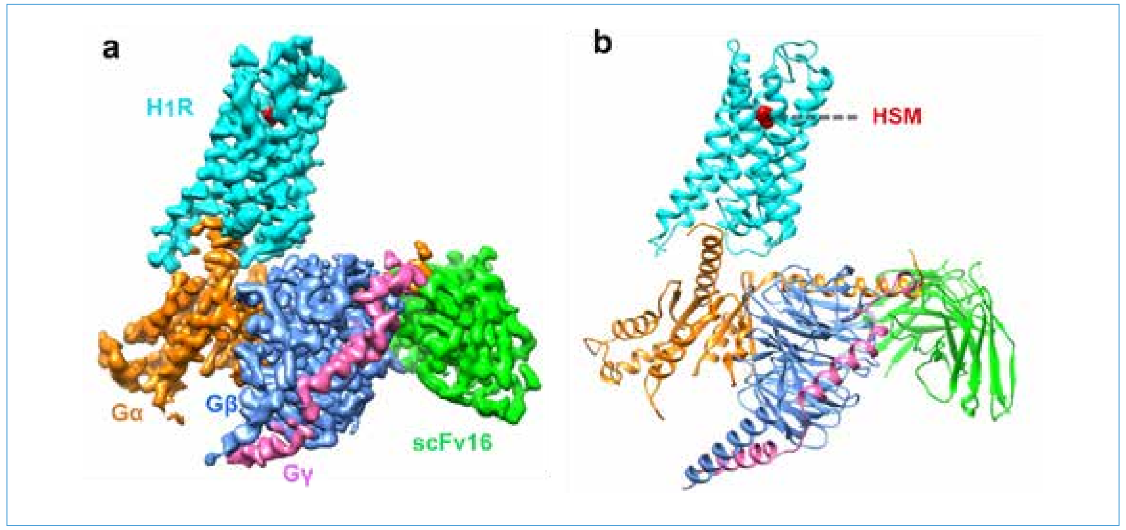
Jinzhen Huang, Hongyuan Sheng, R. Dominic Ross, Jiecai Han, Xianjie Wang, Bo Song and Song Jin. Modifying redox properties and local bonding of Co_3O_4 by CeO_2 enhances oxygen evolution catalysis in acid. Nature Communications, 2021, 12, 3036. DOI: 10.1038/s41467-021-23390-8

HIT TEAM REVEALED THE MECHANISM OF HISTAMINE ACTIVATION VIA CRYO-EM

Dr. He Yuanzheng's group in HIT Center for Life Science (HCLS) recently reported the cryo-EM structure of human histamine receptor H_1R/G_q complex and revealed the mechanism of histamine activation. This result was published in *Nature Communications*.

Histamines play an active role in allergy and anaphylaxis, and its effects are mainly mediated by histamine receptor 1 (H_1R). For more than half century, antihistamines targeting H_1R have been first choice for many allergic disorders, such as allergic rhinitis, hay fever, and urticarial. However, structural information of H_1R activation remains elusive, which heavily hampered the design and development of novel antihistamines with more specificity and less side effects. The structure reveals that histamines activate receptors via interacting with the key residues of both transmembrane domain 3 (TM3) and TM6 to squash the binding pocket on the extracellular side and to open





the cavity on the intracellular side for the engagement of G_q protein in a model of "squash to activate and expand to deactivate". A comparison with other receptor/G-protein complexes reveals features for G_q coupling, including the interaction between intracellular loop 2 (ICL2) and the αN-β junction of $G_{q/11}$ protein. The detailed analysis of the structure will provide a framework for understanding G-protein coupling selectivity and clues for designing novel antihistamines. ■

REFERENCE

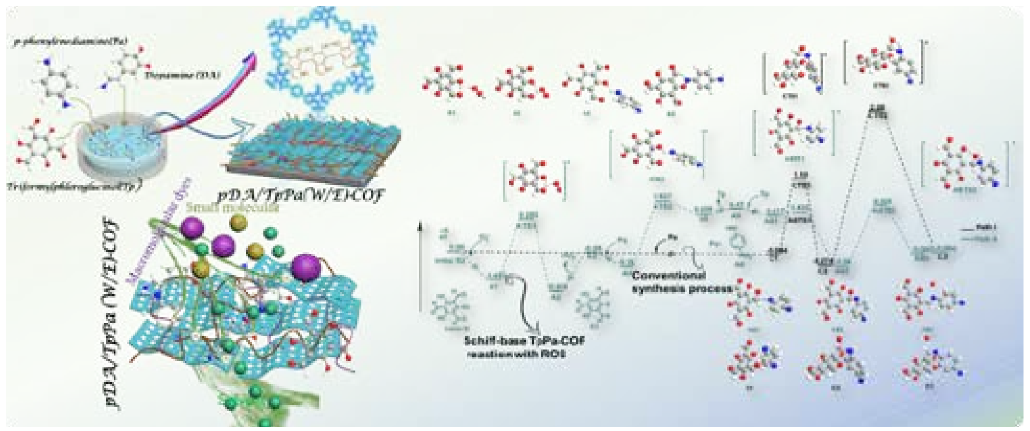
Xia R, Wang N, Xu Z, Lu Y, Song J, Zhang A, Guo C, He Y. Cryo-EM structure of the human histamine H_1 receptor/G_q complex. Nature Communications, 2021, 12(1):2086. DOI: 10.1038/s41467-021-22427-2

Research & Academia
HIT TIMES 2021

ULTRAFAST PRECISE MOLECULAR SEPARATION COF NANOFILTRATION MEMBRANES

Covalent organic frameworks (COFs) are a class of crystalline porous materials connected by covalent bonds. Compared with traditional porous nanomaterials (MOFs and Zifs), COFs have excellent properties, such as low mass density, good topological structure, and structural diversity. Therefore, COFs have become an important candidate and hot research object for high-quality membrane materials. However, it is still a great challenge to prepare COFs with sub-nanometer pore size. In addition to the lack of effective methods to synthesize high-quality COFs membrane, its complex synthesis steps, high temperature, high pressure, and difficult to scale limit its practical application. Furthermore, to realize the combination of rigidity and flexibility and size control of COFs composite nanofiltration membrane is also an urgent problem to be solved in the research of separation membrane.

Recently, Professor Shao Lu, a member of Royal Society of Chemistry and a member of State Key Laboratory of Urban Water Resources and Water Environment, proposed for the first time the strategy of a facile *in situ* molecularly soldered strategy to fabricate defect-free ultrathin COF membranes with precise sieving abilities utilizing the typical chemical environment for COF condensation



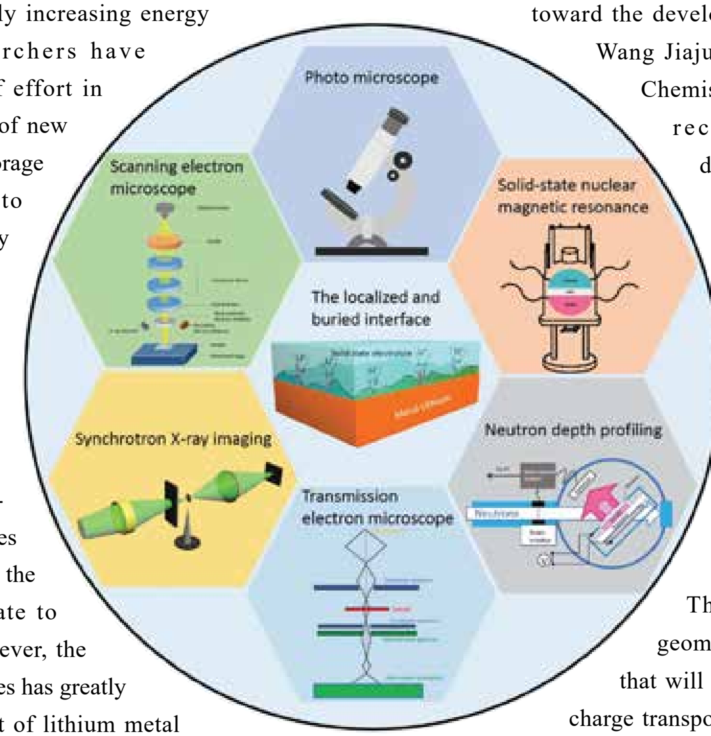
polymerization and dopamine self-polymerization. The experimental data and density functional theory simulations proved that the reactive oxygen species generated during dopamine (DA) polymerization catalyze the nucleophilic reactions of the COF, thus facilitating the counter-diffusion growth of thin COF layers. Notably, dopamine can eliminate the defects in the stacked COF by soldering the COF crystals, fortifying the mechanical properties of the ultrathin COF membranes. The COF membranes exhibited ultrafast precision sieving for molecular separation and ion removal in both aqueous and organic solvents, which surpasses that of state-of-the-art membranes. Moreover, the covalent interactions of DA with the COF and COF ligands reduced the separation size of the membrane and greatly enhanced the mechanical properties and stabilities of the membranes. The simplicity of the membrane fabrication process potentially enables the large-scale production of durable high-performance COF membranes for crucial energy-efficient separations to tackle the ever-increasing energy and environmental issues.

