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SYNTHESIS AND ABSOLUTE CONFIGURATION OF TRICYCLO(4,4,0,$0^{3,8}$)DEC-4-ENE (TWISTENE)

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Our interest in compounds containing strained multiple bonds directed our attention to the simplest unsaturated derivative of the hydrocarbon twistane, i.e. tricyclo(4,4,0,$0^{3,8}$)dec-4-ene (twistene) (I). This olefin possesses a rigid structure and the angle of torsion about the double bond can be estimated from Dreiding models to be about 20°.

Syntheses of 4-substituted derivatives of twistane have been reported (1,2); however, since the twistane skeleton is known to be prone to rearrangement (3), we wanted to devise a simple procedure which would not require H-X elimination for the introduction of the double bond. A five-step synthesis fulfilling this desideratum is outlined in Scheme 1.

The starting ester III was obtained, together with a lesser amount of the position isomer IV, by condensation of methyl 4,5-dihydrobenzoate* with methyl acrylate; the di-esters were assigned endo configuration from the known steric course of the Diels-Alder reaction. The mixture was not separated but subjected to catalytic hydrogenation which proceeded with a high degree of stereospecificity, the product consisting of the saturated di-esters Va and VI in a 7 to 3 ratio, together with only 15% of other isomers. The pure di-ester Va, m.p. 40 - 41°C, could be obtained from the product by crystallisation from pentane (-20°C) in 40% yield. Assignment of the structure Va and VI, respectively, to the two esters was effected on the basis of the fact that the acid Vb could be resolved via the brucine salt; the resolved acid had m.p. 198 - 199°C, $[\alpha]_D^{25}$ -125° (c 0.500) (5).

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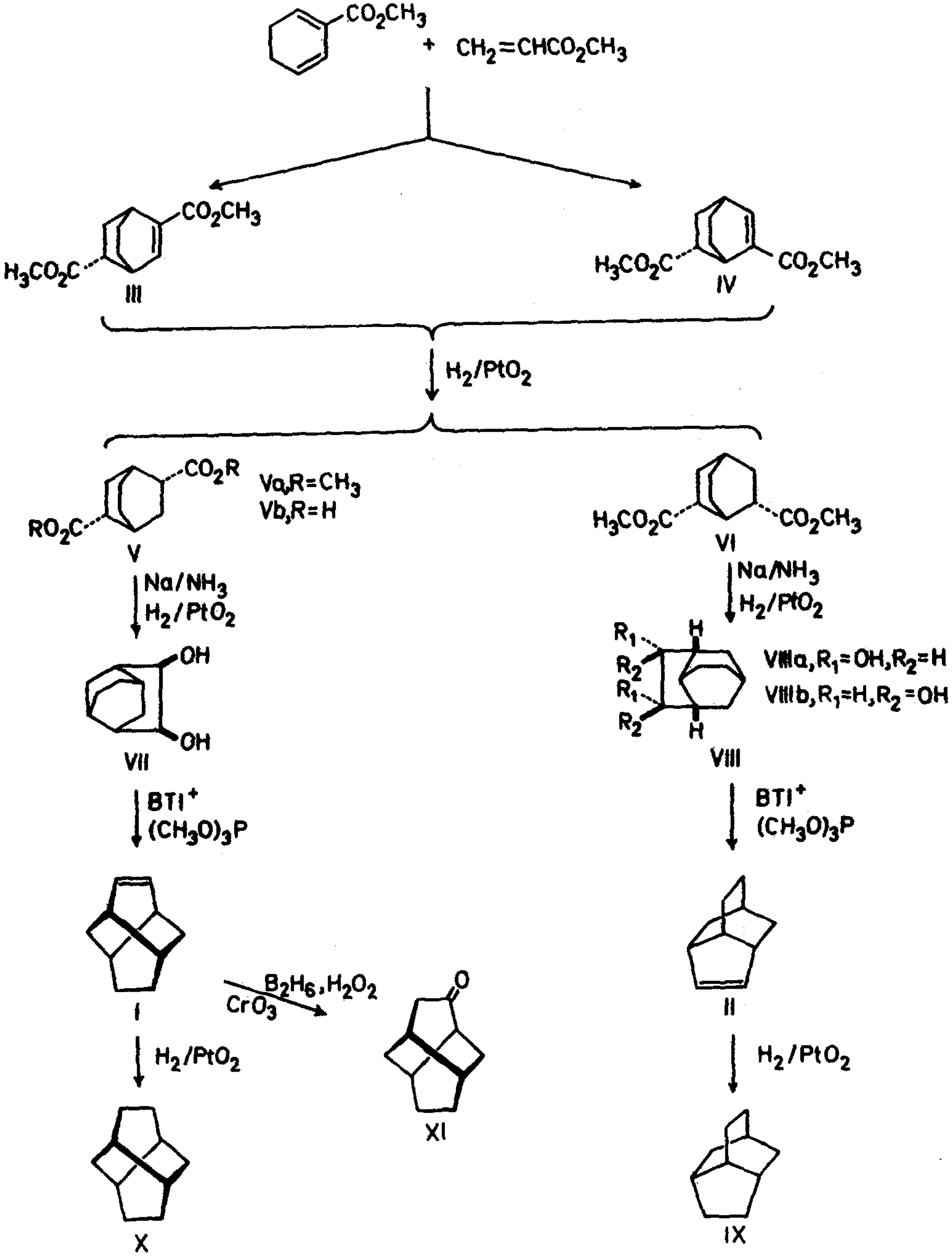
*Prepared by esterification of 4,5-dihydrobenzoic acid (4) with diazomethane.



