sodium hydroxide and refluxed 3 hr. Samples of the cooled solution were spotted on strips of filter paper, along with known solutions (*ca.* 3 mg. per ml.) of 1,6-diaminohexane, δ-aminocaproic acid, and ε-aminovaleric acid, individually and mixed together. ω-Aminoenanthic acid was spotted on identical paper, but at a later date because of the unavailability of a sample at the time. The strips were developed by descending paper chromatography for 12 hr., with an eluant prepared by thoroughly mixing 1-butanol, glacial acetic acid, and water in the ratio 40:10:50 and discarding the lower layer. The strips were air-dried for 4 hr., sprayed with 0.25% alcoholic ninhydrin, and dried for 30 min. The R_f values calculated[12] were those listed above. Similar results were obtained when the Beckmann rearrangement was initiated with phosphorus pentachloride.

Birch reduction of benzocycloöctene. $\Delta^{1,6}$-*Bicyclo[4.6.0]-dodecene.* Benzocycloöctene was prepared by the method of Huisgen and Rapp,[6] except that methyl acid adipate (Eastman Kodak Co.), was employed instead of the ethyl ester. The hydrocarbon (1.6 g., b.p. 95–100°/5 mm., n_D^{25} 1.5376 to 1.5380, lit.[6] n_D^{21} 1.5392) was added dropwise to a stirred mixture of 0.7 g. of clean lithium wire and 50 ml. of dry ethylamine, under an atmosphere of nitrogen in an apparatus fitted with a Dry Ice cooled condenser, at such a rate that the blue color of the solution was not discharged. At the end of the addition more (0.15 g.) lithium was introduced and stirring was continued 2 hr. The unchanged lithium was removed and the solution was concentrated at room temperature. About 50 ml. of water was added with cooling and the solution was extracted with 80 ml. of ether in four portions. The extracts were washed with dilute hydrochloric acid and water, and dried over sodium sulfate. Removal of the solvent gave 1.34 g. of an oil (b.p. 45–46°, 0.15–0.2 mm.; n_D^{25} 1.5024) which was twice redistilled from a micro still. The fraction analyzed boiled at 42° (0.1 mm.); n_D^{25} 1.5022.

Anal. Calcd. for $C_{12}H_{20}$: C, 87.73; H, 12.28. Found: C, 87.75; H, 12.28.

The infrared spectrum of this substance was very similar to that of the $C_{12}H_{20}$ product obtained from cyclododecatriene, the peaks being sharper in the Birch reduction product presumably as the result of higher purity.

1,6-Cyclododecadione. The ozonolysis of 0.534 g. of the above olefin in 75 ml. of carbon tetrachloride was conducted with 4% ozonized oxygen at 0° for 2 hr. The product, isolated as described above, melted at 91–94° after one crystallization from petroleum ether (b.p. 00–00°), and at 94–95° after sublimation, undepressed by admixture with the sample described above. The infrared spectra of the two samples were indistinguishable.

Anal. Calcd. for $C_{12}H_{20}O_2$: C, 73.41; H, 10.27. Found: C, 73.27; H, 10.23.

The dioxime melted at 240°.

Anal. Calcd. for $C_{12}H_{22}O_2N_2$: C, 63.68: H, 9.80. Found: C, 63.92; H, 9.87.

The di-*p*-nitrophenylhydrazone[11] melted at 203–206°, undepressed by admixture of the derivative (m.p. 203–207°) described above, but the analyses of this sample indicated incomplete removal of solvent. No depression of melting point occurred when the (unanalyzed) disemicarbazones[11] from the two samples of diketone were mixed; in this instance the derivative of the diketone prepared from the triolefin melted higher (212° dec., *vs.* 202–205° dec.). The bisdinitrophenylhydrazone[11] (unanalyzed) melted at 266–267° dec.

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[12] E. Lederer and M. Lederer, "Chromatography," Elsevier Publishing Co., New York, N. Y., 1957, p. 115.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF KENTUCKY]

Preparation and Acid-Catalyzed Solvolysis of 6-Tosyloxyisophorone

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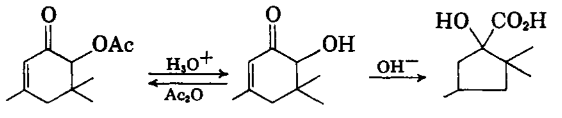
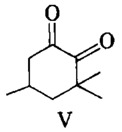
6-Tosyloxyisophorone (I) in dioxane-hydrochloric acid undergoes loss of *p*-toluenesulfonic acid to give 3,4,5-trimethylphenol. In methanolic hydrogen chloride I gives 3,4,5-trimethylanisole.

6-Tosyloxyisophorone (I) has been prepared in three steps from isophorone. Some acid-catalyzed solvolysis reactions have been examined briefly and are reported here.

