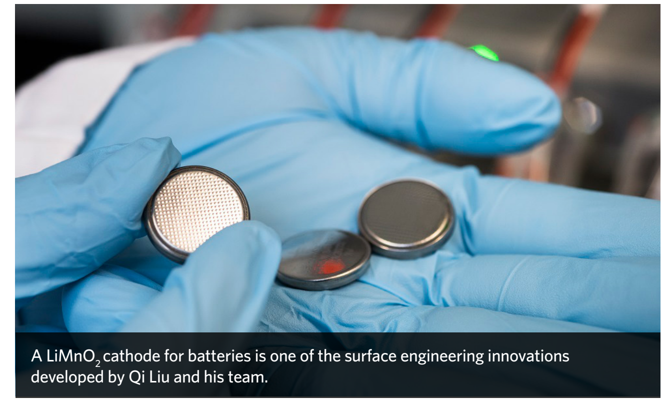
ADVERTISEMENT FEATURE

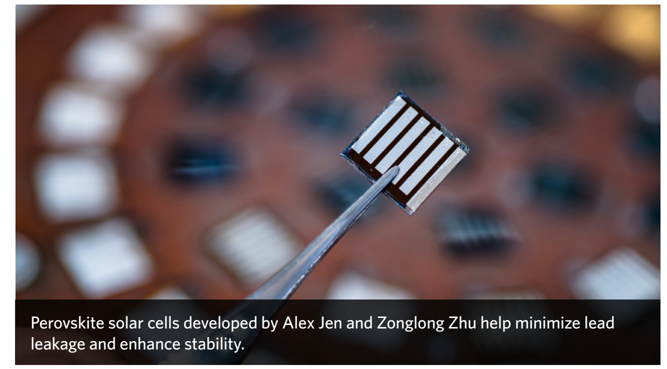
Accelerating clean energy innovations

City University of Hong Kong is driving new research ideas and collaborations for CLEAN ENERGY-RELATED TECHNOLOGIES AND POLICIES.

The i^2Cool team applies their cooling paint to the roof of a refurbished historic building in Hong Kong.



A $LiMnO_2$ cathode for batteries is one of the surface engineering innovations developed by Qi Liu and his team.



Perovskite solar cells developed by Alex Jen and Zonglong Zhu help minimize lead leakage and enhance stability.

Critical global challenges related to carbon neutrality have spurred the formation of a growing research hub at City University of Hong Kong (CityU) in pursuit of new solutions for clean energy. Working across academic departments in cross-disciplinary collaborations, such as the School of Energy and Environment, the College of Science, and the College of Engineering, scientists and students at CityU are set to influence the development of sustainable energy.

Their research is contributing to the global goal of net-zero carbon emissions and turning clean energy research into viable technologies and policies — one of the founding goals for the Hong Kong Institute for Clean Energy (HKICE) in 2021.

"HKICE is part of the university's plan to promote the development of cutting-edge clean energy technologies," said Way Kuo, president and university distinguished professor at CityU. "The HKICE will draw together a rich variety of experts to collaborate closely with universities, research organizations, government agencies and industries, both locally and globally."

GREEN FUEL AND PHOTOCATALYSTS

HKICE's founding director, Alex Jen, a materials scientist, explains that HKICE aims to promote new research projects on clean energy in six key areas: generation, storage, saving, distribution, smart city, as well as energy analysis and policy. According to their work published in *Nature Nanotechnology* in 2020, Jen and his solar energy team have been working on printable solar cells (PSCs), seeking better efficiencies, superior stability and safety of perovskite solar cells with minimal lead leakage. In their work published in *Nature Nanotechnology* in 2021, they have also conducted extensive photophysical studies on multi-component organic solar cells to reveal the fundamental mechanism behind their high efficiencies.

Green hydrogen generation from solar power is the goal for another CityU energy scientist, Yun-hau Ng. In an article published in 2021 in *ACS Energy Letters*, Ng's team observed quantum confinement effect in a 3D-ordered macroporous photocatalyst. Quantum confinement effects are changes in electronic and optical properties such as energy levels and band gaps when the size of the material is reduced to the nanoscale. The effect enables hydrogen production under visible light.

