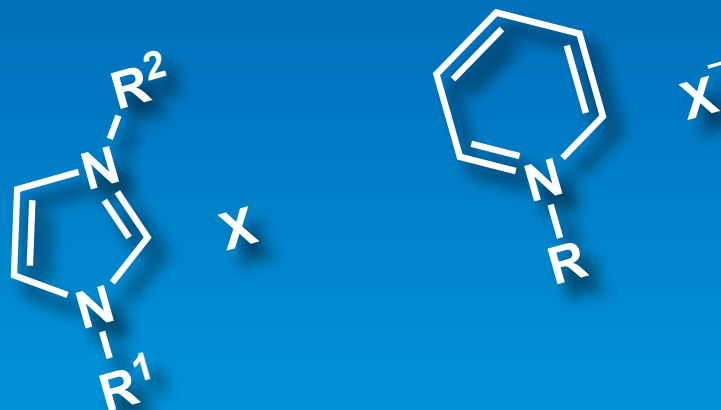


Ionic Liquids



Ammonium Salts

Imidazolium Salts

Morpholinium Salts

Phosponium Salts

Piperidinium Salts

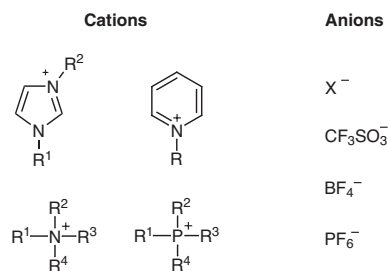
Pyridinium Salts

Pyrrolidinium Salts

Sulfonium Salts

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.



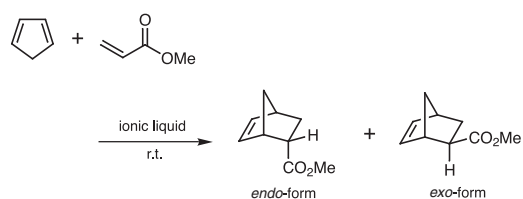
As seen above, ionic liquids are salts, consisting of cations such as imidazolium, pyridinium, quaternary ammonium and quaternary phosphonium, and anions such as halogen, triflate, tetrafluoroborate and hexafluorophosphate, which exist in the liquid state at relatively low temperatures. Their characteristic 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

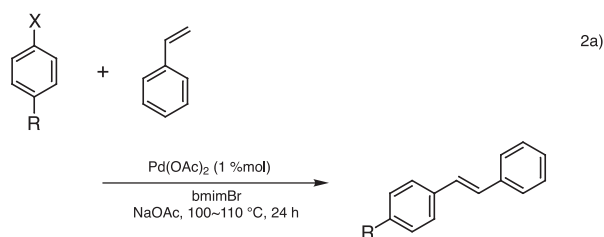
The Diels-Alder reaction between cyclopentadiene and methyl acrylate ester has been reported. In the Diels-Alder reaction using 1-ethyl-3-methylimidazolium chloride / chloroaluminate [emimCl/(AlCl₃)_x], the *endo* / *exo* ratio of the products varies largely, depending on the ratio of emimCl/(AlCl₃)_x. The amount of *endo*-form increases four-fold with the acidic emimCl/(AlCl₃)_x, compared to that of the basic emimCl/(AlCl₃)_x.^{1a)} When the same reaction is carried out with 1-butyl-3-methylimidazolium tetrafluoroborate (bmimBF₄), it showed similar reactivity to Lewis basic emimCl/(AlCl₃)_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)}

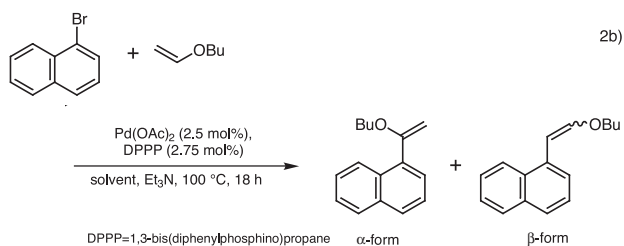
2. Heck reaction

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 bmimBF₄ as solvent gives only α -substituents specifically.^{2b)} In addition, the Heck reaction employing tetrabutylammonium bromide (Bu₄NBr), which is a quaternary ammonium salt, has been reported.^{2c)}

