

## Synthesis of Zeolitic imidazole framework-8 (ZIF-8) by different solvents

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### Abstract:

Zeolitic imidazolate frameworks (ZIFs), are a special kind of Metal organic frameworks (MOFs) that have been the subject of much research recently. Zeolitic imidazolate framework (ZIF-8) was synthesized effectively through a solvothermal method, using zinc nitrate as the metal precursor and 2-methylimidazole as the natural ligand. The synthesis involved two distinct organic solvents, namely dimethylformamide and methanol. The resulting ZIF-8 samples were characterized using X-ray diffraction and Fourier-transform infrared spectroscopy, which confirmed the effective fabrication of extremely crystalline ZIF-8. The study also highlighted the importance of dissolvable choice in influencing ZIF-8 morphology. In conclusion, the solvothermal approach is illustrated to be a solid and cost-effective technique for the mix of extreme-quality ZIF-8.

**Keywords:** ZIF-8, Nanoparticles, solvothermal.

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## 1.Introduction

Coordination polymers are compounds formed by metal ions and inorganic/organic ligands through coordination bonds (Hayat, Rauf et al. 2024). Such compounds have been widely studied due to their adjustable structure and diverse functions (Liu, Wu et al. 2025). A variety of related compounds were synthesized on the basis of coordination polymers, in which metal–organic frameworks (MOFs) are coordination frame materials with a porous structure formed by the coordination of metal ions or metal clusters and organic ligands (Mahmoud 2025). MOFs have attracted much attention due to their structural characteristics.

Metal–organic frameworks are a distinguished category of materials recognized for their remarkable crystallinity and exceptionally high porosity (Li, Zhang et al. 2023). Compared with pure inorganic molecular sieves and porous carbon materials, MOFs have the following advantages: (1) the highly crystalline state of MOFs is very conducive in determining their precise spatial structure with single crystal and polycrystalline diffraction methods; (2) MOFs have high porosity and a specific surface area; (3) MOFs can be composed of various different metal ions and organic

bridging ligands, and they have structures that are easy to design; (4) the single bond in the organic ligand structure gives MOFs a certain degree of flexibility, so that they have characteristic functions; and (5) the structure is easy to modify: MOFs frame and the structure of the pore surface can be adjusted by modifying the metal center and organic ligands in the MOFs framework so as to give MOFs a variety of functions (Cheng, Lan et al. 2025). MOFs have shown excellent performance and broad application prospects in adsorption, separation, catalysis, sensing, and drug delivery.

Among these, zeolitic imidazolate framework-8 is the foremost broadly explored for a wide extend of applications (Carraro, Williams et al. 2020). This structure enables them to present unique properties of both zeolites and MOFs (Carraro, Williams et al. 2020). Zeolitic imidazolate systems constitute a special subclass of crystalline, permeable MOFs, synthesized through self-assembly forms (Wang, Sun et al. 2020). The crystal structures of ZIFs exhibit topologies that are analogous to those of aluminosilicate zeolites. While traditional zeolites comprise of tetrahedral aluminum or silicon atoms connected by oxygen bridges, ZIFs substitute the tetrahedral

silicon or aluminum with move metals, such as zinc (Zn) or cobalt (Co), and supplant the oxygen bridges with imidazolate linkers (Pérez-Miana, Reséndiz-Ordóñez et al. 2021). Like zeolites, ZIF frameworks possess well-defined pores and channels that allow the ingress of guest molecules and enable molecular-level differentiation of species (Li, Zhou et al. 2016, Wang, Sun et al. 2020).

