Adsorption Characterization of Aluminum Fumarate Metal-organic Framework

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Adsorption Characterization of Aluminum Fumarate Metal-organic Framework

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Abstract: *Microporous metal-organic frameworks (MOFs) having higher difference between adsorption and desorption uptake per cycle are considered as one of the most potential adsorbents for future designing of adsorption heat pumps. In this study, the porous properties and water adsorption isotherm of a commercially available MOF- aluminum fumarate were studied. The porous properties confirmed this to microporous material. The obtained water adsorption isotherms were S-shaped. These S-shaped isotherms ensured that the uptake offtake difference was large within a very short range of pressure.*

Keywords: Aluminum fumarate; microporous material; porous properties; water uptake.

1. INTRODUCTION

MOFs are highly crystalline powdered like materials having higher surface area and regular pore geometry than the conventional adsorbents. MOFs can be easily synthesized in their pure form and modifications in MOFs synthesise have made them more stable than ever before. As a result, they become great potential materials for various applications involving microporous materials As the MOFs are known to possess highewr surface area and adequate pore volume, they fulfil one of the primary conditions to be an adsorbent for adsorption chiller [1,2]. Water adsorption has been done on a number of MOFs including MOF-805, MOF-806, Mg-MOF-74, Ni-MOF-74, CAU-10 etc. They showed better performance when compared with silica gel and zeolite [3]. Thus MOFs are becoming more and more popular for water assisted AHT applications. The pore diameter and hydrophilicity plays an important role in water adsorption in an adsorbent. The adsorbents having a pore radious below the critical (10.38 Å) for water, would trigger water adsorption in the pores without condensation. Moreover, hydrophilicity in the pore must be sufficient enough to permit the molecules of water to fill the pores below the relative pressure (P/Ps=0.3) for adsorption heat transfer applications [4].

We have a goal to synthesize aluminum fumarate, a promising MOF water adsorption using a green technology involving water as a solvent instead of DMF (Dimethylformamide). After synthesizing we need to have the commercial sample's adsorption characteristic data to valid our synthesized aluminum fumarate. This study thus focuses on obtaining the adsorption characteristics for the adsorption properties such as porous properties and water uptake isotherms. 3D view of aluminum fumarate is shown in fig. 1.

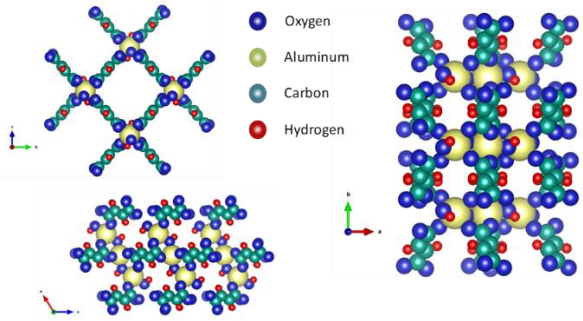

Fig. 1. 3D view of aluminum fumarate

2. EXPERIMENT

The porous properties of the commercial aluminum fumarate was obtained by N_2 adsorption isotherms at 77K. Aluminum fumarate sample was degassed at a temrperature of 120˚C for 3h before N_2 adsorption experiment was perforemed. The N_2 adsorption/desorption isotherm on aluminum fumarate was investigated using volumetric method. 3Flex™ Surface Characterization Analyzer was used to do the experment. NLDFT (Non-localized density functional theory) method was applied on the ontained N_2 adsorption isotherm to investigate about the pore size distribution. The micro-pore volume was determined before the isotherm reaches saturation.macro pores are not filled until saturation. As a result the micro-pore volume is determined appropriately. Near saturation the N_2 adsorption isother has a sharp increase before reaching the limiting uptake value due to macropore filling.This limiting uptake defined the total pore volume of aluminum fumarate.

Water adsorption on aluminum fumarate was measured at different temperature and pressure using thermogrametric method. A thermogrametric analyzer (TGA) was used as it had high accuracy and good control over the temperature and pressure at the time of the experiment. Rubotherm of type MSB-VG-S2 supplied by BEL Japan, Inc is a magnetic suspension adsorption measurement unit which was used for the experiment.