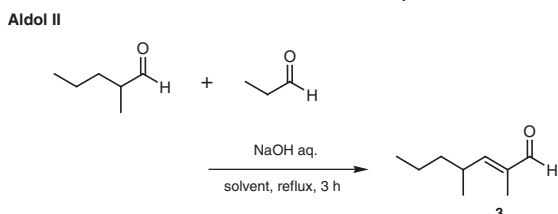
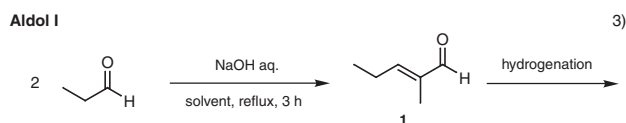


entry	solvent	conv. (%)	α/β	E/Z	Y. (%)
1	toluene	23	46/54	68/32	
2	DMSO	100	75/25	79/21	
3	bmimBF ₄	50	>99/1		
4*	bmimBF ₄	100	>99/1		95

*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⁾

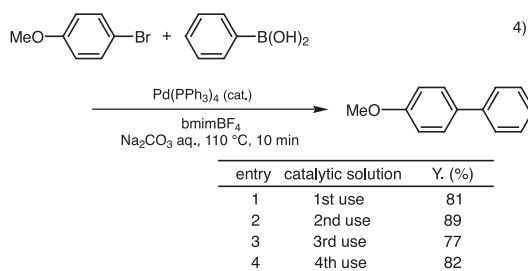


entry	solvent	reaction type	conv. (%)	selectivity (%)			
				1	2*	3	4**
1	bmimBF ₄	Aldol I	99	64	2	-	33
2	H ₂ O	Aldol I	100	82	0	-	18
3	emimBF ₄	Aldol II	100	4	6	69	21
4	bmimBF ₄	Aldol II	100	3	3	80	14
5	H ₂ O	Aldol II	100	36	0	59	5

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

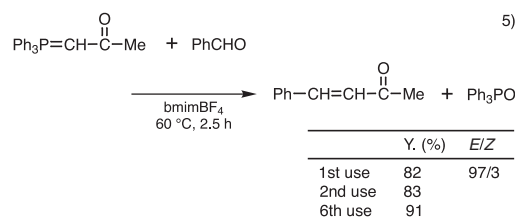
4. Suzuki-Miyaura coupling reaction

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⁾



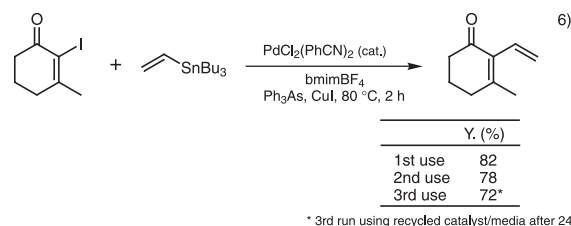
5. Wittig reaction

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⁾



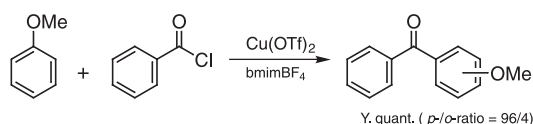
6. Stille reaction

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 iodocyclohexenone 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⁾



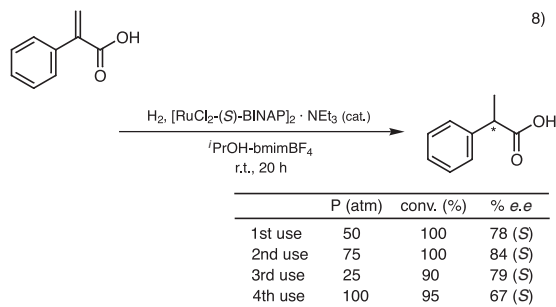
7. Friedel-Crafts reaction

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)}



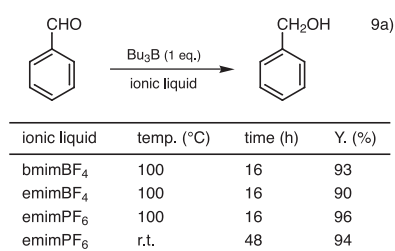
8. Hydrogenation

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.



