

Ионные жидкости

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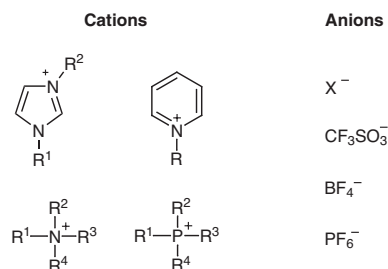
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Ionic Liquids

In recent years, environmentally-friendly reaction processes have vigorously been studied from the standpoint of green chemistry. For example, oxidation reactions with the air, or reactions in water, supercritical fluids, and fluorosolvents are cited. Most recently, ionic liquids have gained much attention as green reaction solvents for organic synthesis.



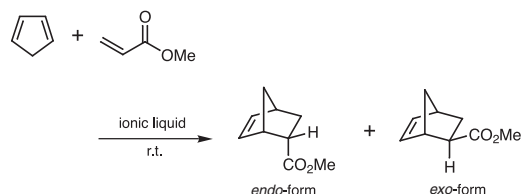
As seen above, ionic liquids are salts, consisting of cations such as imidazolium, pyridinium, quaternary ammonium and quaternary phosphonium, and anions such as halogen, triflate, tetrafluoroborate and hexafluorophosphate, which exist in the liquid state at relatively low temperatures. Their characteristic features include almost no vapor pressure, non-flammability, non-combustibility, high thermal stability, relatively low viscosity, wide temperature ranges for being liquids, and high ionic conductivity. When an ionic liquid is used as a reaction solvent, the solute is solvated by ions only, where the reaction proceeds under quite different conditions as compared to using water or ordinary organic solvents. Hence, they are expected to exhibit unconventional reactivity, and their applications in a variety of organic reactions are being explored.

Ionic liquids containing chloroaluminate as the anion have been investigated for many years. These ionic liquids are not only used as reaction solvents, but also exhibit Lewis acid or Lewis base properties, when the ratio of cations and anions is changed. However, they can only be used under an inert atmosphere or vacuum, due to their high moisture sensitivity. On the other hand, it has been found that ionic liquids containing anions such as hexafluorophosphate form stable salts in air, which lead to the synthesis of numerous stable ionic liquids today. Furthermore, some ionic liquids have very low solubility in water and polar organic solvents. Utilization of this property enables recovery and reuse of ionic liquids, after extracting the product with an organic solvent. That can help to reduce the waste of traditional solvents which are rarely reused. Moreover, ionic liquids have attracted much attention as safe solvents, due to their low volatility.

The followings are some reaction examples using ionic liquids.

1. Diels-Alder reaction

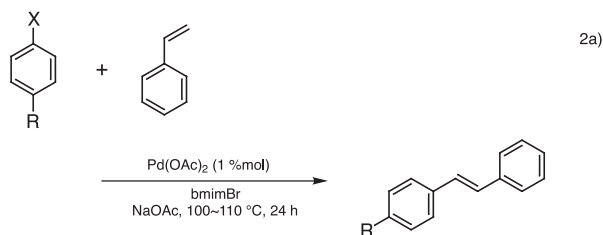
The Diels-Alder reaction between cyclopentadiene and methyl acrylate has been reported. In the Diels-Alder reaction using 1-ethyl-3-methylimidazolium chloride / chloroaluminate [$emimCl/(AlCl_3)_x$], the *endo* / *exo* ratio of the products varies largely, depending on the ratio of $emimCl/(AlCl_3)_x$. The amount of *endo*-form increases four-fold with the acidic $emimCl/(AlCl_3)_x$, compared to that of the basic $emimCl/(AlCl_3)_x$.^{1a)} When the same reaction is carried out with 1-butyl-3-methylimidazolium tetrafluoroborate ($bmimBF_4$), it showed similar reactivity to Lewis basic $emimCl/(AlCl_3)_x$.^{1b)}



ionic liquids	composition (% $AlCl_3$)	time (h)	<i>endo</i> / <i>exo</i> ratio	Y. (%)	
$emimCl/(AlCl_3)_x$	48 (basic)	22	4.88	32.3	1a)
$emimCl/(AlCl_3)_x$	48 (basic)	72	5.25	95	1a)
$emimCl/(AlCl_3)_x$	51 (acidic)	22	19	53	1a)
$emimCl/(AlCl_3)_x$	51 (acidic)	72	19	79.4	1a)
$bmimBF_4$	-	72	4.3	91	1b)

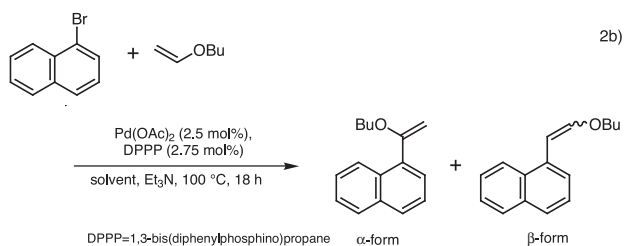
2. Heck reaction

In the Heck reaction using palladium catalysts, polar solvents such as DMF and acetonitrile are employed, and aryl iodides are normally used as substrates. In cases where the less expensive but less reactive aryl bromides or chlorides are employed, it is necessary to use more active catalysts or add phosphine ligands in order to retain the catalytic activity. By utilizing 1-butyl-3-methylimidazolium bromide ($bmimBr$) as solvent, aryl bromides react with styrene to afford stilbenes in high yields without adding a phosphine ligand.^{2a)}



entry	X	R	conv. (%)	Y. (%)
1	I	H	100	99
2	Br	CHO	100	90
3	Br	MeCO	79	88

The reaction of enol ethers bearing an electron donating group with aryl halides generates a mixture of α -substituents and β -substituents under the normal Heck reaction conditions. However, the reaction of vinyl ethers with aryl halides using $bmimBF_4$ as solvent gives only α -substituents specifically.^{2b)} In addition, the Heck reaction employing tetrabutylammonium bromide (Bu_4NBr), which is a quaternary ammonium salt, has been reported.^{2c)}

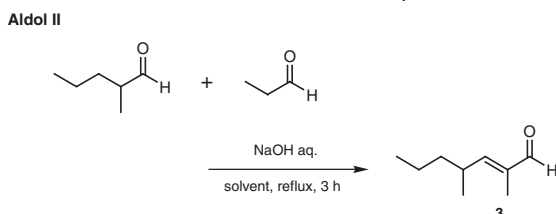
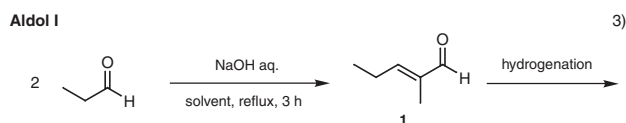


entry	solvent	conv. (%)	α/β	E/Z	Y. (%)
1	toluene	23	46/54	68/32	
2	DMSO	100	75/25	79/21	
3	bmimBF ₄	50	>99/1		
4*	bmimBF ₄	100	>99/1		95

