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Hydrogen Adsorption on MOF Composites: A Review

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In order to overcome the challenges posed by storage of hydrogen as a liquid or compressed gas, alternate hydrogen storage technologies are being explored. These technologies include storage of hydrogen on materials with which it forms a chemical bond (metals or their alloys forming metal hydrides/complex metal hydrides) and on high surface area materials where it is physisorbed. Metal organic frameworks (MOFs) are high surface area material, known for high gas adsorption capacity. MOFs can be structurally modified; MOF composites are formed to obtain enhanced hydrogen uptake with higher enthalpy of adsorption.

Hydrogen adsorption capacities of MOF composites are better than virgin MOFs owing to the synergetic effect of its constituent MOF and the other substrate used in the composite such as activated carbon (AC), Graphene Oxide (GO), and Expanded Natural Graphite (ENG) etc.Formation of MOF/GO composites via interactions between functional groups of GO and metallic centers of MOF, where the synergetic effect between MOF units and GO layers are responsible for enhanced adsorption amounts on ZIF-8 composite, (ZIF-8 is structured as $Zn(MeIM)_2$;MeIM = 2-methyl imidazolate) compared to the pure ZIF-8. Nanosized Cu-BTC and ZIF-8 can be induced by the incorporation of GO component. Cr-BDC/AC composite synthesizedunder hydrothermal conditions reduce the unutilized voids in Cr-BDC by incorporating microporous activated carbon.Zn-BDC/ENG compositesform a compact structure has more thermal stability, however, hydrogen uptake reported is slightly less compared to pure MOF.

Incorporation of heavy transition metals effectively into the MOF structure considerablycontributes to reduction in gravimetric storage capacity. In order to overcome the difficulty, transition metals are introduced into the MOF structure by synthesis of a MOF composite with materials such as activated carbon, graphene oxide etc. Doping metal nanoparticles through in-situ synthesis method into MOF/GO units exhibit more controllable and reliable synthesis procedure. The carbonaceous materials (activated carbon or graphene) may be pre-loaded with transition metals such as Platinum or palladium to desired percentage thereby effectively incorporating Pd/Pt into the MOF structure. Metals such as Pt/Pd result in enhanced loading of hydrogen in highly porous materials such as activated carbon and MOFs due to so called spillover effect, if a successful "bridge" can be created between the metal and the MOF. Hydrogen molecules first dissociate on the Pd/Pt nanoparticles to form hydrogen atoms that then spill over to the MOF/carbon support. The enthalpy of hydrogen adsorption reported are higher for the modified MOFs. Even though the hydrogen uptake capacity is low compared to saturation capacity of pure MOFs;studies show that enthalpy of adsorption in classical physisorption systems can be considerably improved in MOF composites.

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