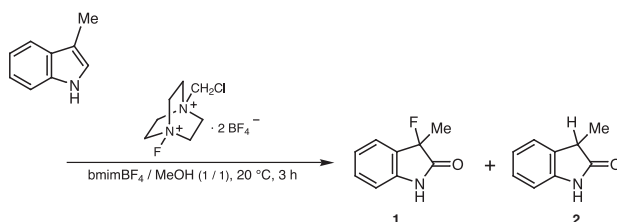
9. Reduction

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

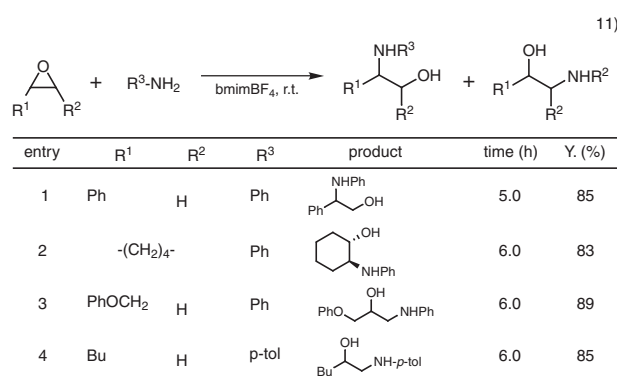
The introduction of fluorines in to heterocyclic compounds is important in the synthesis of bioactive compounds. In the electrophilic fluorination of indoles using *N*-fluoro-*N'*-(chloromethyl)triethylenediamine bis(tetrafluoroborate) as fluorinating agent and bmimBF₄ as a solvent, 3-fluorinated 2-oxindoles 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 ^{10a)}
2	bmimBF ₄	MeOH	20	3	99	- ^{10b)}

11. Ring opening reaction

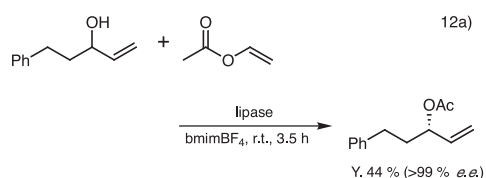
β-Aminoalcohols are utilized as useful building blocks for the synthesis of bioactive compounds. One of the synthetic methods to obtain β-aminoalcohols involves the ring opening of epoxides using amines. However, these reactions require a large excess of the amines at elevated temperatures. The high 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

- 1) a) C. W. Lee, *Tetrahedron Lett.* **1999**, *40*, 2461; b) T. Fischer, A. Sethi, T. Welton, J. Woolf, *Tetrahedron Lett.* **1999**, *40*, 793.
- 2) a) L. Xu, W. Chen, J. Xiao, *Organometallics* **2000**, *19*, 1123; b) L. Xu, W. Chen, J. Ross, J. Xiao, *Org. Lett.* **2001**, *3*, 295; c) V. P. W. Böhm, W. A. Herrmann, *Chem. Eur. J.* **2000**, *6*, 1017.
- 3) C. P. Mehnert, N. C. Dispenziere, R. A. Cook, *Chem. Commun.* **2002**, 1610.

- 4) C. J. Mathews, P. J. Smith, T. Welton, *Chem. Commun.* **2000**, 1249.
- 5) V. L. Boulaire, R. Grée, *Chem. Commun.* **2000**, 2195.
- 6) S. T. Handy, X. Zhang, *Org. Lett.* **2001**, *3*, 233.
- 7) a) J. Ross, J. Xiao, *Green Chem.* **2002**, *4*, 129; b) K.-S. Yeung, M. E. Farkas, Z. Qiu, Z. Yang, *Tetrahedron Lett.* **2002**, *43*, 5793; c) A. Stark, B. L. MacLean, R. D. Singer, *J. Chem. Soc., Dalton Trans.* **1999**, 63; d) C. J. Adams, M. J. Earle, G. Roberts, K. R. Seddon, *Chem. Commun.* **1998**, 2097.
- 8) A. L. Monteiro, F. K. Zinn, R. F. de Souza, J. Dupont, *Tetrahedron: Asymmetry* **1997**, *8*, 177.
- 9) G. W. Kabalka, R. R. Malladi, *Chem. Commun.* **2000**, 2191; b) J. L. Reynolds, K. R. Erdner, P. B. Jones, *Org. Lett.* **2002**, *4*, 917.
- 10) a) Y. Takeuchi, T. Tarui, N. Shibata, *Org. Lett.* **2000**, *2*, 639; b) J. Baudoux, A.-F. Salit, D. Cahard, J.-C. Plaquevent, *Tetrahedron Lett.* **2002**, *43*, 6573.
- 11) J. S. Yadav, B. V. S. Reddy, A. K. Basak, A. V. Narsaiah, *Tetrahedron Lett.* **2003**, *44*, 1047.
- 12) a) T. Itoh, E. Akasaki, K. Kudo, S. Shirakami, *Chem. Lett.* **2001**, 262; b) R. M. Lau, F. van Rantwijk, K. R. Seddon, R. A. Sheldon, *Org. Lett.* **2000**, *2*, 4189; c) S. Park, R. J. Kazlauskas, *J. Org. Chem.* **2001**, *66*, 8395; d) T. Itoh, S.-h. Han, Y. Matsushita, S. Hayase, *Green Chem.* **2004**, *6*, 437; e) T. Ito, *Yuki Gosei Kagaku Kyokaiishi (J. Synth. Org. Chem. Jpn.)* **2009**, *67*, 143.
- 13) M. Badri, J.-J. Brunet, *Tetrahedron Lett.* **1992**, *33*, 4435.
- 14) C. M. Gordon, A. McCluskey, *Chem. Commun.* **1999**, 1431.
- 15) G. S. Owens, M. M. Abu-Omar, *Chem. Commun.* **2000**, 1165.
- 16) a) J. Peng, Y. Deng, *New J. Chem.* **2001**, *25*, 639; b) J. F. Dubreuil, J. P. Bazureau, *Tetrahedron Lett.* **2000**, *41*, 7351.
- 17) a) K. Qiao, Y. Deng, *New J. Chem.* **2002**, *26*, 667; b) D. Zim, R. F. de Souza, J. Dupont, A. L. Monteiro, *Tetrahedron Lett.* **1998**, *39*, 7071.
- 18) S. V. Dzyuba, R. A. Bartsch, *Angew. Chem. Int. Ed.* **2003**, *42*, 148.
- 19) a) P. Bonhote, A.-P. Dias, N. Papageorgiou, K. Kalyanasundaram, M. Gratzel, *Inorg. Chem.* **1996**, *35*, 1168.
- 20) a) S. Hayashi, H. Hamaguchi, *Chem. Lett.* **2004**, *33*, 1590; b) H. Hamaguchi, *Expected Materials for the Future (Mirai Zairyo)* **2005**, *5*, 29.

