

night. When hydrolysis was complete the mixture was worked up in the usual manner. A small amount of an oil with the odor of acetophenone was found after evaporation of the benzene layer. A similar product was obtained by steam distillation of the water layer. This oil solidified at approximately 19° and formed a semicarbazone melting at 195–196°, which corresponds to that of acetophenone. An authentic sample of the semicarbazone of acetophenone also melted at 195–196°; a mixed melting point evidenced no lowering of this value.

Summary

1. It has been shown that carbon suboxide will undergo a Friedel-Crafts reaction with benzene.
2. We conclude that benzoylactic acid was formed as an intermediate in the reaction.
3. Acetophenone was isolated from the reaction mixture.

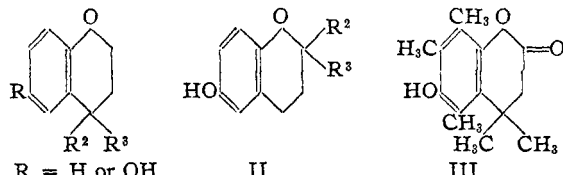
RECEIVED JANUARY 23, 1940

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY OF THE UNIVERSITY OF MINNESOTA]

Polymethylbenzenes. XXV. The Reaction between Dimethylacrylic Acid and the Trimethylbenzenes¹

BY LEE IRVIN SMITH AND WILLIAM W. PRICHARD²

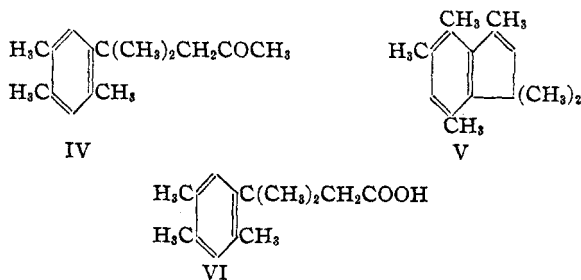
The work described in this paper was begun as an attempt to synthesize some 4,4-disubstituted chromans (I) or hydrocoumarins (III) in which the 6-position was occupied by a hydrogen atom or hydroxyl group.



Such compounds were of interest because of their relationship to the tocopherols (vitamin E) which are analogous 2,2-dialkyl chromans, II. Very few examples of 4,4-disubstituted chromans are known,³ and there is only a single example (III) of the synthesis of a 4,4-disubstituted hydrocoumarin.⁴

The difficulty in the synthesis of these substances appeared to be the introduction of the quaternary carbon atom,^{5,6} hence attention was turned to methods for closing the chroman and hydrocoumarin rings after introduction of the quaternary carbon atom. The necessary intermediates, however, proved impossible to prepare. Appropriate alkylation of malonic ester failed because dimethyl-*o*-hydroxyphenylcarbinol^{7,8}

could not be converted to the chloride. Likewise unsuccessful were all attempts to obtain any crystalline products when mesityl oxide in the presence of aluminum chloride was condensed with any of a number of substituted phenols and hydroquinones or their ethers,^{8a,9} and it appeared that the unsaturated ketone could be condensed successfully only with hydrocarbons.⁷ It was known that β -[2,4,5-trimethylphenyl]-propionic acid could be converted into a quinone and then to a 6-hydroxyhydrocoumarin¹⁰ and the analogous propionic acid, completely substituted in the β -position, should be accessible through the ketone IV resulting from the condensation of pseudocumene and mesityl oxide. The result of this condensation, however, was an indene V, although in view of the rearrangements described below the orientation of the methyl groups in the benzene ring of this compound is not certain.



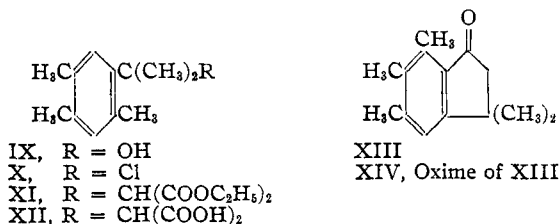
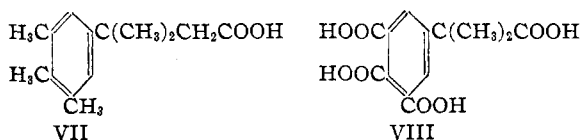
The possibility remained that the condensation of pseudocumene with β,β -dimethylacrylic acid might lead to the acid VI, in which case the series of reactions could be carried out as planned. The product of this condensation was a mixture of

- (1) Polymethylbenzenes, XXIV, THIS JOURNAL, 61, 989 (1939).
- (2) Abstracted from a thesis by W. W. Prichard, presented to the Graduate Faculty of the University of Minnesota, in partial fulfillment of the requirements for the Ph.D. degree, October, 1939.
- (3) (a) Niederl, THIS JOURNAL, 51, 2426 (1929); (b) Dianin, J. Russ. Phys.-Chem. Soc., 46, 1310 (1914).
- (4) John, Günther and Schmeil, Ber., 71, 2617 (1938).
- (5) Kostanecki, et al., Ber., 35, 861, 2889 (1902); 37, 774 (1904).
- (6) Hill, Chem. Rev., 19, 25 (1936).
- (7) Hoffman, THIS JOURNAL, 51, 2542 (1929).
- (8) Béhal and Tifeneau, Bull. soc. chim., [4] 3, 315 (1908).

