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Characterization of Two Fumarate based MOFs for Water based Adsorption Heat Pumps

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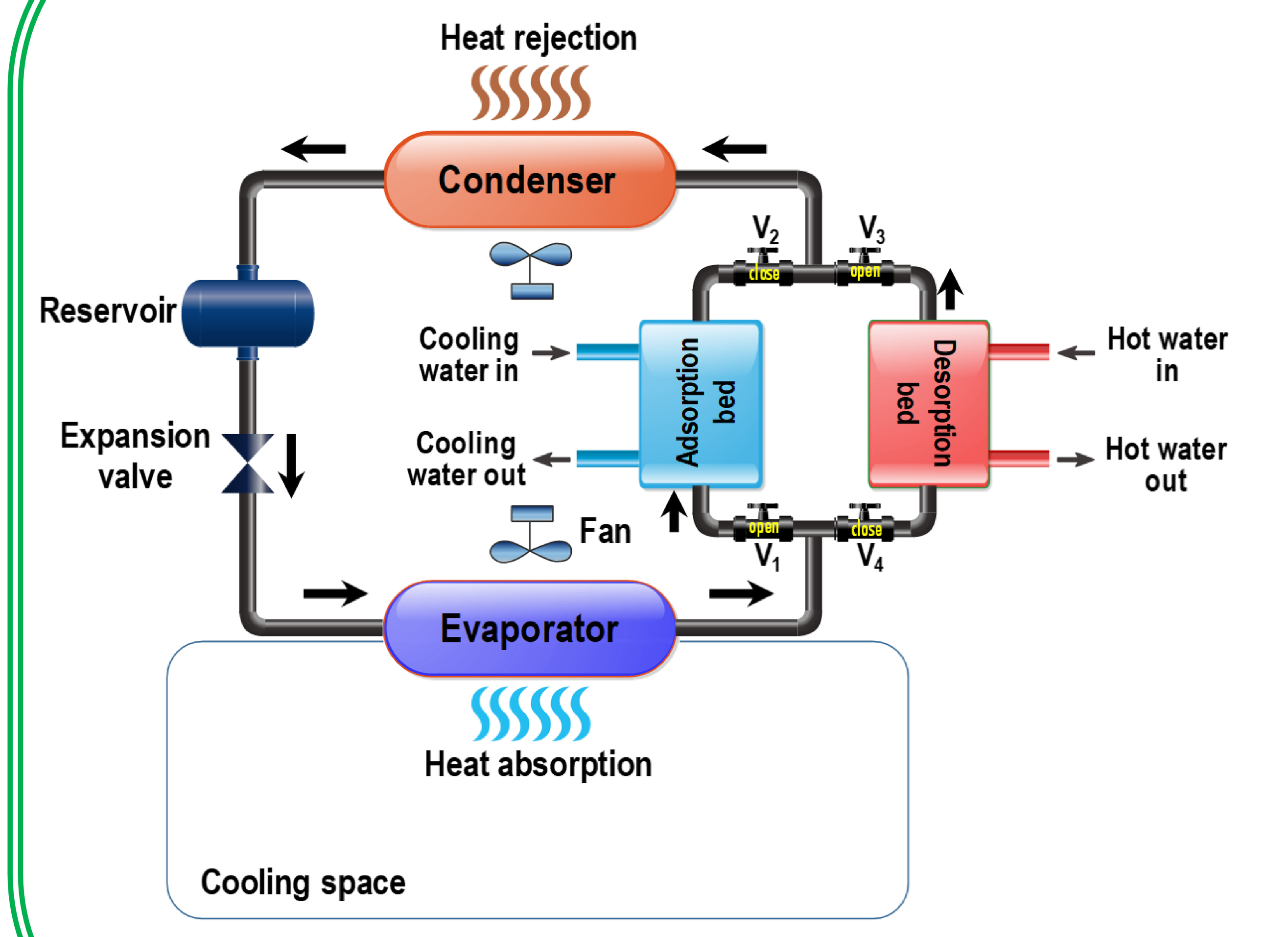
1. Introduction

Thermodynamic compatibility is one of the major issues associated with the realization of a commercial MOF/water paired adsorption cooling system. This study provides a comparative analysis of water adsorption characteristics on two fumarate based metal organic frameworks- Aluminum fumarate and MOF 801 in terms of their thermodynamic performance indicators (theoretical coefficient of performance and specific cooling effect). Both the MOFs showed improved performance than that of commonly used silica gel/water based adsorption systems. This information along with the adsorption isotherms and kinetics find immense importance in the design of an adsorption chiller.