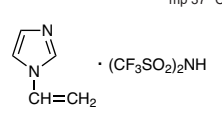
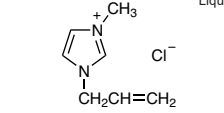
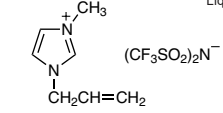
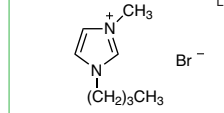
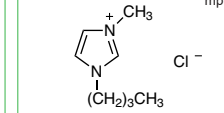
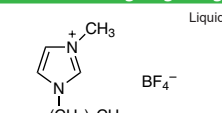
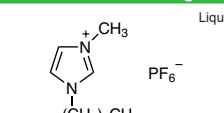
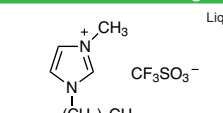
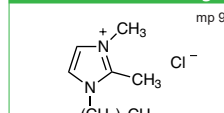
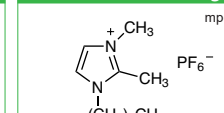
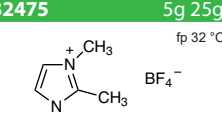
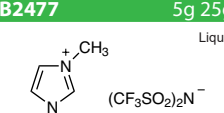
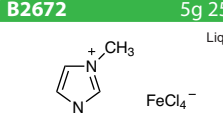
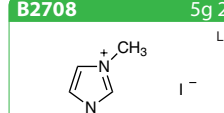
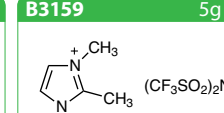
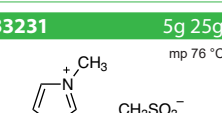
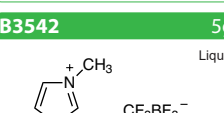
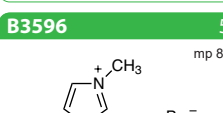
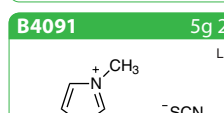
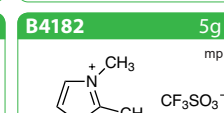
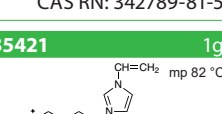
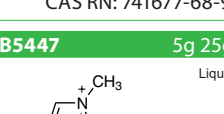
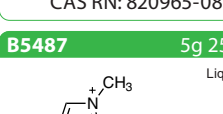
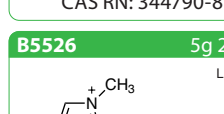
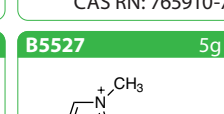
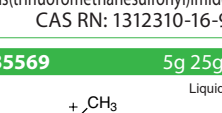
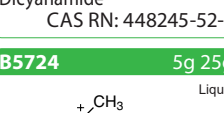
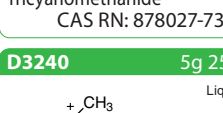
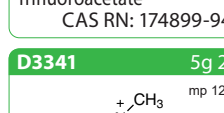
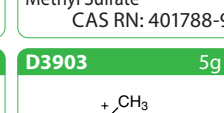
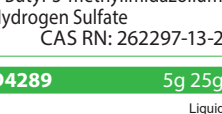
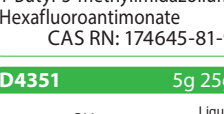
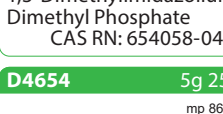
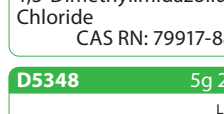
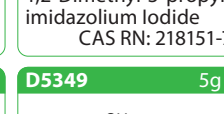
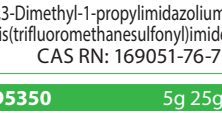
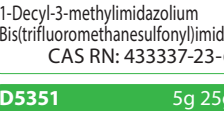
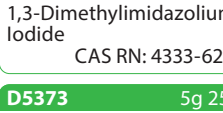
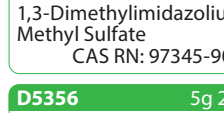
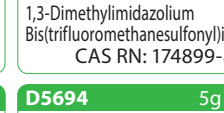
Reviews

