

Preparation and Characterization of Metal-Organic Frameworks and Zeolite Imidazolate Frameworks for Carbon Dioxide Adsorption

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The last century has witnessed humanity actively exploiting organic fossil fuels like coal, petroleum, and natural gas as energy sources. The firing of these fuels produces significant quantities of CO₂. In order to mitigate global warming, gas capture material must be developed out. Metal-organic frameworks (MOFs) are a new emerging class of crystalline porous materials. Zeolite imidazolate framework (ZIF) is the use of inorganic zinc (Zn) and the organic imidazole group with a bond formed with a porous compound. Both have porous tunability, high thermo stability, and easy synthesis making it becoming an ideal gas adsorption/separation material. Hence our main goal is to investigate the relationship between structures and gas adsorption/separation efficiencies by XRD, FE-SEM/EDS, ASAP, TGA, ESCA, TEM, and XANES/EXAFS analyzing the relationship of structure. In experiment section, this study will offer metal reaction position by using nitrate nonahydrate of Al, Cr, and Fe. Then react with 1,4-terephthalic acid function group by hydrothermal and microwave for synthesis. Reaction temperatures range from 150 to 220°C. The materials synthesis by hydrothermal method must go through calcination (250°C -400°C) steps. Because of long reaction time could make some unreacted materials remains in the sample. In microwave method is not required, because of short reaction time. Only attention to the synthesized conditions. As a series of products for a variety of characterization of this study found that only MIL-101 (Cr) varies in different synthesis method presented XRD patterns characteristic crystalline summit. TGA analysis also obvious that thermal stability can be raised in the MIL-53 series of two synthesis methods and hydrothermal synthesis method of MIL-101 series. The maximum temperature of the heat loss can achieve 400°C to 600°C. Obviously, there are lots of bonds exist in the samples. The BET specific surface area of MIL-53(Al) in hydrothermal method and microwave method were 986 and 1,114 m²/g, respectively. MIL-101(Cr) in hydrothermal method and microwave method were 2,173 and 1,383 m²/g, respectively. MIL-53(Fe) in hydrothermal method and microwave method were 444 and 284 m²/g, respectively. The CO₂ adsorption ability in this study that the MIL-101 series are better than MIL-53 series. The microwave synthesis method is better than hydrothermal synthesis method in MIL-53 series. The hydrothermal synthesis method is better than microwave synthesis method in MIL-101 series. The maximum CO₂ adsorption ability of MIL-53(Al), MIL-53(Cr), and MIL-53(Fe) were 23.9, 55.8, and 23.5 cm³/g by microwave method, respectively. The maximum CO₂ adsorption ability of MIL-101(Al), MIL-101(Cr), and MIL-101(Fe) were 31.0, 109.4, and 35.6 cm³/g by hydrothermal method, respectively.

Keywords: Porous materials, Metal-organic frameworks, Zeolite imidazolate frameworks, Microwave synthesized, Gas separation, CO₂ adsorption.

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