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Substitution Reactions by Azide and Thiocyanide Anions in Room Temperature Ionic Liquids

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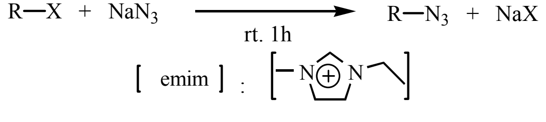
Abstract: Conducted in the ionic liquids, activated and inactivated halides, acyl chlorides, tosylate, and bezotriazolyl acylates were converted to corresponding azide and thiocyanide compounds in high yields under mild conditions.

Keywords: Room temperature ionic liquids, azide, thiocyanide, substitution reactions.

One of the prime concerns of industry and academia is the search for replacements to the environmentally damaging solvents used on a large scale, especially for those which are volatile and difficult to preserve. With a wide temperature window, the ionic liquids, which have no vapor pressure and lack of flammability, and are moisture stable at room temperature, such as 1, 3-*dialkylimidazolium cations*, are attracting increasing interest[1] as environmentally benign reaction media. These liquids have been found to be an excellent solvent for a number of purposes[2-13]. Their physicochemical behaviors are unlike water or organic solvents. These liquids possess adjustable hydrophobicity –hydrophilicity. The investigation of the substitution for classical solvents by [bmim]PF_6 and [bmim]BF_4 type ionic liquids is underway.

At the room temperature ionic liquids are entirely constituted of ions they are more powerful solvents to dissolve ionic substrates than conventional organic ones, and more suitable to carry the reactions concerning ionic substrates. But there is only one example of nucleophilic substitution reaction carried out in ionic liquids[14] and just one reagent and a few substrates were concerned. We tried S_N2 substitution reaction of alkyl halides by azide anion .



We chose [emim][BF_4] (1-ethyl-3-methylimidazolium tetrafluoroborate) as the reaction media. The reaction was carried out at room temperature smoothly. The

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coordination between imidazolium cation and azide did not happen. The rate of the substitution reactions was faster than that with conventional procedures[15, 16]. Most of the reactions were completed less 1 h, and the yields were satisfactory (see **Table 1**).

Table 1 Azido products and the yields

Entry	Substrates	Products	React.Time (min.)	.mp °C (Found)	.mp °C (Lit.)	Yield (%)*
1	$PhCH_2Cl$	$PhCH_2N_3$	70	oil	oil[17]	92
2	$PhCH_2Ots$	$PhCH_2N_3$	50	oil	oil[17]	88
3	$PhCOCH_2Br$	$PhCOCH_2N_3$	60	15	17[18]	89
4	p-$BrC_6H_4COCH_2Br$	p-$BrC_6H_4COCH_2N_3$	75	82	86-87[19]	88
5	p-$CH_3OC_6H_4COBt$	p-$CH_3OC_6H_4CON_3$	55	70	70-71[20]	90
6	p-ClC_6H_4COBt	p-$ClC_6H_4CON_3$	70	40	43[20]	90
7	p-$CH_3C_6H_4SO_2Cl$	p-$CH_3C_6H_4SO_2N_3$	60	20	22[21]	92
8	$PhCOCl$	$PhCON_3$	70	31	32[20]	85
9	n-$C_{16}H_{33}Br$	n-$C_{16}H_{33}N_3$[24]	80	oil		83

* Isolated Yields

The another merit of this reaction lies in the simple separation of the reaction product. The ionic liquids almost could be quantitatively recovered and thus allowed to recycle. The recovering procedure of ionic liquids is simple. After the product was extracted with ether, to the lower layer, some amount of acetone was added and the inorganic salts were filtered off. The filtrate was recovered ionic liquid which can be reused.

Another substitution reaction in the ionic liquids was tried with thiocyanide as the nucleophile:

$$\mathrm{R{-}X} + \mathrm{KSCN} \xrightarrow[\text{rt. 1h}]{[\text{emim}][\text{BF}_4]} \mathrm{R{-}SCN} + \mathrm{KX}$$

The results were shown in **Table 2**.

Table 2 Thiocyanide products and the yields

Entry	Substrates	Products	React.Time (min.)	.mp °C (Found)	.mp °C (Lit.)	Yield (%)*
10	$PhCH_2Cl$	$PhCH_2SCN$	55	40	41-42[22]	89
11	p-$CH_3C_6H_4SO_2Cl$	p-$CH_3C_6H_4SO_2SCN$	50	28	28.5[23]	91
12	$PhCH_2OTs$	$PhCH_2SCN$	50	40	41-42[22]	92

* Isolated Yields

In summary, at the room temperature ionic liquid [emim][BF_4] gave significant reaction rate and good yields for these substitution reactions. The products were readily separated from the ionic liquids *via* extraction. The reactions with recycled ionic solvent were found no obvious decrease in yields. Further studies of interesting applications of the ionic liquids are also being actively pursued.

General procedure: To a 10 mL flask, was added a mixture of NaN_3 (0.108 g, 2.2 mmol) in 2 mL ionic liquids. Benzyl chloride (0.253 g, 2 mmol) was added with stirring to the solution. When the benzyl halide was consumed, the reaction mixture was extracted with ether(3×5 mL). The ether layer was separated. The lower ionic liquid phase can be reused. The extracts were combined and the ether was removed under reduced pressure to afford the crude benzyl azide. It could be further purified by preparative TLC with petroleum ether / ethyl acetate as eluent. All the products were fully characterized by NMR, IR, MS and elemental analysis.

