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LETTERS

Nitrogen Atom Transfer to Alkenes Utilizing Chloramine-T as a Nitrogen Source[1]

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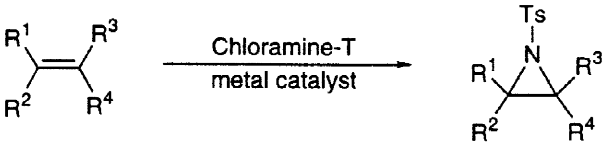
Abstract: Aziridination of alkenes proceeds successfully using Chloramine-T (*N*-chloro-*N*-sodio-*p*-toluenesulfonamide). When anhydrous Chloramine-T was added to an acetonitrile solution of alkenes in the presence of various CuCl catalysts and MS-5A, the corresponding aziridines were obtained in moderate to good yields.

While metal-catalyzed atom transfer reactions to alkenes, such as epoxidation and cyclopropanation, have been widely used in organic synthesis, metal-catalyzed nitrogen atom transfer reactions have not been extensively investigated. One of the few examples is the aziridination, employing PhI=NTs ([*N*-(*p*-toluenesulfonyl)imino]phenyliodinane),[2,3] which is prepared from PhIO using $TsNH_2$,[4] as a nitrogen source. Chloramine-T is a well-known, commercially available oxidant,[5] but it is rarely used as a nitrogen source. Known examples of synthetic applications of Chloramine-T include aminohydroxylation[6] and aminochalcogenation[7] of alkenes, and allylic amination via selenium diimide intermediate.[8] We believed that Chloramine-T could also serve as a nitrogen source in the aziridination of alkenes (eq 1). This paper reports the results of some experiments in this area.



(1)

Chloramine-T was initially reacted directly with *trans*-β-methylstyrene at room temperature in acetonitrile, but no products were obtained. However, in the presence of a catalytic amount of CuCl, *trans*-β-methylstyrene was successfully aziridinated. The results of control experiments are shown in Table 1. When 5 equivalents of *trans*-β-methylstyrene were treated with anhydrous Chloramine-T in the presence of 5 mol% CuCl in acetonitrile for 3 h at 25 °C, the aziridination of *trans*-β-methylstyrene proceeded stereospecifically to give the *trans*-aziridine isomer of **1** (32 %, run 2).[9] The presence of 5Å powdered molecular sieves (MS-5A) in the reaction mixture increased the yield of **1** to 64% (run 3).[10] Increasing the amount of catalyst to 10 mol% had no significant effect on improving the yield of the aziridine (run 4). A variety of Cu(I) and Cu(II) salts were tested as the catalyst (runs 5-9), all of which proved to be less effective than CuCl. The use of other solvents

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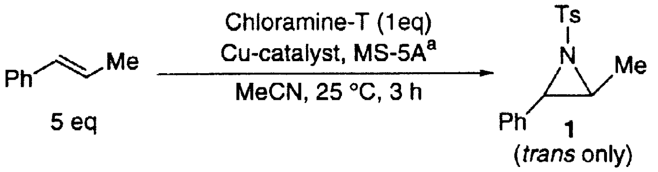
such as benzene, CH_2Cl_2, THF and methanol under typical conditions did not give an aziridination product. Consequently, CuCl/MS-5A/CH_3CN was found to be the most suitable catalyst system for this reaction.

Table 1. Copper-Catalyzed Aziridination of *trans*-β-Methylstyrene.



