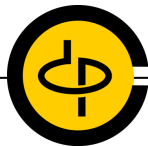


Sonication of 2D Metal-Organic Framework for Atomic Force Microscopy

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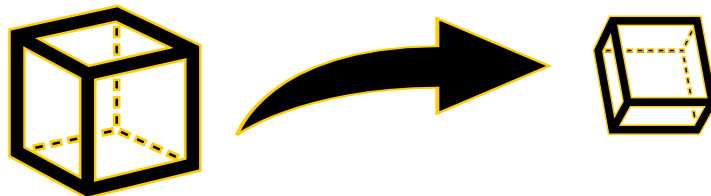
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Introduction

What if Bulk crystal of 2D MOF* is transformed into a nanosheet?

*(MOF - metal-organic framework)



Decreasing the size of MOFs to the nanometer scale is a fruitful approach to extend MOF applications



Working compound: MOF

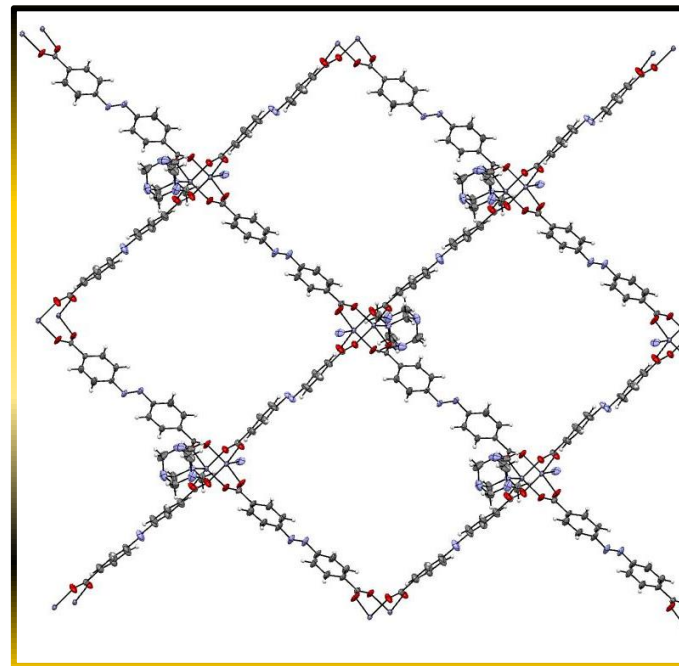
The main idea of our work is to exfoliate the nanosheets of 2D MOF via sonication process to study further the topology and mechanics by atomic force microscopy (AFM).

As working sample the CSV 153¹ MOF was chosen.

CSV 153: $[\text{Zn}(\text{ur})(\text{abcd})]_x\text{DMF}_x\text{H}_2\text{O}$

*ur – Urotropine

abcd- AzoBenzeneDiCarboxylate*



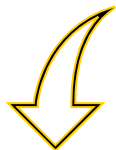
Reference:

[1] Sapchenko, S.A., Barsukova, M.O., Nokhrina, T.V. *et al.* Urotropine as a ligand for the efficient synthesis of metal-organic frameworks. *Russ Chem Bull* **69**, 461–469 (2020).



Creation procedure

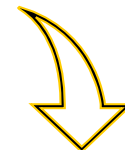
There are two approaches to create MOF nanosheets



Bottom - up



Direct assembling
of MOF from metal
ions and organic
linkers



Top - down



Sonication,
freeze-thaw,
intercalation, and milling
processes





Sonication process as a chosen method

Ultrasonic bath was used to implement the sonication process



Working frequency: 35 kHz



Time range from 10 to 30 min



Room temperature (24–25 °C)

