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Nanostructured Materials for Energy Applications

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This talk includes the following two topics:

1) Porous metal-organic frameworks (MOFs) for energy applications

We have developed new applications of porous MOFs, especially for energy conversion and storage.[1,2] Novel porous metal-organic frameworks have been synthesized, which present stable catalytic activities for the oxidation of CO to CO_2. Metal nanoparticles (NPs) have been immobilized to MOFs by the solid-grinding method, impregnation method and double-solvents approach in combination with the H_2 reduction, liquid-phase concentration-controlled reduction and the CO-directed reduction at the solid-gas interface, which exhibit excellent catalytic performances for various reactions, including hydrogen generation from chemical hydrides. “Quasi-MOFs” have been prepared by controlled deligandation of MOFs, which have a transition-state structure between the porous MOFs and metal oxides. The metal cluster/quasi-MOF composites not only retain a porous structure but also achieve a strong interaction between the metal clusters (eg, Au) and the inorganic nodes (eg, Cr–O) of the quasi-MOF, leading to dramatically enhanced catalytic performance in the low-temperature oxidation of carbon monoxide (CO). Porous carbons have been synthesized by using MOFs as templates/precursors and the resultant carbons display high specific surface areas and excellent electrochemical properties as electrode materials for electric double-layered capacitor (EDLC) and as catalysts for oxygen reduction reaction (ORR).

2) Metal nanoparticle-catalyzed hydrogen generation

We have reported liquid-phase hydrogen generation systems, which are based on metal nanoparticle-catalyzed hydrolysis of ammonia borane (NH_3BH_3), complete decomposition of hydrous hydrazine (H_2NNH_2) and decomposition of formic acid.[3,4] The metal nanoparticles catalysts immobilized by the double-solvents method (DSM) inside the pores of MOFs, by the non-noble metal sacrificial approach (NNMSA) to reduced graphene oxide and by the weakly-capping growth approach (WCGA) to carbon nanospheres will be discussed. The use of soluble porous organic cages as a stabilizer and homogenizer toward the homogenization of heterogeneous metal nanoparticle catalysts with enhanced catalytic performance will also be discussed.

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