[Contribution from The Chemistry Laboratory of The Ohio State University]

A NEW SYNTHESIS OF 2,9-DIMETHYLPICENE[1]

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A number of methyl and polymethyl picenes have been isolated from the selenium or palladium-on-charcoal dehydrogenation of triterpenoids (1). The synthesis of 2,9-dimethylpicene,[3] identical with a hydrocarbon isolated from the dehydrogenation of β-amyrin, has been reported by Ruzicka and Hoffmann (2). These workers prepared this hydrocarbon by a method which involved, in the final step, the formation of an aromatic ring by shaking 1-(5-methyl-1-naphthyl)-2-(7-methyl-1-naphthyl)ethane with aluminum chloride in carbon disulfide for three days. The lability of alkyl groups on the aromatic nucleus in the presence of aluminum chloride is well known (3) and, in a cyclization very similar to that mentioned, the loss of a methyl group has been reported (4). Consideration of these facts made it seem desirable to synthesize 2,9-dimethylpicene by a method not involving this type of cyclization.

The synthesis of 2,9-dimethylpicene herein described was modeled after the general picene synthesis previously developed in this laboratory (5) and is outlined in the chart.

The β-1-(5-methylnaphthyl)ethyl bromide (I) required was prepared through the following sequence: β-*o*-toluylpropionic acid; γ-*o*-tolylbutyric acid; 1-keto-5-methyl-1,2,3,4-tetrahydronaphthalene; 5-methyl-3,4-dihydro-1-naphthaleneacetic acid; 5-methyl-1-naphthaleneacetic acid; and β-(5-methyl-1-naphthalene) ethanol. It is of interest that the reduction of β-*o*-toluylpropionic acid to γ-*o*-tolylbutyric acid was accomplished both by the Clemmensen-Martin (6) method and the Huang-Minlon modification (7) of the Wolff-Kishner method, but cyclization in good yield to the tetralone could only be effected with acid obtained by the latter procedure.

m-Xylyl chloride was obtained by chlorinating purified *m*-xylene with sulfuryl chloride in the presence of a peroxide catalyst (8). The chloride was converted to *m*-tolylacetonitrile (II) by treatment with aqueous-alcoholic potassium cyanide.

m-Tolylacetonitrile was alkylated with I in the presence of sodium amide. The best yield of the acid (IV) obtained by hydrolysis of the crude nitrile (III) was rather low (34% from I). From the neutral fraction of the hydrolysis product, there was isolated from 2 to 5% of the cyclic ketone V. The bulk of IV was cyclized to V by the action of anhydrous hydrogen fluoride in high yield.

The Reformatsky reaction of V with ethyl bromoacetate was sluggish, and the best yield of VI obtained was 20%. Two apparently isomeric acids were isolated in separate experiments. These acids probably differ in the location of the double bond arising from dehydration of the hydroxy ester. In formula VI the location of the double bond is assumed.

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[1] From the doctoral dissertation of Warren K. Cline, 1950.

