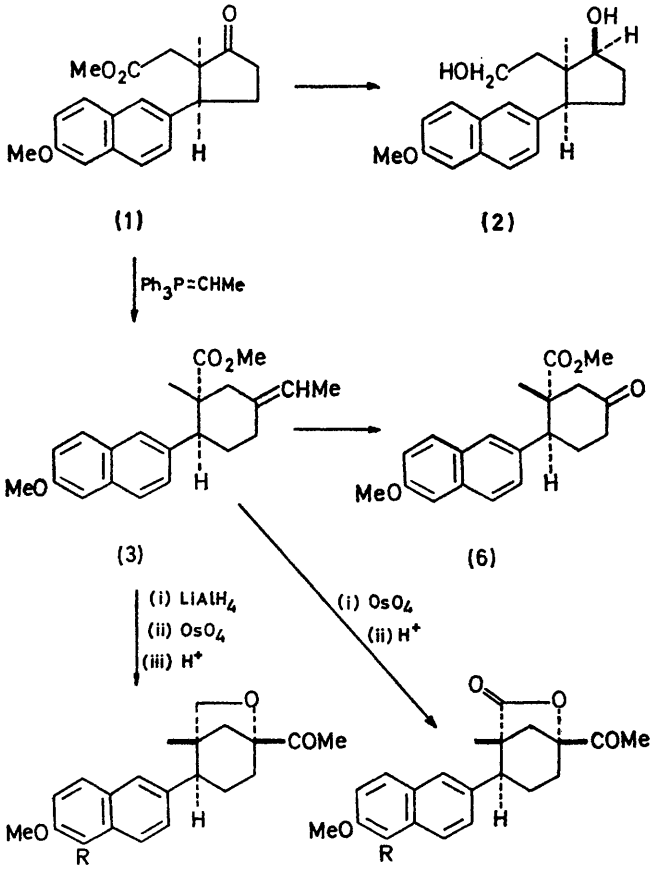
A Wittig Reaction Involving a Novel Rearrangement: Confirmation by X-Ray Crystallography

By E. G. BRAIN, F. CASSIDY, and A. W. LAKE*
(*Beecham Research Laboratories, Medicinal Research Centre, Harlow, Essex*)
and P. J. Cox and G. A. SIM*
(*Chemistry Department, University of Glasgow, Glasgow* G12 8QQ)

Summary Reaction of the cyclopentanone (**1**) with the Wittig reagent ethylidenetriphenylphosphorane gives as product not the expected ethylidenecyclopentane but the ethylidenecyclohexane (**3**); structures of the alcohol (**2**), the lactone (**4a**), and the ether (**5a**) were established by *X*-ray diffraction methods.

DURING recent studies in the synthesis of secosteroids we



prepared compounds (**1**) and (**2**) and some related cyclopentanes, as (±)-mixtures.[1] The relative stereochemistries of these compounds were confirmed by a three-dimensional *X*-ray analysis of (**2**) (see Figure 1). Further work in this series has revealed a novel rearrangement during the Wittig reaction of (**1**) with a five-fold excess of ethylidenetriphenylphosphorane generated by the action of sodium methylsulphinylmethide ($MeSOCH_2^-$ Na^+) on ethyltriphenylphosphonium bromide. The product is the cyclohexane derivative (**3**) and not the expected ethylidenecyclopentane. The analogous reaction between androst-17-ones and the ethylidene Wittig reagent, on the other hand, is known to yield the expected pregn-17(20)-enes.[2] The mechanism of the rearrangement is by no means clear; several possibilities have been considered but none has much in the way of precedent.

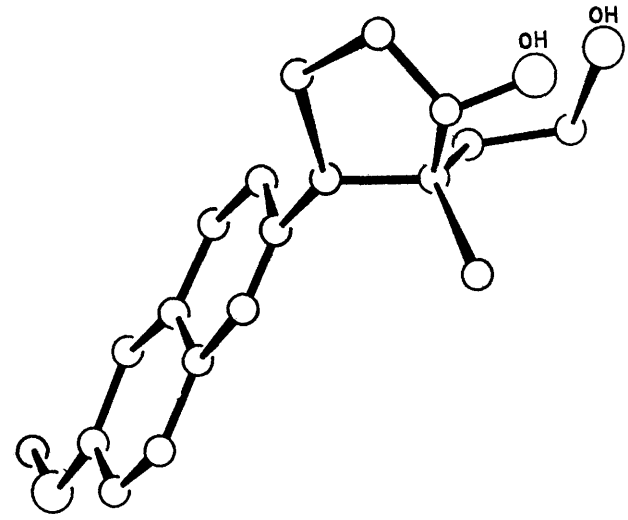


FIGURE 1. *Molecular structure of the alcohol* (**2**).

