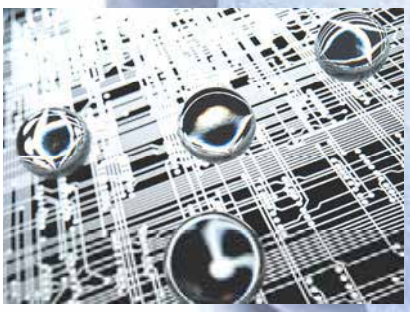
KOEI CHEMICAL CO.,LTD.

Ionic Liquids

KOELIQ™



We love the earth,
we love chemistry.

KOEI CHEMICAL CO.,LTD.

Contents:

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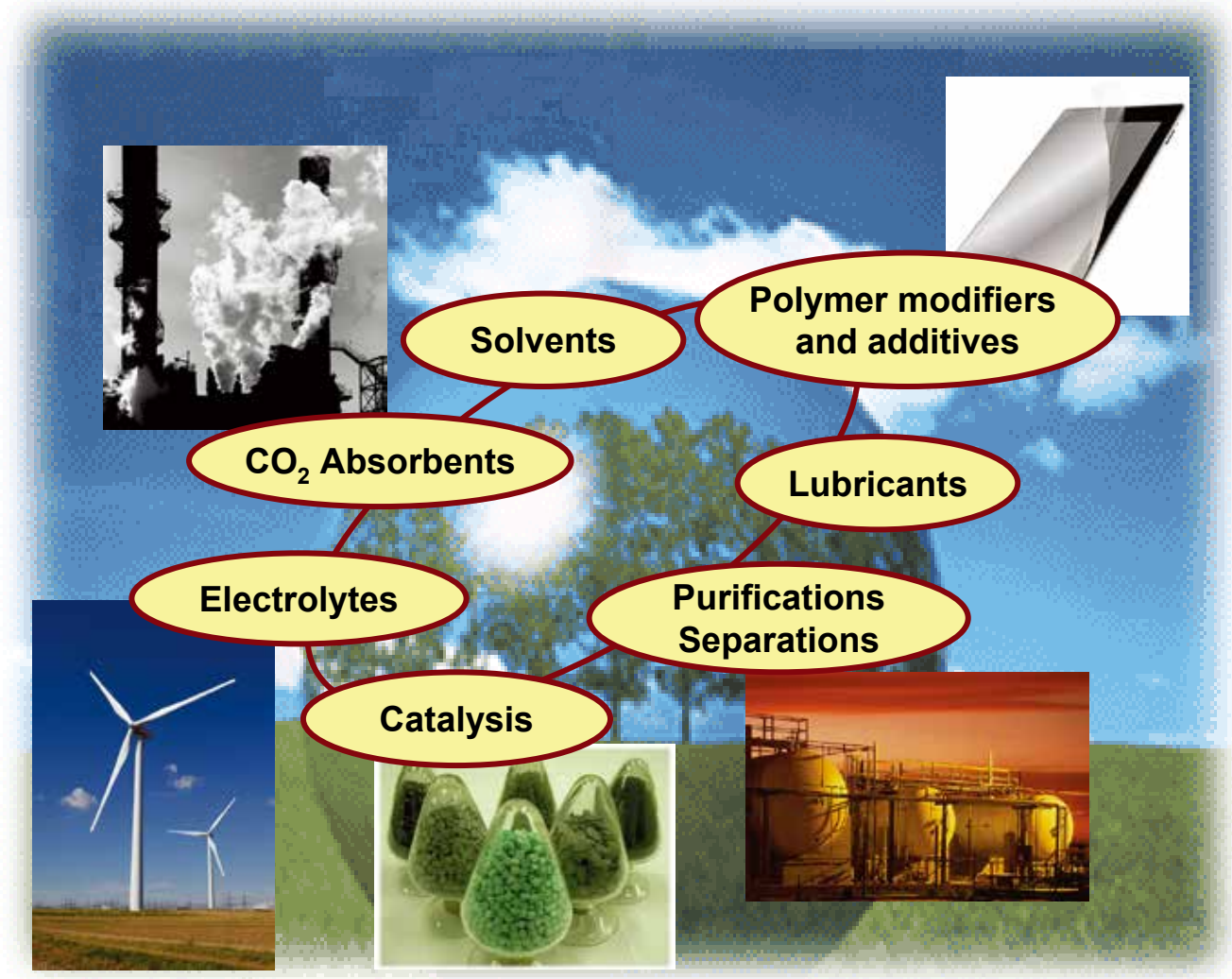
Introduction:

We are experts in manufacturing various kinds of products containing nitrogen, such as pyridines, pyrazines and amines. Using in-house technology, we have converted these compounds to ionic liquids. Our current product line of ionic liquids consists of over 500 compounds.
All of the ionic liquids we provide are guaranteed to be of a defined high quality.