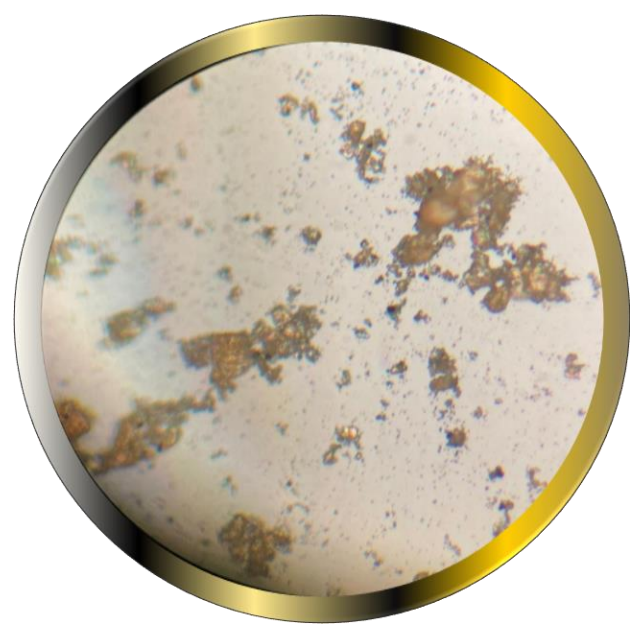


Working solvent: DMF

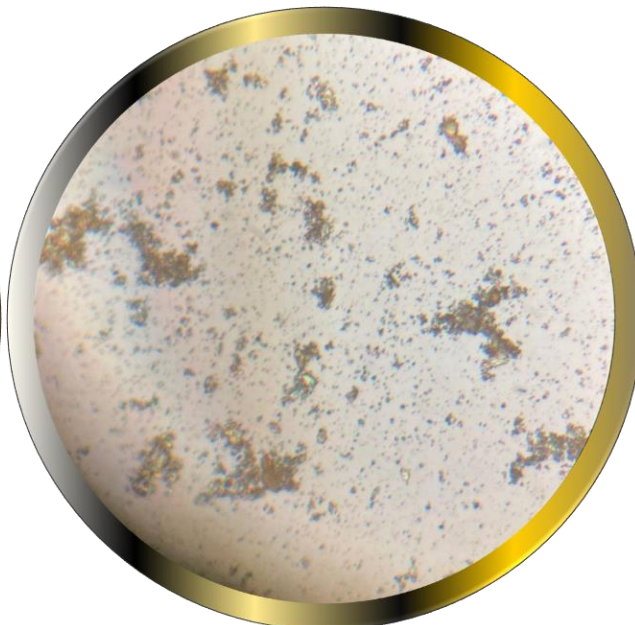




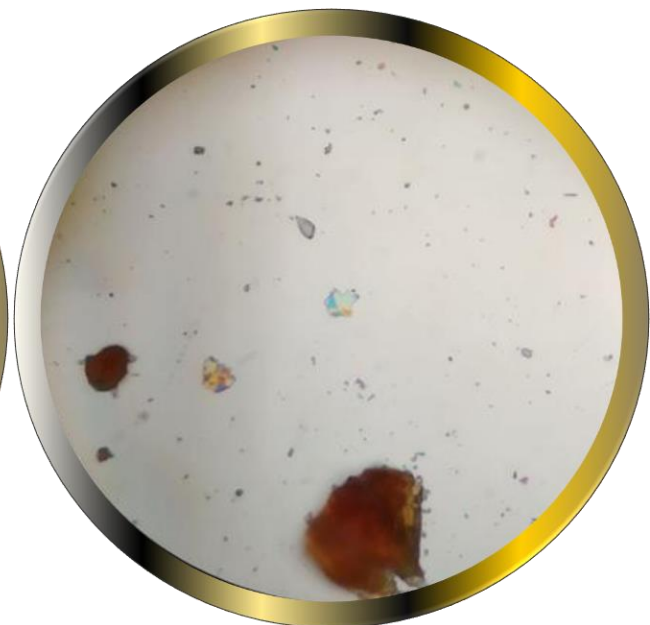
Result of sonication: optical images



○ 10 minutes



