

Methanol and Aqueous Synthesis of ZIF-8 Metal-Organic Framework

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Introduction

- Metal-organic frameworks (MOFs) are crystalline materials that are made up of metal ions connected by organic molecules known as linkers.
- The MOF that was synthesized was zeolitic imidazolate framework-8 (ZIF-8); structure shown in Figure 1.
- Organic solvents like methanol, which are usually used to prepare ZIF-8, are more expensive and can cause environmental damage, so aqueous preparation is being studied.¹

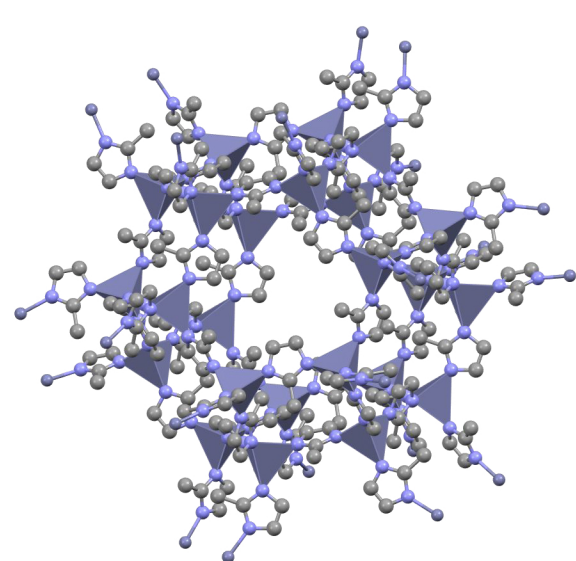


Figure 1. ZIF-8 structure. The zinc ion is within the pyramid. The 2-methylimidazole linker is made up of all other atoms shown.

Experimental

- ZIF-8 was synthesized in methanol and aqueous solutions.
- ZIF-8 was synthesized at different molar ratios of ligand to zinc.
- Zinc nitrate hexahydrate and 2-methylimidazole were dissolved in methanol and combined. The resulting solution was stirred for 1 hour, centrifuged, and rinsed with methanol. The product was then air-dried overnight.
- Zinc nitrate hexahydrate and 2-methylimidazole were dissolved in water and combined. The resulting solution was stirred for 24 hours, centrifuged, and rinsed with methanol. The product was dried at 40°C for 48 hours.

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Analysis

Fourier Transform Infrared (FTIR) Spectroscopy

FTIR is used to determine the chemical composition of a given material.

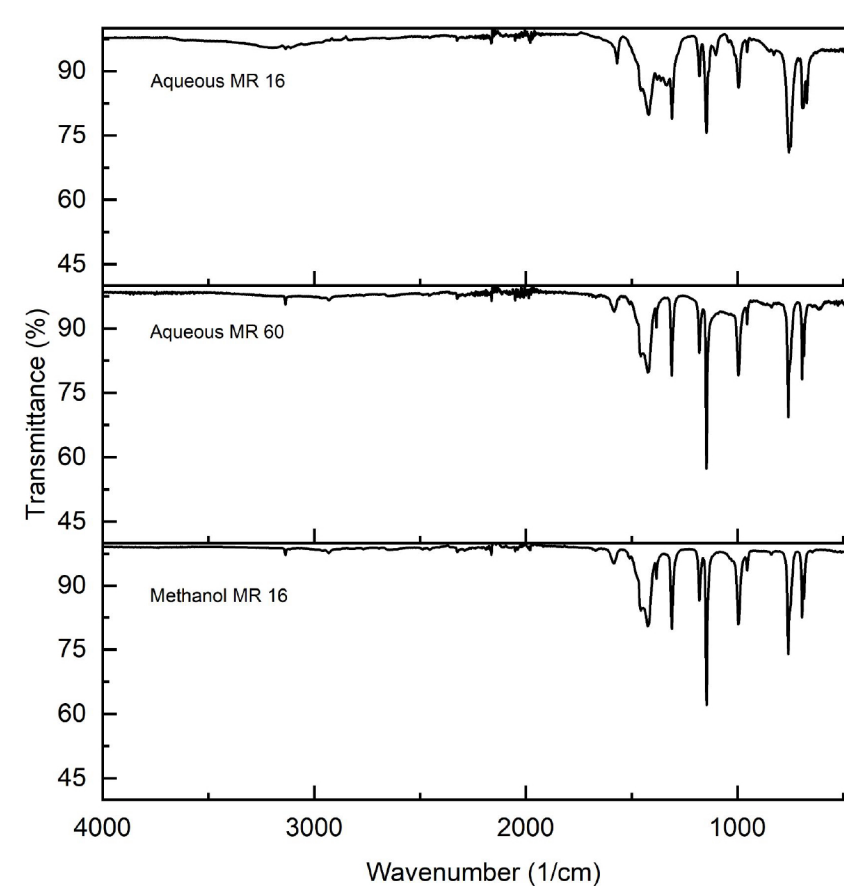


Figure 2. The FTIR spectra for the methanol synthesis and the high molar ratio aqueous synthesis are consistent with literature values for ZIF-8. The spectrum for the low molar ratio aqueous solution has mainly similar peaks but also several additional peaks, potentially indicating different bonds in this product than ZIF-8.

