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UNIVERSIDADE DE MACAU
UNIVERSITY OF MACAU

應用物理及材料工程研究院
INSTITUTO DE FÍSICA APLICADA E ENGENHARIA DE MATERIAIS
INSTITUTE OF APPLIED PHYSICS AND MATERIALS ENGINEERING

IAPME Newsletter

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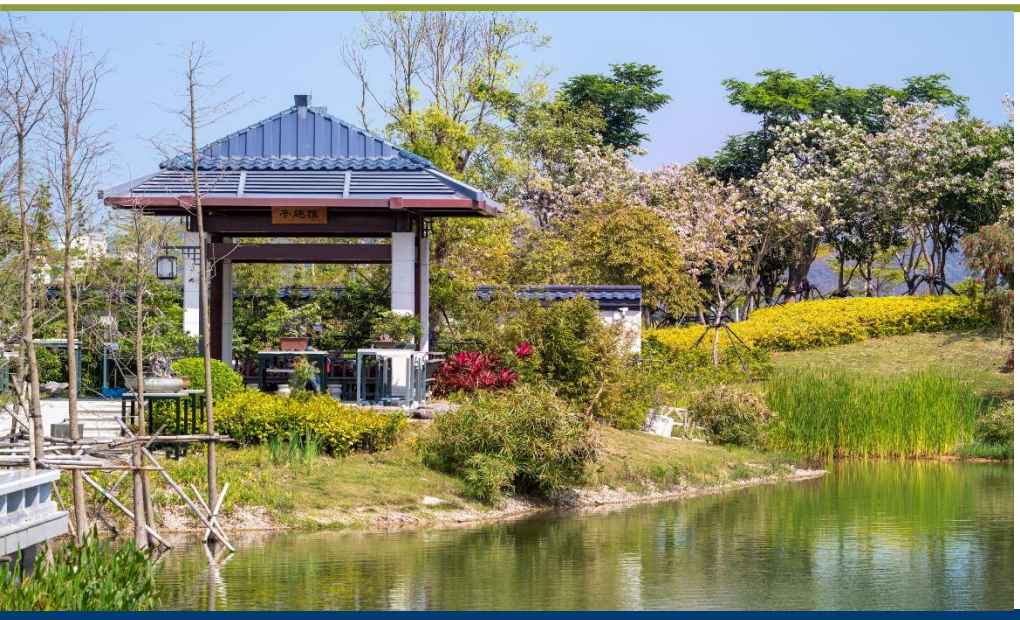

ISSUE 13

18 December 2024

✧ Content

❖ Publications (IF≥8; *corresponding author)

1. **He Feng**, Yangjian Hong, Qinglin Li, **Songnan Qu***. Advancements in research on the carbon dots nanomaterials in immune modulate and immunotherapy. *Chemical Engineering Journal*, 157991 (2024). DOI: 10.1016/j.cej.2024.157991 [2023 IF=13.4]

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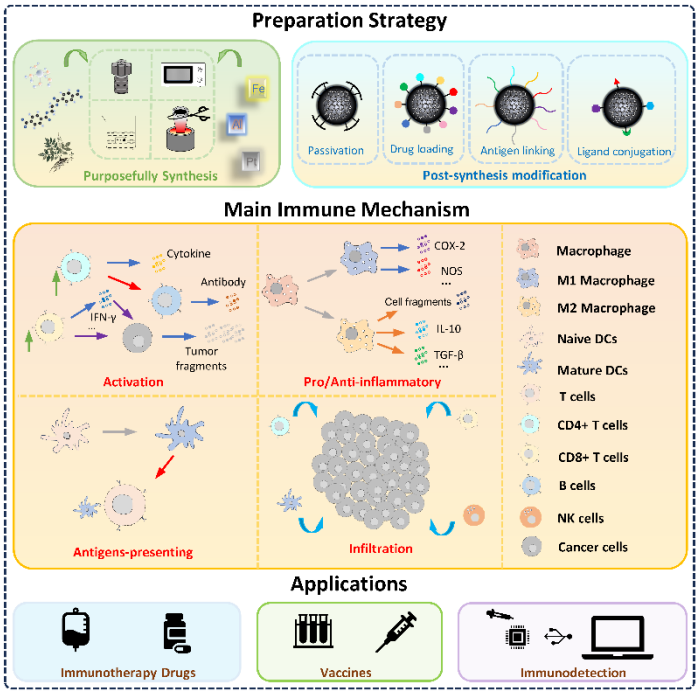
❖ Research Stories