The research results are published in *Science Advances*, under the title of "Molecularly Soldered Covalent Organic Frameworks for Ultrafast Precision Sieving". ■

REFERENCES

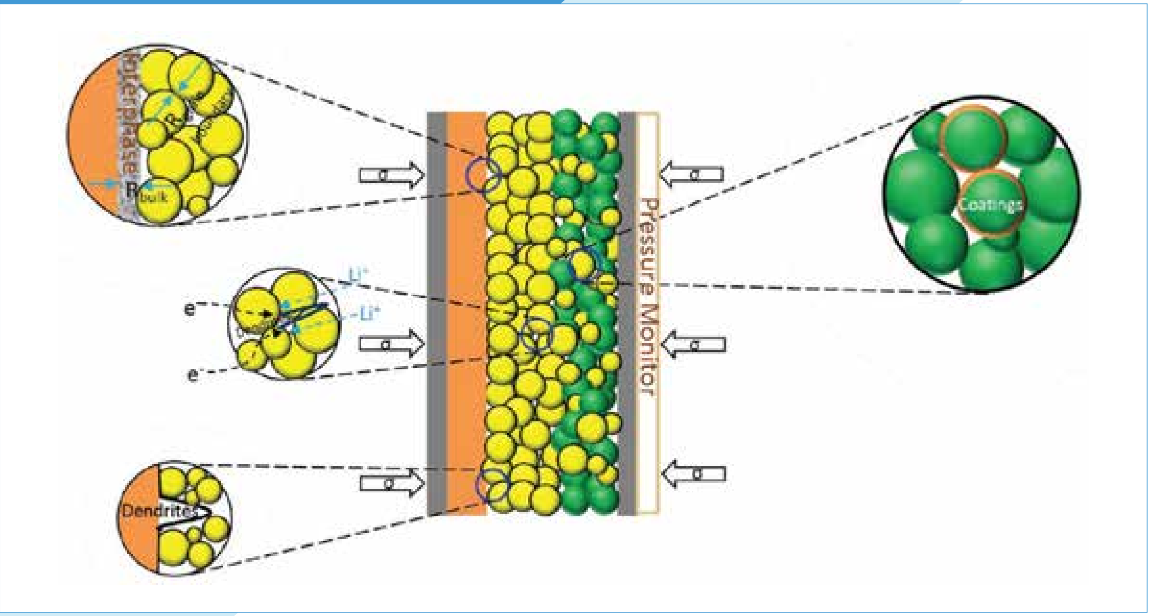
Yanqiu Zhang, Jing Guo, Gang Han, Yongping Bai, Qingchun Ge, Jun Ma, Cher Hon Lau, Lu Shao. Molecularly soldered covalent organic frameworks for ultrafast precision sieving. Science Advances, 2021, 7: eabe8706.

DENDRITES IN SOLID-STATE BATTERIES: ION TRANSPORT BEHAVIOR, ADVANCED CHARACTERIZATION AND INTERFACE REGULATION



To meet the rapidly increasing energy demand, researchers have invested a lot of effort in the development of new electrochemical energy storage materials and systems to achieve efficient energy storage, high safety, high energy density and long cycle life. Among them, lithium metal anode combined with solid-state electrolyte system, namely solid-state lithium metal batteries (SSLMBs), is expected as the most promising candidate to achieve these goals. However, the problem of lithium dendrites has greatly hindered the development of lithium metal batteries, even in SSLMBs. It is of great importance to systematically discuss and analyze the problems of lithium dendrites as well as providing rational solutions. As a step toward the development of SSLMBs, Professor Wang Jiajun's group from the School of Chemistry and Chemical Engineering recently published a review discussing the major issues and prospective of lithium dendrites in SSLMBs in Advanced Energy Materials. Advanced characterization technologies are recommended to characterize the interface and rational solutions are provided to engineer functional interfaces to suppress lithium dendrites.

The authors first discussed the geometric properties of the interface that will affect the electrodeposition and charge transport kinetics. The inhomogeneous physical and chemical properties at the interface generate additional electro-chemical-mechanical potentials, which lead to the nucleation and formation of lithium dendrites.



In addition, this review focuses on the use of advanced visual characterization techniques, such as synchrotron X-ray tomography, nuclear magnetic resonance imaging, scanning/transmission electron microscopy imaging, cryo-electron microscopy imaging, etc. to detect changes in the structure and composition of the interface under operating conditions. These advanced characterization techniques enable us to answer various questions related to lithium dendrites growth. Finally, the authors also provide possible ways and strategies about controlling interface engineering to inhibit the growth of interfacial lithium dendrites.

This work was supported by the start-up fund and the "Young Scientist Studio" of Harbin Institute of Technology, the National Natural Science Foundation of China, the Natural Science Funds of Heilongjiang Province and the HIT Research Institute (Zhao Yuan) of New Materials and the Intelligent Equipment Technology Co., Ltd. Scientific and Technological Cooperation and Development Fund. ■

REFERENCE

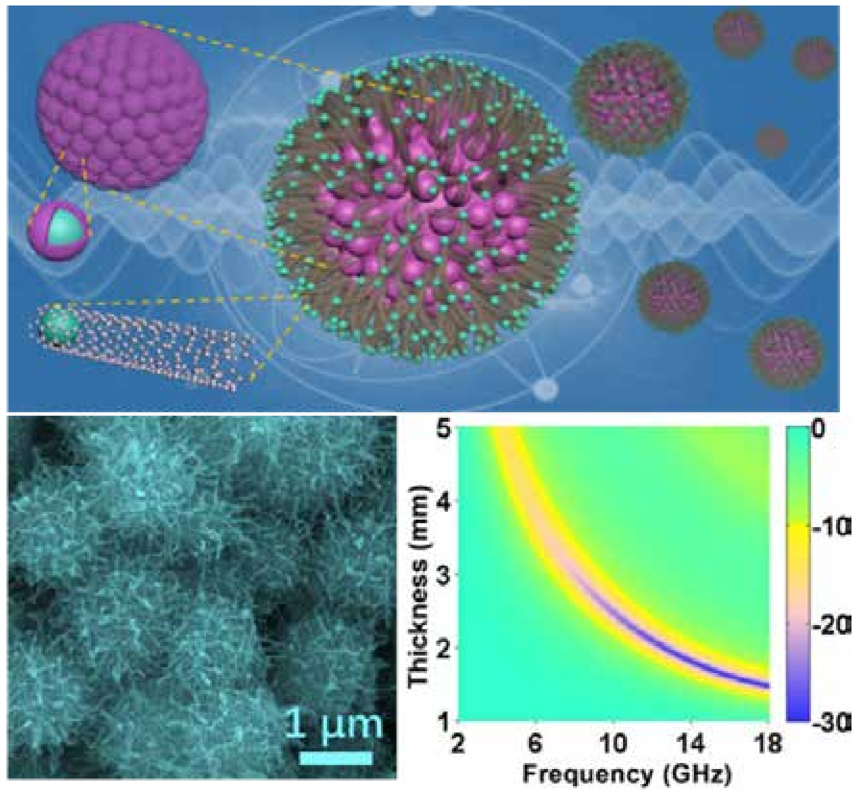
Zhenjiang Yu, Xueyan Zhang, Chuankai Fu, Han Wang, Ming Chen, Geping Yin, Hua Huo and Jiajun Wang. Dendrites in solid-state batteries: ion transport behavior, advanced characterization, and interface regulation. Advanced Energy Materials, 2021, 11, 2003250.

A "DOUBLE-HIERARCHICAL" MICROWAVE ABSORBOR AGAINST ELECTROMAGNETIC POLLUTION

On February 28th, 2021, Professor Du Yunchen's group from the School of Chemistry and Chemical Engineering published a research paper titled "Rationally Designed Hierarchical N-Doped Carbon Nanotubes Wrapping Waxberry-Like Ni@C Microspheres for Efficient Microwave Absorption" in *Journal of Materials Chemistry A*.

The ever-growing electromagnetic (EM) pollution resulting from the rapid development of electronic industry and EM technology has become a serious societal issue in recent years. The application of microwave absorbing materials (MAMs) has proven to be an effective means and is in urgent demand to protect human beings and sensitive electronic devices from excessive EM radiation. Although desirable progress has been made in some MAMs with special microstructures nowadays, the functional performance of MAMs can strive for further developments through rational design on more advanced configurations and the simultaneous regulation on chemical composition.

In this work, researchers demonstrate rational design and successful synthesis of a series of "double-hierarchical" N-doped CNTs wrapping waxberry-like Ni@C microspheres (NC@NCNTs). The loading amount of NCNTs, which grow *in situ* on the hierarchical waxberry-like Ni@C microspheres,



can be easily modulated by changing the dosage of melamine in synthesis process. EM analysis reveals that the unique "double-hierarchical" architecture and effective chemical composition modulation take their synergistic effects on improving the functional performance of NC@NCNTs. Benefited from the synergistic effect of multiple loss mechanisms, sufficient attenuation ability, and good impedance matching, NC@NCNTs-2, whose relative carbon content is 51.1 wt%, exhibits excellent microwave absorption properties, including the minimum reflection loss intensity of -41.5 dB and effective absorption bandwidth of 5.2 GHz, with an absorber thickness of only 1.7 mm, superior to many homologous Ni/C composites reported previously. These results may provide a feasible pathway for the rational design and fabrication of high-performance microwave absorbing materials with superior microstructures.

This work was financially supported by the National Natural Science Foundation of China.

