How Morphology in Cyclodextrin Metal-Organic Framework Synthesis affects its Adsorption

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FEM Lab
Functionally
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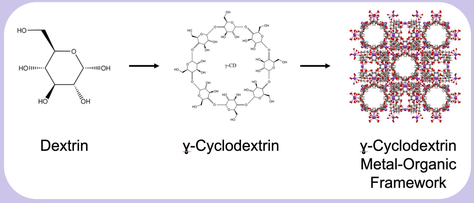
Materials

Background

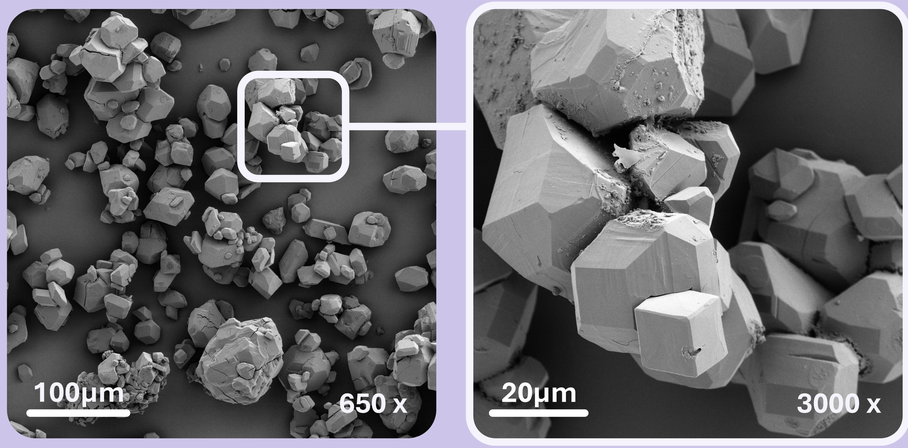
Metal organic frameworks (MOFs) are nanoporous crystal structures made of organic molecules and metal ions. They excel at capturing and storing many chemicals, which makes them great for purposes like safer gas storage, water treatment, selective absorbance, and more.

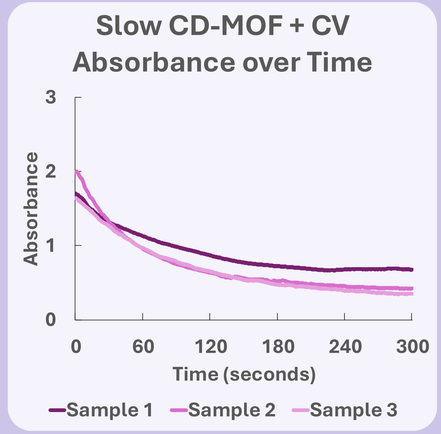
Our research focuses specifically on **gamma cyclodextrin MOFs**. Cyclodextrin is made from starch, which is common in potatoes, corn, and wheat. This availability and safeness makes it great for research purposes and everyday use.

With multiple ways to manufacture CD-MOFs, there are multiple ways these crystals can look, and even have different crystal structures. Even though the compound itself is the same, these differences can affect its properties. We study how two **different ways of manufacturing CD-MOFs affect its adsorption properties**, on the example of **crystal violet**.

