COMMUNICATION

Simple one-pot transformations of toluene-*p*-sulfonates of 2,3-epoxy alcohols into allylic alcohols

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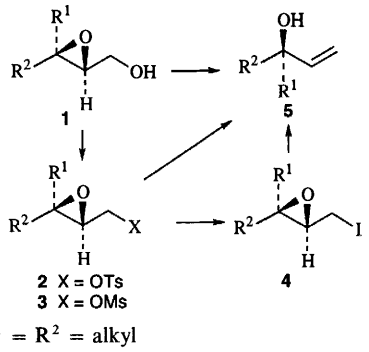
A simple synthetic method for the preparation of scalemic allylic alcohols from toluene-*p*-sulfonates of scalemic 2,3-epoxy alcohols is reported. Satisfactory yields are obtained by treatment of toluene-*p*-sulfonates of 2,3-epoxy alcohols with potassium iodide followed by triphenylphosphine and iodine in a one-pot synthesis.

Allylic alcohol functionality-bearing compounds are often vital structural units of biologically active compounds.[1] In addition, the importance of scalemic allylic alcohols † as key intermediates for the synthesis of various types of compounds has focused widespread synthetic attention on these moieties.[2]

During synthetic studies directed towards the botryococcene family terpenoids,[3] we needed a simple synthetic route which would allow the convenient preparation of scalemic allylic alcohols from readily available scalemic 2,3-epoxy alcohols or related compounds. Existing syntheses of allylic alcohols from 2,3-epoxy alcohols or similar substrates include: (i) titanocene(III)-induced deoxygenation of 2,3-epoxy alcohols **1**;[4] (ii) reduction of tosylates **2** with zinc–copper in the presence of sodium iodide;[5] (iii) telluride(II)-mediated[6] or sodium-mediated[7] reduction of mesylates **3**; and (iv) reduction of iodides **4** with zinc–copper,[8] zinc or alkyllithiums.[10] We now



Scheme 1 $R^1 = R^2$ = alkyl

describe the simple transformation of tosylates of type **2** into allylic alcohols of type **5** by treatment with potassium iodide followed by triphenylphosphine or 4-(dimethylamino)phenyldiphenylphosphine (4-DMAPDP) in the presence of iodine in a one-pot manner.

The requisite scalemic tosylates **6**–**14** (ee or de >90%) shown in Scheme 2 for the present study were readily prepared in high yields from the corresponding scalemic 2,3-epoxy alcohols which in turn were obtained by Sharpless asymmetric epoxidation of the respective allylic alcohols.

Although all controlling factors involved in the overall one-pot transformation are not clear, the following conclusions may be drawn: (i) a mixed solvent of acetone and DMF (6:1 ~ 3:1) is the solvent of choice, since although conversion of the tosylates into the corresponding iodides by treatment with potassium iodide in refluxing acetone is rather sluggish, acceleration of the reaction is accomplished by the addition of DMF; (ii) without isolation of the intermediate iodides, effective conversion of the iodides into the corresponding allylic alcohols can be achieved by successive addition of triphenylphosphine (1–1.5 equiv.) and iodine (0.01–0.5 equiv.) to a stirred solution of the iodides; (iii) in cases where the protecting groups in starting tosylates are rather acid sensitive (substrates **13** and **14**), 4-DMAPDP (1.5 equiv.) and iodine (1 equiv.) serve as substitutes for triphenylphosphine and a catalytic amount of iodine; and (iv) triphenylphosphine or 4-DMAPDP could not be replaced by trialkylphosphines such as tributylphosphine.

Although a mechanistic rationale for the transformations of intermediates into allylic alcohols by treatment with triarylphosphine and iodine as reported here is somewhat difficult, it is clear from the preliminary experiments shown in Scheme 2 that the desired allylic alcohols could be obtained by using a simple procedure. The compatibility of diverse protecting groups under the reaction conditions used for the present transformation is also an advantage of this technology.

