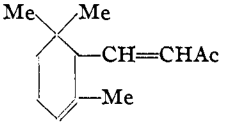
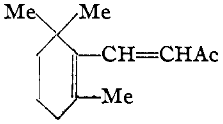
[CONTRIBUTION FROM THE CHEMICAL LABORATORIES OF COLUMBIA UNIVERSITY AND OF THE COLLEGE OF THE CITY OF NEW YORK]

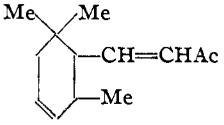
The Synthesis of 1,1,2,6-Tetramethyltetralin and the Constitution of Irene[1]

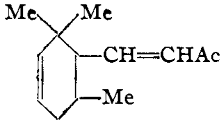
BY MARSTON TAYLOR BOGERT AND PERCY MAX APFELBAUM

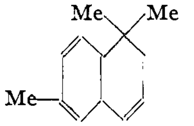
Tiemann and Krüger,[2] the discoverers of irone (IV) and irene (VII), assigned to them a C_{13} skeleton, on the basis of analytical results and oxidation products. They concluded that irone (IV) and the two ionones (I and II) all had the same carbon skeleton, and differed only in the location of the nuclear double bond. Merling, Welde, Eichwede, and Skita[3] claimed to have synthesized, from the appropriate cyclocitral,

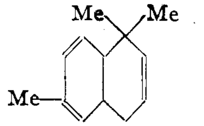

α-Ionone (I)

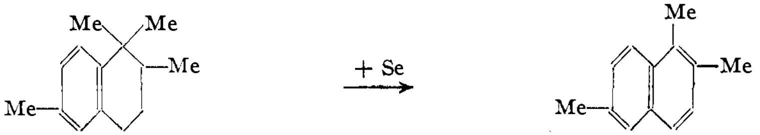

β-Ionone (II)

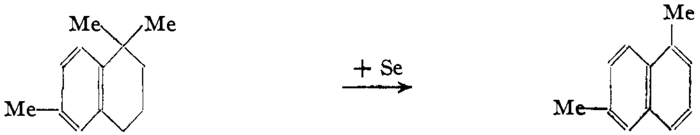

α-Irone (III)

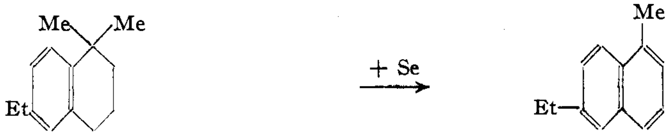

β-Irone (IV)


T. K. Ionene (V)

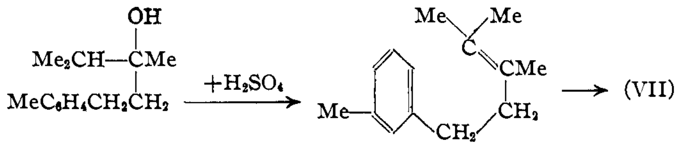

T. K. Irene (VI)


(VII) Irene (VIII)


(IX) Ionene (X)


(XI) (XII)

$$m\text{-MeC}_6\text{H}_4\text{Br} \xrightarrow[+\text{Mg}]{+(\text{CH}_2)_2\text{O}} \underset{\text{(XIII)}}{\text{MeC}_6\text{H}_4\text{CH}_2\text{CH}_2\text{OH}} \xrightarrow{+\text{HBr}} \underset{\text{(XIV)}}{\text{MeC}_6\text{H}_4\text{CH}_2\text{CH}_2\text{Br}} \xrightarrow[+\text{Mg}]{+\text{AcCHMe}_2}$$



(XV) (XVI)

		From irone[6]	From irone[7]	Synthetic
Irene (VII), b. p.		113–115°(9 mm.)	119–123(10 mm.)	120–125(10 mm.)
Irene (VII), n_D		1.5274	1.521(20°)	1.511(20°) 1.5261(25°)
Irene (VII), sp. gr.		0.9402(20°)	—	0.9379(25°)
1,2,6-Trimethylnaphthalene	picrate, m. p., °C.		122–123	121–122
	styphnate, m. p., °C.		150–151	150

