

# WP 2.2 Storage

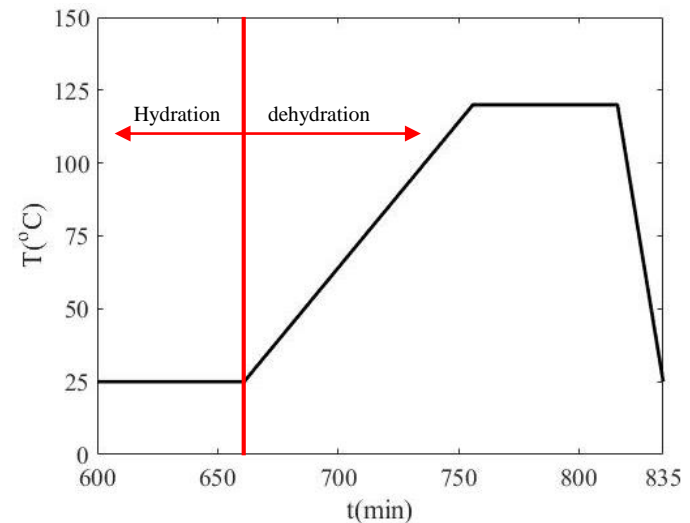
# Experiments – Mixture materials Hydration

## Materials Used

- (1) Silica Gel
- (2) Silica Gel + 5%  $\text{MgCl}_2$
- (3) Silica Gel + 10%  $\text{MgCl}_2$
- (4) Silica Gel + 15%  $\text{MgCl}_2$