UM research team presented an updated view on the carbon dots nanomaterials with the function of immunomodulatory and immunotherapy

- Discussed the advantages of carbon dots nanomaterials as immunotherapeutic drugs, vaccines and detection materials of immune indicators.
- Put forward the selection principles of raw materials and methods for the synthesis of carbon dots, so that make the nanomaterials can be controlled for immune regulation.

(from left) Dr. He Feng and Prof. Songnan Qu

- Discussed the surface chemical properties of carbon dots, which gives the huge advantages of carbon dots as immunotherapeutic drugs and antigen presentation carriers.
- Put forward the quaternary theory of developing carbon dots drug delivery system for cancer treatment.
- Discussed the limitations of current carbon dots nanomaterials in the treatment of immune-related diseases, and proposed new perspectives on the future development.



He Feng, Yangjian Hong, Qinglin Li, **Songnan Qu***. Advancements in research on the carbon dots nanomaterials in immune modulate and immunotherapy. *Chemical Engineering Journal*, 157991 (2024). DOI: 10.1016/j.cej.2024.157991 [2023 IF=13.4]

Prof. Songnan Qu is the corresponding author of this study. The first author is Mr. He Feng, a Ph.D. student in the IAPME. This project was funded by the Science and Technology Development Fund of Macao SAR (File no: 0139/2022/A3, 0131/2020/A3, 0007/2021/AKP, and 006/2022/ALC), the Shenzhen-Hong Kong-Macao Science and Technology Innovation Project (Category C) (File no: SGDX20210823103803021).

❖ Ph.D. Student Thesis Oral Defenses

Yingzi Gu of Prof. Guoxing Sun's group presented "Thermal insulated and phase change construction materials achieved by foam composites" in her oral defense on December 10, 2024.

Congratulations to Dr. Yingzi Gu!

(from left) Prof. Binmeng Chen, Prof. Yinning Zhou, Prof. Shengyuan Yang, Dr. Yingzi Gu, Prof. Guoxing Sun and Prof. Zeyu Lu (SEU)

❖ IAPME Professors Attended NSFC-FDCT Joint Forum on Advanced Materials 2024

NSFC-FDCT joint forum on Advanced Materials 2024 was organized by NSFC and FDCT, supported by Qinzhou Government, and hosted by Beibu Gulf University in Qinzhou, Guangxi, from November 29 to December 1, 2024. The forum was focused on the collaboration of science and technology, especially the industrialization of technologies, among Mainland, Macao, and Hong Kong. The mission of the forum was to develop innovative materials for the new opportunities in sustainable society. Therefore, the forum had a focused discussion on two main topics, including (1) energy materials and (2) optoelectronics. The energy materials spanned from energy harvesting to storage, such as solar power harvesting, battery, green hydrogen energy, catalysis, green ammonia production and CO_2 reduction. The optoelectronics covered bioimaging, senser, quantum dot, QLED, OLED, and cancer treatment based on quantum technologies. A delegation from UM, including IAPME (Prof. Hui Pan, Prof. Songnan Qu, Prof. Shuangpeng Wang, Prof. Qing Li, and Prof. Haomin Song) and FST-EME (Prof. Junwen Zhong), was invited to join the forum and give invited talks. During the period, they had deep and fruitful discussions and communications with other participants from universities and industries on the opportunities, challenges, and future development in Materials Science and technology, especially the practical needs from industries.

They do believe that the forum provided a good platform to establish closest collaboration between Macao and Mainland, which shall accelerate the development of new materials and industrialization of technologies in materials science for solving the key issues.

