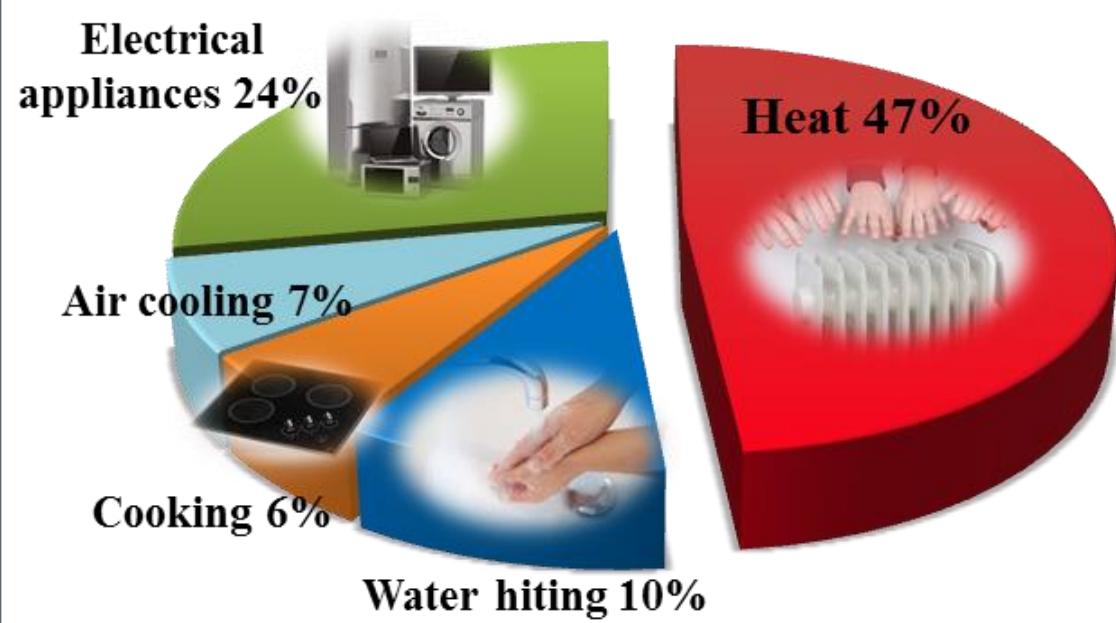


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## Context



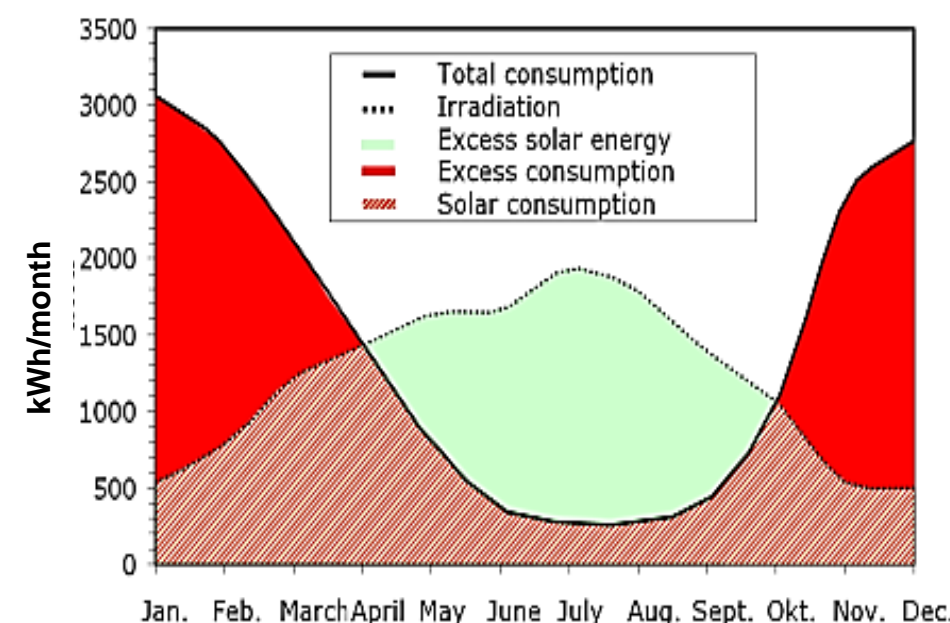
Energy consumption for households in France [1]