**Wetness  
Impregnation**

## Experimental Mode



Raw Silica Gel



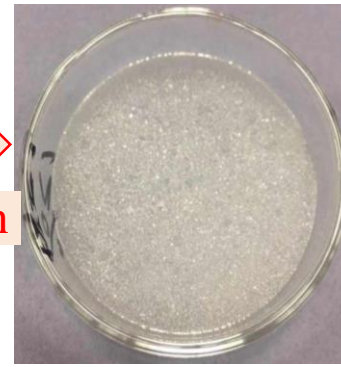
Drying



Silica Gel



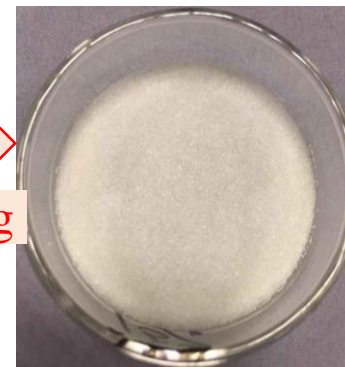
Absorption



Silica Gel +  $\text{MgCl}_2$  Solution



Drying



Dried Silica Gel &  $\text{MgCl}_2$

# Experiments – Mixture materials Hydration

$$\text{Water uptake capacity } \chi = \frac{m_{\infty} - m_0}{m_0}$$

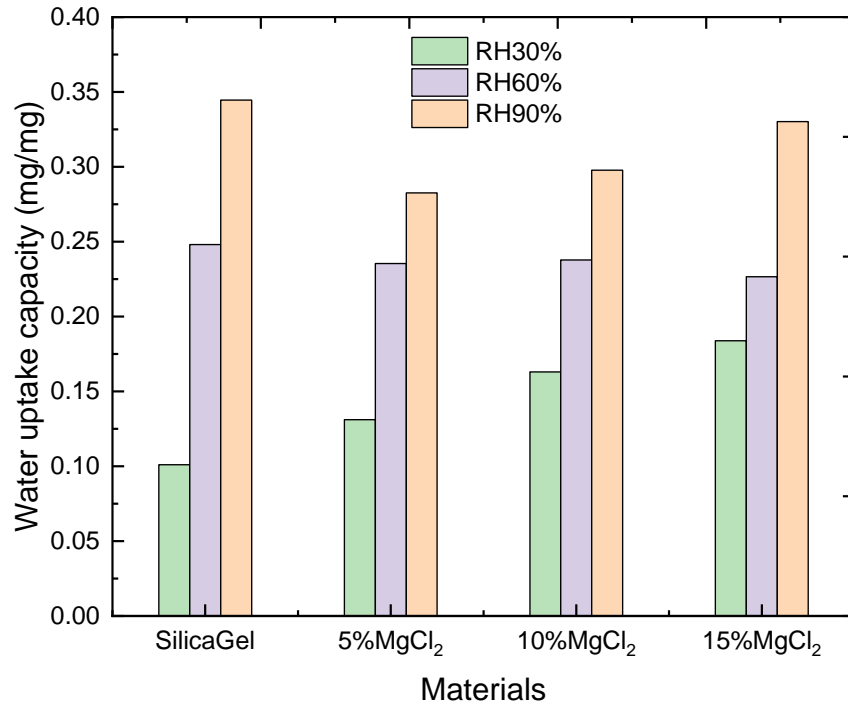


Fig 1. Water uptake capacity compare among materials during hydration.

Sorption characteristic time  $\tau$ :

$$1 - \exp(-t/\tau) = \frac{m - m_0}{m_{\infty} - m_0}$$

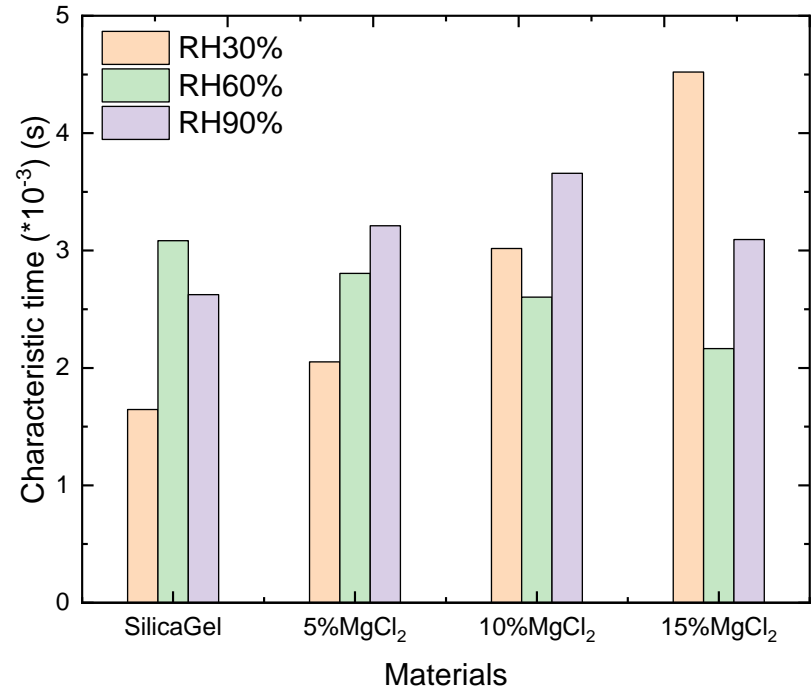


Fig 2. Sorption characteristic time compare among materials during hydration.

$m$ : water uptake;  $m_0$ : initial water uptake;  $m_{\infty}$ : maximum water uptake;  $t$ : time.

# Experiments – Mixture materials Hydration

*Example: Relative Humidity 90%*

Dimensionless water uptake rate:

