Tetrahedron Letters No.4, pp. 341-344, 1971. Pergamon Press. Printed in Great Britain.

SYNTHESES OF [8][8] AND [8][10]PARACYCLOPHANES

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(Received in Japan 24 November 1970; received in UK for publication 24 December 1970)

In this communication, we wish to report the first successful synthesis of [m][n]paracyclophane[1](1), a novel class of paracyclophane with two p-polymethylene bridges spanning a single benzene nucleus.

The synthesis of [8][8]paracyclophane (1a) with two octamethylene bridges was our first project because of the following reasons: 1. constraction of p-octamethylene bridge should be accomplished easily through a relatively few steps thanks to the elegant method developed by Cram[2]. 2. octamethylene so far has been the smallest bridge to link the p-positions of a benzene nucleus to exhibit anomalous physical and chemical properties[2], rendering the preparation of [8][8]paracyclophane (1a) with two such smallest bridges to be attractive. The scheme of synthesis is outlined in Chart I*.

Bromomethylation[3] of 10-methyl[8]paracyclophane(2)[4] with formaldehyde, hydrobromic acid and phosphoric acid afforded the bromomethyl compound (3a), which was further converted into the quaternary ammonium bromide (3b), decomp.p. 198~200°. Nmr spectrum of (3b) which exhibits absorption (10.1τ) due to heavily shielded methylene hydrogens excludes a possibility of side chain migration during the bromomethylation, and this is also supported by the formation of the [2.2]paracyclophanes (6a) and (7a) which also show pertinent nmr spectral data.

An equimolar mixture of the quaternary ammonium bromide (3b) and 5-methylfurfuryltrimethylammonium iodide (5a)[5] was treated with silver hydroxide to furnish a mixture of the Hofmann bases (3c) and (5b), which was pyrolyzed in toluene. Evolution of trimethylamine occured smoothly and the reaction product was extracted with n-hexane to separate from polymeric substances. The n-hexane-soluble portion was fractionated by chromatography over neutral alumina to provide: 1. the doubly octamethylene-bridged [2.2]paracyclophane (6a), m.p.229~231°,(3% yield) (the trans configuration was assigned in analogy with multilayered [2.2]paracyclophane[6].) 2. the desired benzene-furan "hybrid" [2.2]paracyclophane (7a), (8% yield). 3. [2.2]furanophane (8).

This order of elution is in line with the number of exposed aromatic nucleus, necessary for adsorption in these paracyclophanes.

Because of instability of the "hybrid" [2.2]paracyclophane (7a), the

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* New compounds and their derivatives prepared in this work have been characterized satisfactorily by elemental analysis and various spectroscopies.

chromatography was performed in a cold room, and the oily product (7a) was directly hydrolyzed with 10% sulfuric acid in acetic acid without further purification. The 1,3-diketone(9a), m.p. 156~157° was treated with ethanedithiol and boron trifluoride to give the thioketal (10a) which was desulfurized with Raney nickel in refluxing ethyl acetate affording [8][8]paracyclophane (1a), m.p. 60~61°.

Our next attention was directed toward the synthesis of a higher homolog, [8][10]paracyclophane (1b).

