CaO makes the graphene hierarchy for high-power lithium-sulfur batteries

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Porous Graphene Casted on CaO template

Structural hierarchy is the cornerstone of the biological world, as well as the most important lesson that we have learned from nature to develop ingenious hierarchical porous materials for various applications in energy conversion and storage. Recently, a research group from China, led by Prof. Qiang Zhang in Tsinghua University, has developed a novel kind of hierarchical porous graphene (HPG) via a versatile chemical vapor deposition (CVD) on CaO templates for high-power lithium-sulfur (Li-S) batteries. This work is published in the journal *Advanced Functional Materials*.

"Due to the urgent demand for sustainable energy systems and portable energy storage devices, the Li-S battery has been cited as the most promising alternative for next-generation energy storage devices, due to its high theoretical energy density of 2600 Wh kg-1, low cost, and eco-friendliness," said Prof. Zhang. "Despite these advantages, the practical application still suffers from a formidable challenge due to the intrinsic insulation of sulfur and lithium sulfides, the dissolution of polysulfides with a shuttle effect, and the huge volume change of cathode materials during operation."

Researchers have been seeking to develop hierarchical nanocarbon materials with tunable structural hierarchies and surface features for use as Li-S cathode scaffolds to address these issues effectively. Hierarchical porous materials exhibit porosities on more than one length scale with different properties and roles, respectively. It is important for the improvement in Li-S battery performances.

"However, strategies with a multistep process or/and multiscale templates are dominantly employed to obtain hierarchical porosities. It is always complicated and unfavorable to the structure regulations," says Cheng Tang, a graduate student and the first author.

For the first time, Cheng proposed the hierarchical porous CaO particles as effective catalytic templates for the facile CVD growth of graphene. CaO is a very common and promising material with a low cost, easy purification, and promising cyclic utilization. Additionally, various hierarchical structures can be readily obtained for CaO, making it a versatile strategy to fabricate HPG materials with tunable structural hierarchy.

Based on this concept, they obtained a hierarchical porous structure of graphene with abundant microsized inplane vacancies, mesosized wrinkled pores, and macrosized strutted cavities. It can serve as a

favorable scaffold for cathodes of Li-S batteries with enhanced utilization of sulfur, high discharge capacity and efficiency, superior stability, and excellent rate capability. The small mesopores facilitate the entrapment of sulfur and polysulfides; the micropores and defective graphene layers with a high SSA accommodate a high sulfur loading with intimate affinity; the interconnected large mesopores and macropores shorten the transport distance of ion and electrolyte.

"We hope that the novel fabrication strategy of hierarchical porous graphene materials can improve the properties of cathode scaffolds for the practical application of Li-S batteries." said Qiang. Further improvements are expected with more meticulous design of the hierarchical structure and additional surface modification. The idea presented here opens up new perspectives to develop nanoarchitectured graphene with metal oxide catalysts, which is fresh but versatile towards tunable structures, variable properties, and promising applications.

More information: 10.1002/adfm.201503726 Cheng Tang et al. CaO-Templated Growth of Hierarchical Porous Graphene for High-Power Lithium-Sulfur Battery Applications, *Advanced Functional Materials* (2016). DOI: 10.1002/adfm.201503726

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