Typical features of ionic liquids

- Liquid over a very wide temperature range
- High electrical conductivity
- High electrochemical stability (wide electrochemical window)
- High thermal conductivity
- Good thermal stability
- Nonvolatile and nonflammable

Applications



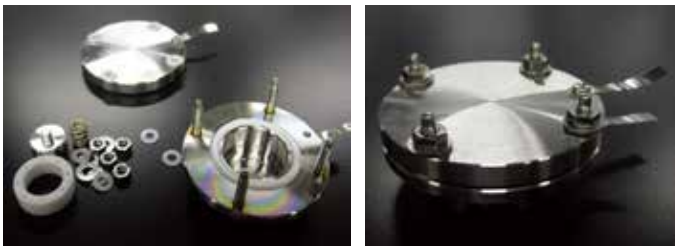
1. Solvents

Environmentally friendly “green processes” are required in the chemical industry, and ionic liquids have attracted worldwide attention in this field as good solvents.
Ionic liquids, which can be easily separated from a reaction mixture and recycled, may be useful as extraction media from wastewater.
Since they are nonvolatile and nonflammable, ionic liquids are safe and hygienic solvents. They may be selected or designed to be either hydrophobic or hydrophilic.

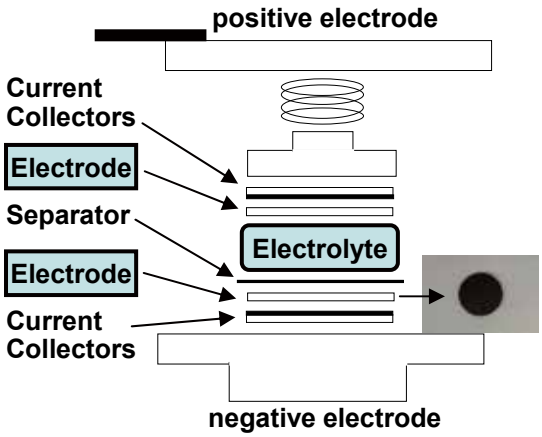
2. Electrolytes

Ionic liquids are suitable materials for use in electrochemical devices such as electric double layer capacitors (EDLC), lithium ion batteries (LIB) and dye-sensitized solar cells (DSSC).
Various problems associated with current electrolytes may be resolved with ionic liquids, including

* Improved safety (nonvolatile and nonflammable compounds)
* Improved battery performance (high conductivity and wide electrochemical window)



Coin-type cell



Assembling coin-type cell

3. CO_2 absorbents

Carbon dioxide (CO_2) is a major greenhouse gas that contributes to Earth's global warming. Therefore, the development of cost-effective methods for the separation and capture of CO_2 from flue gas is now receiving significant attention. Ionic liquids have been used as nonvolatile and reversible absorbents for CO_2 separation.

4. Polymer modifiers and additives

Ionic liquids, as additives, significantly enhance the performance of polymers, such as polyurethane rubbers, polycarbonates, PETs and epoxy resins.
Value-added polymers can be obtained by the addition of ionic liquids.

5. Lubricants

Lubricants are used in various devices and machines. They reduce friction between moving parts and improve efficiency.
Ionic liquids have been tested as lubricants in a vacuum environment for use in as well as forming novel liquid pistons.

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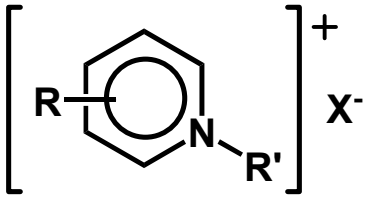
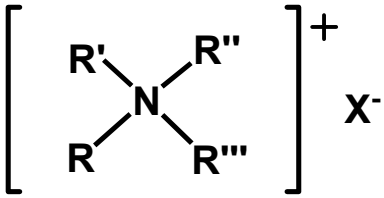
We provide the following ionic liquids.