*DPPP (2 eq.), time : 24 h

3. Aldol condensation

The Aldol condensation reaction using ionic liquids has been reported. In the reaction for obtaining 2,4-dimethylhept-2-enal **3** from propanal via two Aldol condensations, the conversion values of the ionic liquid phase is comparable to water medium in the Aldol I reaction. However, the product selectivity is reduced, as can be seen in the figure below. This is due to a side reaction proceeding from the high solubility of product **1** toward the ionic liquid. In contrast, in the Aldol II reaction, as compared with the reaction in water, the product selectivity in ionic liquids are increased. This is because the hydrogenated product of **1** is difficult to dissolve in water but easy in ionic liquids.³⁾

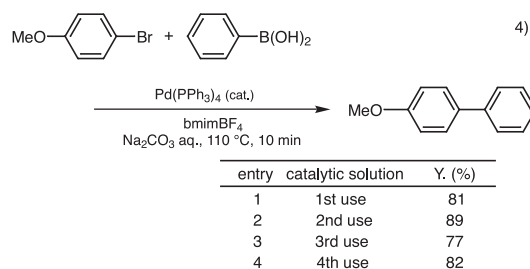


entry	solvent	reaction type	conv. (%)	selectivity (%)			
				1	2*	3	4**
1	bmimBF ₄	Aldol I	99	64	2	-	33
2	H ₂ O	Aldol I	100	82	0	-	18
3	emimBF ₄	Aldol II	100	4	6	69	21
4	bmimBF ₄	Aldol II	100	3	3	80	14
5	H ₂ O	Aldol II	100	36	0	59	5

*2: 3-hydroxy-2-methylpentanal, **4: higher boiling aldehydes and oligomers.

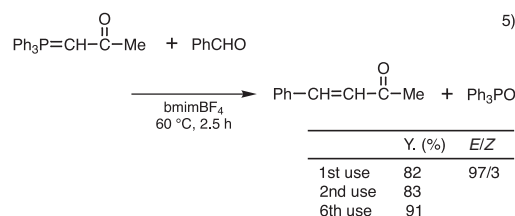
4. Suzuki-Miyaura coupling reaction

In the Suzuki-Miyaura coupling reaction where biaryls are produced from aryl halides and aryl boronic acids in the presence of a palladium catalyst and a base, the removal of the catalyst is often a problem. In the system where an ionic liquid is used as solvent, the product can be extracted with ether after the reaction is complete, with the catalyst being retained in the ionic liquid. The ionic liquid and the catalyst can then be reused as they are.⁴⁾



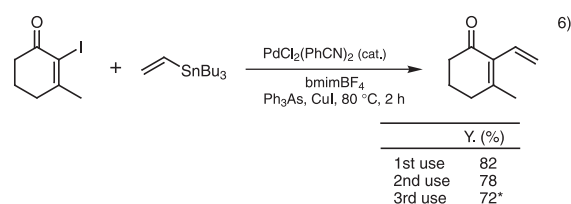
5. Wittig reaction

The Wittig reaction is a useful method for C-C double bond formation. However, the separation of the product and the by-product, triphenylphosphine oxide, is a classic problem. The separation and purification are usually carried out by crystallization or chromatography. When an ionic liquid is used as solvent, the product and phosphine oxide can be easily separated by combining an ether extraction and a toluene extraction after the reaction is complete. In addition, it is possible to efficiently reuse the ionic liquid.⁵⁾



6. Stille reaction

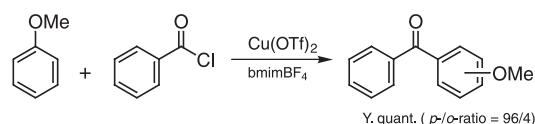
The Stille reaction is a useful reaction, where an organotin compound and an electrophilic reagent are reacted to form a C-C bond under mild conditions in the presence of palladium catalyst. In the reaction of vinyltributyltin and iodo-cyclo-hexenone in an ionic liquid, the product can be extracted with ether, and the catalyst is retained in the ionic liquid. The ionic liquid and the catalyst can be reused as they are. This ionic liquid / catalyst phase is air and moisture stable, and thus can be used after a long storage without loss in activity.⁶⁾



* 3rd run using recycled catalyst/media after 24 days

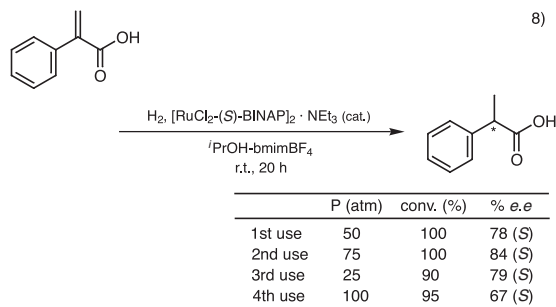
7. Friedel-Crafts reaction

Here is an example of the Friedel-Crafts reaction. In the benzoylation of anisoles catalyzed by copper triflate in bmimBF₄, methoxybenzophenone is quantitatively obtained within 1h, with a *p*-/*o*-product ratio of 96/4.^{7a)} The same reaction performed using acetonitrile gave a lower conversion of 64% at 1h, with the reduced *p*-/*o*-product ratio of 93/7. In addition, the regioselective acylations of indoles using emimCl/(AlCl₃)_x has been reported as well.^{7b)}



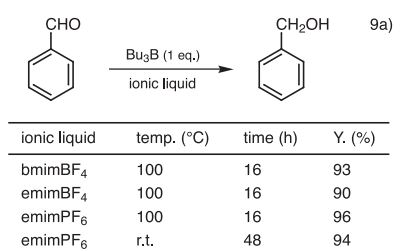
8. Hydrogenation

In the asymmetric hydrogenation of C-C double bond using homogeneous chiral transition metal complexes, the recovery of the catalyst and the separation of the products are often troublesome.⁸⁾ Dupont *et al.* have reported an example in which the reagents are allowed to react in a two phase system of an ionic liquid and an alcohol. After the reaction is complete, the product exists in the alcoholic phase, while the catalyst in the ionic liquid phase. Thus, the product and the catalyst can be easily separated by decantation. In addition, the catalyst which exists in the ionic liquid phase can be reused without loss in activity.



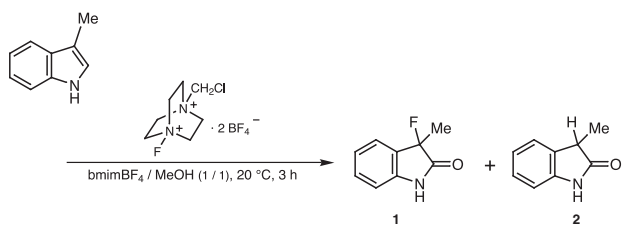
9. Reduction

The reduction of aldehydes using trialkylboranes is an important organic transformation reaction. However, reductions using simple trialkylboranes generally require reaction temperatures in excess of 150 °C. Kabalka *et al.* have reported this reduction using trialkylborane in which bmimBF₄, emimBF₄, and 1-ethyl-3-methylimidazolium hexafluoro-phosphate (emimPF₆) are used as solvents.^{9a)} For example, when benzaldehyde was reduced by tributylborane in emimPF₆, the reaction proceeded rapidly at 100 °C to give the product in high yield. Although long reaction time is needed comparatively, the product can be obtained even at room temperature. In addition, a photoreduction has also been reported using ionic liquids.^{9b)}