Reduction of utilisation

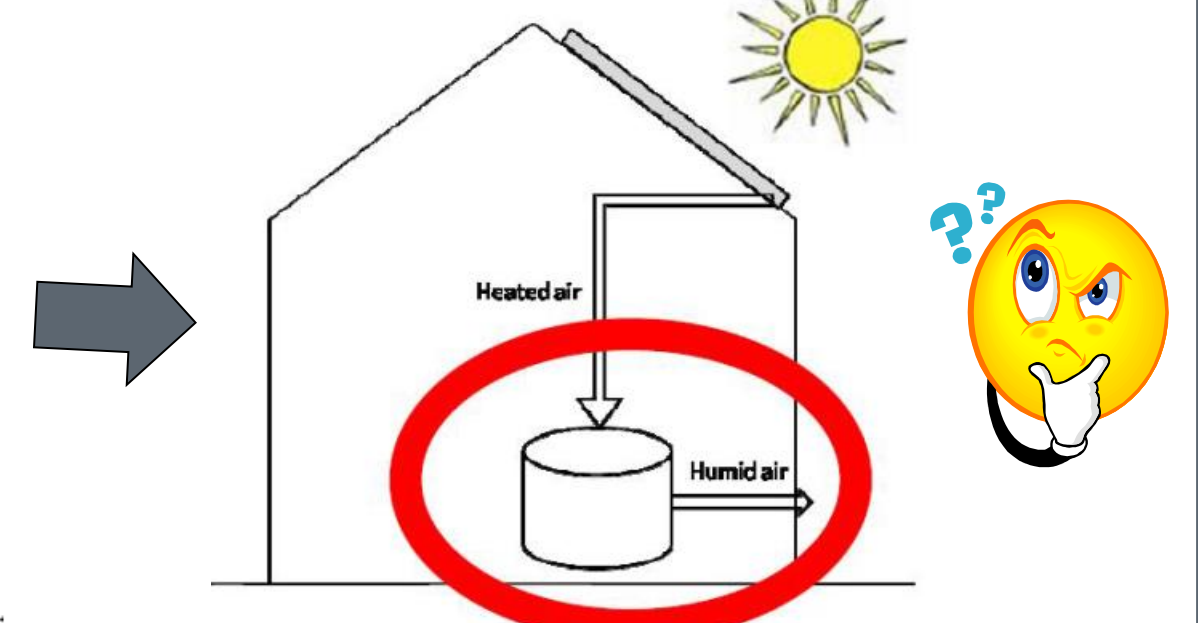


## Solar irradiation during seasons



Shift between the supply and the demand of the solar energy

## Inter-seasonal heat storage needed



## Solution

■ zeolite@  $MgSO_4$  composite [2,3]:

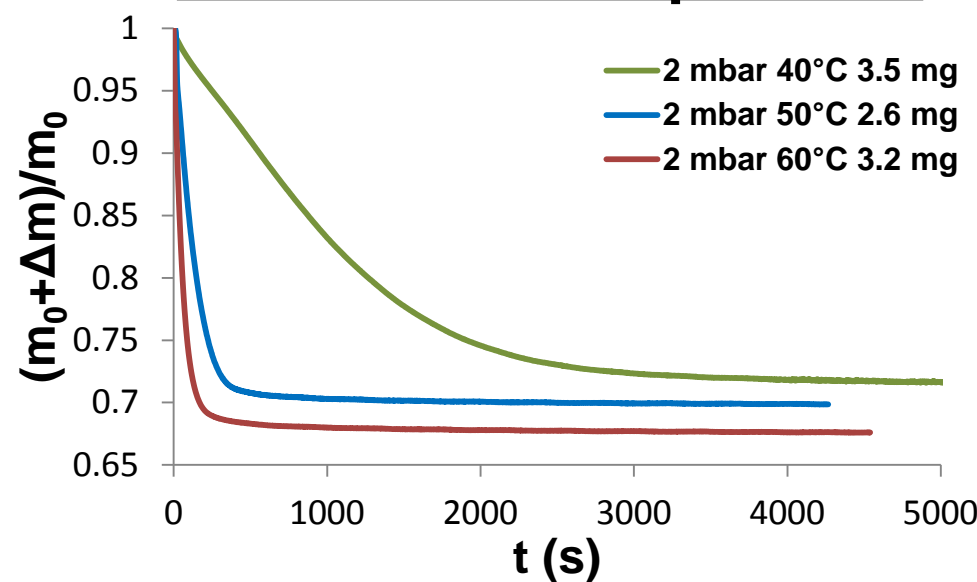
- Heat of hydration
- Energy density
- Sufficient power to a low energy building