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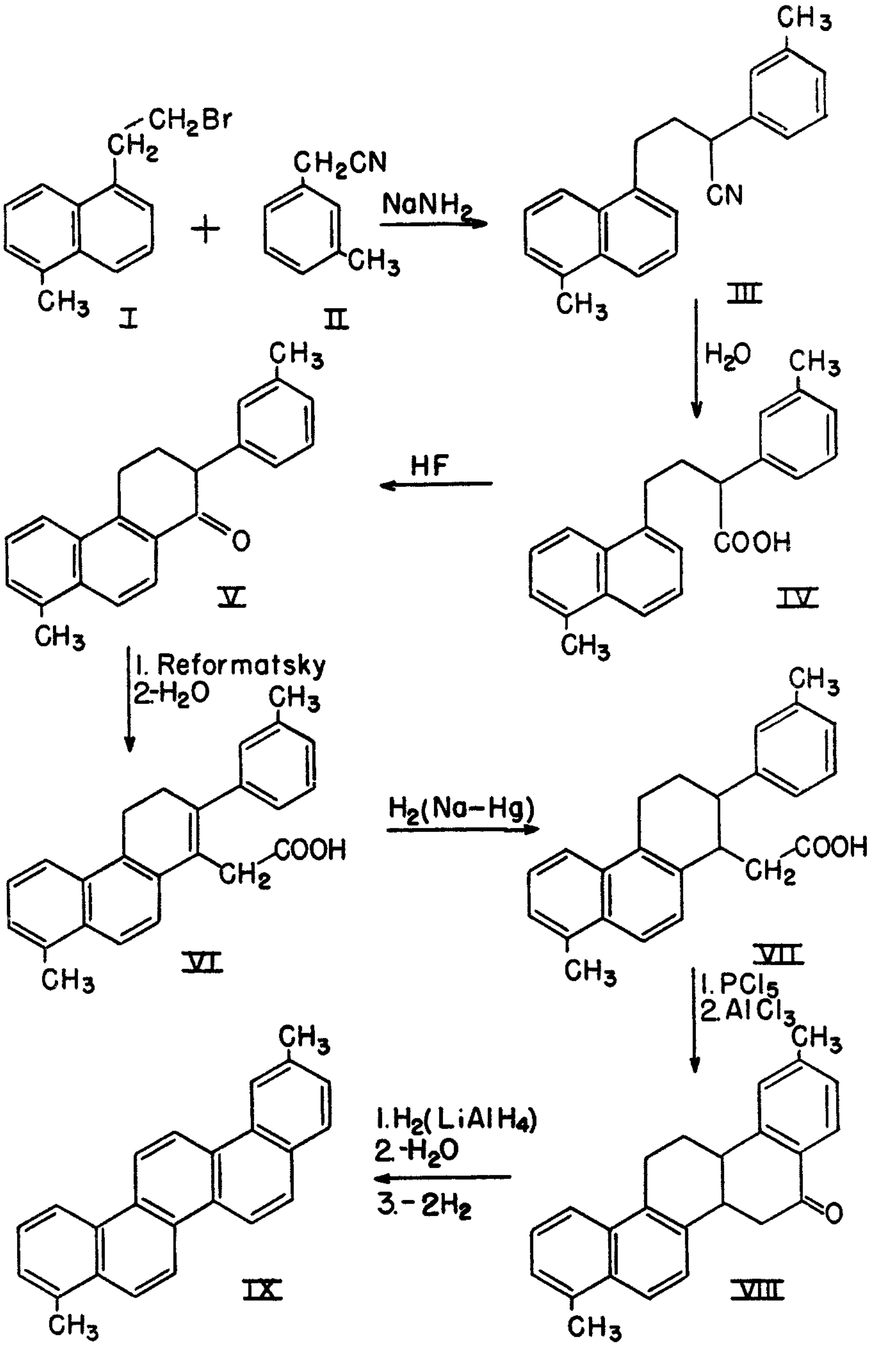
[3] Chemical Abstracts numbering.



The unsaturated acid (VI) was reduced to VII without apparent loss of material by the action of 2% sodium amalgam on an aqueous solution of the potassium salt. The two racemic forms of the saturated acid were not separated completely but one form melting at 160–164.6° was obtained by repeated recrystallization.

Cyclization of the saturated acid was accomplished in fair yield by the action of aluminum chloride on the acid chloride. The ketone (VII) obtained in this manner was reduced to the corresponding alcohol with lithium aluminum hydride. This alcohol was not isolated but was dehydrated and dehydrogenated by heating with the theoretical quantity of sulfur, giving the desired hydrocarbon IX in 25% yield from VII. The 2,9-dimethylpicene was purified by sublimation, preparation of the 2,4,7-trinitrofluorenone derivative, and decomposition of this derivative on activated alumina. The hydrocarbon obtained in this manner melted at 304.2–304.8°. It caused no melting point depression when mixed with either Ruzicka's synthetic 2,9-dimethylpicene or with that isolated from the dehydrogenation of β-amyrin (9).