Prof. Hui Pan gave a talk entitled “Reconstruction control for enhanced electrocatalytic performance”. First, he briefly introduced the University of Macau, the Institute of Applied Physics and Materials Engineering, and Macao Centre for Research and Development in Advanced Materials. Then, Prof. Pan talked about his research on catalysis for carbon neutrality, focusing on green hydrogen production, green ammonia production and CO_2 reduction. In particular, he talked a general phenomenon that was found in his research, that is, reconstruction of catalyst in electrocatalysis. Prof. Pan emphasized the roles of surface reconstruction and phase transition in chemical reactions with a focus on the electrolysis of water, CO_2 reduction and nitrate reduction and the predictive design of catalysts. For the electrolysis of water, crystalline oxide transferred to a mixture of amorphous phase and crystalline particles in the hydrogen evolution reaction (HER), and metal hydroxides/oxyhydroxides were formed on the surface of catalyst in the oxygen evolution reaction (OER). For the nitrate reduction to ammonia, the surface reconstruction strongly depended on the working condition and pre-catalyst. For the CO_2 reduction, the surface reconstruction was greatly affected by the electrolyte, and may be beneficial or harmful to the reaction. He concluded that the pre-catalysts need to be well designed for achieving the high performance and the theoretical study is necessary to reveal and control the reconstruction process.

Prof. Songnan Qu gave a talk entitled “Spectra regulation and biological applications of Carbon dots”. The luminescent carbon dots (CDs), with their excellent biocompatibility, have shown promising application prospects in fields such as bioimaging, medicine, and lighting. Prof. Qu addressed his group’s recent works on CDs. In the context of biomedical applications of CDs, Prof. Qu’s group developed CDs with effective NIR absorption/NIR emission characteristics, enabling multiphoton fluorescence processes in the red and NIR regions, and significant photothermal/photocatalytic properties. Furthermore, through intravenous injection, his group demonstrated the use of NIR-emissive CDs for in vivo photoacoustic imaging, photothermal/photocatalytic tumor therapy in mice, and the development of a cancer immunotherapy vaccine based on CDs-induced pyroptosis. Prof. Qu also reported his recent work on CDs crosslinked egg white hydrogels and proved that they can promote hair follicle regeneration and accelerate wound healing.

Prof. Shuang-Peng Wang shared his research on quantum dot light-emitting diodes in the presentation entitled “Modulation of Charge Transport Layer Interface for High-Performance QLED”. During his presentation, Prof. Wang addressed several critical issues in QLED technology, including luminescence uniformity, carrier transport efficiency, and stability. He introduced their innovative strategies to enhance QLED performance, focusing on developing new charge functional layer materials. He shared methods for observing interface states in sandwich-structured devices and using atomic layer deposition and hybrid layer techniques to modulate these interface states, which can improve the luminescence efficiency and stability of QLEDs. Additionally, Prof. Wang shared his insights on the aging mechanisms of QLEDs.

Prof. Qing Li gave a talk entitled "Building Reliable Aqueous Zinc Batteries." She first introduced the background and significance of aqueous battery research, further elaborating on the optimal choice of zinc as a balanced aqueous battery material, considering factors such as kinetics, safety, cost, and energy density. She then analyzed the reliability challenges of aqueous batteries, addressing issues related to electrolytes, interfaces, anodes, and cell-level performance. Prof. Li discussed her work in these three areas: at the electrolyte and interface level, she proposed an adhesive hydrogel based on high-concentration electrolytes to address slippage and interface instability, and studied co-solvents and artificial SEI layers to adjust double-layer capacitance and optimize battery performance. In the anode section, she presented research comparing the differences between electrodes used in initial stripping and plating processes, as well as a study on soft short circuits, proposing methods to identify this unhealthy battery state. At the cell level, she emphasized environmental adaptability, including working temperature and calendar aging performance, and proposed modifications to the electrolyte and substrate to address these challenges. Finally, she summarized her research and proposed future directions for improving the reliability of aqueous zinc batteries.

