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Self-Assembled Formation of Conjugated 3D Reduced Graphene Oxide-Wrapped Helical CNTs Nanostructure and Nitrogen-Doped Using Photochemical Doping for High-Performance Supercapacitor Electrodes

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Abstract: Interconnected three-dimension (3D) networks of novel helical carbon nanotubes (HCNTs) wrapped with reduced graphene oxide nanosheets (HCNTs/rGO) are successfully fabricated via a facile solution of self-assembly method, as well as a robust process for the simultaneous reduction and high N-doping of HCNTs/rGO composites (N-HCNTs/rGO) by photoreduction under NH_3 atmosphere. The as-prepared N-HCNTs/rGO are directly employed as binder-free supercapacitor electrodes, and exhibit a highly conductive 3D-interconnected structure (5.85 S cm^{-1}), large surface area (528.9 m^2 g^{-1}), low internal resistance (0.5 Ω), and good wettability. As a result, N-HCNTs/rGO show high specific capacitance (368 F g^{-1}), high energy density (12.8 Wh kg^{-1}), and cycling stability (90.7% retention at 1 A g^{-1} for 5000 cycles) in two-electrode systems. Moreover, the 3D N-HCNTs/rGO hybrid networks exhibit enhanced electrochemical performance in supercapacitors, which combine the synergistic effects of the two carbon nanostructures, enhanced wettability, low internal resistance, and improved ion-diffusion ability, together with the large surface areas of 3D hybrid networks and high-level N-doping. The as-synthesized composite is a potential candidate for flexible and binder-free electrodes for high-performance supercapacitors.

Keywords: Helical carbon nanotubes, Graphene oxide, Photochemical reduced, Nitrogen-doped, Supercapacitors