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DICP's 70th Anniversary Special Issue on Advanced Materials for Clean Energy

Zhong-Shuai Wu, Xianfeng Li,* Feng Wang,* and Xinhe Bao**

This special issue features *Reviews, Progress Reports, and Research News* articles highlighting the remarkable contributions from leading faculty members and alumni at Dalian Institute of Chemical Physics (DICP), Chinese Academy of Sciences (CAS), celebrating its 70th anniversary. The issue aims to showcase the monumental progresses made by DICP in different fields promoting the growth of science and technology through the interplay between multiple disciplines.

Established in 1949, the seven-decade long history of dedicated research and excellent results have put DICP at a prominent position in the Chinese as well as global scientific environment. DICP has always paced itself according to the scientific goals of China, for example, petroleum research in 1954 to basic science in 1962. Presently, it is a multidisciplinary institute with focus on wide-ranging topics like energy generation (solar), conversion (catalysis) and storage (batteries, supercapacitors), sustainable synthesis of value-added chemicals, biotechnology, and environmental monitoring. DICP spans a vast 1.05 million square meters, with four campuses, hosting two state key laboratories, five research laboratories, and Dalian National Laboratory for Clean Energy (DNL, or call Innovation Academy for Clean Energy, CAS). Relying on DICP, the CAS has attracted the dominant energy research power to establish the DNL, focusing on the clean and efficient use of fossil resources and coupling substitution, multi-energy complementation and scaling application of clean energy, and low-carbon multi-energy strategic integration. DNL aims to realize the integrated development of fossil energy, renewable energy, and nuclear energy by the breakthrough of transformational key technologies and providing key energy scientific and technological support for energy security and sustainable development. DICP offers the best infrastructure to foster a collaborative and highly productive work environment for talented researchers from different age-groups and levels. Highly motivated individuals at DICP receive the freedom and resources to carve their unique research path through experimentation and guidance from eminent scientists. This has consistently enabled research at DICP to be fresh and ground-breaking. This Special Issue emphasizes the impactful work of such researchers and their views regarding the future of some important topics.

Given the conducive environment, researchers at DICP have earned countless laurels for their achievements. Notably, Cunhao Zhang received the Highest National Award of Science and Technology in 2013 for his contribution to the field of chemical lasers. The innovative project of "Methanol to Olefins (DMTO)" led by Zhongmin Liu won the First Prize at State Technological Invention Awards in 2014, Xinhe Bao received the Award for Excellence in Natural Gas Conversion in 2016 and Alwin Mittasch Prize in 2017 for his contributions to the development of novel catalysis concepts for methane and syngas conversion and on fundamental research of nanocatalysis. Can Li won the International Catalysis Award (2004) and the Japanese Photochemistry Association Elsevier Lectureship Award (2017). Not only that, but DICP is leading the world in various other fields, such as developing the brightest ultraviolet light source in the world, the proposal of nanoconfined catalysis and single-atom catalysis, powering the future with liquid sunshine, large-scale commercialization of flow batteries, record-breaking solar cells, innovation in lignocellulosic biomass utilization, world-class instruments for monitoring toxic chemicals, and swift detection of trace illegal drugs.

Scientific achievements with large-scale manufacturing potential can empower the world. DICP cooperates with local governments and companies for demonstrating entrepreneurship and innovation. At present DICP has established 37 spin-off companies encompassing different sectors including catalysis, new energy, membrane separation, coal chemical industries, biotechnology, environmental monitoring and protection, fine chemicals, energy storage, and many more. Four achievement transfer funds set up by DICP further empower this synergy to support fundamental scientific research and commercialization. Apart from local collaboration, DICP harbours international cooperation endeavours with 9 joint research units established by reputed scientific research institutions in the UK, The Netherlands, France, and other countries; DICP-BP Energy Innovation Laboratory, SABIC-DICP Research Centre for Advanced Chemicals Production Technologies being some notable examples. For knowledge sharing and proliferation, DICP has been very active in organizing international forums and conferences like, the 16th International Congress on Catalysis (2016) and International Forum on Clean Energy (2017 and 2018) where hundreds of world-leading scholars from all around the world come together to share their perspectives and to enrich their own research. These achievements and collaborations have made DICP the home for not only cutting-edge research on clean energy but also unique ideas and perspectives about the future of such vast interdisciplinary research. This Special Issue of *Advanced*

Prof. Z.-S. Wu, Prof. X. F. Li, Prof. F. Wang, Prof. X. H. Bao
Dalian Institute of Chemical Physics
Chinese Academy of Science
Dalian 116023, P. R. China
E-mail: wuzs@dicp.ac.cn; lixianfeng@dicp.ac.cn; wangfeng@dicp.ac.cn
Prof. X. H. Bao
University of Science and Technology of China
96 Jinzhai Road, Hefei 230026, China
E-mail: xhbao@dicp.ac.cn

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Zhong-Shuai Wu received his Ph.D. in materials science from Institute of Metal Research, CAS in 2011, and worked as a postdoctor at Max-Planck Institute for Polymer Research from 2011 to 2015. He then joined DICP as a full Professor and group leader of 2D Materials & Energy Devices. In 2018, he was promoted to DICP Chair Professor. His research focuses on graphene and 2D materials, microscale electrochemical-energy-storage devices (micro-supercapacitors, micro-batteries) and their integrated systems, supercapacitors, batteries (Li–S, Li/K/Na-ion, solid-state), and catalysis.

Feng Wang received his B.Sc. at Zhengzhou University (1999) and his Ph.D. at DICP, CAS (2005). He spent 2005–2006 as a postdoctoral fellow at the University of California, Berkeley, USA, and 2006–2009 at the Hokkaido University-Catalysis Research Center in Japan. At DICP, he serves as a full professor and an independent PI (2009), a joint professor in the State Key Laboratory of Catalysis (2013), and is the director of the Division of Biomass Conversion & Bio-Energy (2018). He served as the Cheung Kong Professor at Dalian University of Technology in 2016. His current research focuses on heterogeneous catalysis and biomass conversion.

