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REGIOSELECTIVE RING OPENING OF SILYL EPOXY ALCOHOLS WITH AZIDE ION

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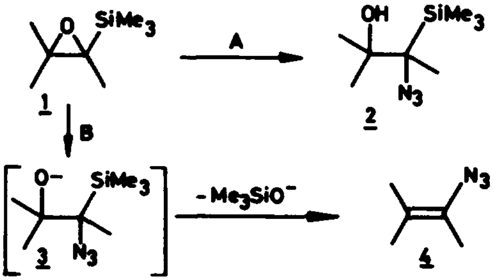
Abstract: Presence of silyl group on epoxy ring allows azide ion to open 2,3-epoxy alcohols exclusively at the silicon bearing carbon.

Regioselectivity in nucleophilic ring opening of 2,3-epoxy alcohols depends on both steric and electronic factors[1]. Numerous methods are available where regiospecificity is achieved either by manipulating nature of nucleophiles or by changing reaction conditions. For ring opening with azide ion reagents of choice include sodium or trimethylsilyl azide in presence of various metals[2], $Ti(OiPr)_2(N_3)_2$[3], NaN_3 supported on calcium zeolite[4], Bu_3SnN_3[5] etc.. Moderate to excellent regiospecificity was achieved in many of these methods though the extent of selectivity in all these methods varies from substrate to substrate. Whereas metal-mediated reactions largely favour C-3 opening steric bulk or increased electron-withdrawing inductive effect at C-4 and C-5 directs nucleophiles towards C-2[1c].

We were interested to address the problem by placing silyl group on epoxy ring and explore its role in determining regiospecificity in the ring opening with azide ion. Thus when epoxides 1a-g[6,7] were treated with NaN_3/NH_4Cl in $MeOH:H_2O$ (8:1) clean ring opening was observed.



A : NaN_3 (5.0 eq), NH_4Cl(2.2 eq), $MeOH:H_2O$ (8:1), r.t
B : NaN_3 (3.0 eq), DMF, r.t. or 110°C.

Yields were good and in all cases cleavage occurred exclusively at the silyl substituted center[8]. No rearrangement was noticed. The presence of silyl group also made reactions proceed at room temperature under mild condition. Simple epoxysilanes 1e-g also exhibited similar results[9]. The results of our study are summarised in Table I. For the first time we have achieved "substrate-controlled" selectivity in the opening of 2,3-epoxy alcohols which require very simple reagents

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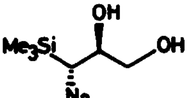
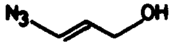
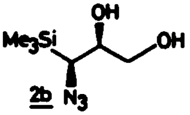
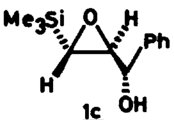
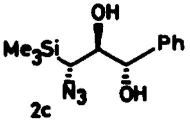
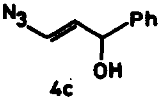
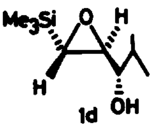
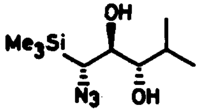
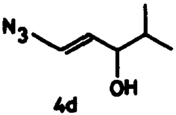
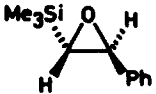
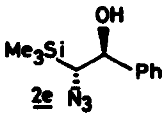
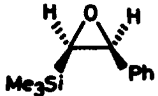
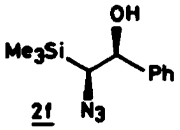
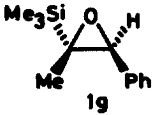
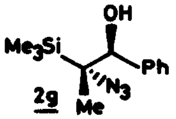
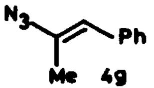
and condition. With the availability chiral silyl-epoxy alcohols[7] and stereospecific protiodesilylation methods[10] our results open an easy access to many potential multifunctionalised chiral molecules specially chiral amino alcohols, amino acids and hydroxy amino acids.

TABLE-1

Epoxy alcohol^a	Reaction A time (h)	Product ^{b}	(%Yield^c)	Reaction B time (h)^d	Product^b	(%Yield^c)
 1a	3	 2a	(90)	0.5	 4a	(37)
 1b	3	 2b	(88)	0.5	 4b	(34)
 1c	12	 2c	(96)	0.5	 4c	(54)
 1d	20	 2d	(92)	0.5	 4d	(51)
 1e	12	 2e	(93)	48.0	 4e	(36)
 1f	12	 2f	(90)	48.0	 4f	(38)
 1g	10	 2g	(65)	48.0	 4g	(36)

a) For epoxysilanes 1c and 1d corresponding syn-isomers also gave similar results.

b) All products were characterized by standard spectroscopic methods (NMR, IR, Mass).

c) Yields corresponding to azido-alcohol 2 refer to isolated yields whereas those for vinyl azides are based on recovered starting material.

d) "Reaction B" for 1a-d were done at 110° whereas for 1e-g they were done at room temperature.

