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The Abnormal Claisen Rearrangement of Crotyl *p*-Carbethoxyphenyl Ether

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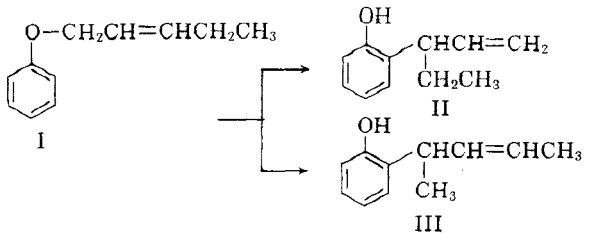
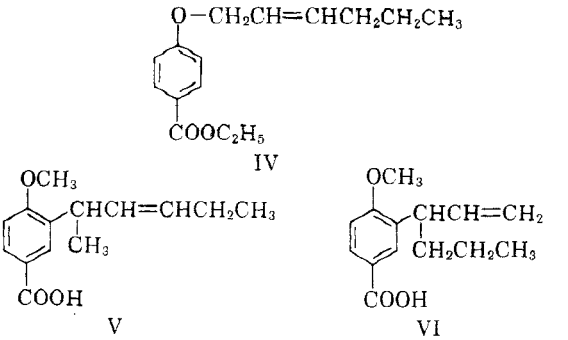
The thermal rearrangement of crotyl-δ-C^{14} *p*-carbethoxyphenyl ether gives *o*-(α-methylallyl)-*p*-carbethoxyphenol in which the C^{14}-label appears in two positions. These positions are the ones predicted on the basis that this rearrangement product is the result of *both* normal and abnormal rearrangement processes.

The occurrence of an abnormal Claisen rearrangement was first reported in 1936 by Lauer and Filbert.[4] They rearranged γ-ethylallyl phenyl ether (I) and obtained a product identified as *o*-(α,γ-dimethylallyl)phenol (III). Later,[5] it was shown that the product of a normal rearrangement, *o*-(α-ethylallyl)phenol (II), was also formed during this rearrangement.



Since then additional examples have been described.[6] In the cases studied, only the γ-alkyl-substituted allyl ethers gave products corresponding to the abnormal rearrangement, in addition to the normal rearrangement products. The pyrolysis of ethyl *p*-(γ-propylallyloxy)benzoate (IV) is of special importance.[7] Treatment of the mixture of rearrangement products with dimethyl sulfate in the presence of alkali yielded 3-(α-methyl-γ-ethylallyl)-4-methoxybenzoic acid (V) and 3-(α-propylallyl)-4-methoxybenzoic acid (VI). These acids were obtained in pure form by fractional



crystallization, and ozonolysis gave propionaldehyde and formaldehyde, respectively. In addition to furnishing another convincing example of the abnormal Claisen rearrangement, this case supplies evidence for β-attachment of the allyl group in the abnormal rearrangement.

The normal Claisen rearrangement involves an inversion of the substituted allyl group with γ-attachment to the aromatic nucleus, whereas the abnormal rearrangement apparently requires a hydrogen shift and a β-attachment of the substituted allyl group. All of the cases in which abnormal

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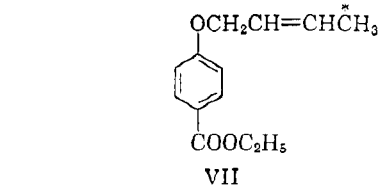
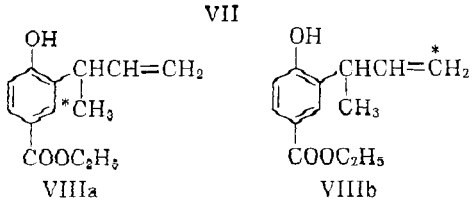
(3) M.S., University of Minnesota, 1956.
(4) W. M. Lauer and W. F. Filbert, *J. Am. Chem. Soc.*, **58**, 1388 (1936).
(5) C. D. Hurd and M. A. Pollack, *J. Org. Chem.*, **3**, 550 (1939).
(6) For an excellent treatment of the Claisen rearrangement, see D. S. Tarbell, *Chem. Revs.*, **27**, 495 (1945), and D. S. Tarbell, *Org. Reactions*, **Vol. II**, 1 (1944).
(7) W. M. Lauer and R. M. Leekley, *J. Am. Chem. Soc.*, **61**, 3043 (1939).