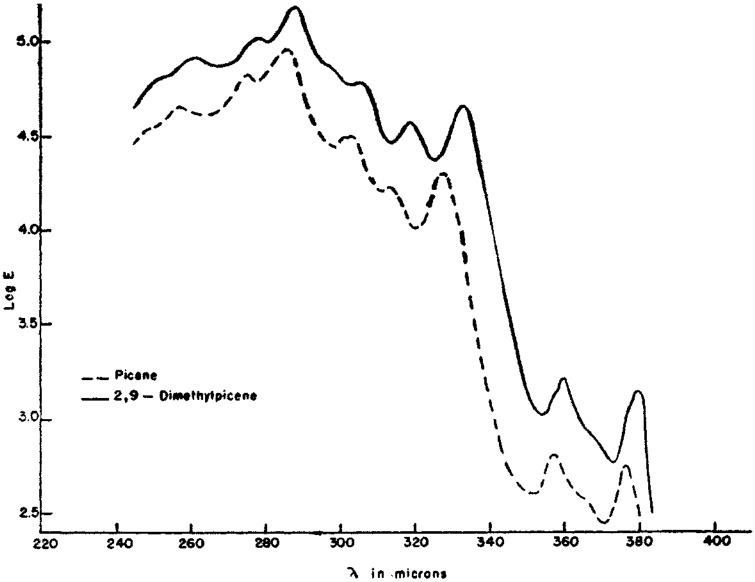


FIGURE 1. ULTRAVIOLET ABSORPTION SPECTRA OF PICENE AND 2,9-DIMETHYLPICENE

The ultraviolet absorption spectra of picene and 2,9-dimethylpicene are presented in Figure I.

EXPERIMENTAL[4]

β-o-Toluylpropionic acid. The Grignard reagent prepared from 428 g. (2.5 moles) of *o*-bromotoluene and 65 g. of magnesium in 2 l. of ether was added slowly with *efficient* stirring to a slurry maintained below −70° of 400 g. (4.0 moles) of finely ground succinic anhydride in 2 l. of dry pyridine and 1.2 l. of ether in a 12-l. three-neck flask. It is important to add the Grignard reagent slowly (when the time for addition was 1.5 hours the yield was about 33%; when 7 hours[5], the yield was 49%). The mixture was then allowed to come to room

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[4] All melting points corrected. Analyses marked [c] by H. S. Clarke Microanalytical Laboratory, Urbana, Illinois; [k] by Mrs. E. H. Klotz.

[5] Dr. Hugh Anderson performed this experiment.

temperature and was treated with excess hydrochloric acid. The ether extract of the ketoacid, after washing free of pyridine with acid, was concentrated at room temperature by blowing with air. The crystals, m.p. 103–105°, obtained in several crops, amounted to 235 g. (49%). A pure sample, m.p. 104.4–106.0°. was obtained by crystallization from benzene-ligroin.

Anal. Calc'd for $C_{11}H_{12}O_3$: C, 68.7; H, 6.3.
Found: [k]C, 68.7; H, 6.4.

γ-o-Tolylbutyric acid. The above ketoacid could be reduced by either the Clemmensen-Martin (6) or Huang-Minlon-Wolff-Kishner (7) procedure in high yield. However, since the cyclization of acid produced by the latter procedure proceeded in much better yield, only this reduction is described. A mixture of 14.2 g. of ketoacid, 14 g. of potassium hydroxide, 10 cc. of 85% hydrazine hydrate, and 100 cc. of triethylene glycol was refluxed for two hours. The temperature of the reaction mixture was then raised to 195° by allowing water to escape and was held at 195–210° for 3 hours. The crude acid thus obtained was distilled to yield 11.6 g. (88%) of colorless crystalline acid, b.p. 151–153° at 2 mm., m.p. 56–58° (2, 10). The yield of good acid was less if less pure ketoacid was used.

1-Keto-5-methyl-1,2,3,4-tetrahydronaphthalene. A solution of the acid chloride, free of phosphorus oxychloride, in 300 cc. of dry benzene was added slowly to a stirred suspension of 113 g. of aluminum chloride in 600 cc. of benzene, the temperature being held below 10°. The mixture was stirred for two hours during which the temperature rose to 25°. After suitable treatment the colorless ketone, b.p. 120–121° at 2 mm., m.p. 49–50° (11) was isolated in 91% yield. The cyclization was effected in 97% yield by adding 9.2 g. of acid to 50 g. of hydrogen fluoride in a silver cup.

5-Methyl-3,4-dihydro-1-naphthaleneacetic acid. A solution of 158 g. (0.99 mole) of ketone and 165 g. (0.99 mole) of ethyl bromoacetate in 250 cc. of benzene was distilled until all moisture was absent. To this solution was added 65 g. of granular zinc which had been activated. (12). When the vigor of the reaction abated the mixture was refluxed for 15 minutes. The addition of 80 g. of bromoester and 33 g. of zinc caused a second exothermic reaction. After this subsided the mixture was refluxed for 15 minutes. Another addition of 41 g. of bromoester and 20 g. of zinc was made and the mixture refluxed for 10 minutes. The reaction mixture was then decomposed with 10% sulfuric acid and the neutral portion of the reaction product was heated to effect dehydration. Distillation afforded 200 g. of liquid, b.p. 140–155° at 1 mm. After alkaline saponification the acid fraction was re-esterified to yield 174 g. (75%) of ethyl 5-methyl-3,4-dihydro-1-naphthalene acetate (position of double bond assumed), b.p. 144–145° at 1.1 mm. The crystalline unsaturated acid, m.p. 113.4–114.2°, was analyzed.

