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Mesoporous Graphene-Based Bulk Materials with Hierarchical Morphologies for Energy Applications

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Mesoporous graphene-based bulk materials with tunable three-dimensional morphologies can be fabricated by sol-gel techniques, either by self-assembly of individual graphene building blocks or by converting sol-gel derived polymer foams into networks of sp^2-hybridized carbon atoms. These materials have a unique combination of properties including high surface area, electrical conductivity, chemical inertness, and environmental compatibility, and thus have received considerable attention for energy related applications such as supercapacitors, rechargeable batteries, capacitive deionization, and catalysis. Polymer derived graphitic carbon aerogels were first developed at Lawrence Livermore National Laboratory (LLNL) in the late 1980s. Since then we have developed synthetic methods to control material morphology and pioneered efforts to functionalize the materials by incorporating inorganic components, with an eye towards real-world applications. More recently we focused on interfacial phenomena such as a charge induced macroscopic strain effect that may enable carbon based actuation. This contribution will highlight recent advances in graphene aerogel research at LLNL ranging from the development of graphene oxide-based aerogels and graphene/metal oxide hybrids to electronic structure engineering by doping, and will discuss the related improvements in electrical, electrochemical, and mechanical properties.

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