REFERENCE

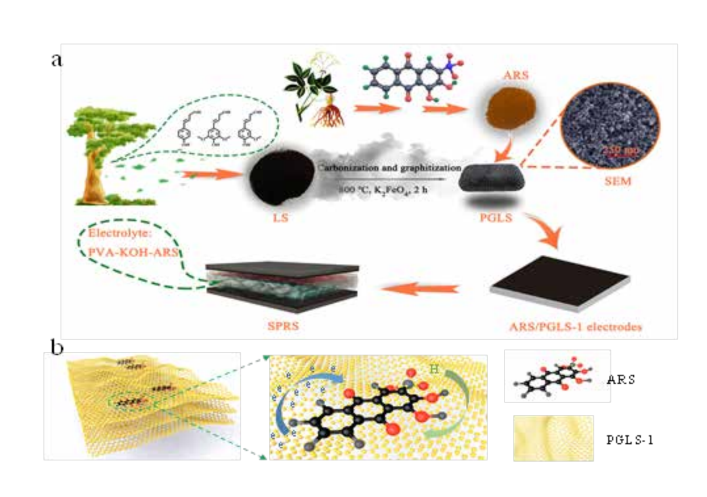
Dawei Liu, Yunchen Du, Ping Xu, et al. Rationally designed hierarchical N-doped carbon nanotubes wrapping waxberry-like Ni@C microspheres for efficient microwave absorption. Journal of Materials Chemistry A, 2021, 9, 5086-5096. DOI: 10.1039/d0ta10942h

BOOSTING THE CAPACITY OF BIOMASS-BASED SUPERCAPACITORS USING CARBON MATERIALS OF WOOD DERIVATIVES AND REDOX MOLECULES FROM PLANTS

On April 14th, 2021, Professor Xu Jie's group from Harbin Institute of Technology reported new progress on the capacity of biomass-based supercapacitors. The article, titled "Boosting the Capacity of Biomass-Based Supercapacitors Using Carbon Materials of Wood Derivatives and Redox Molecules from Plants", was published in *Journal of Materials Chemistry A*.

Biomass-based supercapacitors, which are based on porous carbons derived from renewable biomass materials such as salvia splendens, flaxseed residue, wood sawdust, lignin, and garlic skin, have emerged as a promising energy storage device due to the considerable power density, fast charge/discharge rate, excellent cycle stability and safety, sustainability, renewability, low cost, and the environmental friendliness of biomass materials. Biomass-derived porous carbon can obtain a high specific surface area and hierarchical pore structure by pyrolysis carbonization, their poor conductivity leads to unacceptable capacitance retention at high current density.

Although the introduction of catalysts such as Fe, Co, and Ni can obtain graphitized porous carbon materials with high electrical conductivity, significant improvement of the graphitization degree results in the destruction of the porous structure, leading to a decrease in the specific surface area, which greatly reduces the charge storage capacity. Furthermore, the time- and energy-consuming nature of the process, as well as the expensive and corrosive agents used, still present a challenge for the implementation in low-cost applications. In addition, the application of biomass-derived porous carbon in supercapacitors has been limited due to their low theoretical specific capacitance.



(a) Schematic illustration of the SPRS preparation process
(b) Mechanism model of the ARS/PGLS-1 composite electrode material network with ARS molecular structure

Herein, Professor Xu and his collaborators reported a hybrid system electrode made from biomass-based material sodium lignosulfonate-derived hierarchical porous graphitic carbon (PGLS) and an organic redox compound (alizarin). A derivative of alizarin called "Alizarin Red S" (ARS) improves energy storage capacity while PGLS-1 synthesized from high-molecular-weight sodium lignosulfonate (LS), using K_2FeO_4 to attain synchronous carbonization and graphitization, provides a continuous 3D porous framework with a certain graphitic order for the bulk charge transport and ARS self-organization within the composite electrode. The composite ARS/PGLS-1 electrode exhibits outstanding gravimetric specific capacitances (469.5 and 200.2 F g^{-1} at current densities of 0.5 and 10.0 A g^{-1}, respectively, for the ARS/PGLS-1 = 1 sample), indicating that ARS is compatible with PGLS-1 carbon-based supercapacitor systems that can be produced on a large scale. Furthermore, the assembled symmetric prototype redox-enhanced supercapacitor (SPRS) in an aqueous gel electrolyte (PVA/KOH/ARS) is demonstrated to have considerable specific capacitance, operational stability of over >2000 cycles, and synergetic energy-power output characteristics in practical applications. This new class of supercapacitors, based on biomass materials, represents a significant step toward green and sustainable energy storage technologies.

Professor Xu Jie from HIT and Professor Zhang Jiaheng from HITsz are the corresponding authors. Their Ph.D. student, Dr. Wang Tiansheng, is the first-author. This work was supported by the National Natural Science Foundation of China, the Shenzhen Science and Technology Innovation Committee, the Economic, Trade and Information Commission of Shenzhen Municipality through the Graphene Manufacture Innovation Center, and the Guangdong Province Covid-19 Pandemic Control Research Fund. ■

REFERENCES

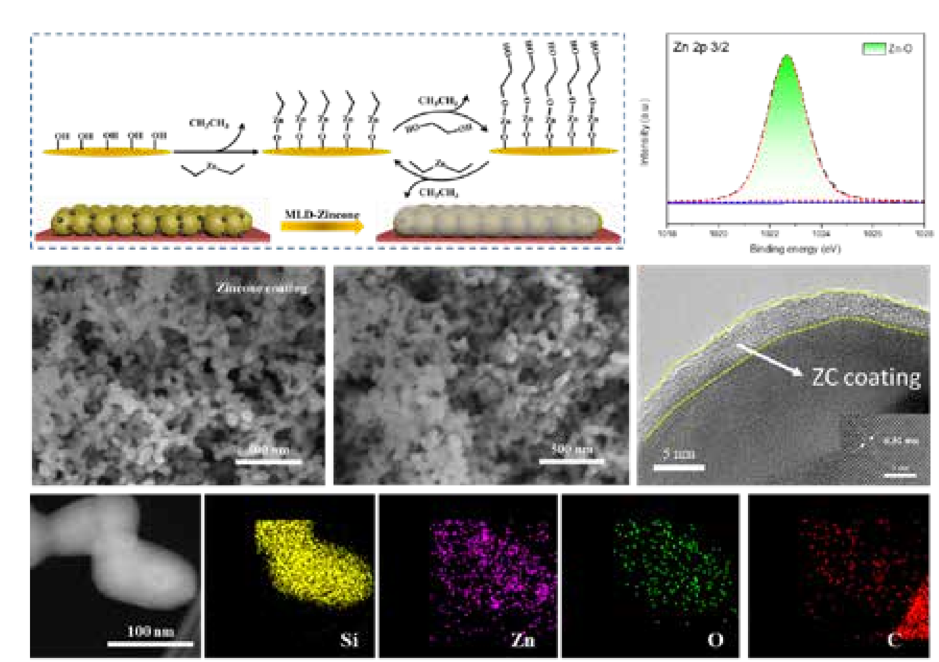
Tiansheng Wang, Shunyou Hu, Dong Wu, Weiwei Zhao, Wen Yu, Mi Wang, Jie Xu, Jiaheng Zhang. Boosting the capacity of biomass-based supercapacitors using carbon materials of wood derivatives and redox molecules from plants. Journal of Materials Chemistry A, 2021, 9, 11839-11852.

Research & Academia
HIT TIMES 2021

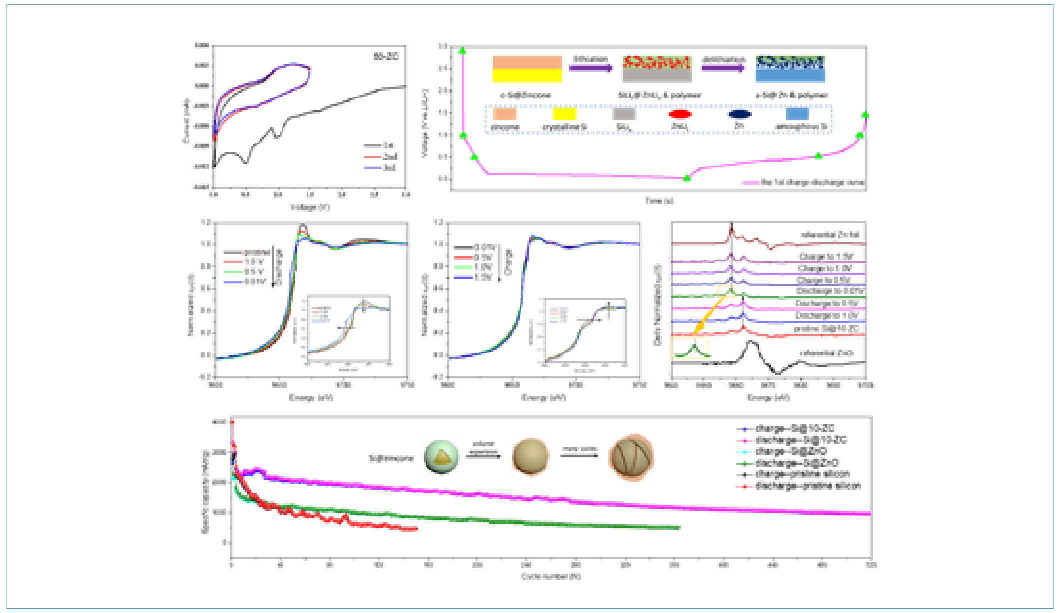
STABLE SILICON ANODES BY MOLECULAR LAYER DEPOSITED ARTIFICIAL ZINCONE COATINGS

Recently, a team led by Professor Yin Geping, from the School of Chemistry and Chemical Engineering, Harbin Institute of Technology, published a research paper titled "Stable Silicon Anodes by Molecular Layer Deposited Artificial Zincone Coatings" in *Advanced Functional Materials.*

For lithium-ion batteries, silicon (Si) anode is considered one of the most competitive candidates to replace commercial graphite anode due to its high theoretical capacity (4200 mAh/g). However, the volume change and unstable interfacial chemistry hinder the commercialization of Si anodes. Recently, some developed carbonaceous coatings and oxide coatings have been proposed and notably improve the cyclability of Si anodes. However, they still have limitations, including the



The process diagram of MLD-zincone coating and characterization result



The interfacial chemical evolution of Zincone coating and the improved electrochemical stability

catalytic effect of carbon on the decomposition of liquid electrolytes and the fragility of oxides, which restricts the long-stem electrochemical reversibility. Artificial polymer coatings with good flexibility and toughness have attracted widespread attention and are expected to improve the structure and interface stability of Si anodes. However, the controllable construction of the artificial polymer interface still faces challenges, and the mechanisms behind the electrochemical evolution of the polymer coatings still remain unknown.

