N-doped carbon encapsulated transition metal catalysts to optimize performance of zinc-air batteries

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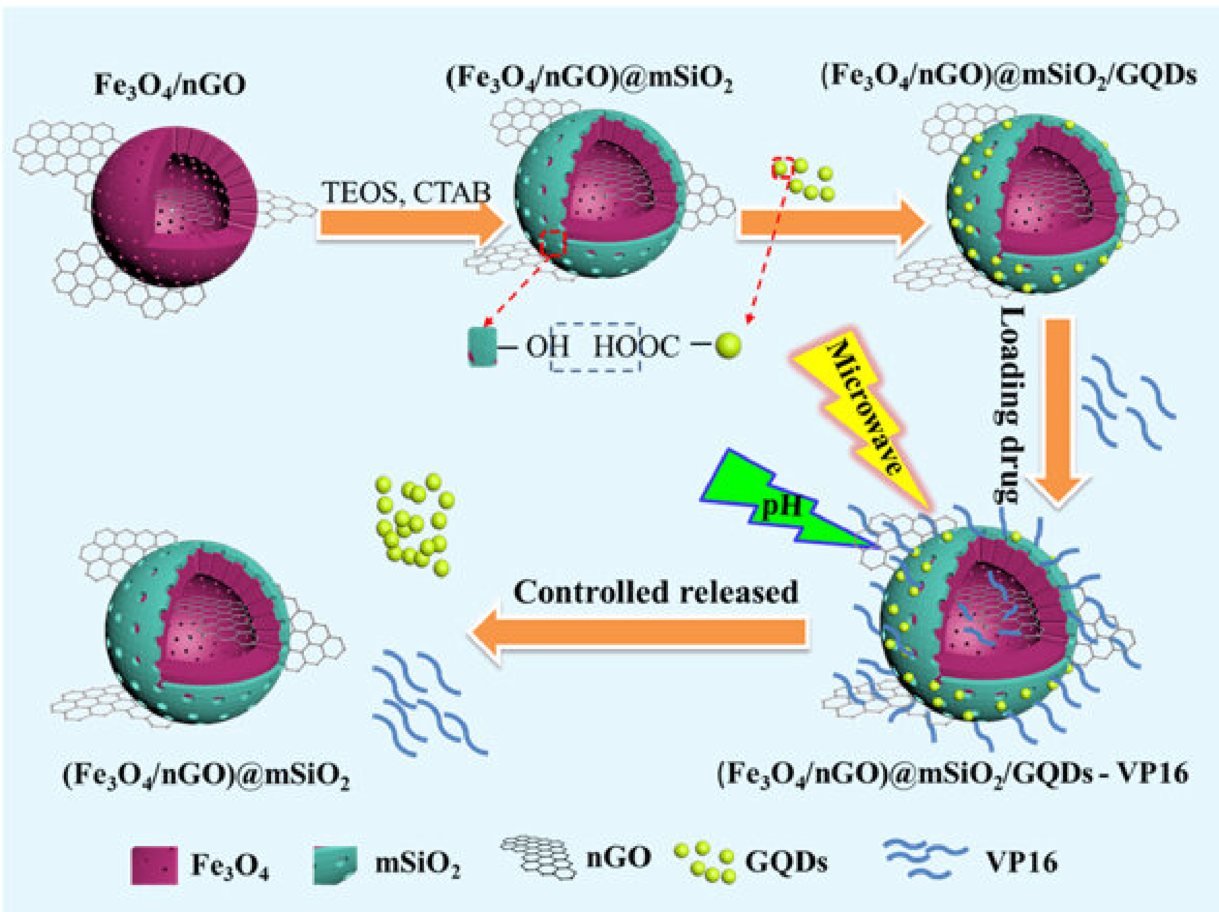

Fe@NCG was be prepared by pyrolyzing solvent-free formed Fechitosan chelates and additional small molecule nitrogen source urea. The formed catalyst exhibits bifunctional catalytic performance toward ORR and OER in alkaline medium and higher power density and superior charge-discharge durability in zinc-air battery. Credit: World Scientific Publishing

In a report published in *Nano*, a team of researchers from Sichuan University of Science and Engineering, China have developed N-doped carbon encapsulated transition metal catalysts for oxygen reduction reactions (ORR) and oxygen evolution reactions (OER) to optimize performance of zinc-air batteries.

A three-dimensional porous graphene-like carbon layer encapsulated Fe/Fe_3C (Fe@NCG) was prepared by pyrolysis of the mixture of Fe-chitosan chelate assembled without solvent and urea with small molecular nitrogen source. The space limiting effect of the chelate suppressed the agglomeration of Fe^{3+} ions, and the small molecular nitrogen source promoted the regulation of N configuration. The zinc-air battery assembled with Fe@NCG catalyst shows good performance.

The catalyst Fe@NCG shows remarkable ORR/OER bifunctional catalytic activity with a half wave potential of 0.86 V for ORR and a moderate potential difference of 0.85 V in alkaline medium. "The zinc-air battery assembled with Fe@NCG as positive and negative catalyst showed good discharge platform, high peak power density, high energy density, and high cycle stability." says Lei Ying, Ph.D., the corresponding author of the paper.

What is special about the study is that the Fe@NCG was prepared by pyrolyzing solvent-free formed fechitosan chelates and additional small molecule nitrogen source urea. The in-situ nitrogen doping and etching of self-nitrogen-doped carbonized chitosan by CN gas produced by g-C_3N_4 decomposition (such as $C_2N_2^+$, $C_3N_2^+$, $C_3N_3^+$) is helpful to the regulation of electronic structure and the formation of pore structure in the carbon skeleton.

Moreover, the uniform distribution of Fe could be attributed to the molecular-level chelating space confinement effect of Fe-chitosan chelate compound precursor, wherein chitosan molecular served as a 'fence' to effectively reduce excess aggregation of Fe^{3+} ions. The group then tested the product electrocatalytic performance.

The work of this team of researchers from Sichuan University of Science & Engineering has led to the exciting development of electrocatalytic materials. This work suggests that a simple and universal strategy can also be extended to the synthesis of other transition metal electrocatalysts coated with carbon.

One of the most fascinating frontiers in this research field might be combining chelating space confinement strategy and regulation of N configuration. Understanding these processes will improve the performance of materials and equipment, which will improve the lives of all of us. More recently, the group has been working on multifunctional conversions of electrocatalytic materials and assembly of devices.

More information: Renxing Huang et al, Solvent-Free Assembled Fe-Chitosan Chelates Derived N-Doped Carbon Layer-Encapsulated Fe/Fe3C for ORR and OER, *Nano* (2020). DOI: 10.1142/S1793292020500708

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