10. Fluorination

The introduction of fluorines in to heterocyclic compounds is important in the synthesis of bioactive compounds. In the electrophilic fluorination of indoles using *N*-fluoro-*N'*-(chloromethyl)triethylenediamine bis(tetrafluoroborate) as fluorinating agent and bmimBF₄ as a solvent, 3-fluorinated 2-oxindoles can be obtained in high yield in a short period of time compared to the conventional method (entry 1).¹⁰⁾



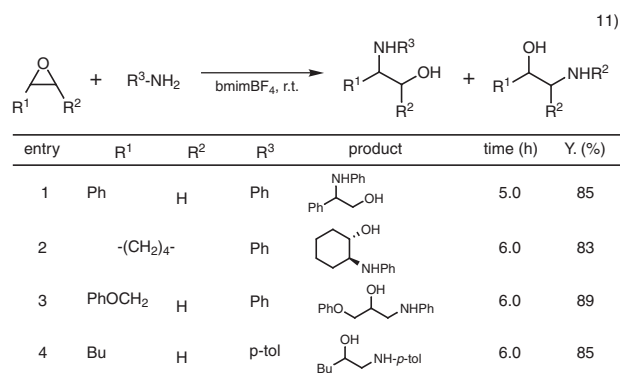
entry	solvent	cosolvent (1/1)	temp. (°C)	time (h)	1 (%)	2 (%)
1	MeCN	H ₂ O	r.t.	overnight	71	small amount
2	bmimBF ₄	MeOH	20	3	99	-

10a)

10b)

11. Ring opening reaction

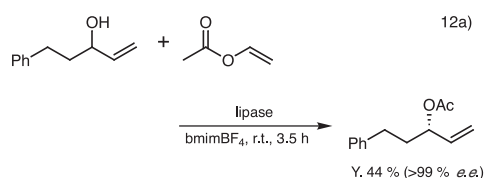
β-Aminoalcohols are utilized as useful building blocks for the synthesis of bioactive compounds. One of the synthetic methods to obtain β-aminoalcohols involves the ring opening of epoxides using amines. However, these reactions require a large excess of the amines at elevated temperatures. The high temperature reaction conditions are not only detrimental to certain functional groups but also to the control of regioselectivity. Subsequently, a variety of activators or promoters such as metal amides, metal triflates and transition metal halides have been developed. However, many of these are often expensive or are needed in stoichiometric amounts, thus limiting their practicality. In the system using ionic liquids, the reaction proceeds at room temperature to give β-aminoalcohols in high yield.¹¹⁾



In the cases of glycidyl ether or alkyloxiranes in entry 3 and 4, amines attack on the less sterically hindered site on the epoxides. After the reaction, the product was extracted with ether, followed by drying at 80 °C under reduced pressure. The ionic liquid was reused in five runs without any loss of activity.

12. Enzymatic reaction

Enzymatic reactions using ionic liquids have also been reported.¹²⁾ It is known that lipase tolerates non-natural reaction conditions, and reactions in organic solvents have intensively been carried out. For example, transesterifications in organic solvents are well known as a useful synthetic methods for the preparation of optically-active compounds. In the asymmetric transesterification of allylic alcohols using ionic liquids, the desired products are afforded in similar yields to those of organic solvent systems.^{12a)}



As described above, a variety of reactions utilizing ionic liquids have been conducted, and the improvement of yields and the recovery and reuse of solvents have been reported. Furthermore, they are also applied to alkylations¹³⁾, allylations¹⁴⁾, epoxidations¹⁵⁾, cycloadditions¹⁶⁾, hydroesterifications¹⁷⁾, and reactions using supercritical CO₂¹⁸⁾, in which they are reported to be effective.

13. Other application

Ionic liquids are attracting attention in electrochemical application, because they consist of only ions and have high ionic conductivity. For example, they have been extensively studied as secondary battery electrolytes. These electrolytes require properties such as high ionic conductivity, non-volatility, thermal stability, non-flammability, and non-corrosiveness. Ionic liquids meet these requirements. Moreover, 1-alkyl-3-methylimidazolium iodide has been recently examined as an electrolyte of dye-sensitized solar cells.¹⁹⁾

Recently Hamaguchi *et al.* reported that 1-butyl-3-methylimidazolium tetrachloroferrate is magnetic ionic liquid.²⁰⁾ Traditional magnetic fluids have had problems of volatility and phase separation. The new magnetic ionic liquid overcomes these problems, and is expected to be applied to many fields, including the use as a sealing agent for the motor axis.