In this work, a zincone polymer coating is controllably deposited on a silicon electrode using the molecular layer deposition technique. The study showed that enhanced electrochemical cycling depends on the thickness of zincone coating. The optimal zincone coating of ~3 nm markedly improves the lithium storage performance of Si anodes, resulting in the outstanding cycling stability (1011 mAh/g after 500 cycles) and superior rate capability (1580 mAh/g at 2 A/g). Such remarkable electrochemical reversibility stems from in-situ conversion of the zincone coating and a zincone-driven thin LiF-rich SEI, which endow the Si electrode with superior electron/ion transport and structural stability.

This research provides a new perspective for the design of an artificial polymer coating on Si anodes and also opens a door for constructing functional interface on other electrodes, such as Li/Na/Zn metal anodes. ■

REFERENCE

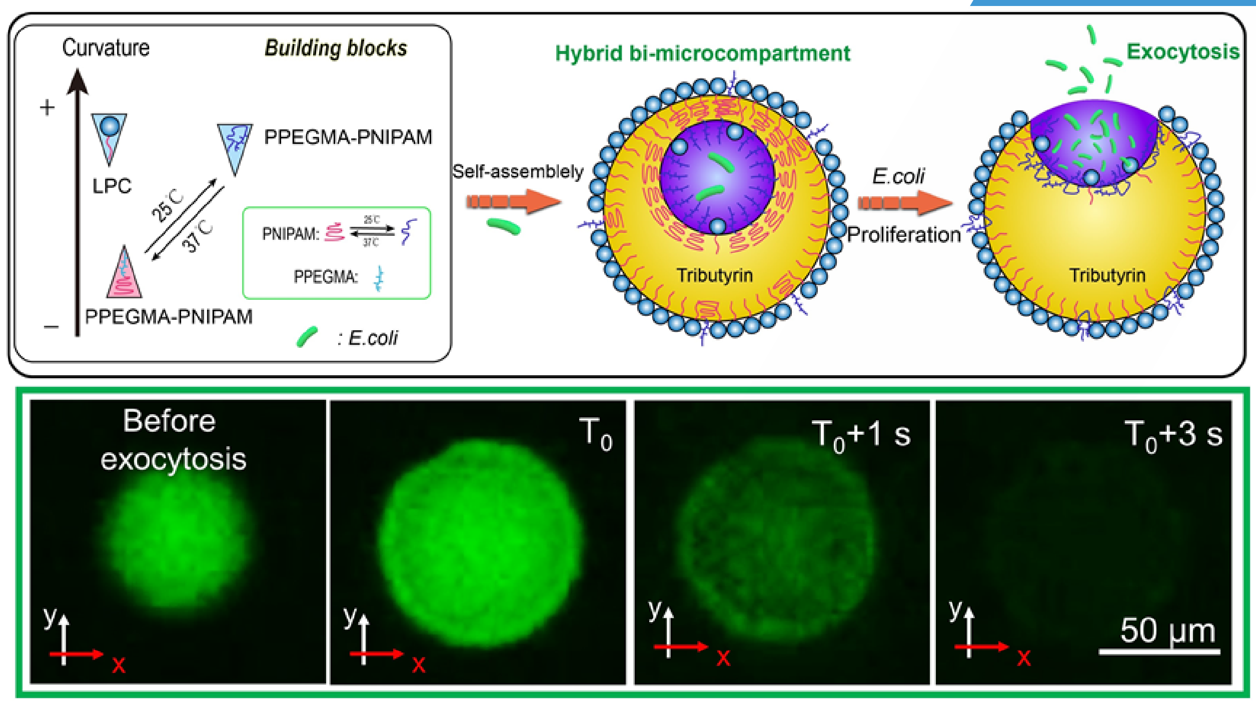
Tiansheng Mu, Geping Yin, et al. Stable silicon anodes by molecular layer deposited artificial zincone coatings. Advanced Functional Materials, 2021, 2010526.

HYBRID MICROCOMPARTMENTS WITH EXOCYTOSIS-INSPIRED BEHAVIOR TOWARD TRANSPORTATION OF LIVING ORGANISMS

Inspired by the unique characteristics of living cells, the creation of life-inspired functional ensembles is a rapidly expanding research topic, enabling transformative applications in various disciplines. Recently, Professor Huang Xin's group, from Harbin Institute of Technology, published a paper titled "Construction of Hybrid Bi-Microcompartments with Exocytosis-Inspired Behavior Toward Fast Temperature-Modulated Transportation of Living Organisms" in *Angewandte Chemie International Edition*.

Exocytosis is the primary way to release intracellular macromolecule, which plays an important role in signal transduction and metabolism regulation. Therefore, the development of a microcompartment capable of exocytosis-like behavior could not only contribute toward integrating cellular characteristics into artificial models to further the understanding of related pathological procedures, but also enrich microcompartment functionality applications to include cargo transportation or nanoreactors. However, few studies have successfully demonstrated a technique for generating microcompartments with exocytosis-like behavior *in vitro*.

The researchers developed a facile way to generate a new type of hybrid bi-microcompartments by spontaneous asymmetric assemble of phospholipid and temperature-sensitive block copolymer at the interfaces of O/W and



W/O, respectively. Being different from the reported spatiotemporally control of fusion between the microcompartments in the solution, the challenge of achieving exocytosis-like behaviour lies in the controllable fusion of the inner small microcompartments towards the outer microcompartment, which is successfully achieved in the fabricated system by the temperature-mediated dewetting of the inner microcompartments. Also, by controlling the fusion of the inner microcompartment towards the outer phospholipid-based membrane, both the exocytosis position and starting time could be exactly modulated. Significantly, although the tributyrin is used as the oil phase, the whole system still demonstrates excellent biocompatibility towards various living organisms, and the loaded living organisms could proliferate normally in the inner microcompartments. Therefore, the created bi-microcompartments could be taken as a chassis for the storage and transportation of living organisms on demand.

Taken together, this study not only achieved the mimic of exocytosis behaviour, which was first found in the synthetic biology systems, but also the created system showed excellent biocompatibility and provided a novel platform for the delivery of multi-size substances ranging from small molecular substance to living organisms. ■