2. Adsorption chiller and the Mathematical models



Adsorption enthalpy

$$\Delta Q_{st} = R\frac{T_1 T_2}{T_2 - T_1}\ln\left(\frac{P_2}{P_1}\right)$$

Coefficient of performance

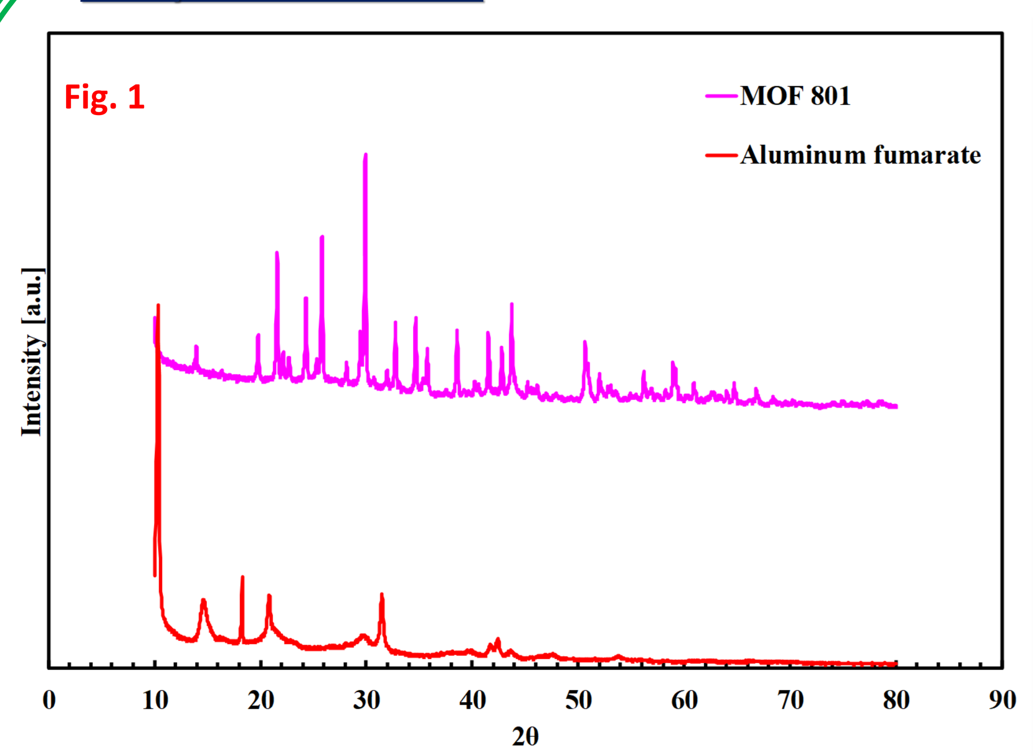
$$COP_{th} = \frac{h_{fg}(T,\theta)}{Q_{st}(T,\theta)}$$