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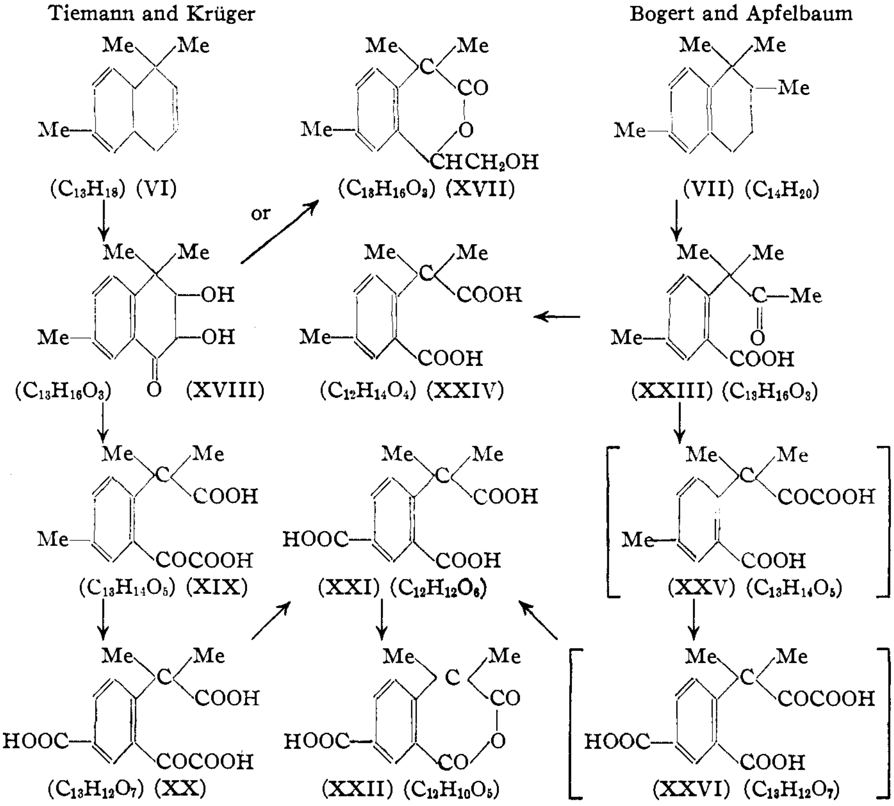
[1] A preliminary announcement of this research appeared in *Science*, [N. S.], **79**, 280 (1934).

[2] Tiemann and Krüger, *Ber.*, **26**, 2675 (1893); **28**, 1757 (1895).

[3] Merling, Welde, Eichwede, and Skita, *Ann.*, **366**, 129 (1909).

not only the naturally occurring irone of Tiemann (beta-irone) (IV), but also an isomeric alpha-irone (III). No experimental evidence has ever been published in support of this statement, either by these investigators or by anyone else, so far as we have been able to ascertain.

Oxidation Flow Sheet



Catalytic hydrogenation of irone to the tetrahydro derivative, however, does not give tetrahydroionone, as Ruzicka proved,[4] and he suggested, therefore, on the assumption of the correctness of the Tiemann and Krüger irone formula (IV), that the distinction was probably due to *cis–trans* isomerism, the ionones being of *cis* form and irone *trans*.

The hydrocarbons ionene (V) and irene (VI), obtained from ionone and irone by dehydration, were assigned analogous structures by Tiemann and Krüger. The work of Bogert and Fourman,[5] and of Bogert, Davidson and Apfelbaum,[6] however, has since furnished evidence that the constitution of ionene is more probably that shown by formula (IX); and Ruzicka, Seidel, and Schinz,[7] in their later studies of the irone obtained from orris oil, expressed the opinion that the hydrocarbon irene, which results from the dehydration of irone, was not $C_{13}H_{18}$, as determined by Tiemann and Krüger,[2] but $C_{14}H_{20}$, and assigned to it the structure shown by (VII).

