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# Interfacing graphene with nanoparticles for energy and gas storage as well as sensors

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 [1]. The extraordinary properties of graphene including high (ballistic) charge mobility and the potential for n- or p-doping can provide high conductivity materials depending on their structural quality. Multiple applications including as materials for gas and energy storage could be within reach if irreversible aggregation, or re-stacking, of graphene nanosheets could be inhibited. Furthermore, its chemical inertness makes it difficult to attach gas molecules on the surface of graphene directly and interfacing the graphene surface with other nanoparticles is a possible solution [2,3]. In our recent work, graphene oxide was enlisted 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.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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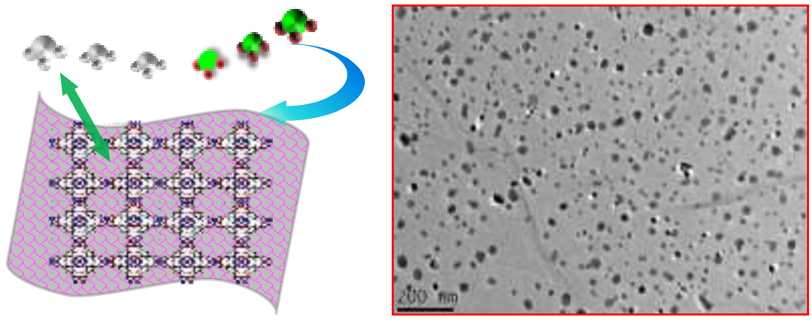


**Figure 1:** Graphene oxide induced nanosized Cu-BTC for gas adsorption.