Specific cooling effect

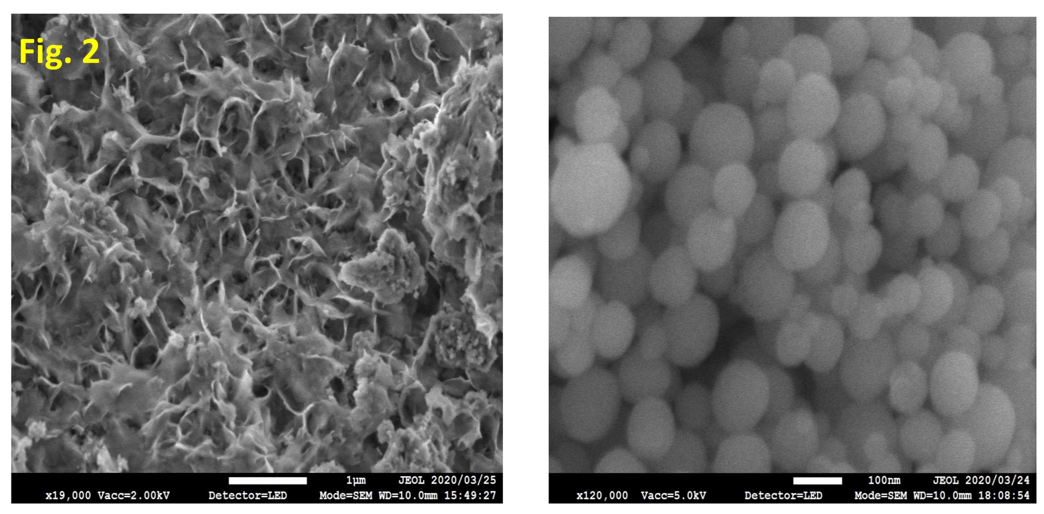
$$SCE = (W_{ads} - W_{des})\left\{h_{fg}(T_{evap}) - \int_{T_{evap}}^{T_{cond}} dh_f\right\}$$