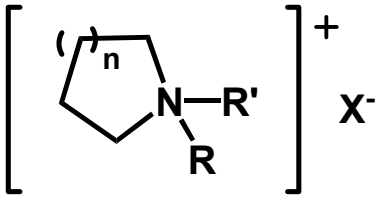
IL-P series



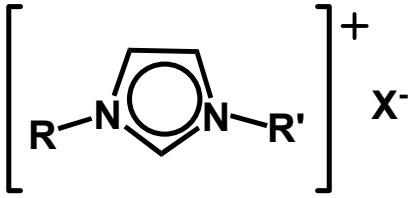
IL-A series



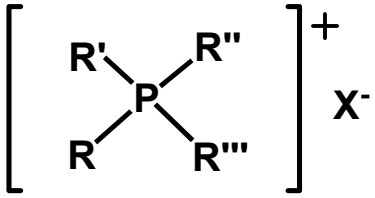
IL-C series



IL-IM series



IL-AP series

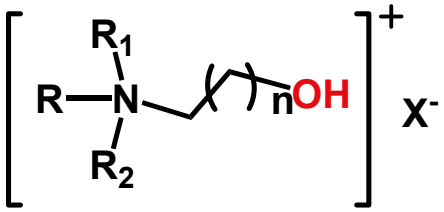


X^- : $[BF_4]^-$, $[PF_6]^-$, $[NTf_2]^-$, Cl^-, Br^- *etc.*

"Reactive ILs"

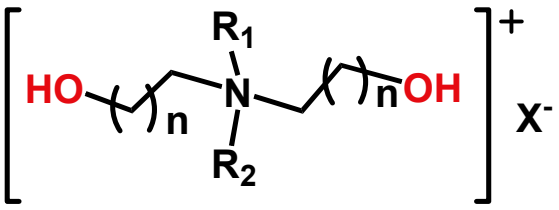
OH series

Ex.1



mono-OH Type

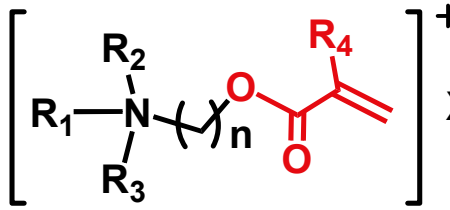
Ex.2



di-OH Type

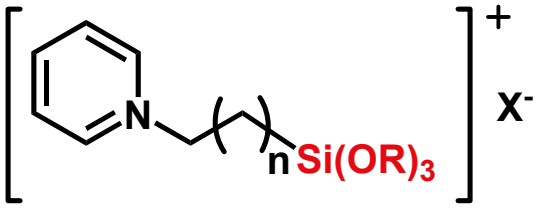
MA series

Ex.



S series

Ex.