Michael Leung and Jin Shang, CityU scientists, have developed a photocatalyst that can produce ammonia, a carbon-free fuel that can be used to generate electricity, from atmospheric nitrogen at room temperature using sunlight. This sustainable way of producing ammonia was published in *ACS Nano* in 2021, featuring a newly developed porous biomimetic photocatalyst. Upon activation by sunlight, the photocatalyst induces artificial nitrogen fixation to achieve renewable ammonia production at a high yield rate.

Another research team co-led by Qi Liu, a physicist at CityU, addresses the demand for lithium-ion batteries. That demand has increased dramatically in recent years because of the growing market for electric cars and because the main cathode materials for the batteries, cobalt and nickel, are not abundant. Liu's team has developed a much more stable manganese-based cathode material for lithium rechargeable batteries. Liu says the new material is more durable than traditional cathodes, and 90% of capacity is retained even when the number of charging-recharging cycles doubles.

"Our findings shed light on the development of high-energy and low-cost manganese-based lithium-ion batteries, holding great promise for electric vehicles and large-scale energy storage systems," he says. "Successful implementation of manganese-based lithium-ion batteries would make the cost-to-mileage ratio of electric vehicles competitive to that of petrol-fuelled cars."

ELECTROCHEMICAL CARBON DIOXIDE REDUCTION

CityU scientists also publish studies related to the electrochemical carbon dioxide reduction reaction (CO_2RR), a method for converting the greenhouse gas carbon dioxide into chemicals used in industry.

The synergistic effect between two crystal phases of inorganic nanomaterials could significantly improve their optical, electronic and catalytic properties, but the challenge to synthesize well-defined heterophase noble metal nanomaterials remains. Chair professor of Nanomaterials at CityU, Hua Zhang, and chemistry assistant professor, Zhanxi Fan, contributed to a *Nature Communications* paper in 2020, reporting the controlled synthesis of well-defined heterophase of gold nanorods as catalysts in the CO_2RR process, which exhibit higher electrocatalytic activity and selectivity for carbon monoxide production.

"This project demonstrates that the heterophase of our nanorods has great potential for downstream applications such as Fischer–Tropsch synthesis, a collection of chemical reactions that converts a mixture of carbon monoxide and hydrogen or water gas into liquid hydrocarbons," says Zhang.

Chemist, Ruquan Ye, and his team worked on the interface design and kinetics for developing effective CO_2RR electrocatalysts. They came up with strategies to make effective interfaces for CO_2RR, such as the covalent grafting method, to directly link metal centres on to the carbon nanotube. Their study, published in *Angewandte Chemie* in 2019, suggests that this structure favours electron transfer and can reach both high current densities and turnover frequencies for molecular catalysts.

ACCELERATING TECHNOLOGY TRANSFER

CityU positions itself as a world-class university that supports education and applicable research suitable for translating practical technologies for society, according to Kuo. For example, the university-funded, large-scale entrepreneurship programme HK Tech 300 will accelerate translational research findings into practical applications.

One success so far is a new environmentally friendly passive radiative cooling paint developed and patented by the i^2Cool team, one of the HK Tech 300 start-up teams established by CityU PhD students and research staff. The dissipating heat properties of the paint were inspired by the structure of hair on a species of desert ant. These qualities allow for solar reflection and thermal emission, enabling cooling without electricity and ozone-depleting refrigerants.

The team tested the cooling effect of the paint on the rooftop of a building in Hong Kong and found that it lowered the indoor temperature by 5 to 6°C, reducing the use of electricity for air conditioners by 8 to 10%. i^2Cool launched its patented paint in Hong Kong in late 2021 and will soon launch the product across China.

Collaborations among CityU scientists will nurture more innovators and leaders in clean energy. "We are working with industry, governments and NGOs to establish viable energy strategies and policies for the world to achieve the carbon neutral goal," says Kuo. ■

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