3. Results and Discussion

3.1 Synthesis of MOFs

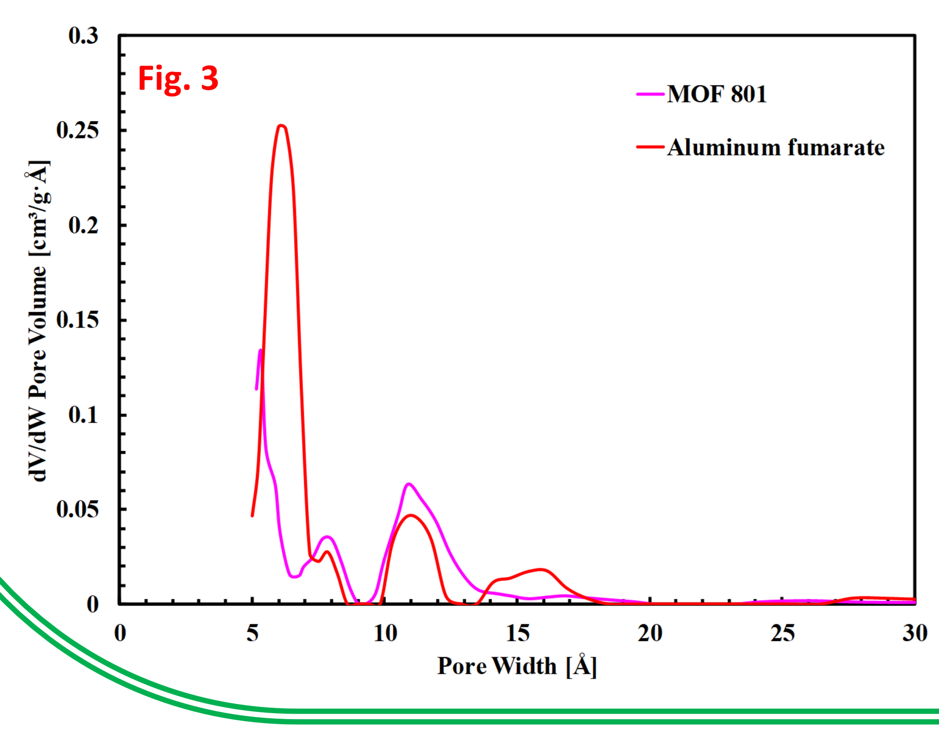


3.2 Morphological properties of MOFs

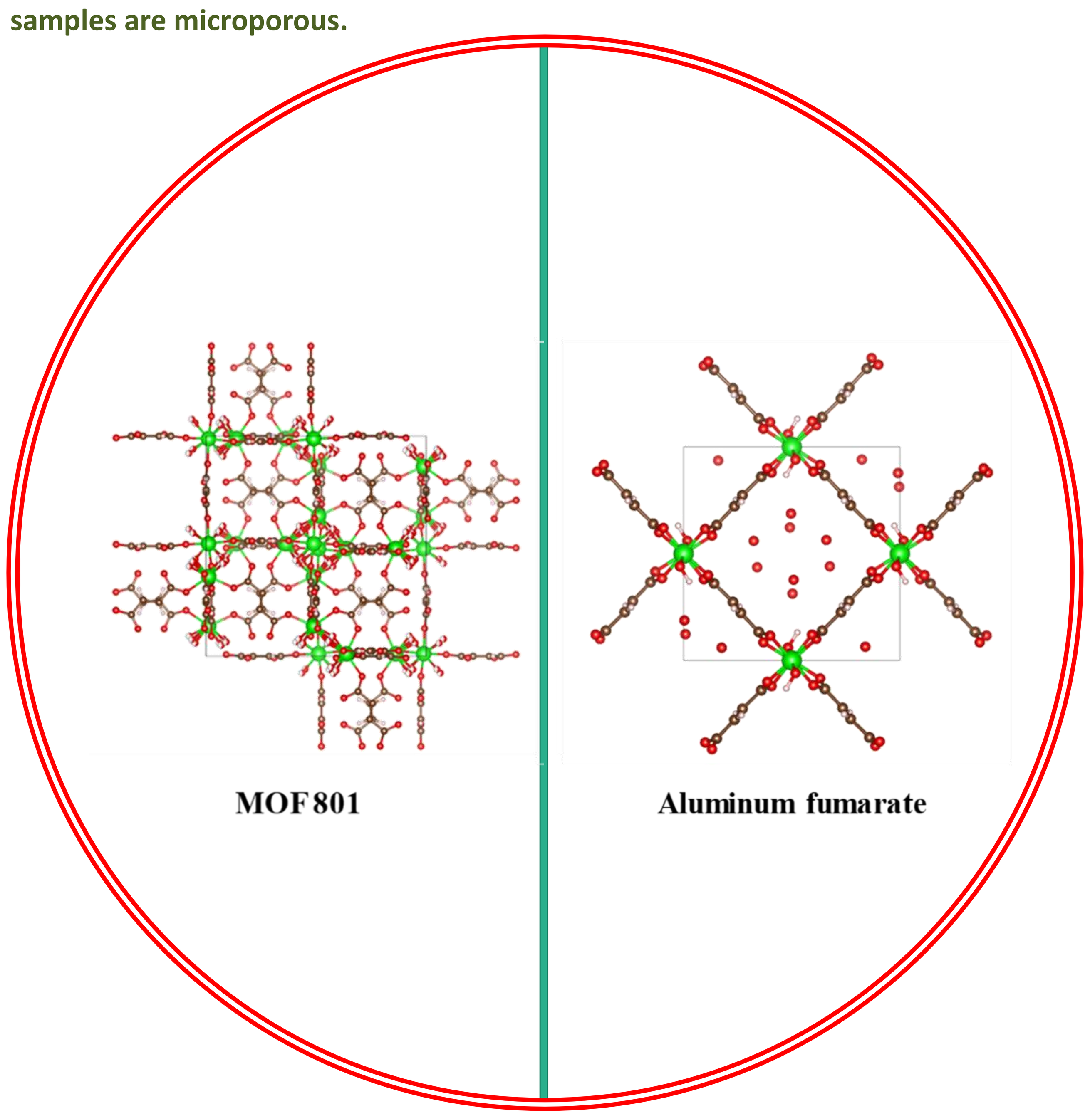


Aluminum fumarate MOF 801

3.3 Porous properties



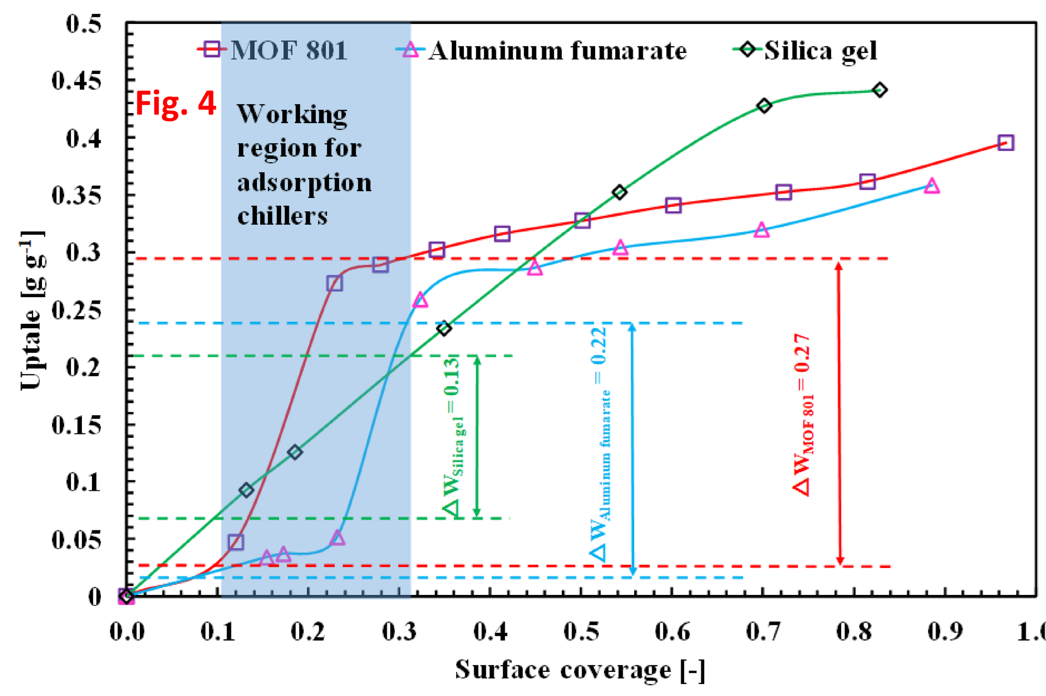
- PXRD in Fig. 1 ensured the successful synthesis of the MOFs
- Fig. 2 shows the FESEM images of the two studied samples. Micro domain sizes of Aluminum fumarate are irregular whereas, in case of MOF 801 they are spherical.
