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HIGHLY NUCLEOPHILIC TRIBUTYLTIN AZIDE IN OXIRANE RING CLEAVAGE LEADING TO 1,2-AZIDO ALCOHOL

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Abstract: Enhanced reactivity of tributyltin azide has been demonstrated in nucleophilic ring cleavage of oxiranes without solvent and promoter to give 1,2-azido alcohols in good to excellent yields.

Elaboration of 1,2-azido alcohol functionality by means of a nucleophilic oxirane-ring cleavage with an organometallic azide such as trimethylsilyl azide (TMS-N_3) promoted by Lewis acids[1] or transition-metal complexes[1b,2] is a well-known synthetic transformation. In these cases, however, such promoters are necessarily required in large excess to gain access to the practical rate because of a low reactivity of TMS-N_3 itself. Accordingly, highly reactive azide species, capable of cleaving oxirane ring without any activating means, if realized, should be valuable to organic synthesis.

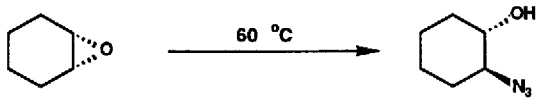
In our current investigation on this line, we have found that tributyltin azide (TBT-N_3), which is available readily after the equation depicted below,[3] fulfill primarily such a requirement. TBT-N_3 has been used less frequently in organic synthesis with a few exceptions.[4] It is rather surprising that no attemps have been made to test the feasibility of TBT-N_3 in oxirane-ring cleavage notwithstanding that it appeared as early as 1966.[3] We describe herein such a chemistry for the first time.

$$(Bu)_3SnCl + NaN_3 \xrightarrow[86\%]{\text{THF, reflux, 48 h}} (Bu)_3SnN_3 + NaCl$$

J. S. Thayer has discussed on the difference in the nature of metal-nitrogen bonds between TMS-N_3 and TBT-N_3 on the basis of infrared frequencies which are observed at the lower and the higher regions, respectively, than that of methyl azide in which the N_3 group is bonded to the carbon by a covalent σ bond.[3] He proposed that the lower frequency for TMS-N_3 can be rationalized by assuming a π-bond character of the Si-N bond, whereas there is no such a contribution for TBT-N_3 whereby the Sn-N bond may become more susceptible to chemical attack. The outcome of TBT-N_3 ring opening of cyclohexene oxide was satisfactory as shown in Table I. In particular, when compared with TMS-N_3, the reactivity of the tin reagent turned out to be very high, reflecting the J. S. Thayer's proposal.

It seems quite interesting that TMS-N_3 enjoyed a marked rate enhancement in DMF solvent, whereas the rate for TBT-N_3 slowed down simply as a consequence of dilution with DMF. Rationale of what is meant by

Table I. DMF effect on the rate of oxirane cleavage with TMS-N3 and TBT-N3.



Azide	Solvent	Time/h	Yield/%
$TMS\text{-}N_3$	no	336	85
$TMS\text{-}N_3$	DMF	50	89
$TBT\text{-}N_3$	no	0.4	80
$TBT\text{-}N_3$	DMF	3	58

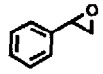
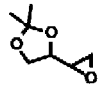
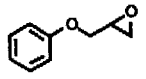
finding seems to be difficult at present stage and must await future study on this subject. One possible explanation can be provided relying on the mechanism for nucleophilic substitution at silicon in R3SiX compounds proposed by R. J. P. Corriu.[5] Thus, the silicon can be reversibly coordinated by DMF because of its donor nature, which may result in a loss of $d\pi$-$p\pi$ overlap between silicon and nitrogen[3] and , thus, in an activation of the Si-N bond or an increase in Lewis acidity of the silicon center of such a pentacoordinated adduct.[5] In any event, large increase in the rate of nucleophilic oxirane ring cleavage with TMS-N3 in DMF was generally observed.[6]

Thus, reactions of various oxiranes with TBT-N3 have been executed without solvent. In a typical experiment, a mixture of oxirane (1.5 mmol) and TBT-N3 (3 mmol) was stirred at 60 °C until the oxirane was completely consumed. To the mixture were added ether (20 ml) and water (10 ml) and the resulting mixture was vigorously stirred at room temperature for 30 minutes. The ether solution was separated, dried (Na2SO4), and concentrated to give an oil, which, on column chromatography (SiO_2), afforded the 1,2-azido alcohols. Sometimes an impurity originated from the tin compound incorporated with the desired product and, in this case, rechromatography was needed to gain access to an analytical sample. The ratio of regioisomers was determined by ^1H NMR. The results are summarized in Table II.

The rate of the reactions turned out to depend highly on the structural types of oxiranes employed. As a general trend, the isolated oxiranes can be converted into 1,2-azido alcohols within an hour (Entries 1-3) and the oxiranes with neighboring alkoxyl (Entries 4 and 5) or ester groups (Entries 6-8) required 5 ~ 6 hours or about two days, respectively. Apparently, the presence of donor groups other than the epoxide-oxygen such as ester, acetonide, or ether, retarded the reaction, which probably means that Lewis acidity of the tin compound plays an important role in this transformation.