rearrangement has been demonstrated are γ-alkyl-substituted allyl ethers, and the simplest representative which should be capable of showing this behavior is γ-methylallyl phenyl ether. A number of examples in which the migrating group is the γ-methylallyl group have been studied, and in each case of *ortho* rearrangement, the process has been formulated as a normal rearrangement. Indeed, the earliest evidence, introduced by Claisen,[8] for inversion of the rearranging allyl group was based on studies of the cinnamyl and crotyl phenyl ethers. It should be noted, however, that in the case of the crotyl ethers, formation of an *o*-(α-methylallyl)phenol could be the result of either a normal or abnormal rearrangement, or both. In order to obtain information on this point, the following C^{14}-tagged crotyl phenyl ether (VII) was prepared and subjected to rearrangement.



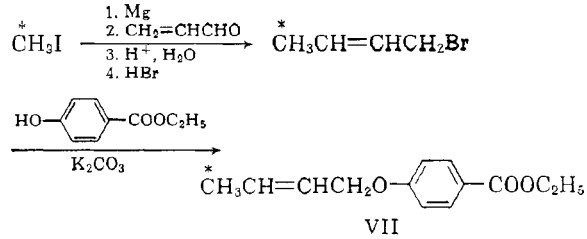
VII



VIIIa VIIIb

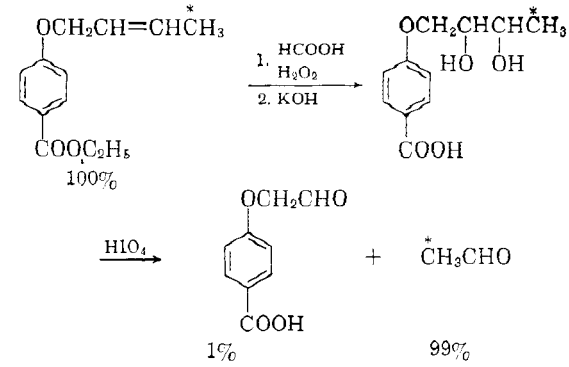
A normal Claisen rearrangement would give rise to VIIIa and an abnormal rearrangement involving a hydrogen shift from δ-carbon to α-carbon and β-attachment would lead to VIIIb. Ozonization, followed by a study of the radioactivity of the formaldehyde produced, should establish occurrence of any abnormal rearrangement in this case. Two completely independent studies were carried out, and in both cases, radioactive formaldehyde was obtained, though in different amounts. The first study (R.L.), which was completed in 1956, showed that approximately 29% of the total radioactivity resided in the terminal methylene group of the rearrangement product. Under the conditions used in this earlier study, a yield of approximately 50% of the rearrangement product was isolated. Later, the yield of the rearrangement product was increased to 91% by using the procedure described in the experimental part, and the product obtained under these conditions contained 15% of the total radioactivity in the terminal methylene group.

The synthesis of crotyl-δ-C^{14} *p*-carbethoxyphenyl ether (VII) is outlined as follows:



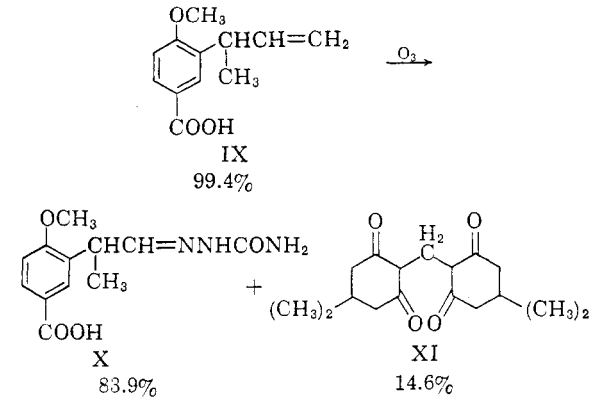
VII

Degradation of this ether, for purposes of allocating the radioactivity, was accomplished as follows:



The acetaldehyde was isolated as its dimedone derivative, and the *p*-(carboxyphenoxy)acetaldehyde was isolated as its semicarbazone. The cleavage product, acetaldehyde, accounted for 99% of the radioactivity, and it was therefore assumed that the C^{14} was in the 1-position, as indicated.