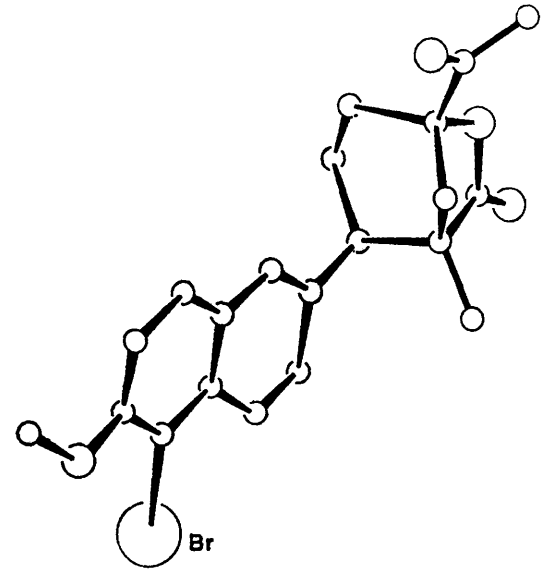


FIGURE 2. *Molecular structure of the lactone* (**4a**).

Oxidation of (**3**) with osmium tetroxide–triethylamine oxide peroxide followed by acid work-up gave the lactone (**4**). Reduction of (**3**) with lithium aluminium hydride, followed by oxidation with osmium tetroxide–triethylamine oxide peroxide and acid cyclization gave the ether (**5**). (**4**) and (**5**) were treated with bromine at −20° in the presence of anhydrous sodium carbonate and magnesium sulphate in dry chloroform as solvent to give the monobromo-derivatives (**4a**) and (**5a**), the structures and relative stereochemistries of which were fully characterized by three-dimensional *X*-ray analyses (see Figures 2 and 3). Treatment of the Wittig product (**3**) with osmium tetroxide and sodium chlorate followed by cleavage of the resultant vic-glycol with sodium metaperiodate did not give the cyclopentanone (**1**) but, instead, a compound having spectroscopic properties consistent with structure (**6**) (*e.g.* ν_{CO} 1715 cm^{-1}, absence of CH_3CO_2Me signal in n.m.r. spectrum).

The alcohol (**2**) crystallizes in the monoclinic space group $P2_1/c$ with $Z = 2$ and cell dimensions $a = 17{\cdot}010(10)$, $b = 7{\cdot}264(5)$, $c = 13{\cdot}368(7)$ Å, $\beta = 93{\cdot}52(4)°$. The lactone (**4a**) crystallizes in the triclinic space group $P\bar{1}$ with $Z = 2$ and cell dimensions $a = 12{\cdot}056(5)$, $b = 13{\cdot}026(5)$, $c = 7{\cdot}593(3)$ Å, $\alpha = 90{\cdot}38(3)$, $\beta = 106{\cdot}07(3)$, $\gamma = 124{\cdot}42(3)°$. The ether (**5a**) crystallizes in the triclinic space group $P\bar{1}$ with $Z = 2$ and cell dimensions $a = 12{\cdot}076(6)$, $b = 13{\cdot}090(5)$, $c = 7{\cdot}490(3)$ Å, $\alpha = 92{\cdot}65(5)$, $\beta = 104{\cdot}90(5)$, $\gamma = 124{\cdot}55(5)°$. *X*-Ray intensity data for all three compounds were measured with Mo-K_α radiation on a computer-controlled four-circle diffractometer. The crystal structure of (**2**) was solved by direct methods, and the crystal structures of (**4a**) and (**5a**) were solved by the heavy-atom procedure. The atomic co-ordinates were refined by least-squares calculations, and current values of *R* are 0·077 over 2006 reflections for (**2**), 0·055 over 2928 reflections for (**4a**), and 0·091 over 2330 reflections for (**5a**).

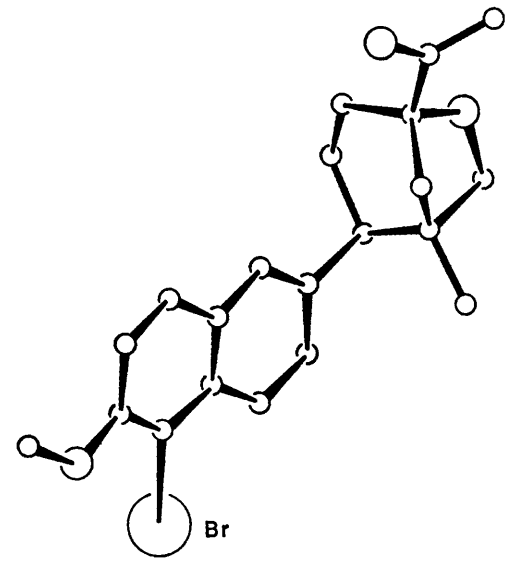


FIGURE 3. *Molecular structure of the ether* (**5a**).

We thank the S.R.C. for an equipment grant.

(*Received, 17th January* 1972; *Com.* 064.)

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[2] A. M. Krubiner and E. P. Oliveto, *J. Org. Chem.*, 1960, **31**, 24; G. Drefahl, K. Ponsold, and H. Schick, *Chem. Ber.*, 1965, **98**, 604.