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1,5-Hydrogen Transfers from Carbon to *N*-Tributyltin Substituted Nitrogen

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Summary: 1,5-H transfers from carbon to N-tributyltin substituted nitrogen proceeded smoothly and were much more efficient than 1,5-H transfers from carbon to ordinary nitrogen. 1,5-Tribuyltin group transfer from carbon to nitrogen and intramolecular addition of an aminyl radical to a nirile group were also observed for the first time.

Recently, we have reported a new method for the generation of *N*-tributyltin substituted aminyl radicals by the reaction of alkyl azides with Bu_3SnH/AIBN.[1,2] Although aminyl radicals have been known to be electrophilic and relatively unreactive,[3] somewhat surprisingly, we have found that intramolecular addition of aminyl radicals to carbonyl groups proceeded smoothly.[1] We envisaged that *N*-tributyltin substituted aminyl radicals might have nucleophilic properties to some extent and might be more reactive than ordinary aminyl radicals.

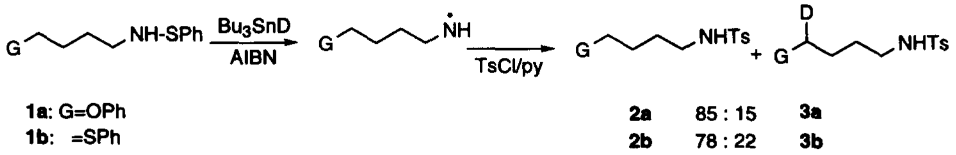
Table 1. SOMO Energy value and charge density of aminyl radicals

aminyl radical	SOMO-energy[a]	charge density
$CH_3\dot{N}Sn(CH_3)_3$	-9.65	-0.358
$CH_3\dot{N}CH_3$	-9.87	-0.154
$CH_3\dot{N}H$	-10.41	-0.120

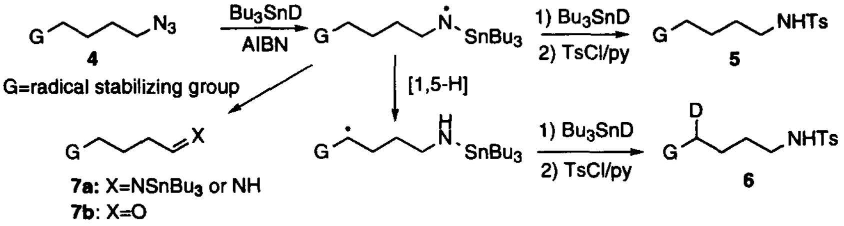
[a] ionization potential in electron volts.

In order to see the effect of tributyltin group on the energy of SOMO (singly occupied molecular orbital) and the electron density at the nitrogen atom, computational studies were performed by the use of PM3-UHF method.[4] From Table 1, two noteworthy features are apparent. First, the trimethyltin substituted aminyl radical has higher energy of SOMO than ordinary aminyl radicals. Second, it has higher electron density at the nitrogen atom, indicative of its more nucleophilic nature.

Radical rearrangements involving 1,5-hydrogen transfers in nitrogen-centered radicals have useful synthetic applications, which are exemplified by well-known Hofmann-Loeffler reaction.[5] 1,5-Hydrogen transfers normally utilize electrophilic nitrogen-centered radicals such as aminium,[5] amidyl,[6] and sulphonamidyl radicals,[7] although a Hofmann-Loeffler type of photocyclization in the absence of a strong acid was reported.[8] In connection with our interest in radical rearrangements,[9] we have studied an intriguing possibility of 1,5-hydrogen transfers in *N*-tributyltin substituted aminyl radicals. We began our studies with sulphenamide **1a**.[10] The addition of a 0.1M benzene solution of n-Bu_3SnD (1.1 equiv) and AIBN (0.1 equiv)



by a syringe pump over 3 h to a 0.05 M refluxing benzene solution of **1a** with additional stirring for 1 h afforded a mixture of direct reduction product **2a** and 1,5-H transferred product **3a** in 80% yield after tosylation. The ^{1}H NMR spectrum indicated a 85:15 mixture of **2a** and **3a**, showing inefficiency of 1,5-H transfer in an aminyl radical. A similar result was also obtained with sulfenylimine **1b**.