In summary, a new one-pot method for the synthesis of allylic alcohols from the corresponding tosylates of 2,3-epoxy alcohols has been developed.

Experimental

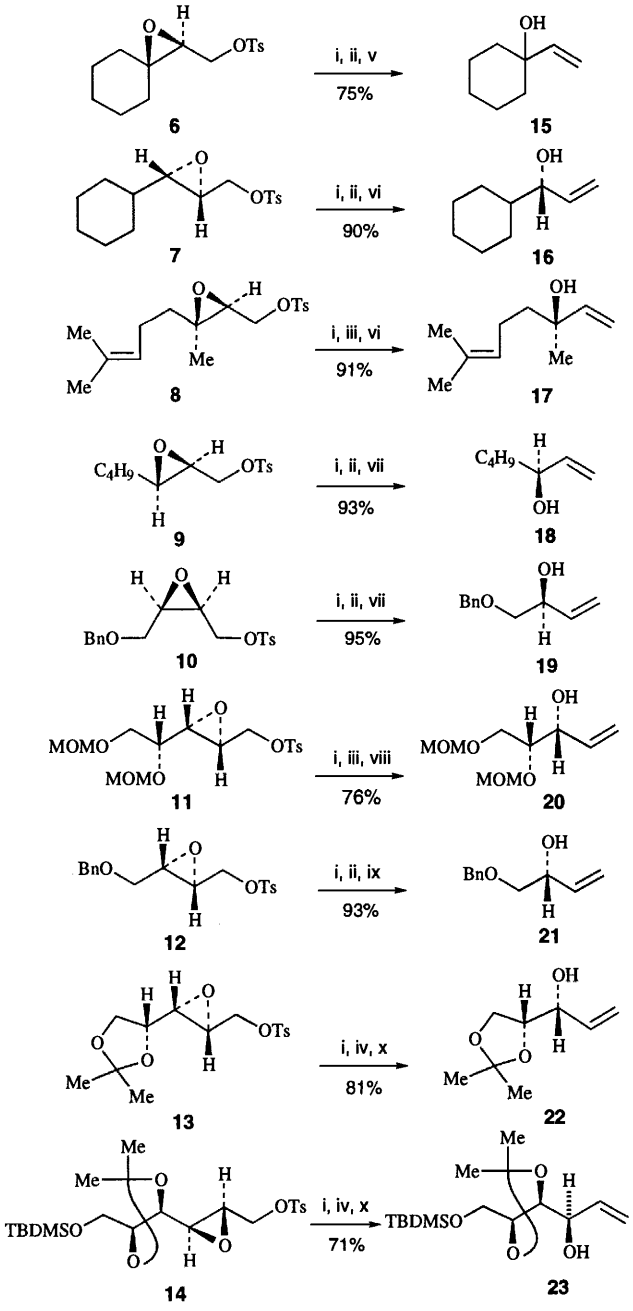
The following are sample procedures by the use of triphenylphosphine or 4-(dimethylamino)phenyldiphenylphosphine (4-DMAPDP).

(2*S*)-1-Benzyloxybut-3-en-2-ol 19

A mixture of the toxylate **10** (348 mg, 1 mmol), KI (498 mg, 3 mmol), acetone (6 cm^3) and DMF (1 cm^3) was heated under reflux for 1 h. It was then cooled to 0 °C, and triphenylphosphine (262 mg, 1 mmol) and iodine (25 mg, 0.1 mmol) were added sequentially with stirring, and the whole was stirred at 0 °C for 1 h. The mixture was extracted with Et_2O, and the extract was washed successively with 5% $Na_2S_2O_3$ and brine, and dried over $MgSO_4$. The usual work-up followed by flash chromatography over silica gel with hexane–EtOAc (4:1) gave 169 mg (95% yield) of the title compound **19** as a colourless oil; Kugelrohr distillation, 140 °C/2 mmHg (Found: C, 74.1; H, 7.9. $C_{11}H_{14}O_2$ requires C, 74.3; H, 8.2%); $[\alpha]_D^{20}$ −4.0 (*c* 1.37 in $CHCl_3$); δ_H(270 MHz; $CDCl_3$) 2.49 (1 H, d, *J* 3.6‡), 3.38 (1 H, dd, *J* 9.6 and 7.9), 3.55 (1 H, dd, *J* 9.6 and 3.5), 4.35 (1 H, m),