- Fig. 3 shows their pore size distributions, from where it can be concluded that the samples are microporous.



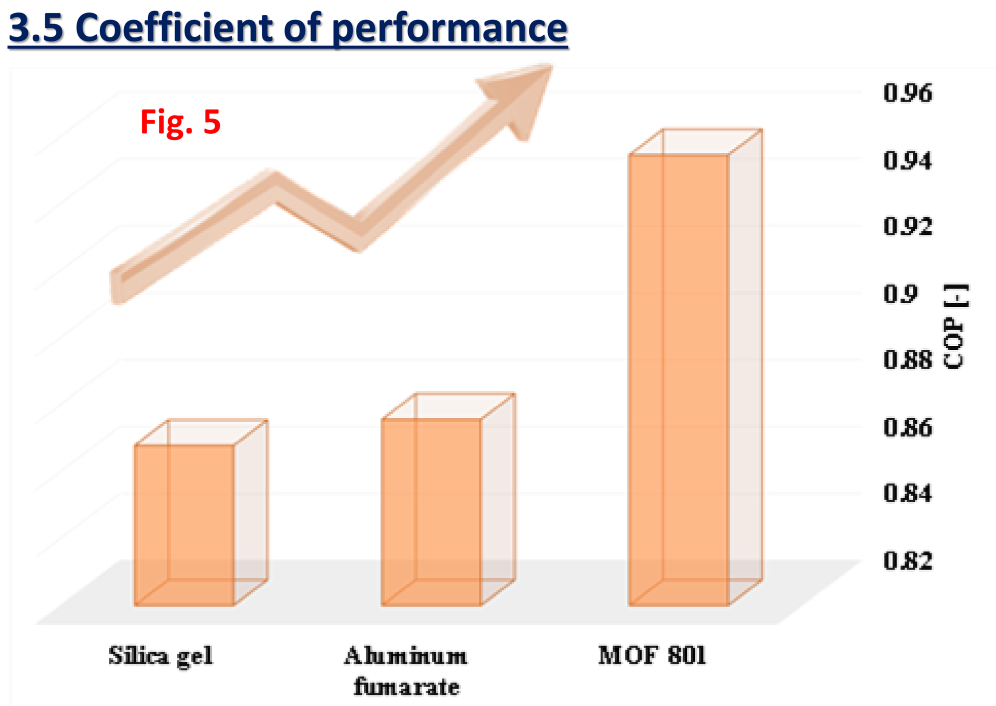
- The s-shaped water adsorption isotherms (in Fig. 4) on MOFs enabled them to have a higher net uptake (difference between adsorption and desorption uptake) than the conventional silica gel (RD type)
- Fig. 5 and 6. illustrates significant improvement of the performance indicators for both the studied MOF/water based systems over the silica gel/water based systems.