- 21) a) T. Welton, *Chem. Rev.* **1999**, *99*, 2071; b) J. D. Holbrey, K. R. Seddon, *Clean Prod. Proc.* **1999**, *1*, 223; c) P. Wasserscheid, W. Keim, *Angew. Chem. Int. Ed.* **2000**, *39*, 3772; d) R. Sheldon, *Chem. Commun.* **2001**, 2399; e) D. Zhao, M. Wu, Y. Kou, E. Min, *Catal. Today* **2002**, *74*, 157.

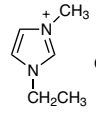
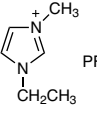
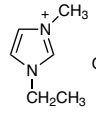
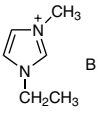
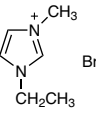
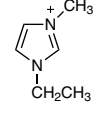
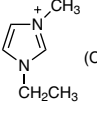
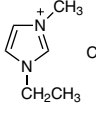
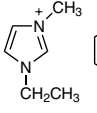
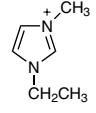
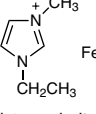
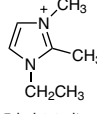
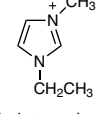
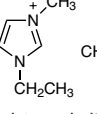
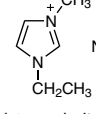
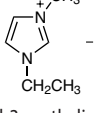
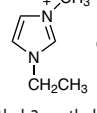
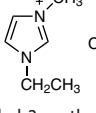
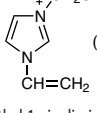
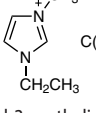
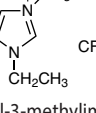
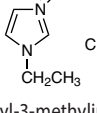
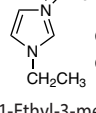
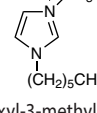
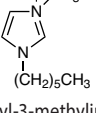
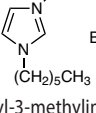
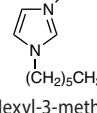
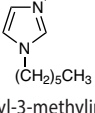
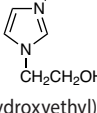
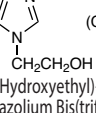
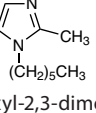
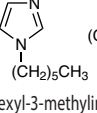
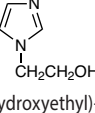
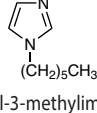
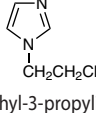
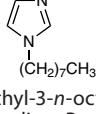
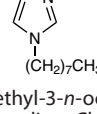
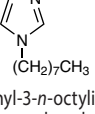
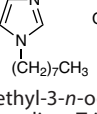
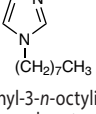
Ammonium Salts