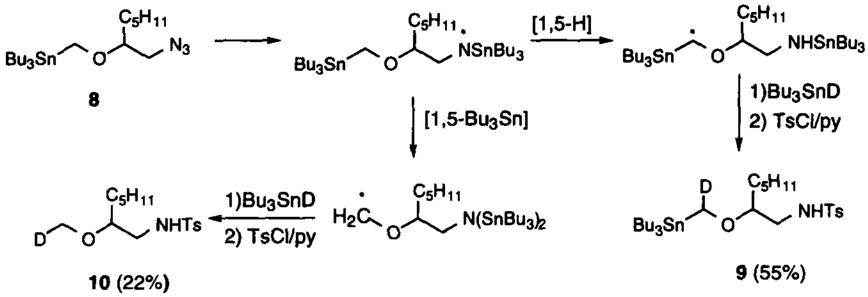
We next examined 1,5-H transfer reaction in *N*-tributyltin substituted aminyl radicals. When the radical reactions of azide **4** were carried out under the similar conditions, much better results were realized, yielding much higher ratio of 1,5-H transferred product **6** relative to direct reduction product **5**. Apparently, *N*-tributyltin substituted aminyl radicals are more reactive than ordinary aminyl radicals, thereby facilitating 1,5-H transfer from carbon to nitrogen. As shown in Table 2, most substrates bearing radical stabilizing groups such as phenoxy, phenyl, and acetal groups gave similar results. Furthermore, isolation of aldehyde **7b** as a minor product is noteworthy. Radical reaction of alkyl azides with Bu_3SnH/AIBN under a high dilution normally afforded aldehydes in variable amounts, depending on the nature of the substrate.[11] Although the mechanism for the conversion of azides to aldehydes is not clear, the reaction would proceed via imine **7a**.[12]

Table 2. 1,5-Hydrogen transfer from carbon to nitrogen

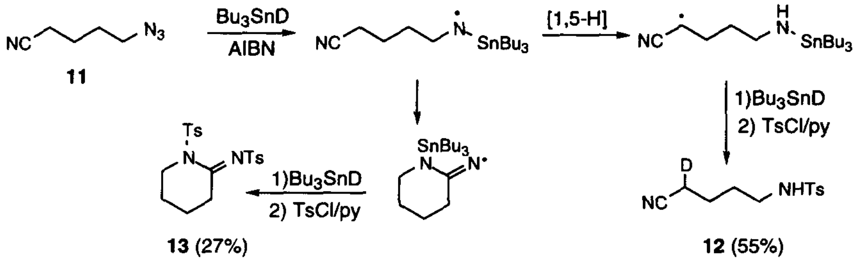
entry	substrate (**4**)	1,5-H transfer (%)	product (**5** + **6**)	aldehyde (**7**)
1	G=$(CO_2Et)_2$	>99	71%[a]	9%
2	G=PhS	95	73%	6%
3	G=CO_2Et	92	57%[a]	5%
5	G=Ph(CH_3)N	88	85%	8%
7	G=PhO	84	71%	13%
8	G=Ph	80	76%	trace
9	G=TBSO	79	70%	trace

[a] isolated as a lactam

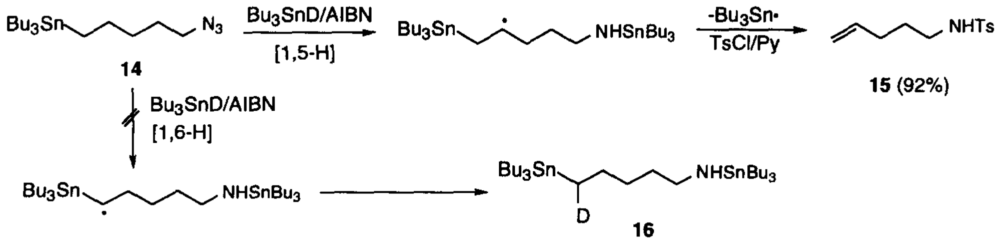
When the radical reaction of **8** with Bu_3SnD/AIBN was carried out under the similar conditions, 1,5-Bu_3Sn group transfer from carbon to nitrogen was observed for the first time, yielding a mixture of **9** (55%) and **10** (22%).[9]

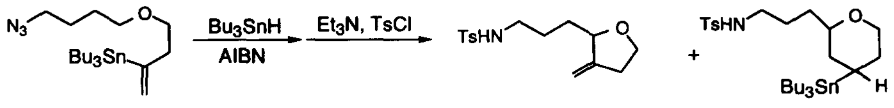


Furthermore, the reaction of **11** under the similar conditions afforded **12** in 55% yield along with **13** (27%), indicating that 1,5-hydrogen transfer competed with radical cyclization of an aminyl radical to a nitrile group. To the best of our knowledge, this is the first example for intramolecular addition of an aminyl radical to an nitrile group.



