CASE STUDY

Revolutionizing Li–S Battery for Energy Storage with Metal–Organic Framework Materials

The Challenge

The lithium–sulfur (Li–S) battery is regarded as a next-generation energy storage technology because it is lighter, cheaper, more environmentally friendly, and can store more energy than today's lithium-ion batteries. However, several challenges hinder its widespread adoption: (1). The **polysulfide shuttle effect**, where sulfur compounds dissolve and migrate between the electrodes, causing loss of active material and capacity. (2). A short cycle life, as the battery's capacity gradually fades after repeated charging and discharging. (3). **Dendrite penetration**, in which needle-like lithium structures grow and can pierce the separator, leading to short circuits and safety risks.

The Solution

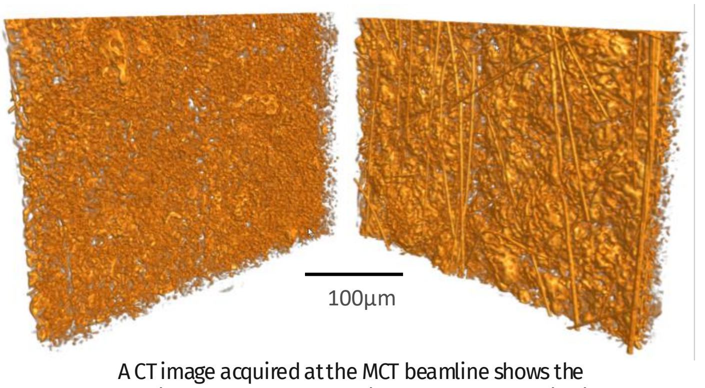
To address these challenges, many efforts have been directed in developing porous composite cathode materials such as metal–organic frameworks (MOFs) that can stabilize polysulfides. Moreover, combining MOFs with graphene—where the porous crystalline MOF nanoparticles act as building blocks and the flexible, conductive graphene provides mechanical support—offers a promising strategy for developing high-performance ionic separators. MOF-based materials possess a large surface area and highly ordered, tunable porosity, making them excellent candidates for ionic sieves that can suppress the shuttling of polysulfide ions.

Researchers from the **University of Sydney** have demonstrated excellent electrochemical performance in Li–S batteries by synthesizing a graphene/MOF-modified separator using a simple filtration process.

At the **Micro-Computed Tomography (MCT) Beamline** at the Australian Synchrotron, high-resolution 3D imaging provides a powerful, non-destructive method for analyzing separator structures. The high-flux synchrotron X-ray beam enables rapid scanning within minutes, minimizing the risk of movement artefacts and preserving structural integrity.

The Impact

Ongoing research using MOFs to improve the lifetime, stability, and performance of Li–S batteries represents an exciting step toward the future of sustainable energy storage. Li–S batteries offer higher energy density than conventional lithium-ion systems, while advanced MOF based separators enhance safety and stability. Optimizing separator design and materials is crucial for meeting future energy storage demands, especially for large-scale stationary storage and battery electric vehicles.



A CT image acquired at the MCT beamline shows the detailed structure on both side of the separator in Li-S battery.

Reference(s):

1. Yao, H. B. et al. *Improving lithium–sulphur batteries through spatial control of sulphur species deposition on a hybrid electrode surface*. Nature Commun. 5, 3943 (2014).

Research Priority

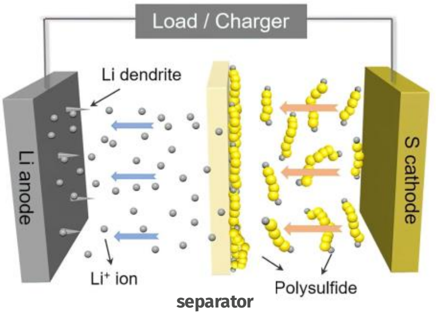
Molecular separation and storage

ANSTO capability/instrument

Micro Computed Tomography (MCT) Beamline
ANSTO Australian Synchrotron

Collaborators/Client

The University of Sydney
Dr. Zhi Zheng
Dr. Yuan Chen



ANSTO contributors

Dr. Benedicta Arhatari
Dr. Andrew Stevenson

UN Sustainable Development Goals

7 AFFORDABLE AND CLEAN ENERGY

Contact

Dr. Benedicta Arhatari
EMAIL
arhatarb@ansto.gov.au