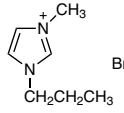
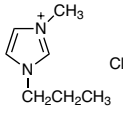
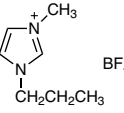
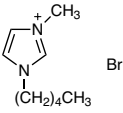
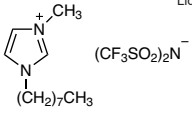
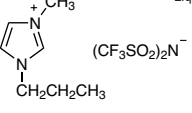
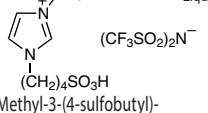
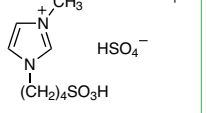
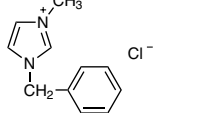
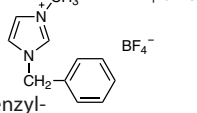
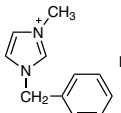
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		C1966 5g Solid  Cyclohexyltrimethylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 952155-74-7		D5237 1g Liquid  Diethyl(methyl)propylammonium Bis(fluorosulfonyl)imide CAS RN: 1235234-32-8		D5238 1g Liquid  Diethyl(2-methoxyethyl)methylammonium Bis(fluorosulfonyl)imide CAS RN: 1079129-48-8		E1275 1g Liquid  Ethyl(2-methoxyethyl)dimethylammonium Bis(fluorosulfonyl)imide CAS RN: 1235234-35-1	
E1282 5g Liquid  Ethyl(3-methoxypropyl)dimethylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 1373334-05-4		E1283 1g 5g Liquid  Ethyl(dimethyl)(2-phenylethyl)ammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 1804970-28-2		M1660 5g Liquid  Methyltri-n-octylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 375395-33-8		T0055 5g 25g 100g mp 70 °C  Tetrabutylammonium Chloride CAS RN: 1112-67-0		T0057 25g 100g 500g mp 147 °C  Tetrabutylammonium Iodide CAS RN: 311-28-4	
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T2761 5g 25g Liquid  Trimethylpropylammonium Bis(trifluoromethanesulfonyl)imide CAS RN: 268536-05-6		T3533 5g Liquid  Tributyl(methyl)ammonium Dicyanamide CAS RN: 1262230-03-4		T3660 5g 25g mp 69 °C  Tetrabutylammonium p-Toluenesulfonate CAS RN: 7182-86-7		T3692 5g 25g mp 184 °C  Tributylmethylammonium Iodide CAS RN: 3085-79-8			
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					

Imidazolium Salts

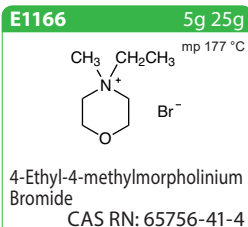
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B2195 5g 25g 100g  Liquid 1-Butyl-3-methylimidazolium Tetrafluoroborate CAS RN: 174501-65-6	B2320 5g 25g  Liquid 1-Butyl-3-methylimidazolium Hexafluorophosphate CAS RN: 174501-64-5	B2337 5g 25g  Liquid 1-Butyl-3-methylimidazolium Trifluoromethanesulfonate CAS RN: 174899-66-2	B2473 5g 25g  mp 99 °C 1-Butyl-2,3-dimethyl- imidazolium Chloride CAS RN: 98892-75-2	B2474 5g 25g  mp 38 °C 1-Butyl-2,3-dimethylimidazolium Hexafluorophosphate CAS RN: 227617-70-1
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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-dimethyl- imidazolium 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
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Ionic Liquids

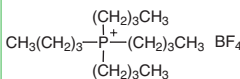
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<p>E0556 5g 25g mp 79 °C</p>  <p>1-Ethyl-3-methylimidazolium Iodide CAS RN: 35935-34-3</p>	<p>E0599 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-82-2</p>	<p>E0650 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Ethyl Sulfate CAS RN: 342573-75-5</p>	<p>E0651 5g 25g Solid</p>  <p>1-Ethyl-3-methylimidazolium <i>p</i>-Toluenesulfonate CAS RN: 328090-25-1</p>	<p>E0680 1g 5g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Dicyanamide CAS RN: 370865-89-7</p>
<p>E0706 5g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Tetrachloroferrate CAS RN: 850331-04-3</p>	<p>E0753 5g 25g Liquid</p>  <p>1-Ethyl-2,3-dimethylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 174899-90-2</p>	<p>E0754 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Hydrogen Sulfate CAS RN: 412009-61-1</p>	<p>E0755 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Methanesulfonate CAS RN: 145022-45-3</p>	<p>E0775 5g 25g Solid</p>  <p>1-Ethyl-3-methylimidazolium Nitrate CAS RN: 143314-14-1</p>
<p>E0776 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Thiocyanate CAS RN: 331717-63-6</p>	<p>E0836 5g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Trifluoro(trifluoromethyl)borate CAS RN: 681856-28-0</p>	<p>E0883 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Acetate CAS RN: 143314-17-4</p>	<p>E1280 5g Liquid</p>  <p>3-Ethyl-1-vinylimidazolium Bis(trifluoromethanesulfonyl)imide CAS RN: 319476-28-3</p>	<p>E1298 5g 25g Liquid</p>  <p>1-Ethyl-3-methylimidazolium Tricyanomethanide CAS RN: 666823-18-3</p>
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<p>M1904 5g 25g Liquid</p>  <p>1-Methyl-3-<i>n</i>-octylimidazolium Bromide CAS RN: 61545-99-1</p>	<p>M2062 5g 25g Liquid</p>  <p>1-Methyl-3-<i>n</i>-octylimidazolium Chloride CAS RN: 64697-40-1</p>	<p>M2063 5g 25g Liquid</p>  <p>1-Methyl-3-<i>n</i>-octylimidazolium Hexafluorophosphate CAS RN: 304680-36-2</p>	<p>M2440 5g 25g Liquid</p>  <p>1-Methyl-3-<i>n</i>-octylimidazolium Triflate CAS RN: 403842-84-2</p>	<p>M2732 5g 25g Liquid</p>  <p>1-Methyl-3-<i>n</i>-octylimidazolium Tetrafluoroborate CAS RN: 244193-52-0</p>

