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Functionalized graphene oxides for gas adsorption, gas sensing and energy storage

Graphene, a very attractive two-dimensional carbon nanomaterial with superior electrical conductivity, excellent mechanical flexibility, and high thermal and chemical stability, has been widely used in many fields such as integrated electronics and optoelectronics [1]. Graphene can be simply made into either graphene oxide (GO) or reduced graphene oxide (rGO). Compared with raw graphene, oxidized graphene is hydrophilic and has good dispersion in water, which is important criteria for solution processing and further modification [4]. Meanwhile, these oxygen-containing groups enable graphene sheets to strongly interact with small polar molecules or polymers to form graphene-intercalated or exfoliated composites [2]. However, pristine GO is not suitable for gas adsorption, sensing and energy storage applications because of the low adsorption energies of gas molecules on the GO surface and low surface area [3]. To overcome this drawback, functionalization of GO with metal particles, a polymer or a metal oxide is considered to be an effective way to improve the properties of GO because of the synergistic effects of GO and the additives. In our recent work, graphene oxide was enlisted as a substrate to induce nanosized MOFs. By growth of nanosized Cu-BTC on the surface of graphene, the GO/Cu-BTC composite shows improved hydrogen storage and CO_2 capture performance.The composite material exhibited about a 30% increase in CO_2 and H_2 storage capacity (from 6.39 mmolg^{-1} of Cu-BTC to 8.26 mmol g^{-1} of CG-9 at 273 K and 1 atm for CO2; from 2.81 wt% of Cu-BTC to 3.58 wt% of CG-9 at 77 K and 42 atm for H_2) [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 [5]. By doping graphene oxide with flower-like cobalt–nickel–tungsten–boron oxides, the Co–Ni–W–B–O/rGO composites resembled three-dimensional flowers with high surface area; they also exhibited superior electrochemical performance when compared to most previously reported electrodes based on nickel–cobalt oxides. Furthermore, the Co–Ni–W–B–O/rGO composite prepared in an ethanol solution showed much higher electrochemical performance than that the composite prepared in water. The Co–Ni–W–B–O/rGO electrode showed an ultrahigh specific capacitance of 1189.1 F g^{-1} at 1 A g^{-1} and exhibited an high energy density of 49.9 Wh kg $^{-1}$ along with remarkable cycle stability, which is promising for application in energy storage devices [6]. By spontaneous polymerization of pyrrole and formation of PB nanocubes on GO, the resultant supercapacitor based on PPy–PB–GO exhibits both double-layer and pseudocapacitance. The hybrid electrode showed a maximum specific capacitance of 525.4 F g^{-1} at a current density of 5 A g^{-1}. It also exhibited excellent cyclic stability of 96% retention for up to 2000 cycles [7].

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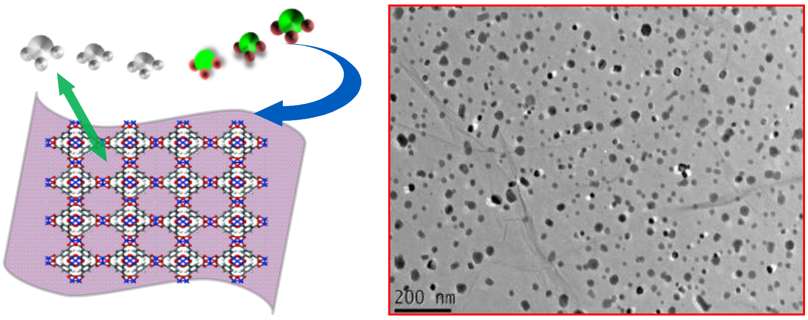

Figure 1: Graphene oxide induced nanosized Cu-BTC for gas adsorption.