+bis(thiocarbonyl)imidazole

Scheme 1

Acyloin condensation, either of the pure diester Va, or of the mixture of Va and VI, with sodium in liquid ammonia (6), followed directly by hydrogenation on Adams' catalyst, furnished, respectively, the diol VII, m.p. 174°C in 49% yield, or a mixture separable on silica gel into two diols, one m.p. 174°C, identical with VII, and another, m.p. 102 - 103°C, presumably VIII. Both the diols react smoothly with periodic acid and their IR spectra in dilute solution show strong intramolecular hydrogen bonding ($\Delta\nu_{OH}$ 81 and 92 cm^{-1}, respectively). This shows that the hydroxyl groups in both the diols are cis to each other and leads to an unequivocal assignment of configuration in the diol VII, and two alternative structures, VIIIa or VIIIb, for the diol m.p. 102 - 103°C, the former being the more probable one. The diol VII is the first 4,5-difunctionally substituted twistane derivative to be synthesised.

The diols VII and VIII were transformed in 80% yield to their cyclic thiocarbonyl derivatives, m.p. 228 - 229°C and m.p. 160 - 161°C, respectively, which after heating in trimethylphosphite (7) afforded the olefins I and II (m.p. 128.5 - 129°C and 95 - 96°C, respectively) in 50% yield. Analytical, nmr and mass spectroscopic data are in agreement with the proposed structures. Hydrogenation of the olefin I (m.p. 128.5 - 129°C) gave a compound m.p. 163 - - 165°C, identical in all respects with twistane (X), prepared by another route (1), thus confirming that the compounds I, III, V, VII belong to the twistane series. Hydrogenation of the olefin II (m.p. 95 - 96°C) afforded a hydrocarbon of m.p. 92°C which must be tricyclo(4,3,1,$0^{3,7}$)decane (IX).

Having in hand the resolved acid (-)Vb, we were in a position to prepare the compounds VII, I, X and XI in optically active form, as required for projected mechanistic studies.

The synthetic route shown in the Scheme, applied to the optically active di-ester (-)Va, m.p. 35.5 - 36.5°C, $[\alpha]_D^{25}$ -89.5° (c 0.500), gave (+)twistene, m.p. 119 - 120°C, $[\alpha]_D^{25}$ +417° (c 0.438, EtOH), via the diol (+)VII, m.p. 173 - - 173.5°C, $[\alpha]_D^{25}$ +336° (c 0.503). (+)-Twistene, on hydroboration and subsequent oxidation, gave (+)-4-twistanone, m.p. 172 - 174°C, which exhibits a positive Cotton effect (8) (Fig. 1). Application of the Octant Rule (9) and the empirical rule of Klyne and Djerassi for twist boat cyclohexanones (10) suggests that this compound and, perforce, also the other derivatives with a twistane skeleton prepared in this study, have right-handed helicity, i.e. the P configuration (11), as depicted in the Scheme (12).

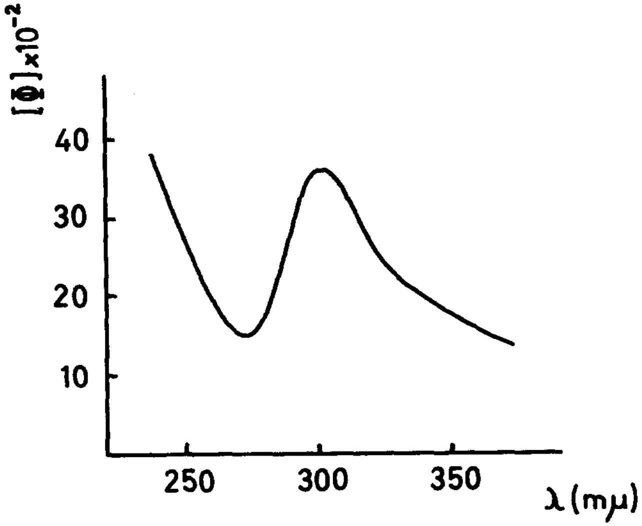


Fig. 1. The ORD curve of (+)-twistan-4-one

(+)-Twistene on catalytic reduction afforded (+)-twistane, m.p. 161 - 163.5°C, $[\alpha]_D^{25}$ +434° (c 0.482, EtOH). The synthesis of this compound, by another route, has recently been reported by Adachi and coworkers (13). Their product had m.p. 162 - 163°C, $[\alpha]_D^{22}$ +414° (c 0.489, EtOH) and is evidently identical with our compound; the Japanese workers also ascribed it the P configuration, on the basis of the ORD behaviour of the intermediate bicyclo(2,2,2)octan-2-one-6-carboxylic acid and of twistan-2-one.

Results of studies of reactions of twistene will be reported subsequently.

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(12) This assignment also establishes the absolute configuration of (-)-endo-2,5-bicyclo(2,2,2)octane dicarboxylic acid (-)Vb as 2(S),5(S).

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