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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 Solid  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
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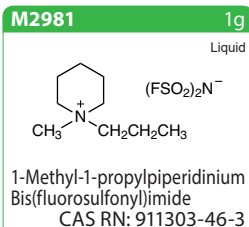
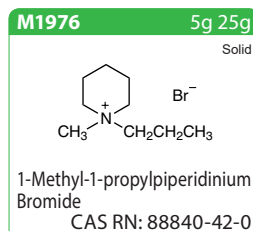
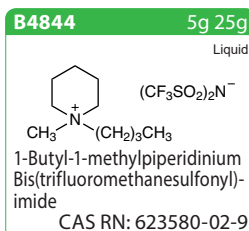
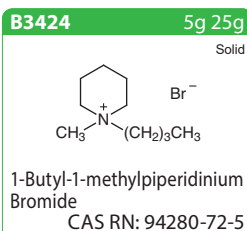
Morpholinium Salts



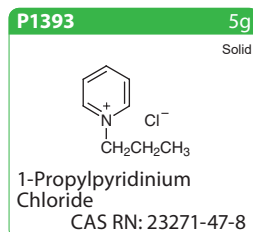
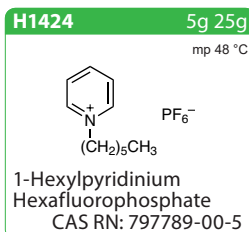
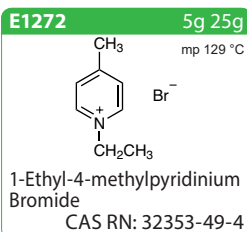
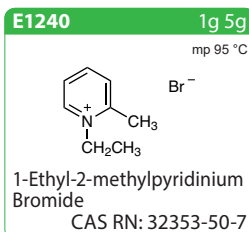
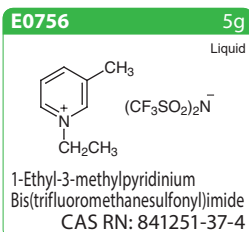
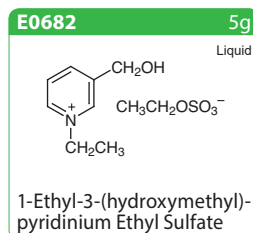
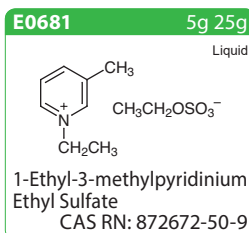
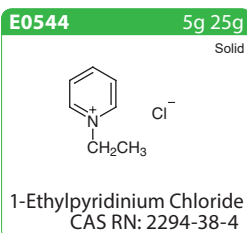
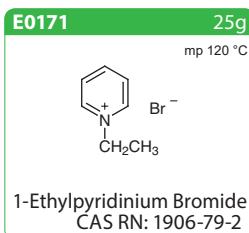
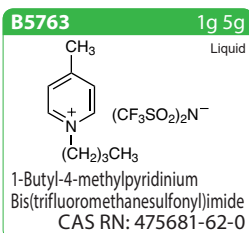
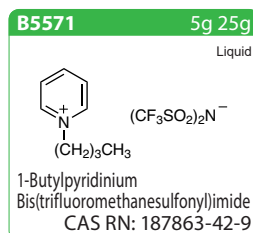
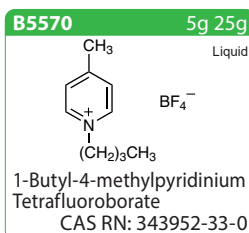
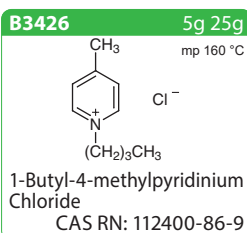
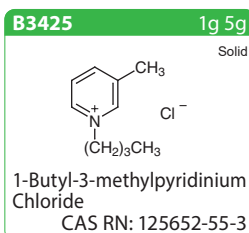
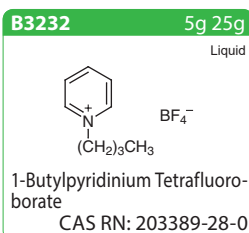
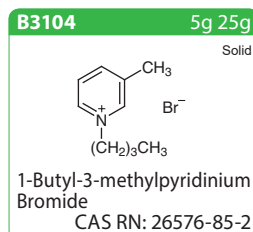
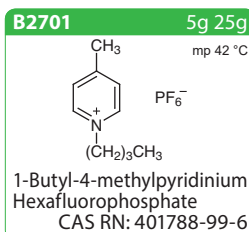
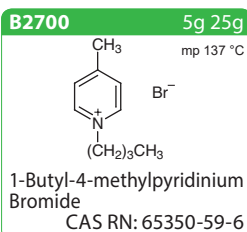
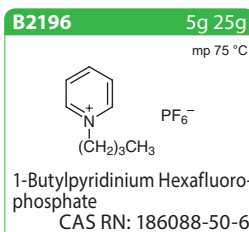
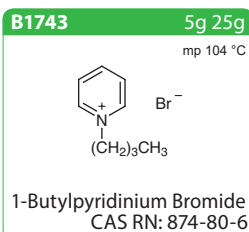
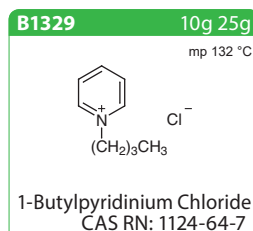
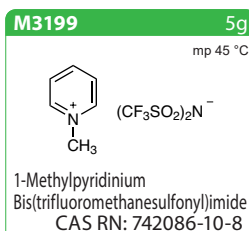
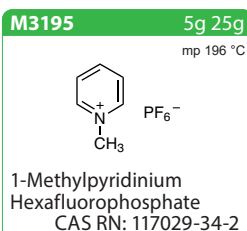
Phosphonium Salts

