Graphene-based nanoporous carbons for energy applications

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So far various types of unique carbon materials have been synthesized using the template carbonization method. Here we introduce the unique structures of the two types of porous carbons and demonstrate how such unique structures are useful for energy applications.

Zeolite-templated carbon (ZTC) consists of a buckybowl-like nanographene assembled into a three-dimensional regular network. Both sides of the buckybowl-like unit are fully exposed, and, in addition, the narrow nanographene-based framework has a significant number of edge sites. Consequently, ZTC has a very large specific surface area close to 4000 m^2/g. Due to such a large surface area, ZTC shows as large a H_2 storage capacity as 2.2 wt% under 34 MPa at room temperature[1]. Moreover, with the loading of Pt subnanoclusters[2], ZTC exhibits a higher storage capacity than the pristine ZTC due to the hydrogen spillover effect. The performance of ZTC as an electrochemical capacitor was excellent both in organic[3] and aqueous[4] electrolyte solutions.

Graphene mesosponge (GMS) is prepared using alumina nanoparticles as a template[5]. It has a sponge-like mesoporous framework (mean pore size is 5.8 nm) consisting mostly of single-layer graphene walls, which realizes a high electric conductivity and a large surface area (1940 m^2/g). Moreover, the graphene-based framework contains a very small amount of edge sites, thereby achieving much higher stability against oxidation than conventional porous carbons. Thus, GMS can simultaneously possess seemingly incompatible properties; the advantages of graphitized carbon materials (high conductivity and high oxidation resistance) and porous carbons (large surface area). These unique features allow GMS to exhibit a sufficient capacitance (125 F/g), wide potential window (4 V), and good rate capability as an electrode material for electric double-layer capacitors utilizing an organic electrolyte.

References

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