$$\delta = \frac{m - m_0}{m_\infty - m_0}$$

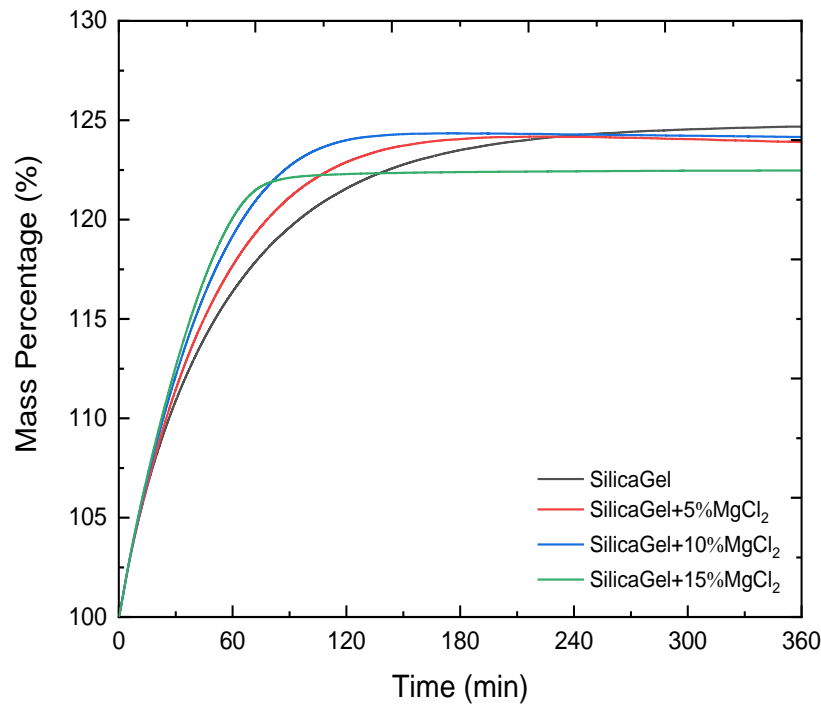


Fig 3a. Transient sample mass change compare among materials during hydration. RH 90%

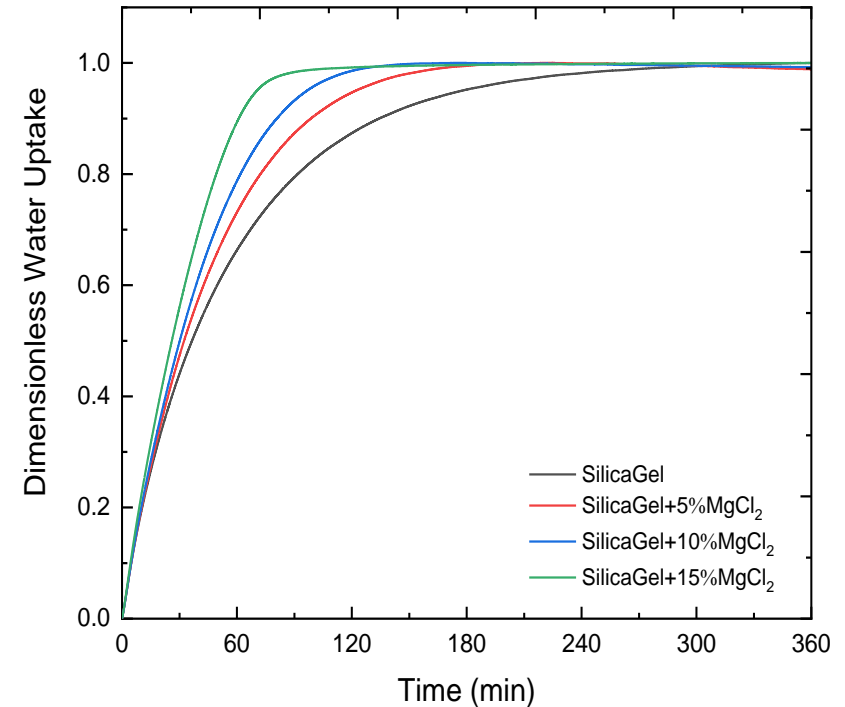


Fig 3b. Dimensionless water uptake rate compare among materials during hydration. RH 90%

