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BORESKOV INSTITUTE OF CATALYSIS

$CaCl_2$-MIL-101(Cr) composite as adsorbent for potable water extraction from the atmosphere

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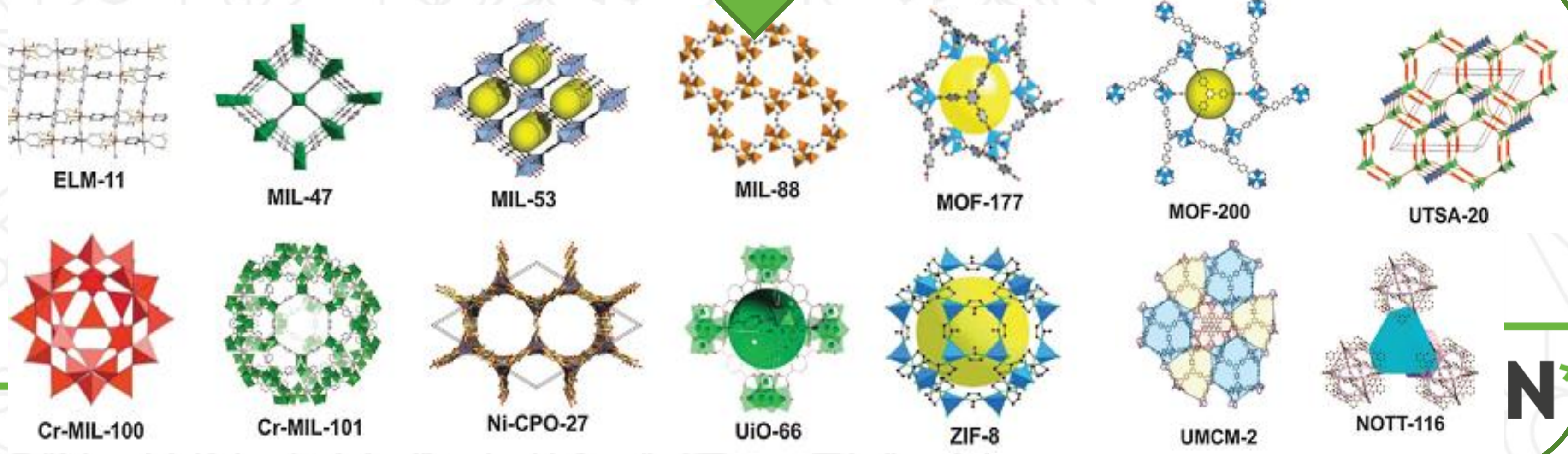
* Metal-Organic Frameworks (MOFs)

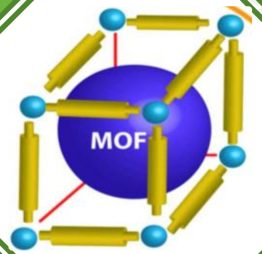
MOFs – a family of crystalline solids with permanent porosity in which the metal ions or metal-oxygen clusters are bonded through bridging organic linkers.



Metal-Organic Frameworks (MOFs)

APPLICATIONS

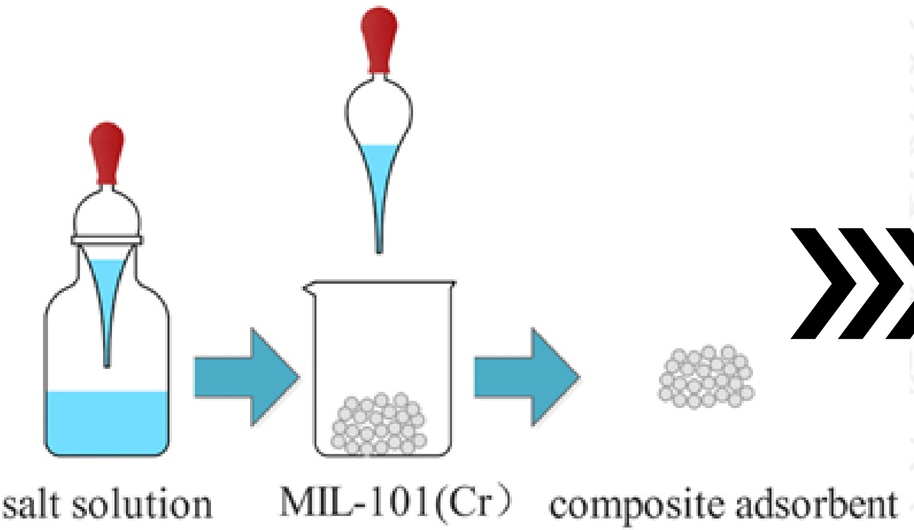
- Catalysis
- Gas storage/ separation
- Adsorption Water Extraction from Air (AWEA)
- Water purification



PROPERTIES

- Huge surface area $S = 500\text{-}4500 m^2/g$
- Large adsorption capacity
- High porosity (50-90%)
- Tunable adsorption properties

*Composites "salt inside porous matrix" (CSPMs)



