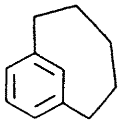
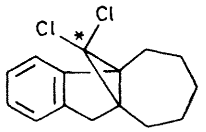
7,8-Benzo-11-chloro[5]metacyclophane

By PETER GRICE and COLIN B. REESE*
(*Department of Chemistry, King's College, Strand, London* WC2R 2LS)

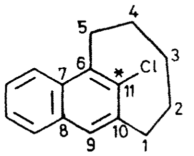
Summary The [5]metacyclophane derivative (**3**) was obtained in 55% isolated yield by treatment of (**2**) with silver perchlorate in the presence of 2,6-lutidine in tetrahydrofuran solution; (**3**) isomerizes to (**6**) in acidic solution and is converted by hydrogen bromide in benzene–acetic acid–water into a mixture consisting mainly of (**6**), (**8a**), and (**8b**).

RECENTLY, [5]metacyclophane (**1**) was obtained[1] as an unexpected by-product, in low yield, following a series of reactions starting with the addition of dibromocarbene to 1,2-dimethylenecycloheptane. We are unaware of any other report in the literature relating to the synthesis of the strained [5]metacyclophane system. We now report that when the tetracyclic compound (**2**)[2] was treated with silver perchlorate in the presence of 2,6-lutidine in tetrahydrofuran solution† at room temperature, 7,8-benzo-11-chloro[5]-metacyclophane (**3**) was obtained Compound (**3**) was isolated as a t l c -homogeneous, colourless crystalline solid [purity (n m r) ≥90%], m p 87 °C, in 55% yield This may therefore be regarded as the first instance in which the synthesis of a [5]metacyclophane derivative has been accomplished by design and in satisfactory yield


(1)



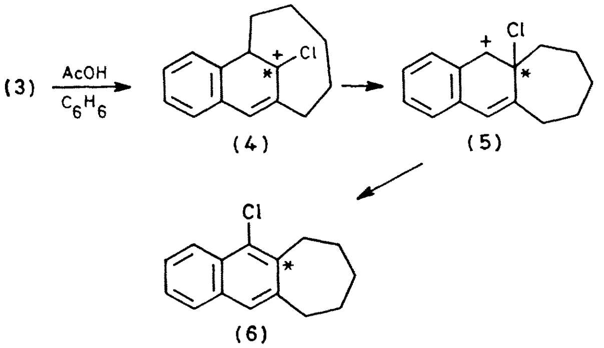
(2)



(3)

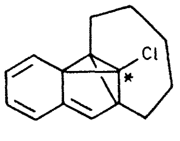
The [5]metacyclophane (**3**) was characterized on the basis of its mass [M^+ at *m/e* 230 0861, $C_{15}H_{15}{}^{35}Cl$ requires 230·0862] and ^{1}H n m r [270 MHz (CD_2Cl_2) includes the following signals δ 2 56 (1H, dt, *J* 12 and 4 Hz), 3 28 (1H, dt, *J* 13 and 4 Hz), 3 72 (1H, ddd, *J* 4, 11, and 12 Hz), and 3 90 (1H, ddd, *J* 4, 12, and 13 Hz)] spectra The chemical shifts and multiplicity of the latter benzylic proton resonances and the high field absorption (to *ca* δ 0 3) in the n m r spectrum of (**3**) are characteristic of metacyclophanes [3,4]

The [5]metacyclophane (**3**) is reasonably stable under neutral and basic conditions and was recovered in 49% yield after it had been treated with an excess of 0 58 M potassium t-butoxide in dimethyl sulphoxide–t-butyl alcohol (2: 1 v/v) solution for 10 min at 20 °C, however, when it was allowed to stand in acetic acid–benzene (10: 1 v/v) solution for 14 h at 20 °C, it was completely consumed and (**6**) was isolated in 58% yield Compound (**6**) had previously been obtained[2] in 61% yield directly from (**2**) by treating it with silver perchlorate in anhydrous benzene solution at room temperature Although it was not clear at the time [2] it now seems very likely that the [5]metacyclophane derivative (**3**) was also an intermediate in the conversion of (**2**) into (**6**) under the latter conditions The perchloric acid released during the reaction would be expected to catalyse the isomerization of (**3**)

