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Design and fabrication of graphene composites for energy storage and sensors

Graphene, a novel carbon nanomaterial, has attracted considerable attention in many fields due to its unique two-dimensional structure, high electronic mobility, exceptional thermal conductivity, excellent optical transmittance, good mechanical strength, and ultrahigh surface area [1]. Composite materials with graphene additives have long been considered as exciting prospects among nanotechnology applications [2]. So that, graphene-based materials and their composites possess promising applications in wide range of fields such as, electronics, biomedical aids, membranes, gas and energy storage and sensors. In this presentation, I will summarize the recent research on fabrication, characterization and applications of graphene-based nanocomposites in my group. (1) We enlisted graphene oxide as a substrate to induce nanosized MOFs. By growth nanosized Cu-BTC on the surface of graphene, the GO/Cu-BTC composite shows improved hydrogen storage and CO_2 capture performance [3]. (2) NiCo nanoalloy (4~6 nm) encapsulated in grapheme layers (NiCo@G) has been prepared by thermolysis of a 3D bimetallic complex $CoCo[Ni(EDTA)]_2{\cdot}4H_2O$ and successfully employed as a catalyst to improve the dehydrogenation performances of $LiAlH_4$ by solid ball-milling. For $LiAlH_4$ doped with 1 wt% NiCo@G ($LiAlH_4$-1 wt% NiCo@G), the onset dehydrogenation temperature of LiAlH4 is as low as 43 °C, which is 109 °C lower than that of pristine $LiAlH_4$ [4]. (3) We reported a novel method for preparing three-dimensional hierarchical graphene-like carbon nanocomposites with highly dispersed mixed Co-Ni oxide nanoparticles by a facile process, with low environmental impact, involving carbonization and subsequent oxidation of metal ion doped biopolymer precursors. The nanocomposites were fully characterised and showed excellent electrochemical performance arising from favourable nano-structuring. Specific capacitance of 1586 $F{\cdot}g^{-1}$ was measured (current density 1.0 $A{\cdot}g^{-1}$), with capacitance retention of 94.5% after 10,000 cycles demonstrating exceptional stability [5]. (4) By doping graphene with polyaniline and Pd nanoparticles, the resulting Pd-PANI-rGO nanocomposite was highly sensitive and selective to hydrogen gas, with fast response time in air at room temperature. The significantly enhanced sensitivity resulted from the faster spill-over effect, dissociation of hydrogen molecules on Pd, and the high surface area of the PANI-GO composite [6]. (5) To improve the thermal conductivity and thermal stability of the phase change materials, we successfully designed and synthesized novel polymeric SSPCMs with lamellar structures by introducing graphene oxide as the skeleton material. The composites supplied excellent phase change behavior, good thermal cycling stability, and high thermal conductivity [7].

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Figures

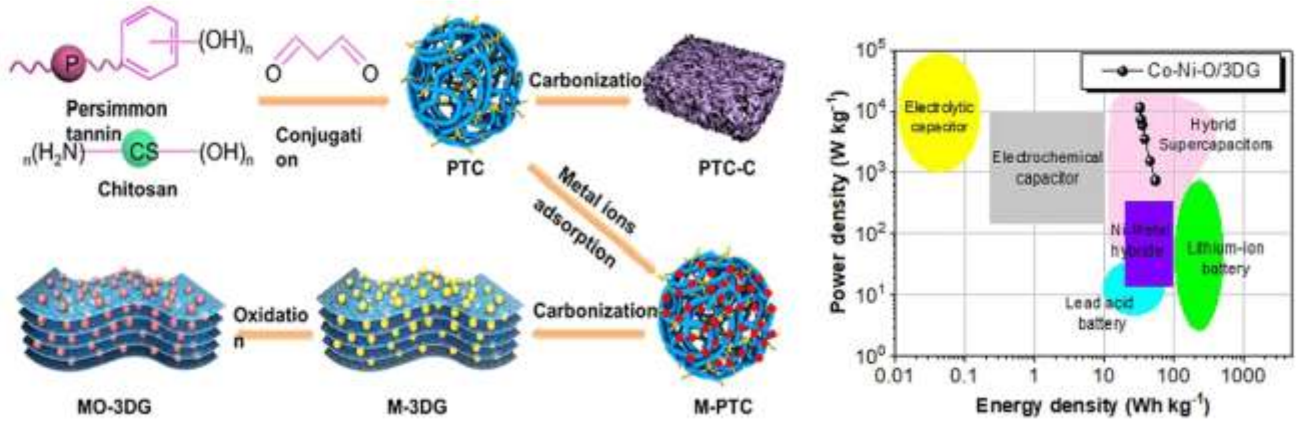

Figure 1: Schematic representation of the one-pot biopolymer-based process to form M−O/3DG nanocomposites.