A number of rearrangement studies were carried out. It was found that an excellent yield (*ca.* 90%) of the crystallized rearrangement product was obtained if the tube containing the ether, after having been evacuated and sealed, was heated to 220–235° for eighty minutes. The rearrangement product was converted to *o*-(α-methylallyl)-*p*-carboxyanisole (IX). There was no significant loss of radioactivity during rearrangement and methylation since 99.4% of the radioactivity originally present in the unrearranged ether VII remained in the methyl ether (IX) of the rearrangement product after crystallization to constant radioactivity. Ozonolysis was used for the degradation of the methyl ether of the rearrangement product. The following diagram indicates the results, which were obtained.

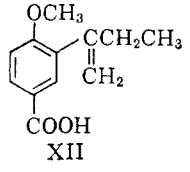


(8) L. Claisen and E. Tietze, *Ber.*, **58**, 275 (1925); **59**, 2344 (1926).

The percentages refer to the C^{14} content as determined by radioactivity measurements and are based on the C^{14} content of the original ether (VII). In each case, samples were purified by crystallization until successive measurements of radioactivity showed no significant change. Thus, it becomes apparent that the formaldehyde produced on ozonolysis contains an appreciable amount of the C^{14} label.

DISCUSSION

This study provides further evidence of an abnormal Claisen rearrangement and shows that crotyl phenyl ethers behave in a manner consistent with that of the γ-ethyl- and γ-propylallyl phenyl ethers, already recorded. There are several alternatives to this conclusion, which should perhaps be discussed. The first of these supposes that the radioactive formaldehyde originates from the methyl group in the side chain of IX. This methyl group on the basis of a normal Claisen rearrangement should carry all of the C^{14} label. It is conceivable that on ozonolysis this methyl group gives rise to radioactive formaldehyde, thus accounting for the 14.6% of radioactivity found in XI. However, in this event, since all of the C^{14} label is presumed to reside in the methyl group, the C^{14} content of X should correspond to that of IX. This is not the case. A second alternative assumes that the methyl ether derived from the rearrangement product (IX) is, in reality, a mixture of IX and XII.

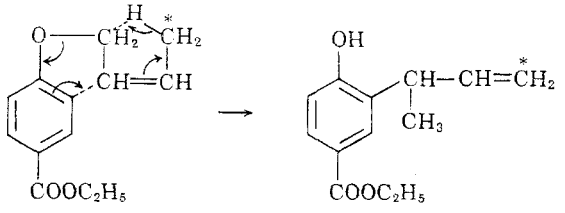


XII

It is perhaps a bit difficult to rationalize the formation of XII, but, nevertheless, the methods of ultraviolet and NMR spectroscopy can be expected to supply pertinent information. In the case of XII, the double bond in the side chain is in ring conjugation, while in IX this is not the case. The signal from the methyl group in IX should appear as a doublet on account of spin-spin interaction, while in XII it should appear as a triplet. Tamayo and Perez[9] have reported that allylbenzene and ethylbenzene have analogous spectra, with single maxima at 262 and 260 mμ, respectively, while propenylbenzene shows two bands with maxima at 283 and 294.5 mμ. The carboxylic acid, IX showed a single band at 258 mμ, and its hydrogenated product possessed a similar spectrum with a maximum at 256 mμ. Ozonolysis of XII would be expected to yield a ketone. A ketone of the expected structure was prepared, together with its semicarbazone and 2,4-dinitrophenylhydrazone. These derivatives were compared with the corresponding derivatives of the methyl ether IX obtained from the rearrangement product. The 2,4-dinitrophenylhydrazone of 2-methoxy-5-carboxy propiophenone melted at 237–238° and, in chloroform, showed an absorption maximum at 371 mμ. The 2,4-dinitrophenylhydrazone, obtained from the ozonolysis of the methyl ether IX derived from the rearrangement product, melted at 231–232° (mixed with the 237–238° melting 2,4-dinitrophenylhydrazone, 218–226°) and, in chloroform, showed an absorption maximum at 361 mμ. The corresponding semicarbazones exhibited the following properties: (a) The one derived from XII; m.p. 210–212°; λ_{max} (ethanol) 246; log ε 4.29; (b) the one derived from IX; m.p. 226–228°, λ_{max} (ethanol) 235; log ε 4.32.

