Basic isoreticular metal-organic framework-3 (IRMOF-3) porous nanomaterial as a suitable and green catalyst

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Abstract

In the previous decade, a lot of consideration has been paid to metal-organic frameworks (MOFs) made by connecting metal units with organic ligands through coordination bond [1]. MOFs have been given much attention from both scientific and commercial aspects regarding their application to gas storage, separation, drug delivery, adsorption, gas/chemical sensing and catalytic reaction. MOF-assisted organic synthesis using organic–inorganic hybrid micro-channels has been utilized not only to accelerate a number of synthetic reactions, but also it is a green catalyst to increase reaction rate and yields. Also, MOFs have been considered as flexible precursors for synthesis of different nano-materials and novel multifunctional nanocomposites hybrids with preferable functional characteristics compared to their initial components [2]. MOF-based structures demonstrate various advantages such as high surface area, adjustable pore size and the simplicity of processing, tunability and use of stable alternative materials.

In this work, $CoFe_2O_4$/IRMOF-ZnO was synthesized. Initially IRMOF-3 as one of the known selective and afficient metal-organic frameworks (MOFs) was successfully magnetized with $CoFe_2O_4$ nanoparticles and then Zno assembled on the $CoFe_2O_4$/IRMOF at room temperature. The composite possess high crystallinity, porosity characteristic, rapid magnetic response and good stability.

The prepared materials were characterized by X-ray diffraction (XRD), Differential reflectance spectroscopy(DRS).

Keywords: metal-organic frameworks; porous materials; MOF catalysts; $CoFe_2O_4$ nanoparticles; IRMOF3; Magnetic metal-organic frameworks

INTRODUCTION

Among the recent developed porous materials, metal organic frameworks (MOFs) are distinct from other traditional porous materials because of their high porosity and thermal stability. MOFs are a new development on the interface between molecular coordination chemistry and materials science. Research on synthesis, structures and properties of various MOFs has shown that this new class of porous materials has attracted a tremendous amount of interest because of its fascinating structural topologies, high surface area, tunable cavities, tailorable chemistry and thermal stability in several applications such as energy storage, gas purification, sensing, separations, drug delivery, adsorption and catalysis. This high degree of customizability of MOFs properties has attracted the interest of many researchers. To date, there are more than 20,000 different structures of MOFs being reported and studied.[2]

Among the hundreds of known NMOFs, the isoreticular metal-organic framework (IRMOF-3) that belongs to inorganic–organic hybrid particularly has attracted considerable attention due to their attractive features, such as large surface areas, ultrahigh tunable functionality, highly porosity, enhanced stability and free amine groups on its backbone structure.

Due to the instability of MOFs in water and falling apart their structure, leaching of metal and ligand to the solution is inevitable. To eliminate this problem, researchers used magnetic MOFs to simplify the separation process by utilizing an external magnetic field and preventing the increment of pollution by MOFs. Many different magnetic particles such as Fe_2O_3, Fe_3O_4, $ZnFe_2O_4$, $MnFe_2O_4$, $NiFe_2O_4$, and $CoFe_2O_4$ were applied by researchers. one of the most appealing magnetic materials is cobalt ferrite. $CoFe_2O_4$ as a vigorous magnetic nanoparticle which has thin optical bandgap and great antibacterial properties is considered due to its desired magnetic, mechanical and chemical properties in various fields.

In this work, exquisite method with high efficiency has been utilized to synthesized $CoFe_2O_4$/IRMOF-ZnO. Initially IRMOF-3 as one of the known selective and afficient metal-organic frameworks (MOFs) was successfully magnetized with $CoFe_2O_4$ nanoparticles and then Zno assembled on $CoFe_2O_4$/IRMOF. The obtained compound possess high crystallinity, porosity characteristic, rapid magnetic response and good stability.