Growth of the amount of water adsorbed at low relative pressure

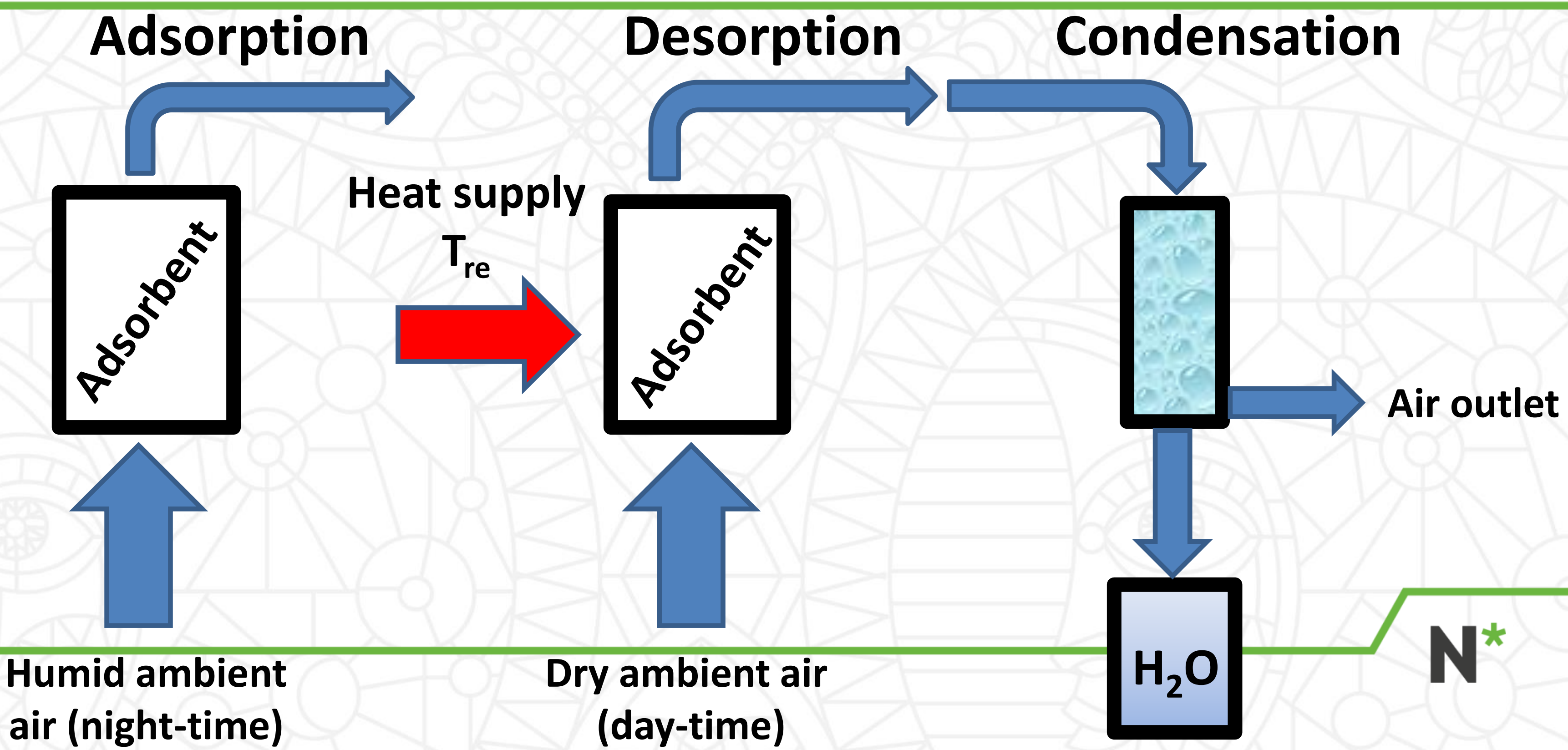
*Tan B. et al. Composite salt in MIL-101 (Cr) with high water uptake and fast adsorption kinetics for adsorption heat pumps //Microporous and Mesoporous Materials. – 2019. – T. 286. – C. 141-148.

*The aim of the work

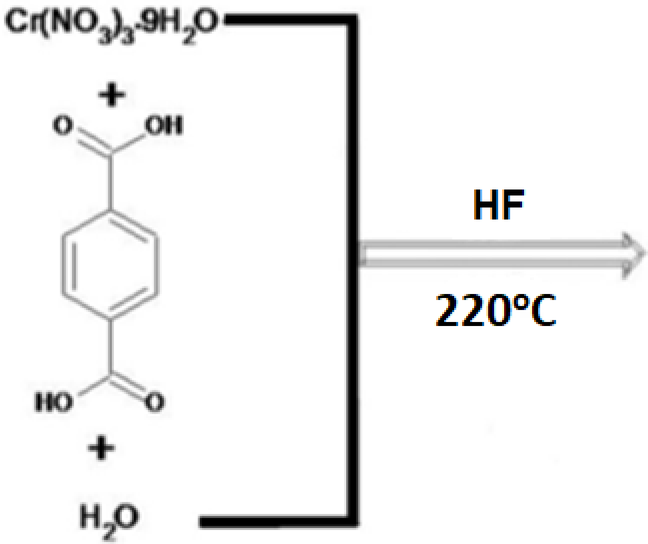
Study of CSPMs $CaCl_2$-MIL-101(Cr) as adsorbents for the process of Adsorption Water Extraction from the Air (AWEA)