† The term scalemic refers to unequal mixtures of enantiomers (C. H. Heathcock, B. L. Finkelstein, E. T. Jarvi, P. A. Radel and C. R. Hadley, *J. Org. Chem.*, 1988, **53**, 1922).

‡ *J* Values in Hz.



Scheme 2 *Abbreviations:* Ts = toluene-*p*-sulfonyl; Bn = benzyl; MOM = methoxymethyl; TBDMS = *tert*-butyldimethylsilyl. *Reagents and conditions:* i, KI (3 equiv.), acetone–DMF (6:1 ~ 3:1), reflux, 1 ~ 2 h; ii, PPh_3 (1 equiv.); iii, PPh_3 (1.5 equiv.); iv, 4-(dimethylamino)phenyldiphenylphosphine (1.5 equiv.); v, I_2 (1 mol%), 0 °C, 20 min; vi, I_2 (5 mol%), 0 °C ~ room temp., 1 h; vii, I_2 (10 mol%), 0 °C, 1 h; viii, I_2 (20 mol%), 0 °C, 45 min; ix, I_2 (50 mol%), 0 °C, 1 h; x, I_2 (100 mol%), 0 °C, 1 h.

4.58 (2 H, s), 5.20 (1 H, ddd, *J* 10.5, 1.5 and 1.5), 5.36 (1 H, ddd, *J* 17.5, 1.5 and 1.5), 5.84 (1 H, ddd, *J* 17.5, 10.5 and 5.6) and 7.25–7.40 (5 H, m).

(2*S*,3*S*,4*R*)-1-*tert*-Butyldimethylsiloxy-2,3-*O*-isopropylidene-hex-5-en-2,3,4-triol 23

A mixture of the tosylate **14** (160 mg, 0.34 mmol), KI (169 mg, 1.02 mmol), acetone (2 cm^3) and DMF (0.5 cm^3) was heated under reflux for 1 h. It was then cooled to 0 °C, and 4-DMAPDP (155 mg, 0.51 mmol) and iodine (86 mg, 0.34 mmol) were added sequentially with stirring, and the whole was stirred for 1 h at 0 °C. To this solution were added 5% $NaHCO_3$ (5 cm^3) and 5% $Na_2S_2O_3$ (2 cm^3), and the mixture was stirred for 10 min. The mixture was extracted with Et_2O–EtOAc (4:1), and the extract was washed with brine and dried over $MgSO_4$. The usual work-up followed by flash chromatography over silica gel with hexane–EtOAc (5:1) gave 73 mg (71% yield) of the title compound **23** as a colourless oil; Kugelrohr distillation, 125 °C/1 mmHg [Found (FAB): $(M + H)^+$, 303.1997. $C_{15}H_{31}O_4Si$ requires M + H, 303.1991]; $[\alpha]_D^{15}$ +25.3 (*c* 0.734 in $CHCl_3$); δ_H(270 MHz; $CDCl_3$) 0.08 (6 H, s, $SiMe_2$), 0.90 (9 H, s, Me × 3), 1.40 (3 H, s), 1.42 (3 H, s), 2.68 (1 H, d, *J* 8.0), 3.65–3.71 (1 H, m), 3.79–3.83 (1 H, m), 3.97 (2 H, m), 4.22 (1 H, m), 5.23–5.43 (2 H, m), 5.94 (1 H, ddd, *J* 17.5, 10.6 and 5.6); *m/z* FAB–LRMS 303 (MH^+), 287, 245, 228, 187, 175, 159, 131, 117, 89 and 73 (base peak).

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