- (9) Liebermann and Hartmann, Ber., 24, 2586 (1891).
- (10) Smith and Denyes, THIS JOURNAL, 55, 304 (1936).

acids from which there was isolated 50–60% of a pure acid which melted at 111–112° and which had the composition required by formula VI.

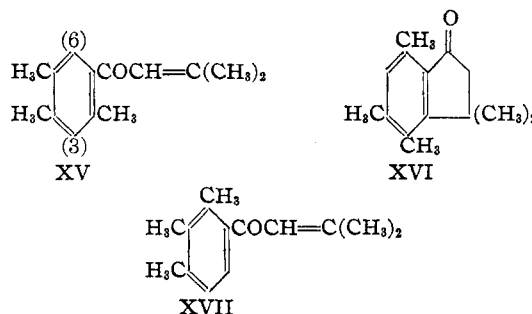
However, investigation of this acid soon showed that it could not be the substance VI, but must be an isomer having the structure VII. Oxidation to a known benzenetetracarboxylic acid failed because the quaternary carbon atom was resistant to oxidation,¹¹ and the oxidation product was an unknown tricarboxyphenylisobutyric acid, VIII. It was necessary, therefore, to use other methods in determining the orientation of the substituents, and as a first approach VI was synthesized from 5-acetopseudocumene by the method Hoffman⁷ used in synthesizing β -phenylisovaleric acid.



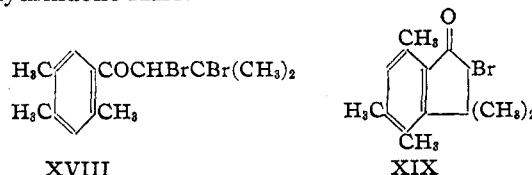
Methylmagnesium iodide was added to 5-acetopseudocumene to give the carbinol IX; the ketone is enolized to the extent of 25% by the Grignard reagent¹² and consequently the product contained much of the starting material. Since the carbinol could not be crystallized, and the risk of dehydration precluded distillation, this product was subjected to the action of hydrochloric acid at 0° and the mixture containing the chloride X was used to alkylate sodium malonic ester. The product of this reaction was saponified and a malonic acid (XII) was isolated in 5–10% yield. This malonic acid melted with decomposition to give a monobasic acid VI isomeric with, but different from, the acid VII.

The acid VII, in contact with sulfuric acid, was readily converted to the hydrindone XIII, which gave an oxime XIV with ease. Since acetyl chloride condensed readily with pseudocumene in the 5-position, it seemed likely that any other acid chloride would attack the same position. Accordingly β,β -dimethylacrylic acid chloride was condensed with pseudocumene in the presence

of aluminum chloride. The product XV was obtained in good yield, and shown to have this structure by oxidation to pyromellitic acid.



The ketone XV was then cyclized by aluminum chloride¹³ to the hydrindone XVI, in quantitative yield. This hydrindone XVI was an *isomer* of XIII, and since the acyl group in XV was known to be in position 5, cyclization of XV must have involved position 6 in this compound. Consequently the condensation of pseudocumene with β,β -dimethylacrylic acid could not have involved the 6-position of the aromatic nucleus, for this would also have led ultimately to the indone XVI. Since the synthetic acid VI was different from VII, neither could this condensation have involved the 5-position. Condensation in the 3-position of pseudocumene would lead to an acid which could not be converted to a hydrindone. Hence it followed that VII could not be a derivative of pseudocumene; nor could it be a derivative of mesitylene, for the acid analogous to VI and VII, derived from mesitylene, likewise would not be convertible to a hydrindone. The only possibility remaining was that VII was a derivative of hemimellitene. The ketone XV gave a dibromide XVIII, identical with the product obtained by condensing α,β -dibromoisovaleryl chloride with pseudocumene. This dibromide XVIII was cyclized by aluminum chloride, giving the bromohydrindone XIX.



Condensation of 1,2,3-trimethylbenzene with dimethylacrylic acid chloride under the same conditions used in the synthesis of XV, produced the ketone XVII. Oxidation of XVII gave benzene-1,2,3,4-tetracarboxylic acid, proving the orienta-

(11) Tiemann and Kruger, *Ber.*, **26**, 2685 (1893); Bogert and Applebaum, *This Journal*, **60**, 930 (1928).