## Objectifs

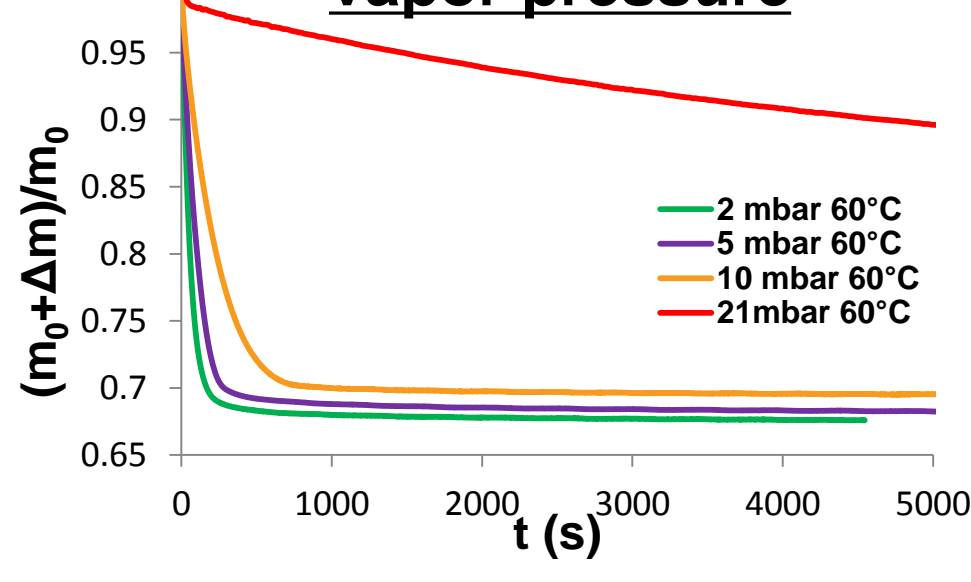
- Kinetic study of dehydration/hydration of  $MgSO_4$
- Determination of reaction mechanisms
- Analysis of coupled phenomena: kinetics (adsorption + chemical reaction) + mass and heat transfer in the zeolite@ $MgSO_4$  composite