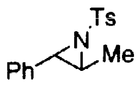
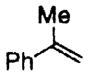
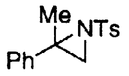
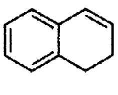
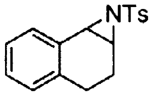
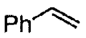
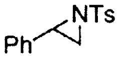
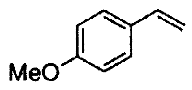
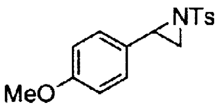
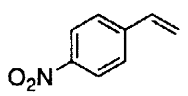
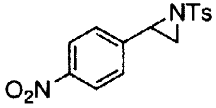
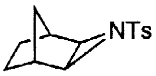
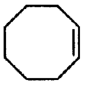
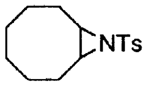
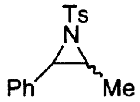
run	cat. (mol%)[b]	additive	yield (%)[c]
1	–	–	0
2	CuCl (5)	–	32
3	CuCl (5)	MS-5A	64[d]
4	CuCl (10)	MS-5A	60
5	$Cu(CH_3CN)_4PF_6$ (5)	MS-5A	55
6	$(CuOTf)_2{\cdot}C_6H_6$ (5)	MS-5A	39
7	$CuCl_2$ (5)	MS-5A	56
8	$Cu(OTf)_2$ (5)	MS-5A	49
9	$Cu(acac)_2$ (5)	MS-5A	40

[a] 50 mg. [b] Based on Chloramine-T. [c] ^{1}H-NMR yield. [d] Isolated yield.

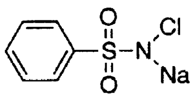
A variety of alkenes were examined for this copper-catalyzed aziridination using Chloramine-T. The results are summarized in Table 2. When α-methylstyrene and 1,2-dihydronaphthalene were employed, good yields of the corresponding aziridines (75 and 67%, respectively) were obtained (run 2, 3). In contrast, styrene gave only a modest yield of aziridination product (run 4) without any polymerized. An electron-rich alkene, such as *p*-methoxystyrene, showed the same reactivity toward Chloramine-T, but *p*-nitrostyrene was less reactive than styrene (run 5, 6). These results suggest that disubstituted alkenes are good substrates for the reaction. The aziridination of alkyl-substituted olefins also proceeded to afford moderate yields of the corresponding aziridine derivatives. In the case of norbornene the *exo*-adduct was obtained exclusively (run 7). Allylic insertion by the metal nitrenoid is frequently the major side reaction, but no allylic amination product was formed in this reaction. As mentioned above, *trans*-aziridine was the sole product from *trans*-β-methylstyrene. To better understand the stereospecificity of the present reaction, we also carried out the aziridination of *cis*-β-methylstyrene. In contrast to the *trans* counterpart, it afforded a 48:52 *cis*/*trans* ratio of aziridines (run 9).[11]

We also tested some Chloramine-T analogs. The aziridination of *trans*-β-methylstyrene using Chloramine-B (**2**), which is not only inexpensive but also a Chloramine-T analog which contains no substituent on the benzene ring, as a nitrogen source afforded the corresponding aziridine in 69% yield. Compound **3**, which is a *p*-nitro-substituted analog, also reacted albeit the yield was slightly lower (53%). This suggests that other Chloramine-T analogs should be investigated further with respect to this reaction.

Table 2. Copper-Catalyzed Aziridination of Alkenes.[a]

run	substrate	product	yield (%)[b]
1			64[c]
2			75
3			67
4			31[c]
5			33
6			18
7			45[c]
8			38
9			40[d]

[a] Conditions : CuCl (5 mol% based on Chloramine-T for runs 1, 2, 3 and 7, or 10 mol% for runs 4, 5, 6, 8 and 9), substrate (2.5 mmol), MS-5A (50 mg), Chloramine-T (0.5 mmol), 25 °C, 3 h. [b] ^{1}H-NMR yield. [c] Isolated yield. [d] *Cis/trans* = 48/52



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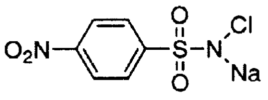

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In summary, we have demonstrated for the first time that the readily available and inexpensive Chloramine-T and its analogs can be used as nitrogen transfer reagents for the catalytic aziridination of alkenes. Copper catalysts were found to work well for this reaction. A search for more effective catalysts as well as scope and limitation is in progress.