Zeolitic imidazolate frameworks (ZIFs) present distinct advantages over zeolites, due to their hybrid framework structures, which offer enhanced flexibility for surface modification and, in some instances, enable the targeted design of surface properties (Tsai, Langner et al. 2016). In comparison to other metal–organic framework (MOF) materials, ZIFs typically exhibit superior thermal, hydrothermal, and chemical stabilities, microporosity, high surface areas, and structural adaptability (Demir, Topuz et al. 2014). These attributes have positioned ZIFs as promising candidates for applications such as, alkane/alkene separation, carbon dioxide adsorption, heterogeneous catalysis, and hydrogen storage (Yao, Dong et al. 2011). This is often credited to their auxiliary adaptability, which encourages the sound plan of pore sizes and surface usefulness,

as well as their generally warm solidness and chemical steadiness (Park, Ni et al. 2006). The aim of this study to prepare Zeolitic imidazole framework-8 (ZIF-8) by different solvents materials and Methods.

## 2. Materials:

In this consider, the synthesis of ZIF-8 utilized zinc nitrate hexahydrate ( $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , 99%) as the zinc source and 2-methylimidazole (MeIm, 99%) as the natural ligand, both obtained from Sigma-Aldrich. Methanol (MeOH) (99.8%), obtained from Merck, served as the polar dissolvable, while N,N-dimethylformamide (DMF) was sourced from Harmony (Tianjin, China). All chemicals were utilized as gotten, without any advance filtration. increasing focus on solvothermal method. A particular emphasis has been set on controlling the measure of ZIF-8 during synthesis (Romero-Guerrero, Moscoso et al. 2025). In this consider, ZIF-8 was synthesized utilizing the customary solvothermal strategy, employing two diverse organic solvents: methanol (MeOH) and dimethylformamide (DMF). The synthesis conditions were found to have a critical effect on the physicochemical properties of the coming about ZIF-8. The optical and basic properties of the synthesized ZIF-8 were decided (Cravillon, Schröder et al. 2012, Lai, Yeong et al. 2016).

### 2.1. Preparation of ZIF-8:

All reagents were of analytical grade and used without further purification. In a typical solvothermal synthesis, 4 mmol of  $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  and 3 mmol of 2-methylimidazole (Hmim) were dissolved separately in 50 mL of dimethylformamide (DMF) and 50 mL of methanol (MeOH) as solvents. The reaction mixtures were mixed to create a clear arrangement, which was at that point exchanged into a 100 mL Teflon-lined autoclave. The autoclave was warmed in an oven at  $140^\circ\text{C}$  for 10 hours. After the solvothermal reaction, the reaction mixture was cooled to room temperature. ZIF-8 particles were then recovered by centrifugation at 7800 rpm for 5 minutes. The coming about particles were washed three times with new methanol and dried overnight at  $80^\circ\text{C}$  in an stove. The mix strategy was repeated by changing the temperature from  $80^\circ\text{C}$  to  $140^\circ\text{C}$ . A fine, white powder was gotten and carefully collected for help characterization.

### 3. Characterization:

ZIF-8 was analyzed using X-ray diffraction (XRD) with  $\text{CuK}\alpha$  radiation on a Bruker D8 Advance diffractometer at room temperature. Measurements were performed with a step size of  $0.02^\circ$  over a  $2\theta$  range of  $2^\circ$  to  $50^\circ$ .

Also, Fourier-transform infrared (FT-IR) spectroscopy was performed utilizing KBr pellets, with spectra recorded within the extend of  $4000\text{--}400\text{ cm}^{-1}$  on a Nicolet 6700 infrared spectrometer (Nico, USA).

