Molten Salts and Ionic Liquids
Normally we think of Sodium Chloride as a Solid:

- Melting Point: 801°C
- Boiling Point: 1465°C
- Lattice: fcc
- Lattice Parameter $a = 564$ pm
Normally we think of Sodium Chloride as a Solid:

Melting Point:  801 C
Boiling Point:  1465 C

But it WILL form a liquid at high Temperature (>800C) and high Pressure.

"Molten Salts" are compounds that are ionic solids at room temperature and liquid at elevated temperatures.

Actually LiF/BeF₂
Useful Properties of Molten Salts

- High Heat Capacity
- Conductive
- Very Low Vapor Pressure

Actually LiF/BeF$_2$

Many Applications
Molten Salt Application:

NaCl electrolysis for Na and Cl₂
Molten Salt Application:

Energy raw material (wet SDW, sludge + SDW).

Gas for consumers

Receiver, filter

Process flow diagram of gasification (pyrolysis) design in molten salt is very simple

Molten salt (930 °C)

Non-organics, ash

Waste Processing
Molten Salt Application:

Nuclear Energy -- Thorium Fluoride Molten Salts
Molten Salt Application:

Lunar oxygen generation?
Molten Salt Application:

Solar Energy Applications
Molten Salt Application:

Hot Salt
Molten salt can be used in solar-power generation to store heat until it is needed.

Large mirrors focus the sun’s rays on a central collection tower.

Molten salt is heated in the tower, then pumped into a storage tank.

The heated salt is then pumped through a steam generator.

The steam is used to power an electric turbine.

Cooled salt is returned to a second storage tank to be sent back through the cycle.

Source: United Technologies

Graphic by Eric Anderson

Solar Energy
Molten Salt Application:

Solar Energy Direct Salt Heating
Molten Salt Application:

Solar Energy at Night
Room Temperature Ionic Liquids (RTILS)

"Ionic Liquids" are ionic compounds that are liquid at temperatures under 100 C.

"Green Chemistry"
Room Temperature Ionic Liquids (RTILS)

- Good Solvent
- Conductive
- Very Low Vapor Pressure

Many Applications
Ions frequently used for ILs

Cations

Anions

Cl\(^-\), Br\(^-\), I\(^-\), AlCl\(_4^-\), BF\(_4^-\), PF\(_6^-\)

\[
\begin{align*}
&\text{F}_3\text{C} = \text{S} = \text{N} = \text{S} = \text{CF}_3 \\
&\text{F}_5\text{C}_2 = \text{S} = \text{N} = \text{S} = \text{C}_2\text{F}_5
\end{align*}
\]
Characteristics of RTILs

• Liquid at wide temperature range  up to −100～400°C

• Negligibly low volatility  No odor. “Green” chemistry

• Low flammability  Safe (many exceptions)

• Reasonable ionic conductivity  $10^{-1} \sim 10^{-5}$ S cm$^{-1}$

• Stability (heat, chemical, electrochemical)

• Solvation environment different from that in molecular solvents
A typical ionic liquid

1-Dodecyl-4-phenylpyridinium $\text{C}_{12}\text{PPy}^+$

Bis(perfluoroethylsulfonyl)imide $\text{C}_2\text{C}_2\text{N}^-$

Table. Physicochemical properties for water-saturated $[\text{C}_{12}\text{PPy}][\text{C}_2\text{C}_2\text{N}]$.

<table>
<thead>
<tr>
<th>$T_g$ ($^\circ$C)</th>
<th>$d$ $^b$ (g cm$^{-3}$)</th>
<th>$\eta$ $^b$ (mPa s)</th>
<th>$\kappa$ $^b$ ($\mu$S cm$^{-1}$)</th>
<th>$S_{\text{R/W}}$ $^b$ (mol dm$^{-3}$)</th>
<th>$S_{\text{W/R}}$ $^b$ (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-57^a$</td>
<td>1.209</td>
<td>529</td>
<td>77.9</td>
<td>$2 \times 10^{-5}$</td>
<td>0.36</td>
</tr>
</tbody>
</table>

$^a$ Melting point was not observed. $^b$ At 25$^\circ$C.
RTILs - The Third solvent

Can be immiscible with both water and organic solvents

**Water / NiCl$_2$**

**1-Bromodecane / Perylene**

**Ionic liquid / Rose bengal**
Liquid Mirror Telescopes!
Liquid Mirror Telescopes!

NASA/Photo by Paul Hickson (University of British Columbia)
The Large Zenith Telescope
Liquid Mirror Telescopes!

A NASA rendering of a lunar liquid mirror telescope

Recently, scientists have discovered a class of liquids that might make an LLMT possible. They are known as ionic fluids, and they have these important properties:

- They are liquid at temperatures below -212° F (-136° C).
- They are composed entirely of ions.
- They possess no vapor pressure at room temperature or below, which means they won’t evaporate.
- They are highly viscous.
Molten Salts and Ionic Liquids