Acknowledgment

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References and Notes

1 Dedicated to the memory of the late Prof. Gerrit L'abbé.

2 a) Evans, D. A.; Faul, M. M.; Bilodeau, M. T. *J. Org. Chem.* **1991**, *56*, 6744-6746. b) Evans, D. A.; Faul, M. M.; Bilodeau, M. T. *J. Am. Chem. Soc.* **1994**, *116*, 2742-2753. c) Pérez, P. J.; Brookhart, M.; Templeton, J. L. *Organometallics* **1993**, *12*, 261-262. d) Södergren, M. J.; Alonso, D. A.; bedekar, A. V.; Andersson, P. G. *Tetrahedron Lett.* **1997**, *38*, 6897-6900.

3 For catalysis with chiral ligands, see: a) Li, Z.; Conser, K. R.; Jacobsen, E. N. *J. Am. Chem. Soc.* **1993**, *115*, 5326-5327. b) Evans, D. A.; Faul, M. M.; Bilodeau, M. T.; Anderson, B. A.; Barnes, D. M. *J. Am. Chem. Soc.* **1993**, *115*, 5328-5329. c) Li, Z.; Quan, R. W.; Jacobsen, E. N. *J. Am. Chem. Soc.* **1995**, *117*, 5889-5890. d) Lowenthal, R. E.; Masamune, S. *Tetrahedron Lett.* **1991**, *32*, 7373-7376. e) O'Connor, K. J.; Wey, S.-J.; Burrows, C. J. *Tetrahedron Lett.* **1992**, *33*, 1001-1004. f) Nishikori, H.; Katsuki, T. *Tetrahedron Lett.* **1996**, *37*, 9245-9248. g) Noda, K.; Hosoya, N.; Irie, R.; Ito, I.; Katsuki, T. *Synlett* **1993**, 469-471.

4 a) Yamada, Y.; Yamamoto, T.; Okawara, M. *Chem. Lett.* **1975**, *4*, 361-362. b) Besenyei, G.; Németh, S.; Simándi, L. I. *Tetrahedron Lett.* **1993**, *34*, 6105-6106.

5 a) Campbell, M. M.; Johnson, G.; *Chem. Rev.* **1978**, *78*, 65-79. b) Bremner, D. H. In *Synthetic Reagents*; Pizey, J. S., Ed.; Wiley: New York, 1985; Vol. 6, pp 9-59.

6 a) Sharpless, K. B.; Chong, A. O.; Oshima, K. *J. Org. Chem.* **1976**, *41*, 177-179. b) Li, G.; Chang, H. -T.; Sharpless, K. B. *Angew. Chem. Int. Ed. Engl.* **1996**, *35*, 451-454. c) Rudolph, J.; Sennhenn, P. C.; Vlaar, C. P.; Sharpless, K. B. *Angew. Chem. Int. Ed. Engl.* **1996**, *35*, 2810-2813. d) Li, G.; Angert, H. H.; Sharpless, K. B. *Angew. Chem. Int. Ed. Engl.* **1996**, *35*, 2813-2817.

7 Barton, D. H. R.; Britten-Kelly, M. R.; Ferreira, D. *J. Chem. Soc., Perkin Trans. 1* **1978**, 1090-1100.

8 Sharpless, K. B.; Hori, T.; Truesdale, L. K.; Dietrich, C. O. *J. Am. Chem. Soc.* **1976**, *98*, 269-271.

9 The commercially available Chloramine-T trihydrate was dried at 90 °C under vacuum (see ref. 8).

10 A typical experimental procedure is as follows (Table 1, run 3). To a solution of CuCl (0.025 mmol) and *trans*-β-methylstyrene (2.5 mmol) in acetonitrile (5 mL) was added anhydrous Chloramine-T (0.5 mmol) and 5Å powdered molecular sieves (MS-5A, 50 mg). The solution was stirred at 25 °C for 3 h under an atmosphere of nitrogen. The reaction mixture was then passed through a 3-cm plug of silica gel with CH_2Cl_2. The solvent was removed *in vacuo* to give an oil which was purified by flash column chromatography.

11 This phenomena is also observed in Evans' copper catalyzed aziridination by PhI=NTs. It is known that the stereospecificity is highly dependent on the copper catalyst employed (see ref. 2b). We are currently pursuing this problem.