### 4. Results and discussion:

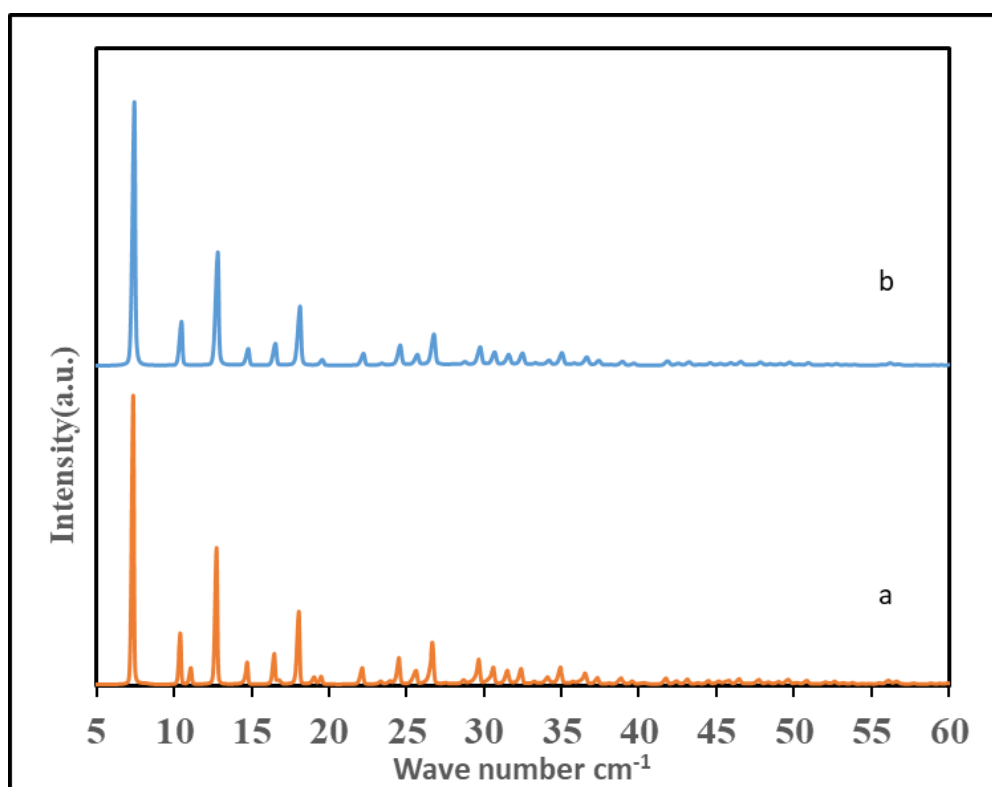
#### An investigation of the synthesized ZIF-8 XRD Studies

The excited design of the ZIF-8 structure was in excellent agreement with the X-ray diffraction (XRD) designs of all ZIF-8 tests [(a)–(b)] produced in this study (Fig. 1). The ZIF-8 samples synthesized using different solvents (DMF and MeOH) are shown in Fig. 1. All samples displayed the characteristic diffraction peaks of ZIF-8, consistent with previous reports (Li, Yao et al. 2013, Moh, Brenda et al. 2013, Lai, Yeong et al. 2016). Using a Philips PW1840 X-ray diffractometer with Ni-filtered  $\text{Cu-K}\alpha$  radiation at a filter rate of  $0.05^\circ/\text{sec}$ , phase confirmation of the solid products was carried out. Separately, 30 kV and 24 mA were set for the voltage and current. The six characteristic diffraction peaks of ZIF-8 are clearly observed at Bragg angles of  $7.44^\circ$ ,  $10.48^\circ$ ,  $12.90^\circ$ ,  $14.87^\circ$ , and  $16.63^\circ$  and  $18.24^\circ$ , corresponding to its typical crystal structure and were utilized to compute the relative crystallinities. Among all the synthesized tests, the one appearing strongest peaks, (ZIF-8.6) was chosen as

the reference, with hundred percentage crystallinity, and the relative crystallinities of the other tests were decided relative to this reference [11]. XRD design of the test affirmed the arrangement of nanosized gems. The normal measure of the requested ZIF-8 nanoparticles was assessed utilizing the Scherrer equation, which relates the complete width at half greatest (FWHM) of the XRD peaks to the nanoparticle size through the Debye-Scherrer formula.

$$D = 0.9\lambda / \beta \cos \theta \quad (\text{Eq.1})$$

where  $\theta$  is the Bragg angle,  $\beta$  is the line broadening at half maximum intensity (FWHM) in radians,  $\lambda$  is the X-ray wavelength, and 0.9 is the shape factor. Using this equation, the crystallite size of ZIF-8 synthesized with DMF was calculated to be 45 nm, while the crystallite size for ZIF-8 synthesized with MeOH was calculated to be 38 nm.



