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SYNTHESIS OF BICYCLOBUTANES: EXCLUSIVE INSERTION OF A CYCLOPROPYLIDENE INTO PRIMARY RATHER THAN TERTIARY CARBON-HYDROGEN BONDS.

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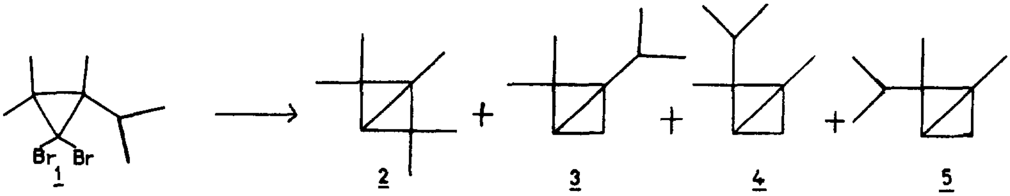
We have been interested in the synthesis of 2,2,4,4-tetramethyl-bicyclobutanes for some time, and it was of interest to see if the method developed independently by Skattebøl[2] and by Moore and his co-workers[3], involving the reaction of methylithuim with gem-dibromocyclopropyl derivatives, could be extended to produce such compounds. The molecule chosen for study was the dibromocyclopropyl derivative 1. This is a tetrasubstituted derivative which, except in exceptional circumstances[4], seems to be required for bicyclobutane formation from mono-cyclic precursors. Using this molecule there is a possibility of either primary or tertiary C-H group insertion reactions for the intermediate cyclopropylidene, thus giving rise to the possibility of four bicyclobutanes 2,3,4 and 5. However, the selectivity shown by cyclopropylidenes [5,6,7] to insertion into C-H bonds follows the order of tertiary > secondary > primary, as would be expected for carbenoid reactions[8], and therefore one might anticipate compound 2 as the predominant product. This paper reports that bicyclobutanes are formed in the reaction but compound 2 has not been detected.

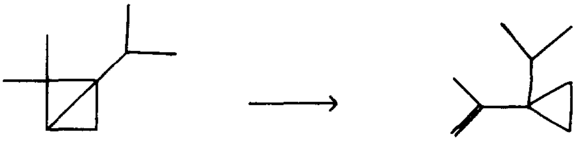
The dibromo compound 1 was prepared by the reaction of bromoform and potassium tert-butoxide in pentane on 2,3,4-trimethyl-pent-2-ene, m.p. 51-53° (35% yield). Compound 1 was treated with methylithium in ether at three temperatures, -40°,10° and 36°, according to the procedure for analogous compounds[2]. The hydrocarbon fraction in each case was obtained in high yield and consisted only of the bicyclobutanes 3,4 and 5, in the approximate[9] relative yields shown in the diagram.



1 2 3 4 5

T°	%			
-40	0	88	9	3
10	0	82	14	4
36	0	79	15	6

The compounds could be separated by preparative g.l.c. (3.6m x 6mm glass, 20%SE 30 1% NaOH on Chromosorb W) and the structures assigned on the following basis. The major component had the shortest retention time and showed the following absorptions in its n.m.r. spectrum[10] which are consistent with structure 3. δ=0.79 (d,7Hz,-CH(C$\underline{H}_3$)$_2$), 0.80 (s,*endo*-2-C$\underline{H}_3$),0.98 (br,C3-$\underline{H}$), 1.05 (s,*exo*-2-C$\underline{H}_3$), 1.15 (s,*endo*-4-$\underline{H}$), 1.45 (m,*exo*-4-$\underline{H}$) 2.13 (br septet, 7Hz, -C$\underline{H}$(CH$_3$)$_2$). The mass spectrum showed a molecular ion at $^m/e$=124 and correct elemental analyses were obtained. Further support for the assigned structure came from the rearrangement of 3, with Mg Br$_2$ in ether at 0°[3], to the cyclopropyl olefin 6, the structure of which was assigned on the basis of the following data. The mass spectrum showed a molecular ion at M/e=124; the n.m.r. spectrum showed absorptions at δ=0.41 (4 cyclopropyl $\underline{H}$), 0.85 (d, 6Hz,-CH(C$\underline{H}_3$)$_2$), 1.75 (br with fine splitting C=C-C$\underline{H}_3$) superimposed on multiplet of -C$\underline{H}$(CH$_3$)$_2$, 4.77 (vinyl $\underline{H}$).



3 6

The compound of intermediate retention time gave the following n.m.r. spectrum[10] which is consistent with the structure 4.δ=0.82(d,8Hz,-CH(C$\underline{H}_3$)$_2$) superimposed on 0.83 (C-3$\underline{H}$) and 0.88 (*endo*-4-$\underline{H}$), 0.90 (s, *exo*-2-C$\underline{H}_3$), 1.30 (br, *exo*-4-$\underline{H}$), 1.50 (s, C1-C$\underline{H}_3$) superimposed on multiplet of $-C\underline{H}(CH_3)_2$. The mass spectrum showed a molecular ion at $^m/e=124$. The compound of longest retention time gave the following n.m.r. spectrum [10] which is consistent with the structure 5. $\delta=0.65$(s,*endo*-2-$C\underline{H}_3$), 0.87(C_3-$\underline{H}$) superimposed on 0.93(d,6Hz-$CH(C\underline{H}_3)_2$), 1.15(br,*endo*-4-$\underline{H}$), 1.35(m,*exo*-4-$\underline{H}$), 1.50(s,C-1-$C\underline{H}_3$) superimposed on multiplet of $-C\underline{H}(CH_3)_2$. The mass spectrum showed a molecular ion at $^m/e=124$. The n.m.r. spectrum of each component showed no evidence for contamination by the pentamethyl bicyclobutane 2.

The preferential insertion into the methyl group geminate to the isopropyl group appears to support the suggestion that opening of the angle between geminate groups forces a C-H bond into a better orientation for reaction with the empty p orbital, the presumed locus of initiation of the carbon-hydrogen insertion reaction[4]. However, this should also affect the isopropyl group. A study by Moore and his co-workers[5] of systems containing ethyl groups indicates that the product ratio is largely influenced by steric crowding developed in a product-like transition state. Insertion into the methine C-H group to form compound 2 would cause severe crowding between the two *endo*-methyl groups. It seems that these severe interactions (absent in 3, 4, and 5) are sufficient to preclude insertion in this direction.

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N.m.r. spectra determined in carbon tetrachloride with T.M.S. as internal standard.

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9. Detector responses not determined.

10. The assignments were made by analogy with previous compounds (see refs. 2 and 3).