○ 20 minutes

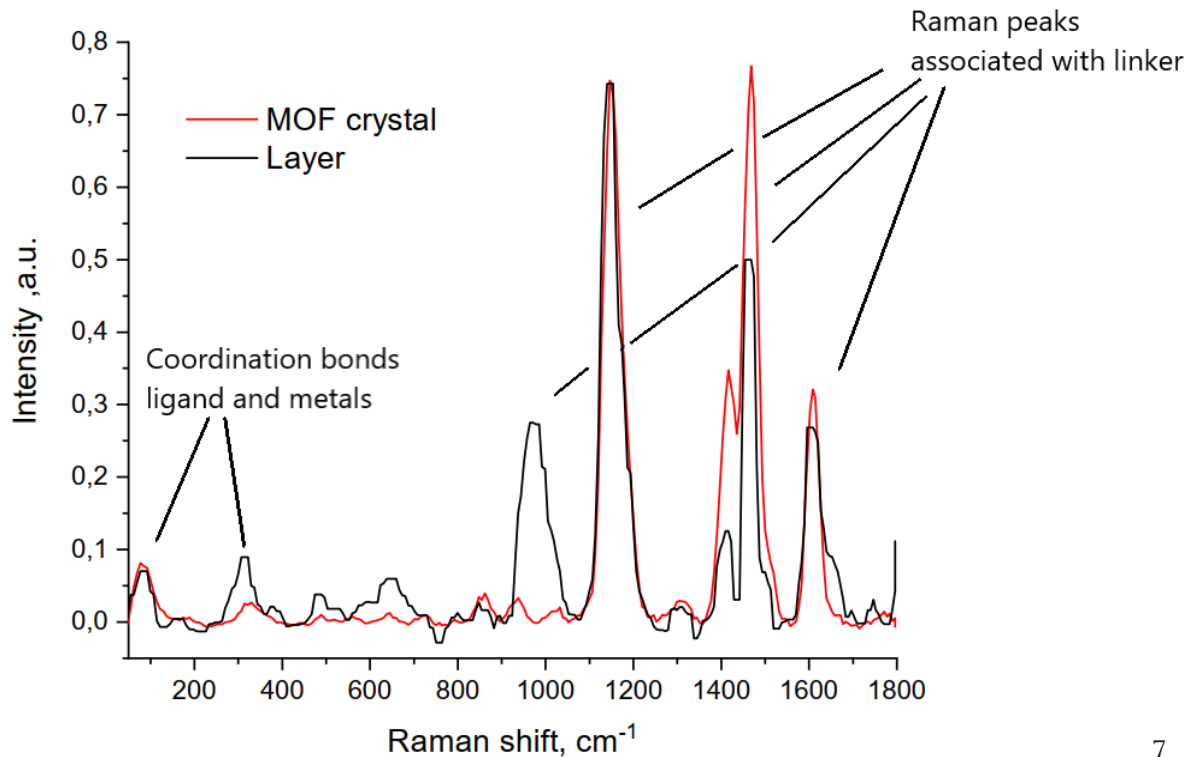


○ 30 minutes



Analysis of nanosheets: Raman

To make sure that objects from previous slide are MOF's nanosheets Raman spectra-analysis was done