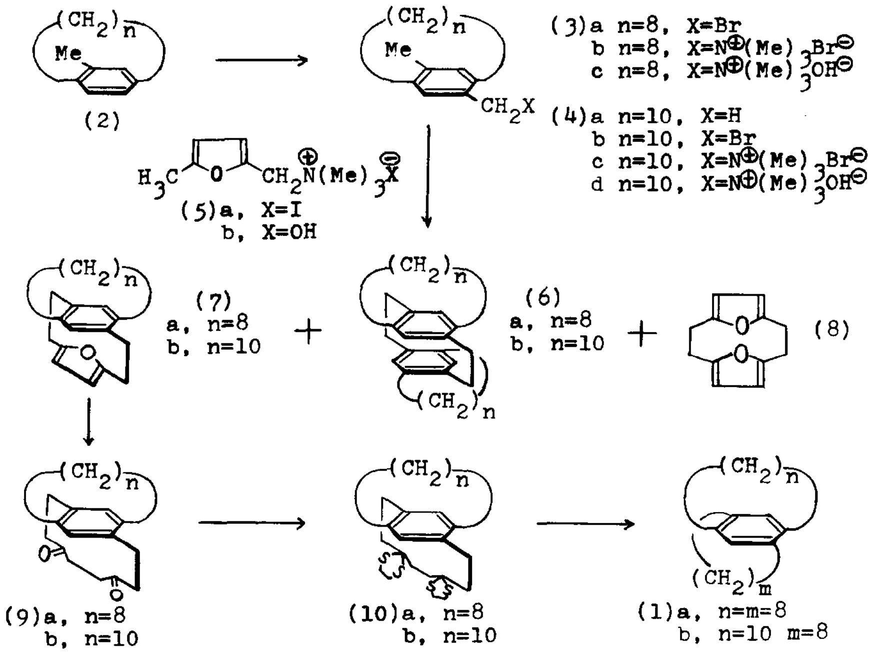
The requisite starting material, 12-bromomethyl-15-methyl[10]paracyclophane (4b) was prepared by the bromination of 12,15-dimethyl[10]paracyclophane (4a)$^{7)}$ in carbon tetrachloride, and the bromide (4b) was futher converted into the quaternary salt (4c), m.p. 224~226°.

"Cross-breeding" pyrolysis of a mixture of the two Hofmann bases (4d) and (5b) gave the doubly decamethylenebridged [2.2]paracyclophane (6b), m.p. 240~241° (12% yield), the benzene-furan hybrid [2.2]paracyclophane (7b), m.p. 74~75° (11% yield) together with [2.2]furanophane (8).

The same sequence of steps described for [8][8]paracyclophane led the hybrid paracyclophane (7b) to [8][10]paracyclophane (1b), b.p. 179~181°/2.0 Torr, n_D^{24}1.5472.

Fig.1 records the ultraviolet absorption spectra data of [8][8] (1a) and [8][10]paracyclophane (1b) with that of 10,13-diethyl[8]paracyclophane as the reference compound.

CHART I



Allinger and co-workers8) calculated the ultraviolet spectrum of [n]paracyclophane for various degree of non-planarity of the aromatic ring, and estimated about 20° out of plane distortion for [8]paracyclophane making this molecule to have a boat-like shape C_{2v} symmetry. Thus two octamethylene bridges in [8][8]paracyclophane (1a) twist the benzene nucleus to have a twist boat symmetry D_2, and the rather conspicuous shift in the ultraviolet spectrum (Fig.1) apparently reflects this serious distortion.

The ultraviolet absorption spectra of the doubly bridged [2.2]paracyclophanes (6a) and (6b) are recorded in Fig.2, and again anomalous behaviors of these compounds suggest the twisted benzene rings which can be seen from the molecular models. These pertinent spectral data are summarized in Table I.

Nmr spectra10) of [8][8] (1a) and [8][10]paracyclophane (1b) are shown in Fig.3 and 4. Although general absorption patterns of (1a) and (1b) appear similar to thats of [8] and [10]paracyclophane , the high-field's bands move toward slightly higher field.

Fig.5 and 6 show nmr spectral data9) for the doubly bridged [2.2]paracyclophanes (6a) and (6b), and the most remarkable feature observed is the presence of the heavily shielded four methylene hydrogens absorbing at 10.55τ10) in the compound (6a).

An interesting feature inherent in these molecules (1a), (1b), (6a) and (6b), is the presence of the benzene nuclei doubly flanked from both sides which explains the incapability of (6a) to form tetracyanoethylene complex.

Another interesting feature for chemical topology is that these molecules are chiral: (1a), (6a), and (6b) have D_2 symmetry, (1b) has C_2 symmetry.

Further works are planned to prepare these compounds in enantiomeric forms and to elucidate their absolute configurations for the study of CD of these interesting substances, especially (1a) with D_2 deformed benzene chromophor.

