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Development of Nanosheets of Metal Organic Framework of Aluminium (III) with 1,4-Benzene dicarboxylic acid

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ABSTRACT

Nanosheets of crystalline aluminium (III) metal organic framework were synthesized using solvothermal method with 1,4-benzene dicarboxylic acid as ligand. FT-IR spectrum shows interaction between the metal and the ligand in the synthesized MOF.

Keywords: Metal Organic Frameworks, Aluminium, 1,4-Benzene Dicarboxylic Acid, Nanosheets, Terephthalic Acid

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INTRODUCTION

Research on metal organic framework (MOF) has an exponential growth due to their applicability in different areas like gas storage, luminescence, catalysis, non- linear optics, magnetism and sensors mostly due to their high porosity. There are attempts to enhance the pore size to mesopore and to reduce the crystallite size to the nanometer, which enhances the encapsulation of large molecule MOFs [1-3].

The study of aluminium MOFs is significant because of their stability and applications. MOFs of aluminium were reported in which functional groups like –OH, and methyl groups have been introduced to terephthalic acid for CO_2 capture from post combustion flue gas. They may find applications as a water absorbent for indoor moisture control [4-5]. Many aluminium MOFs efficient in catalytic activity, adsorption applications and in gas storage have been reported [6-11]. The literature review reveals the applicability of MOFs especially, aluminium based MOFs [12-13]. Hence, we have selected aluminium as the metal for the development of MOF in our present investigation. The objective of the present work is to develop MOF of Al (III) using 1,4-benzene dicarboxylic acid (1,4-BDC) under hydrothermal conditions with a view to develop novel multifunctional MOF materials for various applications and also to understand the interaction of aluminium(III) with the ligand molecule in the MOF.

MATERIALS AND METHODS

All the chemicals used for synthetic purpose were of analar grade. A.R quality aluminium acetate was used for the present investigation. Methanol was used as the solvent for the preparation of MOF. Other reagents used are LR samples of terephthalic acid (BDC).

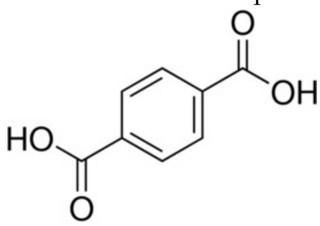

Figure 1: 1,4-BDC

Synthesis of aluminium MOF

A mixture of 1mmol each of aluminium acetate and terephthalic acid in 10 mL of methanol was transferred into an autoclave and kept at 150^{0}c for three days. After cooling, it is filtered and washed with methanol. Then the product was dried at room temperature.

PHYSICO-CHEMICAL MEASUREMENTS

The IR analysis of the sample was recorded using KBr pellet method with Perkin- Elmer spectrometer at Department of Chemistry, MG College, Kesavadasapuram, TVPM. Powder XRD pattern was recorded by BRUKER D8 advance XRD at Department ofChemistry, Karyavattom campus, TVPM. SEM images were recorded using FE-SEM with EDS, Sputter coat at Department of Optoelectronics, Karyavattom Campus, TVPM. EDX analysis of the sample was done using Carl Zeiss EVO 18 SEM with EDS at SICC, Karyavattom campus TVPM.

RESULTS AND DISCUSSION

Metal organic framework of aluminium with terephthalic acid was synthesized and was characterized using FT-IR, Powder XRD, FE-SEM and EDS.

Infrared spectral studies

The carbon-oxygen stretching frequency of acid was observed at 1270 cm^{-1} in the ligand (Fig. 2) and is shifted to 1280 cm^{-1} in MOF (Fig. 3). The -OH bending bands at 1420 cm^{-1} and 928 cm^{-1} in the ligand were observed at 1421 cm^{-1} and 926 cm^{-1} respectively in the MOF. The peak observed at 1675 cm^{-1} in the ligand corresponding to COOH group, was shifted to 1673 cm^{-1} in the MOF. These shifts in frequencies indicate the interaction of the metal with the ligand to form the MOF.

