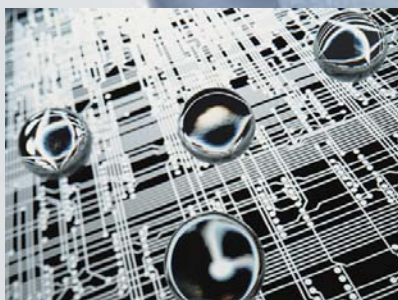
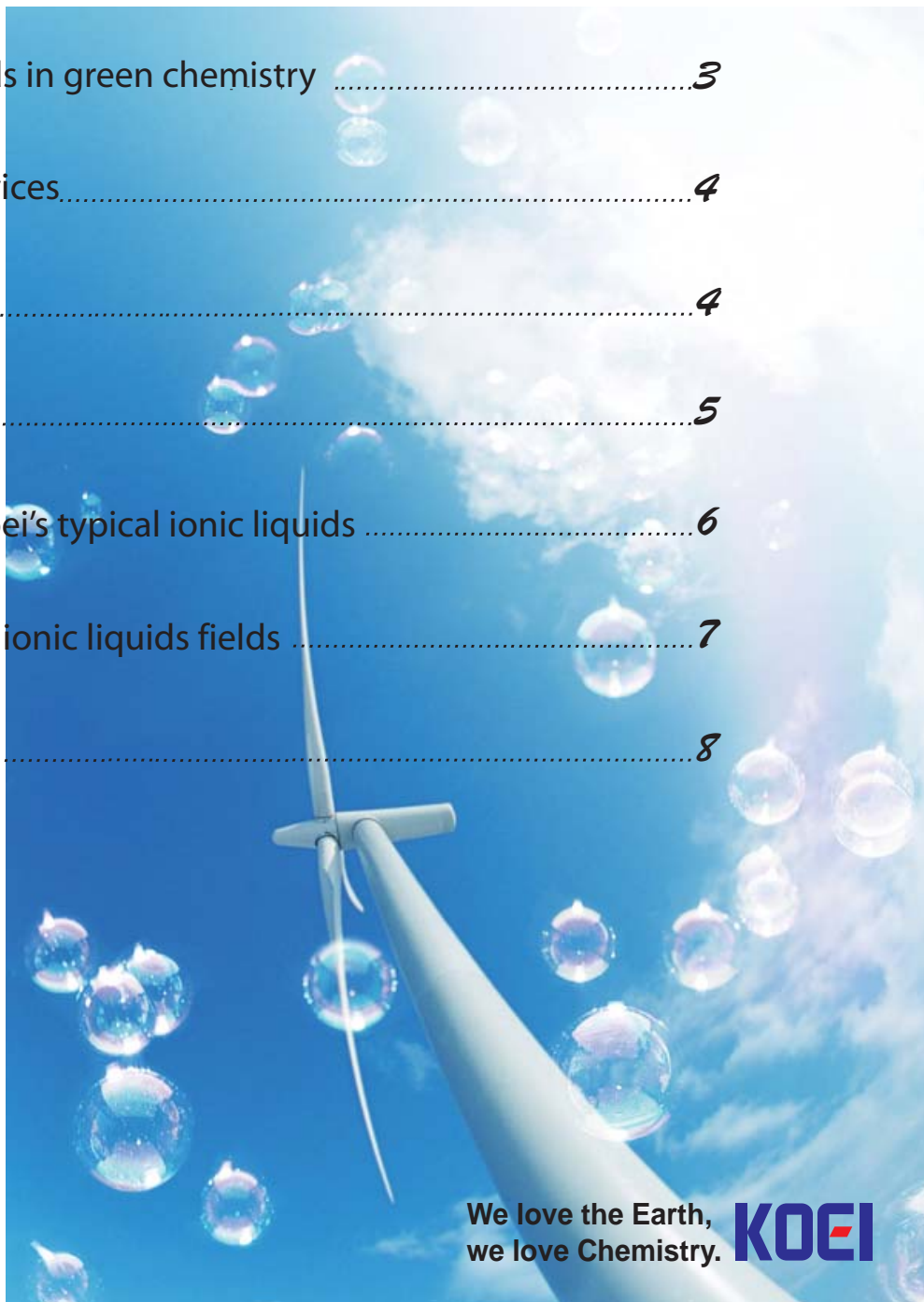


