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Characterization of Porous Materials:
From Ångströms to Millimeters
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Unique characterization data of graphene mesosponge

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Graphene MesoSponge® (GMS) is a new type of graphene-based mesoporous material synthesized via template-directed chemical vapor deposition, followed by template removal and high-temperature annealing at 1800 ℃1,2. GMS consists mainly of single-layer graphene walls with minimal number of edge sites and enriched topological defects (non-hexagonal carbon rings)3. From its unique structure, the characterization data of GMS are distinct from other porous carbon materials, and it makes us aware of the insight into the interpretation of common characterization techniques used for carbon materials. In this talk, the unique properties of GMS are discussed with its extraordinary characterization data.

X-ray diffraction (XRD) of GMS shows a weak carbon 002 and an intense 10 peaks, indicating not significantly stacked structures and developed graphene domain. Raman spectrum of GMS shows very intense D-band, while exhibiting intense G- and 2D-bands, which are the characteristics of single-graphene structures. Such XRD and Raman data indicate its "non-graphitic"structure, wherease GMS exhibits extraordinaly oxidation resistance even better than single-walled carbon nanotubes (SWCNT)4. Moreover, the electric conductivity of GMS is higher than activated carbons and most of carbon blacks1. Thus, the "low crystallinity"of carbon does not directly related to its chemical stability and conductivity, and XRD and Raman spectroscopy cannot properly evaluate these performances of carbon materials. Is there any good method? Yes, our answer is high-sensitivity temperature-programmed desorption (TPD) up to 1800 ℃, which can determine the number of edge sites at a ppm-level in any sp2-based carbon materials. We found that the number of edge sites is directly related to oxidation resistance1 as well as electrochemical stability5,6. Once the number of edge sites is obtained, it is possible to calculate average graphene domain size which is directly related to conductivity of carbon materials.

GMS shows unique elasticity due to its single-graphene walls7, inducing a significant degree of adsorption-induced expansion8. We have developed home-made device which can evaluate adsorption/desorption induced by the application of mechanical force onto mechanically soft nanoporous materials7.

Reference

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