Three Dimensional Graphene-based Assemblies

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Graphene has shown the potential to significantly impact a number of different technologies, including energy storage. Properties such as high surface areas and electrical conductivity make it a promising material for hydrogen storage, battery, and ultra capacitor applications. One route to realizing the full potential of graphene in energy storage applications is the assembly of three-dimensional macroscopic graphene networks that retain the properties of individual graphene sheets. Herein we report the assembly of graphene sheets into a hierarchical architecture with length scales extending from the nanoscale to the macroscopic regime. These graphene macroassemblies are formed via cross-linking reactions between single- and/or few-layer graphene oxide (GO) sheets in suspension. The hierarchical structure possesses a number of novel properties including mechanical stiffness (up to 10 GPa) and electrical conductivities (up to 10^5 S/m) orders of magnitude higher than previously reported, surface areas that approach the theoretical values expected for a single graphene sheet (~2500 m^2 /g), and extraordinarily large mesopore volumes (up to 5 cm^3/g). Energy storage behavior for capacitor and Li-ion battery applications were evaluated. The graphene-based electrode simultaneously exhibited high energy (~10^2 Wh/kg) and power densities (~10^2 kW/kg) in aqueous electrolytes (symmetric cell), while metal oxide-coated graphene cathodes exhibited large Li-ion capacities (~1000mAh/g). The details of the synthesis and characterization of these novel graphene assemblies will be presented.