414. *Two* trans-*Hexahydroindanones and their Rotatory Dispersion Curves.*

By MISS P. M. BOURN and W. KLYNE.

(+)-*trans*-Hexahydroindan-5-one has been made by methods previously used for the preparation of the racemic compound; its configuration has been allotted from its rotatory dispersion curve.

The rotatory dispersion curve of (—)-*trans*-hexahydroindan-2-one has also been measured and the large amplitudes of the curves given by some compounds containing a carbonyl group in a five-membered ring are discussed.

(+)-*trans*-HEXAHYDROINDAN-5-ONE (I; X = H), required for determination of the absolute configuration of gibberellic acid [1] by optical rotatory dispersion studies, has been prepared from (—)-*trans*-cyclopentane-1,2-diacetic acid [2,3] by way of (+)-*trans*-bicyclo-[3,3,0]octan-3-one (II) by the method used for the preparation of the racemic compound.[4,5,6]

In the preparation of *trans*-cyclopentane-1,2-diacetic acid by reduction of ethyl α-cyano-α-2-ethoxycarbonylmethylcyclopentylideneacetate in the presence of palladised charcoal, followed by hydrolysis, the ratio of *trans* to *cis* acid obtained (7 : 3) was greater than that obtained by Nau,[6] but less than that claimed by Bergmann and Ikan.[7]

The identity of sign between the rotatory dispersion curves of the ketones (I; X = H and Me) [8] and the similarity in their amplitudes (for nomenclature see ref. 9) prove that the *trans*-hexahydroindan-5-one prepared has the configuration shown (I; X = H) and not its mirror-image.

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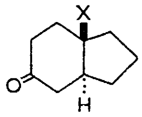
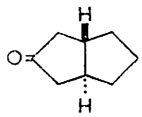
[1] Cross, Grove, McCloskey, Mulholland, and Klyne, *Chem. and Ind.*, 1959, 1345.
[2] Barrett and Linstead, *J.*, 1935, 436.
[3] Barrett and Linstead, *J.*, 1935, 1069.
[4] Granger, Nau, and Nau, *Trav. Soc. Pharm., Montpellier*, 1957, **17**, 177.
[5] Granger, Nau, and Nau, *Bull. Soc. chim. France*, 1958, 531.
[6] Nau, Thesis, Montpellier, 1958.
[7] Bergmann and Ikan, *J. Amer. Chem. Soc.*, 1956, **79**, 1482.
[8] Djerassi, Marshall, and Nakano, *J. Amer. Chem. Soc.*, 1958, **80**, 4853.
[9] Djerassi and Klyne, *Proc. Chem. Soc.*, 1957, 55.

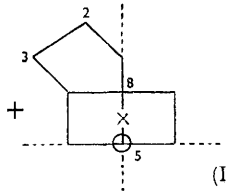
This allotment on the grounds of general similarity of the dispersion curves is supported by the application of the octant rule;[10] compounds (I; X = H and Me) should have almost identical dispersion curves since the angular methyl group falls in a plane of symmetry of the carbonyl group and should thus make no contribution to the Cotton effect [cf. the octant projection (III)].



(I)



(II)



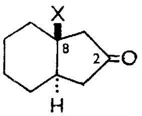
(III)

The rotatory dispersion curve of *trans*-hexahydroindan-2-one [3,11] (IV; X = H) was also measured. In this series also the corresponding 8-methyl compound (IV; X = Me) had been prepared by Djerassi, Riniker, and Riniker[12] from starting materials of known absolute configuration, and had been found to have an unusually large negative Cotton effect curve (amplitude, $10^{-2}a$, −219). The near-identity of the curves for the ketones (IV; X = H, $10^{-2}a$, −222; and X = Me) is almost complete evidence for the identity of their absolute configurations.

Octant projections (cf. V) of the two compounds (IV; X = H and Me) show that the angular methyl group is nearly in one of the planes of symmetry of the carbonyl group, and would therefore not be expected to make any major contribution to the Cotton effect.