Isophorone was acetoxylated with lead tetraacetate to give a fair yield of an acetoxyisophorone which has been assigned structure II on the basis of its conversion to III and IV. The ketol III, obtained by hydrolysis of II, was oxidized by Fehlings solution and also gave a positive acyloin test.[1] Acetylation of the ketol gave back II. The structure of III was established by its conversion to the known compound, 1-hydroxy-2,2,4-trimethylcyclopentanecarboxylic acid (IV), by the action of hot alcoholic alkali. The transformation of III to IV undoubtedly proceeds through the α-diketone V, which, however, was not isolated in the present work. The rearrangement of III to V has a fairly close analogy in the conversion of 2-hydroxypulegone to diosphenol in hot aqueous alkali.[2] It has been shown that V is converted into IV in hot alkali.[3]



II III IV



V

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[1] W. Rigby, *J. Chem. Soc.*, 793 (1951).

[2] R. H. Reitsema, *J. Am. Chem. Soc.*, **79**, 4465 (1957).

[3] M. Qudrat-I-Khuda and S. K. Ghosh, *J. Ind. Chem. Soc.*, **16**, 287 (1939).

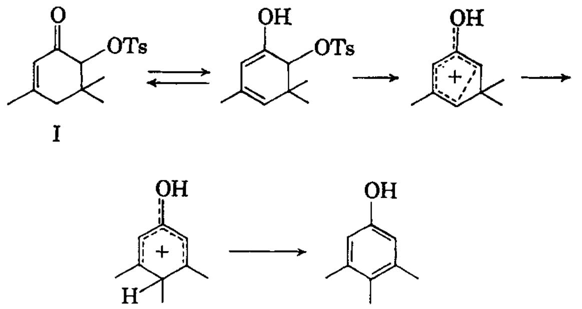
The reaction of III with *p*-toluenesulfonyl chloride in cold pyridine gave 6-tosyloxyisophorone (I).

I was boiled under reflux in dioxane-6*N* hydrochloric acid (1:1). The phenolic reaction product was identified as 3,4,5-trimethylphenol by its melting point, infrared spectrum, and the melting point of its dibromide. The same trimethylphenol was obtained by Doering and Beringer as the product of reaction of isophorone with 30% oleum,[4] and the product-forming stage of the latter reaction is undoubtedly similar to the present reaction.[5]

Methanolysis of I in the presence of hydrogen chloride, like the preceeding reaction, gave aromatization with shift of a methyl group from C-5 to C-4. The crude product of this reaction was almost pure 3,4,5-trimethylanisole, identified by comparison of its infrared spectrum with that of an authentic sample, and by the melting point of its bromide. The infrared spectrum of this product showed weak absorption at 5.95 μ, indicating the presence of a trace of a carbonyl compound, but there was no indication of the presence of 2,3,5-trimethylanisole.

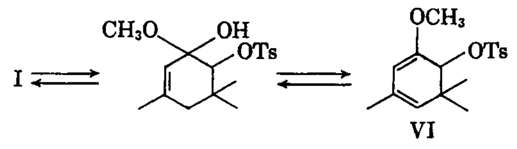
DISCUSSION

The primary function of the acid catalyst in the present reactions is probably that of catalyzing the conversion of I to the corresponding enol, thereby permitting easy ionization to a carbonium ion *via* an allylic sulfonate.[6] Protonation of ester oxygen may also aid ionization of I or its enol form by permitting the tosyloxy group to leave as a molecule of *p*-toluenesulfonic acid. A possible mechanism for the solvolysis of I in dioxane-hydrochloric acid is outlined in the following reaction sequence, for each step of which there are well-known analogies.



I

The methanolysis of I in the presence of hydrogen chloride would be expected to give the same product obtained in dioxane-hydrochloric acid.[7] The isolation of the methyl ether of 3,4,5-trimethylphenol instead of the trimethylphenol itself indicates a pre-equilibrium of I with methanol to give the enol ether VI which ionizes and undergoes aromatization.



VI

EXPERIMENTAL

Melting points are corrected. Microanalyses are by Drs. Weiler and Strauss, Oxford, England and Clark Microanalytical Laboratory, Urbana, Ill.

Isophorone. A practical grade of isophorone was purified by fractional distillation. Four cuts of material boiling from 105° to 106° (21 mm.), were taken, n_D^{24} 1.4767–1.4764 (lit. b.p. 99° (18 mm.),[8] n_D^{22} 1.4761[9]). Two oximes of isophorone as described by Kon[9] were obtained in low yield. The *2,4-dinitrophenylhydrazone* was obtained in only one form and was easily purified by recrystallization from absolute ethanol, m.p. 147–148°; the melt sometimes crystallized above 149° and melted again near 155°.

