An Easy and Efficient Epoxide Opening to give Halohydrins using Tin(II) Halides

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Epoxides are readily converted into halohydrins by tin(II) halides in a variety of solvents.

We recently described a sonochemical method for the nucleophilic addition of allylic groups in the presence of metallic tin in aqueous media.[1] In an attempt to apply this method to epoxides, we found that incorporation of the allylic residue did not occur, but instead the corresponding halohydrin was formed as the major product. Examination of the conditions revealed that during the process tin(II) halides were formed and reacted in a second step with the epoxide. Owing to the general interest in the smooth and selective cleavage of these compounds, the reaction conditions and some possible synthetic generalizations were studied further.

When stirred at room temperature with commercial tin(II) chloride dihydrate, epoxides are readily transformed to the coresponding chlorohydrins in a moderately exothermic reaction. The process appears to be remarkably tolerant to the reaction medium as shown by the results in Table 1. Previous methods generally do not allow such a variety of solvents to be used.[2]

Extension to various epoxides proved to be satisfactory, except for ethyl (±)-2,3-epoxy-3-phenylpropionate which was left unchanged. The method was found to be compatible with ketone and ether groups. No halogen exchange was observed with α-halogeno epoxides (Table 2). The epoxide ring opening occurs in a *trans*-manner; significant *cis*-opening is observed in the related iron(III) chloride method.[3]

Extension to other tin(II) halides also gave encouraging results. The expensive tin di-iodide can be efficiently prepared simply by sonication of tin powder in the presence of iodine.† When stirred with an epoxide, SnI_2 forms the iodohydrin with decolourisation of the mixture, thus providing a colour test for completion of the reaction.

Whereas tin dichloride and di-iodide give excellent results, tin dibromide unexpectedly led to significantly lower yields, which could not be improved by varying the conditions (solvent, stoicheiometry). Attempts to form the corresponding fluorohydrins failed as the reactions using cyclohexene oxide and SnF_2 gave instead an 80% isolated yield of the *trans-vic*-diol.

Formation of halohydrins from epoxides has been extensively studied, with a variety of reagents. From the original methods using hydrogen halides,[2] modifications have been proposed making use of more or less sophisticated and/or expensive reagents, such as pyridinium chloride,[4] and palladium,[5] iron(III),[3] and titanium[6] salts. Tin(II) salts appear to be of comparable applicability, with the advantages of their use under simple conditions in wide variety of media.

Table 1. Formation of *trans*-2-chlorocyclohexanol from cyclohexene oxide and tin(II) chloride.[a]

Solvent	Time/h	Yield,[b]%
Me_2CO	0.50	83
MeCN	0.75	79
CCl_4	1	76
CH_2Cl_2	0.5	90
Et_2O	1	87
EtOAc	0.5	78
Heptane	4	93
Distilled water	1	75
Tap water	1	72

[a] $SnCl_2 \cdot 2H_2O$ (1.8 mmol) and cyclohexene oxide (3 mmol) were stirred at room temp. in 3 ml of the solvent. After completion (t.l.c.) the mixture was filtered (Celite) and the solid residue washed (Et_2O). Extraction when necessary with ether, drying, and evaporation gave the crude chlorohydrin which was purified by column chromatography (SiO_2). [b] Isolated yields.

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† Tin powder (0.60 g) and iodine (1.27 g) in 2 M aq. HCl (5 ml) were sonicated in a Sonoclean ultrasonic bath at 15—18 °C. The orange solid which rapidly formed (*ca.* 5 min) was filtered off, washed with cold water, and dried for 2 h *in vacuo*. SnI_2 thus obtained can be stored in the dark without decomposition and used without purification.

Table 2

Epoxide	Reagent	Solvent	Product	Yield, %
Cyclohexene oxide	$SnBr_2$	Et_2O	*trans*-2-Bromocyclohexanol	55
,,	,,	H_2O	,,	61
,,	SnI_2	CH_2Cl_2	*trans*-2-Iodocyclohexanol	89
1-Methylcyclohexene oxide	$SnCl_2$	CH_2Cl_2	*trans*-2-Methyl-2-chlorocyclohexanol	60
			trans-1-Methyl-2-chlorocyclohexanol	20
trans-But-2-ene oxide	$SnCl_2$	CCl_4	*threo*-Me-CHCl-CH(OH)Me	76
Epichlorohydrin	$SnCl_2$	CH_2Cl_2	$ClCH_2$-CH(OH)-CH_2Cl	70
,,	$SnBr_2$	CCl_4	$ClCH_2$-CH(OH)-CH_2Br	63
,,	SnI_2	Et_2O	$ClCH_2$-CH(OH)-CH_2I	90
Epibromohydrin	$SnCl_2$	CCl_4	$ClCH_2$-CH(OH)-CH_2Br	76
Styrene oxide	$SnCl_2$	Et_2O	$PhCHClCH_2OH$	77
,,	SnI_2	CH_2Cl_2	$PhCHICH_2OH$	71
3-Phenoxyprop-1-ene oxide	$SnCl_2$	Et_2O	$PhOCH_2CHClCH_2OH$	71
Chalcone oxide	$SnCl_2$	CH_2Cl_2	*threo*-PhCHClCH(OH)COPh	63

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