(12) Smith and Guss, *ibid.*, **59**, 804 (1937).

(13) Kohler, *Am. Chem. J.*, **42**, 376 (1909).

tion of the groups in the ketone. Cyclization of XVII with aluminum chloride gave the hydrindone XIII, identical with the product obtained by cyclizing VII. The structure of VII, therefore, must be β -[3,4,5-trimethylphenyl]-propionic acid. The only weakness in this argument is the fact that aluminum chloride was used in cyclizing the ketone XVII, and a rearrangement in this step was possible. Against this is the fact that the ketone XV gave an isomeric hydrindone on similar treatment and hence if rearrangement had occurred in either case both ketones should have given the same hydrindone, *i. e.*, the one stable in the presence of aluminum chloride. Moreover, the cyclizations gave pure hydrindones, while if rearrangement had occurred, a mixture would have been more likely.

As a further proof of the structure of VII, hemimellitene and β , β -dimethylacrylic acid were condensed under conditions identical with those used in the condensation of pseudocumene. The result was a single acid, obtained in almost quantitative yield, identical in every way with VII. Thus the interesting fact emerges that hemimellitene condenses with an acid chloride in the 4-position, while the product obtained by adding the hydrocarbon to the conjugated system in dimethylacrylic acid has the acid residue in the 5-position. These results are in agreement with those of Nightingale¹⁴ and Perry¹⁵ who found that *t*-butyl chloride condensed with *m*-xylene in the 5-position, while acetyl chloride condensed in the 4-position. The β -phenylisovaleric acids may be regarded as *t*-butyl derivatives, and hence they should behave toward aluminum chloride in a manner similar to that of the hydrocarbons themselves, and Nightingale, as well as Perry, have shown that 4-*t*-butyl-*m*-xylene rearranges readily in the presence of aluminum chloride to give 5-*t*-butyl-*m*-xylene. The formation of VII, a 1,2,3,5-tetrasubstituted benzene, in the presence of aluminum chloride is also in accord with experience obtained in methylating xylene and other hydrocarbons in the presence of aluminum chloride; in these reactions, little if any 1,2,3-trimethyl- and 1,2,3,4-tetramethyl-benzenes are formed.¹⁶ With these facts in mind, it was of interest to subject the 1,2,4,5-acid VI (m. p. 77–79°) to the action of aluminum chloride. The product was a mixture having the same melting point range as that

of the mixture of acids obtained by condensation of pseudocumene with β , β -dimethylacrylic acid; because of the small amount of material available, it was not possible to isolate the 1,2,3,5-acid VII from this mixture in an entirely pure state. However, the impure acid obtained in this way (m. p. 101–107°) when mixed with pure VII (m. p. 111–112°) melted at 104–108°. It was thus established that aluminum chloride would bring about rearrangement of acid VI, and that the product, if not quite entirely VII, contained a large proportion of it. While not strictly comparable to the rearrangement of VI, migrations of this type have been noted by v. Auwers in connection with his studies on the Fries rearrangement.¹⁷ Thus the acetates of pseudocumenol-5 and -6, of mesitol and of hemimellitene-4 all give 4-hydroxy-5-acetohemimellitene, the first three with rearrangement of the methyl groups, and the last with no such rearrangement.

It was not possible to determine all of the constituents of the mixture of acids obtained when pseudocumene was condensed with dimethylacrylic acid. Saponification of the lower boiling fractions of the ester made from the crude acid product gave a mixture of acids melting at 68–90°. It is likely that these are dimethylphenylisovaleric acids, since a part of the pseudocumene used was always converted into durene. Hence some xylenes must also have been formed, and as no xylenes could be obtained from the alkali-insoluble portion of the product, these must have condensed with the acrylic acid. Several crystallizations of the residue from which most of the acid VII had been removed gave an acid melting at 85–89°, but repeated crystallization failed to give a product with a sharper melting point.

p-Xylene condensed readily with dimethylacrylic acid to give a dimethylphenylisovaleric acid. If no migration of methyl groups occurred, this acid could have but one structure, that in which the methyl groups are in positions 2 and 5. But in view of the rearrangement of the butyl xylenes and of acid VI in the presence of aluminum chloride, this product may well be the 3,5-dimethyl compound. The orientation of the methyl groups in this compound was not established, but the acid was readily cyclized to a hydrindone.

(17) (a) v. Auwers, Bundesmann and Wieners, *Ann.*, **447**, 162 (1926); (b) v. Auwers and Mauss, *ibid.*, **460**, 240 (1928); (c) v. Auwers and Dersch, *ibid.*, **462**, 112 (1928); (d) v. Auwers and Bergmann, *ibid.*, **472**, 287 (1929); (e) v. Auwers and Janssen, *ibid.*, **483**, 44 (1930).

