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TRIPHENYLSILANETHIOL: A SOLID H_2S EQUIVALENT IN THE RING OPENING OF EPOXIDES

John Brittain, Yves Gareau*

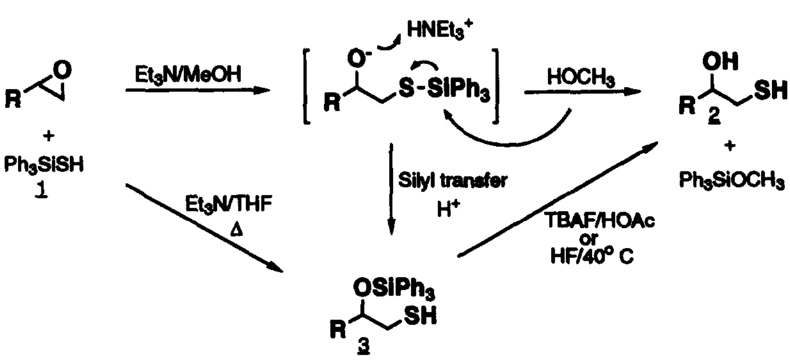
Merck Frosst Centre for Therapeutic Research
P.O. Box 1005, Pointe Claire-Dorval, Québec, Canada, H9R 4P8

Abstract: Triphenylsilanethiol, a white crystalline solid, can be used in the opening of epoxides to form ß-hydroxymercaptans or ß-dihydroxysulfides.

The opening of epoxides is a well studied process and has been accomplished with a wide variety of nucleophiles.[1] In the case of sulfur nucleophiles, it seems that only a few methods leading to ß-hydroxymercaptans are described in the literature. Among those worth mentioning are H_2S,[2] the Lalancette sulfurated borohydride ($NaBH_2S_2$)[3] and the ring opening by thiourea.[4] These methods either have harsh conditions or unpleasant odor. In view of this, we found that triphenylsilanethiol 1, the monoprotected form of H_2S, could be a better reagent to effect the same transformation. It is a white crystalline solid, easy to handle, with only a slight odor. It is readily prepared from elemental sulfur and triphenylsilane.[5]

When submitted to various epoxides in methanol-triethylamine, 1 added on the less hindered side of the epoxide to yield after methanolysis of the intermediate triphenylsilylsulfide, the most substituted alcohol 2 in 50-60% yield. A minor product 3, which arises from the transfer of the silyl group from the sulfur to the oxygen was also isolated in 10-20% yield. In turn, 3 can be converted easily to 2 either by treatment with HF/40°C or with TBAF/HOAc in yield greater than 95%. Also in an aprotic solvent like THF, 3 is the sole product, and can be isolated or converted to 2 in good yield (Scheme 1).

Scheme 1



In general, monosubstituted epoxides can be opened using 1.3 equivalents of thiol 1 and 1 equivalent of Et_3N in a 0.4 M methanol solution of the epoxide at room temperature (procedure A). After the disappearance of the starting material 1.5 equivalents of TBAF and 3-4 equivalents of acetic acid are added to convert 3 to 2 (1h) before work up. For disubstituted epoxides, slightly more vigourous conditions are necessary. The reagents are mixed in the same proportions as above and heated to reflux for 20 h in THF (Procedure B). In such aprotic medium, the epoxide goes totally to 3 which is not isolated but treated at room temperature with TBAF/HOAc to yield the desired ß-hydroxymercaptan. For trisubstituted epoxides there is practically no reaction.

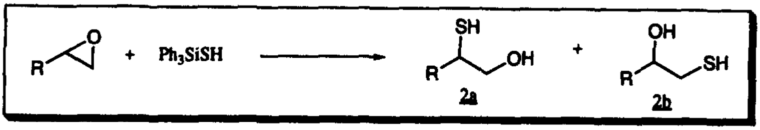
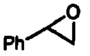
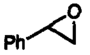
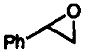
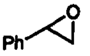
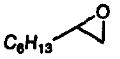
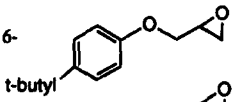
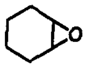
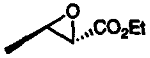
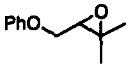


Table I: Ring opening of epoxides with Ph_3SiSH and triethylamine.