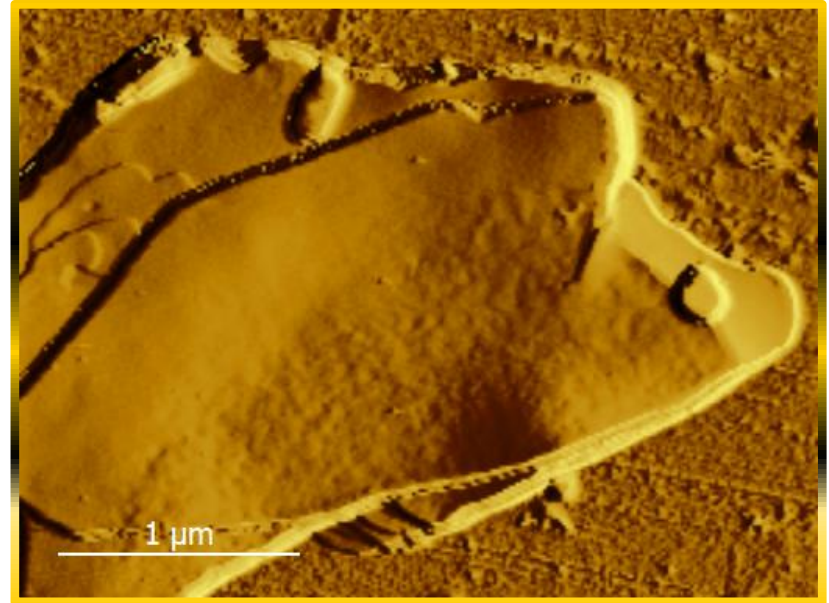




Analysis of nanosheets: AFM

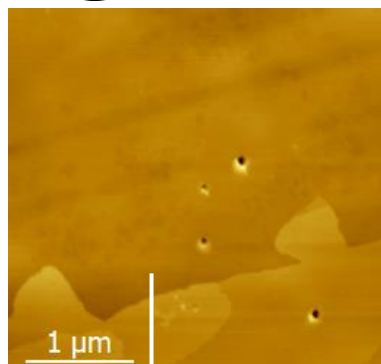
The best option to study surface topology and roughness is atomic force microscopy (AFM)

All images in this slide and next ones are represented as the Magnitude signal of AFM tip. The use of such signal is more convenient to describe small objects.

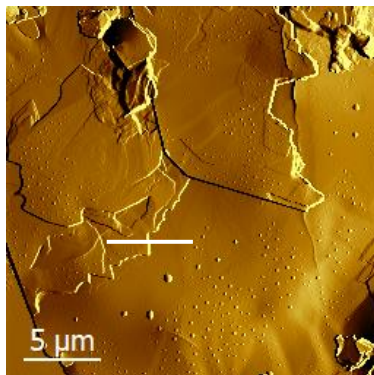
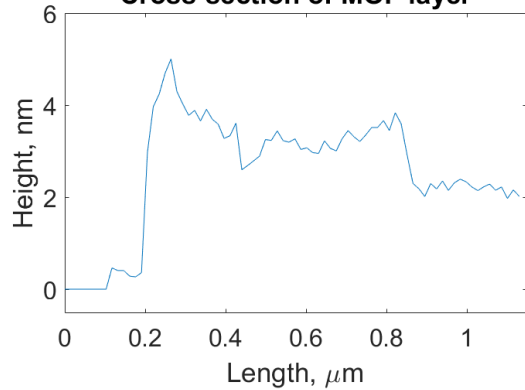




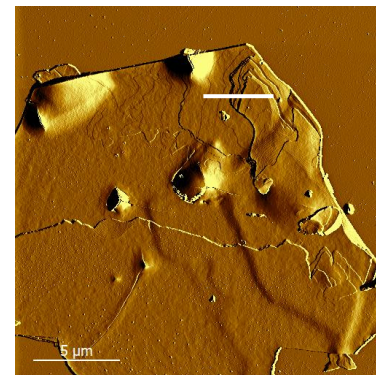
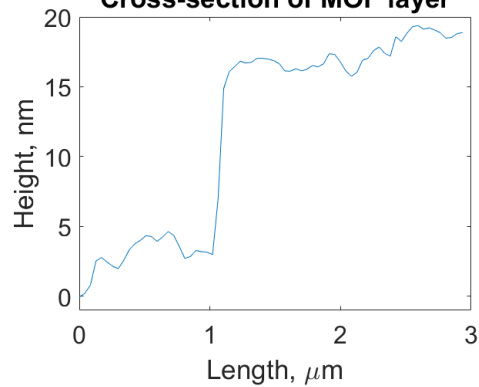
Analysis of nanosheets: AFM