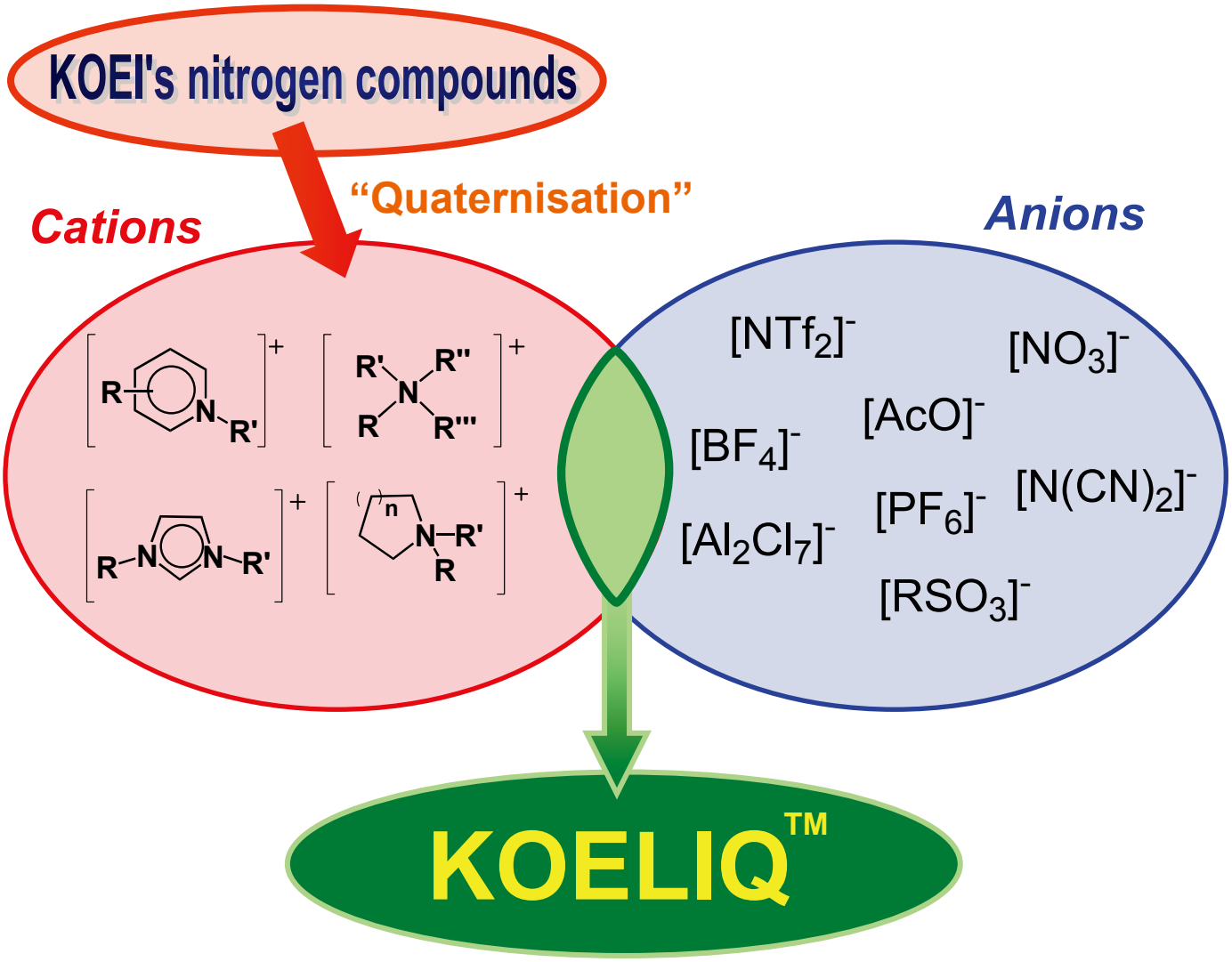
Physical Properties of Some of Koei's Ionic Liquids

Product Name	T_g/℃[*1]	T_m/℃[*2]	T_d/℃[*3]	η/mPa s[*4]	ΔE/V[*5]	E_{red}/V[*6]	E_{ox}/V[*7]	σ/mS cm^{-1} [*8]	n[*9]
IL-P series									
IL-P14	-	12	369	85	4.7	-1.3	+3.4	1.80	1.449
IL-P18	-77.1	16	379	99	4.6	-1.3	+3.3	1.10	1.448
IL-A series									
IL-A1	-84.3	-	314	301	5.8	-2.5	+3.3	0.53	1.436
IL-A2	-81.0	-	347	635	6.6	-3.1	+3.5	0.06	1.440
IL-A3	-88.7	-	341	225	5.1	-2.9	+2.2	1.20	1.414
IL-A4	-	-	336	68	5.3	-3.0	+2.3	2.50	1.420
IL-A5	-	34	374	168	6.3	-3.0	+3.3	1.10	1.415
IL-A12	-	17	393	72	6.1	-2.9	+3.2	2.80	1.406
IL-C series									
IL-C1	-76.6	-	401	214	6.2	-3.0	+3.2	1.05	1.432
IL-C3	-88.4	-8	407	88	6.2	-2.9	+3.3	2.53	1.424
IL-C5	-63.3	-	369	813	6.4	-3.0	+3.4	0.17	1.435
IL-C6	-68.6	-	354	303	6.1	-3.0	+3.1	0.51	1.430
IL-IM series									
IL-IM1	-89.0	11	390	32	4.7	-2.2	+2.5	13.00	1.413
IL-IM4	-	-	380	106	4.9	-2.4	+2.5	3.30	1.421
IL-AP series									
IL-AP1	-	82	373	-	6.4	-3.1	+3.3	-	-
IL-AP3	-78.5	18	369	338	6.5	-3.1	+3.4	0.16	1.446
IL-MA series									
IL-MA1	-49.1	52	309	-	5.3	-1.9	+3.4	-	-
IL-MA2	-50.5	-	340	704	4.8	-1.9	+2.9	0.30	1.430
IL-MA3	-60.2	-	356	397	5.0	-2.0	+3.0	0.57	1.427
IL-S series									
IL-S2	-70.6	23	334	115	5.4	-3.1	+2.3	0.98	1.446
IL-S3	-62.0	-	324	408	5.0	-2.7	+2.3	0.29	1.431
IL-S4	-49.3	-	280	1520	5.7	-3.0	+2.7	0.10	1.433