(14) Nightingale and Smith, *This Journal*, **61**, 101 (1939).

(15) Smith and Perry, *ibid.*, **61**, 1411 (1939).

(16) Moyle and Smith, *J. Org. Chem.*, **2**, 114 (1937).

Mesitylene also condensed with dimethylacrylic acid. The product was a mixture, from which a pure dimethylphenylisovaleric acid was isolated in poor yield. This acid likewise was readily cyclized to a hydrindone. It is interesting that acid VII, the acid from *p*-xylene and the acid from mesitylene all melt at about 110–112°, yet a mixture of any two of them exhibits a marked depression in melting point.

Experimental Part¹⁸

β -[3,4,5-Trimethylphenyl]-isovaleric Acid, VII.—Dimethylacrylic acid (10 g., 0.1 mole) was dissolved in pseudocumene (44 g., 0.36 mole). The solution was cooled (–10°) and stirred, and aluminum chloride (26.6 g., 0.2 mole) was added at such a rate that the temperature did not exceed –10°. The mixture became viscous and dark red, and there was a slight evolution of hydrochloric acid. Stirring at –10° was continued for two hours after all the catalyst was added; the mixture was then poured over a large amount of iced hydrochloric acid. The organic layer was removed and the aqueous layer was extracted three times with ether (30 cc. each time). These extracts were combined with the organic layer and were washed thoroughly with water and then were extracted with carbonate (10%) until the aqueous washings were strongly alkaline. The alkaline solution was warmed gently to remove dissolved ether and then was made strongly acid with hydrochloric acid. The oil which separated soon solidified; the crude acid so obtained weighed 20.8 g. and melted at 84–96°. Repeated recrystallization from dilute alcohol or dilute acetic acid gave a product melting at 111–112° (VII), but the losses were great and it was much better to esterify the crude product and fractionate the ester.

Anal. Calcd. for $C_{14}H_{20}O_2$: C, 76.36; H, 9.09; n. e., 220. Found: C, 75.72, 76.79; H, 8.73, 8.96; n. e., 217.7, 217.9, 216.2.

The carbonate insoluble portion of the reaction mixture was fractionated under 11 mm. pressure. There resulted 26 g. of a liquid boiling at 52–53° (pseudocumene) and a residue (4 g.) of a white solid (durene, m. p. and mixed m. p., 76–78°).

Methyl Ester.—The crude acid VII (63.5 g., m. p. 99–102°) was refluxed for two hours in methanol (300 cc.) containing sulfuric acid (10 cc.). The reaction mixture was diluted with water (600 cc.). The ester layer was removed and the aqueous layer extracted three times with benzene (30 cc. each time). The combined organic layers were washed with water, then twice with carbonate (10%) and again with water. The benzene was removed under reduced pressure on the water-bath and the residual oil was fractionated under 4 mm. pressure through a 30-inch (76-cm.) Fenske column. The products were: A, 4.0 g., b. p. 111–118.5°; B, 8.7 g., b. p., 118.5–123°; C, 3.0 g., b. p. 124–129°; D, 41.5 g., b. p. 129–130°; E, 6.0 g., residue. Hydrolysis of fraction D gave crude acid VII, m. p. 103–107°. After two crystallizations from dilute alcohol, the acid weighed 28 g. and melted at 111–112°.

A portion of this purified acid (10.4 g.) was re-esterified, giving 13.3 g. of methyl ester, practically all of which boiled at 130–130.5° under 6 mm. pressure.

Anal. Calcd. for $C_{14}H_{20}O_2$: C, 76.87; H, 9.16. Found: C, 76.92, H, 9.40.

Hydrolysis of fraction B (2 cc.) gave 2.0 g. of a crude acid which melted at 68–90°. Crystallization of this acid from dilute ethanol gave a product melting at 85–90°; several more crystallizations did not give a product with a higher melting point. A mixture of this acid and the pure acid VII melted at 79–87°.

Acid VII from Hemimellitene.—Dimethylacrylic acid (2.5 g.) and hemimellitene (6 g.) were condensed at –10° with aluminum chloride (6.65 g.) as described above. The crude product, isolated as described above, weighed 5.4 g. and melted at 106–107°; when mixed with the pure acid VII from pseudocumene, the substance melted at 109–110°. One crystallization of this product from dilute ethanol gave a product melting at 111–112°; it was not necessary to convert the acid made from hemimellitene into the ester in order to purify it, and from the yield and purity of the crude product, it is apparent that this condensation gives a single substance, VII.

