Titanocene Induced Regioselective Deoxygenation of 2,3-Epoxy Alcohols: a New Reaction for the Synthesis of Allylic Alcohols

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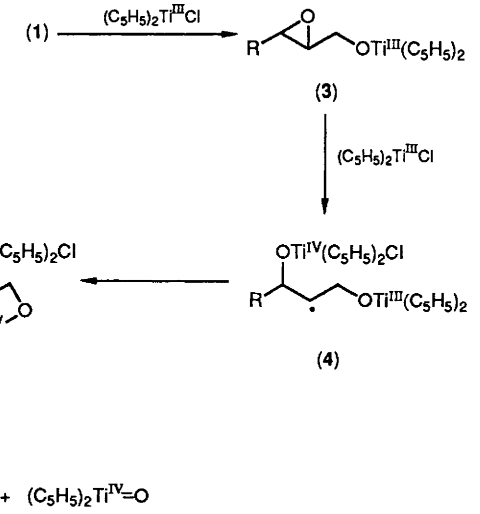
A new titanium(III) mediated [$(C_5H_5)_2TiCl$] reduction of 2,3-epoxy alcohols to alk-1-en-3-ols is described.

Transition metal mediated reactions provide new dimensions for selectivity in organic synthesis. On examining the titanium(III) induced homolysis[1,2] of the C–O bond of 2,3-epoxy alcohol (**1**) with the possibility of enhancing its utility, we observed remarkable regioselectivity; deoxygenation of (**1**) occurred exclusively from the least substituted carbon end to produce terminal alkenic alcohol (**2**) [equation (1)] in high yield.

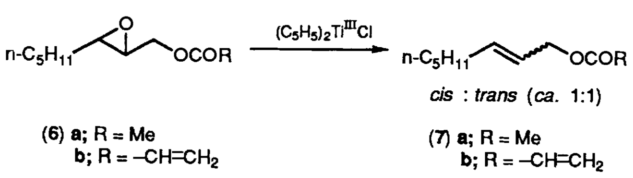

(1)

(**1**) (**2**)

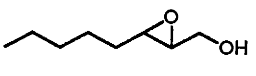
The high regioselectivity observed may be due to the participation of the hydroxy group in the transition state. Accordingly, a workable mechanism has been postulated for the deoxygenation of 2,3-epoxy alcohols with $(C_5H_5)_2TiCl$, which is depicted in Scheme 1. The initial step is the formation of Ti^{III}-alkoxide (**3**) and HCl which consumes a stoicheiometric amount of $(C_5H_5)_2TiCl$. Compound (**3**) reacts in the usual way[3,4] with $(C_5H_5)_2TiCl$ to produce the radical (**4**) which subsequently participates intramolecularly with the unfilled d-orbital of Ti^{III} to form (**5**), an intermediate proposed by Green *et al.*[5] for the deoxygenation of epoxide to alkene (Scheme 1). When the epoxy acetates (**6a**) or acrylates (**6b**) were subjected to the same reaction, the usual deoxygenation of the epoxide occurred[4,6] to produce the expected 1 : 1 *cis* : *trans* mixture of allylic acetate (**7a**) or acrylate (**7b**) respectively thus supporting the above hypothesis (Scheme 2).



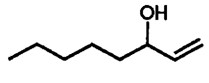
Scheme 1



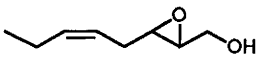
Scheme 2



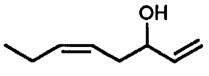
(1a)



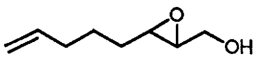
(2a)



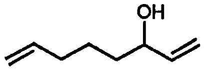
(1b)



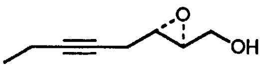
(2b)



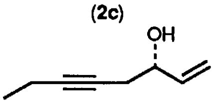
(1c)



(2c)

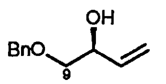


(1d)

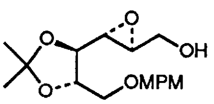


(2d)

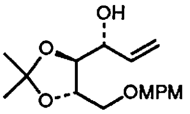
(1e)



(2e)



(1f)



(2f)

Bn = $PhCH_2$
MPM = p-$MeOC_6H_4CH_2$

To establish generality and functional group compatibility in this reaction, several epoxides (**1a—f**) were prepared and subjected to the deoxygenation reaction using $(C_5H_5)_2TiCl$. The results are listed in Table 1 which clearly shows the generality, versatility, mildness, regioselectivity, and efficacy of the process. Entries 4—6 in Table 1 illustrate that chirality of the epoxides (**1d—f**) at C-3 is totally conserved in the allylic alcohols (**2d—f**) which have been analysed.[7]

It is easy to make optically active 2,3-epoxy alcohols employing Sharpless asymmetric epoxidation,[8] therefore, our protocol demonstrates a convenient single step synthesis of optically active secondary allyl alcohols which are versatile chiral building blocks.[10,11]

Typically 2,3-epoxy alcohol (**1a**, 0.7 mmol) in tetrahydrofuran (THF) (1 ml) was added to a green solution of $(C_5H_5)_2$-TiCl (2.1 mg atom) in THF (10 ml), prepared[1,12] *in situ* from $(C_5H_5)_2TiCl_2$ and granulated zinc containing $ZnCl_2$ (1 equiv.) under N_2 at room temperature.† After 2—5 min the reaction mixture was diluted with 10% aq. H_2SO_4 (10 ml) and the product was extracted with ether. The allyl alcohol (**2a**) was isolated in 82% yield by passing through a silica gel column.

Table 1. Preparation of alk-1-en-3-ols (**2**).

Entry	Epoxy alcohols (**1**)	Alk-1-en-3-ols (**2**)	Yield[a] /%
1	(**1a**)	(**2a**)	82
2	(**1b**)	(**2b**)	85
3	(**1c**)	(**2c**)	85
4	(**1d**)	(**2d**)	80
5	(**1e**)	(**2e**)	91
6	(**1f**)	(**2f**)	88

[a] Isolated yield.

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† This reaction could also be performed using $(C_5H_5)_2TiCl_2$ (1.2 equiv.), excess Zn (5 equiv.), and $ZnCl_2$ (1.2 equiv.) over a little longer time (30 min). This may be due to 1 equiv. of $(C_5H_5)_2TiCl$ being utilised for the formation of Ti-alkoxide (**3**, Scheme 1) with the hydroxy group, while the rest of the reaction proceeds using a catalytic amount of Ti^{III}, which is replenished by the reduction of Ti^{IV} (formed during the reaction) with zinc.

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