上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Thermodynamic and kinetic characteristics of composite sorbents and their multi-mode sorption heat storage

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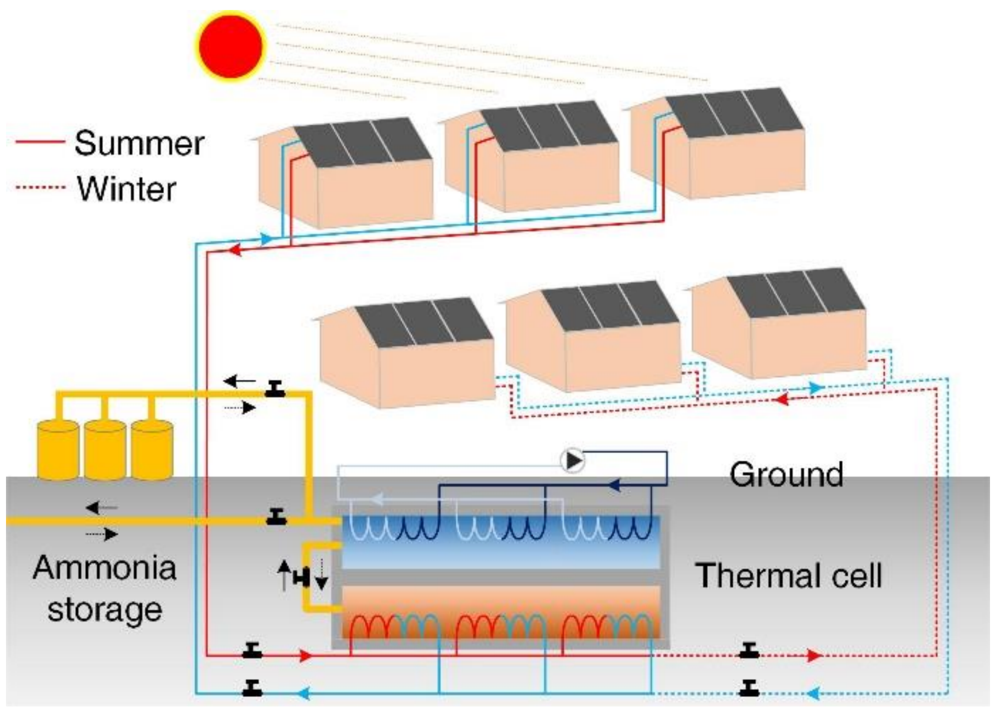
Thermal energy storage



Long-term thermal energy storage

- Storage density (material, system)
- Storage grade (material, cycle)
- Heat loss (material, structure)
- Heat adaptability (material, cycle)

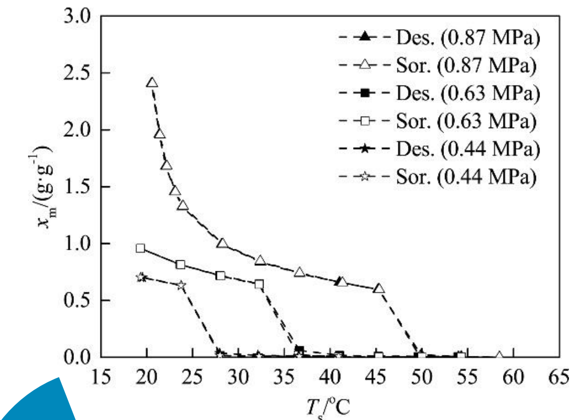
Comparison between thermal energy storage

Storage	Sensible	Latent	Sorption
Density	Low	Middle	High
Grade	Decline	No decline	Decline
Loss	Large	Large	Almost none
adaptability	Good	Not good	Not good

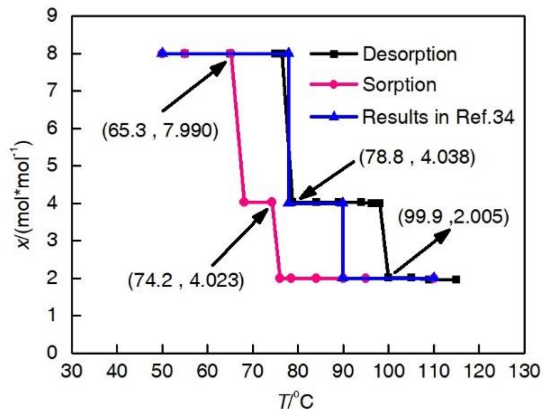
Target：
1 Slow down the decline of sorption thermal energy storage (STES) grade
2 Improve the heat source adaptability of STES

Background | **Thermodynamics** | Kinetics | Application

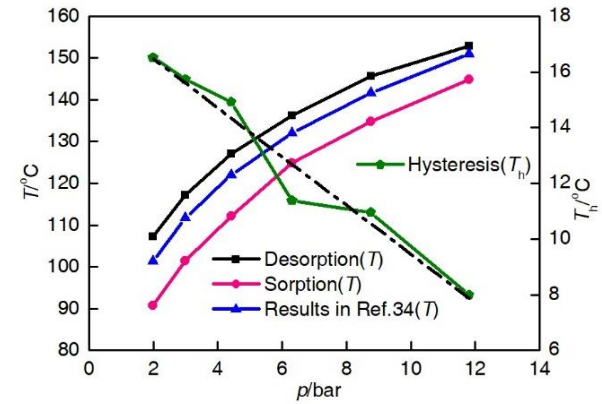
Halide/ENG-TSA



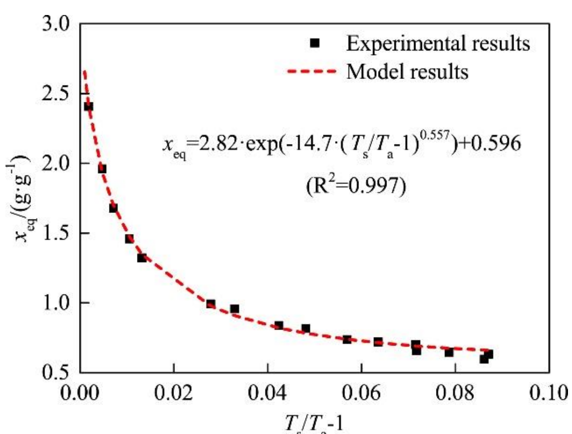
NH_4Cl



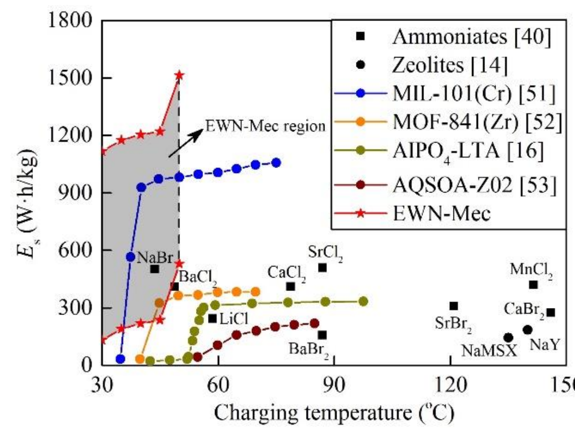
$CaCl_2$



$MnCl_2$

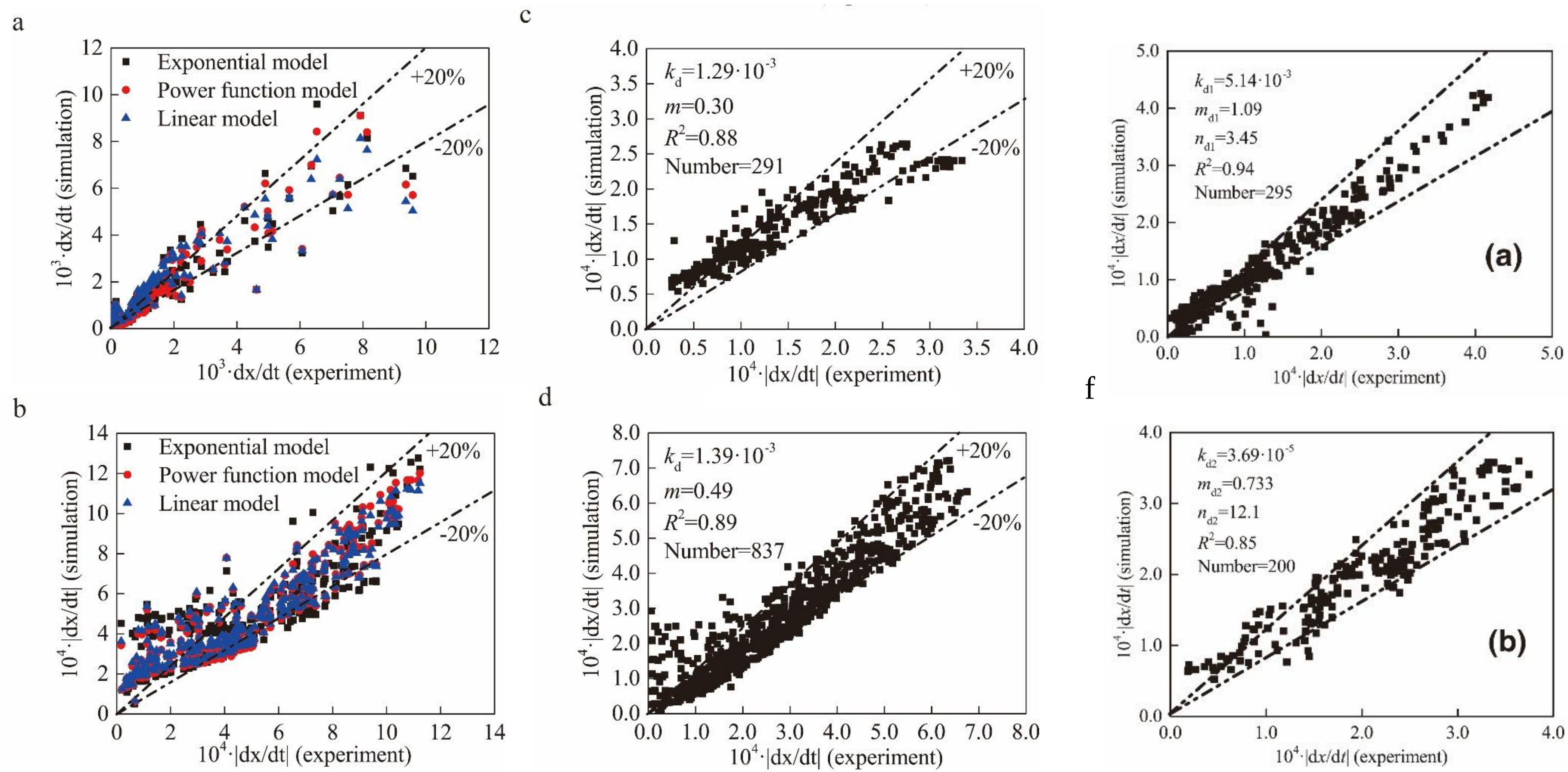


Thermodynamics model



Storage density

Model selection



$MnCl_2$ $CaCl_2$ NH_4Cl

Parameter results

Reaction	Analogical model	Range
$Mn_{2\text{-}6}$	$\frac{dX}{dt}=1.19\cdot10^{-2}(1-\frac{p_{eq}(T_s)}{p_c})(1-X)^{0.64}$	$X\in(0,\,1)$
$Mn_{6\text{-}2}$	$\frac{dX}{dt}=-2.08\cdot10^{-3}(\frac{p_{eq}(T_s)}{p_c}-1)X^{0.36}$	$X\in(1,\,0)$
$Ca_{2\text{-}4}$	$\frac{dX}{dt}=2.14\cdot10^{-3}(1-\frac{p_{eq}(T_s)}{p_c})(1-3X)^{0.17}$	$X\in(0,\,1/3)$
$Ca_{4\text{-}8}$	$\frac{dX}{dt}=2.6\cdot10^{-3}(1-\frac{p_{eq}(T_s)}{p_c})(\frac{3}{2}-\frac{3}{2}X)^{0.50}$	$X\in(1/3,\,1)$
$Ca_{8\text{-}4}$	$\frac{dX}{dt}=-9.27\cdot10^{-4}(\frac{p_{eq}(T_s)}{p_c}-1)(\frac{3}{2}X-\frac{1}{2})^{0.49}$	$X\in(1,\,1/3)$
$Ca_{4\text{-}2}$	$\frac{dX}{dt}=-4.30\cdot10^{-4}(\frac{p_{eq}(T_s)}{p_c}-1)(3X)^{0.30}$	$X\in(1/3,\,0)$
$NH_{4\ 0\text{-}max}$	$\frac{dx_m}{dt}=6.41\cdot10^{-3}\left[x_{eq}(T_s)-x_m(T_s)\right]^{0.648}\cdot\left(1-\frac{p_{eq}(T_s)}{p_c}\right)^{1.55}$	$T_s<T_c$
	0	$T_s>T_c$
$NH_{4\ max\text{-}0}$	$\frac{dx_m}{dt}=-5.14\cdot10^{-3}\left[x_m(T_s)-x_{eq}(T_s)\right]^{1.09}\cdot\left(\frac{p_{eq}(T_s)}{p_c}\right)^{3.45}$	$T_s<T_c$
	$\frac{dx_m}{dt}=-3.69\cdot10^{-5}\left[x_m(T_s)-0\right]^{0.733}\cdot\left(\frac{p_{eq}(T_s)}{p_c}\right)^{12.1}$	$T_s>T_c$

Material kinetics

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Heat/mass transfer

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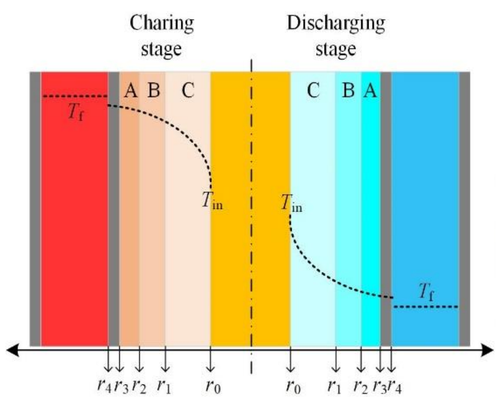
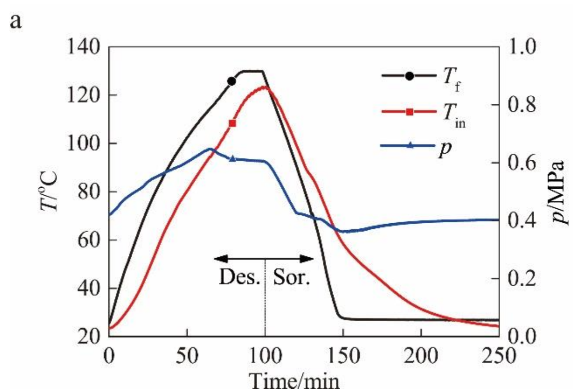
Reactor model

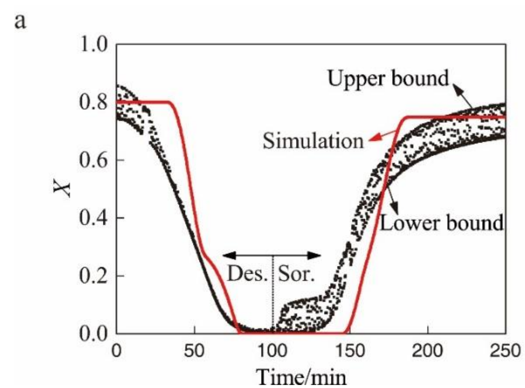
Model verification



Reactor model



Temperature

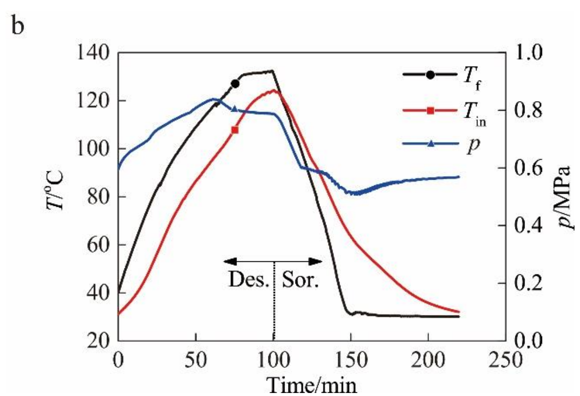


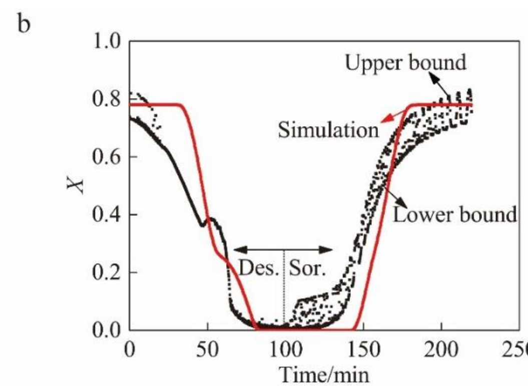
Sorption capacity

$$\rho c\frac{\partial T}{\partial t}=\frac{1}{r}\frac{\partial}{\partial r}(\lambda r\frac{\partial T}{\partial r})+S$$

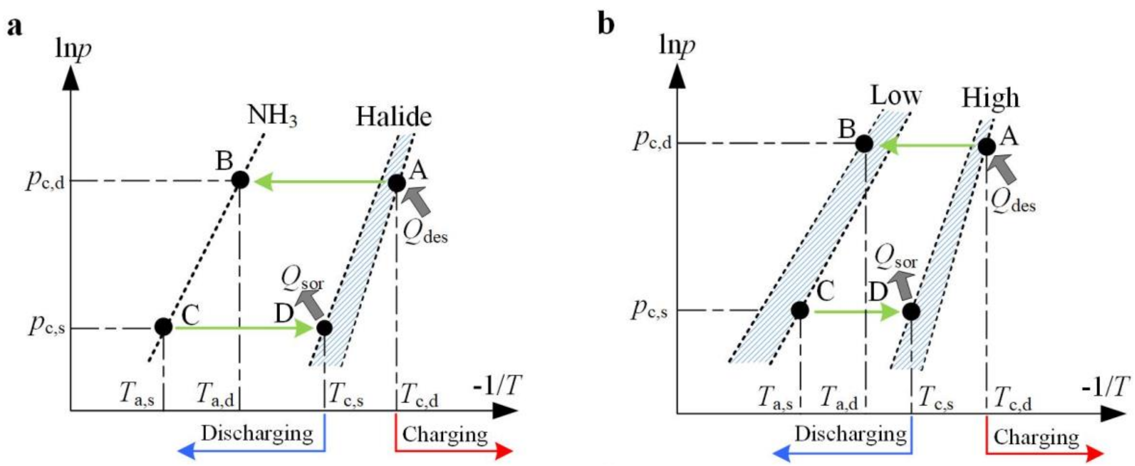
$$\frac{\partial T}{\partial r}|_{r=r_0}=0$$

$$h_f\left(T_{f\_in}-T|_{r=r_4}\right)=\lambda\frac{\partial T}{\partial r}|_{r=r_4}$$





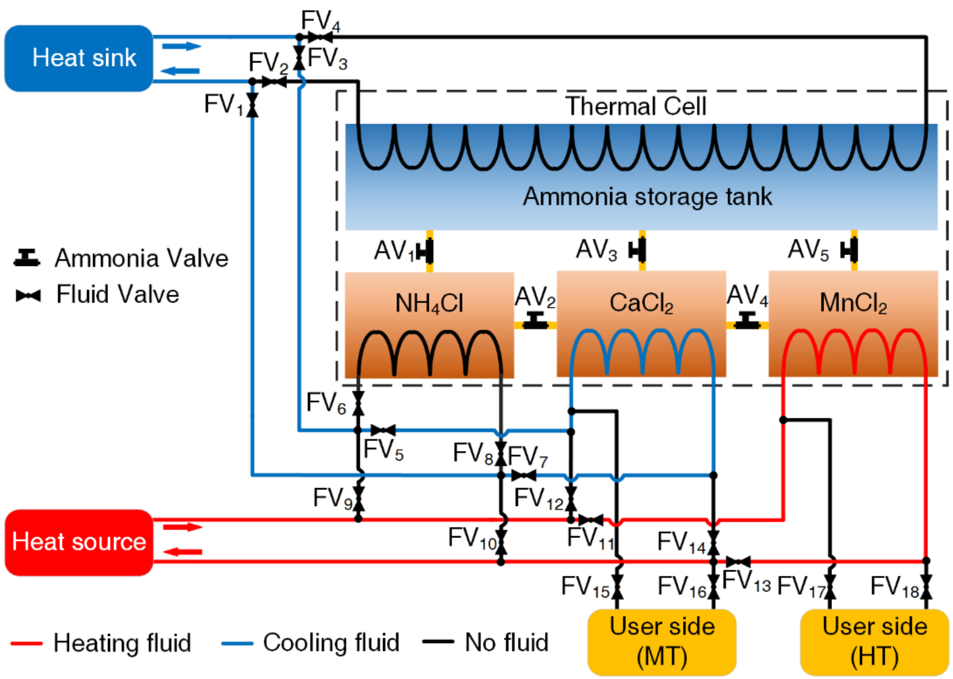
Cycle evaluation

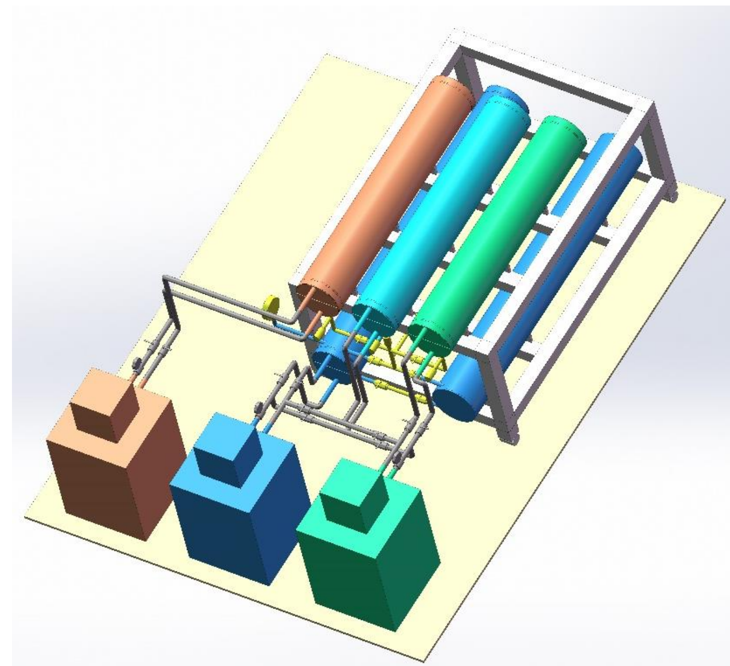


- Single/multi-halide
- Sorption/resorption
- Short/long term storage

T_{f_in} (°C)	50	60	70	80	90	100	110	120	130	140	150	160	170	180
E_{s_dis} (short)	NH_4				NH_4-Ca		Ca							
E_{s_dis} (long)														
t_{dis} (short)	NH_4													
t_{dis} (long)														
ΔT_f (short)	NH_4-Mn	Ca-Mn	NH_4-Mn		Ca	Mn		NH_4-Mn				Mn		
ΔT_f (long)	NH_4		NH_4-Ca		Ca					NH_4-Mn				
ΔE_{dis} (short)	NH_4				NH_4-Ca		Ca							
ΔE_{dis} (long)														
ECOP (short)	Mn				NH_4									
ECOP (long)	NH_4													

System construction





Based on two-stage cascading desorption cycle

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Thanks for your attention

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