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AN UNUSUAL DIVERSION OF THE COURSE OF BIRCH REDUCTION OF POLYCHLORINATED OLEFINS. FORMATION OF CYCLOPROPANES

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Birch reduction and variants thereof constitute a well-established and synthetically useful method for the reduction of halogenated olefins $^{\mathrm{l}}.$  Dehalogenation usually occurs by the simple reductive removal of halogen to leave the basic skeleton unaltered and the double bond intact. In certain cases, namely where a conjugated or homo-conjugated diene is concerned, further reaction of just one of the double bonds also takes place<sup>2</sup>.

We now wish to report some Birch reductions of polychlorinated cyclic monoolefins which occur in an unprecedented manner to produce cyclopropanes.

Treatment of  $exc-2,3,4-trichlorobicyclo[4.2.1]$ non-3-ene (1) with sodium in liquid ammonia gives a single product, endo-tricyclo $\lceil 4.2.1.0^{2.4}\rceil$ nonane (2) in 55% yield after purification by sublimation<sup>3</sup>. No trace of the expected olefin 3 or of the exo isomer  $4$  is found under these conditions<sup>4</sup>.



We also find that the number of chlorines and the dimensions of the cycloalkene moiety control the genesis of the three-membered ring.

Reduction of the dichloro or tetrachloro olefins 5 and 6 proceeds entirely normally to give  $\underline{3}$ . Moreover, it is significant that  $\underline{5}$  and  $\underline{6}$  under the reaction conditions undergo easy elimination of hydrogen chloride to bicyclo $[4.2.1]$ nonadienes, whereas the trichloro derivative remains intact. The dienes undergo reduction to give only 2.

Birch reduction of the bridged trichlorocyclohexenyl compound 7 gives merely bicyclo[3.2.1]oct-2-ene  $(\underline{8})^5$ . However, reduction of the cyclo-octenyl derivative, 2,3,4-trichlorobicyclo[5.2.1]dec-3-ene (9) furnishes both the exoand endo-bicyclo<sup>[5.2.1.0<sup>2,4</sup>] decanes (10 and 11) in yields of 31 and 4%.</sup>

Lastly, for the non-bridged, conformationally free, 1,2,3-trichlorocycloheptene  $(12)$ , l-methylcyclohexene  $(13)$  and bicyclo $[4.1.0]$ heptane  $(14)$  are formed in yields of 14 and  $178^6$ .



In summary, 1,2,3-trichlorocycloalkenes having rings larger than cyclohexene undergo reductive dechlorination to afford bicyclo $[n.1.0]$ alkanes. On the basis of the present evidence it is difficult to unequivocally acccunt for this unexpected divergence of reaction course. Clearly two competing reduction pathways

exist. When elimination is possible, or the ring is too small, then the usual reduction obtains. To explain the usual, and in particular the unusual courses, carbanions or radicals of some kind must be invoked. A carbanion mechanism appears unlikely. Internal nucleophilic displacement by a neighbouring carbanion on a chlorine substituted carbon is geometrically impossible as the ring prevents Walden inversion. Similarly, alkyl radical intermediates can be discounted, although closure of a 1,3 diraaical is feasible. A better intermediate is an alkenyl radical. A sign to this effect is the production of the ring contracted olefin  $(13)$ . Evidently, a cyclopropane derivative, but not  $14$  which is stable under the reaction conditions, must be the precursor to  $13$ . As a working hypothesis we suggest that this precursor is the dichlorocyclopropane 15. Reaction of 15 with an atom of sodium cangenerate the bridgehead cyclopropyl radical <u>16</u> which then opens to the allyl radical <u>17</u> and thence to  $\frac{13}{12}$ . The reverse of this process should explain how the cyclopropanes themselves are formed. Similar action of sodium on 12 would produce the allylic radical 18 which on electrocyclic closure gives the cyclopropyl radical 19 thereby leading to 15.



These remarkable findings indicate that electrocyclic closure of an alkenyl radical with all its stereochemical implications exists as a distinct and intriguing possibility; a possibility which awaits confirmation by a study of the behaviour of radicals related to  $17$  and  $18$ .

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