NMR studies[10] of IX, carried out in carbon tetrachloride, showed a doublet corresponding to a methyl group with one adjacent proton (τ = +8.70; J = 7.1 c.p.s.). Compound XII would give rise to a triplet since there are two adjacent protons. The view that the methyl ether derived from the rearrangement product consists of a mixture of IX and XII receives no support, therefore, from the ultraviolet and NMR studies.

It should be noted that the radiochemical balance is excellent. There can be no doubt that radioactive formaldehyde is obtained by ozonolysis of the methyl ether derived from the rearrangement product (IX). In view of these findings, it is suggested that the rearrangement, described in the present study, proceeds by two paths. One of these paths is the normal Claisen rearrangement, with the resultant formation of VIIIa. Our results indicate that approximately 85% of the rearrangement follows this course. The 15% of the rearrangement product (VIIIb), which gives rise to radioactive formaldehyde on ozonolysis, apparently follows the pattern of the abnormal rearrangement, already demonstrated in several other cases. The following formulation suggests a path for the formation of the abnormal rearrangement product:



EXPERIMENTAL

A. Synthesis of crotyl-δ-C^{14} p-carbethoxyphenyl ether (VII). *1. δ-Butene-2-ol-C^{14}.* Radioactive methyl iodide (1 millicurie) was diluted with nonradioactive methyl iodide (240

(9) M. L. Tamayo and R. Perez, *Anales real. soc. españ. fis. y quim. (Madrid)*, **47B**, 369 (1951).

(10) The authors are indebted to Dr. George V. D. Tiers of the Minnesota Mining and Manufacturing Co., St. Paul, Minn., for these measurements and their interpretation.

g.) and dry ether (400 ml.). The ether solution of the diluted radioactive methyl iodide was then added dropwise with stirring to magnesium (41.0 g.) in anhydrous ether (300 ml.). The reaction system was continually flushed with dry nitrogen, and a Dry Ice–acetone condenser was used to prevent any loss of methyl iodide. The rate of addition of the methyl iodide was controlled so that gentle refluxing was maintained (*ca.* 2 hr.). After all of the methyl iodide had been added, the reaction mixture was heated under reflux for 1 hr. Acrolein (84.1 g.) in ether (600 ml.) was then added dropwise with stirring to the Grignard reagent at room temperature. After all of the acrolein had been added, the reaction mixture was heated under reflux for 0.5 hr. and then added very slowly to a mixture of ice and 5% aqueous sulfuric acid solution. The water layer was separated and saturated with sodium chloride. This layer was extracted four times with ether and the main ether layer combined with the four ether extracts. After drying the ether solution over anhydrous potassium carbonate for three days, it was distilled through a column. The colorless alcohol (69.0 g.; b.p. 94–105°) was obtained in 64% yield.

2. *4-Bromo-2-butene-1-C*^{14}. 3-Butene-2-ol-1-C^{14} (45.0 g.; 0.625 mole) was cooled in an ice bath and hydrobromic acid (198 ml.; 48%; sp. gr. 1.50; 1.76 moles) was added dropwise, with stirring over a period of 2 hr. After all of the hydrobromic acid had been added, the reaction mixture was stirred for an additional 2 hr. The ice bath was then removed, and stirring was continued for 23 hr. At the end of this time, the two-phase solution was poured into cold water (250 ml.), and the layers were separated. The organic layer was dried over anhydrous calcium chloride and then distilled through a short column (62.7 g.; 0.465 mole; 74% yield; b.p. 100–108°).

