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Electrostatic Assembly of Nanomaterials for Hybrid Electrodes and Supercapacitors

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Electrostatic assembly methods have been used to generate a range of new materials systems of interest for electrochemical energy and storage applications. Over the past several years, it has been demonstrated that carbon nanotubes, metals, metal oxides, polymeric nanomaterials, and biotemplated materials systems can be incorporated into ultrathin films to generate supercapacitors and battery electrodes that illustrate significant energy density and power. The unique ability to control the incorporation of such a broad range of materials at the nanometer length scale allows tailoring of the final properties of these unique composite systems, as well as the capability of creating complex micron-scale to nanoporous morphologies based on the scale of the nanomaterial that is absorbed within the structure, or the conditions of self-assembly. Recently we have expanded these capabilities to achieve new electrodes that are templated atop electrospun polmer fiber scaffolds, in which the polymer can be selectively removed to achieve highly porous materials. Spray-layer-by-layer and filtration methods of functionalized multiwall carbon nanotubes and polyaniline nanofibers enable the generation of electrode systems with unusually high surface. Incorporation of psuedocapacitive nanoparticles can enhance capacitive properties, and other catalytic or metallic nanoparticles can be implemented to enhance electrochemical or catalytic function.