A cogent argument for the correctness of this deduction is the fact that when irene (VII) is heated with selenium, 1,2,6-trimethylnaphthalene (VIII) is formed; just as 1,6-dimethylnaphthalene (X) results from the action of selenium upon the analogously constituted hydrocarbon ionene (IX), from the violet perfume ionone,[8] and 1-methyl-6-ethylnaphthalene (XII), by a similar treatment of methylionene (XI), from "methylionone."[9]

Syntheses of ionene,[6] and of two methyl ionenes,[9] already have been reported from these Laboratories. That of the 1,1,2,6-tetramethyltetralin is recorded in the following pages, and may be summarized thus.

m-Bromotoluene was condensed with ethylene oxide and magnesium to the beta-(*m*-tolyl)-ethanol (XIII), whose bromide (XIV), subjected to a Grignard reaction with methyl isopropyl ketone, gave the requisite tertiary alcohol (XV). Heated with sulfuric acid, this alcohol lost water, presumably with formation first of the intermediate olefin (XVI), which then promptly rearranged to the tetramethyltetralin (VII). Dehydrogenation of this tetralin, by fusion with selenium, yielded a 1,2,6-trimethylnaphthalene (VIII) identical with the trimethylnaphthalene obtained by Ruzicka, Seidel and Schinz,[7] by the fusion of irene (VII) with selenium. Further,

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(4) Ruzicka, *Helv. Chim. Acta*, **2**, 352 (1919).

(5) Bogert and Fourman, THIS JOURNAL, **55**, 4670 (1933).

(6) Bogert, Davidson and Apfelbaum, *ibid.*, **56**, 959 (1934).

(7) Ruzicka, Seidel and Schinz, *Helv. Chim. Acta*, **16**, 1143 (1933).

(8) Ruzicka and Rudolph, *ibid.*, **10**, 918 (1927).

(9) Pope and Bogert, *J. Org. Chem.*, **2**, 276 (1937).

as given beyond in detail, the physical constants of our synthetic tetralin (VII) agreed satisfactorily with those reported by Tiemann and Krüger[2] and by Ruzicka, Seidel and Schinz,[7] for the irene (VII) obtained by the dehydration of irone from orris roots.

Ruzicka and his collaborators,[7] however, did not report any oxidation reactions, or other investigation of irene (VII) itself, aside from its behavior when fused with selenium. We have, therefore, carried out some of these oxidations with our synthetic product and compared them with similar reactions employed by Tiemann and Kröger in their study of the irene (VII) prepared from orris root irone, to which they assign formula (VI). The course of this progressive oxidation in the two cases is shown in the Oxidation Flow Sheet.

The compounds whose formulas appear in large brackets were not isolated.

An examination of this Flow Sheet will disclose the fact that the oxidation of irene (VII), $C_{14}H_{20}$, occurs with the loss of an atom of carbon, thus giving rise to acids containing only 13 atoms of carbon. A similar loss of carbon in such oxidations has been observed in these Laboratories in the study of the methyl ionenes,[9] and of 1,1-dimethyltetralin.[6] Further, von Braun and his co-workers[10] have also shown that in the case of alpha-substituted tetralins, this same saturated ring opens during oxidation, with concurrent elimination of one carbon atom. It is easy to understand, therefore, why Tiemann and Krüger, on the basis of their analyses of these C_{13} oxidation products, assigned to both irone and irene (VI) a C_{13} formula.

The structures we have assigned to our oxidation products differ somewhat from those of Tiemann and Krüger, but are more in conformity with the aromatic constitution of irene (VII) and ionene (IX). The formula (VII) proposed for irene by Ruzicka, Seidel and Schinz,[7] therefore, explains satisfactorily the oxidation products of Tiemann and Krüger, particularly if we can assume for the keto acids (XIX and XX) the isomeric structures (XXV and XXVI) we have suggested upon the Flow Sheet, although these intermediate keto acids were not encountered in the course of our work.

Acknowledgments.—The analyses recorded in the Experimental part which follows were carried out by Mr. S. Gottlieb, using micro methods.

We are indebted also to Mr. A. L. Greenberg, who aided in the preparation of the *m*-tolylethanol; and to Mr. A. Weissler, who carried out a large part of the laboratory work on the oxidation of irene (VII).