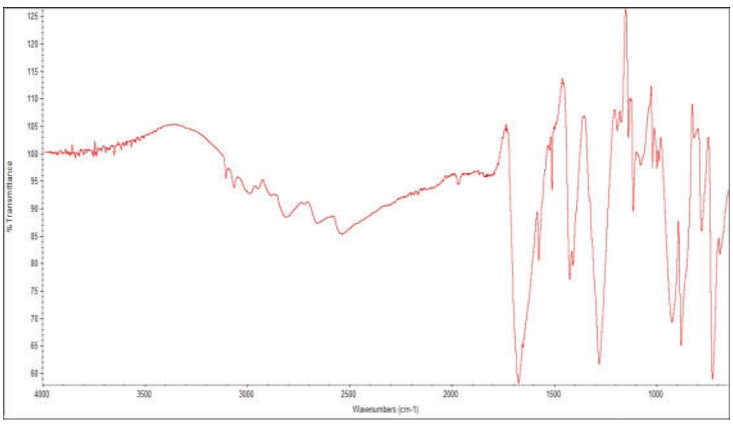

Figure 2: FTIR spectrum of the ligand 1,4- BDC

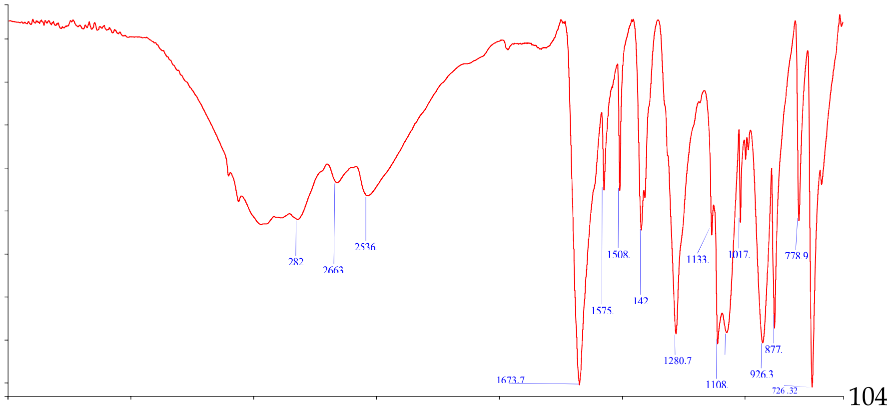

Figure 3: FTIR spectrum of Al-BDC MOF

Powder XRD data

The powder XRD pattern (Fig.4) showed high intensity Bragg diffraction peaks at 2θ= 17.43, 25.98 and 28.10^0. Sharp peaks indicate the crystalline nature of the MOF.

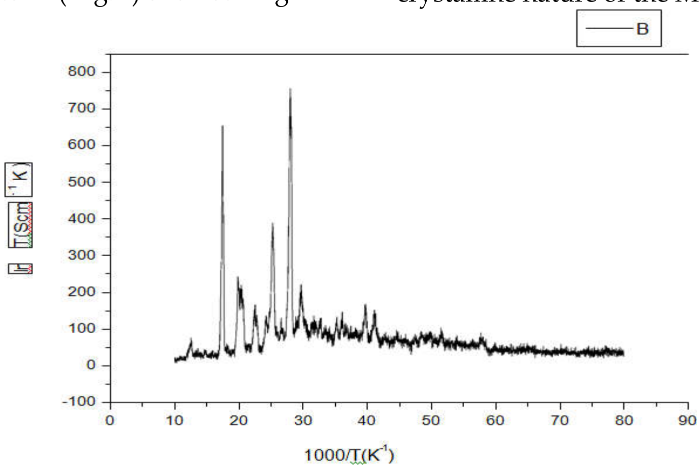

Figure 4: PXRD pattern of Al BDC MOF

SEM and EDS Analysis

The SEM images of the synthesized MOF under different magnifications (Fig. 5) indicate the existence of beautiful nanosheet like morphology in the aluminium MOF.

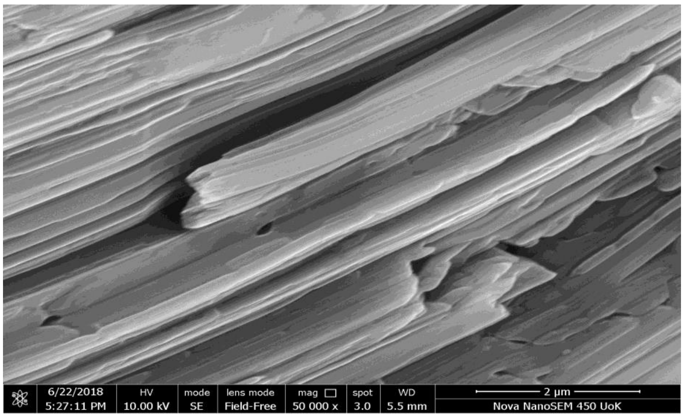

Figure 5: SEM image of Al BDC MOF

Aluminium and all relevant species are seen in the EDS of the MOF (Fig.6, Table 1) indicating the successful synthesis of MOF.

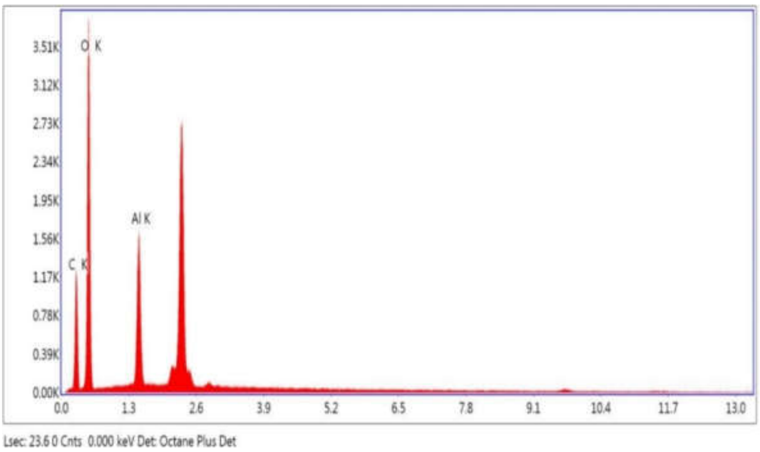

Figure 6: EDS spectrum of Al-BDC MOF

Table 1: Element composition in Al BDC MOF

Element	Weight %	Atomic %	Net Int.
C K	32.69	40.43	621.4
O K	59.56	55.3	1907.65
Al K	7.76	4.27	984.85

CONCLUSION

Metal organic framework of aluminium (III) with 1,4-benzene dicarboxylic acid was solvothermally synthesized and was characterized using FT- IR, powder XRD, SEM and EDS. The FT-IR spectrum indicates the interaction of carboxylic acid group with aluminium in the MOF. The PXRD pattern indicates the crystalline nature of the synthesized MOF. The SEM image indicates a nano sheet like morphology for the aluminium MOF. The presence of aluminium atom and all other expected elements in the EDS indicate the successful synthesis of Al-BDC MOF. A complete confirmation of the structure is possible only after performing SXRD analysis. The synthesized metal organic framework may be developed into materials which may find applications in gas storage systems, catalytic studies, separation of gases, sensors and luminescent materials.

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