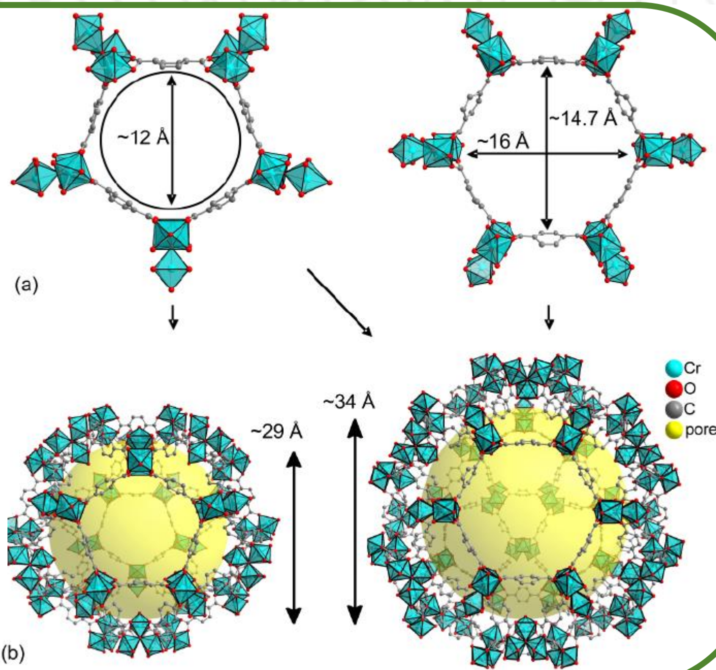
- Synthesis of $CaCl_2$-MIL-101(Cr) composites with different salt content in the composite
- Study of textural and structural characteristics as well as the morphology of composites using low-temperature N_2 adsorption, PXRD, SEM
- Study of water adsorption equilibrium on $CaCl_2$-MIL-101(Cr) by thermogravimetric analysis (TG)
- The efficiency estimation of the AWEA using $CaCl_2$-MIL-101(Cr) composites as the adsorbents

* Adsorption Water Extraction from Air (AWEA)



Synthesis of MIL-101(Cr)





G. Férey, C. Mellot-Draznieks, C. Serre, F. Millange, J. Dutour, S. Surblé, I. Margiolaki. *Science*. 309 (2005) 2040-2042.

*Synthesis of $CaCl_2$-MIL-101(Cr)

MIL-101(Cr) + $CaCl_2$ solution = CSPMs

$CaCl_2$(16%)/MIL-101 ↔ $CaCl_2$ (16)

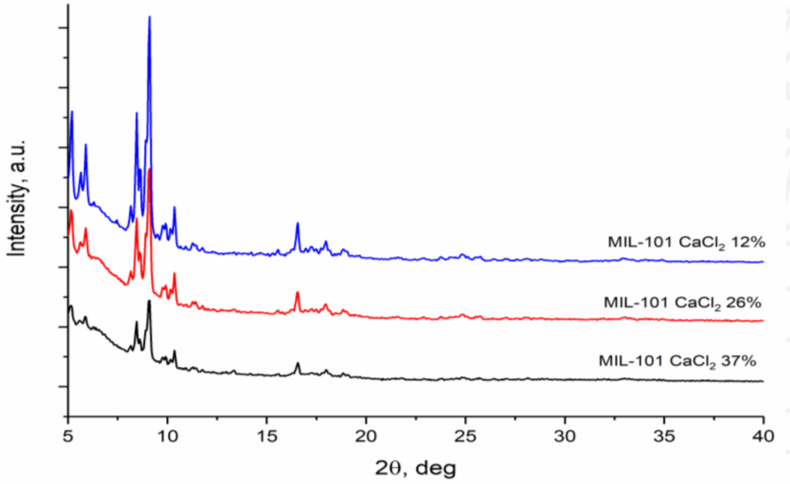
$CaCl_2$(29%)/MIL-101 ↔ $CaCl_2$ (29)

$CaCl_2$(39%)/MIL-101 ↔ $CaCl_2$ (39)

*Structural and textural characteristics of $CaCl_2$-MIL-101(Cr)