**Fig.1. XRD plots of (a) ZIF-8 by (DMF), (b) ZIF-8 by (MeOH)**

#### 4.1. FT-IR Spectra Studies

The structural characteristics and purity of all synthesized ZIF-8 tests were analyzed utilizing Fourier-transform

infrared (FT-IR) spectroscopy. The absorption band watched at  $3135\text{ cm}^{-1}$  was credited to the C-H extending vibrations of

aromatic imidazole ring. A band at  $2929\text{ cm}^{-1}$  compared to the C-H extending vibrations of the methyl group within the linker. Assimilation groups at  $1678.13\text{ cm}^{-1}$  and  $1585.54\text{ cm}^{-1}$  were allotted to N-H twisting and imidazole extending vibrations, individually. Various absorption bands between  $1350$  and  $1500\text{ cm}^{-1}$  were related to the amplifying vibrations of the imidazole ring.

Absorption bands between  $900$  and  $1350\text{ cm}^{-1}$  were related with the in-plane turning of imidazole ring, though peaks underneath  $800\text{ cm}^{-1}$  were attributed to the out-of-plane turning of the imidazole ring. The "distinct absorption band at  $420\text{ cm}^{-1}$  was characteristic of Zn-N expanding mode in ZIF-8 (Hu, Kazemian et al. 2011, Zhang, Zhao et al. 2019) .

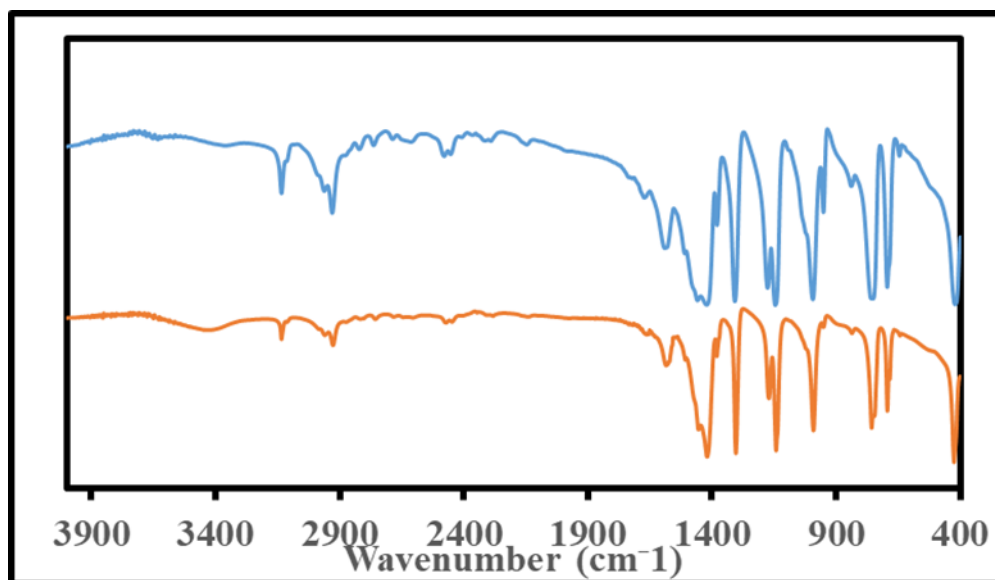


Fig.2. FT-IR spectra of the prepared ZIF-8 (a) by (DMF) ,(b) by (MeOH)

## 5. CONCLUSION:

In this consider, ZIF-8 precious stones with a uniform molecule estimate dissemination and a permeable hydrangea-like morphology were effectively synthesized utilizing the solvothermal strategy at diverse response temperatures. When the solvothermal union was conducted at  $140^{\circ}\text{C}$  for 14 hours, ZIF-8 was

arranged utilizing dimethylformamide (DMF) and methanol (MeOH) as solvents. Eminently, the utilize of methanol as a dissolvable come about in littler gem sizes of ZIF-8 compared to the utilize of DMF.

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