## Thermodynamics of $MgSO_4-H_2O$ system

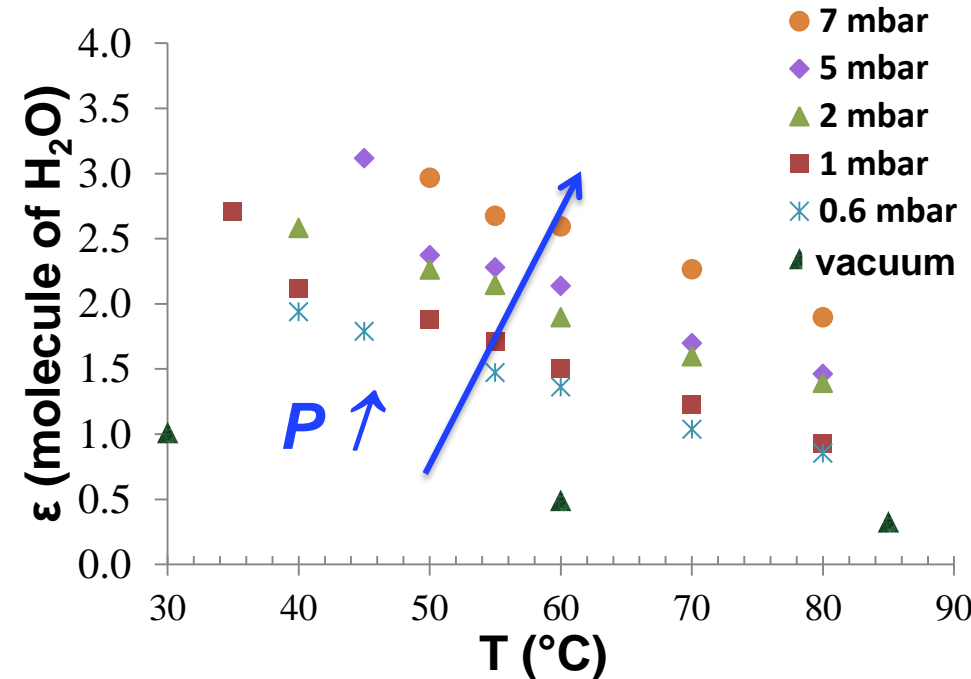
### Influence of temperature



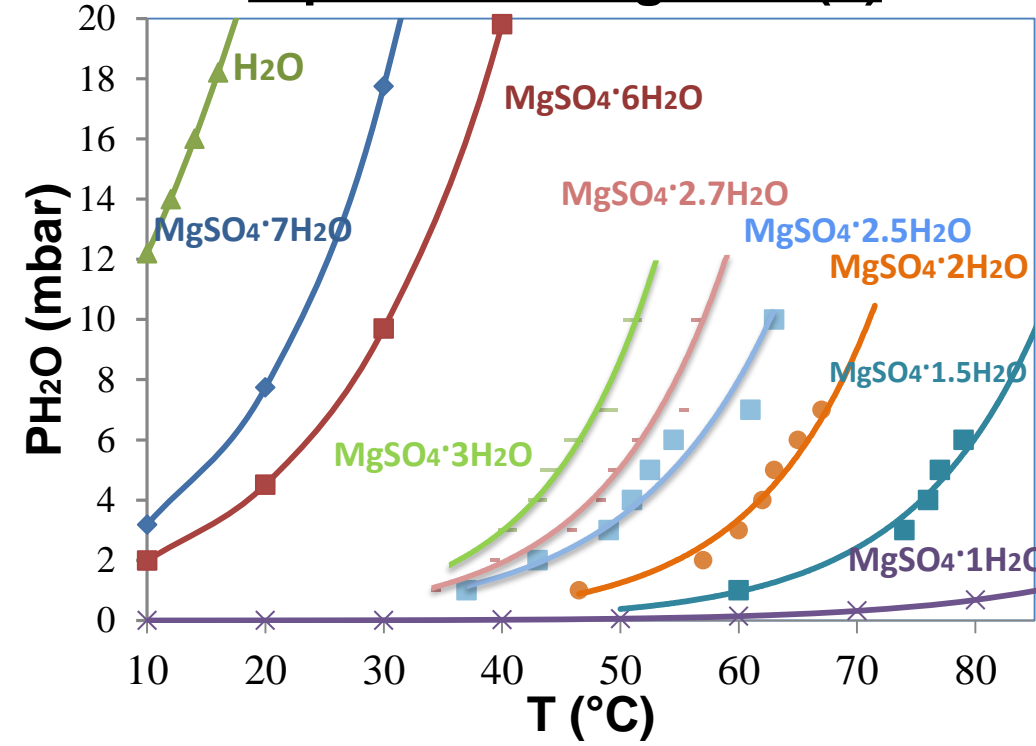
### Influence of water vapor pressure



Isobaric of 1, 2, 5, et 10 mbar



Equilibrium diagram P(T)



$\epsilon(H_2O) = f(T)$  at  $P_{const}$  → Divariant equilibria between water vapor and water molecules of solid

Localized water molecules isotherm:

$$\epsilon = n + \frac{p \frac{Y_1 P q}{Y_2}}{K + \frac{Y_1 P q}{Y_2}}$$

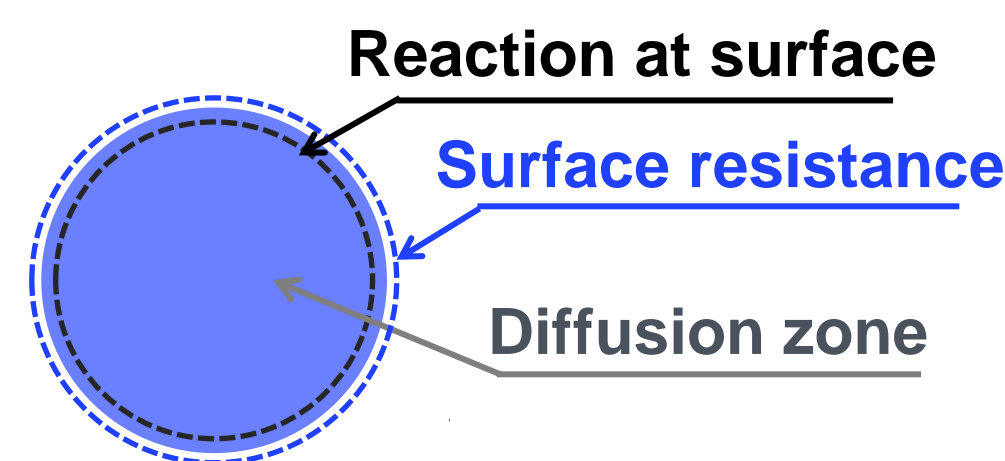
van't Hoff law:

$$\ln K = -\frac{\Delta H^0}{RT} + \frac{\Delta S^0}{R}$$

$$\Delta H^0 = 67.3 \text{ kJ.mol}^{-1}$$

$$\Delta S^0 = 107.3 \text{ J.mol}^{-1}.K^{-1}$$

## Kinetics of dehydration



### Surface resistance model

$$\alpha_\epsilon = \frac{m_t}{m_\infty} = 1 - \exp\left(-\frac{3kt}{r_0}\right)$$

$k = \frac{D}{\delta}$  is mass transfer coefficient

$D = D_0 \frac{\partial \ln P_{H_2O}}{\partial \ln C}$  is diffusion coefficient

$\delta$  is thickness of film surface

$r_0$  is spherical radius

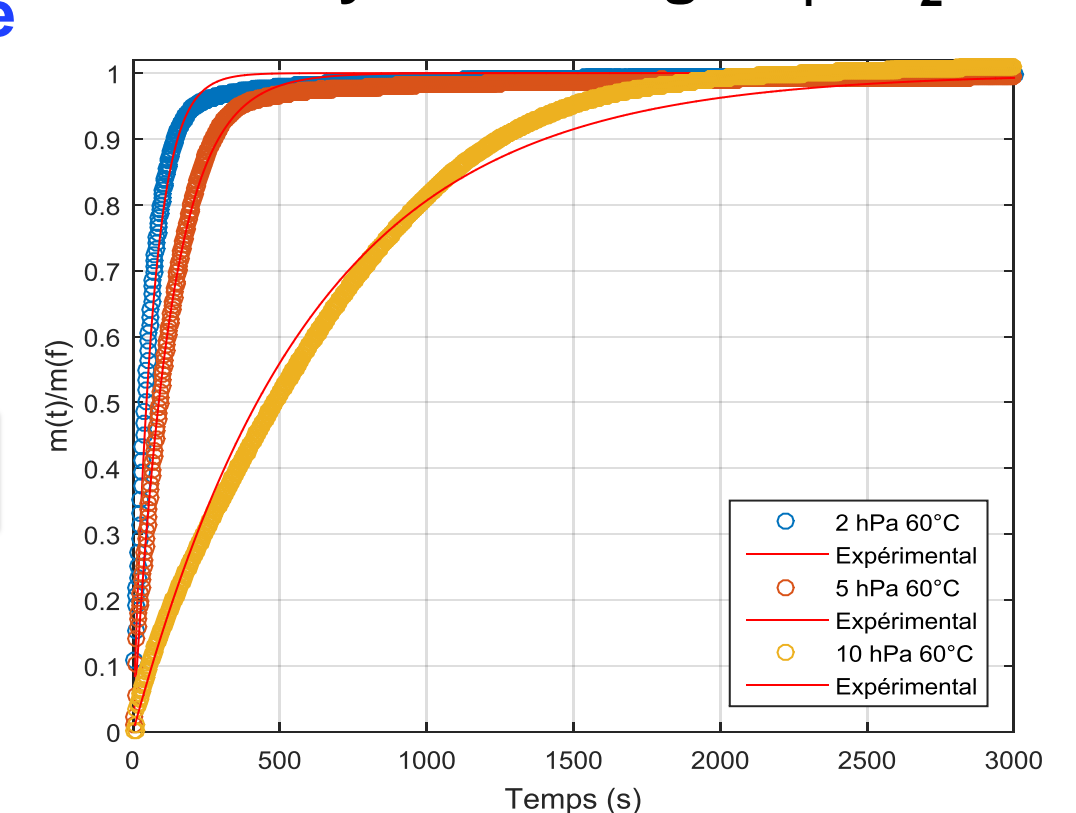
Arrhenius law:

$$\ln k = \ln k_0 - \frac{E_A}{RT}$$

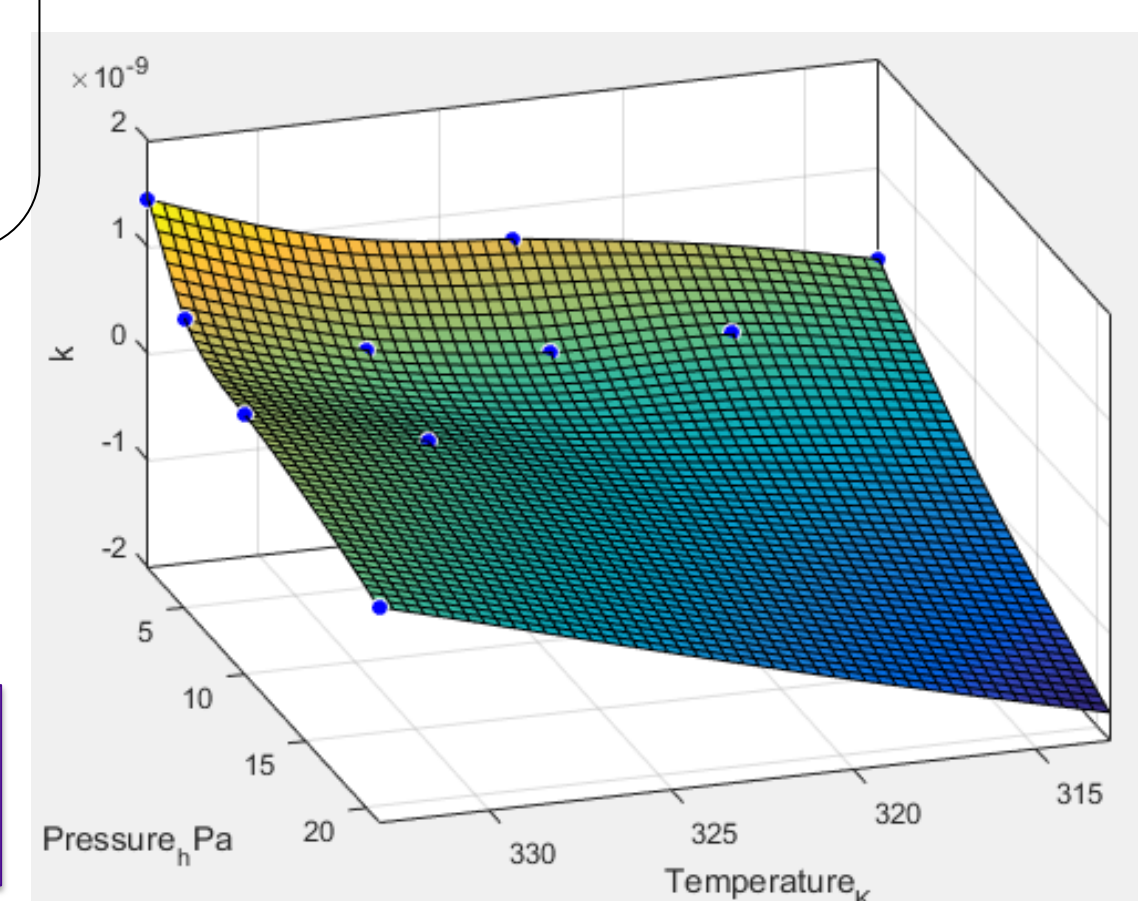
$$E_A = 102.3 \text{ kJ.mol}^{-1}$$

$$k_0 = 8,9 \cdot 10^6 \text{ m.s}^{-1}$$

### Experimental kinetic curves of dehydration $MgSO_4 \cdot 6H_2O$



### Pressure and temperature dependence of mass transfer coefficient



## Conclusions

- $MgSO_4$  hydrate is non-stoichiometric of water
- Rate controlled by diffusional resistance through a thin film at the surface, diffusion coefficient is  $P_{H_2O}$  and T dependent
- Activation energy  $E_A = 102.3 \text{ kJ.mol}^{-1}$

## Outlooks

- Characterization of porous matrix and composites
- Kinetic modeling zeolite@ $MgSO_4$  composite

Références:

- [1] ADEME 2015
- [2] G. Whiting, D. and all, Solar Energy Materials & Solar Cells (2013).
- [3] S. Hongois, Ph.D. thesis, INSA of Lyon (2011).