# *Ionic Liquids*



## Contents:

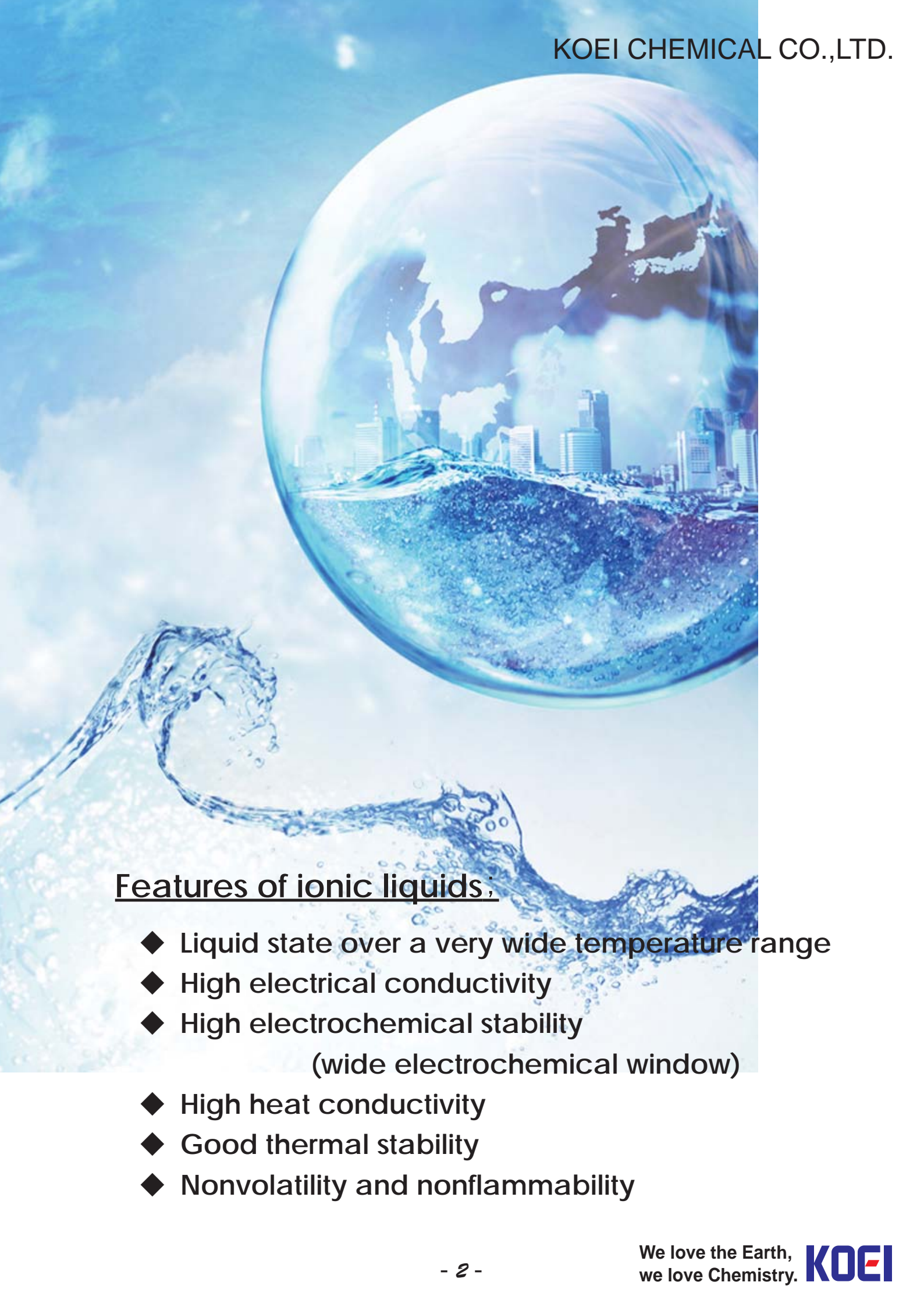
Introduction .....	1
Features of ionic liquids .....	2
Applications	
1.Usage of ionic liquids in green chemistry .....	3
2.Electrochemical devices.....	4
3.Other applications .....	4
KOEI's IONIC LIQUIDS .....	5
Physical properties of Koei's typical ionic liquids .....	6
KOEI's Technology in the ionic liquids fields .....	7
Business Procedure .....	8



## Introduction:

We have strong expertise in manufacturing various kinds of products containing nitrogen such as pyridines, pyrazines and amines. Utilizing these compounds as cations, we have been developing ionic liquids. Our current product line of ionic liquids exceeds 500 compounds. We guarantee the high quality of all the ionic liquids we provide at customer's requests !!