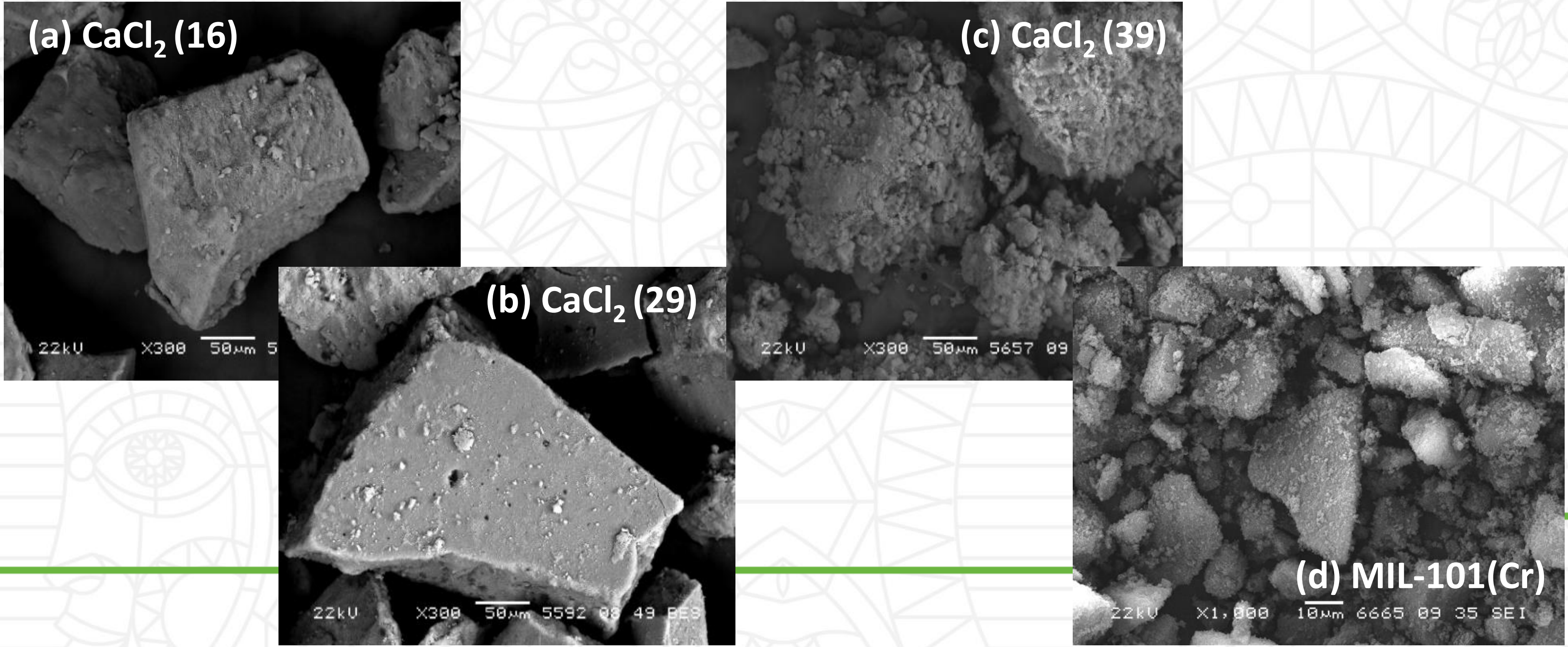
Characteristics of porous structure $CaCl_2$-MIL-101(Cr).

$CaCl_2$ content, wt%	S_{BET}, m^2/g	V_{pore}, cm^3/g
0	2040	2,00
16	1805	1,60
29	1075	1,30
39	555	1,00

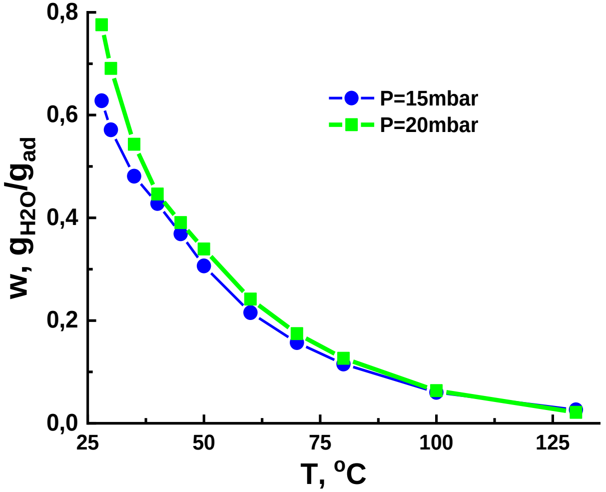


PXRD patterns of the composite $CaCl_2$-MIL-101(Cr) containing 12, 26, 37 wt% of $CaCl_2$

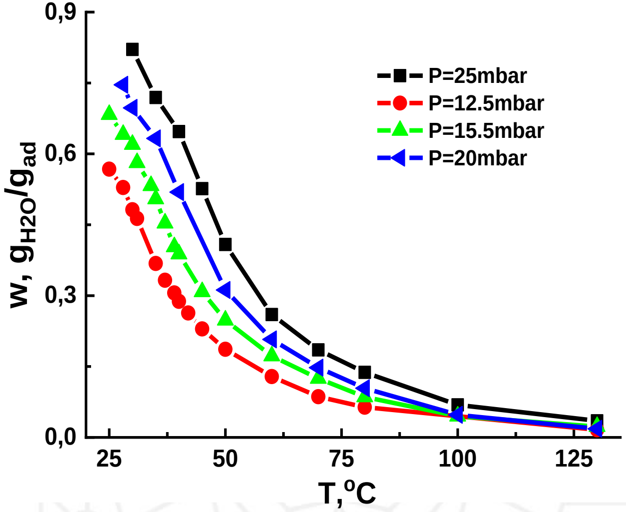
* Structural and textural characteristics of the studied CSPMs