3,4,5-Tricarboxyphenylisobutyric Acid, VIII.—The acid VII (1.0 g.) was refluxed with potassium permanganate (11.1 g.) in water (210 cc.) containing potassium hydroxide (20 cc., 20%) for eighteen hours. Ethanol was added to decolorize excess permanganate, the precipitated manganese dioxide was filtered off and the filtrate was concentrated to 20 cc. and made faintly acid with acetic acid. Barium chloride (saturated solution) was added to the hot solution until no more precipitate formed. The barium salt was removed and dissolved in hydrochloric acid (4 N, 8 cc.). The barium was precipitated with sulfuric acid (6 N), care being taken to avoid an excess of the acid. The barium sulfate was removed and the acid VIII was isolated from the filtrate. After crystallization from 6 N hydrochloric acid, the substance melted at 192–194°. It did not correspond in melting point with any of the known tri- or tetracarboxybenzenes. Repetition of the oxidation, refluxing for thirty hours, gave the same product.

Anal. Calcd. for $C_{13}H_{20}O_8$: C, 52.70; H, 4.02. Found: C, 52.78, 52.24, 52.99; H, 4.99, 5.27, 4.84.

A small amount of the acid was esterified with diazomethane in ether, but the methyl ester was an oil which could not be crystallized.

β -[2,4,5-Trimethylphenyl]-isovaleric Acid, VI.—5-Aceto-pseudocumene (16.2 g., 0.1 mole) was added to a solution of methylmagnesium iodide (magnesium 2.5 g., methyl iodide 16 g.) in ether (60 cc.) under nitrogen. The mixture was refluxed for an hour and then decomposed with iced ammonium chloride solution. The product was removed by several ether extractions and the ether solution was washed with water, then with dilute bicarbonate and again with water and dried over sodium sulfate. Removal of the ether under vacuum left a light yellow oil (18 g.) which could not be crystallized. It was a mixture of aceto-pseudocumene and the carbinol IX. This oil was dissolved in petroleum ether (20 cc., b. p. 38–40°) and the solution was saturated with dry hydrogen chloride at 0°; a layer of water separated. After standing for thirty minutes,

(18) Microanalyses by J. W. Opie, C. O. Guss and H. H. Hoehn.

the product was washed several times with water and dried over sodium sulfate. This solution of the chloride X was added to sodium malonic ester (ethyl malonate 16.5 g., sodium 2.3 g.) in dry ether (100 cc.) and the mixture was refluxed for two and one-half hours. The mixture was poured into water and the organic layer was removed and washed first with water, then with dilute hydrochloric acid, and again with water. The solvent was removed and the residual oil (XI) was refluxed for five hours with potassium hydroxide in methanol (75 cc., 30%). Water was added and the solution was extracted thoroughly with ether. The aqueous layer was then acidified; a yellow oil (1.3 g.) formed, which was removed, taken up in ether, and then extracted from the ether solution with dilute carbonate. Acidification of the carbonate regenerated the oil, which was again taken up in ether and dried over Drierite. Removal of the solvent left an oil which slowly crystallized. Recrystallization from dilute alcohol gave a white crystalline product melting at 143.5–148.5° with decomposition. This was the malonic acid XII. It was not analyzed, but was decarboxylated by heating it in a test-tube to 160°. The escaping gas was identified as carbon dioxide; the melt solidified on cooling. After crystallization from dilute ethanol, the product, VI, melted at 79–81°. A mixture with the acid VII (m. p. 111–112°), melted at 67–69°.

Anal. Calcd. for $C_{14}H_{20}O_2$: C, 76.36; H, 9.09. Found: C, 76.39; H, 9.02.

Rearrangement of VI to VII.—The acid VI (0.085 g.) was dissolved in carbon disulfide (3 cc.) and aluminum chloride (0.10 g.) was added. A vigorous reaction occurred and a red oil precipitated. The mixture was refluxed for fifteen minutes, after which the solvent was removed. The residual oil was decomposed with dilute hydrochloric acid and the resulting white solid was extracted with ether (5 cc.). The ethereal solution was washed with water and then extracted with carbonate. Acidification of the carbonate solution produced a solid melting at 78–95°. After two crystallizations from dilute alcohol, the substance (VII) melted at 101–107°. A mixture of this and pure VII (m. p. 111–112°) melted at 104–108°; a mixture of this specimen of VII and the starting material VI melted at 65–69°.

3,3,5,6,7-Pentamethylhydrindone, XIII.—The acid VII (4.4 g.) was dissolved in concd. sulfuric acid (30 cc.) and allowed to stand for four hours at room temperature. The mixture was poured over cracked ice and the hydrindone (4 g., 99%, m. p., 100–101°) was removed and crystallized from dilute ethanol. It formed long white needles which melted at 103.5–104°.

Anal. Calcd. for $C_{14}H_{18}O$: C, 83.16; H, 8.91. Found: C, 83.21; H, 8.70.