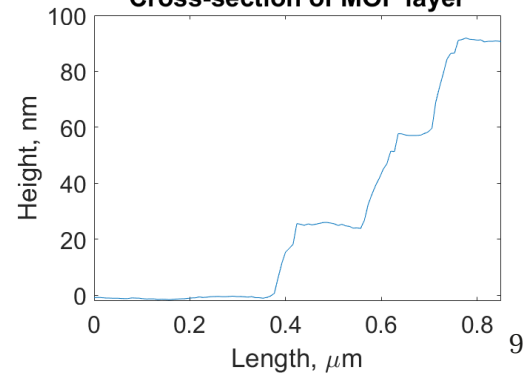
Cross-section of MOF layer



Cross-section of MOF layer



Cross-section of MOF layer



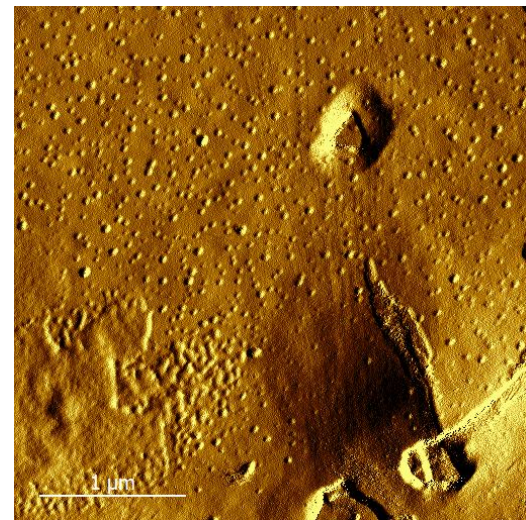
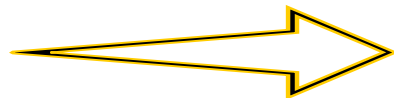


Cleaning of nanosheets

Problem:

After exfoliation procedure nanosheets are not always ready for AFM scanning

Dried solvent drops,
solvent films





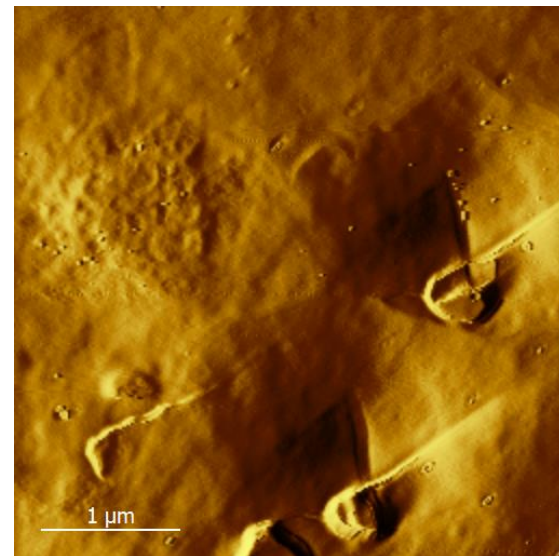
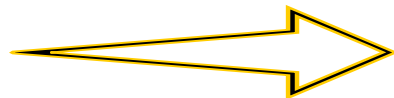
Cleaning of nanosheets

Solution:

To clean and prepare the surface of MOF for scanning the corresponding procedure was developed :

Solvent bath

Cleaned surface





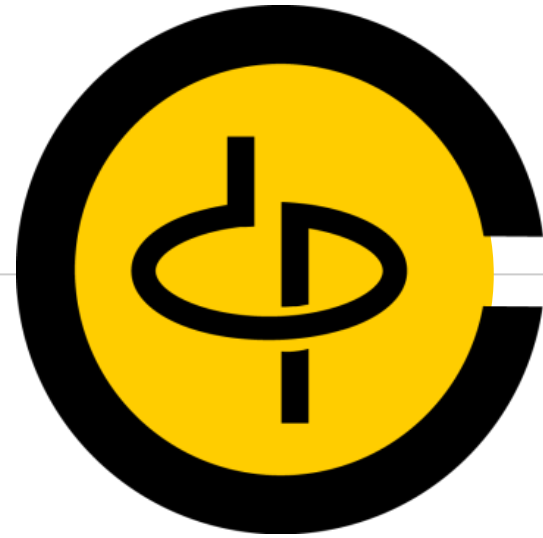
Conclusions

- Well developed exfoliation procedure to layered MOF with contaminate-free surface
 - AFM scanning and Raman analysis as checking procedure were used
 - Solvent bath was introduced as additional step for surface cleaning

Acknowledgements:

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**We are open for
collaboration!**



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