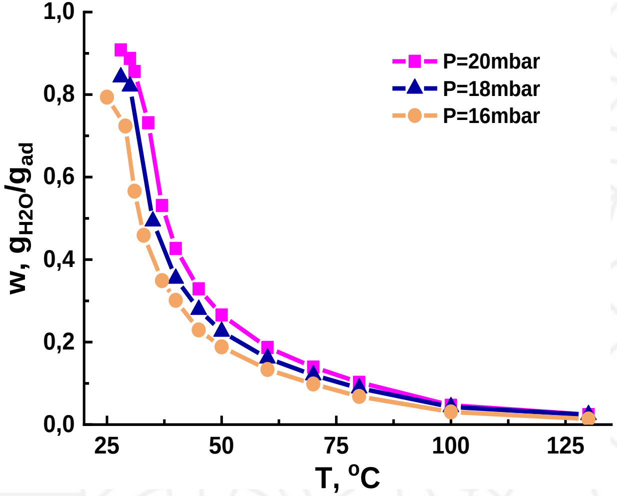
* Water adsorption equilibrium on $CaCl_2$-MIL-101(Cr)



Isobar of water adsorption on $CaCl_2$ (39)

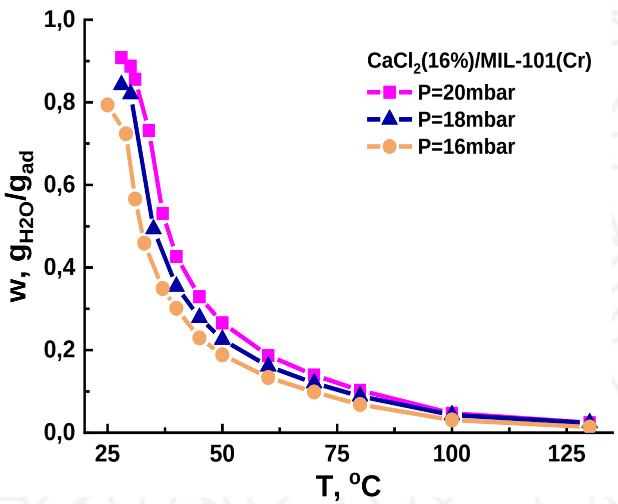


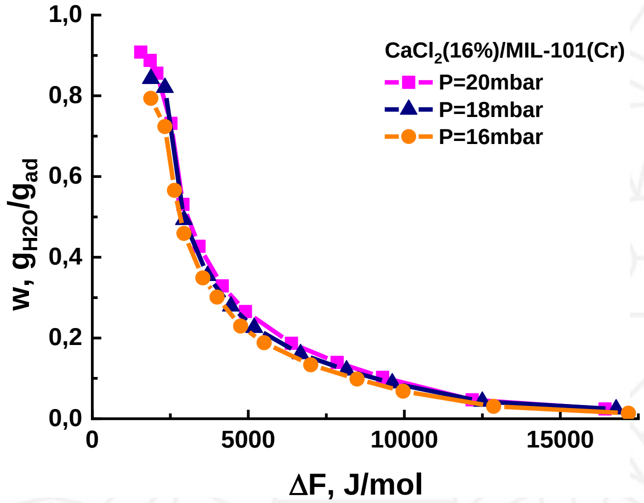
Isobar of water adsorption on $CaCl_2$ (29)



Isobar of water adsorption on $CaCl_2$ (16)

*The adsorption potential ΔF





$\Delta w = f(\Delta F)$

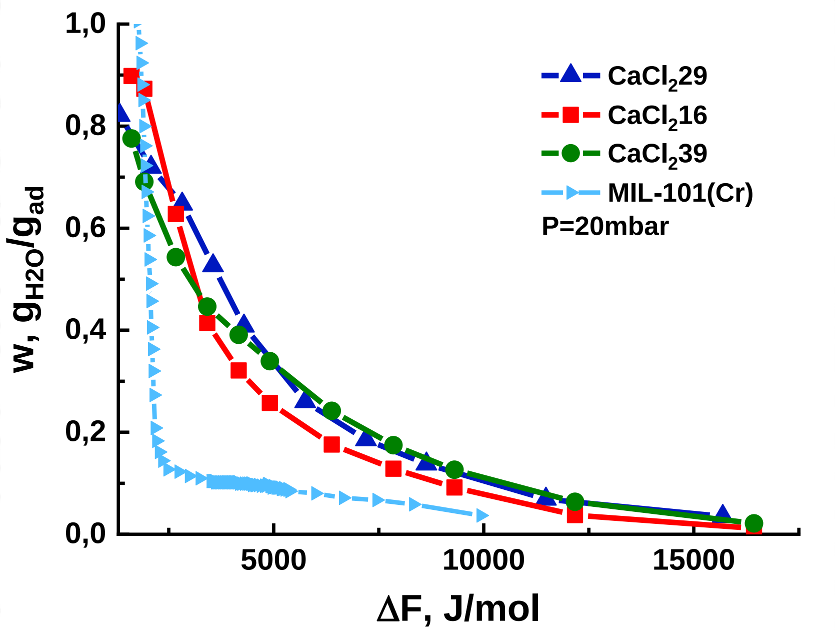
The adsorption potential $\Delta F = -RT\ln(P/P_0)$

