Carbon Dioxide Separation Using Ionic Liquids

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Biogas is a valuable alternative energy resource

Sources:
- sewage digesters, biowaste digesters, landfills

Application area:
- heat and electricity

‘Waste-to-energy’ concept

Sweden and Germany occupy the leading positions in biogas production sector
Biogas composition

**CH₄ (40-60 vol. %), CO₂ (25 – 45 vol. %),**
**N₂ (1 - 15 vol. %), others (< 1 vol. %)**

Others:
- numerous S-containing compounds,
- siloxanes,
- aromatic,
- halogenated compounds...

Biogas upgrading:
- Increasing the heating value
- Improving of biogas quality
Current research in the field

Biogas Production

Biogas Upgrading

![Diagram of biogas production process]

![Diagram of biogas upgrading process]

Number of publications by year:

- **Biogas Production**
- **Biogas Upgrading**
The main methods for removal of carbon dioxide

- Chemical solvent scrubbing
- Physical solvent scrubbing
- Chemical mineral trapping
- Adsorption
- Cryogenics
New process for removing CO$_2$ – using an ionic liquid absorbent

What is an ionic liquid? Briefly...

- **Structure**

![Ionic Liquid Structure]

- **The most important properties:**
  - They are salts that are fluid over a wide temperature range including room temperature
  - Negligible vapor pressure (nonvolatile), often with thermal stability to over 350 °C
  - Properties are adjustable, adding flexibility to this class of solvents
  - Perspective on Green Chemistry
'Switchable' ionic liquids

8-diazabicyclo[5.4.0]undec-7-ene (DBU)

heat, N₂

poly[2-(1-butylimidazolium-3-yl)ethyl methacrylate hexafluorophosphate

‘Switchable’ ionic liquids (SILs)

- ‘Switchable’ ionic liquid*

1,8-diazabicyclo[5.4.0]undec-7-ene (DBU)

An ionic liquid formed upon CO₂ bubbling
No cumbersome synthesis required

Low-Polarity Solvent ↔ High-Polarity Solvent

+ CO₂ → - CO₂

CO₂ capture with novel solvents (ILs vs. SILs)

Conditions: P = 1 bar, T = 298 K, V_L = 2 ml

After CO₂ capture, the viscosity slightly decreased in the case of the studied ionic liquids.

In case of SILs (DBU + ROH) mixtures, the viscosity dramatically increased.

It was observed that a rise in temperature provides an attractive decline in the viscosity of SILs.

An increase in temperature from 298 to 328 K decreased the viscosity of the mixture (CO₂ + DBU + 4-amino-1-butanol) by a factor of 20 while for a less viscous mixture (CO₂ + DBU + 1-hexanol) the viscosity changed by a factor of 10.

Conclusions

✓ Ionic liquids appeared to be promising sorbents in case of both CO$_2$ and volatile organic compounds removal.

✓ ‘Switchable’ ionic liquids are sorbents that combine high CO$_2$ capturing efficiency with the advantages of simple synthesis.

✓ In terms of CO$_2$ removal efficiency, the ‘switchable’ ionic liquids were found clearly superior to ‘classical’ ionic liquids (by a factor of two).

✓ The study also revealed some of the structural effects of various mixtures based on DBU and (amino) alcohols.
Collaboration:

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Thank you