Features of ionic liquids ;

- ◆ Liquid state over a very wide temperature range
- ◆ High electrical conductivity
- ◆ High electrochemical stability  
(wide electrochemical window)
- ◆ High heat conductivity
- ◆ Good thermal stability
- ◆ Nonvolatility and nonflammability

## Applications;

### 1. Usage of ionic liquids in green chemistry <sup>1)~3)</sup>

Recently, the environmentally friendly "clean process" is required in the chemical industry and ionic liquids have attracted worldwide attention in the field of "Green Chemistry" as a good solvent.

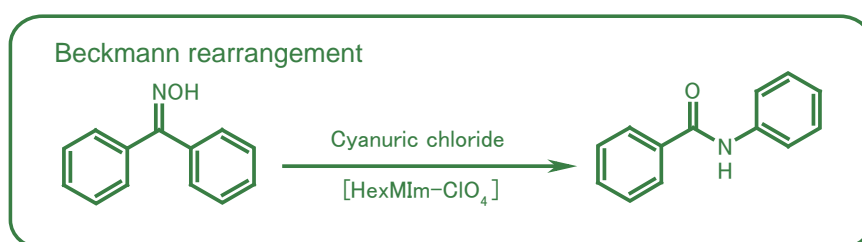
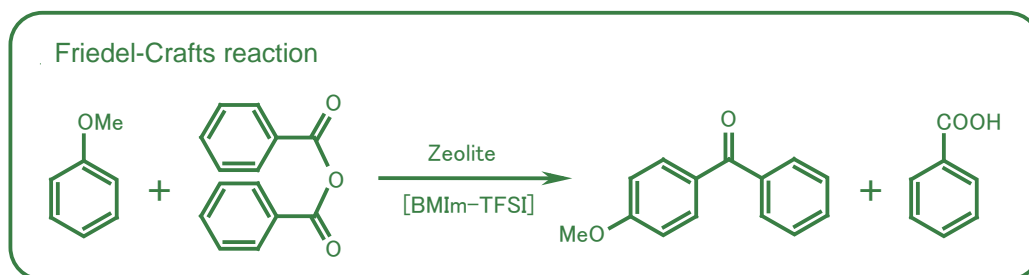
Ionic liquids, which are easily separated from a reaction mixture and recycled, are expected to be used as an extraction media from wastewater.

Utilizing their characteristics of nonvolatility and nonflammability, ionic liquids are used as safety and hygienical solvents.



#### < Typical reactions >

Friedel-Crafts reaction	Wittig reaction	asymmetric Aldol reaction,
Diels-Alder reaction	Beckmann reaction	enzyme-catalyzed reaction,
Heck reaction	Claisen rearrangement	polymerization, and etc.



## 2. Electrochemical devices <sup>4)~5)</sup>

Ionic liquids are expected as suitable materials for electric chemical devices such as electric double layer capacitors, lithium ion battery and solar cells.

There are possibilities that various problems of current electrolytes would be solved by ionic liquids .



- \* Improvement of safety (nonvolatile and nonflammable compounds)
- \* Improvement of battery performance  
(high conductivity and wide electrochemical window)

## 3. Other applications <sup>6)~11)</sup>



Recently, other applications of ionic liquids besides solvents and electrolytes are being investigated.

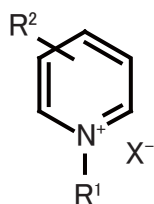
- \* lubricants  
( low coefficient of friction)
- \* CO<sub>2</sub> absorption  
( high physical adsorption)
- \* heating media  
( good thermal stability)