Oxime XIV.—The hydrindone XIII (3.82 g.) was dissolved in ethanol (50 cc.) and a solution of hydroxylamine hydrochloride (4.0 g.) and sodium acetate (8.0 g.) in water (10 cc.) was added. The mixture was refluxed for thirty minutes and then cooled. The solid (3.12 g., m. p. 179–185°) was removed and crystallized from dilute ethanol. It was white, and melted at 196–196.5°.

Anal. Calcd. for $C_{14}H_{18}ON$: C, 77.42; H, 8.75. Found: C, 76.08, 76.65; H, 8.51, 8.62.

Isopropylidene - 2,3,4 - trimethylacetophenone, XVII.—Hemimellitene (6 g., 0.05 mole) and dimethylacrylic acid chloride (5.0 g., 0.042 mole) were dissolved in carbon disulfide (15 cc.). Aluminum chloride (5.64 g., 0.042 mole) was slowly added to the rapidly stirred, cooled (–10°) solution. After nearly all of the catalyst had been added, a vigorous evolution of hydrogen chloride began. The reaction mixture was allowed to warm to room temperature (twelve minutes) and was then immediately poured over iced hydrochloric acid. The organic layer was removed and the aqueous layer was extracted three times with ether (10 cc. each time). The extracts were combined with the main organic layer and the whole was washed several times with water, then with dilute carbonate, and again with water. Solvent and unchanged hydrocarbon were removed by steam distillation (total distillate 100 cc.). The residue was extracted with ether and the extract was dried over Drierite. After removal of the solvent, the residual oil was distilled under reduced pressure (6 mm.) through a six-inch (16-cm.) column packed with glass helices. After a small forerun (0.8 g.) boiling at 136–138°, the bulk of the product (3.4 g.) came over at 138–139°.

Anal. Calcd. for $C_{14}H_{18}O$: C, 83.16; H, 8.91. Found: C, 82.63; H, 8.90.

Oxidation of the ketone (1.0 g.) by permanganate (14.6 g. in 300 cc. of water) and alkali (20% KOH, 30 cc.) was accomplished by refluxing the mixture for six hours. The product was isolated through the barium salt as described above in the preparation of VIIIa from VIII. **Benzene-1,2,3,4-tetracarboxylic acid** was obtained but the specimen melted indefinitely about 170°. It accordingly was converted into the tetramethyl ester by action of diazomethane; after crystallization from dilute methanol, the ester melted at 130–130.5° alone or when mixed with an authentic specimen.

Hydrindone, XIII.—The ketone XVII (1 g.) was dissolved in carbon disulfide (5 cc.) and aluminum chloride (0.7 g.) was added. The solution was saturated in the cold with dry hydrogen chloride and then refluxed for forty minutes. The solvent was evaporated and the residual red oil was decomposed with iced hydrochloric acid. A white solid (0.90 g.) formed at once; it melted at 90–95°. Crystallized once from dilute ethanol, it separated in long white needles which melted at 103.5–104°, alone or when mixed with a specimen of XIII prepared from the acid VIII.

Isopropylidene - 2,4,5 - trimethylacetophenone, XV.—Pseudocumene (15 g., 0.10 mole) was condensed with dimethylacrylic acid chloride (10.5 g.) in carbon disulfide (25 cc.), using aluminum chloride (13.3 g.) in exactly the same manner described above for the preparation of XVII. The product (8.5 g.) isolated and purified in the same way, boiled at 131–131.5° under 6 mm. pressure.

Anal. Calcd. for $C_{14}H_{18}O$: C, 83.16; H, 8.91. Found: C, 82.27; H, 9.12.

Oxidation of this ketone (1.0 g.) using the procedure described above for oxidation of XVII gave pyromellitic acid (0.4 g.) melting with decomposition at about 225°. Esterification of this acid by diazomethane gave the tetramethyl ester, m. p. 138–139°, alone or when mixed with an authentic specimen.

3,3,4,5,7-Pentamethylhydrindone, XVI.—The ketone XV (2 cc.) was cyclized with aluminum chloride (1.3 g.) in carbon disulfide (10 cc.) by the procedure used in cyclizing XVII. The hydrindone XVI, obtained in quantitative yield, crystallized in flat plates from dilute ethanol. It melted at 54–55.5°.

Anal. Calcd. for $C_{14}H_{18}O$: C, 83.16; H, 8.91. Found: C, 83.37; H, 9.05.

2,4,5-Trimethyl- α,β -dibromoisovalerophenone, XVIII.—A solution of the ketone XV (1.0 g.) in dry ether (10 cc.) was brominated by liquid bromine (0.79 g.). The color was discharged instantly and no hydrogen bromide was evolved. Evaporation of the solvent left an oil which solidified rapidly. After crystallization from ethanol, the substance melted at 74–76°.