References and Notes

1. For recent reviews on ionic liquids in green chemistry, see:
   a) T. Welton, *Chem. Rev*., **1999**, *99*, 2071.
   b) P. Wasserscheid, W. Keim, *Angew. Chem. Int. Ed*., **2000**, *39*, 3772.
2. a) J. G. Hunddleston, H. D. Willauer, R. P. Swatloski, A. E. Visser, R. D. Rogers, *Chem. Commun*., **1998**, 1765.
   b) S. Dai, Y. H. Ju , C. E. Barnes, *J. Chem. Soc., Dalton Trans*., **1999**, 1201.
   c) A. E. Visser, R. P. Swatloski, W. M. Reichert, R. D. Rogers, R. Mayton, S. Sheff, A. Wierzbicki , J. H. Davis, *Chem. Commun*., **2001**, 135.
3. a) C. J. Adams, M. J. Earle, G. Roberts, K. R. Seddon, *Chem. Commun*., **1998**, 2097.
   b) A. Stark, B. L. MacLean, R. D. Singer, *J. Chem. Soc., Dalton Trans*., **1999**, 63.
4. a) T. Fischer, A. Sethi, T. Welton, J. Woolf, *Tetrahedron Lett.*, **1999**, 793.
   b) C. W. Lee, *Tetrahedron Lett.*, **1999**, 2461.
5. a) V. M. Kobryanskii, S. A. Arnautov, *J. Chem. Soc*., *Chem. Commun*., **1992**, 727.
   b) S. A. Arnautov, *Synth. Metals,* **1997**, *84*, 295.
   c) L. M. Goldenberg, R. A. Osteryoung, *Synth. Metals* **1994**, 63.
6. C. M. Gordon, A. McCluskey, *J. Chem. Soc., Chem. Commun*., **1999**, 1431.
7. a) A. J. Carmichael, M. J. Earle, J. D. Holbrey, P. B. McCormac, K. R. Seddon, *Org. Lett*., **1999**, *1*, 997.
   b) J. Howarth, A. Dallas, *Molecules*, **2000**, *5*, 851.
8. J. Howarth, P. James, J. Dai, *Tetrahedron Lett.,* **2001**, 7517.
9. Y. Chauvin, L. Mussmann, H. Olivier, *Angew. Chem., Int. Ed. Engl*., **1995**, *34*, 2698.
10. J. Howarth, P. James, J. Dai, *Tetrahedron Lett*., **2000**, 20319.
11. V. Calo, A. Nacci, L. Lopez , V. L. Lerario, *Tetrahedron Lett*., **2000**, 8977.
12. M. K. Potdar, S. S. Mohile , M. M. Salunkhe, *Tetrahedron Lett.*, **2001**, 9285.
13. D. W. Morrison, D. C. Forbes , J. H. Davis, *Tetrahedron Lett.*, **2001**, 6053.
14. C. Wheeler, K. N. West, C. L. Liotta , C. A. Eckert, *Chem. Commun*., **2001**, 887.
15. a) E. Lieber, T. S. Chao, C. N. R. Rao, *J. Org. Chem*., **1957**, 238.
    b) A. Hassner, M. Stern, *Angew. Chem., Int. Ed. Engl.*, **1986**, 478.
    c) S. G. Alvarez, M. T. Alvarez, *Synthesis,* **1997**, 413.
    d) D. E. Shalev, S. M. Chiacchiera, A. E. Radkows, E. M. Kosower, *J. Org. Chem.*, **1996**, , 1689.
    e) S. T. Abu-Orabi, M. Adnan Atfah, I. Jibril, F. M. Mari'i, A. Al-Sheikh Ali, *J. Heterocyclic Chem*., **1989**, 1461.
    f) J. M. Harris, D. L. Mount, M. R. Smith, W. C. Neal, M. D. Dukes, D. J. Raber, *J. Am. Chem. Soc*., **1978**, 8147.
    g) N. Buckley, N. J. Oppenheimer, *J. Org. Chem.*, **1996**, 7360.
    h) S. I. Murahashi, Y. Taniguchi, Y. Imada, Y. Tanigawa, *J. Org. Chem*., **1989**, 3292.
16. W. P. Reeves, M. L. Bahr, *Synthesis,* **1976**, 823.
17. J. Buckingham, Dictionary of Organic compounds, 5, Mack Pringting Company, United States of America, Easton, Pennsylvania , **1982**, *1*, 605.
18. Beilsteins,**1931**, *7* (I), 154.
19. J. H. Boyer, D. Straw, *J. Am. Chem. Soc*., **1952**, *74*, 4506-8

20. Y. Yukawa, Y. Tsuno, *J. Org. Chem*., **1957**, *79*, 5530.
21. J. Buckingham, Dictionary of Organic compounds, 5 ed., Mack Printing Company, United States of America , Easton, Pennsylvania, **1982**, *4*, 3750.
22. J. Buckingham, Dictionary of Organic compounds, 5, Mack Pringting Company, United States of America , Easton, Pennsylvania ,**1982**, *1*, 629.
23. CA: **1967**, *66*, 2368n
24. Representative data: Product **9**: ^{1}HNMR ($CDCl_3$/TMS), δ: 0.88 (t, 3H, *J*=6.51), 1.19-1.43 (m, 26H), 1.81-1.89 (m, 2H), 3.41 (t, 2H, *J*=6.89); MS (ab.): 247(M^+, 0.57), 219 (0.99). Calc. for $C_{16}H_{33}N_3$: C, 71.85; H, 12.44; N, 15.71; Found. C, 71.69; H, 12.35; N, 15.69.

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