### <References>

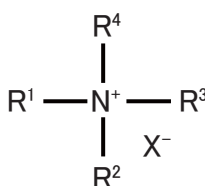
- 1) Cinzia Chiappe, Daniela Pieraccini, *J.Phys.Org.Chem.*, 2004, 18, (4), 275-297
- 2) Hardacre, Christopher, et al., *Organic Process R&D*, 2008, 12, (6), 1156-1163
- 3) Betti,Cecilia, et al., *Synlett*, 2008, 6, 908-910
- 4) Kanako Yuyama, et al., *Journal of Power Sources*, 162, 1401-1408, 2006
- 5) Katsuhiko tsunashima, et al., *Chemistry Letters*, 37, 314-315, 2008
- 6) Chengfeng Ye,et al., *Chem.Comm.*, 2001, 2244-2245
- 7) Ichiro Minami, *The Chemical Times*, 211, 12-16, 2009
- 8) Lynnette A. Blanchard, et al., *Nature*, 399,28-29, 6 May 1999
- 9) Mark J. Muldoon, et al., *J.Phys.Chem.*, B2007, 111, 9001-9009
- 10) Zhang M., et al., *ECS Transactions*, 2007, Volume Date 2006, 2, 27-34
- 11) Van Valkenburg, Michael E., et al., *Thermochimica Acta*, 2005, 425(1-2), 181-188

## KOEI's IONIC LIQUIDS :

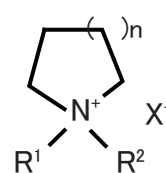
We can provide the following eight series;  
**"P", "A", "C", "IM", "AP", "MA", "S", "OH".**



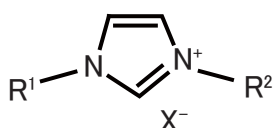
1) IL-P series



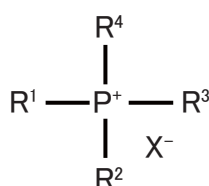
2) IL-A series



3) IL-C series



4) IL-IM series



5) IL-AP series

$X^-$  ;  $BF_4^-$ ,  $PF_6^-$   
 TFSI, etc.

### "Reactive Ionic Liquids"

6) IL-MA series

7) IL-S series

8) IL-OH series

# Physical Properties of Koei's Typical Ionic Liquids ;

Product Name	Tg *1 [°C]	Melting Point [°C]	Decomposition Temp. *2 [°C]	Viscosity at 25°C [mPa·s]	Electrochemical Window *3 [V]	Electrical Conductivity [mS/cm]	Refractive Index
<b>IL-P series</b>							
IL-P14	N.D.	12	369	85	-1.3 ~ +3.4 (4.7)	1.80	1.449
IL-P18	-77.1	16	379	99	-1.3 ~ +3.3 (4.6)	1.10	1.448
<b>IL-A series</b>							
IL-A1	-84.3	N.D.	314	301	-2.5 ~ +3.3 (5.8)	0.53	1.436
IL-A2	-81.0	N.D.	347	635	-3.1 ~ +3.5 (6.6)	0.06	1.440
IL-A3	-88.7	N.D.	341	225	-2.9 ~ +2.2 (5.1)	1.20	1.414
IL-A4	N.D.	N.D.	336	68	-3.0 ~ +2.3 (5.3)	2.50	1.420
IL-A5	N.D.	34	374	168	-3.0 ~ +3.3 (6.3)	1.10	1.415
IL-A12	N.D.	17	393	72	-2.9 ~ +3.2 (6.1)	2.80	1.406
<b>IL-C series</b>							
IL-C1	-76.6	N.D.	401	214	-3.0 ~ +3.2 (6.2)	1.05	1.432
IL-C3	-88.4	-8	407	88	-2.9 ~ +3.3 (6.2)	2.53	1.424
IL-C5	-63.3	N.D.	369	813	-3.0 ~ +3.4 (6.4)	0.17	1.435
IL-C6	-68.6	N.D.	354	303	-3.0 ~ +3.1 (6.1)	0.51	1.430
<b>IL-IM series</b>							
IL-IM1	-89.0	11	390	32	-2.2 ~ +2.5 (4.7)	13.00	1.413
IL-IM4	N.D.	N.D.	380	106	-2.4 ~ +2.5 (4.9)	3.30	1.421
<b>IL-AP series</b>							
IL-AP1	N.D.	82	373	-	-3.1 ~ +3.3 (6.4)	-	-
IL-AP3	-78.5	18	369	338	-3.1 ~ +3.4 (6.5)	0.16	1.446
<b>IL-MA series</b>							
IL-MA1	-49.1	52	309	-	-1.9 ~ +3.4 (5.3)	-	-
IL-MA2	-50.5	N.D.	340	704	-1.9 ~ +2.9 (4.8)	0.30	1.430
IL-MA3	-60.2	N.D.	356	397	-2.0 ~ +3.0 (5.0)	0.57	1.427
<b>IL-S series</b>							
IL-S2	-70.6	23	334	115	-3.1 ~ +2.3 (5.4)	0.98	1.446
IL-S3	-62.0	N.D.	324	408	-2.7 ~ +2.3 (5.0)	0.29	1.431
IL-S4	-49.3	N.D.	280	1520	-3.0 ~ +2.7 (5.7)	0.10	1.433
<b>IL-OH series</b>							
IL-OH1	N.D.	33	365	106	-2.8 ~ +3.1 (5.9)	2.00	1.412
IL-OH2	-76.4	N.D.	319	97	-1.3 ~ +3.0 (4.3)	2.30	1.415
IL-OH7	N.D.	N.D.	345	919	-2.8 ~ +3.3 (6.1)	0.12	1.441
IL-OH8	-62.4	N.D.	284	626	-3.3 ~ +3.3 (6.6)	0.10	1.458
IL-OH9	N.D.	9	320	2036	-3.1 ~ +2.6 (5.7)	0.09	1.451

