Why You Should Care About Ionic Liquids

Raz Abbasi[b], Rachel S. Korchinsky[a], Lautaro Lujan[c], Alex R. MacDonald[a], Erin R. Sturd[d]

[a]Department of Chemistry, and [b]Chemical Engineering Queen's University, Kingston, ON, K7L 3N6, Canada.

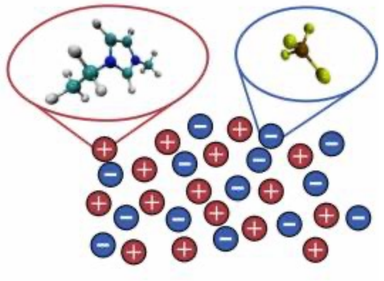
[c]Instituto de Investigación y Desarrollo en Ingeniería de Procesos y Química Aplicada, Universidad Nacional de Córdoba, CONICET, Argentina.

[d]Department of Chemical Engineering, Massachusetts Institute of Technology.

1. Introduction

What is an Ionic Liquid (ILs)[1,2]:

- Compounds consisting of organic cation and either an organic or inorganic anion.
- Strongly related to other ionic compounds, such as molten salts (e.g., NaCl).
- ILs exist in the liquid phase below 100 °C.



ILs are Unconventional Solvents[3]:

NaCl | $NaBF_4$ | $[PiBu_3Me]O_3SC_6H_4Me$

- Non-volatile, non-flammable, do not contribute to smog formation, and have no inhalation hazards.
- $NaBF_4$ is used to synthesize ILs; BF_4 is the anion.

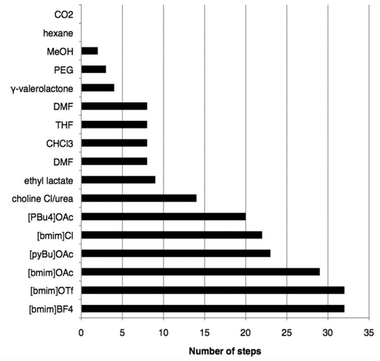
Common Organic Solvents vs ILs[4-5]:

Solvent Type	Advantageous	Disadvantageous
Ionic Liquid	• Catalytic Capability • Large Applicable Range (i.e Tunable) • Non-Flammable • Non-Volatile	• Aquatic Toxicity • Costly • Disposal • Removal of Non-volatile Solutes Requires Additional Material & Energy Input
Organic Solvent	• Reduced Cost • Easier Separation of Solute	• Flammable • Inhalation Toxicity (Volatile)

2. Greenness of Traditional Ionic Liquids

Greenness Overview[3,6,7]:

- ILs require longer and more harmful syntheses than most common solvents.
- The high number of process steps causes ILs to be more harmful in several impact metrics compared to other common solvents.
- Non-volatile solutes must be removed by adsorption, membrane techniques, or stripping processes, increasing cost and waste.
- Though ILs do not produce toxic vapours, many are themselves toxic and have poor biodegradability.



= Hazardous

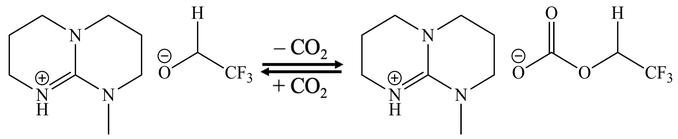
Solvent	ADP	GWP	ODP	HTP	FAETP	MAETP	TETP	POCP	AP	EP	VOC
[Bmim][BF_4]	5.8E-2	3.5E+0	6.1E-7	6.1E-1	5.2E-2	4.4E+3	1.2E-2	4.5E-3	4.2E-2	1.8E-3	1.6E-2
H_2O	3.3E-6	5.7E-4	8.4E-10	1.8E-4	3.5E-5	6.4E-1	1.2E-5	5.5E-7	4.5E-6	1.7E-7	1.6E-6
LPDE	2.6E-2	1.4E+0	3.1E-7	1.8E-1	4.5E-2	3.5E+2	6.7E-3	5.0E-3	1.2E-2	9.1E-4	1.1E-2
Acetone	3.8E-2	2.0E+0	0.0E+0	2.3E-2	3.1E-3	5.4E+1	9.8E-4	4.2E-4	1.4E-2	1.6E-3	4.6E-3
Benzene	3.1E-2	1.6E+0	9.4E-7	1.3E-1	2.0E-2	6.9E+1	3.8E-4	1.9E-3	1.0E-2	9.6E-4	9.1E-3