Anal. Calc'd for $C_{13}H_{14}O_2$: C, 77.2; H, 7.0.
Found: [c]C, 77.2; H, 6.9.

5-Methyl-1-naphthaleneacetic acid. A mixture of 169.4 g. of the above dihydroester and 22.8 g. of sulfur was heated at 230–260° for six hours. Distillation yielded 146.1 g. of ethyl 5-methyl-1-naphthaleneacetate, b.p. 162–163° at 1 mm. A portion was saponified to yield the acid, m.p. 169.8–170.6°, after crystallization from benzene.

Anal. Calc'd for $C_{13}H_{12}O_2$: C, 78.0; H, 6.0.
Found: [c]C, 78.3; H, 6.1.

β-(5-Methyl-1-naphthalene)ethanol. The above ester was reduced in the usual way with lithium aluminum hydride to yield the expected alcohol, b.p. 154–157° at 1 mm., m.p. 39.0–40.5°, in 92.8% yield. An analytical sample recrystallized from low-boiling petroleum ether (Skellysolve F) formed large flat colorless plates, m.p. 40.2–41.2°.

Anal. Calc'd for $C_{13}H_{14}O$: C, 84.1; H, 7.6.
Found: [c]C, 84.1, 84.0; H, 7.4, 7.4.

β-(5-Methyl-1-naphthyl)ethyl bromide (I). In the best of several experiments a mixture of 42.3 g. of the above alcohol and 150 cc. of 48% hydrobromic acid was distilled into a short fractionating column until constant-boiling hydrobromic acid was distilling. A small amount of oil which co-distilled was separated and returned to the pot. About three hours were required but this mixture was allowed to reflux for ten hours. The crude product was washed with 80% sulfuric acid, dried, and distilled to yield 51.2 g. (91.2%) of bromide, b.p. 151–154° at 1 mm., m.p. 31.0–31.5°. Through an oversight no sample was submitted for analysis.

m-Tolylacetonitrile (II). A sample of pure *m*-xylene,[6] b.p. 136.8–137.0°, n_D^{20} 1.4971, was chlorinated with sulfuryl chloride using benzoyl peroxide (8) to yield *m*-xylyl chloride, b.p. 101–102° at 30 mm., in 54% yield. There was also formed a considerable amount of higher-boiling substances and some tar. *m*-Tolylacetonitrile, b.p. 122° at 14 mm., was prepared from this chloride by reaction with potassium cyanide in aqueous-alcoholic solution (13) in 75% yield after purification (14).

α-m-Tolyl-γ-(5-methyl-1-naphthalene)butyric acid (IV). To a stirred suspension of 5.1 g. of sodium amide in 100 cc. of benzene was added dropwise a solution of 16.5 g. of II in 50 cc. of benzene. The color darkened to orange-red and some ammonia was evolved. After 10 minutes 29.0 g. of I was added. Considerable heat was generated, much ammonia was evolved, and a dark crystalline deposit was formed. After refluxing for 4 hours water was added and the organic products were distilled to yield 19.7 g. of crude nitrile (III), b.p. 195–250° at 1 mm. This nitrile was refluxed for 70 hours in a solution containing 30 cc. of 50% sulfuric acid in 170 cc. of acetic acid after which 100 cc. of acetic acid was distilled. The desired acid was extracted with large volumes of dilute potassium hydroxide because of the limited solubility of this salt. After acidification the acid was crystallized from benzene-Skellysolve F to yield 12.7 g. (34% from I) of IV, m.p. 144.4–145.8°. The analytical sample melted at 146.4–146.7°.

Anal. Calc'd for $C_{22}H_{22}O_2$: C, 83.0; H, 7.0.
Found: [c]C, 83.2, 83.2; H, 6.9, 7.1.

From the neutral fraction of the hydrolysis mixture there was isolated 0.7 g. (2%) of V.

1-Keto-8-methyl-2-(m-tolyl)-1,2,3,4-tetrahydrophenanthrene (V). The 12.7 g. of acid from the preceding experiment was dissolved in 100 g. of liquid hydrogen fluoride in a silver cup. After standing overnight at room temperature and warming in hot water for 3 hours, most of the hydrogen fluoride had evaporated. The residue was neutralized with aqueous potassium carbonate. The organic product was taken into benzene and crystallized to yield 11.2 g. (95%) of V, m.p. 193–195°. A sample recrystallized for analysis melted at 195.6–196.8°.