3. RESULTS AND DISCUSSION

Fig. 2. shows the N_2 adsorption-desorption isotherm on commercial aluminum fumarate. Experimental data shows that the volumetric uptake of N_2 gas was 12 mmol/g before reaching the saturated pressure. Near the saturated pressure, the volumetric uptake sharply increases up to approximately 17 mmol/g suggesting macropore filling. This concludes that the material also has macropore besides micro pores. BET analysis and N_2 adsorption isotherms were used to determine the pore size distribution, surface area and pore width. The surface area was found to be 600 m^2g^{-1} and the average pore width is 11 Å. which agrees with the crystallographic data. The pore size distribution is shown in fig. 3.

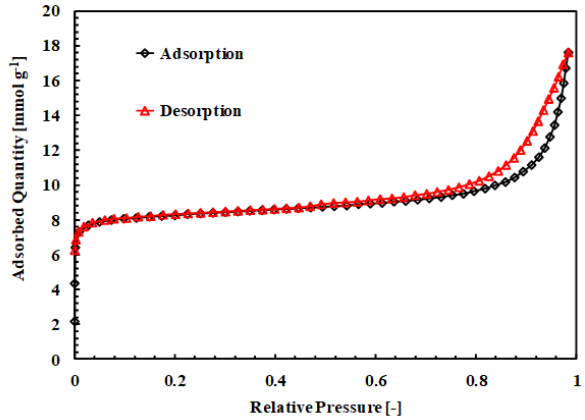

Fig. 2. N_2 adsorption/desorption isotherm at 77 K

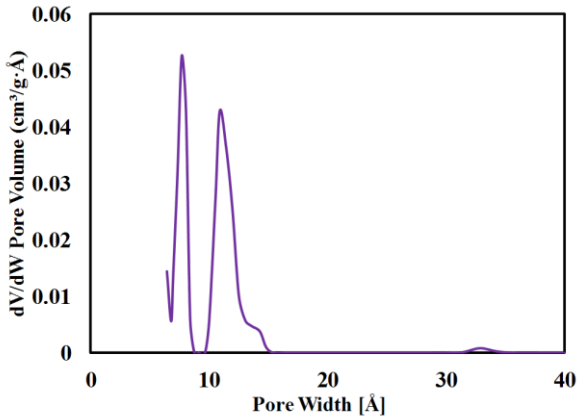

Fig. 3.Pore size distribution of Aluminum fumarate

Water adsorption isotherms were measured for the commercial aluminum fumarate sample at 30 °C, 50 °C and 70 °C. The results are shown in Fig. 4. We obtained S-shaped isotherms in all cases that are the desired one for adsorption chiller application.

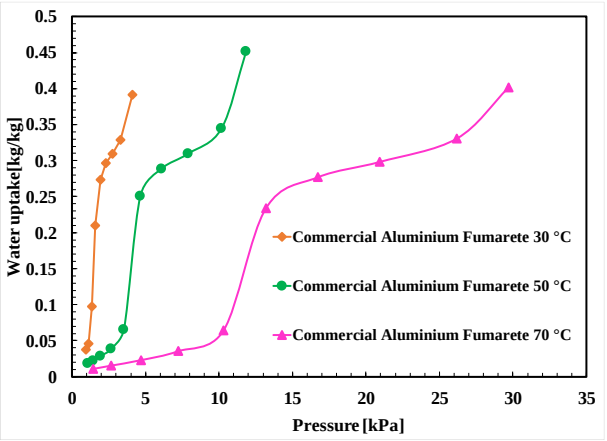

Fig. 4. Water adsorption isotherms o commercial aluminum fumarate

4. CONCLUSION

Water adsorption and porous properties were measured for commercial aluminum fumarate. The average pore width was found 11 Å. the material was mostly microporous. The water adsorption isotherms were all s-shaped. The ultimate goal of this study is to find a green synthesis technique which can produce aluminum fumarate with properties like the commercial one or even better. Then we can apply other MOF medication techniques to make that even better and more aligned to a particular application.

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