It is now necessary to consider the large amplitudes of the Cotton effect curves of these *trans*-hexahydroindan-2-ones (IV) and of their steroid analogues, in contrast to the moderate amplitudes of similar compounds carrying a carbonyl group in a six-membered ring ($10^{-2}a$ generally $\not> \pm 100$). The amplitudes of a wide range of cyclohexanones, decalones, and their extended polycyclic derivatives have been rationalised in terms of the octant rule, and whilst no claim can be made to high precision estimates of the amplitudes due to methyl and methylene groups attached to a cyclohexanone ring in various positions range from 10 to 50 units.

The much larger amplitudes of the hexahydroindan-2-ones must, it is suggested, be ascribed to the asymmetry of the carbonyl-carrying ring itself. This asymmetry is well shown by a comparison of projections (V and VI); in (VI) (cyclohexanone) the ring is symmetrical about the vertical plane (B), and any asymmetry is due to second-order effects of substituents. The contributions of C-3L and C-3R to the Cotton effect cancel out. In the indanone (V) the five-membered ring is not symmetrical and $C_{(8)}$ and $C_{(9)}$ are both in negative octants (the cyclohexane ring adds further small negative contributions).*



(IV)

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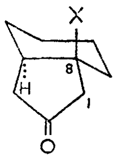

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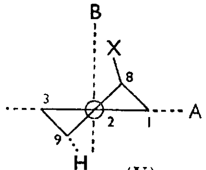
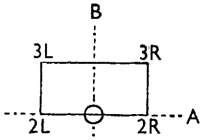


(V)



(VI)

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* One of us (W. K.) presented these ideas in tentative form at colloquia in Zurich and Basle in July, 1959, and this proposal is partly due to discussions with colleagues in Switzerland, notably Professors V. Prelog and W. Kuhn. See also International Colloquium on Stereochemistry, Montpellier, September, 1959; *Bull. Soc. chim. France*, in the press.

[10] Djerassi, *Rec. Chem. Progr.*, 1959, **20**, 101; "Optical Rotatory Dispersion," McGraw-Hill, New York, 1960; Klyne *J. Roy. Inst. Chem.*, 1960, **84**, 50.

[11] Hückel, Sachs, Yantschulewitsch, and Nerdel, *Annalen*, 1935, **518**, 155.

[12] Djerassi, Riniker, and Riniker, *J. Amer. Chem. Soc.*, 1956, **78**, 6362.

EXPERIMENTAL

M. p.s are corrected. Rotations were determined for ethanol solutions, except where stated.

cis- *and* trans-*Cyclopentane*-1,2-*diacetic Acids*.[2,6]—Ethyl α-cyano-α-2-ethoxycarbonylmethylcyclopentylideneacetate (55·3 g.) in ethanol (200 ml.) in the presence of 5% palladised charcoal (1·6 g.) took up hydrogen (4·965 l., 1·01 mol.) during 6·5 hr. Filtration and recovery gave a yellow oil containing ethyl 2-α-cyano-α-ethoxycarbonylmethylcyclopentylacetate which was refluxed with concentrated hydrochloric acid (180 ml.) for 15 hr. and then steam-distilled. The distillat egave crude *cis*-bicyclo[3,3,0]octan-3-one (3·15 g.), and the residue gave a mixture of *cis*- and *trans*-cyclopentane-1,2-diacetic acid. The first crop of acid (17·5 g.), when recrystallised once from water, had m. p. 140—142°. This indicates 65% of the *trans*-acid in the mixture (Barrett and Linstead [2] give pure *cis*-acid, m. p. 173°, and pure *trans*-acid, m. p. 133°). Further crops (9·5 g.) contained up to 80% of the *trans*-acid.