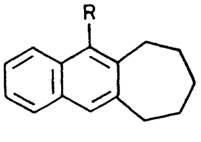


SCHEME

A plausible mechanism for the conversion of (**3**) into (**6**) is indicated in the Scheme intermediate (**4**), which is obtained by protonation of (**3**) on C-6, rearranges to (**5**) and the product (**6**) is then formed as a result of a 1,2-chloride shift followed by the loss of a proton Evidence in favour of this mechanism was obtained by ^{12}C-labelling The tetracyclic compound (**2**) was prepared by a reaction between dichlorocarbene, generated from $^{12}CHCl_3$,‡ and its hydrocarbon precursor,[5] (**2**) was therefore labelled at C-11 (*) and this was apparent from the absence of a signal at δ 77 5 p p m (in $CDCl_3$) in its ^{13}C n m r spectrum Labelled (**2**) was converted first into (**3**), presumably labelled also at C-11 (*) and the latter material was then treated with acetic acid–benzene (10. 1 v/v) to give labelled (**6**) in 22% overall yield [based on (**2**)] The resonance at δ 139 3 p p m (in $CDCl_3$), which may be assigned[2] to C-5a (*), was absent from the ^{13}C n m r spectrum of ^{12}C-labelled (**6**) An alternative mechanism for the conversion of (**3**) into (**6**) involves the benzvalene intermediate (**7**), this mechanism may be ruled out as it would lead to the formation of (**6**) labelled at C-5, the site of attachment of the chloro-substituent



(7)



(8)
a, R = Br
b, R = H

Finally, when a solution of the [5]metacyclophane derivative (**3**) in benzene was treated with hydrogen bromide in acetic acid–water at room temperature,§ the products isolated [*ca* 40% yield by weight, based on (**3**)] were found (g l c) to contain at least six products the most abundant of which were (**6**), (**8a**), and (**8b**) Each of the latter compounds, which were identified on the basis of g l c , t l c , and mass and n m r spectroscopic evidence, accounted for *ca* 30% of the isolated products While the mechanism of the formation of (**8b**) is unclear, it is not unreasonable to suggest that (**8a**) is formed by initial attack of bromide ion on the intermediate (**5**), followed by elimination of hydrogen chloride

One of us (P G) thanks the S R C for the award of a Research Studentship We also thank Dr J Feeney for measuring the 270 MHz n m r spectrum of (3)

(*Received*, 14*th February* 1980, *Com.* **163**.)

---

† 2,6-Lutidine (5 2 mmol) was added to a solution of silver perchlorate (12 0 mmol) in tetrahydrofuran (6 ml) A solution of (**2**) (2 0 mmol) in tetrahydrofuran (3 ml) was then added over a period of 2 min at room temperature to the resulting slurry After a further period of 15 min, the products were worked-up and chromatographed on silica gel

‡ *I e* chloroform free from natural abundance $^{13}CHCl_3$

§ To a stirred solution of (**3**) (*ca* 0 8 mmol) in benzene (0 5 ml) was added 1 M-hydrogen bromide in acetic acid–water (5.1 v/v, 6 ml) After 10 min, the products were partitioned between dichloromethane and aqueous sodium hydrogen carbonate

[1] J W van Straten, W H de Wolf, and F Bickelhaupt, *Tetrahedron Letters*, 1977, 4667
[2] P Grice and C B Reese, *Tetrahedron Letters*, 1979, 2563
[3] W E Parham, D R Johnson, C T Hughes, M K Meilahn, and J K Rinehart, *J Org Chem* , 1970, **35**, 1048
[4] S Hirano, H Hara, T Hiyama, S Fujita, and H Nozaki, *Tetrahedron*, 1975, **31**, 2219
[5] W E Parham and D C Egberg, *J Org Chem* , 1972, **37**, 1545