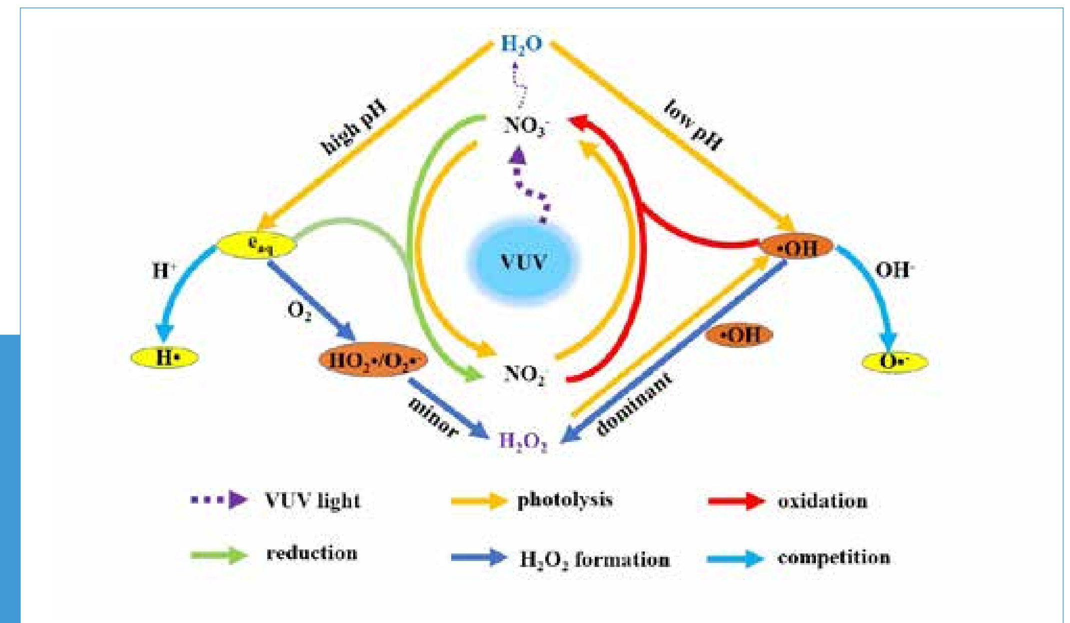
REFERENCE

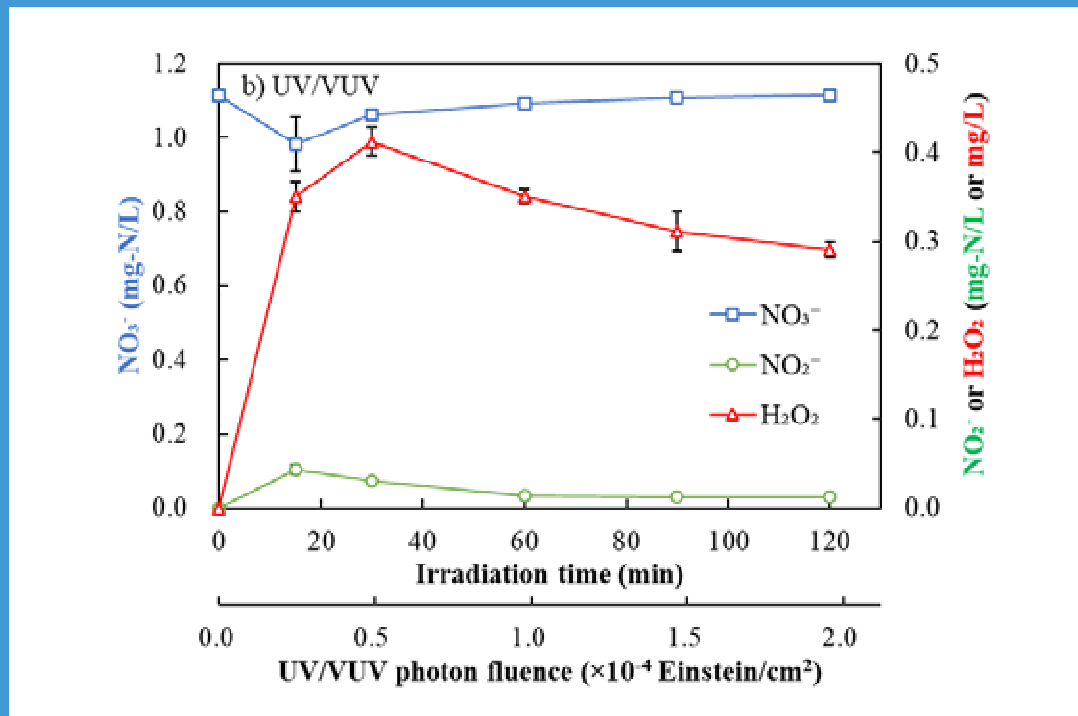
Haixu Chen, Lei Wang, Shengliang, Wang Junbo, Li Zhenhui, Li Youping Lin, Xiaoliang Wang, Xin Huang. Construction of hybrid bi-microcompartments with exocytosis-inspired behavior toward fast temperature-modulated transportation of living organisms. Angewandte Chemie International Edition, 2021, DOI: https://doi.org/10.1002/anie.202102846.

ADVANCED TOOL REVEALS RISKS IN ADVANCED WATER TREATMENT PROCESSES

Recently, a team led by Professor Chen Baiyang from the State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology (Shenzhen), published a research paper titled "Formation of Nitrite and Hydrogen Peroxide in Water During the Vacuum Ultraviolet Irradiation Process: Impacts of PH, Dissolved Oxygen, and Nitrate Concentration" in *Environmental Science & Technology*.

Vacuum ultraviolet (VUV) photolysis has recently become recognized as a promising technology due to its robustness in disinfecting microbials and degrading pollutants. However, to date, its side effects have not been adequately studied. In this study, we present some evidence that both nitrite (NO_2^-, a regulated carcinogenic contaminant) and hydrogen peroxide (H_2O_2, a compound linked to aging, inflammation, and cancer) can be formed significantly and concurrently during the VUV irradiation process. Our work thereby warns of risks associated with the use of VUV for water. Unlike previous studies, this study is novel





in its reporting of concurrent formation of two contaminants during the VUV process. In addition, this study made a systematic evaluation of three influencing factors to facilitate understanding of the conditions favorable for their formation, which might help prevent occurrence of them in future applications. Alongside the study, researchers applied a novel H_2O_2 detection method, which is insensitive to coexisting compounds in water, so that the findings can be observed and reasonably explained. As irradiated real waters clearly demonstrated the formation of NO_2- and H_2O_2 in water at levels near to or greater than current drinking water regulatory limits, this study reminds a holistic view of benefits and disbenefits of VUV process in environmental engineering application. Following the same principles, other advanced oxidation processes (AOPs) and advanced reduction processes (ARPs) are likely to trigger formation of H_2O_2 and/or NO_2- too. ■

REFERENCE

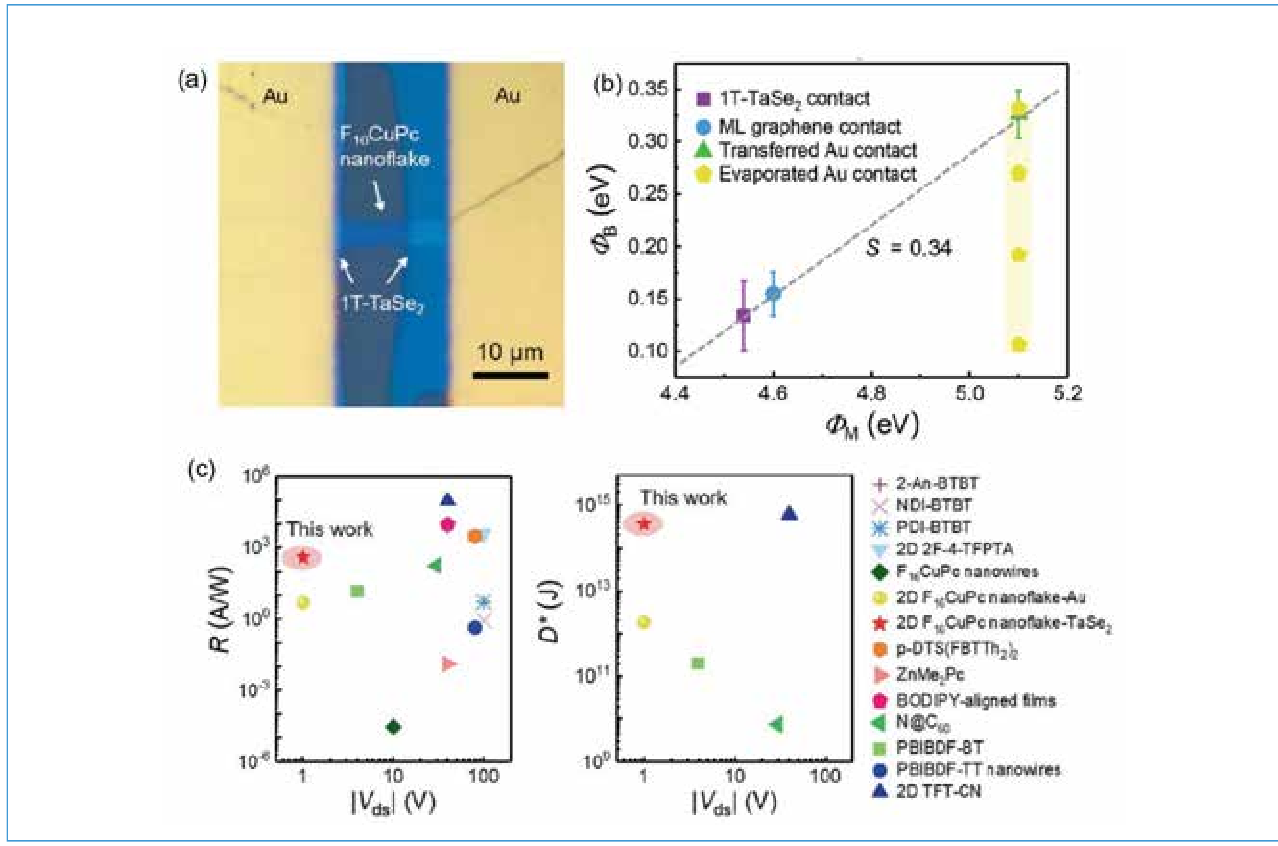
Chen, Baiyang, Yuanxi Huang, Qi Zhang, Dionysios D. Dionysiou, Lei Wang, and Juan Li. Formation of nitrite and hydrogen peroxide in water during the vacuum ultraviolet irradiation process: impacts of pH, dissolved oxygen, and nitrate concentration. Environmental Science & Technology, 2021, 55: 1682–89.

CONTACT ENGINEERING OF TWO-DIMENSIONAL ORGANIC FIELD EFFECT TRANSISTORS

Professor Xu Chengyan and his colleagues from the School of Materials Science and Engineering reported their new progress on the electrical contact engineering of organic $F_{16}CuPc$ by introducing van der Waals (vdW) contacts. The article, titled "Lowering the Contact Barriers of Two-Dimensional Organic $F_{16}CuPc$ Field-Effect Transistors by Introducing van der Waals Contacts", was published in *Small*, a top multidisciplinary journal covering broad topics at the nano- and microscale of advanced materials.

Two-dimensional (2D) organic crystals exhibit efficient charge transport and field-effect characters, making them promising candidates for high performance nanoelectronics. However, the strong Fermi level pinning (FLP) effect and large Schottky barrier height (SBH) induced by the formation of unfavorable gap states between organic semiconductors and metal electrodes largely limit the device performance. Many efforts have been paid to lower the Schottky barrier heights in organic field-effect transistors (OFETs). For example, doping of the contact interface by metal oxides, inorganic salts and organic compounds has been demonstrated to effectively enhance the tunneling probability of carriers by reducing the depletion width. Unfortunately, due to the trade-off between Schottky barrier and tunneling barrier, the optimized thickness of insertion layer is demanded to achieve the lowest contact resistance, and the instability and uncontrollable diffusion of chemical dopants still remain severe challenges.

