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THE THERMAL DECARBOXYLATION OF TRANS-2-PHENYLCYCLOPROPYL-1-ACETIC ACID

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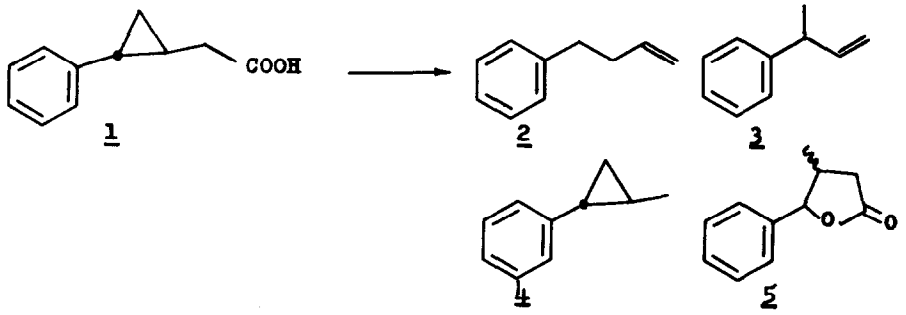
It has recently been demonstrated that cyclopropylacetic acid and some of its derivatives will undergo smooth thermal decarboxylation with attendant opening of the cyclopropane ring (1a-c). We have been investigating other possible cases of this new reaction to assess its value as a synthetic method. Several other compounds have behaved as expected (2) but one compound, trans-2-phenylcyclopropyl-1-acetic acid (3), 1, has given the unexpected results described herein.

When 1 was heated to 320° (bath temperature, N_2, 735 mm) carbon dioxide evolution commenced and became vigorous at 330°. After two hours, 22% of the starting material was recovered unchanged. The neutral material produced contained three hydrocarbons 2 (7%), 3 (14%), 4 (12%) and a γ-lactone 5 (65%).



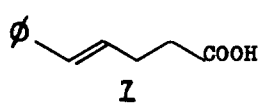
The structures of 2, 3 and 4 were deduced by complete spectral analysis, their physical properties were in agreement with literature values (3,4,5,6) and the structure of 4 was assured by comparison with an authentic sample (6). The structure proof of 5 rests on spectral data (3). Infrared absorbtion at 5.65μ (film) indicated a γ-lactone, ultraviolet absorbtion was indicative of an unconjugated phenyl group and the n.m.r. spectrum of 5 showed a singlet (5H, τ 2.75) for the phenyl protons, a multiplet (1H, 5.15-5.28) for the benzylic proton, a multiplet (3H, 7.30-7.92) for the protons α and β to the carbonyl and a multiplet (3H, 8.88-8.98) for the secondary methyl. The n.m.r. patterns for the benzylic and secondary methyl protons are not simple doublets as would be expected from a first order analysis of the spectrum. Instead each expected doublet is further split because of virtual long range coupling (7). The stereochemistry of 5 is under investigation; apparently only one isomer is formed in the thermolysis.

The formation of olefins 2 and 3 was predictable by either of the two proposed mechanisms (1a-c). A cyclic, 6-membered transition state (1a,b) such as 6a would lead to 2 while 6b would lead to 3. Alternatively, the pathway shown by Bigley and Thurman to be operative in the case of cyclopropyl acetic acid (1c), that is preliminary ring opening to a β, γ unsaturated acid followed by decarboxylation, could also lead to 2 and 3. This latter pathway would produce the six (excluding cis and trans isomers) intermediate acids 7 - 12. Acids 8, 9, 10 and 12 are β, γ unsaturated and would be expected to decarboxylate, 8 giving 2 and 12 giving 3. Acids 9 and 10 should yield a hydrocarbon 13 not found as a product. The remaining acids, 7 and 11 should not decarboxylate but could possibly undergo prototropic shifts leading respectively to 8 and 12 and then via decarboxylation to 2 and 3. Thus Bigley and Thurmans pathway predicts the formation of two acids 7 and 11 and a hydrocarbon 13 none of which were

detected as products of the reaction. The only acid recovered was 1. It would appear in this case that the cyclic 6-membered transition state 6 could be the preferred pathway.

6a R_1 = H R_2 = phenyl

b R_1 = phenyl R_2 = H



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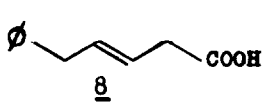

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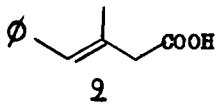

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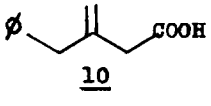

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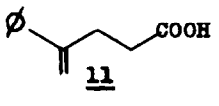

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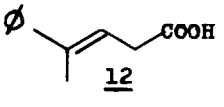

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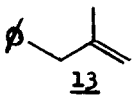

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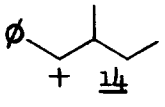

+ 14

The formation of the lactone 7, the major product, was unexpected but may be rationalized in the following way. Acid catalyzed ring opening of cyclopropanes is known (8) to take place in such a manner as to break the bond between the most and least substituted carbon atoms, with protonation on the least substituted carbon atom. Such opening of 1 would produce the carbonium ion 14 which would be expected to yield lactone 5. Acid catalyzed ring opening has been observed as a side reaction in a cyclopropyl acetic acid decarboxylation previously (1b).

The cyclopropane derivative 4 was a completely unexpected product of the reaction! It is not a secondary product since pure samples of 2, 3 and 5 do not produce any 4 when subjected to the reaction conditions. It is pertinent to note that the loss of CO_2 from 1 to form 4 appears to be stereospecific. No cis-4 was detected under conditions where 1% of cis-4 in the presence of trans-4 could be detected. Cis-4 was stable under the reaction conditions and was not converted into trans-4.

A careful search of the literature has revealed no precedent for a decarboxylation such as gives rise to the cyclopropane 4. Appropriate mechanistic studies have been initiated to uncover the pathway of this new reaction.

Acknowledgments

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