References

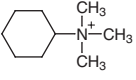
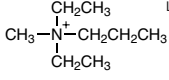
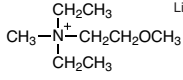
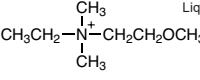
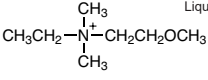
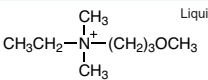
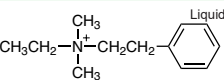
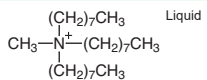
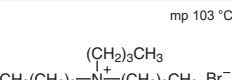
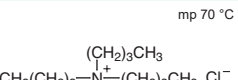
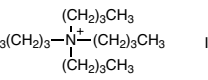
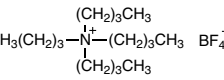
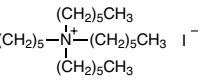
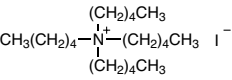
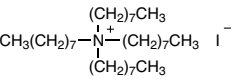
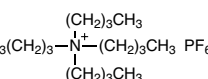
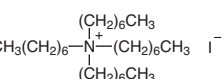
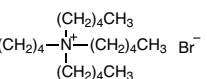
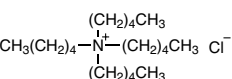
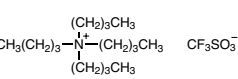
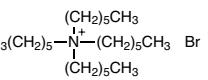
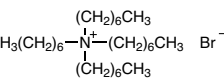
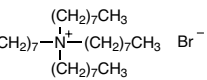
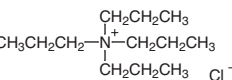
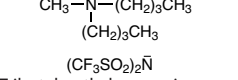
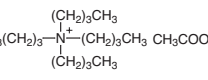
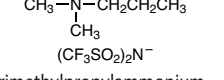
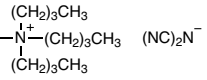
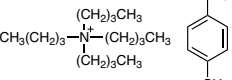
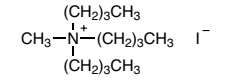
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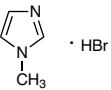
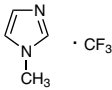
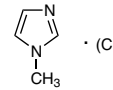
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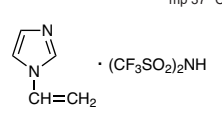
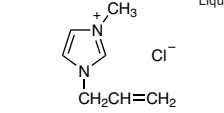
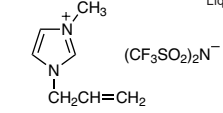
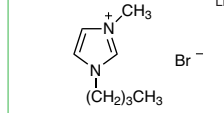
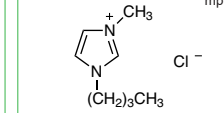
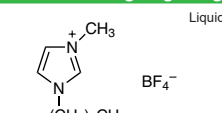
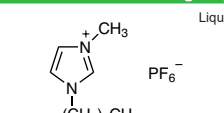
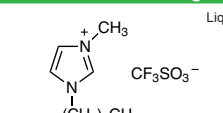
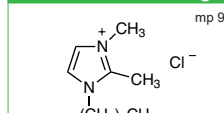
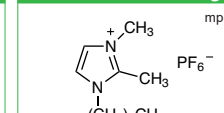
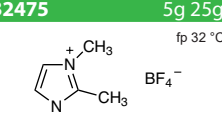
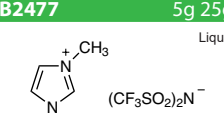
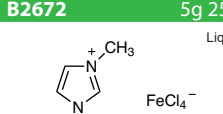
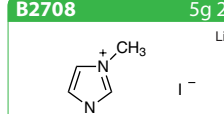
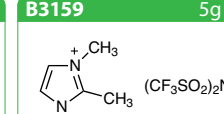
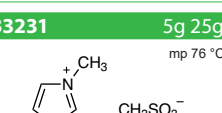
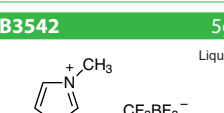
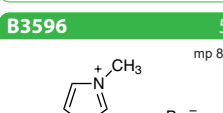
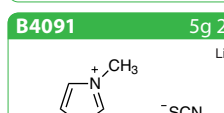
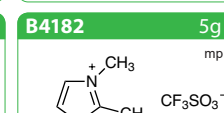
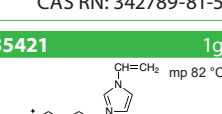
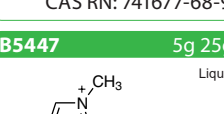
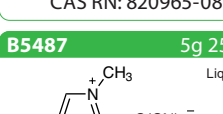
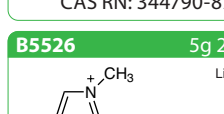
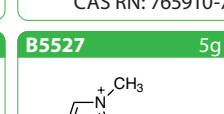
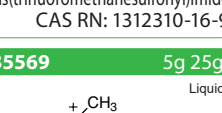
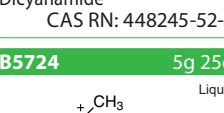
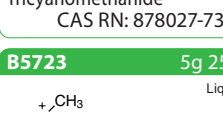
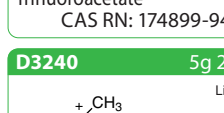
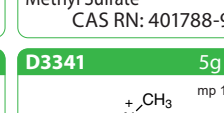
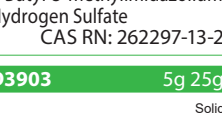
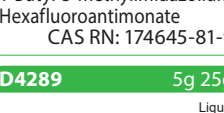
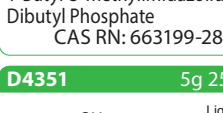
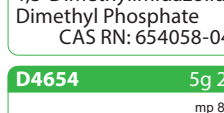
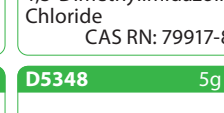
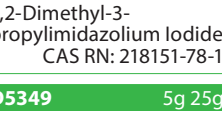
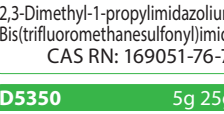
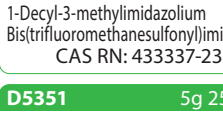
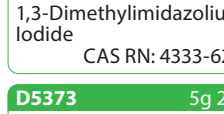
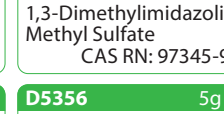
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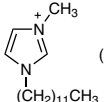
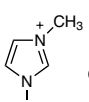
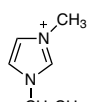
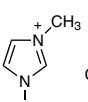
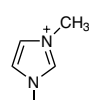
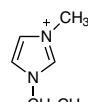
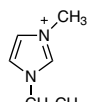
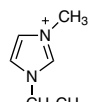
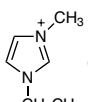
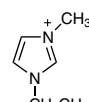
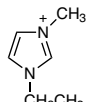
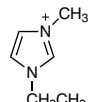
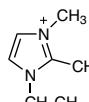
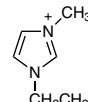
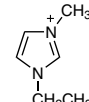
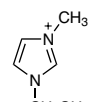
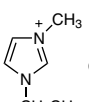
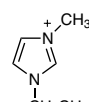
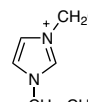
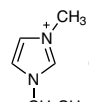
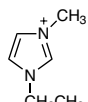
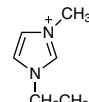
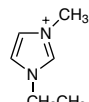
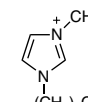
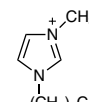
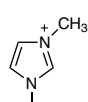
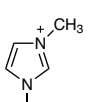
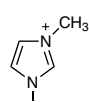
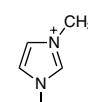
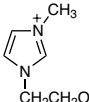
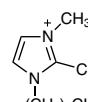
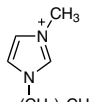
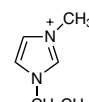
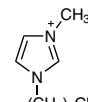
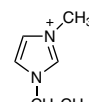
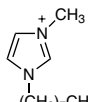
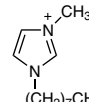
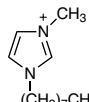
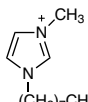
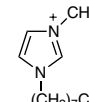
Ammonium Salts

