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Fabrication and Characterization of Metal-Organic Frameworks (MOFs)

Thin Films

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Metal-Organic Frameworks

Metal-organic frameworks (MOFs) consist of organic ligands linked together by metal ions. They belong to a relatively new class of highly ordered porous materials. The interest in obtaining thin films of metal-organic frameworks, has increased in the last decade because of their high surface area.

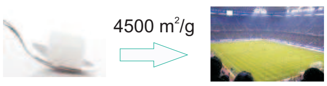
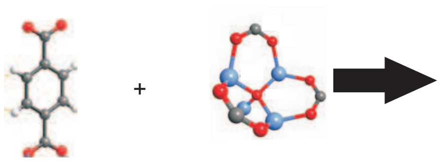
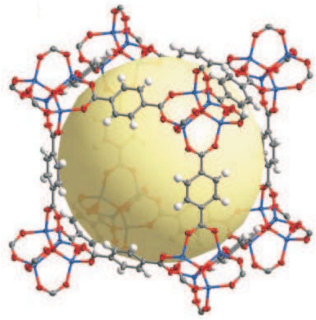


Figure 1: The surface area of the size of one sugar cube is equal to the area of half of a football field

The dimension of pores is given by the lengths of organic ligands and can be different depending on the MOF.



The MOF-5 structure consists of a cubic array of $Zn_4O(CO_2)_6$ units connected by phenylene links.



Literature: Gas Adsorption Sites in a Large-Pore Metal-Organic Framework
Jesse L. C. Rowsell,1 Elinor C. Spencer,2 Juergen Eckert,3,4
Judith A. K. Howard,2 Omar M. Yaghi1*

Figure 2: Structure of MOF-5 unit cell

Growth of MOF thin films on surfaces

The growth of these MOF materials on surfaces (SURMOFs) is a key step, which is considered crucial for applications in the field of nanotechnology, ranging from hydrogen and other energy storage to the delivery of therapeutic agents in medicine and the manufacturing of sensor devices.

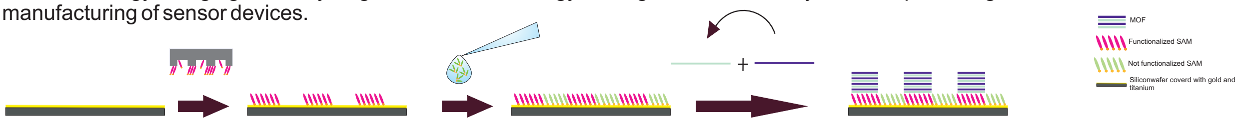


Figure 3: For the growth of SURMOFs on surfaces it is necessary to have a well ordered self-assembled monolayer (SAM) with the right functional head-group as a basis for it. In this case µCP was used to pre-pattern the surface with an active SAM and then incubate in a second SAM which is inactive.In order to grow the SURMOF selectivly on the active SAM.

Analysis with an AFM, correlated with an fluorescent inverse microscope

µCP was used to laterally pre-pattern the surface in order to study the selective growth of MOF which allows determining the rate of SURMOF growth.

a) b)

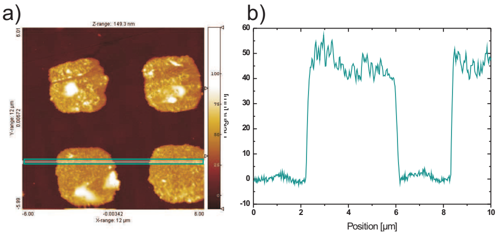


Figure 4: a) AFM image (height mode) of an Eu-MOF selectivly grown in 10 layers on a µCP pre-patterned surface with active mercaptohexadecanoic acid and inactivehexadecanethiol
b) Height profile of the MOF

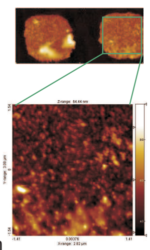


Figure 6: AFM image zoom of Figure 4 for roughness analysis.
Data you can define out of this AFM image are for example:

Sa	**6,15 nm**	*Roughness average*
Sq	**7,75 nm**	*Root mean square (RMS).* *The Root Mean Square Gradient is the RMS - value of the surface slope within the sampling area.*
Ssk	**0.867**	*The Surface Skewness describes the asymmetry of the height distribution histogram.*
Sku	**4.26**	*The Surface Kurtosis describes the "peakedness" of the surface topography.*
Sy	**64.4 nm**	*They are defined as the height difference between the highest and lowest pixel in the image.*
Sz	**53.2 nm**	

a)

b)

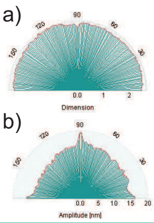
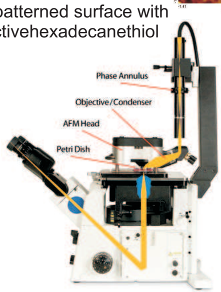
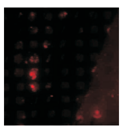


Figure 5:
In this diagramm the dimension of MOF growth is shown by the analysis with the AFM.
a) The fractal dimension
b) The texture direction index





In this case the Eu-MOF linkers are fluorescent. With the combination of an invers fluorescence microscope and an AFM it is possible to detect the fluorescence at the wavelenght of ~300cm^{-1}in addition to the topgography.

Figure 7:
Fluorescence of the EU-MOF and the AFM

Acknowledgements
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