Powder X-ray Diffraction (pXRD)

pXRD is used to determine the crystal structure of a given material.

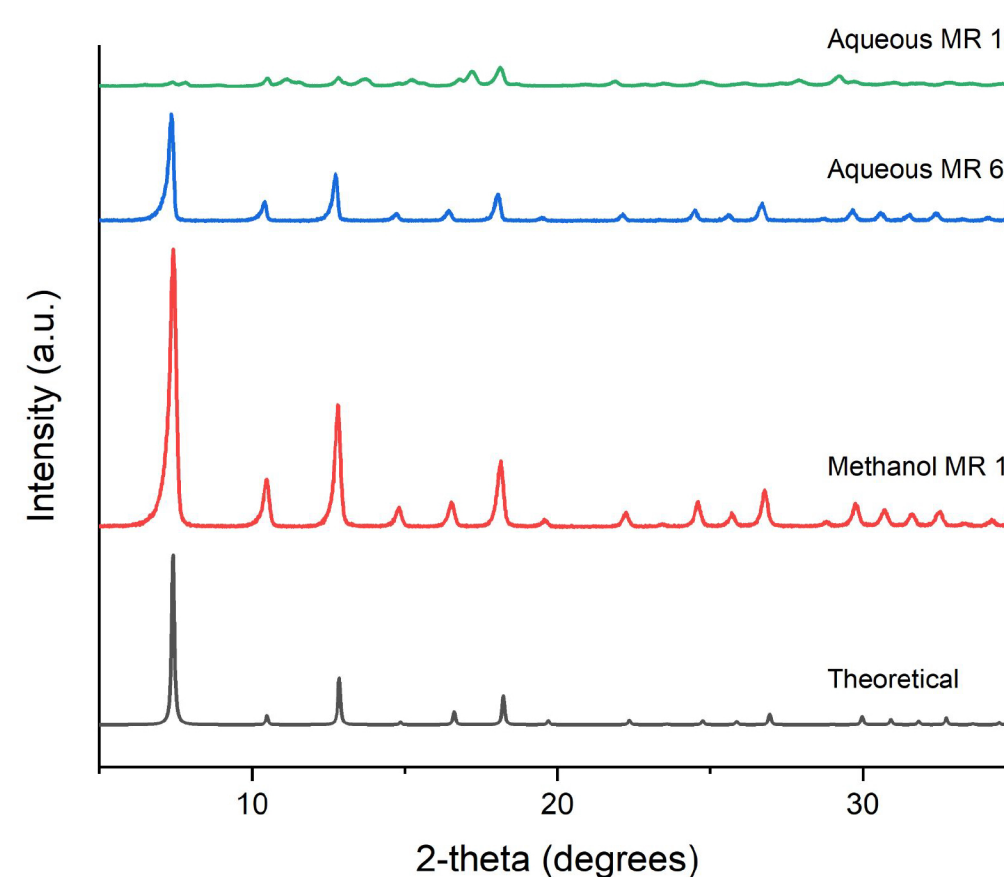


Figure 3. While the pXRD data for the methanol synthesis and the high molar ratio aqueous synthesis are consistent with the theoretical data, the data for the low molar ratio aqueous synthesis is different, indicating that there is a different crystal structure for this product than for ZIF-8.

Conclusion

ZIF-8 was successfully synthesized in aqueous solution at high molar ratios of ligand to zinc. At lower molar ratios, aqueous preparation was not successful, while methanol preparation was.

Future Research

ZIF-8 could be used to host iron nanoparticles. This composite could be used to reduce radioactive technetium waste from soluble TcO_4^- to less soluble TcO_2 , allowing it to be disposed of with other radioactive wastes.

References

1. Tanaka, S.; Kida, K.; Okita, M.; Ito, Y.; Miyake, Y. Size-Controlled Synthesis of Zeolitic Imidazolate Framework-8 (ZIF-8) Crystals in an Aqueous System at Room Temperature. *Chem. Lett.* 2012, 41 (10), 1337–1339.