EXPERIMENTAL

Synthesis of $CoFe_2O_4$/IRMOF-ZnO

$CoFe_2O_4$ was prepared by the method as described by D. Moitra at low temperature in a co-precipitation method.[3]**(Fig. 1)** The chemical reactions of preparing CoFe2O4 were presented as follows:

$$Co^{2+}(aq) + 2OH^-(aq) \xrightarrow{H_2O} Co(OH)_2(s) \quad (1)$$

$$Fe_3^+(aq) + 3OH^-(aq) \xrightarrow{H_2O} FeOOH(s) + H_2O(L) \quad (2)$$

$$Co(OH)_2(s) + 2FeOOH(s) \xrightarrow{Reflux} CoFe_2O_4(s) + 2H_2O(L) \quad (3)$$

The preparation of the IRMOF-3 was followed by a known procedure reported in the literature.[4] (Fig. 2) For the synthesis of CFMOF, 0.01 g CF NPs was slowly added to the prepared mixture and sonicated 15 min to get a homogenous mixture.an aqueous zinc acetate dehydrate solution was prepared with deionized water, CFMOF was added to above solution and kept under continuous stirring then were washed by double distilled water, dried and calcined at 200 °C for 2h in an Oven.

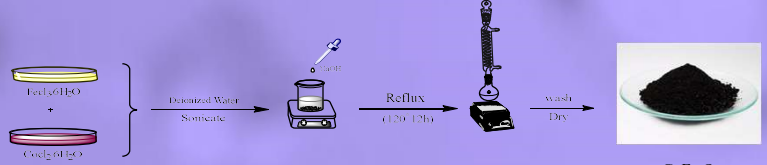
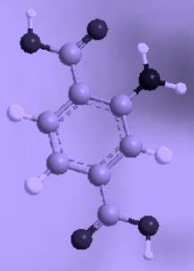
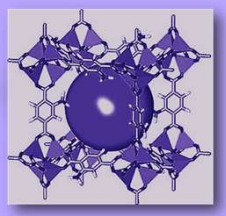


Fig. 1. Preparation of $CoFe_2O_4$



2-aminoterephthalic acid

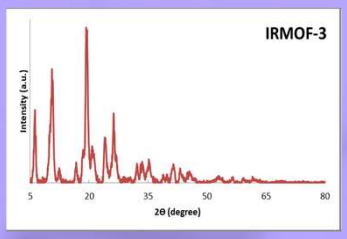
+ $ZnO(OAC)_2.H_2O$ **DMF** ⟶

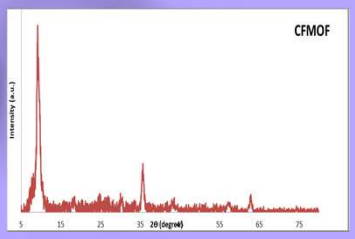


IRMOF-3

Fig. 2. Preparation of IRMOF-3

RESULT AND DISSCUSSION





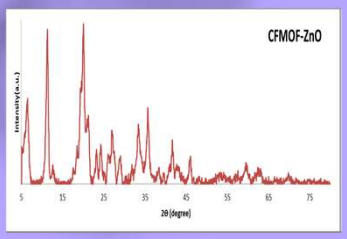


Fig. 3. XRD patterns of IRMOF-3, CFMOF, CFMOF-ZnO

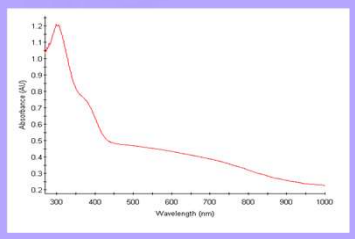


Fig. 4. DRS

CONCLUSION

In summary, exquisite method with high efficiency has been utilized to synthesized $CoFe_2O_4$/IRMOF-ZnO. This is a novel method in which some simple chemicals such as iron chloride, cobalt chloride, Dimethylformamide, zinc acetate, ethnol, and acetone were used. A catalytic was found to be an efficient, selective and waste-free green in which possess high crystallinity, porosity characteristic, rapid magnetic response and good stability. The obtained compound was evaluated by XRD and DRS.IRMOF3, CoFe2O4 and $CoFe_2O_4$/IRMOF-ZnO could be seen in the XRD pattern.

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