***P* - the vapor pressure,**

P_0 - the saturation vapor pressure at temperature *T*

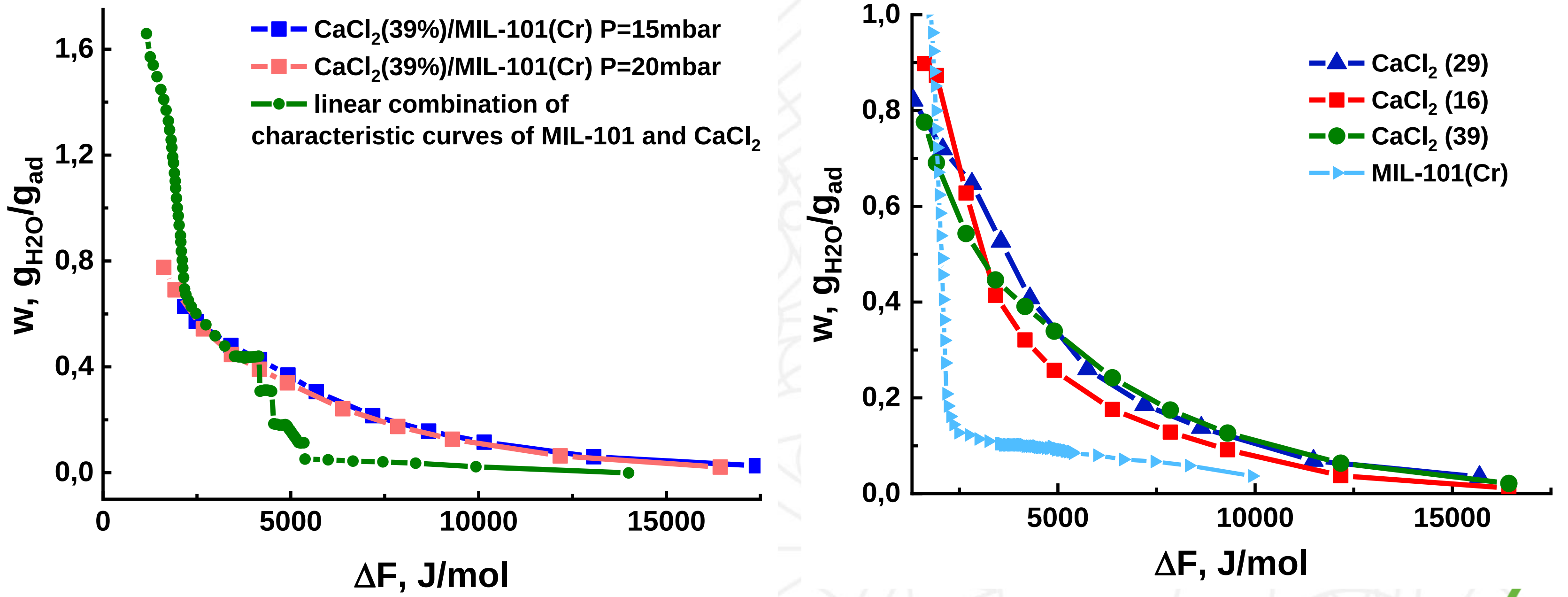
*Polani, M. (1932) Transactions of the Faraday Society no 28 pp. 316–333

*The adsorption potential ΔF



Characteristic curves for $CaCl_2$-MIL-101(Cr) and MIL-101(Cr)

*Water adsorption equilibrium on $CaCl_2$-MIL-101(Cr)