Entry	Epoxide	Method[a]	Ratio 2a/2b	Yield[6]
1-		A	7:1	87%
2-		A (5 eq. Et_3N)	1:2	65%
3-		A (25 eq. Et_3N)	1:8	40%
4-		B	1:8	87%
5-		A	0:100	85%
6-		A	0:100	81%
7-		A	100:0	74%[b]
8-		B	-	78%
9-		B	-	60%[c]
10-		A,B	-	N.R.

a) Method A: 1.3 eq.of 1 was added to the epoxide in a 0.4 M methanol solution with 1 eq. of triethylamine and then treated with TBAF/HOAc. Method B: 1.3 eq. of 1 was added to the epoxide in a 0.4 M THF solution, reflux and then treated with TBAF/HOAc.

b) Sulfur adds α to the phenyl. c) Sulfur adds α to the carbonyl.

It is interesting to note that in the case of styrene oxide one can get either one of the regioisomers as the major product by varying the conditions. Using the general procedure A with 1 equivalent of base, the thiol adds mainly at the benzylic position in a 7/1 ratio. A 5-fold excess of base favours the other isomer although in a lower yield, and a 25-fold excess gives in a 1/8 ratio the regioisomer 2 with an even lower yield. However, in aprotic conditions (procedure B), the same selectivity for the more hindered alcohol was obtained in good yield (entry 4).

The choice of base can also change the course of the reaction. Using 1 equivalent of 1, 2 equivalents of the epoxide and 2 equivalents of Cs_2CO_3 in methanol, gave as the only compound the symmetrical β-dihydroxysulfide. Presumably the first step of the reaction is the normal addition of 1 at the less substituted side of the epoxide followed by the cleavage of the silicon-sulfur bond by the carbonate or methanol. The hydroxythiolate thus formed reacts with a second molecule of the starting epoxide to give the corresponding dihydroxysulfide. The reactions seem to be quite general. Table II summarizes the results for some of the mono and disubstituted epoxides. Again in the case of styrene oxide, a mixture of sulfides was obtained in a ration of 1:1.

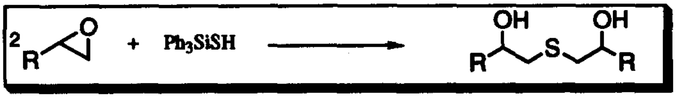
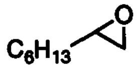
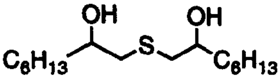
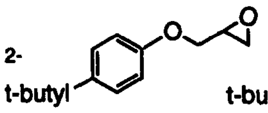
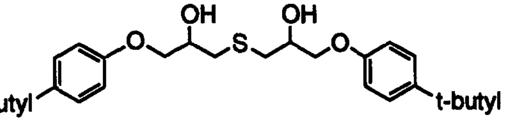
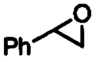
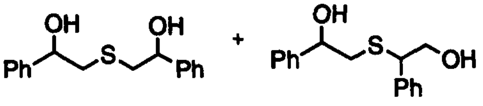
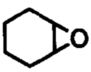
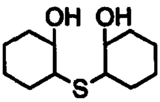


Table II: Ring opening of epoxides with Ph_3SiSH and Cs_2CO_3.

Entry	Epoxide	Product	yield^6
1-			83%
2-			95%
3-			(1:1) 64%
4-			75%

In conclusion we have shown that triphenylsilanethiol is a good equivalent of H_2S for the formation of β-hydroxymercaptans and symmetrical β-dihydroxysulfides.

References

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6. Isolated yields; all new compounds gave satisfactory elemental analysis and/or high resolution mass spectra.

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