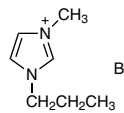
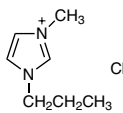
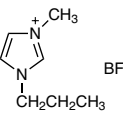
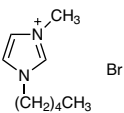
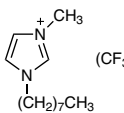
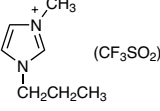
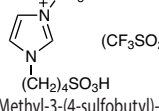
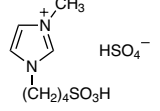
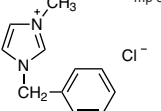
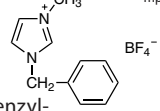
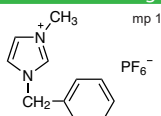
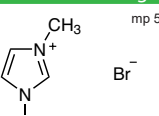
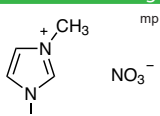
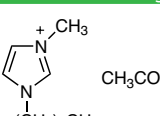
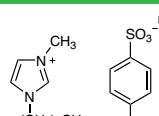
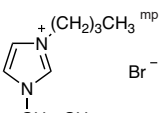
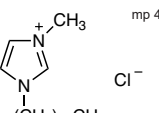
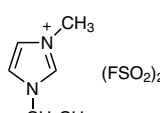
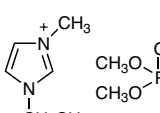
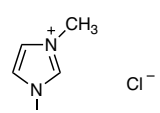
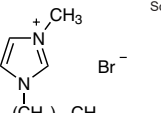
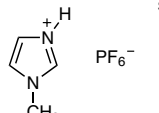
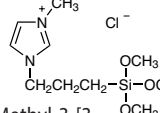
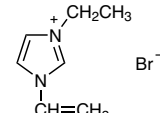
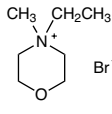
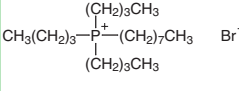
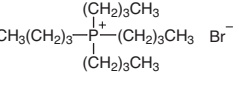
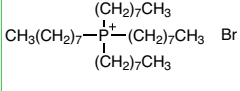
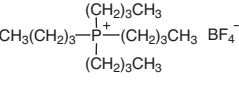
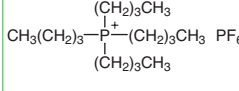
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E1282 5g  Liquid (CF ₃ SO ₂) ₂ N ⁻ Ethyl(3-methoxypropyl)dimethylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 1373334-05-4	E1283 1g 5g  Liquid (CF ₃ SO ₂) ₂ N ⁻ Ethyl(dimethyl)(2-phenylethyl)ammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 1804970-28-2	M1660 5g  Liquid (CF ₃ SO ₂) ₂ N ⁻ Methyltri-n-octylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 375395-33-8	T0054 25g 100g 500g  mp 103 °C (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ Br ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Bromide CAS RN: 1643-19-2	T0055 5g 25g 100g  mp 70 °C (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ Cl ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Chloride CAS RN: 1112-67-0
T0057 25g 100g 500g  mp 147 °C (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ I ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Iodide CAS RN: 311-28-4	T0914 25g 100g 500g  mp 161 °C (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ BF ₄ ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Tetrafluoroborate CAS RN: 429-42-5	T1010 5g 25g  mp 100 °C (CH ₂) ₅ CH ₃ CH ₃ (CH ₂) ₅ -N ⁺ -(CH ₂) ₅ CH ₃ I ⁻ (CH ₂) ₅ CH ₃ Tetrahexylammonium Iodide CAS RN: 2138-24-1	T1011 5g 25g  mp 137 °C (CH ₂) ₄ CH ₃ CH ₃ (CH ₂) ₄ -N ⁺ -(CH ₂) ₄ CH ₃ I ⁻ (CH ₂) ₄ CH ₃ Tetraamylammonium Iodide CAS RN: 2498-20-6	T1155 5g  mp 129 °C (CH ₂) ₇ CH ₃ CH ₃ (CH ₂) ₇ -N ⁺ -(CH ₂) ₇ CH ₃ I ⁻ (CH ₂) ₇ CH ₃ Tetra-n-octylammonium Iodide CAS RN: 16829-91-7
T1279 25g 250g  Solid (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ PF ₆ ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Hexafluorophosphate CAS RN: 3109-63-5	T1396 25g  mp 123 °C (CH ₂) ₆ CH ₃ CH ₃ (CH ₂) ₆ -N ⁺ -(CH ₂) ₆ CH ₃ I ⁻ (CH ₂) ₆ CH ₃ Tetraheptylammonium Iodide CAS RN: 3535-83-9	T1432 5g 25g  mp 101 °C (CH ₂) ₄ CH ₃ CH ₃ (CH ₂) ₄ -N ⁺ -(CH ₂) ₄ CH ₃ Br ⁻ (CH ₂) ₄ CH ₃ Tetraamylammonium Bromide CAS RN: 866-97-7	T1433 5g 25g  Solid (CH ₂) ₄ CH ₃ CH ₃ (CH ₂) ₄ -N ⁺ -(CH ₂) ₄ CH ₃ Cl ⁻ (CH ₂) ₄ CH ₃ Tetraamylammonium Chloride CAS RN: 4965-17-7	T1568 10g 25g  mp 113 °C (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ CF ₃ SO ₃ ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Triflate CAS RN: 35895-70-6
T1599 25g  mp 99 °C (CH ₂) ₅ CH ₃ CH ₃ (CH ₂) ₅ -N ⁺ -(CH ₂) ₅ CH ₃ Br ⁻ (CH ₂) ₅ CH ₃ Tetrahexylammonium Bromide CAS RN: 4328-13-6	T1602 5g 25g 100g  mp 89 °C (CH ₂) ₆ CH ₃ CH ₃ (CH ₂) ₆ -N ⁺ -(CH ₂) ₆ CH ₃ Br ⁻ (CH ₂) ₆ CH ₃ Tetraheptylammonium Bromide CAS RN: 4368-51-8	T1603 10g 25g  mp 97 °C (CH ₂) ₇ CH ₃ CH ₃ (CH ₂) ₇ -N ⁺ -(CH ₂) ₇ CH ₃ Br ⁻ (CH ₂) ₇ CH ₃ Tetra-n-octylammonium Bromide CAS RN: 14866-33-2	T2106 25g  Solid CH ₃ CH ₂ CH ₂ -N ⁺ -CH ₂ CH ₂ CH ₃ CH ₂ CH ₂ CH ₃ Cl ⁻ Tetrapropylammonium Chloride CAS RN: 5810-42-4	T2679 5g 25g  Liquid (CH ₂) ₃ CH ₃ CH ₃ -N ⁺ -(CH ₂) ₃ CH ₃ (CH ₂) ₃ CH ₃ (CF ₃ SO ₂) ₂ N ⁻ Tributylmethylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 405514-94-5
T2694 25g 100g  Solid (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ CH ₃ COO ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium Acetate CAS RN: 10534-59-5	T2761 5g 25g  Liquid (CF ₃ SO ₂) ₂ N ⁻ Trimethylpropylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 268536-05-6	T3533 5g  Liquid (NC) ₂ N ⁻ Tributyl(methyl)ammonium Dicyanamide CAS RN: 1262230-03-4	T3660 5g 25g  mp 69 °C (CH ₂) ₃ CH ₃ CH ₃ (CH ₂) ₃ -N ⁺ -(CH ₂) ₃ CH ₃ SO ₃ ⁻ (CH ₂) ₃ CH ₃ Tetrabutylammonium p-Toluenesulfonate CAS RN: 7182-86-7	T3692 5g 25g  mp 184 °C (CH ₂) ₃ CH ₃ CH ₃ -N ⁺ -(CH ₂) ₃ CH ₃ I ⁻ (CH ₂) ₃ CH ₃ Tributylmethylammonium Iodide CAS RN: 3085-79-8