# Experiments – Mixture materials Dehydration

*Example: Relative Humidity 90%*

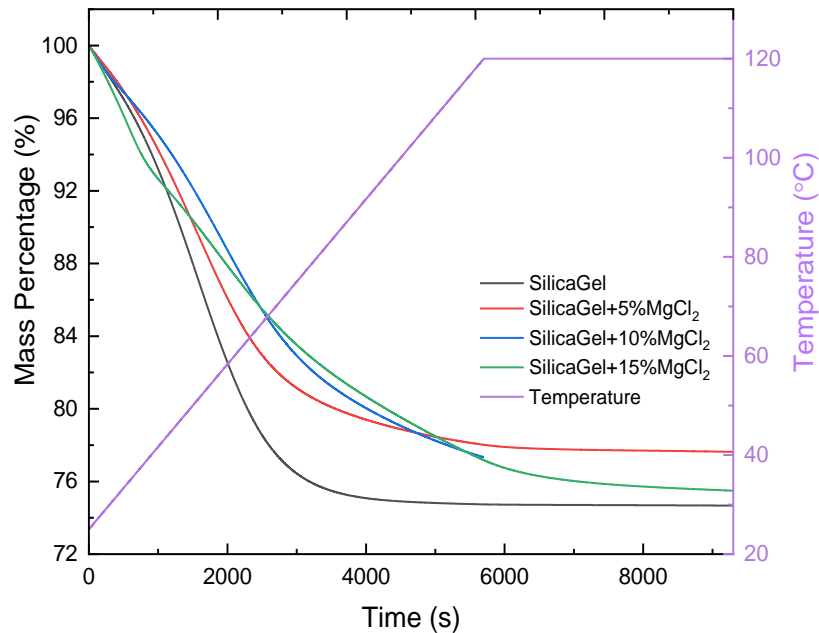


Fig 4a. Transient sample mass change compare among materials during dehydration. (RH90%)

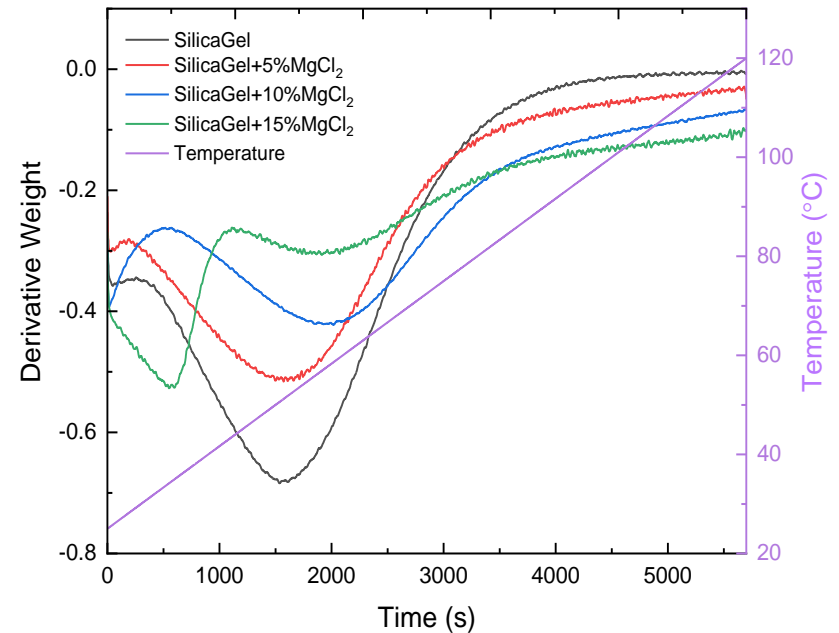


Fig 4b. Derivative weight change compare among materials during dehydration. (RH90%)

