

## Steric and Electronic Effects in [2,2]Paracyclophane Systems

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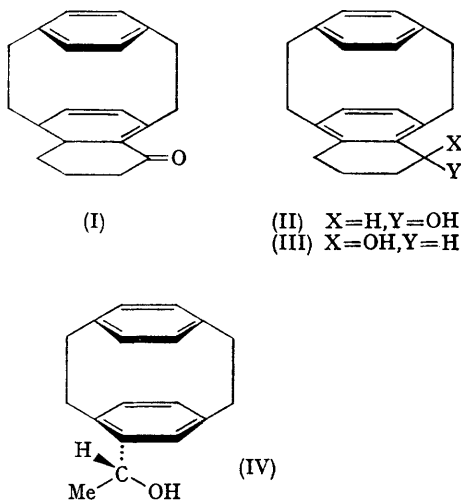
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A RECENT publication by Cram and Harris<sup>1</sup> concerning the stereochemistry of [2,2]paracyclophane as a neighbouring group prompts us to report our independent investigation of the steric and electronic effects in [2,2]paracyclophanyl ketones and alcohols. While Cram and Harris have dealt with acyclic paracyclophane derivatives, we have restricted our research to paracyclophane systems in which the position of

the reaction site is fixed with respect to the paracyclophane moiety so that we can more easily assess the contribution of steric and electronic factors. We report now the novel stereochemistry of reduction of 4,5-tetramethylene-17-oxo-[2,2]-paracyclophane (I)<sup>2</sup> and the spectral properties of the *exo*- and *endo*-alcohols, (II) and (III).

Lithium aluminium hydride reduction of the ketone (I) followed by chromatography of the

products on silica gel gives 80% *exo*-alcohol (II) (m.p. 135—137.5) and 20% *endo*-alcohol (III) (m.p. 113—116).<sup>†</sup> Reduction with ethanolic sodium borohydride gives a mixture of 68% of (II) and 32% of (III). Only with the selective reducing agent, disiamylborane,<sup>3</sup> does hydrogen addition to carbon occur exclusively from the least hindered side of the molecule to produce the *endo*-alcohol (III). These results contrast with



those obtained by Cram and Harris<sup>1</sup> who accounted for the predominant formation of (IV) from the lithium aluminium hydride reduction of 4-acetyl-[2,2]paracyclophane in terms of the predominant hydride attack occurring on carbon from the least hindered side of the molecule. The stereochemistry of the metal hydride reductions of ketone (I) cannot be explained by initial attack of hydride on carbon from the least hindered side of the molecule.<sup>4</sup> It seems reasonable to conclude that the first-formed intermediate is an oxygen-metal hydride complex which then undergoes hydride addition to carbon *via* a transition state which does not place the metal-oxygen complex in the sterically unfavourable environment between the two aromatic rings (interannular region).

The infrared spectra of the isomeric alcohols (II) and (III) show no special effects due to different electronic environments of the hydroxy-group. Dilute solutions (0.003 M) of either alcohol in carbon tetrachloride show only a sharp absorption at 3617—3618  $\text{cm}^{-1}$  in the hydroxyl region; however, the n.m.r. spectra of these alcohols show 0.2 p.p.m. difference in the chemical shifts of the methine protons in (II) and (III) with the methine proton in alcohol (II) at higher field (4.50 p.p.m.). Apparently, the interannular proton in (II) is shielded relative to the extra-annular proton in (III).

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<sup>†</sup> Satisfactory elemental analyses were obtained for each alcohol. The assignment of structures to the *exo*- and *endo*-isomers are based on their chromatographic behaviour. The sterically hindered *endo*-alcohol is eluted first from the column. In all cases the total yield of alcohol was 70—90%.

<sup>1</sup> D. J. Cram and F. L. Harris, jun., *J. Amer. Chem. Soc.*, 1967, **89**, 4642.

<sup>2</sup> D. J. Cram, C. K. Dalton, and G. R. Knox, *J. Amer. Chem. Soc.*, 1963, **85**, 1088.

<sup>3</sup> H. C. Brown, "Hydroboration," W. A. Benjamin, New York, 1962, pp. 255—264.

<sup>4</sup> N. G. Gaylord, "Reduction with Complex Metal Hydrides," Interscience, New York, 1956, pp. 86—89.