N.B. For Fig. 5 and 6, Cooling temperature was considered as 283K while having 343K as desorption temperature.

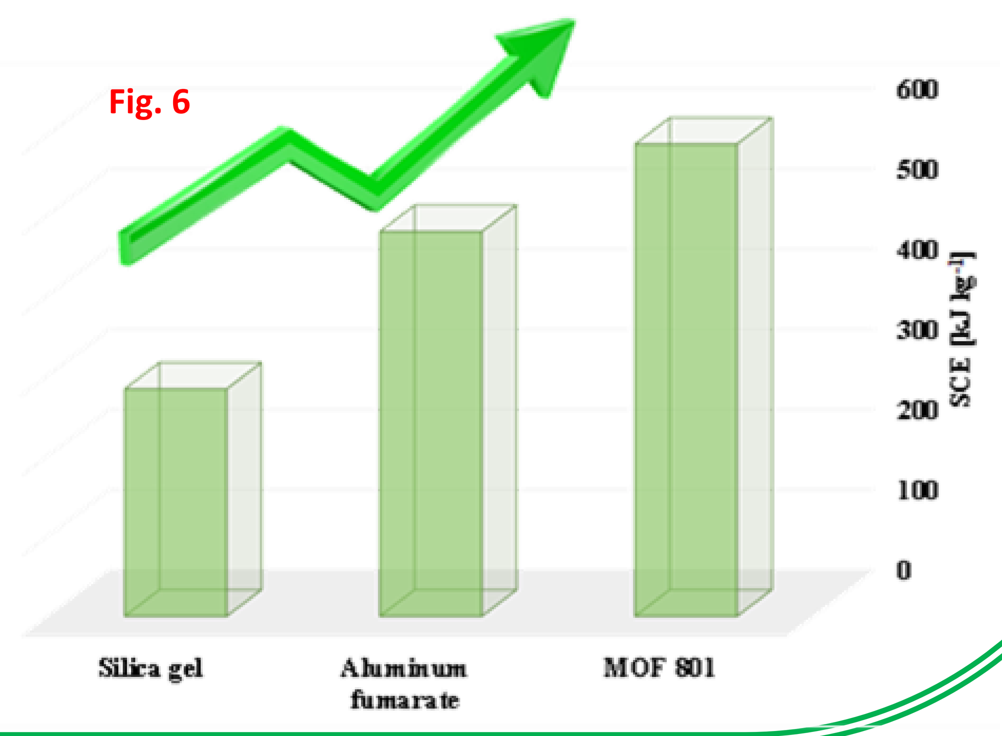
3.4 Water adsorption charactérisitcs



3.5 Coefficient of performance



3.6 Specific cooling effect



4. Conclusions

Incorporation of MOFs can bring the next revolutionary advancement in adsorption chillers. MOF 801 stands out as one of the most efficient adsorbents to this date for the practical adsorption chiller because of its having a lower release temperature and higher net uptake along with its hydrothermal stability. The SCE and COPth for both the MOFs/water pair was found higher than the silica gel/water pair. Further improvements can take place in the MOFs to increase the uptake capacity and sorption kinetics.

5. References and acknowledgements

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