Anal. Calc'd for $C_{22}H_{22}O$: C, 88.0; H, 6.7.
Found: [c]C, 88.1; H, 6.9.

8-Methyl-2-m-tolyl-3,4-dihydro-1-phenanthreneacetic acid (VI). In the best of several experiments, 10.9 g. (0.036 mole) of V and 6.1 g. (0.037 mole) of ethyl bromoacetate were dissolved in 50 cc. of benzene and 100 cc. of toluene. To the refluxing mixture was added 3.2 g. of sand-papered zinc foil and a small amount of iodine. The reaction proceeded slowly as evidenced by a gradual darkening of the color. After refluxing for 3 hours, an additional 6.1 g. of bromoacetate and 3.2 g. of zinc were added. The mixture was refluxed 3 hours longer and worked up as usual. Dehydration was carried out by heating the hydroxyester with iodine near 250°. Distillation yielded 10.4 g. of viscous orange colored oil, b.p. 230–248° at 0.06 mm. This oil was saponified with alcoholic potassium hydroxide. The acid was recrystallized from benzene to give 2.4 g. (19%) of fine colorless needles, m.p. 200.0–200.5°.

Anal. Calc'd for $C_{24}H_{22}O_2$: C, 84.2; H, 6.4.
Found: [c]C, 84.4, 84.2; H, 6.7, 6.9.

In another similar experiment the unsaturated acid (VI) obtained melted at 247–249°. Either the low- or high-melting isomer gave a similar mixture of the saturated acids on reduction (see below). An analytical sample of the higher-melting acid melted at 248–249°. The melting point was depressed on adding acid of m.p. 200°.

Anal. Calc'd for $C_{24}H_{22}O_2$: C, 84.2; H, 6.4.
Found: [c]C, 84.6; H, 6.3.

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[6] We are indebted to the Oronite Chemical Company for a gift of *m*-xylene and to Jack Durst and Donald Staker for further purification and chlorination thereof.

In each of these reactions after saponification of the dehydrated ester, there remained a large amount of neutral, unsaponifiable glassy solid. No ketone was recovered from this residue.

8-Methyl-2-m-tolyl-1,2,3,4-tetrahydro-1-phenanthreneacetic acid (VII). A solution of 1 g. of VI in 400 cc. of warm 1% potassium hydroxide was stirred with 100 cc. of 2% sodium amalgam for 4 hours at 50–60°. On acidification a voluminous precipitate of hydrated acid separated. Drying for two hours at 80° decomposed the hydrate, leaving 1.0 g. or an essentially quantitative yield of crude acid. The two possible racemic pairs of acids were not isolated, but recrystallization from benzene-Skellysolve F gave 0.1 g. of VII, m.p. 160–164.6°.

Anal. Calc'd for $C_{24}H_{24}O_2$: C, 83.7; H, 7.0.
Found: [k]C, 83.4, 83.4; H, 6.8, 7.0.

5-Keto-2,9-dimethyl-5,6,6a,13,14,14a-hexahydropicene (VIII). The mother liquors from the recrystallization of VII were concentrated to a small volume. The acid in this benzene solution was converted to the acid chloride with phosphorus pentachloride. Phosphorus compounds were removed by the successive addition of three 20-cc. portions of benzene and evaporation on the water-pump. The acid chloride was taken up in 20 cc. of chlorobenzene and cooled in an ice-bath. On addition of 0.4 g. of aluminum chloride, the mixture darkened immediately to a deep brownish-red and after warming at about 50° for 15 minutes a dark crystalline solid precipitated. After hydrolysis in the usual manner, the organic product was taken up in a large volume of warm benzene, washed with dilute acid and alkali, and dried by distillation of some of the benzene. This material was used in the next step of the synthesis without further purification, but in an exactly similar experiment, the yellow solid, m.p. 92–115°, obtained in 52% yield by evaporation of the benzene solution of cyclization product, was purified by sublimation, crystallization from 95% ethanol, and chromatography on activated alumina using benzene and benzene-alcohol as developers. In this manner there was obtained about 20 mg. of white crystalline ketone (VIII), m.p. 151.8–153.8°.

Anal. Calc'd for $C_{24}H_{22}O$: C, 88.3; H, 6.8.
Found: [c]C, 87.7; H, 6.7.