3. *Crotyl-δ-C*^{14} *p-carbethoxyphenyl ether* (VII). A mixture of ethyl *p*-hydroxybenzoate (91.0 g.; 0.548 mole), acetone (400 ml.), and potassium carbonate (82.0 g.; 0.595 mole) was stirred and heated under reflux for 15 min. 4-Bromo-2-butene-1-C^{14} (62.7 g.; 0.465 mole) was then added dropwise at room temperature over a period of 90 min. After the unsaturated bromide had been added, the reaction mixture was heated under reflux with stirring for 19 hr. Most of the acetone was then removed by distillation, and water (300 ml.) was added to dissolve the inorganic salts. The two layers were separated, and the water layer was extracted four times (4 × 75 ml.) with ether containing a small amount of petroleum ether (b.p. 60–68°). The ether extracts were combined with the original organic layer, extracted with aqueous (10%) sodium hydroxide, and then washed with water. The ether solution yielded a solid residue which after crystallization from ethanol-water melted at 50° (56.5 g., 0.0257 mole, 55% yield). The preparation of a nonradioactive sample of this compound has already been described,[11] and a radioactive specimen of this same substance was first obtained in 1956 (R.L.). The activity of the most recently prepared sample was determined by a Van Slyke-Folch oxidation followed by a barium carbonate counting; (a) 2472 cts/min.; (b) 2463 cts/min. The sample was recrystallized between series a and b.

B. Degradation of crotyl-δ-C^{14} *p-carbethoxyphenyl ether* (VII). 1. *4-(p-Carbethoxyphenoxy)-2,3-dihydroxybutane-1-C*^{14}. A mixture of the crotyl ether (5.0 g.; 0.0227 mole), formic acid (30 ml., 90%, sp. gr. 1.2044), and hydrogen peroxide (3.83 g., 3.44 ml., 30%, 0.0341 mole) was stirred and heated at 40° for 5 hr. The excess formic acid was removed by vacuum distillation, methanolic potassium hydroxide (50 ml., 3*N*) was added, and the mixture heated under reflux for 1 hr. At the end of this time, the methanol was removed by distillation, and water (200 ml.) was added. The basic solution was extracted with ether (75 ml.) and then acidified with sulfuric acid (6*N*). The precipitated potassium sulfate was then removed by filtration, and the filtrate was concentrated to about 100 ml. On cooling, the glycol separated. It was crystallized from ethyl acetate (3.41 g., m.p. 140–141°).

Anal. Calcd. for $C_{11}H_{16}O_5$: C, 58.40; H, 6.24. Found: C, 58.10; H, 6.25.

2. Periodic acid oxidation of 4-(p-carboxyphenoxy)-2,3-dihydroxybutane-1-C^{14}. A mixture of the glycol (1.00 g., 0.0044 mole), periodic acid (1.09 g., H_5IO_6, 0.0048 mole), and water (60 ml.) was carefully neutralized with solid sodium bicarbonate and then allowed to stand at room temperature for 18 hr. The solution was then warmed gently (max. temp. 48°), and a stream of nitrogen was passed through it into two dimedone traps (1.23 g. of dimedone in 15 ml. of 50% ethanol-water) for 45 min. The contents of the traps were combined and heated on a steam bath for 15 min. Water was then added to the hot solution to the cloud point, and then the solution was allowed to cool to room temperature. The dimedone derivative of acetaldehyde was collected and crystallized from methanol-water (m.p. 142°, 0.325 g., 24.1% yield).

Anal. Calcd. for $C_{18}H_{26}O_4$: C, 70.56; H, 8.55. Found: C, 70.41; H, 8.68.

Activity. (a) 1770 cts/min.; (b) 1758 cts./min.; (c) 1785 cts/min. The sample was recrystallized between series a and b and between b and c.

The periodic acid solution remaining after the removal of the acetaldehyde was carefully acidified with sulfuric acid (0.5*N*) and extracted with ether (3 × 30 ml.). The ether solution, after drying with magnesium sulfate, yielded a solid residue which was dissolved in ethanol (10 ml.). The addition of water to the cloud point, semicarbazide hydrochloride (1.0 g.) and sodium acetate (1.5 g.), followed by heating on the steam bath for 5 min. gave a precipitate on cooling. Crystallization from ethanol produced the semicarbazone of 2-(*p*-carboxyphenoxy)acetaldehyde, (m.p. 231–233°).

Anal. Calcd. for $C_{10}H_{11}O_4N_3$: C, 50.63; H, 4.67; N, 17.72. Found: C, 50.33; H, 4.96; N, 17.42.

Activity: (a) 38 cts/min.; (b) 31 cts./min. The sample was recrystallized between series a and b.