Abiotic resource depletion (ADP), global warming potential (GWP), ozone-depleting potential (ODP), human toxicity potential (HTP), freshwater aquatic ecotoxicity potential (FAETP), marine aquatic ecotoxicity (MAETP), terrestrial ecotoxicity (TETP), photochemical ozone creation potential (POCP), acidification potential (AP), eutrophication potential (EP), and volatile organic compounds (VOC).

3. Reversible Ionic Liquids

Switchable ILs[8]:

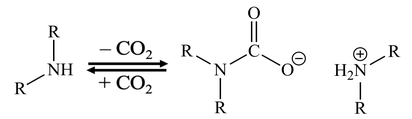
- Reversible ILs alternate between a non-IL and an IL mixture; the polarity change enables solute migration between phases.



Low Polarity | High Polarity

Alkylcarbonate vs Carbamate[8]:

- ILs are created with alkylcarbonate anions or carbamate salts.
- Carbamates remove the water-sensitivity issue of alkylcarbonates.
- Carbamates are best for low polarity ranges as primary and secondary amines are required, which are less polar than alcohols.



4. Potential Industrial Applications

Flue Gas[8]:

- Mixture of CO_2, H_2O vapor, particulates, heavy metals, and acidic gases.
- CO_2-adsorption capacity can achieve as high as 21 wt.%.

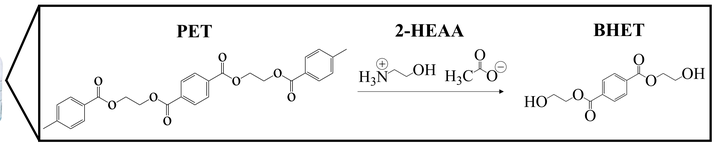
Sorbent	CO_2 Capacity (wt.%)	CO_2 Binding Mode
DBU/1-hexanol	15	Alkylcarbonate
TMG/1-hexanol	17	Alkylcarbonate
N,N,N,trimethylpropane-1,3-diamine	28	Carbamate
Siloxylated ethanolamines	12	Carbamate

Green Corrosion Inhibitors[9]:

- Less hazardous for health and the environment than conventional corrosion inhibitors.
- ILs form a protective coating on the metal surface of Al, Cu, Mg, steel, and other alloys.
- ILs employed: imidazolium, triazolium, thiazolium, phosphonium, pyridinium, ammonium, pyrrolidinium, and pyridinium-based ionic liquids.

Valorization of Plastic Waste[10]:

- *Chemical Recycling Approach:* Post-consumer PET glycolytic conversion into BHET.
- *Catalytic Co-Solvent:* Protic ILs 2-HEAA.



Catalyst	Highlights
Ionic Liquid	• Easy Recovery • Less Costly • Milder Reaction Conditions • Recyclable (ex. 2-HEAA) • Similar Efficiency to Traditional Corrosion Inhibitors

5. Concluding Remarks

- *"Reversible ILs"*: Fewer synthetic steps, are easily recoverable. but are limited by evaporative loss and hydrolysis.
- Production from non-renewable energy sources and persistence in the environment raise questions about *"greenness"*.
- A wide variety of potential industrial applications related to sustainability and green chemistry is being investigated.

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Contact Info

Emails:
21ra37@queensu.ca
rachel.korchinsky@queensu.ca
lautaro.lujan@unc.edu.ar
21arm10@queensu.ca
ersturd@mit.edu


Raz Abbasi


Rachel Korchinsky


Lautaro Lujan


Alex MacDonald


Erin Sturd