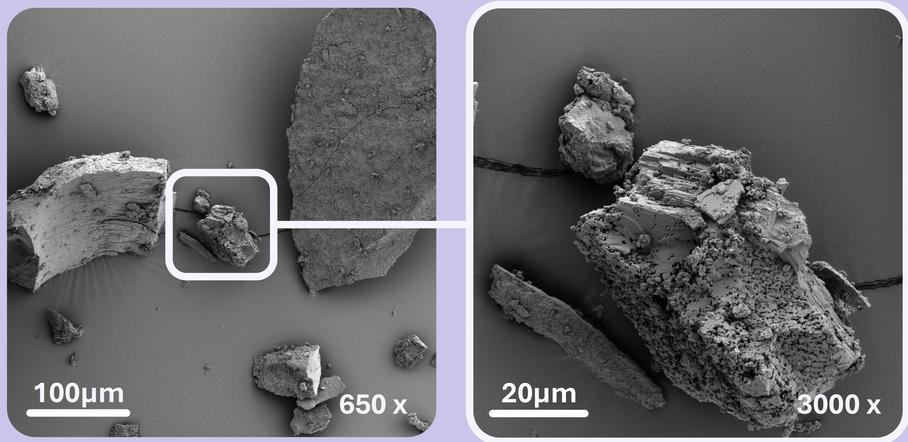


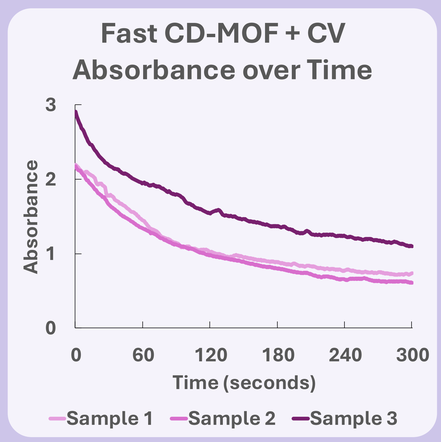
Slow Vapor Diffusion ɣ-Cyclodextrin Metal-Organic Framework





Fast Crystallization ɣ-Cyclodextrin Metal-Organic Framework





Results

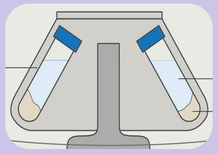
We found that the 2 CD-MOFs have the **same crystal topology**, based on PXRD, but very **different morphologies**, based on SEM. We found that CD-MOFs made by the fast crystallization method were faster at adsorbing Crystal Violet than CD-MOFs made by the slow vapor diffusion method. We believe that this is because fast CDMOFs appear to have a **higher surface** area than the slow, thus having **more nanopores exposed** to adsorb crystal violet.

There is still more we want to test with this MOF. The **charge of the dyes** and the **surface charge** of the crystal itself can play a role in which chemicals are adsorbed faster into the MOF. A **zeta potential test** could be used determine the surface charge of the crystal. This could be used to better understand the properties of CD-MOFs and to find their optimal use cases out in the world.

Due to the **simplicity and safety**, the crystal growth and dye adsorption procedures can be adapted to less professional environments. We have been developing a boiled down **SOP to be run in high school labs**. This can be used to **teach kids** about the differences between topology and morphology, and and their implications in material properties. In January, we ran an **outreach project** demonstrating this procedure. Since then, we had one **teacher reach back out to us** to get this into her class. She will be joining us this summer to help us.

Process

Fast Crystallization: Crystals are formed by adding ethanol all at the same time, leading to rough and irregular crystals crashing out.



Slow Vapor Diffusion: Crystals are formed in an ethanol vapor chamber over a long period of time, leading to well structured geometric crystals.

Adsorption testing: After testing many dyes, crystal violet (CV) has proven to be good dye for CD-MOF adsorption testing.

References

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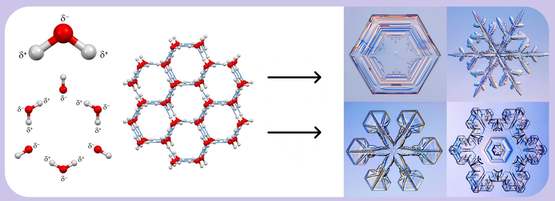
Topology vs Morphology

Topology: The connectivity and arrangement of building blocks at the molecular level.

Morphology: The shape or form of the material on a larger scale.

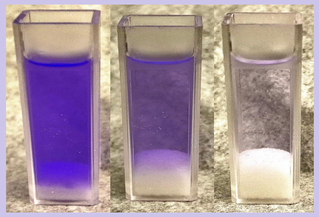


The same topology doesn't mean the same morphology!

What is UV-VIS?

Ultraviolet-visible spectroscopy (UV-VIS) is a technique to analyze the **components** of a sample, or a **reaction** within the sample. This is done by shining specific wavelengths through the sample and measuring their **absorbance/transmittance** over the **spectrum**, or over **time**.

We measured the **adsorption of crystal violet by CD-MOFs** by measuring the absorbance of **590nm light through the sample over time**. This allowed us to see the rate at which crystal violet was adsorbed into the MOF.



What is PXRD?

Powder X-ray diffraction (PXRD) is a technique to analyze the **crystal structure and composition** of a sample. This is done by measuring the **diffraction of X-rays** as they interact with the sample at different angles.

We used this technique to ensure that our two methods yielded CD-MOFS with the **same crystal structure**. In other words, that our samples had the **same topology**, and only **differed in morphology**.