Imidazolium Salts

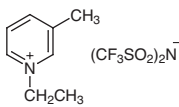
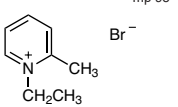
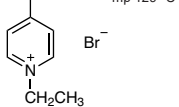
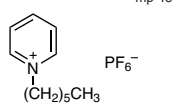
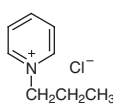
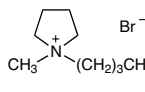
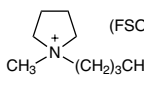
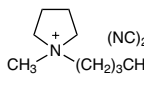
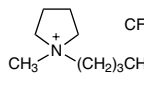
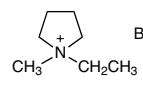
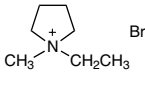
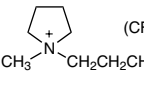
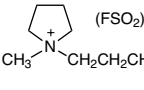
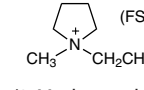
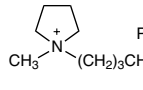
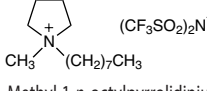
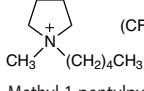
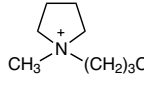
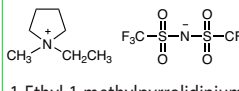
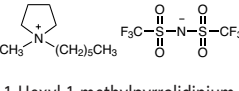
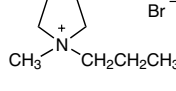
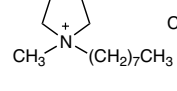
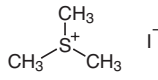
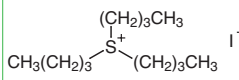
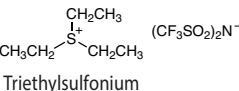
M3212 5g 25g  Solid 1-Methylimidazole Hydrobromide CAS RN: 101023-58-9	M3214 5g 25g  mp 88 °C 1-Methylimidazole Trifluoromethanesulfonate CAS RN: 99257-94-0	M3210 5g 25g  mp 49 °C 1-Methylimidazole Bis(trifluoromethanesulfonyl)imide CAS RN: 353239-08-4
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V0145 5g mp 37 °C  1-Vinylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 1013027-27-4	A2084 5g 25g Liquid  1-Allyl-3-methylimidazolium Chloride CAS RN: 65039-10-3	A3210 5g 25g Liquid  1-Allyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 655249-87-9	B2193 5g Liquid  1-Butyl-3-methylimidazolium Bromide CAS RN: 85100-77-2	B2194 5g 25g 100g mp 41 °C  1-Butyl-3-methylimidazolium Chloride CAS RN: 79917-90-1
B2195 5g 25g 100g Liquid  1-Butyl-3-methylimidazolium Tetrafluoroborate CAS RN: 174501-65-6	B2320 5g 25g Liquid  1-Butyl-3-methylimidazolium Hexafluorophosphate CAS RN: 174501-64-5	B2337 5g 25g Liquid  1-Butyl-3-methylimidazolium Trifluoromethanesulfonate CAS RN: 174899-66-2	B2473 5g 25g mp 99 °C  1-Butyl-2,3-dimethylimidazolium Chloride CAS RN: 98892-75-2	B2474 5g 25g mp 38 °C  1-Butyl-2,3-dimethylimidazolium Hexafluorophosphate CAS RN: 227617-70-1
B2475 5g 25g fp 32 °C  1-Butyl-2,3-dimethylimidazolium Tetrafluoroborate CAS RN: 402846-78-0	B2477 5g 25g Liquid  1-Butyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-83-3	B2672 5g 25g Liquid  1-Butyl-3-methylimidazolium Tetrachloroferrate CAS RN: 359845-21-9	B2708 5g 25g Liquid  1-Butyl-3-methylimidazolium Iodide CAS RN: 65039-05-6	B3159 5g 25g Liquid  1-Butyl-2,3-dimethylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 350493-08-2
B3231 5g 25g mp 76 °C  1-Butyl-3-methylimidazolium Methanesulfonate CAS RN: 342789-81-5	B3542 5g Liquid  1-Butyl-3-methylimidazolium Trifluoro(trifluoromethyl)borate CAS RN: 741677-68-9	B3596 5g mp 8 °C  1-Butyl-3-methylimidazolium Tribromide CAS RN: 820965-08-0	B4091 5g 25g Liquid  1-Butyl-3-methylimidazolium Thiocyanate CAS RN: 344790-87-0	B4182 5g 25g mp 44 °C  1-Butyl-2,3-dimethylimidazolium Triflate CAS RN: 765910-73-4
B5421 1g mp 82 °C  3,3'-(Butane-1,4-diyl)- bis(1-vinyl-3-imidazolium)- Bis(trifluoromethanesulfonyl)imide CAS RN: 1312310-16-9	B5447 5g 25g Liquid  1-Butyl-3-methylimidazolium Dicyanamide CAS RN: 448245-52-1	B5487 5g 25g Liquid  1-Butyl-3-methylimidazolium Tricyanomethanide CAS RN: 878027-73-7	B5526 5g 25g Liquid  1-Butyl-3-methylimidazolium Trifluoroacetate CAS RN: 174899-94-6	B5527 5g 25g Liquid  1-Butyl-3-methylimidazolium Methyl Sulfate CAS RN: 401788-98-5
B5569 5g 25g Liquid  1-Butyl-3-methylimidazolium Hydrogen Sulfate CAS RN: 262297-13-2	B5724 5g 25g Liquid  1-Butyl-3-methylimidazolium Hexafluoroantimonate CAS RN: 174645-81-9	B5723 5g 25g Liquid  1-Butyl-3-methylimidazolium Dibutyl Phosphate CAS RN: 663199-28-8	D3240 5g 25g Liquid  1,3-Dimethylimidazolium Dimethyl Phosphate CAS RN: 654058-04-5	D3341 5g 25g mp 125 °C  1,3-Dimethylimidazolium Chloride CAS RN: 79917-88-7
D3903 5g 25g Solid  1,2-Dimethyl-3-propylimidazolium Iodide CAS RN: 218151-78-1	D4289 5g 25g Liquid  2,3-Dimethyl-1-propylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 169051-76-7	D4351 5g 25g Liquid  1-Decyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 433337-23-6	D4654 5g 25g mp 86 °C  1,3-Dimethylimidazolium Iodide CAS RN: 4333-62-4	D5348 5g 25g Liquid  1,3-Dimethylimidazolium Methyl Sulfate CAS RN: 97345-90-9
D5349 5g 25g mp 22 °C  1,3-Dimethylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-81-1	D5350 5g 25g Liquid  1-Decyl-3-methylimidazolium Bromide CAS RN: 188589-32-4	D5351 5g 25g Liquid  1-Decyl-3-methylimidazolium Chloride CAS RN: 171058-18-7	D5373 5g 25g Liquid  1-Decyl-3-methylimidazolium Tetrafluoroborate CAS RN: 244193-56-4	D5356 5g 25g mp 45 °C  1-Dodecyl-3-methylimidazolium Bromide CAS RN: 61546-00-7

