Tellurium electrodes boost lithium batteries

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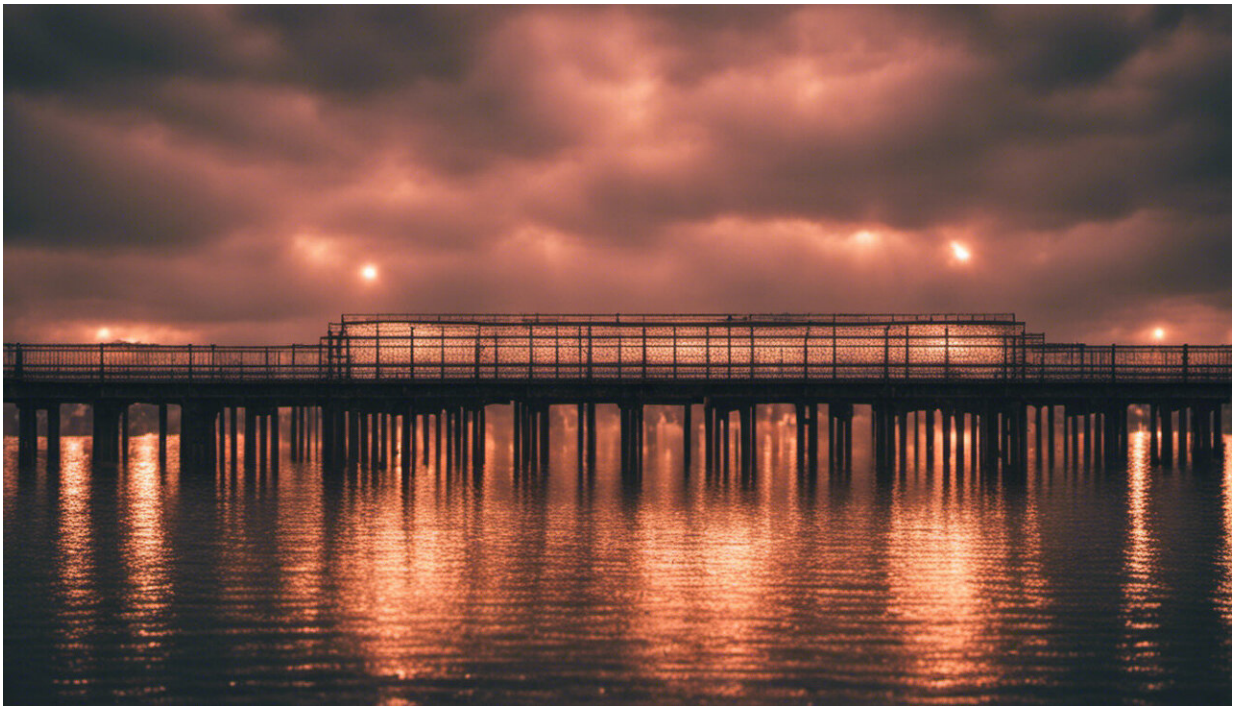

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A*STAR researchers have demonstrated that electrodes made from tellurium can improve the energy storage and power output of rechargeable lithium-ion batteries.

Cathodes in conventional lithium-ion batteries typically contain iron, cobalt and manganese oxides and have a relatively limited energy density. In principle, cathodes in which lithium ions react with oxygen,

sulfur or selenium could offer much higher capacities. In practice, however, these elements are not suitable electrode materials, as oxygen-based cathodes are inefficient, and sulfur and selenium electrodes are poor electrical conductors.

Zhaolin Liu and Yun Zong of the A*STAR Institute of Materials Research and Engineering decided to investigate tellurium—a metalloid element with similar chemistry to sulfur and selenium—as an electrode material. They discovered it was a much better conductor than sulfur and selenium and offered energy densities that were almost as large.

Liu conceded that tellurium is as rare as platinum and not cheap. "Such a battery is definitely not suitable for use in mobile phones or electric vehicles, but it may target high-end applications with special requirements, such as the power source for implantable cardiac pacemakers."

The researchers heated tellurium to 500 degrees Celsius until it melted into a porous carbon electrode, and then tested its performance as a cathode in four different liquid electrolytes. A common solvent called dimethyl sulfoxide gave the best results. They found that when lithium reacts with tellurium as the battery discharges, it forms a compound that is soluble in dimethyl sulfoxide. In contrast, lithium forms insoluble compounds when it reacts with sulfur and selenium, which causes the cathode to expand and damages its structure.

Although their lithium-tellurium battery initially showed a lower capacity than its sulfur and selenium analogs, it charged and discharged more quickly. It also maintained its capacity for much longer, exceeding its rivals' capacity after 50 charging cycles.

The team then developed a cathode made entirely from tellurium nanowires just seven nanometers wide, which they laid together to form

a mat. This formed a flexible tellurium cathode with an energy density of 1800 milliwatt hours per cubic centimeter which allowed it to store 50 per cent more energy than a conventional lithium cobalt oxide electrode of the same size. It also retained more than 98 per cent of its capacity after 80 charging cycles.

"For our next step, we plan to partially substitute tellurium with low-cost sulfur to develop a hybrid system with higher capacity," says Liu.

More information: "Tellurium@ordered macroporous carbon composite and free-standing tellurium nanowire mat as cathode materials for rechargeable lithium–tellurium batteries." *Advanced Energy Materials* 5, 1401999 (2015). dx.doi.org/10.1002/aenm.201401999

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