The vdW contacts obtained by stacking 2D materials with semiconductors by weak vdW interaction have spurred great research interest recently. The choice of 2D metals as source-drain electrodes in 2D OFETs exhibits several advantages over the conventional approaches mentioned above. On the one hand, atomically smooth and dangling-bond free surfaces of both 2D metals and 2D organic semiconductors result in a clean hetero-interface, suppressing the formation of mid-gap states and FLP at the hetero-interface, which are usually generated at evaporated metal/semiconductor interface. On the other hand, the huge family of 2D metals makes it more convenient to choose appropriate candidates as contact electrodes in 2D OFETs, according to the band alignments between 2D metals and OSCs. However, as far as we know, there is a lack of relevant attempts to introduce vdW contacts with 2D metals as source-drain electrodes to realize efficient charge injection at the electrical contacts and the resultanting improvement of electrical and optoelectronic performance of 2D OSCs.



Fermi level depinning effect and optoelectronic performance of devices after insertion of 2D 1T-$TaSe_2$ between Au and $F_{16}CuPc$. The lowering of SBH contributes to significantly improved optoelectronic performance of 2D organic nanodevices.

In this work, by carrying out temperature-dependent transport and Kelvin probe force microscopy (KPFM) measurements, it has been demonstrated that the introducing of 2D metallic 1T-$TaSe_2$ as electrodes for $F_{16}CuPc$ nanoflake filed-effect transistors leads to enhanced field-effect characteristics, especially the lowered SBH and contact resistance, and highly efficient charge transport within the channel, which are attributed to the significantly suppressed FLP effect and appropriate band alignment at the nonbonding van der Waals (vdW) hetero-interface. Moreover, by taking advantage of the improved contact behavior with 1T-$TaSe_2$ contact, the optoelectronic performance of $F_{16}CuPc$ nanoflake-based phototransistor has been drastically improved, with a maximum photoresponsivity of 387 A/W and detectivity of 3.7×10^{14} Jones at a quite low source-drain voltage of 1 V, which is more competitive than those of the reported organic photodetectors and phototransistors. This work provides an avenue to improve the electrical and optoelectronic properties of 2D organic devices by introducing 2D metals with appropriate work function for vdW contacts. ■

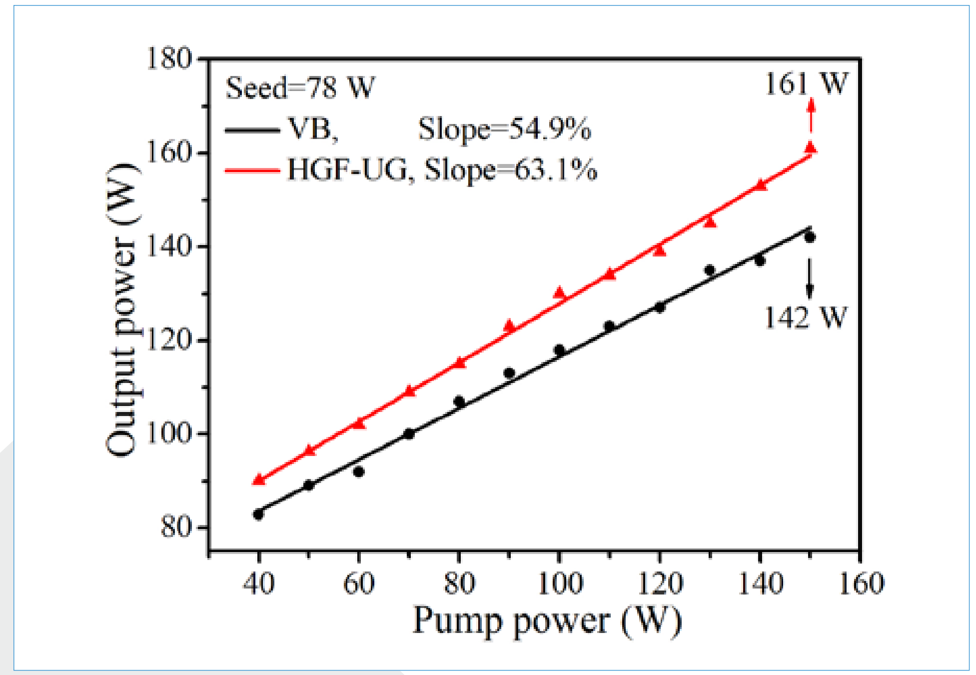
REFERENCE

Hang Yan, Yang Li, Jing-Kai Qin, Bo Xu, Ping-An Hu, Liang Zhen, Cheng-Yan Xu, Lowering the contact barriers of two-dimensional organic $F_{16}CuPc$ field-effect transistors by introducing van der Waals contacts. Small, 2021, 17, 2007739.

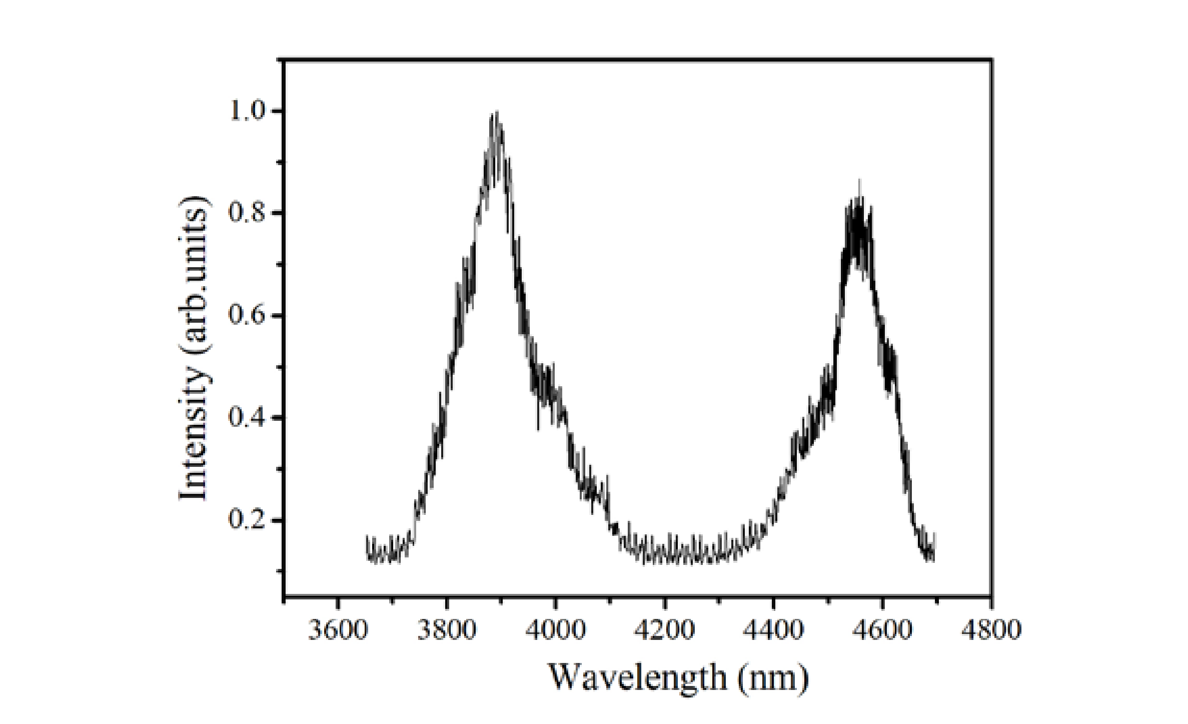
161 W MIDDLE INFRARED $ZnGeP_2$ MOPA SYSTEM PUMPED BY 300 W-CLASS Ho: YAG MOPA SYSTEM

In 2021, Professor Yao Baoquan's group from Harbin Institute of Technology reported their recent progress on 2 μm and 3-5 μm (mid-infrared) solid-state lasers. The article, titled "161 W Middle Infrared $ZnGeP_2$ MOPA System Pumped by 300 W-Class Ho:YAG MOPA System", was published in *Optics Letters*.

2 μm and 3-5 μm are located in the atmospheric transmission window, which has been broadly used in various aspects, including lidar, environmental monitoring, chemical remote sensing, laser medicine, and national defense. Ho:YAG has the advantages of low quantum defect, high thermal conductivity, and long upper laser level lifetimes. $ZnGeP_2$ (ZGP) has the advantages of high optical



Average output powers of ZGP OPA with VB ZGP crystal and HGF-UG ZGP crystal



Spectral measurement and output of middle infrared ZGP OPA

nonlinearity, high damage threshold, and good thermal conductivity. Therefore, Ho:YAG and ZGP crystals have been widely applied to obtain 2 µm and 3-5 µm, respectively.

To obtain high power 2 µm and 3-5 µm lasers with high beam quality, Professor Yao and his collaborators used the Ho:YAG MOPA system and mid-infrared ZGP OPO and ZGP OPA systems. For the Ho:YAG MOPA system, they demonstrated two parallel second-stage Ho:YAG amplifiers could achieve a high power 2 µm pulsed laser with better beam quality, which could be employed to pump mid-infrared ZGP OPO and ZGP OPA systems. In addition, the main advantage of the whole system was that each part sustained reasonable pressure from pulsed output power, which could avoid damages on mirrors and operate safely without damages for a longer period of time.