Ring opening was very slow when reactions were carried out in dry DMF using only NaN_3 (reaction B) and proceeded only to a small extent even after prolonged reaction time. The only isolable product was not the expected azido-alcohol **2** but vinyl azide **4**[11]. This unexpected finding can be explained by in-situ syn-elimination of Me_3SiO^- from the intermediate **3**[12]. At higher temperatures (upto 110°) reactions were much faster though in case of simple epoxysilanes **1e-g** due to extensive decomposition of products they were preferably carried out at room temperature. Here once again expected regioselectivity was achieved with epoxy-ring opening exclusively at the silicon bearing carbon. Complete syn-elimination was observed in all the cases giving rise to cis-vinylazide from cis-epoxysilanes and trans product from the corresponding trans starting materials. Since the epoxysilanes were synthesized from the corresponding vinyl silanes, the overall two-step process, thus emanated, is simply equivalent to the displacement of silyl group from vinyl silanes with azide. Thermal transformation of vinyl azides can lead to many interesting 2H-azirine systems[13]. Further work on standardisation of this process and improvement of yields is presently under progress.

Thus, in conclusion, presence of silyl group on epoxy ring of 2,3-epoxy alcohols render exclusive regioselectivity in epoxy ring opening with azide, a finding which will have many useful applications[14].

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REFERENCES

1. a) C.H. Behrens and K.B. Sharpless, J. Org. Chem., **50**, 5696 (1985); b) C.H. Behrens, S.Y. Ko, K.B. Sharpless and F.J. Walker, J. Org. Chem., **50**, 5687 (1985); c) C.H. Behrens and K.B. Sharpless, Aldrichimica Acta, **16**, 67 (1983).
2. a) M. Caron and K.B. Sharpless, J. Org. Chem., **50**, 1557 (1985); b) K. Maruoka, H. Sano and H. Yamamoto, Chemistry Lett., 599 (1985).
3. M. Caron, P.R. Carlier and K.B. Sharpless, J. Org. Chem., **53**, 5185 (1988).
4. M. Onaka, K. Sugita and Y. Izumi, Chemistry Lett., 1327 (1986).
5. S. Saito, S. Yamashita, T. Nishikawa, Y. Yokoyama, M. Inaba and T. Moriwake, Tetrahedron Lett., **30**, 4153 (1989).
6. **1a-g** were prepared by epoxidation with mCPBA of the corresponding vinyl silanes which, in turn, were obtained by hydrogenating their silyl acetylenic precursors. Cis-reduction (for **1b** and **1f**) was done with H_2/Lindlar's catalyst whereas reduction with RED-Al (for **1a**,**1c** and **1d**) and DIBAL-H[7] (for **1e** and **1g**) gave trans-vinyl silanes. DIBAL-H reduction (in C_6H_{14}) of phenyl-trimethylsilylacetylene on quenching with MeI gave vinylic precursor for **1g**. Two diastereomers were obtained during the synthesis of **1c** and **1d** by mCPBA epoxidation of their corresponding vinylsilanes. In both cases major isomers were anti as determined by ^1H NMR spectra of the acetonides of their azido diols **2c** and **2d**.
7. Y. Kitano, T. Matsumoto and F. Sato, Tetrahedron, **44**, 4073 (1988).
8. Regioselectivity was determined unequivocally by decoupling ^1H NMR Spectra of the products.
9. This is in agreement with results observed earlier in ring openings of epoxysilanes using various other nucleophiles: a) "Silicon reagents in organic synthesis", E.W. Colvin, Academic

Press, 1988; b) "Silicon in Organic Synthesis", E.W. Colvin, Butterworths, 1981, Chapter 7; c) "Comprehensive organometallic chemistry", G. Wilkinson, Ed., Pergamon Press, Vol.2, Chapter 9.1 and Vol. 7, Chapter 48. 1982; d) Y. Zhang, J.A. Miller and E. Negishi, J. Org. Chem., **54**, 2043 (1989); e) E.J. Grayson and G.H. Whitham, Tetrahedron, **44**, 4087 (1988); f) A. Alexakis and D. Jachiet, Tetrahedron Lett., **29**, 217 (1988) and the references cited therein; g) P.F. Hudrlik, A.M. Hudrlik, R.N. Misra, D. Peterson, G.P. Withers and A.K. Kulkarni, J. Org. Chem. **45**, 4444 (1980); h) P.F. Hudrlik, D. Peterson and R.J. Rona, J. Org. Chem. **40**, 2263 (1975).

10. a) Y. Kobayashi, H. Uchiyama, H. Kanbara and F. Sato, J. Am. Chem. Soc., **107**, 5541 (1985); b) H. Uchiyama, Y. Kobayashi and F. Sato, Chemistry Lett., 467 (1985).
11. Formation of vinyl azides was monitored by precoated silica gel TLC plates (Merck 60F 254) using UV (254 nm) light as detector. In "reaction A" longer reaction time sometimes led to the formation of little amount of vinyl azide:**1e** → **4e** (reaction A, 24 h, 5%), **1f** → **4f** (reaction A, 24 h, 7%).
12. For a detailed discussion on base or acid catalyzed 1,2-elimination of β-hydroxysilanes see ref.9b, chapter 8.
13. a) R.W. Saalfrank, U. Wirth and C.J. Lurz, J. Org. Chem., **54**, 4356 (1989) and the references cited therein; b) "The chemistry of azido group", ed. S. Patai, John Wiley and Sons, NY, 1971.
14. Unlike silyl substituent on 3-position where electronic factor is the sole determinant for the course of nucleophilic attack on 2,3-epoxy alcohol silyl group on 2-position does not exhibit exclusive regioselectivity in all cases due to competing steric factor. Which one should predominate depends largely on the group present in 1-position and the diastereomeric configuration of the epoxy alcohol. A detailed study on this will be communicated soon.

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