C. *Rearrangement of crotyl-δ-C*^{14} *p-carbethoxyphenyl ether* (VII). The ether (20.0 g.; 0.091 mole) was placed in a flask and evacuated with an oil pump. After sealing the flask, it was placed in a metal bath and heated to 220–235° for 80 min. This procedure was suggested by studies published by Prof. Schmid and his co-workers in Zurich. After cooling, the solid was crystallized from petroleum ether (b.p. 60–68°); yield: 18.2 g.; 91%; m.p. 75°.

This rearrangement product was identical with the one described earlier.[12]

D. *Degradation of o-(α-methylallyl)-p-carbethoxyphenol-x-C*^{14} (VIII).

1. *o-(α-Methylallyl)-p-carboxyanisole-x-C*^{14} (IX). The rearrangement product (10.0 g.; 0.0455 mole), potassium hydroxide (5.1 g.; 0.091 mole), and water (45 ml.) were heated to 100°. Dimethyl sulfate (5.77 g., 4.27 ml., 0.0458 mole) was added dropwise (80 min.) and with stirring to the hot solution. After complete addition of the dimethyl sulfate, stirring was continued for 1 hr. Potassium hydroxide (5.10 g., 0.091 mole) and water (45 ml.) were added, and then dimethyl sulfate (5.77 g., 4.27 ml., 0.0458 mole) was added dropwise to the hot solution as before, after which the reaction mixture was stirred at 100° for 50 min., and then allowed to stand at room temperature for 16 hr. Water (400 ml.) was added, and the basic solution was extracted with ether. Next, the solution was acidified with hydrochloric acid (10%) and cooled in an ice bath. The product was collected and crystallized from methanol-water (7.10 g., 0.0345 moles, 75.8%, m.p. 158–159°), and was identical with the product described earlier by Lauer and Sanders.[13]

Activity: The radioactivity of the preparation was deter-

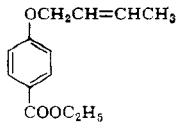
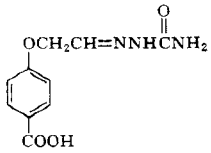
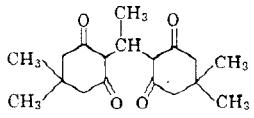
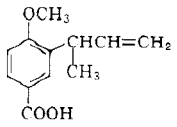
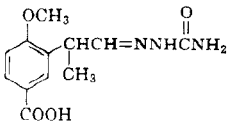
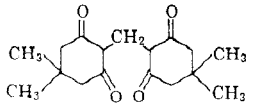
(11) W. M. Lauer and P. A. Sanders, *J. Am. Chem. Soc.*, **65**, 198 (1943).

(12) W. M. Lauer and P. A. Sanders, *J. Am. Chem. Soc.*, **65**, 199 (1943).

(13) *Loc. cit.*

TABLE I

COUNTING DATA

Compound Assayed	Plate No.	Total Activity, c/m/ Sample	Sample Counting Time, Min.	Background Activity, c/m	Background Counting Time, Min.	Net Activity, c/m/ Sample	Activity Corrected to Starting Material	Average Activity and Standard Deviation
	1a	2491	10	19	5	2472	2472	2467 ± 5
	1b	2482	10	19	5	2463	2463	
	2a	57	10	19	5	38	29	27 ± 3
	2b	51	15	20	5	31	24	
	3a	1790	10	20	5	1770	2451	2452 ± 11
	3b	1777	10	19	5	1758	2434	
	3c	1804	10	19	5	1785	2472	
	4a	2666	10	19	5	2645	2442	2453 ± 7
	4b	2675	10	19	5	2656	2452	
	4c	2691	10	20	5	2671	2466	
	5a	2284	10	19	5	2265	2091	2070 ± 12
	5b	2240	10	18	5	2222	2051	
	5c	2259	10	20	5	2239	2067	
	6a	295	10	19	5	276	361	361 ± 0
	6b	295	10	19	5	276	361	

mined. (a) 2645 cts./min.; (b) 2656 cts./min.,; (c) 2671 cts./min.