To Dean Frank C. Whitmore, State College, Pennsylvania, we are under obligations for a supply of methyl isopropyl ketone.

Experimental

beta-(*m*-Tolyl)-ethanol (XIII) was prepared from *m*-bromotoluene and ethylene oxide via the Grignard reaction. The product was a colorless liquid, b. p. 115–118° at 10 mm. Carré,[11] who obtained it from *m*-xylylmagnesium bromide and trioxymethylene, gave its b. p. as 112–113° at 10 mm.

Phenylurethan.—Colorless needles, from ethanol and water, m. p. 59–60°.

Anal. Calcd. for $C_{16}H_{17}O_2N$: N, 5.49. Found: N, 5.60.

1-(*m*-Tolyl)-3,4-dimethylpentanol-3 (XV).—The *m*-tolylethanol was converted into the corresponding *bromide* (XIV) (b. p. 103–106° at 10 mm.), by the action of phosphorus tribromide, and the *m*-tolylethylmagnesium bromide, then condensed with methyl isopropyl ketone to the tertiary alcohol (XV), which formed a clear colorless liquid, of faint rose odor, and boiled at 150–152° at 10 mm.; yield 41.5%.

Anal. Calcd. for $C_{14}H_{22}O$: C, 81.49; H, 10.61. Found: C, 81.92; H, 10.73.

No phenylurethan could be prepared from it.

1,1,2,6-Tetramethyltetralin (irene) (VII).—The tertiary alcohol (XV) was dehydrated by treatment with sulfuric acid,[6,12] and the hydrocarbon thus formed, after rectification over sodium, formed a clear colorless viscous liquid, of characteristic musty odor, much like that of ionene (IX); yield 83.3%. Its physical constants were b. p. 120–125° at 10 mm., d^{25}_4 0.9379, n^{25}_D 1.5261; *M*R calcd. 61.05; found, 61.58.

Anal. Calcd. for $C_{14}H_{20}$: C, 89.29; H, 10.70. Found: C, 88.92; H, 10.31.

Dehydrogenation of Irene (VII).—A mixture of 5 g. of the above tetralin with 5 g. of selenium powder was heated for sixty-five hours at 250–280°. The cooled melt was pulverized and extracted with ether. This extract was divided, one portion being converted into an orange *picrate*, and the other into a yellow *styphnate*. The melting points of these two products are given in the table on page 930.

Oxidation of Irene (VII)

alpha-(4-Methyl-2-carboxyphenyl)-isopropyl Methyl Ketone (XXIII).—Following the process of Tiemann and Krüger for the preparation of "trioxydehydroirene," or "dehydroireneoxylactone," as it was later designated by Tiemann,[13] 2 g. of irene (VII) was oxidized in acetic acid

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[10] Von Braun, *et al.*, *Ber.*, **56**, 2332 (1923).

[11] Carré, *Compt. rend.*, **148**, 1109 (1909); *Bull. soc. chim.*, [4] **5**, 486 (1909).

[12] Bogert and Davidson, THIS JOURNAL, **56**, 185 (1934).

[13] Tiemann, *Ber.*, **31**, 809 (1898).

solution with chromic anhydride. The crude keto acid was purified by solution in alkali and reprecipitation by hydrochloric acid. The pale brownish flocculent precipitate which separated (yield, about 20%) was crystallized twice from benzene, and gave small white crystals, m. p. 154–155° (corr.), in agreement with the melting point reported by Tiemann and Krüger for their "trioxydehydroirene."

Anal. Calcd. for $C_{13}H_{16}O_3$: C, 70.90; H, 7.27; neut. equiv., 220. Found: C, 70.70; H, 7.28; neut. equiv., 222.

Tiemann and Krüger purified their crude acid by solution in sodium carbonate and reprecipitation by carbon dioxide, but we found that method troublesome and unsatisfactory.

Our product gave a very definite iodoform test, indicative of the presence of the acetyl group. It is not clear why Tiemann and Krüger assigned to this acid a constitution which contained neither an acetyl nor a carboxyl group, although they recognized its acidic character. The structure we have proposed is what one would expect if the oxidation followed the same course as in the case of ionene (IX).[5]

As by-products in this oxidation, some unchanged irene was recovered, and a small amount of a substance of agreeable peppermint-like odor, which was not isolated in sufficient quantity for further study.