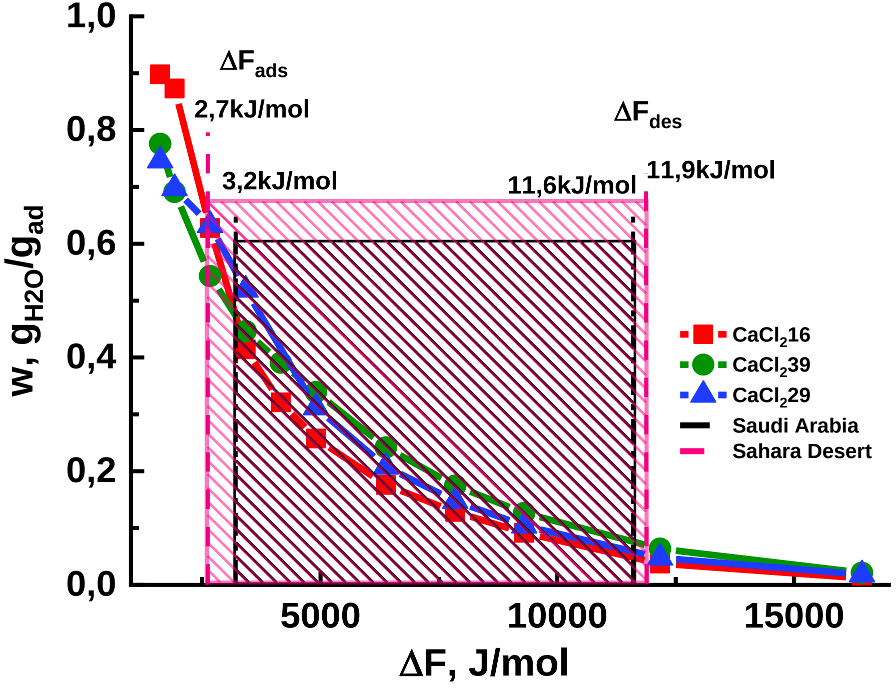
* Climatic data of Saudi Arabia (SA) and Sahara Desert (SD)

Climatic data of Saudi Arabia (SA) and Sahara Desert (SD)

Region	T_n, °C	RH_n, %	T_d, °C	RH_d, %	P_{am}
			January (wet season)		
SA	12,5	55,9	16,3	45,1	8,3
SD	11,1	33,0	14,9	27,2	4,5
			July (dry season)		
SA	32,6	20,2	36,7	16,5	10,1
SD	26,9	25,8	30,4	21,2	9,3

* Database “Meteonorm”

* Water adsorption equilibrium on $CaCl_2$-MIL-101(Cr)



Characteristic curves for composites $CaCl_2$16, $CaCl_2$ (29) and $CaCl_2$ (39) (P = 20mbar). The values ΔF_{ads} and ΔF_{des} for the operating conditions adsorption and regeneration stages in the SA and SD regions.

*Efficiency of AWEA

Efficiency of AWEA

Amount of adsorbed/desorbed water

$$\Delta w = w_{ads} - w_{des}$$

Fraction of water extracted

$$\delta_{ex} = 1 - \frac{P_{out.ad}}{P_{am}}$$

Specific Water Production

$$SWP = \Delta w \cdot \delta_{col}$$

Fraction of water collected

$$\delta_{col} = 1 - \frac{P_0(T_d)}{P_{out.re}}$$

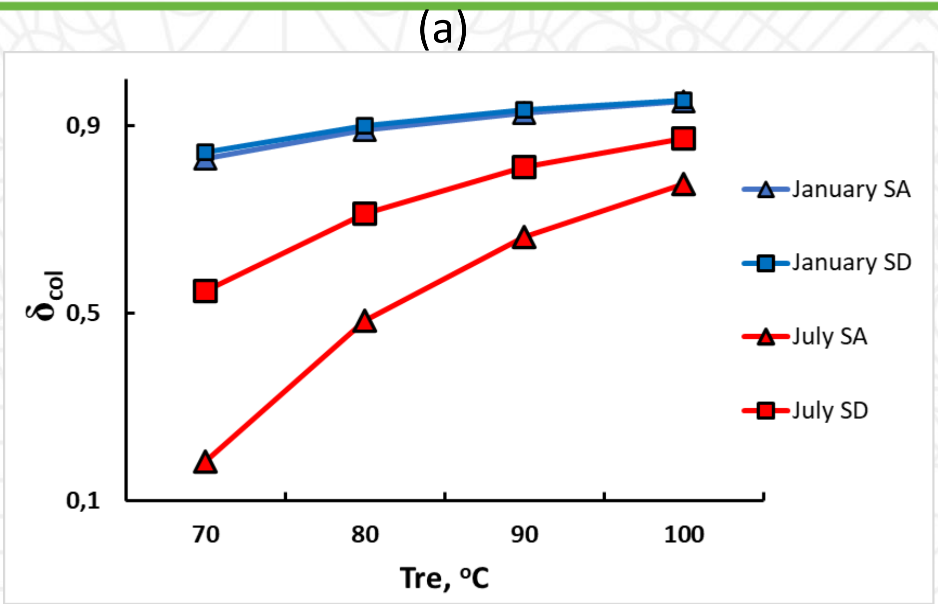
$P_{out.ad}$ – vapor pressure at the adsorption stage