2. *Ozonolysis of o-(α-methylallyl)-p-carboxyanisole-x-C*^{14} (IX). A sample (0.30 g., 0.0015 mole) of IX and purified ethyl acetate (80 ml.) were mixed and cooled in Dry Ice–acetone bath. Ozone was then passed through the cold solution until the first noticeable blue color appeared. The ozonide was reductively decomposed by combining it with a suspension of zinc metal, hydroquinone, silver nitrate, and water (50 ml.). The reaction mixture was brought slowly to boiling and then heated under reflux for 30 min. After cooling, the zinc was removed and washed with ether. The ether was combined with the remainder of the solution, and the two layers were separated. The organic layer was washed with water (3 × 60 ml.), and the combined water extracts were added to the original water layer. The water layer plus the water extract was extracted with ether (3 × 50 ml.) and the ether extract added to the original organic layer. Dimedone (0.42 g., 0.0030 mole) was then added to the aqueous layer. Heating for 30 min. followed by cooling caused the separation of the crystalline dimedone derivative of formaldehyde. It was collected and crystallized from methanol-water (0.18 g., 0.00062 mole, 44% yield, m.p. 189–190°).

Activity. (a) 276 cts./min. (b) 276 cts./min. Recrystallization took place between series a and b.

The organic layer was dried over magnesium sulfate, and the solvent was removed. The solid residue was dissolved in ethanol (10 ml.) and water added to the cloud point. Semicarbazide hydrochloride (1.0 g.) and sodium acetate (1.5 g.) were then added, and the solution was heated on the steam bath for 20 min. After cooling the solution overnight, the semicarbazone of the aromatic aldehyde was collected. It was crystallized from ethanol-water and obtained in pure form. [0.10 g., 26.2% yield, m.p. 226–228°, λ_{max} in 95% ethanol: 235 mμ (log ε 4.32).]

Anal. Calcd. for $C_{12}H_{15}N_3O_4$: C, 54.33; H, 5.70; N, 15.84. Found: C, 55.55; H, 5.84; N, 15.68.

Activity. (a) 2265 cts./min. (b) 2222 cts./min. (c) 2239 cts./min. Recrystallization took place between series a and b, and between b and c.

E. *2-Methoxy-5-carboxypropiophenone.* 1. *p-Propionoxybenzoic acid.* *p*-Hydroxybenzoic acid (100 g., 0.724 mole), propionic anhydride (130 g., 1.0 mole), and sodium acetate (27.0 g., 0.329 mole) were mixed and heated on a steam bath for 45 min. The reaction mixture became homogeneous after heating for about 20 min. and on further heating the product began to separate. After cooling, the product was collected and crystallized from ethanol-water (74.5 g., 53%, m.p. 186–188°).

Anal. Calcd. for $C_{10}H_{10}O_4$: C, 61.85; H, 5.19. Found: C, 61.94; H, 5.33.

2. *2-Hydroxy-5-carboxypropiophenone.* *p*-Propionoxyben-

zoic acid (6.0 g.) and nitrobenzene (60 ml.) were mixed and anhydrous aluminum chloride (9.0 g.) was added portionwise. After the aluminum chloride had been added, the reaction mixture was heated slowly to 150°. It was maintained at this temperature for about 3.5 hr. Ice water was added slowly to the cooled reaction mixture, and the nitrobenzene was then removed by steam distillation. The hot solution was then filtered and strongly acidified with concentrated hydrochloric acid. Cooling (overnight) yielded the ketone, which was collected and crystallized from ethanol-water (1.52 g., 25.2%, m.p. 225–227°).

Anal. Calcd. for $C_{10}H_{10}O_4$: C, 61.85; H, 5.19. Found: C, 62.13; H, 5.37.

3. *2-Methoxy-5-carbomethoxypropiophenone.* 2-Hydroxy-5-carboxypropiophenone (2.30 g.), acetone (30 ml.), and anhydrous potassium carbonate (4.6 g.) were heated under reflux for 15 min. Methyl iodide (6.44 g.) was then added through the top of the condenser, and the mixture heated under reflux for 20 hr. The acetone was then removed by a stream of air, and water (150 ml.) was added to the solid residue. Ether extraction (4 × 60 ml.), followed by drying (magnesium sulfate) and distillation, yielded a solid which was crystallized from ethanol-water (1.78 g., 67.2%, m.p. 74–75°).

Anal. Calcd. for $C_{12}H_{14}O_4$: C, 64.85; H, 6.35. Found: C, 65.07; H, 6.44.