Dimethylacrylic acid (15 g.) in carbon disulfide (25 cc.) was brominated with liquid bromine (7.7 cc.) at 0°. The solvent was pumped off and the solid residue was suspended in benzene (25 cc.). Phosphorus pentachloride (31.2 g.) was added slowly to the cooled (0°) solution. The acid gradually dissolved, and after solution was complete the volatile materials were pumped off and the residue was distilled. The acid chloride (27 g., 66%) boiled at 77–82° under 5 mm. pressure; there was some decomposition during the distillation. The acid chloride was dissolved in pseudocumene (16.5 g., 0.11 mole) and carbon disulfide (25 cc.). The solution was cooled to –10° and aluminum chloride (14.6 g., 0.11 mole) was added with stirring. As soon as all of the aluminum chloride was added, the reaction mixture was poured into iced hydrochloric acid.

The solvent was removed by steam distillation and the residue was extracted with ether. Removal of the ether left an oil which solidified. This solid (XVIII), crystallized from ethanol, melted at 74–76° and was identical with the product obtained by brominating the ketone XV. The yield was 12 g. (33%); a large amount of a greenish oily by-product was also formed.

Anal. Calcd. for $C_{14}H_{18}OBr_2$: C, 46.42; H, 4.97. Found: C, 46.41; H, 5.09.

2-Bromo-3,3,4,5,7-pentamethylhydrindone, XIX.—The dibromo ketone (0.5 g.) was mixed with aluminum chloride (1.0 g.) in a test-tube and the mixture was warmed to 50°. A vigorous reaction occurred, with evolution of hydrogen bromide. The melt was decomposed with ice and the solid product was removed and crystallized from ethanol. It melted at 102–104°.

Anal. Calcd. for $C_{14}H_{17}OBr$: C, 59.79; H, 6.05. Found: C, 59.75; H, 6.52.

β -[2,5-Dimethylphenyl]-isovaleric Acid.—Dimethylacrylic acid (5.0 g.) dissolved in *p*-xylene (8.0 g.) was added slowly with stirring to a cooled (0°) solution of aluminum chloride (16 g.) in *p*-xylene (12 g.). After stirring for one and one-half hours at 0°, the mixture was poured into iced hydrochloric acid. The product, isolated and purified as described for other similar condensations above, weighed 4.12 g. and melted, after crystallization from dilute acetic acid, at 93–100°. After two crystallizations from dilute ethanol, the product melted at 108–110°. Analysis showed that this substance was a dimethylphenylisovaleric acid, but the orientation of the methyl groups in the benzene ring is not certain.

Anal. Calcd. for $C_{13}H_{18}O_2$: C, 75.72; H, 8.71; n. e., 206. Found: C, 75.50; H, 8.60; n. e., 205.7.

3,3,4,7-Tetramethylhydrindone.—The above acid (1.0 g.) was allowed to stand in sulfuric acid (20 cc.) for one hour. The mixture was poured onto ice and the solid was removed and crystallized from dilute ethanol. It melted at 52–53°. The position of the methyl groups in the benzene ring is not certain.

Anal. Calcd. for $C_{13}H_{18}O$: C, 82.99; H, 8.52. Found: C, 82.73; H, 8.79.

Condensation of Mesitylene with Dimethylacrylic Acid.—The hydrocarbon (31.5 g.) was condensed with the acid at 0° by adding aluminum chloride and the product was isolated as described above in similar experiments. A small yield (3.0 g.) of solid resulted. This solid was crystallized successively from dilute methanol, petroleum ether (b. p. 28–35°), dilute ethanol (twice) and dilute acetic acid. It then melted at 110–111°. Although it was a dimethylphenylisovaleric acid, it was not identical with the product (m. p. 108–110°) obtained in a similar manner from *p*-xylene; a mixture of the two substances melted at 85–90°.

Anal. Calcd. for $C_{13}H_{18}O_2$: C, 75.72; H, 8.71. Found: C, 75.53; H, 8.90.

When this acid (0.10 g.) was cyclized with sulfuric acid in the usual way, the product was a **tetramethyl hydrindone** melting at 62–63° which likewise was different from the product similarly derived from *p*-xylene.

Anal. Calcd. for $C_{13}H_{18}O$: C, 82.99; H, 8.52. Found: C, 82.16; H, 8.65.

1,1,3,4,5,7-Hexamethylindene, V.—Pseudocumene (12 g., 0.1 mole) was cooled to 0° and aluminum chloride (15 g., 0.11 mole) was slowly added. To this mixture at 10°, mesityl oxide (8 g., 0.08 mole) was added slowly. The aluminum chloride gradually dissolved to give a cherry-red solution which was allowed to stand at room temperature for three hours. It was decomposed by iced hydrochloric acid, the organic layer was separated and the aqueous layer was extracted with ether. The organic layers were combined, washed first with water and then with carbonate, and dried over calcium chloride. The solvent was removed and the residue was distilled under 11 mm. pressure. Pseudocumene and mesityl oxide (12 g.) came over at 42–50°; the boiling point then rose to 145–146° and 4 g. of distillate which solidified at once was collected. When crystallized from ethanol, this material melted at 87.5–88.5°. No carbonyl derivatives could be obtained, nor could any acid be isolated when the substance was oxidized with hypobromite. The product instantly decolorized bromine in carbon tetrachloride, with evolution of hydrogen bromide.