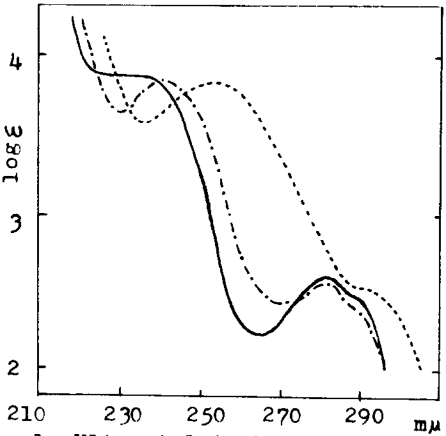


Fig.1. Ultraviolet absorption spectra in iso-octane: - - - - -,(1a); —·—·—,(1b); ———,10,13-diethyl[8]paracyclophane.

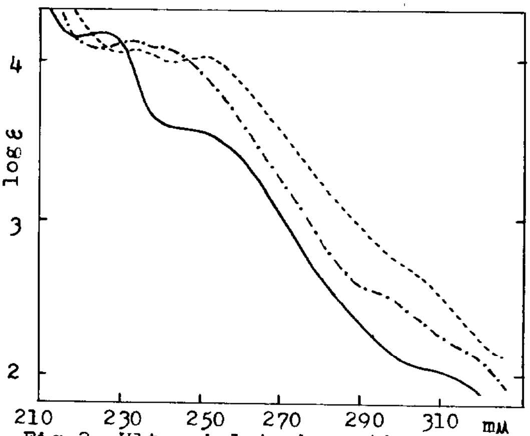


Fig.2. Ultraviolet absorption spectra in iso-octane: - - - - -,(6a); —·—·—,(6b); ———,4,7,12,15-tetraethyl[2.2]paracyclophane.

Table I. Ultraviolet Absorption Data

Compound	λmax, mμ(logε)			
(1a)	255(3.80)		291_{sh}(2.54)	
(1b)	240(3.81)	280(2.51)	289_{sh}(2.41)	
Diethyl[8]paracyclophane	234(3.85)	283(2.56)	288_{sh}(2.53)	
(6a)	236(4.17)	251(4.12)	306_{sh}(2.68)	
(6b)	233(4.23)	241(4.19)	295_{sh}(2.57)	318_{sh}(2.20)
Tetraethyl[2.2]paracyclophane	226(4.26)	250_{sh}(3.57)	308_{sh}(2.10)	

Nuclear Magnetic Resonance Spectra

Fig.3

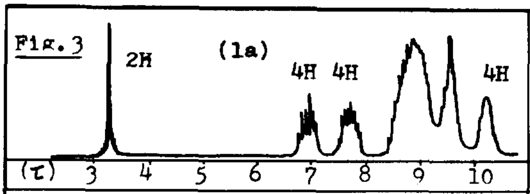


Fig.5

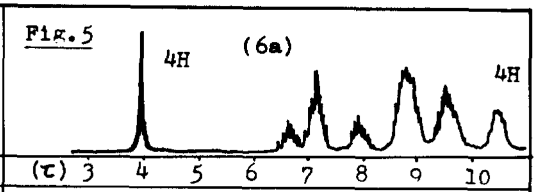


Fig.4

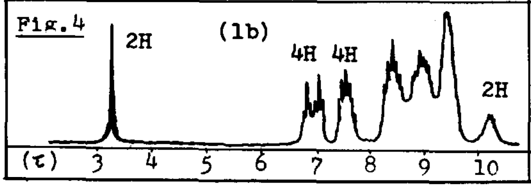
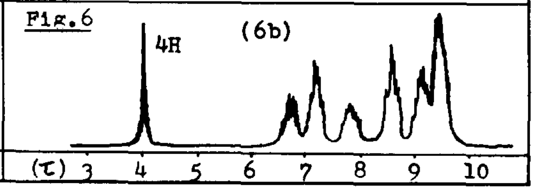


Fig.6



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9) The spectra were taken on a Nucleomagnetic Resonance Spectrometer, JNM-4H-100, Japan Electron Optics Laboratory Co., Ltd.

10) The most highly shielded methylene protones (10.2τ) so far observed in paracyclophanes are thats of 4,4'-dodecamethylenebiphenyl11).

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