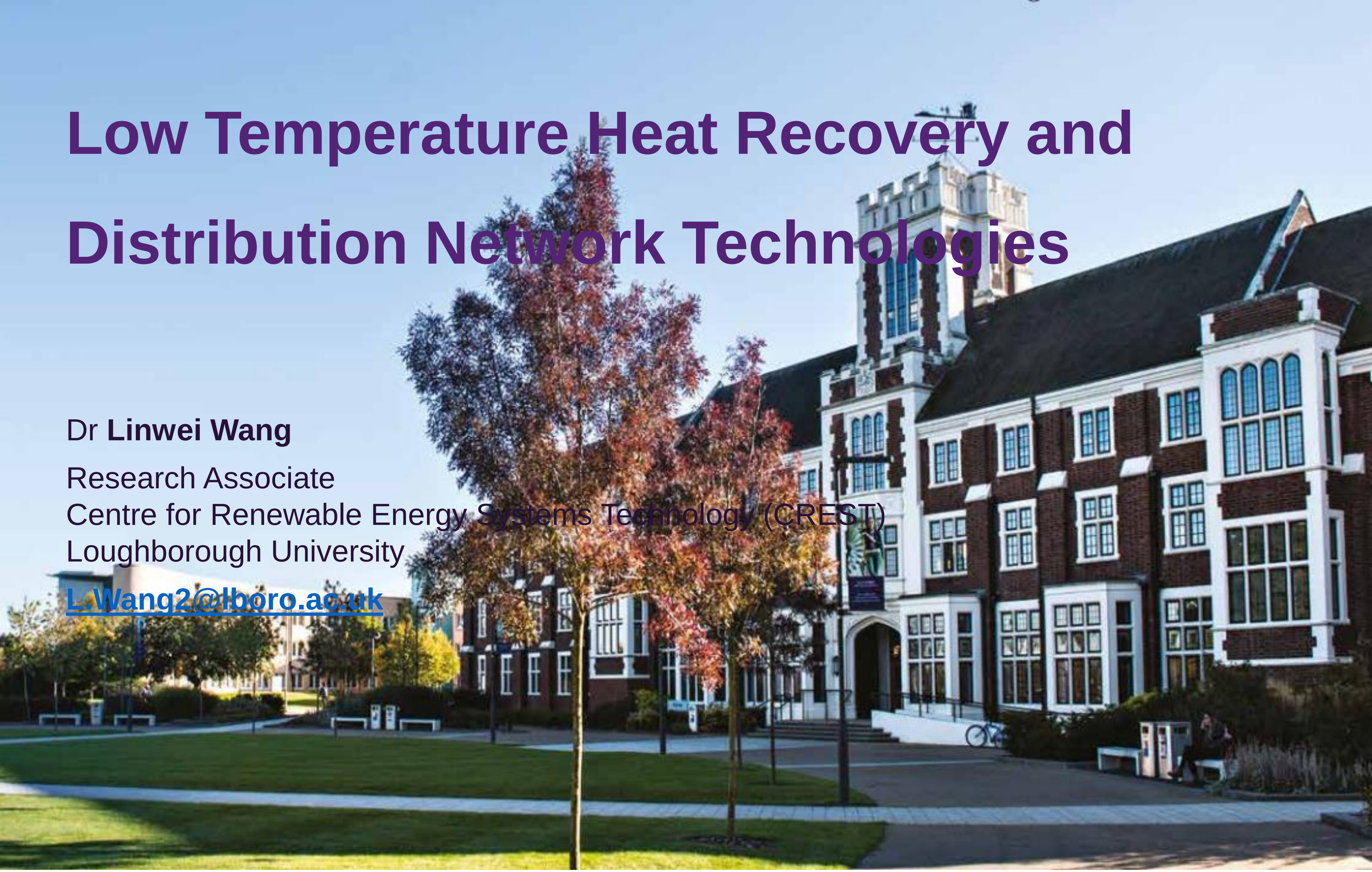

Low Temperature Heat Recovery and Distribution Network Technologies

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WARWICK

Loughborough University

Ulster University

London South Bank University

Experiments – Long Cycle Mode

Materials Used
(1) Silica Gel
(2) Silica Gel + 5% $MgCl_2$
(3) Silica Gel + 10% $MgCl_2$
(4) Silica Gel + 15% $MgCl_2$

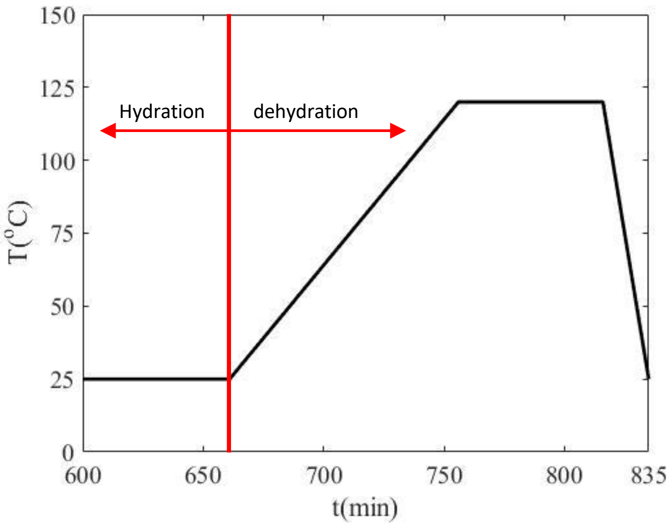

Fig 1. Long cycle experimental mode

Long Cycle Experimental Mode
(i) Before the first cycle, raw materials to be dried;
(ii) 0-660min (11h), at 25°C and relative humidity;
(iii) 660-661 min, at 25°C with relative humidity 0%;
(iv) 661-756 min, from 25°C to 120°C with 1 °C/min heating rate;
(v) 756-816 min, at 120°C;
(Vi) 816-835 min, from 120°C to 25°C with 5 °C/min cooling rate.

Dimensionless water uptake rate $\delta = \frac{m-m_0}{m_\infty - m_0}$;

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

Sorption characteristic time τ: $1 - exp(-t/\tau) = \frac{m-m_0}{m_\infty - m_0}$;

Initial sorption rate for the first 30min of hydration σ:

$$\sigma = d\left(\frac{m - m_0}{m_\infty - m_0}\right)/dt$$

m: water uptake; m_0: initial water uptake;
m_∞: maximum water uptake; t: time.

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Experiments – Long Cycle Mode Hydration

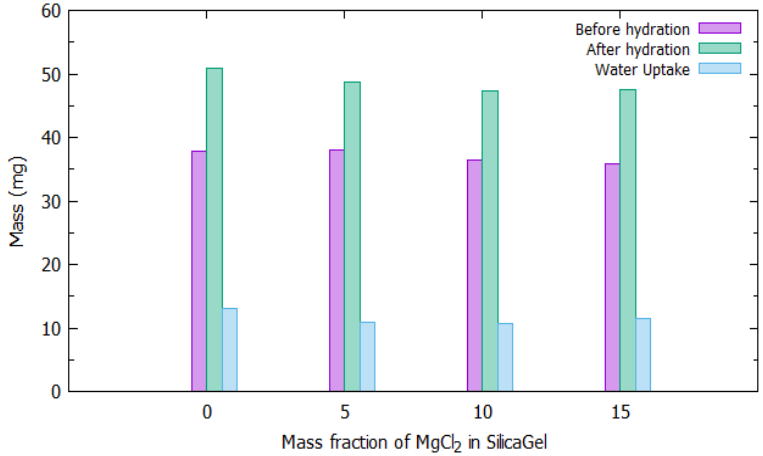


Fig 2a. Mass change compare among materials during hydration in long cycle experimental mode. RH90%

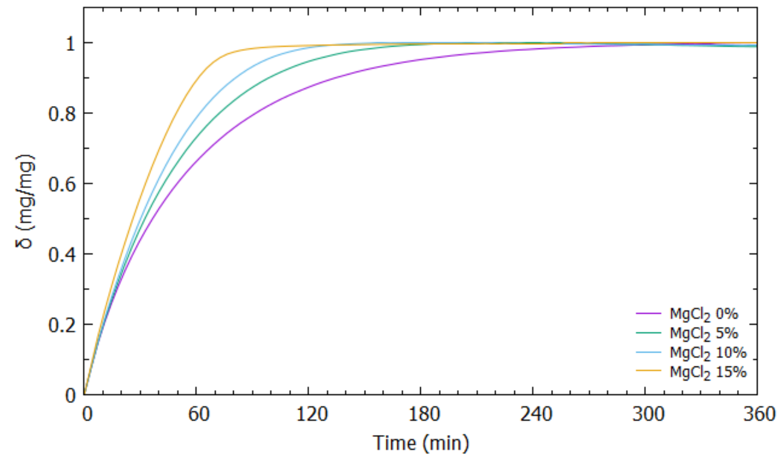


Fig 2b. Dimensionless water uptake rate compare among materials during hydration in long cycle experimental mode. RH 90%

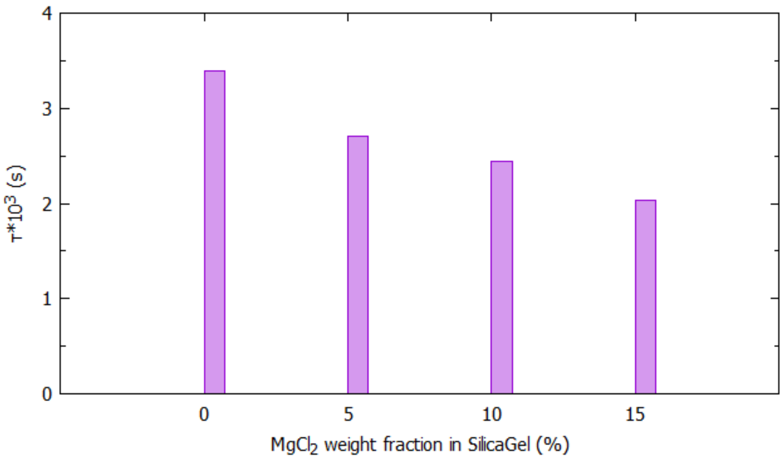


Fig 2c. Sorption characteristic time compare among materials during hydration in long cycle experimental mode. RH 90%

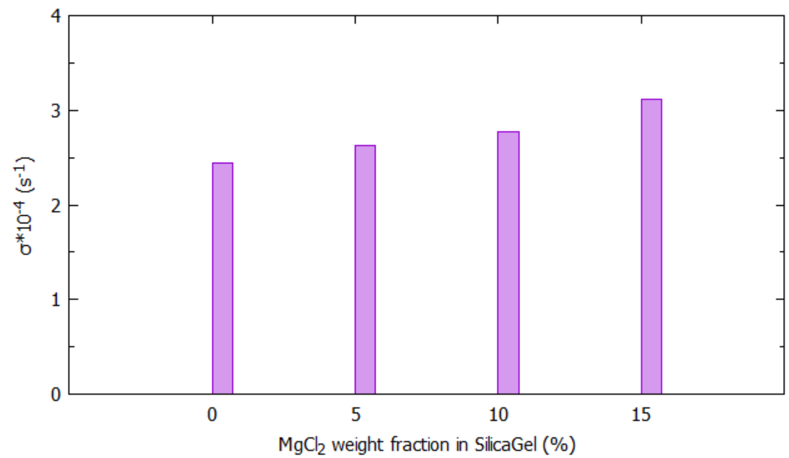
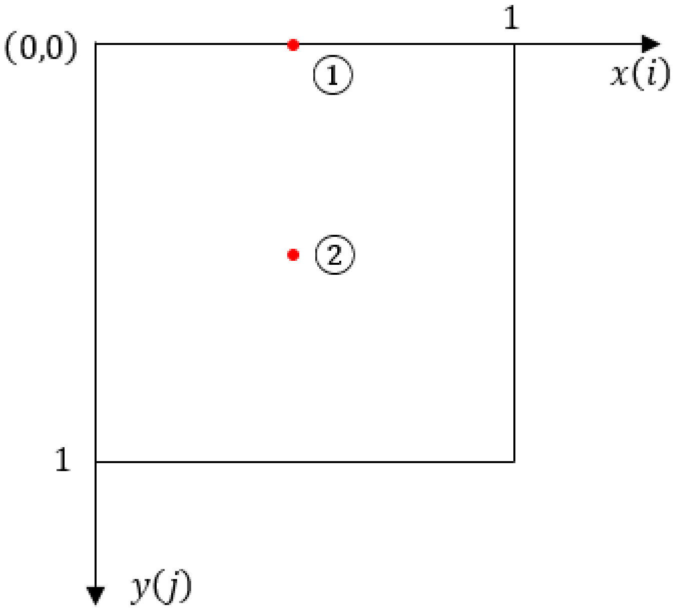


Fig 2d. Initial sorption rate compare among materials during hydration in long cycle experimental mode. RH 90%

Numerical Model



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

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

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

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

Energy conservation:

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

$$\left(K = \eta_h + \frac{C_h k_s}{C_s k_h}\eta_s + \frac{C_h k_g}{C_g k_h}\eta_g\right)$$

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

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

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

(η_h, η_s and η_g represents the concentration of hydrate salt, anhydrous salt and water vapour, respectively.)

Initial conditions:

$T_0 = 0.9366, \eta_{h0} = 0.9, \eta_{s0} = 0, \eta_{g0} = 0$

Dimensionless $T = \frac{T_{real}}{T_r}$ (T_r –dehydration temperature)

Results

Mesh grid:

$$x = 0{:}\,dh{:}\,1;\ nx = length(x);$$
$$y = 0{:}\,dh{:}\,1;\ ny = length(y);$$

$$dt = 0.000001$$
$$dh = 0.005$$

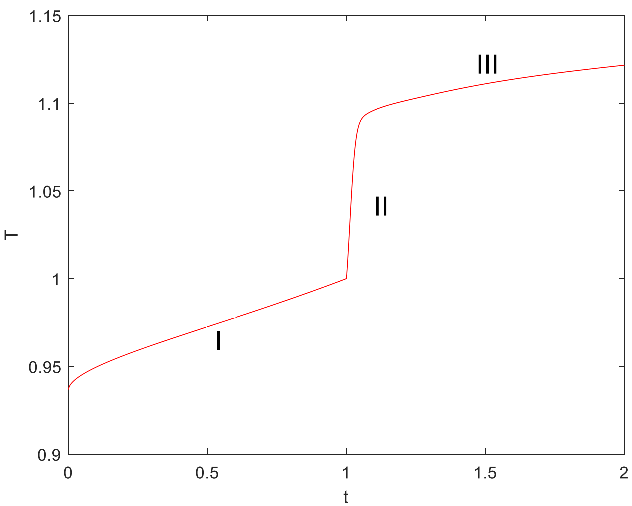


Fig 3a. Transient Evolution of temperature

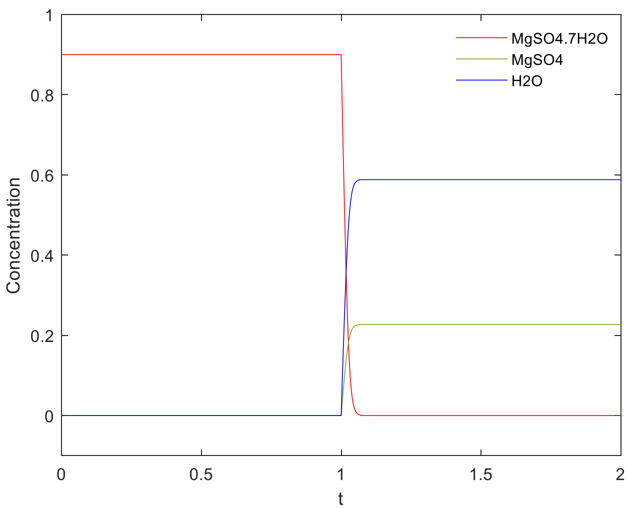


Fig 3b. Transient Evolution of concentration

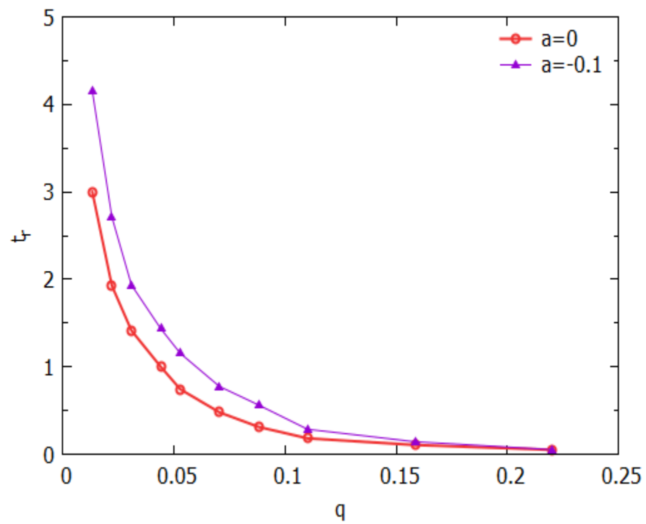
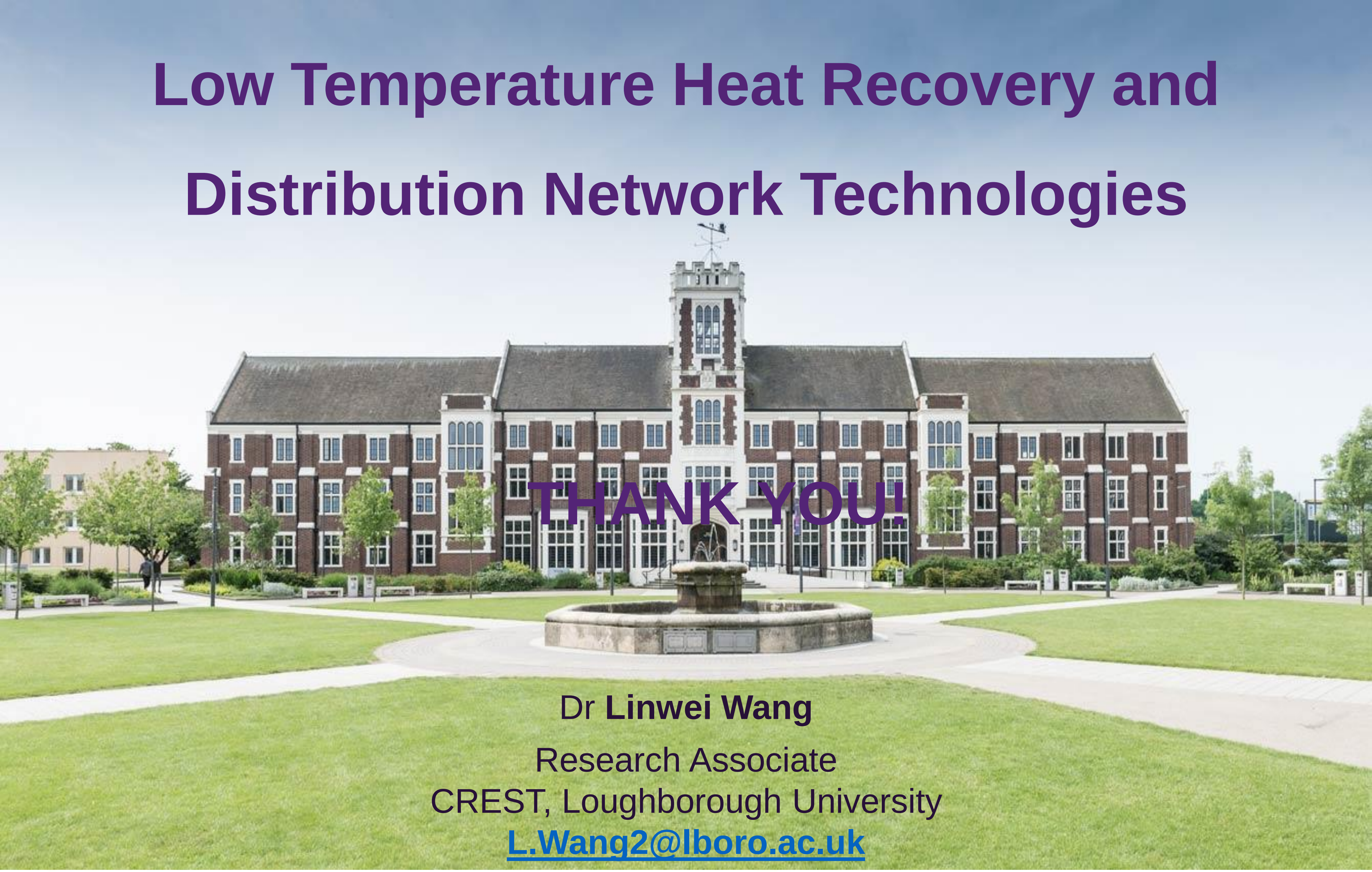


Fig 3c. Time required to initiate the reaction for different values of the heat flux.



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THANK YOU!

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