2,9-Dimethylpicene (IX). The benzene solution of VIII from the first cyclization experiment was added to 0.15 g. of lithium aluminum hydride in 100 cc. of dry ether. Stirring was continued for 30 minutes after addition was complete. The reaction mixture was hydrolyzed and the organic matter taken into benzene-ether and washed with acid and alkali. Evaporation of the solvent left 0.50 g. of a light orange solid. No attempt was made to isolate the alcohol but the crude product was mixed with 0.096 g. of sulfur and heated at 230–270°. The mixture melted, but after 15 minutes the entire mass became solid. Heating was continued for 3 hours. The product was vacuum-sublimed to yield 0.20 g. (25% from VIII) of light tan hydrocarbon, m.p. 294–306° in a sealed Pyrex tube. The hydrocarbon was further purified by preparation of the molecular complex with 2,4,7-trinitrofluorenone (15). This derivative was recrystallized from benzene, and the hydrocarbon was regenerated by passing the benzene solution of the second crop through a column of activated alumina. The slightly yellow effluent solution was decolorized with carbon (Darco G-60). The product which separated on concentration melted at 304.2–304.8° in a sealed Pyrex tube. The sum of the analytical figures for carbon and hydrogen in this material failed by about 0.6% to add up to 100%. This discrepancy was presumed to be due to absorption of oxygen by the sample. A benzene solution of the hydrocarbon was passed through a short alumina column and the effluent was protected by an atmosphere of nitrogen during evaporation of the solvent. The colorless platelets of 2,9-dimethylpicene obtained in this way melted at 304.2–304.8° in a sealed Pyrex tube.

Anal. Calc'd for $C_{24}H_{18}$: C, 94.1; H, 5.9.
Found: [k]C, 93.9, 93.9; H, 6.1, 6.0.

The total amount of pure IX isolated was 0.076 g. or 8.5% of the theoretical yield from one gram of the unsaturated acid, VI.

The *2,4,7-trinitrofluorenone derivative* crystallized in long, bright red needles, m.p. 257.8–258.6°, in a sealed Pyrex tube.

Anal. Calc'd for $C_{37}H_{27}N_3O_7$: C, 71.5; H, 3.7; N, 6.7.

Found: [k]C, 71.4, 71.7; H, 3.6, 3.8; N, 6.6, 6.5.

The ultraviolet absorption spectra of picene and 2,9-dimethylpicene, Figure 1, were determined in chloroform on a Beckman DU instrument[7].

SUMMARY

A new synthesis of 2,9-dimethylpicene and the necessary intermediates has been accomplished. This synthesis substantiates the structure of a hydrocarbon isolated from the dehydrogenation of certain triterpenoids by Ruzicka and other workers and synthesized by another method by Ruzicka and Hoffmann.

Columbus 10, Ohio

REFERENCES

(1) For example: (a) Ruzicka, Hosli, and Ehmann, *Helv. Chim. Acta*, **17**, 442 (1934); (b) Simpson and Williams, *J. Chem. Soc.*, 686 (1938); (c) Drake and Campbell, *J. Am. Chem. Soc.*, **58**, 1684 (1936).
(2) Ruzicka and Hoffmann, *Helv. Chim. Acta*, **20**, 1155 (1937).
(3) Thomas, *Anhydrous Aluminum Chloride in Organic Chemistry*, A. C. S. Monograph No. 87, Rheinhold Publishing Corp., New York, 1941, p. 77–94.
(4) Drake and McVey, *J. Org. Chem.*, **4**, 464 (1939).
(5) Newman, *J. Org. Chem.*, **9**, 518 (1944).
(6) Martin, *Org. Reactions*, **1**, 155 (1942).
(7) Huang-Minlon, *J. Am. Chem. Soc.*, **68**, 2487 (1946).
(8) Kharasch and Brown, *J. Am. Chem. Soc.*, **61**, 2142 (1939).
(9) Private communication from Dr. O. Jeger of Ruzicka's laboratory.
(10) Wessely and Wang, *Ber.*, **73**, 19 (1940).
(11) Harvey, Heilbron, and Wilkinson, *J. Chem. Soc.*, 423 (1930).
(12) Procedure based on that of Bachmann, Cole, and Wilds, *J. Am. Chem. Soc.*, **62**, 824 (1940).
(13) Prepared according to *Org. Syntheses*, Coll. Vol. I, 101 (1938).
(14) See purification in *Org. Syntheses*, **16**, 89 (1935).
(15) Orchin and Woolfolk, *J. Am. Chem. Soc.*, **68**, 1727 (1946).

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[7] Spectra determined by Mrs. Arlene Brooks.