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Abstract

The Physicochemical Properties of Metal–Organic Frameworks Suitable for CO_2 Capture: A Comparative Study of Magnesium- and Zinc-Based Materials †

Glory Makuwa [1,*], Kasturie Premlall [1] and Major Mabuza [2]

[1] Department of Chemical, Metallurgy and Materials Engineering, Faculty of Engineering and the Built Environment, Tshwane University of Technology, Private Bag X680, Pretoria 0001, South Africa; premlallk@tut.ac.za
[2] Department of Chemical Engineering Technology, Faculty of Engineering and the Built Environment, University of Johannesburg, Doornfontein, Johannesburg 2088, South Africa; majorm@uj.ac.za
* Correspondence: glorymakuwa1@gmail.com
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Carbon capture and storage (CCS) is a climate change mitigation technique in which CO_2 is captured from a point source, including coal-fired power plants and other industrial activities, rather than released into the atmosphere. The utilization of metal–organic frameworks (MOFs) is one of the most promising approaches for post-combustion carbon capture due to their unique properties including high porosity, surface area, crystallinity, stability, and selectivity, and their wide range of applications, which include gas separation and storage. This paper presents a study on a unique approach to the synthesis of magnesium (Mg)- and zinc (Zn)-MOF-74 materials under varied reaction temperatures and times using the solvothermal technique. This study further explores the physicochemical properties of the materials to evaluate their suitability for selectively capturing CO_2 from flue gas produced by typical coal-fired power plants.

The MOF crystals were synthesized at 100, 110, and 125 °C for 6, 12, 24, and 48 h. The physical characteristic were examined using BET analysis, while the surface chemistry, crystallinity, and morphology were investigated using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and scanning electron microscopy equipped with energy-dispersive X-ray (SEM-EDX), while the thermal stability was evaluated using thermogravimetric analysis (TGA). The FTIR results showed the presence of carboxyl (C=O) and hydroxyl (-OH) functional groups that demonstrate high affinity potential for CO_2 adsorption in Zn-MOF-74, whereas only a -OH group was present in Mg-MOF-74. The TGA results showed that the Mg-MOF-74 samples were more stable up to 580 °C whereas the Zn-MOF-74 samples were stable up to 430 °C. The highest surface area and pore volume of Zn-MOF-74 synthesized at 125 °C for 24 h were 826 m^2/g and 0.344 cm^3/g, whereas those of Mg-MOF-74 synthesized at 110 °C for 8 h were 24.73 m^2/g and 101.34 cm^3/g. Thus, the physical and chemical properties of the crystalline material prepared at high temperatures were suitable for carbon capture.

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