Prof. Haomin Song delivered a talk titled “Plasmonic-based 'Rainbow' Chip for Dual-functional Intelligent Spectrometer”. During his presentation, he highlighted recent advancements in the development of miniaturized, portable, and cost-effective spectrometer systems. These systems leverage deep learning (DL) algorithms to overcome the limitations of simplified optical designs and compact architectures, which often reduce the spectral identification performance compared to benchtop spectrometers. He introduced a novel compact plasmonic "rainbow" chip designed for dual-functional spectroscopic sensing, capable of surpassing traditional portable spectrometer systems under certain conditions. This innovative chip features one-dimensional or two-dimensional graded gratings fabricated on metal films. Using a single image captured by a standard camera and processed through a deep neural network, the system can simultaneously retrieve spectroscopic and polarimetric information with high accuracy. In addition, he demonstrated how the DL-assisted system characterizes optical rotatory dispersion of glucose solutions with multiple narrowband illuminations, all without the need for moving polarizers or complex optical components. This breakthrough significantly reduces system complexity and analysis time while maintaining exceptional performance. He concluded by discussing the potential of this technology for integration with smartphones and lab-on-a-chip systems, paving the way for new in situ analysis applications.

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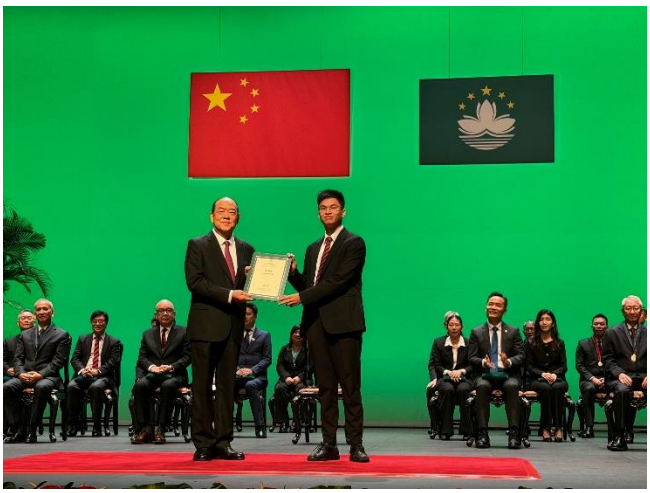
❖ IAPME Professor Offered Research Mentorship to Talented High School Students

IAPME has always been committed to providing general education and offering research mentorship to talented high school students in the Macao community. Leong Pok Hei has been actively involved in research under the guidance of Prof. Kwun Nam Hui from the Institute of Applied Physics and Material Engineering since 2022. With Prof. Hui's mentorship, Leong has conducted research for developing new materials fast-charging batteries.

After three years of diligent study and hard work, Leong successfully completed his latest research project titled "Phosphorus-based Composite Anode Promoting Fast-Charging Performance in Li-ion Batteries." Representing Macao, Leong achieved a Fourth Place Award in the 2024 Regeneron International Science and Engineering Fair, which took place in Los Angeles from May 11 to May 17, 2024. This project brought pride and recognition to Macao. In recognition of his achievement, Leong was awarded a certificate of merit by the Macao Special Administrative Region Government on November 29, 2024, acknowledging his significant contribution to Macao's reputation.



❖ Seminars

Prof Qinghai Tan, Professor in School of Microelectronics at University of Science and Technology of China, delivered an engaging talk on the "Giant Optical Nonlinearity of Interlayer Excitons inWSe_2/MoS_2, Moiré Superlattices" on 3 December 2024. Prof. Tan shared his extensive research on the Exciton Physics and Regulation in Semiconductor Moiré Superlattice Devices.

In recent years, Prof. Tan has published over 30 papers in prestigious international journals such as Nature Materials, Nature Photonics, Nature Electronics, Nature Communications, Science Advances, Physical Review Letters, Nano Letters, and ACS Nano. He has also contributed to the authorship of an English monograph. His research achievements have been featured in Nature Materials, as well as highlighted by Nanyang Technological University, Singapore, and other journals and media outlets. Additionally, Prof. Tan serves as a reviewer for esteemed international journals including Nature Materials, Nature Physics, Nano Letters, and ACS Nano.

Prof. Tan first introduced moiré superlattices and their various novel physical phenomena and applications, such as superconductivity, the quantum anomalous Hall effect, and the fractional quantum anomalous Hall effect. He shared insights into cascade transitions and population inversion in moiré superlattices, as well as enhanced coherence within these structures. Lastly, he shared his experiences in developing new techniques and discovering new phenomena in scientific research.