Anal. Calcd. for $C_{15}H_{18}N_4O_4$: C, 56.59; H, 5.70; N, 17.60. Found: C, 56.29; H, 5.41; N, 17.88.

6-Acetoxyisophorone (II). Isophorone (138 g., 1.00 mole), glacial acetic acid (600 ml.) and acetic anhydride (400 ml.) were placed in a 2-l., 3-necked flask equipped with a mechanical stirrer, reflux condenser, and thermometer. The reaction flask was warmed to 60°, external heating was then discontinued and 700 g. (1.02 moles) of red lead oxide was added to the stirred mixture in small portions at a rate sufficient to maintain the temperature at 75–80° (4 hr.). External heating was resumed and the mixture was stirred at *ca.* 72° for 4 hr. more then the solvent was removed with the aid of an aspirator. The residue was broken up, stirred with warm water, and extracted with two large portions of ether. The combined ether extracts were washed with water, with aqueous sodium carbonate, again with water, and dried. Ether was replaced by ligroin and the ligroin solution was refrigerated. The product that crystallized slowly from ligroin was recrystallized twice from ligroin to give 47 g. of almost colorless II, m.p. 76.5–77°. Evaporation of the ligroin mother liquors and distillation of the oily residue gave an additional 23 g. of II, b.p. 141–145° (12 mm.), which crystallized. Two recrystallizations from ligroin gave 12 g. of colorless product, m.p. 77–77.5°. The yield of twice recrystallized product was 30%.

Anal. Calcd. for $C_{11}H_{16}O_3$: C, 67.32; H, 8.22. Found: C, 67.65; H, 8.55.

6-Hydroxyisophorone (III). Finely ground II (5.5 g., 0.028 mole) was shaken mechanically with 25 ml. of 6*N* hydrochloric acid at room temperature for 5 hr. The mixture was neutralized with sodium bicarbonate solution and extracted with several portions of ether. The combined ether extracts were dried and concentrated by evaporation. Hexane was added and the solution was further concentrated. Refrigera-

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[4] W. von E. Doering and F. M. Beringer, *J. Am. Chem. Soc.*, **71**, 2221 (1949).

[5] Doering and Beringer postulated a 4-isophoronesulfonic acid intermediate to account for exclusive shift of methyl from C-5 to C-4. The present work shows that the same result might be expected if 6-isophoronesulfonic acid were an intermediate in the reaction of isophorone with 30% oleum.

[6] α-Haloketones undergo ionization very slowly. See, for example, E. L. Eliel, in M. S. Newman's *Steric Effects in Organic Chemistry,* J. Wiley and Sons, Inc., New York, 1956, p. 103. 6-Tosyloxyisophorone was recovered almost quantitatively after refluxing for one week in methanol in the presence of a trace of 2,6-lutidine.

[7] If concentrated hydrochloric acid is used as catalyst instead of dry hydrogen chloride in the methanolysis, an appreciable amount of phenolic product is obtained in addition to the aromatic ether.

[8] A. W. Crossley and C. Gilling, *J. Chem. Soc.*, **95**, 19 (1909).

[9] G. A. R. Kon, *J. Chem. Soc.*, **119**, 810 (1921).

tion of the hexane solution gave 3.1 g. (72%) of III, m.p. 45–46°.

Anal. Calcd. for $C_9H_{14}O_2$: C, 70.10; H, 9.15. Found: C, 69.72; H, 8.70.

III gave positive tests with Fehlings solution and bismuth oxide.[1] Reaction of III with acetic anhydride in the presence of sodium acetate gave II, m.p. 76–77° after recrystallization from hexane.

The *oxime* of III was recrystallized from methanol-water, m.p. 144–145°.

Anal. Calcd. for $C_9H_{15}NO_2$: 63.88; H, 8.94; N, 8.28. Found: C, 63.64; H, 8.78; N, 8.09.

The *2,4-dinitrophenylhydrazone* of III was recrystallized from ethanol, m.p. 182–183°.

Anal. Calcd. for $C_{15}H_{18}N_4O_5$: C, 53.88; H, 5.43; N, 16.76. Found: C, 54.04; H, 5.42; N, 16.90.

The *2,4-dinitrophenylosazone* of III was obtained by heating III with an equal weight of 2,4-dinitrophenylhydrazine in methanol (85 ml.) containing concd. hydrochloric acid (3 ml.) for 4 hr. on a steam bath, m.p. 258–259° dec., after recrystallization from ethanol-ethyl acetate.

Anal. Calcd. for $C_{21}H_{20}N_8O_8$: C, 49.22; H, 3.93; N, 21.87. Found: C, 49.36; H, 3.99; N, 21.89.