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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 Solid  Tetrabutylphosphonium Hexafluorophosphate CAS RN: 111928-21-3	
T3946 25g 100g Liquid  Tetrabutylphosphonium O,O-Diethyl Phosphorodithioate CAS RN: 96131-57-6	T2564 5g 25g Liquid  Tributyl(2-methoxyethyl)phosphonium Bis(trifluoromethanesulfonyl)imide CAS RN: 959698-44-3	T2680 5g Liquid  Tributylmethylphosphonium Bis(trifluoromethanesulfonyl)imide CAS RN: 324575-10-2	T3534 5g 25g Liquid  Trihexyl(tetradecyl)phosphonium Dicyanamide CAS RN: 701921-71-3	T3623 5g 25g Liquid  Trihexyl(tetradecyl)phosphonium Chloride CAS RN: 258864-54-9	
T3641 5g 25g Liquid  Tributyl(ethyl)phosphonium Diethyl Phosphate CAS RN: 20445-94-7	T3945 25g 100g mp 17 °C  Tributyl(methyl)phosphonium Dimethyl Phosphate CAS RN: 20445-88-9				

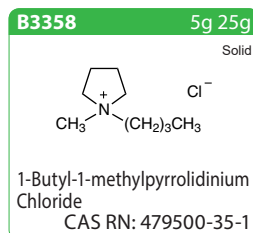
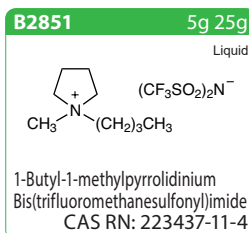
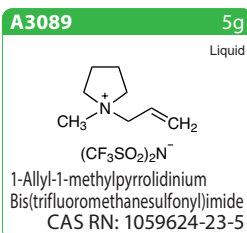
Piperidinium Salts

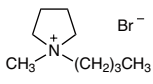
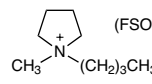
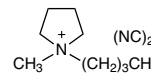
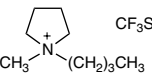
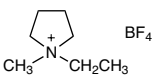
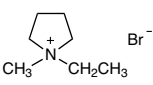
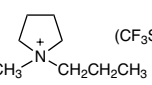
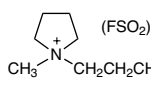
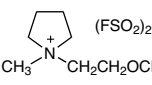
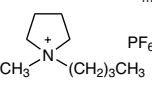
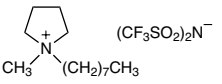
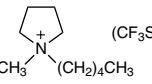
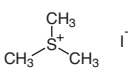
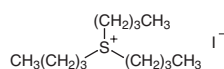
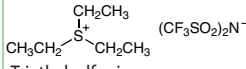


Pyridinium Salts



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	<div style="background-color: #008000; color: white; padding: 20px; text-align: center;"> <h2>Sulfonium Salts</h2> </div>		
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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