D5694 5g 25g  1-Dodecyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 404001-48-5	E0490 5g 25g 250g  1-Ethyl-3-methylimidazolium Chloride CAS RN: 65039-09-0	E0493 5g 25g  1-Ethyl-3-methylimidazolium Hexafluorophosphate CAS RN: 155371-19-0	E0494 5g 25g  1-Ethyl-3-methylimidazolium Trifluoromethanesulfonate CAS RN: 145022-44-2	E0496 5g 25g  1-Ethyl-3-methylimidazolium Tetrafluoroborate CAS RN: 143314-16-3
E0543 5g 25g  1-Ethyl-3-methylimidazolium Bromide CAS RN: 65039-08-9	E0556 5g 25g  1-Ethyl-3-methylimidazolium Iodide CAS RN: 35935-34-3	E0599 5g 25g  1-Ethyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-82-2	E0650 5g 25g  1-Ethyl-3-methylimidazolium Ethyl Sulfate CAS RN: 342573-75-5	E0651 5g 25g  1-Ethyl-3-methylimidazolium p-Toluenesulfonate CAS RN: 328090-25-1
E0680 1g 5g  1-Ethyl-3-methylimidazolium Dicyanamide CAS RN: 370865-89-7	E0706 5g  1-Ethyl-3-methylimidazolium Tetrachloroferrate CAS RN: 850331-04-3	E0753 5g 25g  1-Ethyl-2,3-dimethylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-90-2	E0755 5g 25g  1-Ethyl-3-methylimidazolium Methanesulfonate CAS RN: 145022-45-3	E0775 5g 25g  1-Ethyl-3-methylimidazolium Nitrate CAS RN: 143314-14-1
E0776 5g 25g  1-Ethyl-3-methylimidazolium Thiocyanate CAS RN: 331717-63-6	E0836 5g  1-Ethyl-3-methylimidazolium Trifluoroborate CAS RN: 681856-28-0	E0883 5g 25g  1-Ethyl-3-methylimidazolium Acetate CAS RN: 143314-17-4	E1280 5g  3-Ethyl-1-vinylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 319476-28-3	E1298 5g 25g  1-Ethyl-3-methylimidazolium Tricyanomethanide CAS RN: 666823-18-3
E1307 5g 25g  1-Ethyl-3-methylimidazolium Trifluoroacetate CAS RN: 174899-65-1	E1308 5g 25g  1-Ethyl-3-methylimidazolium Methyl Sulfate CAS RN: 516474-01-4	E1309 5g 25g  1-Ethyl-3-methylimidazolium Diethyl Phosphate CAS RN: 848641-69-0	H1097 5g 25g  1-Hexyl-3-methylimidazolium Chloride CAS RN: 171058-17-6	H1098 5g 25g  1-Hexyl-3-methylimidazolium Hexafluorophosphate CAS RN: 304680-35-1
H1099 5g 25g  1-Hexyl-3-methylimidazolium Tetrafluoroborate CAS RN: 244193-50-8	H1100 5g  1-Hexyl-3-methylimidazolium Triflate CAS RN: 460345-16-8	H1227 5g 25g  1-Hexyl-3-methylimidazolium Bromide CAS RN: 85100-78-3	H1254 5g 25g  1-(2-Hydroxyethyl)-3-methylimidazolium Chloride CAS RN: 61755-34-8	H1670 5g 25g  1-(2-Hydroxyethyl)-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-86-6
H1286 5g  1-Hexyl-2,3-dimethylimidazolium Iodide CAS RN: 288627-94-1	H1423 5g 25g  1-Hexyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 382150-50-7	H1492 5g 25g  1-(2-Hydroxyethyl)-3-methylimidazolium Tetrafluoroborate CAS RN: 374564-83-7	H1633 5g 25g  1-Hexyl-3-methylimidazolium Iodide CAS RN: 178631-05-5	M1440 5g 25g  1-Methyl-3-propylimidazolium Iodide CAS RN: 119171-18-5
M1904 5g 25g  1-Methyl-3-n-octylimidazolium Bromide CAS RN: 61545-99-1	M2062 5g 25g  1-Methyl-3-n-octylimidazolium Chloride CAS RN: 64697-40-1	M2063 5g 25g  1-Methyl-3-n-octylimidazolium Hexafluorophosphate CAS RN: 304680-36-2	M2440 5g 25g  1-Methyl-3-n-octylimidazolium Triflate CAS RN: 403842-84-2	M2732 5g 25g  1-Methyl-3-n-octylimidazolium Tetrafluoroborate CAS RN: 244193-52-0

M3034 5g 25g Liquid  1-Methyl-3-propylimidazolium Bromide CAS RN: 85100-76-1	M3035 5g 25g mp 64 °C  1-Methyl-3-propylimidazolium Chloride CAS RN: 79917-89-8	M3036 5g 25g Liquid  1-Methyl-3-propylimidazolium Tetrafluoroborate CAS RN: 244193-48-4	M3037 5g 25g Liquid  1-Methyl-3-pentylimidazolium Bromide CAS RN: 343851-31-0	M3039 5g 25g Liquid  1-Methyl-3-n-octylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 178631-04-4
M3059 5g 25g Liquid  1-Methyl-3-propylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 216299-72-8	M3119 1g 5g Liquid  1-Methyl-3-(4-sulfobutyl)-imidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 909390-59-6	M3120 5g 25g Liquid  1-Methyl-3-(4-sulfobutyl)-imidazolium Hydrogen Sulfate CAS RN: 827320-59-2	B5543 5g 25g mp 80 °C  1-Benzyl-3-methylimidazolium Chloride CAS RN: 36443-80-8	B5725 5g 25g mp 62 °C  1-Benzyl-3-methylimidazolium Tetrafluoroborate CAS RN: 500996-04-3
B5726 5g 25g mp 132 °C  1-Benzyl-3-methylimidazolium Hexafluorophosphate CAS RN: 433337-11-2	A2765 5g 25g mp 56 °C  AMIMBr CAS RN: 31410-07-8	B5103 5g 25g mp 30 °C  BMIMNO3 CAS RN: 179075-88-8	B5582 5g 25g Liquid  BMIMAc CAS RN: 284049-75-8	B6344 5g 25g mp 63 °C  1-Butyl-3-methylimidazolium Tosylate CAS RN: 410522-18-8
B6428 5g 25g mp 83 °C  3-Butyl-1-vinylimidazolium Bromide CAS RN: 34311-90-5	D5352 5g 25g mp 48 °C  1-Dodecyl-3-methyl-1H-imidazol-3-ium Chloride CAS RN: 114569-84-5	E1452 5g 25g Liquid  EMIMFSI CAS RN: 235789-75-0	E1520 5g 25g Solid  1-Ethyl-3-methylimidazolium Dimethyl Phosphate CAS RN: 945611-27-8	H1632 5g 25g Solid  1-Hexadecyl-3-methylimidazolium Chloride CAS RN: 61546-01-8
H1801 25g Solid  1-Hexadecyl-3-methylimidazolium Bromide CAS RN: 132361-22-9	M3211 5g 25g Solid  1-Methylimidazolium Hexafluorophosphate CAS RN: 57367-08-5	M3446 1g 5g Liquid  1-Methyl-3-[3-(trimethoxysilyl)-propyl]-1H-imidazol-3-ium Chloride CAS RN: 856925-70-7	V0183 5g 25g Solid  3-Ethyl-1-vinyl-1H-imidazol-3-ium Bromide CAS RN: 34311-88-1	
Morpholinium Salts				
E1166 5g 25g mp 177 °C  4-Ethyl-4-methylmorpholinium Bromide CAS RN: 65756-41-4				
Phosphonium Salts				
O0297 25g Solid  Tributyl-n-octylphosphonium Bromide CAS RN: 57702-65-5	T1124 25g 100g 500g mp 104 °C  Tetrabutylphosphonium Bromide CAS RN: 3115-68-2	T1650 25g mp 42 °C  Tetra-n-octylphosphonium Bromide CAS RN: 23906-97-0	T2006 25g mp 95 °C  Tetrabutylphosphonium Tetrafluoroborate CAS RN: 1813-60-1	T2007 5g 25g mp 217 °C  Tetrabutylphosphonium Hexafluorophosphate CAS RN: 111928-21-3