To circumvent the above-mentioned drawback that the tin-derived impurity incorporated with the desired product, a possible catalytic system consisted of TMS-N3 and 10% TBT-N3 was examined for cyclohexene oxide employing DMF as a solvent. Thus, a mixture of TMS-N3 (3 mmol), TBT-N3 (0.3 mmol, 10%), and the oxirane (1.5 mmol) was stirred at 60 °C. The reaction was completed within 12 hours (50 hours without TBT-

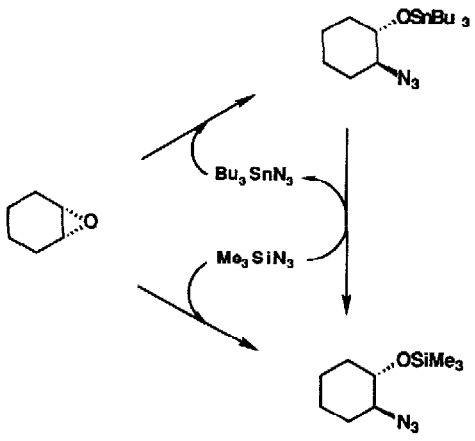
TableII. Oxirane-ring opening with TBT-N_3 at 60 °C: no solvent[a]

Entry	Oxirane[c]	Time/h	Product[b] Yield/%	prim-N_3	sec-N_3
1		0.4	89	——	
2		0.5	88	1 :	1.7 (tert)
3		1.0	86	1 :	14
4		5.0	69	15 :	1
5		6.0	95	17 :	1
6		46	62	5 (α) :	1 (β)
7		48	68	1 (α) :	1.2 (β)
8		32	73	——	

a) Oxirane = 1.5 mmol, TBT-N_3 = 3.0 mmol; b) Structures and regiochemical ratios determined for the products itself or appropriate derivatives such as acetates by proton-NMR (200 or 500 MHz); c) Oxiranes available from commercial products for Entries 1,3, and 5, and synthesized for others.

N_3; see Table I) and was treated under reduced pressure to remove an excess TMS-N_3 to give an oil which, on column chromatography (SiO_2) furnished *O*-trimethylsilyl-2-azido-cyclohexanol without any contaminations in 70% yield. A plausible mechanism for this conversion is shown below.

TBT-N_3 is moisture-stable liquid, easy-to-prepare,[3] and miscible with oxiranes in any proportions. The reaction can be conducted totally under neutral conditions, and, thereby, applicable to oxiranes even in the presence of labile groups such as *t*-butyldimethylsilyl protection. Thus, TBT-N_3 should be a useful azido-transferable reagent in organic synthesis.



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References

1) a) Birkofer, L.; Kaiser, W. *Liebigs Ann. Chem.* **1975**, 266 ; b) Blandy, C.; Choukroun, R.; Gervais, D. *Tetrahedron Lett.* **1983**, *24*, 4189 ; c) M.Caron, M.; Sharpless, K. B. *J. Org. Chem.* **1985**, *50*, 1560 ; d) Maruoka, K.; Sano, H.; Yamamoto, H. *Chem. Lett.* **1985**, 599; e) Sinou, D.; Emziane, M. *Tetrahedron Lett.* **1986**, *27*, 4423 .

2) Caron, M.; Carlier, P. R.; Sharpless, K. B. *J. Org. Chem.* **1988**, *53*, 5187.

3) Thayer, J. S. *Organometal. Chem. Rev.* **1966**, *1*, 157 ; see also Luijten, J. G. A.; Janssen, M. J.; Van Der Kerk, G. J. M. *Rec. Trav. Chim.* **1962**, *81*, 202.

4) For synthetic applications of TBT-N3 as an important building block for tetrazole derivatives (1,3-dipolar cycloaddition reaction) or as a *t*-butoxycarbonyl azide synthon, see Pereyre, M.; Quintard, J.-P.; Rahm, A. *Tin in Organic Synthesis*; Butterworths: London, **1987**; p 310 and references cited therein.

5) a) Boudin, A.; Cerveau, G.; Chuit, C.; Corriu, R. J. P.; Reye, C. *Angew. Chem. Int. Ed. Engl.* **1986**, *25*, 473 and the references cited therein; for discussion pertinent to this issue, see Tamao, K.; Kakui, T.; Akita, M.; Iwahara, T.; Kanatani, R.; Yoshida, J.; Kumada, M. *Tetrahedron* **1983**, *39*, 983 and Tamao, K.; Akita, M.; Kumada, M. *J. Organomet. Chem.* **1983**, *254*, 13.

6) The TMS-N3 ring cleavage of other oxiranes appeared in Table II were highly enhanced unexceptionally when DMF was employed as a solvent: for instance, the reaction of dimethyl 2,3-epoxysuccinate with TMS-N3 never proceeded (no solvent, 60 °C, 2 days) but was completed within 24 hours in DMF (60 °C; 86% yield).

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