\*1: Tg means "glass-transition temperature".

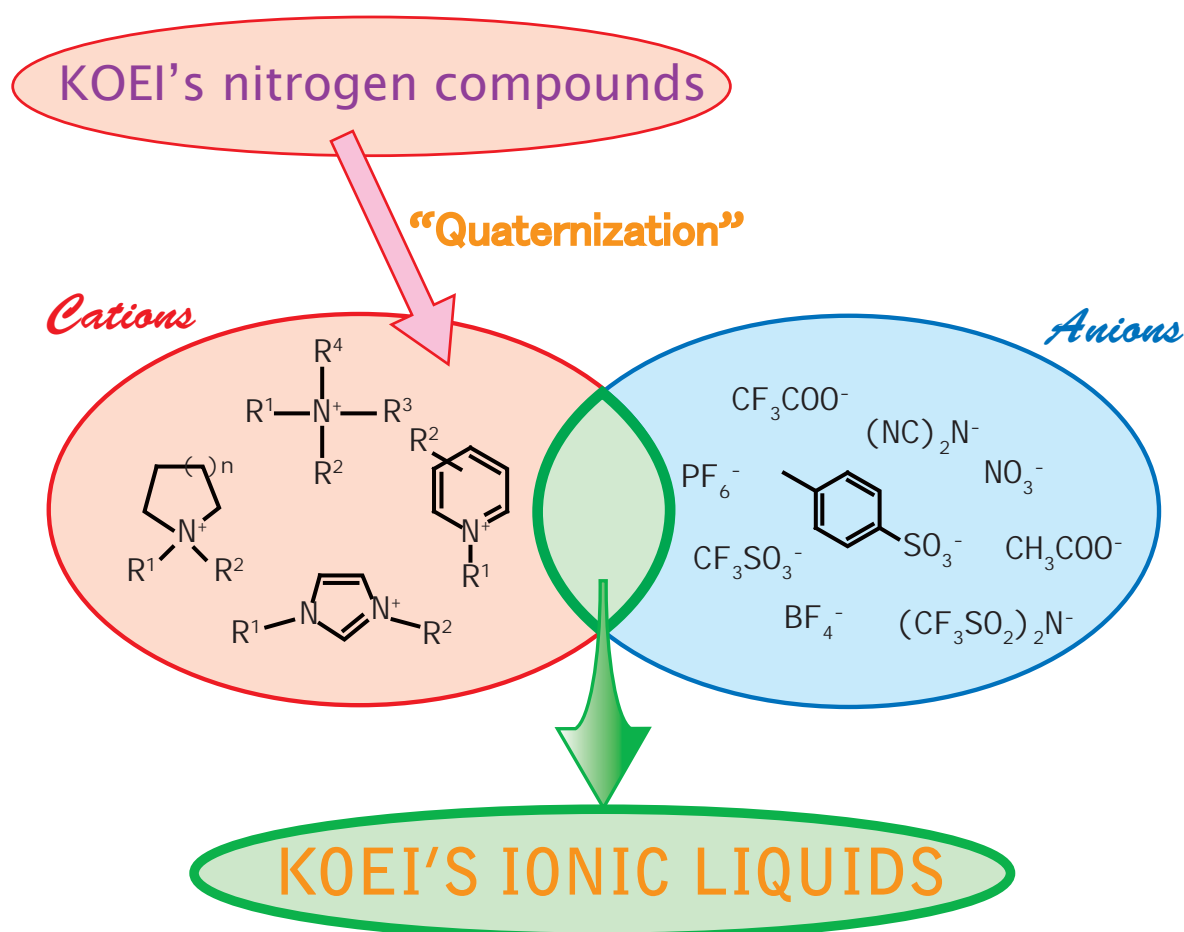
\*2: Decomposition temperature means the temperature corresponding to mark a 5 % decrease by weight on TG-DTA analysis.

