Charging forward with a green power play

A new academic hub in Shenzhen is improving material design for **RECHARGEABLE BATTERIES** to meet sustainable development needs.

As an energy storage system, rechargeable batteries have many applications from electric vehicles to wearable devices. However, significant questions remain around material properties, energy storage mechanisms, and safety. Addressing these key challenges, a team at Tsinghua Shenzhen International Graduate School (Tsinghua SIGS), launched in early 2019, is improving the design and material structures to produce safe secondary cells.

For their low cost, safety, and eco-friendliness, zinc-ion batteries are a popular alternative to lithium-ion batteries, and have been a focus of study for Feiyu Kang, associate dean of Tsinghua SIGS, who leads an interdisciplinary programme on energy and materials. The programme uses materials science discoveries to address national strategic and energy needs.

Kang's team invented the aqueous zinc-ion battery, comprising a manganese dioxide-based cathode, a zinc anode, and an aqueous electrolyte containing zinc ions. Kang revealed a key electrochemical process in which zinc can rapidly dissolve into Zn^{2+} ions that can be inserted into manganese dioxide tunnels during discharging. When charging, the process can be reversed. The resulting system has high capacity, and fast charge/discharge capability. This breakthrough opened a new research direction of aqueous zin-ion batteries.

Another pioneering study by Kang's team explores lithium titanate (LTO) batteries, which, with LTO as the anode material, allows high recharge efficiency. However, gas generation during operation presents a challenge to wider adoption.

By investigating the LTO/electrolyte interface, Kang's team found that the gas arose from the intrinsic interfacial catalytic reaction. Based on this, they proposed a solution combining carbon coating as a modification layer, and a high-density, solid electrolyte interface film to suppress the interfacial reaction. Their work on high-safety secondary batteries was published in leading journals, awarded multiple patents, and the first prize of the Natural Science Award of Guangdong Province.

Kang's team has also made progresses that provide an effective approach towards designing electrode/electrolyte interface with high stability and low impedance, leading to better performance batteries.

Kang's colleague at Tsinghua SIGS, Bilu Liu, led a group focusing on low-dimensional materials to develop functional systems for use in energy and beyond. Recently, they developed a two-dimensional material catalyst for efficient electrochemical hydrogen production. Their stable catalyst is highly active for hydrogen evolution reaction, a key step in electrochemical water splitting to produce hydrogen, and works well at high current densities. This catalyst is based on a concentrate of molybdenite, a low-cost, abundant mineral, and the team has devised a method for large-scale production of two-dimensional materials, paving the way for its commercial application.

Kang is also keen to see broader application of his research on safe secondary batteries in new energy storage devices and electric vehicles. His goals are in line with the energy and materials programme ambition to make breakthroughs in material applications, and promote technological innovations in structure-function integration, intelligence and flexibility, and to develop plans for green manufacturing of advanced materials.

"We aim to become a world-class programme by building a global research centre in advanced functional materials, and establishing a base that cultivates leading scientists and industrial talents with an interdisciplinary vision," said Kang.

This is in line with Tsinghua SIGS's mission of reshaping R&D and graduate education to promote local, national, and global sustainable development. ■

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Interdisciplinary work in Tsinghua SIGS's cutting-edge laboratories

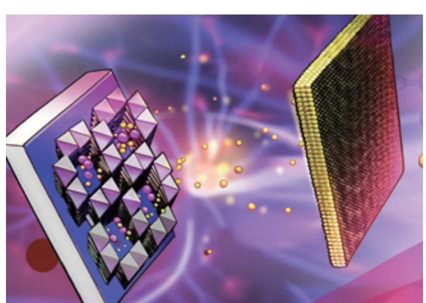
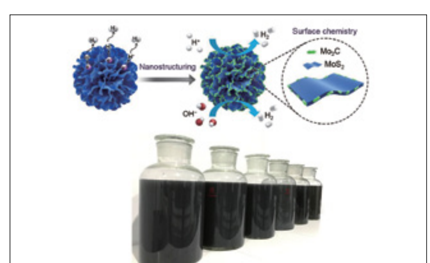


Illustration of the safe and efficient discharge processes for aqueous zinc ion batteries



Cheap two-dimensional mineral-based catalysts enable efficient electrochemical hydrogen production. (*Nature Communications* 2019, 10, 269)