1-Hydroxy-2,2,4-trimethyl-1-cyclopentanecarboxylic acid (IV). A solution of 2.2 g. (0.014 mole) of III and 2.0 g. of potassium hydroxide in 7.0 ml. of absolute ethanol was boiled under reflux for 2.5 hr. One-half of the solvent was removed by distillation and the mixture was cooled, diluted with water, and washed with hexane. The alkaline solution was acidified and extracted with hexane. The hexane solution was washed with a small portion of cold water, dried over anhydrous sodium sulfate, concentrated by evaporation of part of the solvent, and cooled to give 1.1 g. of pale brown crystals. Sublimation and recrystallization from hexane gave 0.8 g. (33%) of IV, m.p. 89–90° (lit.,[3] m.p. 90°). The structure of IV was confirmed by cleavage with lead tetraacetate in benzene to 2,2,4-trimethylcyclopentanone, identified by its 2,4-dinitrophenylhydrazone, m.p. 164–165° (lit.,[10] m.p. 164.0–164.5°).

6-Tosyloxyisophorone (I). Crude III obtained by hydrolysis of 12.3 g. (0.063 mole) of II was dissolved in 10 ml. of cold pyridine and treated with a cold solution of 11.5 g. (0.060 mole) of *p*-toluenesulfonyl chloride in 25 ml. of pyridine. The reaction mixture was refrigerated for 3 days, worked up in the usual manner, and the crude product was recrystallized from acetone to give 10.4 g. (54% overall) of I, m.p. 133° dec.

Anal. Calcd. for $C_{16}H_{20}O_4S$: C, 62.31; H, 6.54; S, 10.40. Found: C, 62.48; H, 6.46; S, 10.34.

3,4,5-Trimethylanisole was prepared from 3,4,5-trimethylphenol, sodium hydroxide and methyl iodide in methanol, b.p. 107–108° (16 mm.), m.p. 26–27° (lit.,[11] m.p. 28–29°).

The *bromo derivative of 3,4,5-trimethylanisole* was prepared in ethanol-water and recrystallized from ethanol-water then from hexane, m.p. 80–80.5°.

Anal. Calcd. for $C_{10}H_{13}BrO$: C, 52.42; H, 5.72. Found: C, 52.35; H, 5.97.

2,3,5-Trimethylanisole was prepared from 2,3,5-trimethylphenol, sodium hydroxide and methyl iodide in methanol, b.p. 92–93° (10 mm.), (lit.,[12] b.p. 213–216°).

The *bromo derivative of 2,3,5-trimethylanisole* was prepared in methanol-water and recrystallized from methanol-water, m.p. 51°.

Anal. Calcd. for $C_{10}H_{13}BrO$: C, 52.42; H, 5.72. Found: C, 52.64; H, 5.71.

Aromatization of 6-tosyloxyisophorone in dioxane-hydrochloric acid. A solution of 3.04 g. (0.010 mole) of 6-tosyloxyisophorone in 15 ml. of dioxane and 15 ml. of 8*N* hydrochloric acid was boiled under reflux for 30 min. The reaction mixture was cooled, made alkaline with ice and excess sodium hydroxide solution, and filtered to remove unchanged starting material (8% recovery). The alkaline solution was concentrated by distilling away part of the solvent, filtered again and acidified. Filtration gave 0.55 g. (45% crude) of slightly discolored 3,4,5-trimethylphenol, m.p. 108.5° after sublimation and recrystallization from hexane (lit.,[13] m.p. 107°). The dibromide was recrystallized twice from ethanol-water, m.p. 144° (lit.,[4] m.p. 144–145°).

Aromatization of 6-tosyloxyisophorone in methanolic hydrogen chloride. 6-Tosyloxyisophorone (3.0 g., 0.010 mole) in 75 ml. of anhydrous methanol saturated with hydrogen chloride was boiled under reflux for 1 hr. The reaction mixture was cooled and neutralized, methanol was removed by distillation, and the mixture was extracted with hexane. The hexane solution was washed with water and dried, and hexane was removed by evaporation. Flash distillation of the residue gave 0.87 g. (60%) of 3,4,5-trimethylanisole, infrared spectrum like that of authentic 3,4,5-trimethylanisole except for a weak peak at 5.95 μ, bromo derivative m.p. 79–80.5° after recrystallization from methanol then from hexane.

Acknowledgment. The author appreciates the assistance of Mr. William W. Hoffman with some of the reactions reported here.

LEXINGTON, KY.

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(10) S. F. Birch and E. A. Johnson, *J. Chem. Soc.*, 1493 (1951).

(11) K. v. Auwers, *Ann.*, **422**, 160 (1921).

(12) K. v. Auwers and E. Borsche, *Ber.*, **48**, 1716 (1915).

(13) K. v. Auwers and K. Saurwein, *Ber.*, **55**, 2372 (1922)