Tetrahedron Letters No. 22, pp 1939 - 1942.
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0040-4039/79/0522-1939$02.00/0

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

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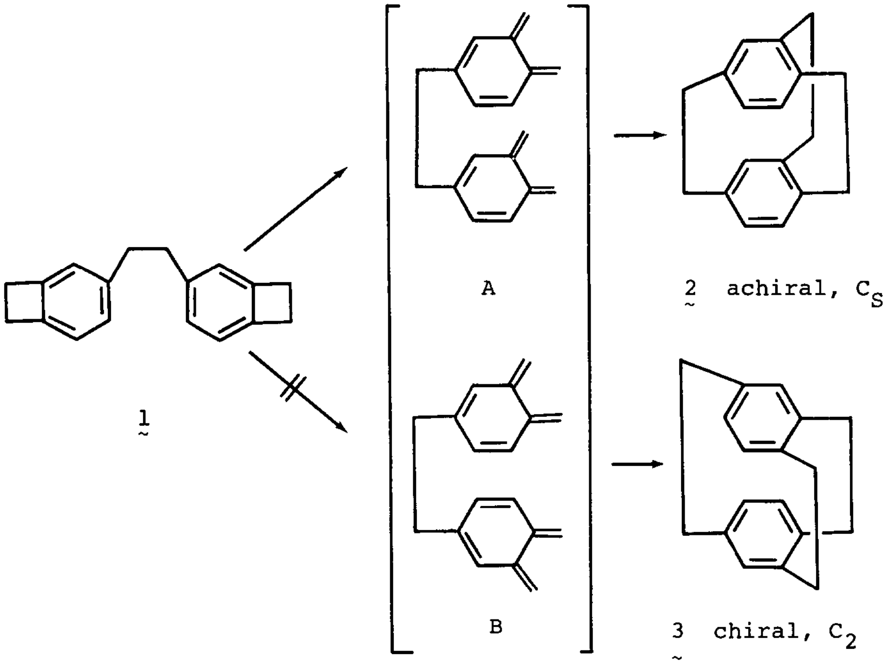
Abstract: Benzocyclobutenes linked by two-carbon bridges undergo flash-pyrolytic conversion to [2.2.2]cyclophanes.

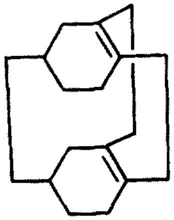
Tightly packed layered compounds of the $[2]^n$cyclophane type are of considerable current interest as models for transannular interactions between π-systems, because of their potential to transfer π-electron density between the various layers ("cyclophane zwitterions"), their model role in the search for organic superconductors, their unique π-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 1 is readily available (55%) by cobalt catalyzed cotrimerization of 1,5-hexadiyne.[5] When 1 is heated in benzene (sealed tube, 200°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°C) gave [2.2.2](1,2,4)cyclophane 2 in 75% yield, in addition to recovered starting material (5%). The physical data on 2 are identical with those reported by Cram[6] in the first synthesis of 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 **2** shows the expected twelve lines: δ (ppm from TMS, $CDCl_3$) 32.9, 33.2, 36.4 (methylenics), 129.2, 133.0, 139.3 (proton bearing aromatics), 139.8, 140.0, 141.2 (quaternary). It is interesting to note that pyrolysis of **1** selectively gives the achiral **2**, none of the chiral **3**[8] being observed. This could be due to a relatively unfavorable transition state B presenting a kinetic barrier to **3**, or (more likely) due to the (presumed) greater thermodynamic stability of the relatively unstrained **2**.

The ready availability of **2** has allowed some preliminary chemical investigation. For example, facile uptake of 4 mole $H_2$ occurs under mild conditions ($PtO_2$, $CH_3COOH$, 22°C) to give **4** [m/e 242 ($M^+$, 95%), 214 (53%), 91 (100%); $^1$H-NMR δ ($CDCl_3$, 60 MHz) 1.0 - 2.24 (m)] and small amounts of **5** [m/e 244 ($M^+$, 100%), 216 (88%); $^1$H-NMR δ ($CDCl_3$, 60 MHz) 1.0 - 2.22 (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 $H_2$, 5 days, **4**:**5** = 1:1), but complete hydrogenation has not been



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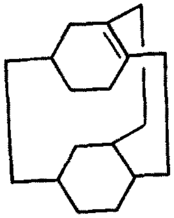

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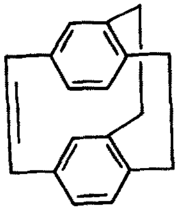

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possible. Reaction with m-chloroperbenzoic acid rapidly gave a mixture of oxidized products, currently under investigation. The Ames test as applied to 2 revealed the absence of mutagenic activity.

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.[5] 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%); $^1$H-NMR, $\delta$ ($CDCl_3$, 60 MHz) 2.42 - 3.13 (8H, m), 6.04 - 6.18 (6H, m), 7.16 (2H, s); $^{13}$C-NMR $\delta$ (ppm from TMS, $CDCl_3$) 31.3, 32.2 (methylenics), 127.6 (olefinics), 131.8, 137.8, 139.5 (proton bearing aromatics); $\lambda_{max}$ (95% EtOH) large endabsorption, 240 sh (lg$\varepsilon$ = 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.[9]

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

Acknowledgments We are grateful for financial support from NSF, NIH (CA-20713), Chevron Research Company, and the Division of Chemical Sciences, Office of Basic Energy Sciences, U.S. Department of Energy under contract No. W-7405 Eng-48. We thank Professor D. J. Cram for valuable experimental and spectral data and Ms. L. M. Donahue for the mutagenicity studies.

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(Received in USA 27 December 1978)