\*3: Electrochemical window is measured as a one (1) molar (mol/L) propylene carbonate solution.

N.D.: Not Detectable

## KOEI's Technology in the Ionic Liquids fields ;

We create various kinds of ammonium and pyridinium cations from our products. We provide our customer with appropriate ionic liquids by combining cations mentioned above and anions. We modify the structure of ionic liquids to adjust the physical properties of the ionic liquids



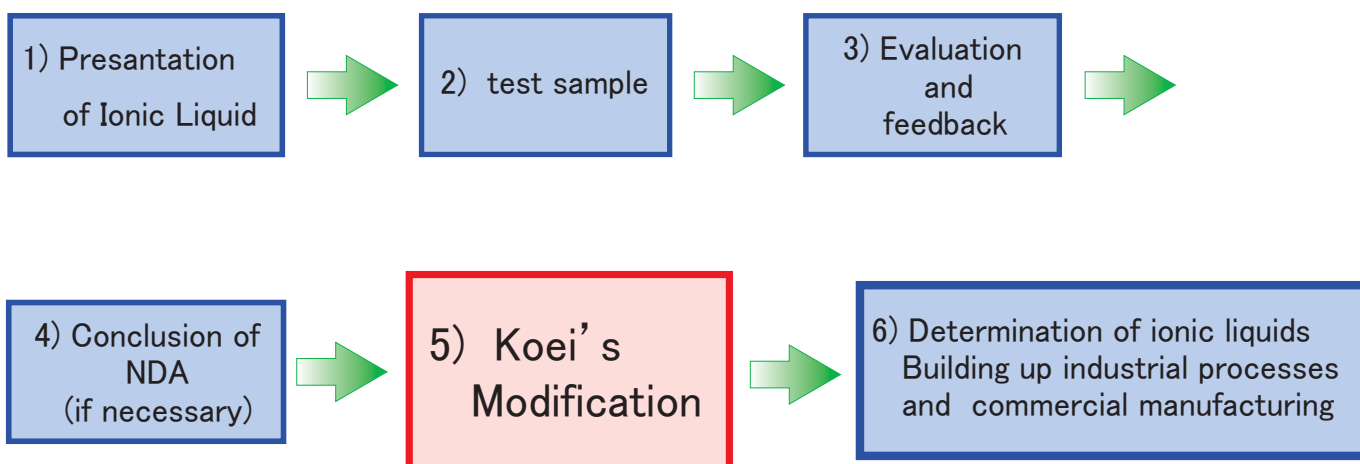
## Business Procedure ;

We respond to customer's requests promptly and adequately.

We have a lot of experiences to have commercialized ionic liquids. Please do not hesitate to consult us at any time.



Typical Procedure is as follows;



- 1) We do our utmost to cater to customer's inquiries concerning our ionic liquids.
- 2) Firstly, 10 gram free sample is provided. If the customers need more than 10 grams of a test sample, basically we charge a fair price.
- 3) We discuss customer's evaluation results and get their feedback.
- 4) If necessary, we conclude a Nondisclosure Agreement and speed up the development.
- 5) We modify the structure of ionic liquids to meet customer's applications.
- 6) After determining the target ionic liquid, we build up an industrial process for commercial manufacturing.

# KOEI CHEMICAL COMPANY LIMITED

Research & Development Division  
Development Office

**Sionogi Honcho Kyodo Bldg.  
3-7-2, Nihonbashihoncho, Chuo-ku, Tokyo, 103-0023, JAPAN**

TEL : 03-6667-8275

FAX : 03-6667-8289

e-MAIL: a-moriyama@**koei**chem.co.jp (Mr. MORIYAMA, Ayao)

<http://www.koeichem.com/english/index.htm>