Alpha - (4 - methyl - 2 - carboxyphenyl) - isobutyric acid (XXIV) has been isolated by Bogert and Fourman[5] as one of the oxidation products of ionene. Attempts to obtain this acid, by the action of hypohalite upon a small amount of the foregoing ketone acid (XXIII), were not very satisfactory. The product melted at 139–144°, and was apparently a mixture of the acid sought (m. p. 131°) and the unaltered ketone acid (m. p. 154–155°). The quantity available was insufficient for further purification.

Alpha-(2,4-dicarboxyphenyl)-isobutyric Acid (4-Carboxy-alpha, alpha-dimethylhomophthalic Acid) (XXI).—Irene (VII) was refluxed for eight hours with an excess of saturated alkaline (sodium hydroxide) potassium permanganate. When cold, the reaction mixture was decolorized with sodium bisulfite, filtered from the precipitated manganese oxides, and the filtrate acidified with hydrochloric acid. The heavy white amorphous precipitate which separated was purified by solution in aqueous sodium hydroxide and reprecipitated by the addition of mineral acid. This is the "ioniregentricarboxylic acid" of Tiemann and Krüger. It has no sharp melting point, but passes gradually into its anhydride (XXII) when heated.

The neutralization equivalent of our acid was found to be 84; calculated for $C_{12}H_{12}O_6$, 84. The melting point of the anhydride was 214° (corr.); as compared with 214° reported by Tiemann and Krüger;[2] 214–215° (corr.), given by Pope and Bogert;[9] and 217° (corr.), found by Bogert and Fourman.[5]

Summary

1. The 1,1,2,6-tetramethyltetralin structure for irene (VII), proposed by Ruzicka, Seidel, and Schinz, has been supported by the synthesis of this tetralin from *m*-bromotoluene.

2. This synthetic irene (VII), which is a methyl homolog of ionene (IX), yields the same oxidation products as the irene (VII) prepared from the irone of the orris root.

3. The $C_{13}H_{18}$ formula given by Tiemann and Krüger for irene (VI), should be replaced by $C_{14}H_{20}$, in conformity with the results obtained by Ruzicka, Seidel, and Schinz, and with those reported above.

4. An explanation is offered as to why Tiemann and Krüger obtained C_{13} oxidation products from a C_{14} hydrocarbon.

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[CONTRIBUTION FROM THE RESEARCH LABORATORIES OF FRITZSCHE BROTHERS, INCORPORATED]

Identification of Citral in California Orange Oil

BY ERNEST S. GUENTHER AND CHARLES H. GRIMM

This investigation was undertaken for the purpose of identifying citral in California orange oil.

According to H. D. Poore,[1] who made an investigation of California orange oil, decylic aldehyde is the only aldehyde present in this oil. Nelson and Mottern[2] identified citral in the oil of Florida Valencia oranges. In the isolation of citral from the terpeneless oil, Nelson and Mottern used the sodium sulfite method of Tiemann.[3] This might be the reason why H. D. Poore, who used sodium bisulfite, was unable to identify citral in California sweet orange oil. Semmler[4] had identified citral in Italian sweet orange oil as far back as 1891, but K. Stephan[5] found only decylic aldehyde in Italian orange oil. However, Stephan like Poore had used the bisulfite method in extracting the aldehydes from the terpeneless oil.

Y. R. Naves,[6] well aware of the existing contradiction between Semmler's and Stephan's findings

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[1] H. D. Poore, Tech. Bull. 241, U. S. Dept. of Agriculture, 1932.

[2] Nelson and Mottern, THIS JOURNAL, **56**, 1238 (1934).

[3] Tiemann, *Ber.*, **31**. 3318–3320 (1898).

[4] Semmler, *ibid.*, **24**, 202 (1891).

[5] K. Stephan, *J. prakt. Chem.*, [II] **62**, 523 (1900).

[6] Y. R. Naves, *Parfums de France*, **112**, 161 (1932).