T3946 25g 100g Tetrabutylphosphonium 0,O-Diethyl Phosphorodithioate CAS RN: 96131-57-6	T2564 5g 25g Tributyl(2-methoxyethyl)- phosphonium Bis(trifluoromethane- sulfonyl)imide CAS RN: 959698-44-3	T2680 5g Tributylmethylphosphonium Bis(trifluoromethanesulfonyl)- imide CAS RN: 324575-10-2	T3534 5g 25g Trihexyl(tetradecyl)- phosphonium Dicyanamide CAS RN: 701921-71-3	T3623 5g 25g Trihexyl(tetradecyl)- phosphonium Chloride CAS RN: 258864-54-9
T3641 5g 25g Tributyl(ethyl)phosphonium Diethyl Phosphate CAS RN: 20445-94-7	T3945 25g 100g Tributyl(methyl)phosphonium Dimethyl Phosphate CAS RN: 20445-88-9	T4093 5g 25g Trihexyl(tetradecyl)phosphonium Bis(trifluoromethylsulfonyl)imide CAS RN: 460092-03-9	Piperidinium Salts	
M2981 1g 1-Methyl-1-propylpiperidinium Bis(fluorosulfonyl)imide CAS RN: 911303-46-3	M3488 5g 25g 1-Methyl-1-propylpiperidinium Bis(trifluoromethanesulfonyl)- imide CAS RN: 608140-12-1	B3424 5g 25g 1-Butyl-1-methylpiperidinium Bromide CAS RN: 94280-72-5	B4844 5g 25g 1-Butyl-1-methylpiperidinium Bis(trifluoromethanesulfonyl)- imide CAS RN: 623580-02-9	M1976 5g 25g 1-Methyl-1-propylpiperidinium Bromide CAS RN: 88840-42-0
Pyridinium Salts		M3195 5g 25g 1-Methylpyridinium Hexafluorophosphate CAS RN: 117029-34-2	M3199 5g 1-Methylpyridinium Bis(trifluoromethanesulfonyl)imide CAS RN: 742086-10-8	B1329 10g 25g 1-Butylpyridinium Chloride CAS RN: 1124-64-7
B1743 5g 25g 1-Butylpyridinium Bromide CAS RN: 874-80-6	B2196 5g 25g 1-Butylpyridinium Hexafluoro- phosphate CAS RN: 186088-50-6	B2700 5g 25g 1-Butyl-4-methylpyridinium Bromide CAS RN: 65350-59-6	B2701 5g 25g 1-Butyl-4-methylpyridinium Hexafluorophosphate CAS RN: 401788-99-6	B3104 5g 25g 1-Butyl-3-methylpyridinium Bromide CAS RN: 26576-85-2
B3232 5g 25g 1-Butylpyridinium Tetrafluoro- borate CAS RN: 203389-28-0	B3425 1g 5g 1-Butyl-3-methylpyridinium Chloride CAS RN: 125652-55-3	B3426 5g 25g 1-Butyl-4-methylpyridinium Chloride CAS RN: 112400-86-9	B5570 5g 25g 1-Butyl-4-methylpyridinium Tetrafluoroborate CAS RN: 343952-33-0	B5571 5g 25g 1-Butylpyridinium Bis(trifluoromethanesulfonyl)imide CAS RN: 187863-42-9
B5763 1g 5g 1-Butyl-4-methylpyridinium Bis(trifluoromethanesulfonyl)imide CAS RN: 475681-62-0	E0171 25g 1-Ethylpyridinium Bromide CAS RN: 1906-79-2	E0544 5g 25g 1-Ethylpyridinium Chloride CAS RN: 2294-38-4	E0681 5g 25g 1-Ethyl-3-methylpyridinium Ethyl Sulfate CAS RN: 872672-50-9	E0682 5g 1-Ethyl-3-(hydroxymethyl)- pyridinium Ethyl Sulfate CAS RN: 1064704-03-5

E0756 5g Liquid  1-Ethyl-3-methylpyridinium Bis(trifluoromethanesulfonyl)imide CAS RN: 841251-37-4	E1240 1g 5g mp 95 °C  1-Ethyl-2-methylpyridinium Bromide CAS RN: 32353-50-7	E1272 5g 25g mp 129 °C  1-Ethyl-4-methylpyridinium Bromide CAS RN: 32353-49-4	H1424 5g 25g mp 48 °C  1-Hexylpyridinium Hexafluorophosphate CAS RN: 797789-00-5	P1393 5g Solid  1-Propylpyridinium Chloride CAS RN: 23271-47-8
Pyrrolidinium Salts				
B3427 5g 25g Solid  1-Butyl-1-methylpyrrolidinium Bromide CAS RN: 93457-69-3	B5398 5g Liquid  1-Butyl-1-methylpyrrolidinium Bis(fluorosulfonyl)imide CAS RN: 1057745-51-3	B5453 5g 25g Liquid  1-Butyl-1-methylpyrrolidinium Dicyanamide CAS RN: 370865-80-8	B5568 5g 25g Liquid  1-Butyl-1-methylpyrrolidinium Triflate CAS RN: 367522-96-1	E0977 5g 25g Solid  1-Ethyl-1-methylpyrrolidinium Tetrafluoroborate CAS RN: 117947-85-0
E1050 5g 25g Solid  1-Ethyl-1-methylpyrrolidinium Bromide CAS RN: 69227-51-6	M2098 5g 25g Liquid  1-Methyl-1-propylpyrrolidinium Bis(trifluoromethanesulfonyl)imide CAS RN: 223437-05-6	M2980 5g Liquid  1-Methyl-1-propylpyrrolidinium Bis(fluorosulfonyl)imide CAS RN: 852620-97-4	M2998 1g 5g Liquid  1-(2-Methoxyethyl)-1-methylpyrrolidinium Bis(fluorosulfonyl)imide CAS RN: 1235234-47-5	B6039 5g 25g mp 86 °C  1-Butyl-1-methylpyrrolidinium Hexafluorophosphate CAS RN: 330671-29-9
M3117 5g 25g mp -12 °C  1-Methyl-1-n-octylpyrrolidinium Bis(trifluoromethanesulfonyl)imide CAS RN: 927021-43-0	M3118 1g 5g mp 8 °C  1-Methyl-1-pentylpyrrolidinium Bis(trifluoromethanesulfonyl)imide CAS RN: 380497-17-6	B6277 5g 25g mp 152 °C  1-Butyl-1-methylpyrrolidinium Tetrafluoroborate CAS RN: 345984-11-4	E1498 5g 25g mp 88 °C  1-Ethyl-1-methylpyrrolidinium Bis[(trifluoromethyl)sulfonyl]azanide CAS RN: 223436-99-5	H1824 5g 25g Liquid  1-Hexyl-1-methylpyrrolidinium Bis[(trifluoromethyl)sulfonyl]azanide CAS RN: 380497-19-8
M3496 5g 25g Solid  1-Methyl-1-propylpyrrolidinium Bromide CAS RN: 608140-09-6	M3499 1g 5g Solid  1-Methyl-1-octylpyrrolidinium Chloride CAS RN: 909398-60-3	Sulfonium Salts		
T1056 25g 500g Solid  Trimethylsulfonium Iodide CAS RN: 2181-42-2			T1564 1g mp 93 °C  Tributylsulfonium Iodide CAS RN: 18146-62-8	T2314 5g Liquid  Triethylsulfonium Bis(trifluoromethanesulfonyl)imide CAS RN: 321746-49-0

The melting points are shown as the reference value. These are not specification value.
 The salts that form liquid or solid state at room temperature are given the description "liquid" or "solid".

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