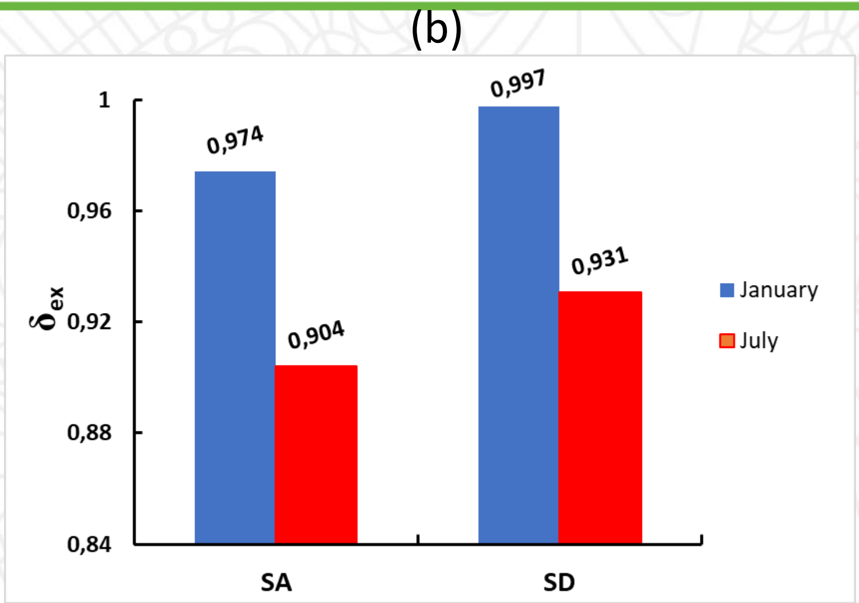
P_{am} – partial water vapor pressure of ambient air

$P_{out.re}$ – vapor pressure at the desorption stage

$P_0(T_d)$ – the saturation vapor pressure at temperature T_d

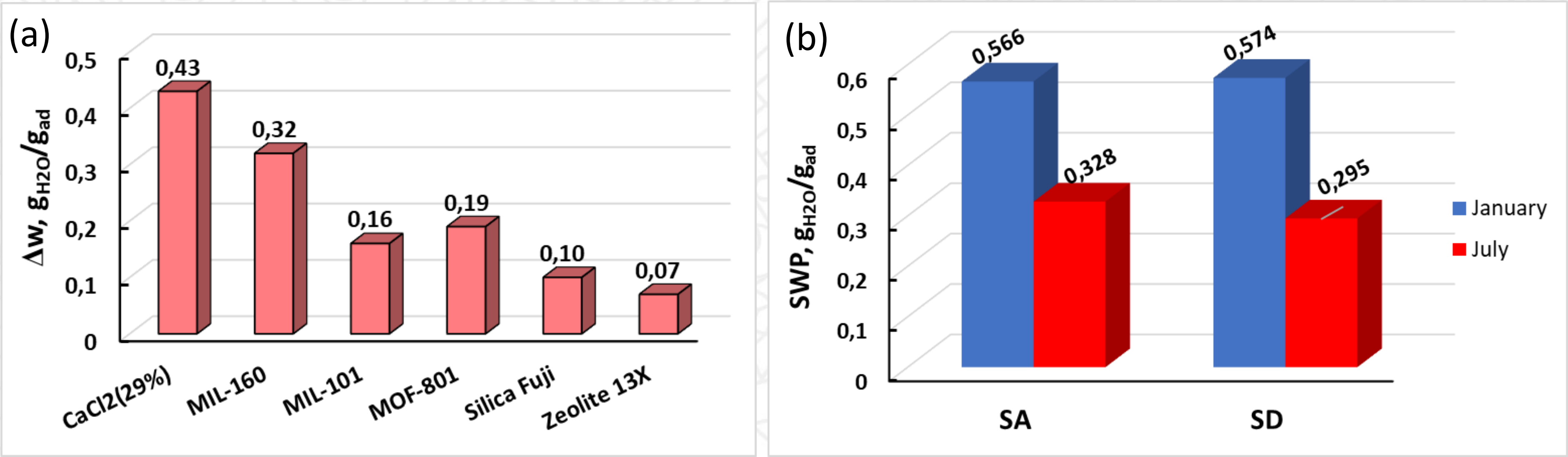
* Efficiency estimation of the AWEA employing $CaCl_2$ (29) as adsorbent





δ_{col}(a) and δ_{ex}(b) values for $CaCl_2$ (29) under climatic conditions of SA and SD regions

* Efficiency estimation of the AWEA employing $CaCl_2$ (29) as adsorbent



(a): Δw values for different adsorbents under climatic conditions of SA (dry season) region; (b): SWP values of AWEA

*Conclusions

CSPMs $CaCl_2$-MIL-101(Cr) with different salt content (16, 29, 39 wt%)were sinthesized

Textural and structural characteristics as well as particle morphology were studied

The synergistic effect of salt and porous matrix in the process of water adsorption was revealed

*Conclusions

Saudi Arabia:

δ_{col} = 0,83-0,95; δ_{ex} = 0,97 – January

δ_{col} = 0,18-0,77; δ_{ex} = 0,90 - July

Sahara Desert:

δ_{col} = 0,84-0,96; δ_{ex} = 0,99 – January

δ_{col} = 0,55-0,87; δ_{ex} = 0,93 - July

Potential of the composite $CaCl_2$ (29) as an adsorbent in the AWEA process was estimated

THANK YOU
FOR YOUR ATTENTION!