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INTRAMOLECULAR CYCLOADDITIONS OF BIS-O-XYLYLENES.
AN EXTREMELY SHORT ROUTE TO [2.2.2]CYCLOPHANES.

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Abstract: Benzocyclobutenes linked by two-carbon bridges undergo flash-
pyrolytic conversion to [2.2.2]cyclophanes.

Tightly packed layered compounds of the [2]n cyclophane type are of con-
siderable current interest as models for transannular interactions between
\( \pi \)-systems, because of their potential to transfer \( \pi \)-electron density between
the various layers ("cyclophane zwitterions"), their model role in the search
for organic superconductors, their unique \( \pi \)-ligand potential in sandwich
complexes, and their strain-related unusual chemical properties.\(^1\) We wish
to report an extremely short route to this class of compounds amenable to
extensive structural variation. Our approach combines recent advances in alkyne
cooligomerization chemistry\(^2\) with gas phase flash pyrolysis techniques.\(^3\) The
latter have also been used recently in a new synthesis of [2.2.2](1,2,4,5)-
cyclophane.\(^4\)

Thus, bisbenzocyclobutene \( \mathbf{1} \) is readily available (55\%) by cobalt catalyzed
cotrimerization of 1,5-hexadiyne.\(^5\) When \( \mathbf{1} \) is heated in benzene (sealed tube,
\( 200^\circ \text{C} \)) a colorless, brittle polymer forms quantitatively. However, vacuum
sublimation (1g) through a quartz-chip filled quartz tube (33 cm, 1.8 cm OD,
\( 10^{-2} \) Torr, \( 750^\circ \text{C} \)) gave \( [2.2.2](1,2,4) \)cyclophane \( \mathbf{2} \) in 75\% yield, in addition to
recovered starting material (5\%). The physical data on \( \mathbf{2} \) are identical with
those reported by Cram\(^6\) in the first synthesis of \( \mathbf{2} \) (7 steps, 15.5\% from
\( [2.2] \)paracyclophane), and Hopf\(^7\) (5 steps, 0.08\% from propargylbromide). Another
preparation employs a low-yield sulfone pyrolysis in the final step (6 steps,
1.5\% from 1,2,4-tricarbomethoxybenzene).\(^8\) The hitherto unreported \(^{13}\)C-NMR


Spectrum of \( \mathcal{Z} \) shows the expected twelve lines: \( \delta \) (ppm from TMS, CDCl\(_3\)) 32.9, 33.2, 36.4 (methylene), 129.2, 133.0, 139.3 (proton bearing aromatics), 139.8, 140.0, 141.2 (quaternary). It is interesting to note that pyrolysis of \( \mathcal{Y} \) selectively gives the achiral \( \mathcal{Z} \), none of the chiral \( \mathcal{Z}^8 \) being observed. This could be due to a relatively unfavorable transition state B presenting a kinetic barrier to \( \mathcal{Z} \), or (more likely) due to the (presumed) greater thermodynamic stability of the relatively unstrained \( \mathcal{Z} \).

The ready availability of \( \mathcal{Z} \) has allowed some preliminary chemical investigation. For example, facile uptake of 4 mole \( \text{H}_2 \) occurs under mild conditions (PtO\(_2\), CH\(_3\)COOH, 22°C) to give 4 \([m/e 242 (M^+, 95%), 214 (53%), 91 (100%)\]; \( ^1\text{H-NMR} \delta (\text{CDCl}_3, 60 \text{ MHz}) 1.0 - 2.24 \text{ (m)} \) and small amounts of 5 \([m/e 244 (M^+, 100%), 216 (88%)\]; \( ^1\text{H-NMR} \delta (\text{CDCl}_3, 60 \text{ MHz}) 1.0 - 2.22 \text{ (m)} \) separated by preparative g.c. (1/4" x 5' SE-30, 5% on Chrom W, 200°C). At higher hydrogen pressure increasing amounts of 5 are generated at the expense of 4 (5 atm \( \text{H}_2 \), 5 days, 4:5 = 1:1), but complete hydrogenation has not been

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\( \mathcal{Z} \) achiral, \( C_s \)

B

3 chiral, \( C_2 \)
possible. Reaction with m-chloroperbenzoic acid rapidly gave a mixture of oxidized products, currently under investigation. The Ames test as applied to 2 revealed the absence of mutagenic activity.

The versatility of the approach may be demonstrated by the synthesis of the new dehydrocyclophane ("cyclophene") 6 from trans-1,2-bis(4-benzocyclobutenyl) ethylene, in turn obtained from 1 by treatment with N-bromosuccinimide. Flash pyrolysis of this compound (770°C, 5 x 10^{-3} Torr) gives 6 [20%; m.p. 120 - 121°C; m/e 232.1245 (M^+, 87%, calcd. for C_{18}H_{16}: 232.1249), 217 (61%), 202 (100%); \textsuperscript{1}H-NMR, δ (CDCl\textsubscript{3}, 60 MHz) 2.42 - 3.13 (8H, m), 6.04 - 6.18 (6H, m), 7.16 (2H, s); \textsuperscript{13}C-NMR δ (ppm from TMS, CDCl\textsubscript{3}) 31.3, 32.2 (methylenics), 127.6 (olefinics), 131.8, 137.8, 139.5 (proton bearing aromatics); λ\textsubscript{max} (95% EtOH) large endabsorption, 240 sh (lgε = 3.16), tailing to 350 nm] in addition to recovered starting material (60%), separated by preparative g.c. It should be noted, that introduction of the additional olefinic unsaturation in going from 2 to 6 does not appear to have a pronounced effect on the physical characteristics of the cyclophane framework.

The generality of this synthetic sequence and its application to the preparation of novel cyclophanes is the subject of current efforts.

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