[*1]: T_g = "glass-transition temperature". [*2]: T_m = "temperature at melting point".
[*3]: T_d = "decomposition temperature at which a 5% weight loss was observed by TG-DTA analysis".
[*4]: η = "viscosity which was measured at 25℃".
[*5]: ΔE = "electrochemical potential window *vs.* SCE. (1.0 M propylene carbonate solution)".
[*6]: E_{red} = "reduction potential". [*7]: E_{ox} = "oxidation potential".
[*8]: σ = "electrical conductivity". [*9]: n = "refractive index".

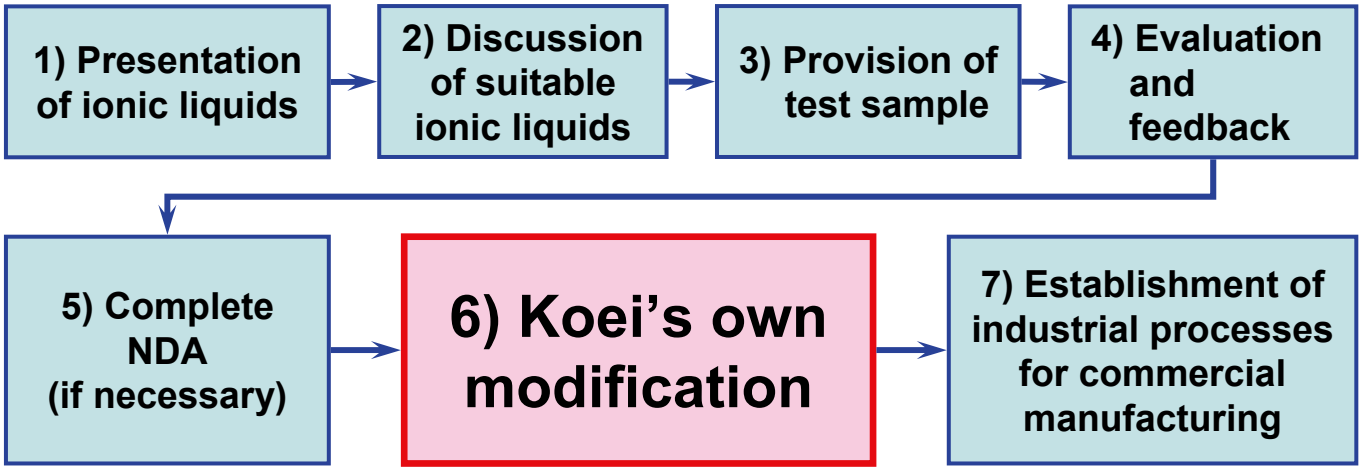
KOEI's Technology for Ionic Liquids;

We produce various kinds of ionic liquids, and their physical properties can be optimised at the request of the customer.



Business Procedure:

We respond to our customers' requests promptly and efficiently. We have considerable experience commercialising ionic liquids,



1) KOEI responds to customer enquiries concerning ionic liquids.
2) We discuss what kinds of ionic liquids are suitable for the customer's project.
3) We select some samples and provide them to the customer.
4) We review the customer's evaluation results.
5) If necessary, we will complete a Nondisclosure Agreement.
6) We optimise the structures of the ionic liquids.
The optimisation process is iterated until the customer is satisfied with the product.
7) We establish an industrial process for commercial manufacturing.

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