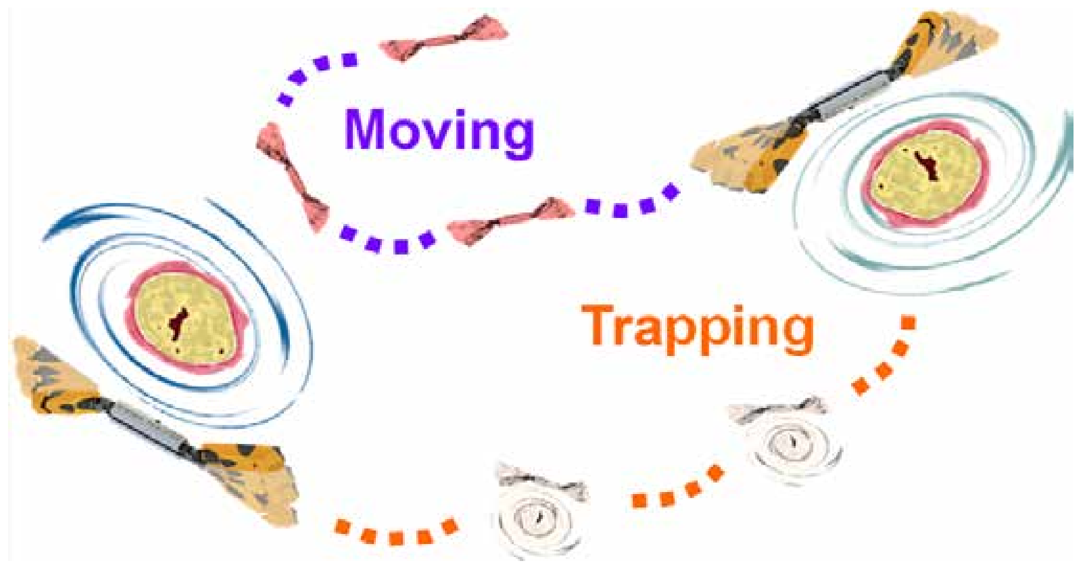
After optimization, with the pulse repetition frequency (PRF) of 20 kHz, the maximum average output powers of 152 W and 180 W were obtained for the two parallel second-stage Ho:YAG amplifiers. A total average output power of 332 W of Q-switched 2.1 µm Ho:YAG laser was achieved. To date, this is the highest output level of 2.1 µm Ho:YAG laser with excellent characteristics. Based on the above Ho:YAG MOPA, the mid-infrared ZGP OPO and ZGP OPA systems were demonstrated respectively. In ZGP OPO, the maximum average output power of 78 W at 3-5 µm was obtained with 140 W pump power. Then in the ZGP OPA part, the maximum average output power of 161 W at 3-5 µm with PRF of 20 kHz and pulse width of 23.3 ns were achieved, which is also the highest output level of 3-5 µm solid-state lasers. ■

REFERENCE

Liu Gaoyou, Mi Shuyi, Yang Ke, Wei Disheng, Li Junhui, Yao Baoquan, Yang Chao, Dai Tongyu, Duan Xiaoming, Tian Lixin, Ju Youlun. 161 W middle infrared $ZnGeP_2$ MOPA system pumped by 300 W-class Ho:YAG MOPA system. Optics Letters, 2021. DOI:10.1364/OL.413755

SWINGING FLEXIBLE NANOMOTORS FOR FLUIDIC TRAPPING

Recently, Professor Li Tianlong from the State Key Laboratory of Robotics and System, Harbin Institute of Technology, in collaboration with Professor Zhang Li from the Department of Mechanical and Automation Engineering from Chinese University of Hong Kong, published a paper titled “Propulsion Gait Analysis and Fluidic Trapping of Swinging Flexible Nanomotors” in *ACS Nano*.



With this research, a model for regulating the motion of a swinging flexible nanomotor (SFN) driven by an oscillating magnetic field was proposed. The coupling of magnetic actuation and the swinging pattern of SFNs are studied to reveal their mobility. Additionally, an optimal frequency occurs from the coupling of magnetic torque and structural deformation, rather than the simply considered step-out phenomenon. Meanwhile, a fluidic trapping region is formulated alongside the SFN. Such a trapping region is demonstrated by trapping a living neutrophil and accomplishing *in vitro* transportation using fluidic mediation. On-demand cargo delivery can be realized using a programmable magnetic field, and SFNs can be recycled with ease after manipulation owing to environmental concerns. These flexible nanomotors may have the potential to promote drug delivery and biomedical operations in noncontact modes. ■

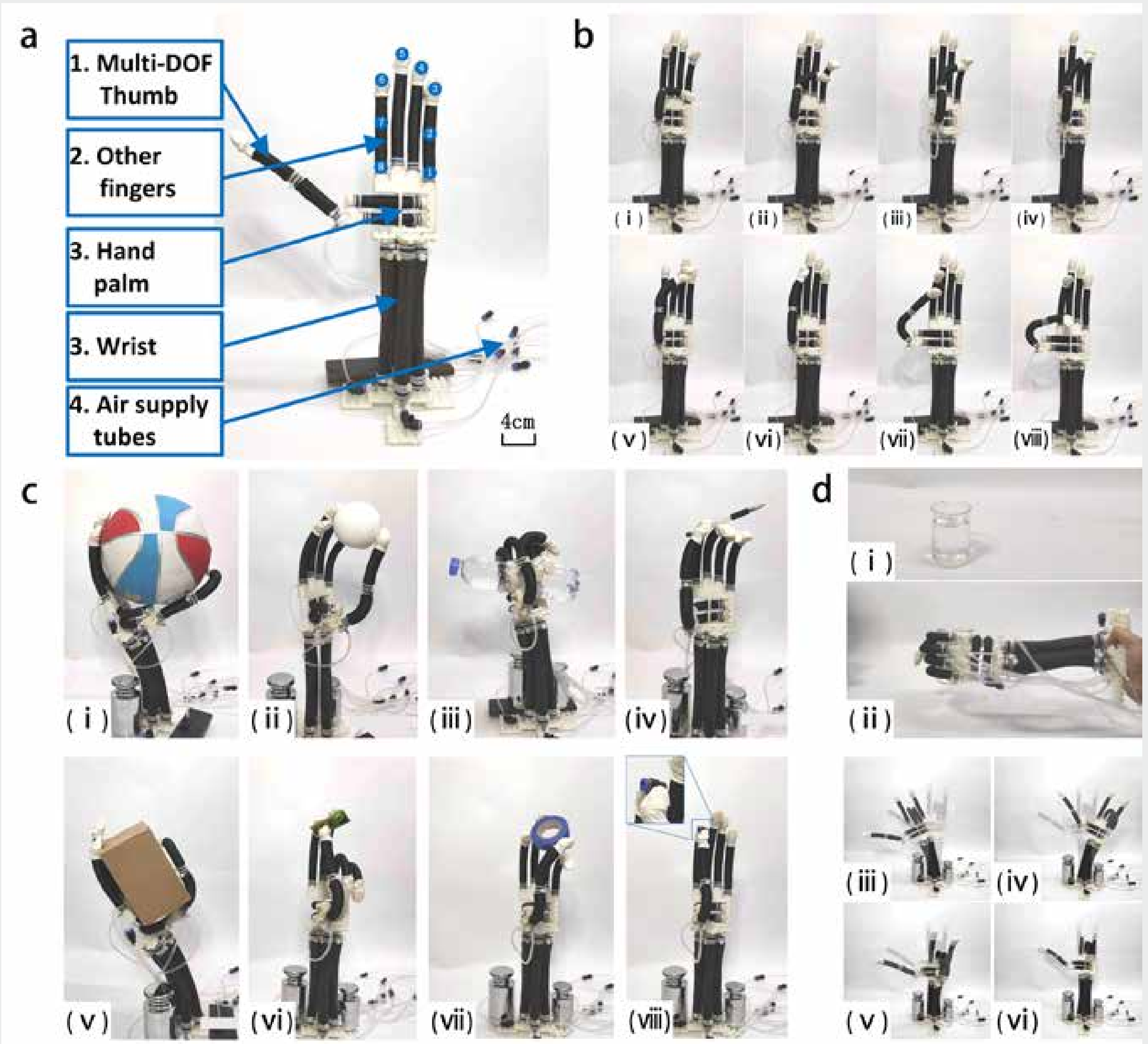
REFERENCE

Fengtong Ji, Tianlong Li, Shimin Yu, Zhiguang Wu, Li Zhang. Propulsion gait analysis and fluidic trapping of swinging flexible nanomotors. ACS Nano, 2021, 15, 5118–5128.

NEW PROGRESS ON THE MODELING AND APPLICATION OF BENDING EXTENSILE AND CONTRACTILE PNEUMATIC ARTIFICIAL MUSCLES

Pneumatic Artificial Muscles (PAMs) are a type of compliant fluidic actuator, usually consisting of a tubular bladder, a braided sleeve and end fittings. The McKibben actuator is the earliest and most well-known PAM actuator. Soft bending actuators are essential components used in soft robotics, an emerging and thriving research field, and important foundations of more complex actuators such as helical and multi-DOF actuators. However, predicting the performance of soft actuators is nontrivial due to their nonlinear responses and complex geometries.

Recently, a group led by Professor Leng Jinsong from the Centre for Composite Materials and Structures at Harbin Institute of Technology (HIT) published a paper titled “Characterization and Nonlinear Models of Bending Extensile/Contractile



A soft humanoid hand based on BEPAMs and BCPAMs. (a) Components of the humanoid hand. (b) Gestures of the dexterous hand. (c) Gripping objects of different sizes, shapes and stiffness with the soft humanoid hand including (i) a basketball (20.4 cm), (ii) a 3D printed sphere (4 cm), (iii) a bottle of water (550 g), (iv) a pen, (v) a corrugated paper box, (vi) a circuit board, (vii) a roll of tape, and (viii) a pneumatic quick connector (8 mm). (d) The wrist based on BC-PAMs, (i-ii) holding a bottle of water (335 g) horizontally and (iii-vi) conducting multi-direction bending motions.