Anal. Calcd. for $C_{16}H_{20}$: C, 90.00; H, 10.00. Found: C, 90.08; H, 10.40.

Phenol and Mesityl Oxide.—The ketone (9.9 g.) and phenol (9.4 g.) were mixed and concd. sulfuric acid (10 cc.) was added slowly at 0°. The light red solution stood at room temperature for six days and was then poured into ice. The viscous product was triturated with water and then taken up in 20% potassium hydroxide. The alkaline solution was extracted with ether, and then saturated with carbon dioxide. A yellow amorphous solid precipi-

tated. This solid could not be crystallized from any of a number of solvents tried; the usual result was a brown sirup. A portion of this sirup was subjected to high vacuum distillation. It started to evolve gas at about 78° and at 100° a sublimate slowly formed. This sublimate resembled shellac, and it could not be crystallized. Repetition of the experiment, using acetic acid as a diluent and a temperature of 85° for one hour, gave the same results.

Pseudocumenol-6 and Mesityl Oxide.—The same treatment converted the mixture of these substances into a brown oil, soluble in potassium hydroxide. Carbon dioxide precipitated from the alkaline solution a tan solid containing some unchanged phenol. This solid, after repeated precipitation from dilute alcohol and dilute acetic acid, melted at 63–70° but it was not crystalline and it could not be purified further.

***p*-Bromophenol and mesityl oxide** likewise gave only amorphous products.

Hydroquinone Dimethyl Ether and Mesityl Oxide.—The ether (6.9 g.) and the ketone (4.95 g.) were dissolved in carbon disulfide (50 cc.) and aluminum chloride (20 g.) was added. After refluxing for one hour, the mixture was decomposed with iced hydrochloric acid. No alkali-soluble product was obtained and 85% of the ether was recovered.

***p*-Chlorophenol** (3.4 g.) and **mesityl oxide** (2.97 g.) were similarly treated with aluminum chloride (4 g.) at 100° for three hours. The product was separated into alkali-soluble and -insoluble parts but nothing but starting materials could be isolated from these.

***p*-Chloroanisole** (4.26 g.) and **mesityl oxide** (2.97 g.) were mixed in nitrobenzene (15 cc.) and heated for two and one-half hours at 100° with aluminum chloride (4.0 g.). Distillation of the steam volatile part of the product showed nothing but the starting materials to be present.

***o*-Hydroxyphenyldimethylcarbinol.**—Methylmagnesium iodide (0.194 mole) was prepared in the usual manner. Methyl salicylate (9.8 g., 0.0645 mole) in ether (40 cc.) was added to the Grignard solution. The mixture was allowed to stand overnight and was then worked up in the usual manner, every precaution being taken to prevent dehydration of the product. The carbinol was obtained in 64% yield; after crystallization from petroleum ether, it melted at 43–44°.

The carbinol (8.85 g.) was dissolved in benzene and a little Drierite was added. The mixture was saturated with dry hydrogen chloride. A layer of water formed. The benzene layer was removed and washed repeatedly with water. Removal of the solvent under reduced pressure left an oil which solidified on standing. This solid (m. p. 95–96°) did not contain halogen, gave a very weak Folin phenol test, and rapidly decolorized bromine in carbon tetrachloride. An orange-yellow color was produced with sulfuric acid. The solid was insoluble in aqueous potassium hydroxide, hot or cold.

Summary

1. In the presence of aluminum chloride, the condensation of pseudocumene with dimethylacrylic acid is accompanied by a rearrangement of the alkyl groups. The product does not have the substituents in positions 1, 2, 4 and 5 (VI) but is β -[3,4,5-trimethylphenyl]-isovaleric acid, VII.

2. Pseudocumene condenses normally with dimethylacrylic acid chloride in the presence of aluminum chloride, the acyl group entering the 5-position.

3. Hemimellitene condenses with dimethylacrylic acid to give the isovaleric acid VII in 95% yield, condensing in the 5-position.

4. Hemimellitene condenses with dimethylacrylic acid chloride, however, in the 4-position.

5. These ketones and acids were converted to hydrindones, and the relationship existing between the different hydrindones thus obtained is discussed.

6. β -[2,4,5-Trimethylphenyl]-isovaleric acid (VI) was synthesized and found to rearrange to the 3,4,5-trimethylphenyl compound in the presence of aluminum chloride.

MINNEAPOLIS, MINNESOTA

RECEIVED NOVEMBER 15, 1939