Xianfeng Li received his Ph.D. in polymer chemistry and physics from Jilin University in 2006. Afterward, he worked as a postdoc fellow at K.U. Leuven, Belgium. In 2009, he was appointed as an associate professor at DICP, CAS. In 2012 he was promoted to full professor at DICP. Currently he serves as the head of the Energy Storage Division at DICP. His research interests focus on electrochemical energy storage, e.g., flow batteries, lithium-based batteries, sodium-ion batteries, etc.

Xinhe Bao received his Ph.D. in physical chemistry from Fudan University in 1987. He held an Alexander von Humboldt Research Fellow position at the Fritz-Haber Institute, Berlin, Germany, between 1989 and 1995, hosted by Prof. Gerhard Ertl. Following that, he joined DICP as a full Professor. He became a member of the Chinese Academy of Sciences in 2009. He held the positions of DICP Director from 2000 to 2007, the President of the Shenyang Branch of the CAS from 2009 to 2014, and the Executive Vice President of Fudan University from 2015 to 2017. He was appointed the President of the University of Science and Technology of China in 2017. His research interests lie in nano- and interfacial catalysis, focusing on the fundamental understanding of heterogeneous catalysis, including the development of new catalysts and novel catalytic processes related to energy conversion and storage.

Materials for Clean Energy features 6 *Reviews*, 16 *Progress Reports*, and 1 *Research News* article; all contributions from authors researching diverse topics at DICP.

Concerning the field of catalysis, Peng et al. (article number 1902181) write about the progress in methanol-to-olefins catalysts as one of the critical constraints in producing basic chemicals from nonpetroleum resources. Zhang et al. (article number 1902031) discuss the synthesis, mechanism, and catalytic applications of supported noble-metal single atoms. Wang et al. (article number 1902033) take on the high-temperature electrolysis of carbon dioxide in solid oxide electrolysis cells and discuss their development, challenges, and prospects. Chen et al. (article number 1902757) analyze the design and optimization of complex hydrides for clean energy storage, conversion, and utilization. Li et al. (article number 1902069) focus on the recent development of water-oxidation catalysts for artificial photosynthesis. Xiao et al. (article number 1901905) summarize the latest developments in sinter-resistant metal-nanoparticle catalysts via different methods. Deng et al. (article number 1901996) present a review regarding 2D confinement catalytic systems using two-dimensional materials for energy conversion. Ma et al. (article number 1901796) review the controlled synthesis and catalytic applications of iron-carbide-based nanomaterials. In the direction of heterogeneous catalysis, Ding et al. (article number 1904976) present an overview of the development

of this heterogenization with the particular example of a novel single-site Rh1/PIP catalyst and how it confers excellent performance in the vapor-phase carbonylation of methanol. Yang et al. (article number 1901997) highlight the recent progress in TiO_2 photocatalysis starting from basic concepts, all the way up to challenges and opportunities. Wang et al. (article number 1901866) analyze the challenges in the path of scissoring lignin into aryl monomers and give an outlook for future directions. Wu et al. (article number 1902080) focus on surface reaction mediation of efficient catalysts, attempting to shed new light connecting the basic theory of physical chemistry and surface reaction mediation strategies. Yang et al. (article number 1902547) highlight the developments in oxygen permeation models for improving oxygen-permeable membrane designs for high-performance membrane reactors.

In the field of energy storage, Wu et al. (article number 1900583) present a progress report highlighting the recent advances of planar micro-batteries and micro-supercapacitors, starting from fundamental design to challenges and prospective solutions. Li et al. (article number 1902025) review the development and challenges in the path of zinc-based flow batteries from a materials point of view. Cui et al. (article number 1902029) pay attention to the advances in solid polymer electrolytes for high-energy density lithium batteries and the corresponding mechanisms and challenges. Yu et al. (article number 1901414) systematically discuss the methods, mechanisms, and electrochemical properties of phosphorous-based composites as anode materials for the promising potassium-ion batteries.

Besides energy storage and conversion, another important area is manipulation of light to meet demands for clean energy. In that respect, Liu et al. (article number 1902037) discuss the progress of metal cations introduced into perovskites for quality optimization of photovoltaic devices and the challenges that lie ahead. With photodetection being a particularly attractive technology for both the military and civilians, the discussion by Peng et al. (article number 1902044) about photodetectors based on the photothermoelectric effect is an interesting read. They address this area from a materials perspective and discuss some exotic phenomena beyond photodetection.

Finally, to highlight biotechnological research at DICP, Zhang et al. (article number 1902048) focus their discussion on the currently representative epitope imprinting technology, and Ye et al. (article number 1902023) review the fabrication and application of monolithic materials with special emphasis on monolithic capillary columns. Qin et al. (article number 1902042) present the remarkable properties of functional hydrogels as an extracellular matrix in 3D culture for instructing cellular behaviors.

This Special Issue is representative of most of the interesting research endeavours at DICP. It shows the importance of interdisciplinary research for rapid progress in science, technology, and industrialization. We hope that our readers will enjoy this issue and be acquainted with DICP's rapid progress at the frontiers of basic science, accelerating science & technology, commercializing the achievements, and promoting personnel training, and fruitful interdisciplinary and international collaborations. We are grateful to Dr. Peter Gregory, Dr. Duoduo Liang, Dr. Lu Shi, and the editorial team of *Advanced Materials* for their great support of this special issue. Finally, we would like to sincerely thank all the co-authors and DNL very much for their important contributions to this special issue.