Research & Academia
HIT TIMES 2021

Pneumatic Artificial Muscles" in *Smart Materials and Structures*. This work was a collaboration with Professor Norman M. Wereley from University of Maryland, College Park. They proposed two nonlinear models for both bending extensile and contractile PAMs, and developed several soft gripping robots, including a humanoid hand.

In this study, BE-PAMs (bending extensile PAM) and BC-PAMs (bending contractile PAM) were built with homologous structures reinforced along the axis with an elastic frame which has enough stiffness to restrain extension or contraction and resist buckling. This offers a chance to characterize and compare the performance of BE-PAMs and BC-PAMs with a homotypic structural design. Moreover, a four-point moment cyclic loading test method was proposed to facilitate the assessment and comparison of bending actuators. With this method, uniform bending loads could be applied during the cyclic test, bringing a better agreement between experimental results and theoretical analyses and making it more convenient to estimate the energy losses of bending actuator. In order to solve the error brought on by the neglect of elastic forces, based on our prior work, we not only considered the non-constant braid angle and the effect of elastic deformation of the rubber tube and elastic frame but also the nonlinear behavior of bladder tube materials via the Mooney-Rivlin hyper-elastic model.

Finally, two three-finger grippers and a humanoid hand with a multi-direction bending wrist based on BE-PAMs and BC-PAMs were developed, in which the BE-PAM gripper showed more adaptive gripping performance due to its better compliance, larger stroke and flexibility, whereas the BC-PAM gripper showed higher gripping force. A humanoid hand with fingers, a palm, and a wrist were then built. The fingers and palm were actuated by BE-PAMs showed excellent flexibility and adaptability in gripping objects with various sizes, shapes and materials, and the wrist built with BC-PAMs achieved four-direction bending and exhibited decent load capability. ■

REFERENCE

Qinghua Guan, Jian Sun, Yanju Liu, Norman M. Wereley, Jinsong Leng. Characterization and nonlinear models of bending extensile/contractile pneumatic artificial muscles. Smart Materials and Structures, 2021, 30, 025024. DOI: 10.1088/1361-665X/abd4b0

NEWS & EVENTS

HIT Party Secretary Xiong Sihao

HIT President Zhou Yu

SUMMARY MEETING COMMEMORATING HIT'S 100TH ANNIVERSARY

On January 2nd, 2021, the Summary Meeting Commemorating HIT's 100th Anniversary was held in the Activity Centre. The meeting comprehensively summarized the achievements and experiences of the work commemorating the centennial anniversary. HIT Party Secretary Xiong Sihao attended the meeting and made a speech, and HIT President Zhou Yu chaired the meeting. The meeting was broadcasted live to HIT's three campuses.

On behalf of the university, Xiong Sihao extended warm congratulations to the award-winning units and individuals and paid high respects to the teachers, students, staff, and alumni. He put forward three requirements: first,


HIT Executive Vice President Han Jiecai

continuous consolidation of achievements, comprehensive study and implementation of the spirit of the University's 13th Party Congress, and close attention to the formulation of the "14th Five Year Plan"; second, to the continuation of learning from the experience and promotion of reform; lastly, the continuation of cohesion effect, the strengthening of self-confidence, and the gathering of greater joint efforts in the new century.

The school leaders-Han Jiecai, Guo Bin, Xu Dianguo, Yao Limin, Liu Hong, Wu Songquan and Zhen Liang, Director of the Organization Department Sun Xue, HIT president's assistants Shen Yi, Hou Yujie, Fan Feng and Huang Yudong, and the former school leader Cai Jujin-attended the meeting. HIT Executive Vice President Han Jiecai made a comprehensive summary of the work of commemorating the centennial anniversary from five aspects.

Three collectives won the honorary title of "Special Contribution Collective"; eight collectives won the honorary title of "Outstanding Contribution Collective", and 13 collectives won the honorary title of "Excellent Collective." Ji Peng and 11 other individuals won the honorary title of "Outstanding Contribution Individual." Yu Hongbo and 71 other teachers, students, and staff won the honorary title of "Excellent Individual." Xu Dianguo, Yao Limin, and Liu Hong presented awards to the winners. ■

HIT Party Secretary Xiong Sihao


HIT President Zhou Yu

FLAG RAISING CEREMONY COMMEMORATING HIT'S 101ST ANNIVERSARY

On June 7th, 2021, a flag-raising ceremony commemorating HIT's 101st anniversary, which was simultaneously broadcasted live through the new media platform, was held in the square of the Electric Machinery Building..

HIT Party Secretary Xiong Sihao reviewed the excellent achievements of the university under the guidance of the spirit of Chinese President Xi Jinping's congratulatory letter in the past year. He also put forward three requirements: the improvement of our strategic position; greater efforts in reform, innovation and hard work; and greater efforts in patriotism, dedication, and the pursuit of excellence.

HIT President Zhou Yu pointed out that from a new starting point, all teachers, students, and staff in the three campuses of the school should consciously improve position, plan actively, reform and innovate, work hard, and devote to the country and pursue excellence.

News & Events
HIT TIMES 2021

HIT PRESIDENT ZHOU YU ATTENDED THE GLOBAL FORUM OF UNIVERSITY PRESIDENTS 2021

On April 24, HIT President Zhou Yu was invited to attend the Global Forum of University Presidents 2021 (GFUP 2021) at Tsinghua University and made a keynote speech at the roundtable discussion with the title of "Building the Development Pattern of a More Open University."

President Zhou introduced HIT's development which has always put self-development in national development and has created many "firsts" in China and in the world. Under the guidance of the spirit of General Secretary Xi Jinping's congratulatory letter to HIT's 100th anniversary, we will build a more open university and make greater contributions to China's development. We will embrace diversity. We will respect cultural diversity and learn from world-class universities with a more open mind so that we can seek common ground while appreciating diversity and striving to build consensus.

GFUP 2021, themed "Innovate for the Future: Vision and New Mission of Universities", convened online and offline from April 19 to 24, 2021. More than 500 representatives from more than 330 universities, 77 international organizations, academic institutions, university alliances and industries participated in the conference via a video link. More than 300 university presidents and guests from 70 universities in China attended the conference in the main building of Tsinghua University. They explored the prospects and challenges of university reform, the path to a more open, integrated and resilient university, and the vision and new mission for future development of universities. UN Secretary-General António Guterres sent a congratulatory letter to the conference. GFUP 2021 has released the "Tsinghua Consensus". The "Tsinghua Consensus" states that universities should strengthen cooperation, build more open, integrated and resilient universities, and work together to promote the further development of higher education.

CHINA SPACE DAY 2021

April 24 witnessed the 6th China Space Day with the theme of "Voyaging into Space, Pursuing Dreams." To commemorate the outstanding achievements of China's aerospace industry and promote its spirit, the Youth League Committee of HIT held a series of events (such as a flag-raising ceremony, a themed carnival, a painting activity, a flight performance, and a quiz competition) on the three campuses of HIT, which was co-organized by the Youth League Committee of the School of Astronautics, the Youth League Committee of the Basic Studies Department, and the Logistics Group. ■

THE 11TH ANNUAL CONSTRUCTION FESTIVAL AND 2021 HOLLOW-PLATE ARCHITECTURAL DESIGN AND CONSTRUCTION COMPETITION

On June 13th, the 11th Annual Construction Festival and 2021 Hollow-Plate Architectural Design and Construction Competition was held. Architecture, a perfect combination of “art and science”, not only has the space attribute of reunion or rest, but also can carry its unique humanistic connotation.

Twenty-five groups of freshmen and sophomores from the School of Architecture of HIT and 11 high school teams participated in the competition, such as Harbin No.3 High School and Daqing Shiyan High School. Fourteen high school teams, including Chengdu Shude High School in Sichuan Province and Hefei 168 Middle School in Anhui Province, participated in the competition through the internet.

The theme of the construction festival was “A Hundred Wonderful Years.” The students used the white hollow-plates to display their imagination, to create a community that not only promotes on-site communication and cultural identity but also embodies the perfect combination and interactive development of "art and science". Architects created different forms of works with different elements, which attracted people to stop and enjoyed the beauty and joy brought by the architecture.

After fierce competition, the works “Scroll with Time” and “Beauty of Strength and Flower” won the first prize in the university group; the works “Rhythm” and “Odd Flowers” won the first prize in the high school group of on-site construction; the work “Flowing Light”, submitted by Mianyang Foreign Languages School in Sichuan Province, won the grand prize in the high school group of off-site construction.

HARBIN INSTITUTE OF TECHNOLOGY
NEWSLETTER 2021 ISSUE 1

CONTACT US:

Address: Editorial Department of Journal of Harbin Institute of Technology, Room 402-2, School of Management, 92 West Dazhi Street, Nan Gang District, Harbin, Heilongjiang Province, China
Post Code: 150001
Email: hit-times@hit.edu.cn

HIT TIMES ONLINE:

The HIT TIMES can be read online at http://hit-times.hit.edu.cn
The views expressed in this publication are the views of the authors and do not necessarily reflect the views of the Harbin Institute of Technology.

Please scan the QR code to read on your phone:

Please scan the QR code to subscribe our WeChat public account: