PCM(Phase Change Material) for Solar Heating System

Jiqin Zhu

Beijing University of Chemical Technology

Main content

1. Existing PCM (solid-liquid):
inorganic, organic or complex material

2. Screening of PCM for solar heating system:
melting point, fusion heat, stability, supercooling, etc.

3. Ionic liquids as PCM: our research results

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Existing PCM:inorganic materials

Name	Melting point，℃	**fusion heat**，J/g	Supercooling，℃
Water	0	334	4~6
$CH_3COONa \cdot 3H_2O$	58	264	<60
$Na_2SO_4 \cdot 10H_2O$	32.4	252	>10
$KAl(SO_4)_2 \cdot 12H_2O$	91	232.4	19.8
$Ca(NO_3)_2 \cdot 4H_2O$	42.7	152.6	-
$Na_2HPO_4 \cdot 12H_2O$	35	205	14
$CaCl_2 \cdot 6H_2O$	29	180	30
$Na_2CO_3 \cdot 10H_2O$	33	247	-

Advantage: high fusion heat, high thermal conductivity，small volume change.

Disadvantage: supercooling， weak stability （phase separation）, corrosive .

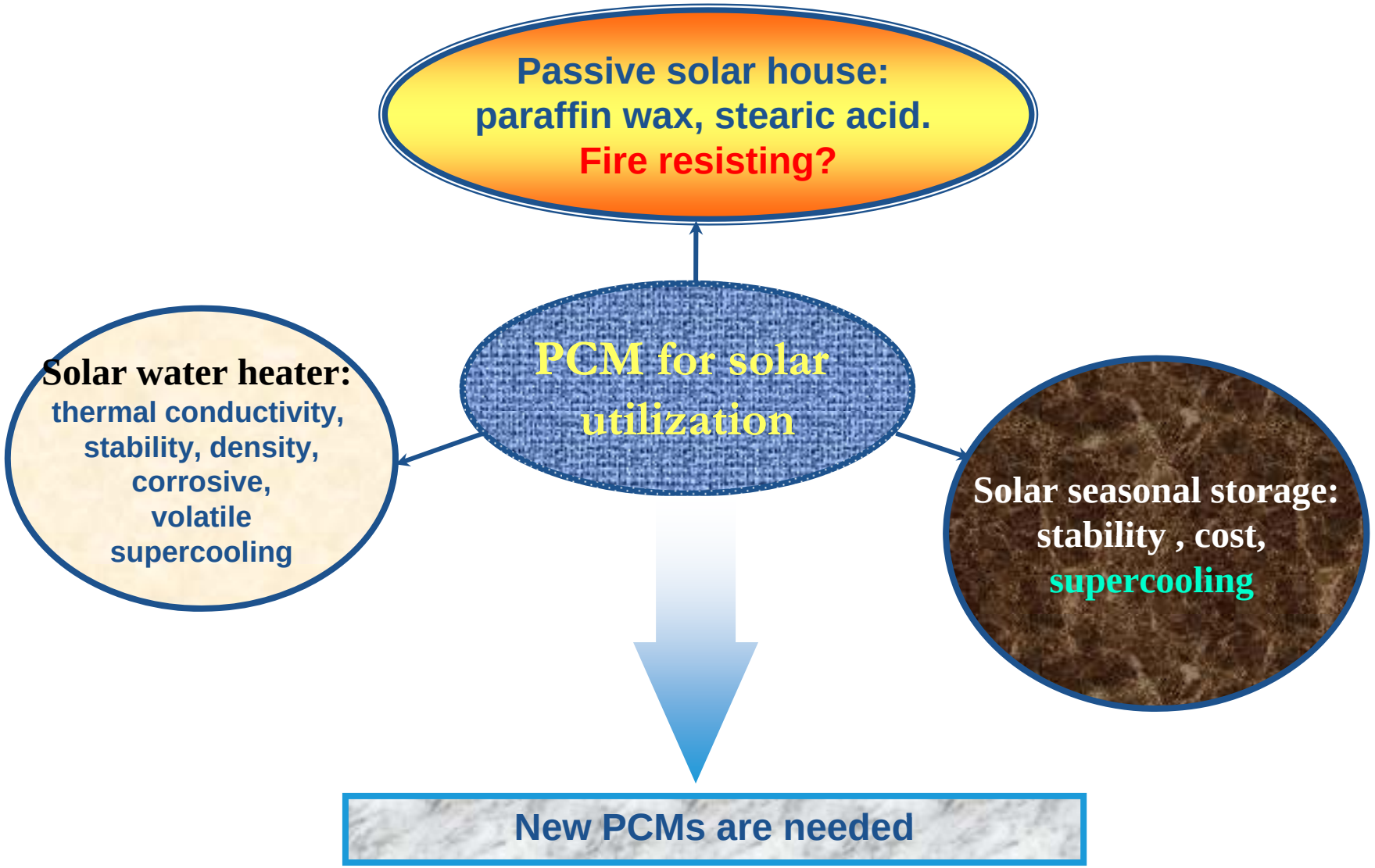
Existing PCM:organic materials

Name	Melting point ℃	fusion heat J/g	Name	Melting point ℃	fusion heat J/g
1-dodecanol	23~25	225.5	acetamide	81	241
paraffin wax （C_{16}~C_{27}）	44~64	167~210	Polyethylene glycol (PEG4000~16000)	63~65	160~175
tristearin	56	191	heptadenone	41	201
lauric acid	41.8	217	naphthalene	80	148
stearic acid	54~56	199	arachidic acid methyl ester	45	230
palmic acid	61	203.4	camphene	44~47	239.4
myristic acid	51.5	204.5	dimethyl oxalate	53~55	179

Advantage: good stability, no supercooling.

Disadvantage: low density, low thermal conductivity, volatile and flammable.

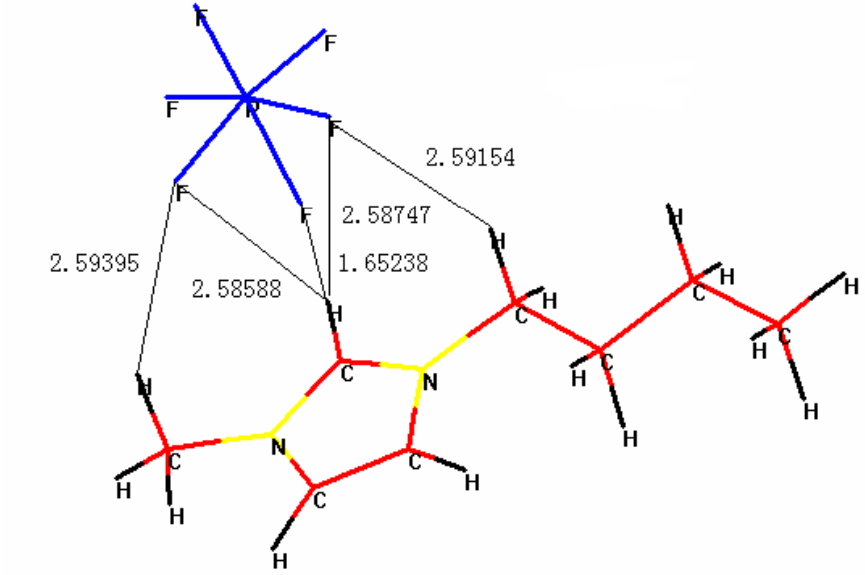
Screening of PCM for solar heating system

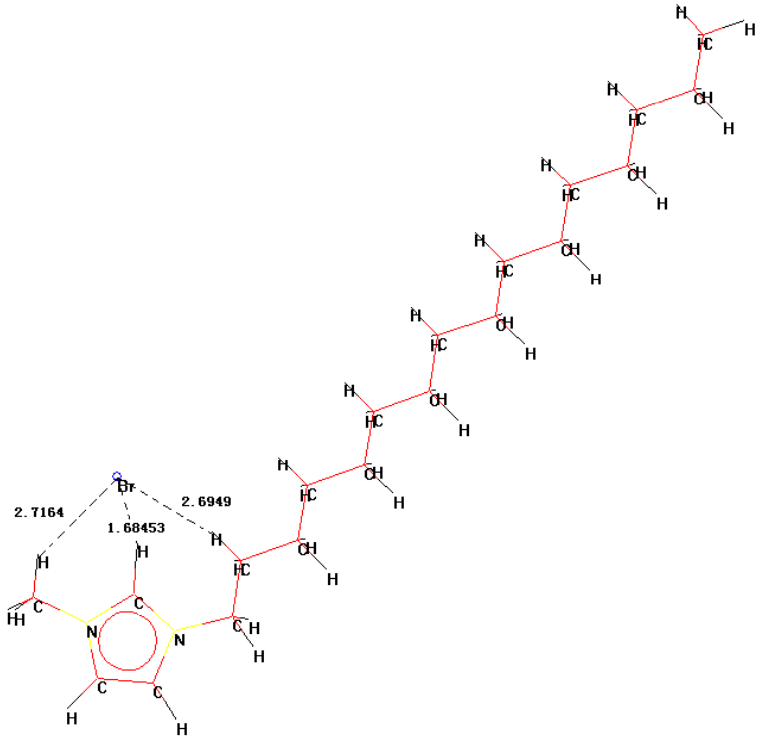


Ionic liquids as PCM

Ionic liquids: salts with organic cations and inorganic anions, several H-bond, large cations, asymmetry, task-specific.

Advantages: high stability, non-volatility, non-flammability, high heat capacity, and high storage density.





Ionic liquids as PCM:our research

Melting points and heats of fusion for ionic liquids

Ionic liquids	Melting points, ℃	Heats of fusion, J/g
$[C_{10}MIM]Br$	74.43	66.789
$[C_{16}MIM]Br$	63.91	152.563
$[C_4MIM]Cl$	53.42	59.004
$[C_4MMIM]Cl$	92.74	76.384
$[C_4MMIM]Br$	76.51	66.977
$[C_{10}MMIM]Br$	68.2	75.395
$[C_{16}MMIM]Br$	98.55	126.616
$[MEA][BF_4]$	33.61	57.867
$[DEA][BF_4]$	30.69	37.625
$[TEA][BF_4]$	72.11	65.186

Heat capacity for ionic liquids

T (K)	[C_{16}MIM]Br (J/g/K)	*T* (K)	[C_{16}MMIM]Br (J/g/K)
	Crystal		Crystal
299.15	1.253	299.15	1.267
303.15	1.550	303.15	1.514
308.15	1.609	308.15	1.617
313.15	1.640	313.15	1.735
318.15	1.700	318.15	1.920
323.15	1.788	323.15	2.315
	liquid	328.15	2.456
343.15	2.327	333.15	2.751
348.15	2.323	338.15	2.625
353.15	2.329	343.15	2.764
358.19	2.326	348.15	3.085
363.15	2.326		
368.15	2.316		
370.15	2.314		

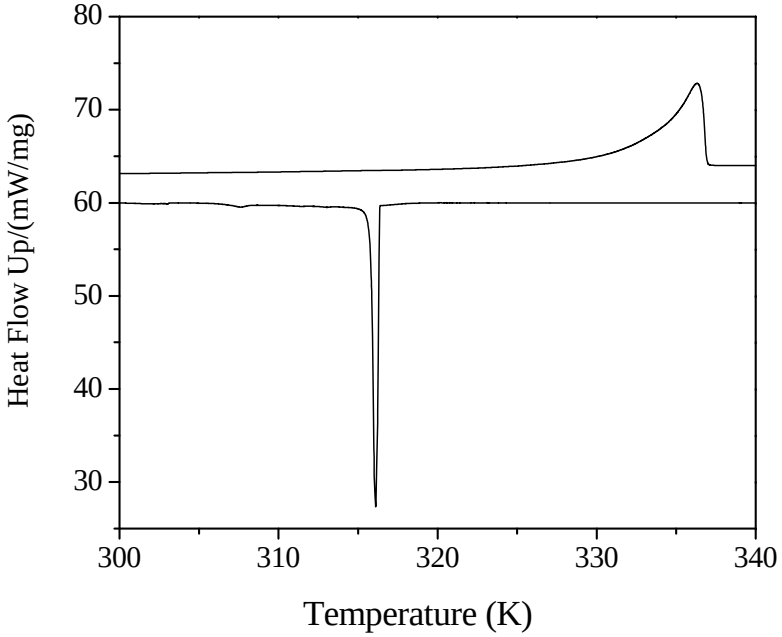
Ionic liquids as PCM:our research

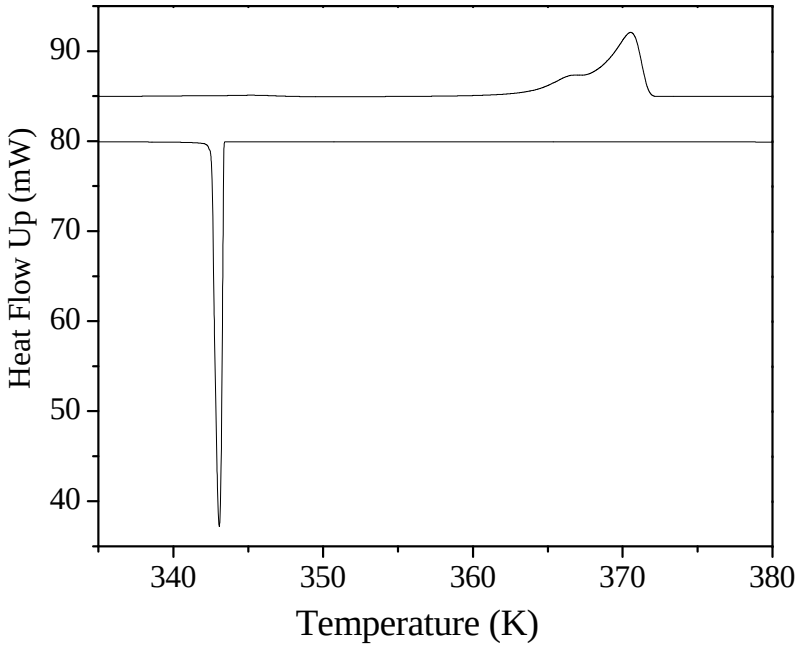
Thermal conductivity and thermal diffusivity at different temperature

$[C_{16}MIM]Br$		
Temperature, ℃	Thermal conductivity, W/mK	Thermal diffusivity, mm^2/s
10	0.3457	0.2515
20	0.3688	0.2295
30	0.3054	0.1365
40	0.2731	0.0998
50	0.2538	0.06697
$[C_{16}MMIM]Br$		
Temperature, ℃	Thermal conductivity, W/mK	Thermal diffusivity, mm^2/s
10	0.2334	0.1762
20	0.2333	0.1442
30	0.2230	0.1201
40	0.1939	0.07741
50	0.1741	0.05357

Ionic liquids as PCM:our research

Melting and freezing curve measured by DSC scan





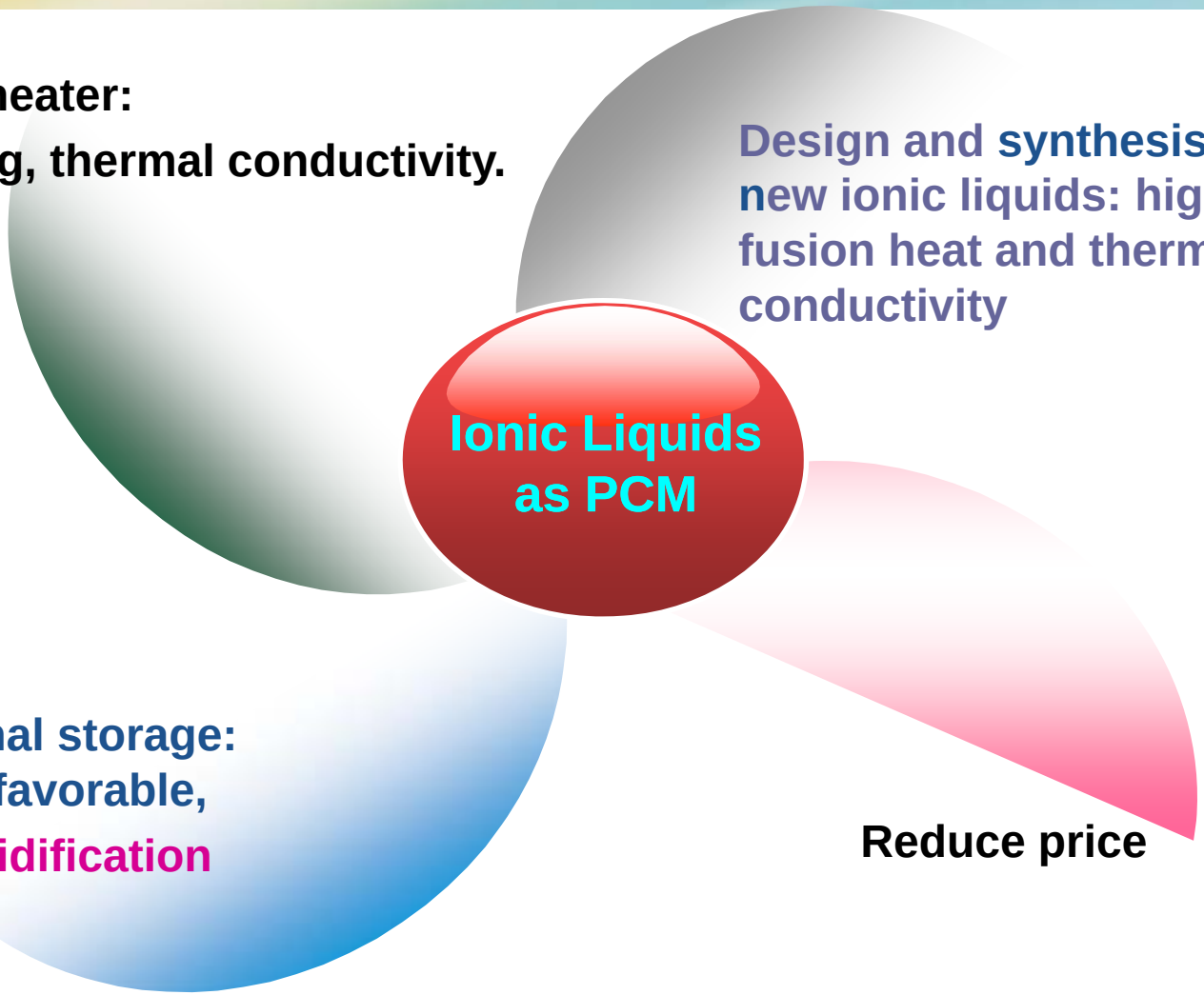
$[C_{16}MIM]Br$

$[C_{16}MMIM]Br$

Future Research Plan

For solar water heater:

anti-supercooling, thermal conductivity.



Thanks for attention