In order to examine 1,6-H transfer from carbon to nitrogen, we prepared azide **14**. When **14** was subjected to the similar radical conditions, 1,6-H transfer was not observed, yielding only **15** resulting from 1,5-H transfer. Furthermore, the reaction could be carried out with a catalytic amount of Bu_3SnD (0.3 equiv) due to the regeneration of Bu_3Sn radical. This observation would be due to the strong preference of 1,5-H transfer relative to 1,6-H transfer[13] along with β-stabilizing effect of the tributyltin group.[14]





17 **18** (53%) **19** (13%)

We briefly studied two-step sequence involving 1,5-H transfer and subsequent cyclization. When **17** was treated with Bu$_3$SnH/AIBN in refluxing benzene under a high dilution, **18** was isolated in 53% yield along with 6-*endo* cyclized product **19** (13%), demonstrating the efficiency of 1,5-H transfer in *N*-tributyltin substituted aminyl radicals.

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Reference and Notes

1. (a) Kim, S.; Joe, G. H.; Do, J. Y. *J. Am. Chem. Soc.* **1993**, *115*, 3328. (b) Kim, S.; Yoon, K. S.; Kim, S. S.; Seo, H. S. *Tetrahedron* **1995**, *51*, 8437.
2. Kim, S.; Joe, G. H.; Do, J. Y. *J. Am. Chem. Soc.* **1994**, *116*, 5521.
3. Curran, D. P. In *Comprehensive Organic Synthesis*; Trost, B. M., Fleming, I., Eds.; Pergamon: Oxford, 1992; vol. 4, pp 779.
4. Stewart, J. J. P. *J. Comput. Chem.* **1989**, *10*, 221. MOPAC version 6 was used and the optimization for the ground state was carried out using EF option.
5. For reviews, see: (a) Wolff, M. E.; *Chem. Rev.* **1963**, *63*, 55. (b) Neale, R. S. *Synthesis* **1971**, 1.
6. (a) Neale, R. S.; Marcus, N. L.; Schepers, R. G. *J. Am. Chem. Soc.* **1966**, *88*, 3051. (b) Kuhn, L. P.; Kleinspehn, G. G. *Tetrahedron Lett.* **1966**, 4901. (c) Joseph, T. C.; Tam, J. N. S.; Kitadani, M.; Chow, Y. L. *Can. J. Chem.* **1976**, *54*, 3571.(d) Sutcliffe, R.; Ingold, K. U. *J. Am. Chem. Soc.* **1982**, *104*, 6071.
7. (a) Okahara, M.; Ohashi, T.; Komori, S. *Tetrahedron Lett.* **1967**, 1629. (b) Okahara, M.; Ohashi, T.; Komori, S. *J. Org. Chem.* **1968**, *33*, 3066. (c) Neale, R. S.; Marcus, N. L. *J. Org. Chem.* **1969**, *34*, 1808.
8. Kimura, M.; Ban, Y. *Synthesis* **1976**, 201.
9. (a) Kim, S.; Lee, S.; Koh, J. S. *J. Am. Chem. Soc.* **1991**, *113*, 5106. (b) Kim, S.; Koh, J. S. *J. Chem. Soc., Chem. Comm.* **1992**, 1377. (c) Kim, S.; Lim, K. M. *Tetrahedron Lett.* **1993**, *34*, 4851. (d) Kim, S.; Do, J. Y.; Lim, K. M. *Chem. Lett.* **1996**, 669.
10. (a) Bowman, W. R.; Clark, D. N.; Marmon, R. J. *Tetrahedron Lett.* **1992**, *33*, 4993. (b) Bowman, W. R.; Clark, D. N.; marmon, R. J. *Tetrahedron Lett.* **1994**, *50*, 1275. (c) Bowman, W. R.; Clark, D. N. Marmon, R. J. *Tetrahedron Lett.* **1994**, *50*, 1295.
11. The conversion of alkyl azides into the corresponding aldehydes and ketones is under investigation and the result will be reported in due course.
12. (a) Roberts, B. P.; Winter, J. N. *J. Chem. Soc., Perkin 1.* **1979**, 1353. (b) Tada, M.; Inoue, K.; Sugawara, K.; Hiratsuka, M.; Okabe, M. *Chem. Lett.* **1985**, 1821; **1986**, 703. (c) Kim, S.; Do, J. Y. *J. Chem. Soc., Chem. Comm.* **1995**, 1607.
13. (a) Wawzonek, S.; Culbertson, T. P. *J. Am. Chem. Soc.* **1960**, *82*, 441. (b) Walling, C.; Padwa, A. *J. Am. Chem. Soc.* **1963**, *85*, 1597. (c) Neal, R. S.; Walsh, M. R.; Marcus, N. L. *J. Org. Chem.* **1965**, *30*, 3683.
14. (a) Jackson, R. A.; Ingold, K. U.; Griller, D.; Nazran, A. S. *J. Am. Chem. Soc.* **1985**, *107*, 208. (b) Kim, S.; Lee, K. M. *Bull. Korean Chem. Soc.* **1994**, *15*, 827.

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