(+)-3-*Cyano*-trans-*bicyclo*[3,3,0]*octan*-3-*ol* (Granger *et al.*[5]).—(+)-*trans*-Bicyclo[3,3,0]octan-3-one [3] (II), b. p. 98°/38 mm., $[\alpha]_{5461}^{25}$ +446° [*c* 0·91 in light petroleum (b. p. 40—60°)] (3·03 g.), in ethanol (20 ml.), to which potassium hydroxide (175 mg.) in water (3 drops) had been added, was treated with redistilled hydrogen cyanide (8 ml.) and stored at 0° for 24 hr. After acidification to pH 3, excess of hydrogen cyanide and the solvent were removed, and the oily residue was extracted with ether. The extract, on recovery, gave (+)-trans-3-*cyanobicyclo*[3,3,0]*octan*-3-*ol* (2·27 g.), b. p. 98°/0·1 mm., $[\alpha]_{5461}^{21}$ +67°, $[\alpha]_D{}^{21}$ +57° (*c* 3·12) (Found: C, 71·9; H, 9·0. $C_9H_{13}ON$ requires C, 71·5; H, 8·7%).

(+)-trans-*Hexahydroindan*-5-*one*.—The above cyanohydrin (2·09 g.) was converted [5] into the acetyl derivative (1·82 g.), $[\alpha]_{5461}^{23}$ −6°, $[\alpha]_D{}^{23}$ −6° (*c* 1·16). This was reduced with lithium aluminium hydride to (+)-3-aminomethyl-*trans*-bicyclo[3,3,0]octan-3-ol (1·52 g.), a yellow oil, b. p. (bath) 110°/0·5 mm., solidifying at room temperature, $[\alpha]_{5461}^{20}$ +20°, $[\alpha]_D{}^{20}$ +20° (*c* 0·94). Treatment of this amino-alcohol (986 mg.) with sodium nitrite [5] gave (+)-trans-*hexahydroindan*-5-*one* (428 mg.), b. p. (bath) 100°/14 mm., $[\alpha]_{5461}^{21}$ +87°, $[\alpha]_D{}^{21}$ +68° (*c* 1·52), $n_D{}^{26}$ 1·4777 (Found: C, 78·1; H, 10·0. $C_9H_{14}O$ requires C, 78·2; H, 10·2%). The *semicarbazone* crystallised from methanol as needles, m. p. 197—199° (decomp.), $[\alpha]_D{}^{25}$ +19° (*c* 0·96 in acetic acid) (Found: N, 21·8. $C_{10}H_{17}ON_3$ requires N, 21·5%). The 2,4-*dinitrophenylhydrazone* crystallised from chloroform–methanol as plates, m. p. 149—151° (Found: C, 56·7; H, 6·0. $C_{15}H_{18}O_4N_4$ requires C, 56·6; H, 5·7%).

Rotatory Dispersion Curves.—Values refer to methanol unless otherwise stated (*c* ∼0·1 for plain curves, or 0·01 for Cotton effect curves). Values are [ϕ], molecular rotation, at 18—22°.

(+)-*trans*-Hexahydroindan-5-one; positive Cotton effect curve. (600 mμ) +80°; (310, peak) +2440°; (265, trough?) −2820°. Amplitude, $10^{-2}a$, +53.

(−)-*trans*-Hexahydroindan-2-one; negative Cotton effect curve in three solvents. Methanol (600 mμ) −220°; (312, trough) −11,150°; (275, peak) +11,100°; (265) +10,200°. Amplitude, $10^{-2}a$, −222. Chloroform (600 mμ) −190°; (315, trough) −11,150°; (275, peak) +11,500°; (270) +11,200°. n-Heptane (600 mμ) −830°; (328, trough) −10,250°; (278, peak) +9750°; (272) +9250°.

(+)-*trans*-Cyclohexane-1,2-diacetic acid; plain positive curve (600 mμ) +120°; (300) +430°; (280) +510°.

(−)-*trans*-Cyclopentane-1,2-diacetic acid; plain negative curve (600 mμ) −90°; (300) −420°; (280) −480°.

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