4. *2-Methoxy-5-carboxypropiophenone.* 2-Methoxy-5-carbomethoxypropiophenone (1.52 g.) and methanolic potassium hydroxide (15 ml., 20%) were mixed and heated for 30 min. The methanol was removed by distillation, and the solid residue was dissolved in water (100 ml.). The basic solution was extracted with ether and then acidified with sulfuric acid (6*N*). The solid precipitate was collected and crystallized from ethanol-water (1.20 g., 84%, m.p. 209–211°).

Anal. Calcd. for $C_{11}H_{12}O_4$: C, 63.45; H, 5.81. Found: C, 63.17; H, 5.75.

The 2,4-dinitrophenylhydrazone of this ketone was prepared, m.p. 237–238°.

Anal. Calcd. for $C_{17}H_{16}O_7N_4$: C, 52.58; H, 4.15; N, 14.43. Found: C, 52.44; H, 4.42; N, 14.42.

The 2,4-dinitrophenylhydrazone of the isomeric 2-(1-methoxy-5-carboxyphenyl)propionaldehyde, obtained as a result of the ozonolysis of the methyl ether derived from the rearrangement product, melted at 231–232°. A mixture of these two dinitrophenylhydrazones melted at 218–226°. The ultraviolet spectra (Beckman Model DU) showed the following:

(a) The 2,4-dinitrophenylhydrazone of 2-methoxy-5-carboxypropiophenone: λ_{max} (chloroform) 371 mμ, log ε 4.36.

(b) The 2,4-dinitrophenylhydrazone of 2-(1-methoxy-5-carboxyphenyl)propionaldehydes: λ_{max} (chloroform) 361 mμ, log ε 4.36.

The semicarbazone of 2-methoxy-5-carboxypropiophenone was prepared in the usual manner and crystallization from *N,N*dimethylformamide–water, m.p. 210–212°.

Anal. Calcd. for $C_{12}H_{15}O_4N_3$: C, 54.33; H, 5.70; N, 15.84. Found: C, 54.10; H, 5.64; N, 15.79.

Ultraviolet spectra (Cary).

(a). Semicarbazone of 2-methoxy-5-carboxypropiophenone: λ_{max} (95% ethanol) 246 mμ, log ε 4.29.

(b). Semicarbazone of 2-methoxy-5-carboxypropionaldehyde, m.p. 226–228°: λ_{max} (95% ethanol) 235 mμ, log ε 4.32.

F. *Radioactivity measurements.* The Van Slyke-Folch wet oxidation method[14] was used for all the oxidations herein described. The counting was done with a Nuclear-Chicago Model 186 Decade Scaler with an automatic timer and with a Nuclear-Chicago Model D-47 Gas-flow (Q-gas) Counter with a Model M-5 semiautomatic sample changer. Table I gives the results which were obtained.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, DUKE UNIVERSITY]

Ortho Substitution Rearrangement *vs.* Elimination Reaction of 2-, 3-, and 4-Benzylbenzyltrimethylammonium Ions with Sodium Amide[1]

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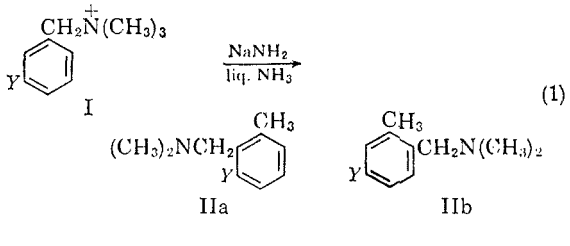
The 3-benzylbenzyltrimethylammonium ion reacted with sodium amide in liquid ammonia to form rearranged amine, whereas the 2- and 4-benzylbenzyltrimethylammonium ions underwent an elimination reaction to give amorphous hydrocarbon material. Evidently α-phenyl-*o*- and -*p*-xylylenes were intermediates in the latter type of reaction.

It has previously been shown that the 2-, 3-, and 4-alkyl-,[3–6] methoxy-,[3,5] and chloro[5]-benzyltrimethylammonium ions undergo the *ortho* substitution rearrangement with sodium amide in liquid ammonia, not the possible Stevens 1,2-shift. The reaction may be illustrated with the 3-methyl- and 3-methoxy- quaternary ammonium ions (I. $Y = CH_3$ and OCH_3), which afford mixtures of the corresponding isomeric rearranged amines IIa and IIb (Equation 1).



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