# Numerical Modeling of thermochemical energy storage

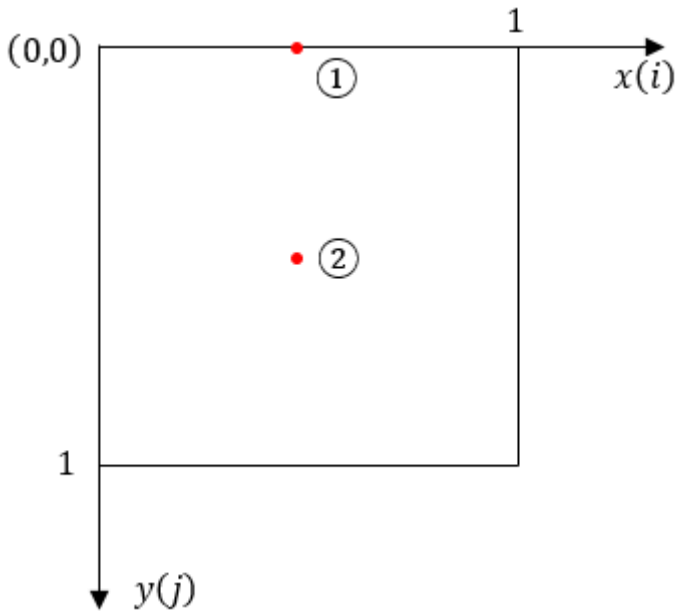


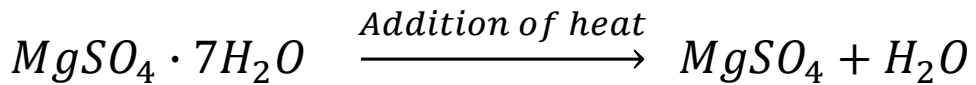
Fig 5. 2D schematic of the simulated domain.

$\eta_h$ ,  $\eta_s$  and  $\eta_g$  represents the concentration of hydrate salt, anhydrous salt and water vapour, respectively;

$C_h$ ,  $C_s$  and  $C_g$  represents the heat capacity of hydrate salt, anhydrous salt and water vapour, respectively;

$T_r$  is the dehydration temperature;  $\Delta H$  is the enthalpy of dehydration.

Take the  $MgSO_4 \cdot 7H_2O$  as a representative salt:



Energy conservation:

$$\frac{\partial}{\partial t} [(\eta_h + \eta_s + \eta_g)T] = K\nabla^2 T + D_m \chi \eta_h \exp(-E/T)$$

$$\text{Mass conservation: } \frac{\partial \eta_h}{\partial t} + \frac{C_h}{C_s} \frac{\partial \eta_h}{\partial t} + \frac{C_h}{C_g} \frac{\partial \eta_h}{\partial t} = 0$$

$$\text{Decomposition of } MgSO_4 \cdot 7H_2O: \frac{\partial \eta_h}{\partial t} = -D_m \eta_h \exp(-E/T)$$

$$\text{Production of } MgSO_4: \frac{\partial \eta_s}{\partial t} = -\frac{M_s C_s}{M_h C_h} \frac{\partial \eta_{sh}}{\partial t}$$

Dimensionless parameters:

$$K = \eta_h + \frac{C_h k_s}{C_s k_h} \eta_s + \frac{C_h k_g}{C_g k_h} \eta_g;$$

$$T = \frac{T_{real}}{T_r}; \chi = \Delta H / C_h T_r$$

Initial conditions:

$$T_0 = 0.9366,$$

$$\eta_{h0} = 0.9, \eta_{s0} = 0, \eta_{g0} = 0$$

# Numerical Modeling Results

Region I: Before Reaction

$$T < 1;$$

Region II: Reacting

Region III: After reaction

$$\eta_h = 0$$

Boundary Conditions:

$$j = 1, \frac{\partial T}{\partial y} = -q$$

$$j = ny, \frac{\partial T}{\partial y} = -aq$$

$$i = 1, \frac{\partial T}{\partial x} = -aq$$

$$i = nx, \frac{\partial T}{\partial x} = -aq$$

$$(q = QL/K_h T_r)$$

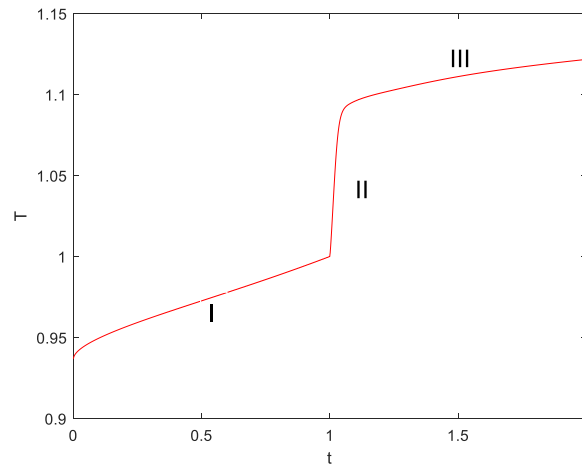


Fig 6a. Transient evolution of temperature

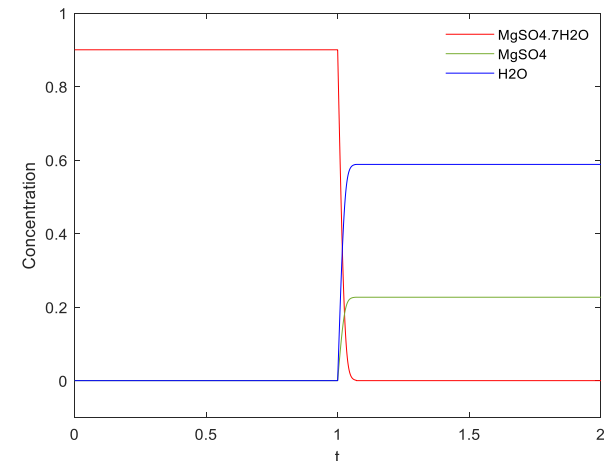


Fig 6b. Transient evolution of concentration

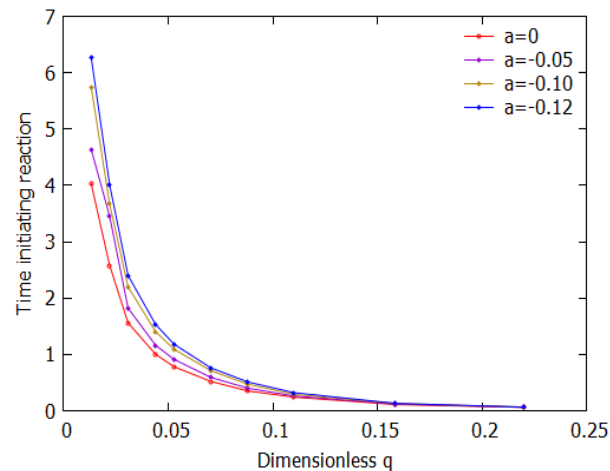


Fig 7a. Time required to initiate the reaction for different values of the heat flux.

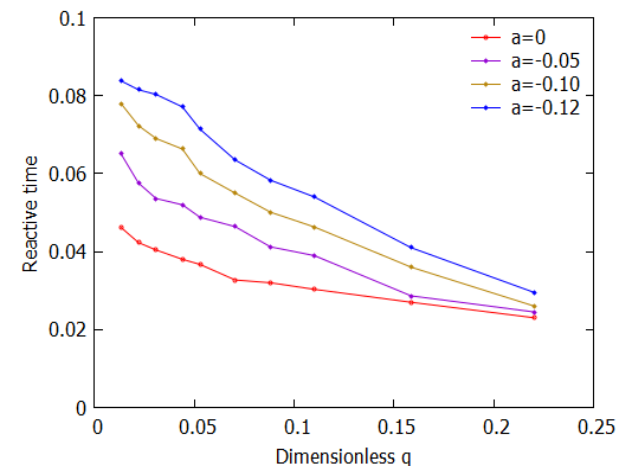


Fig 7b. Time taken for chemical reaction for different values of the heat flux.