3.12 g. (20.6 mmoles, 71%) of **2-amino-3,4,5-trimethylphenol** as colorless plates, m.p. 164.5–165°.

Anal. Calcd. for $C_9H_{13}NO$: C, 71.49; H, 8.66; N, 9.26. Found: C, 71.59; H, 8.56; N, 9.20.

A solution of 0.50 g. (3.3 mmoles) of 2-amino-3,4,5-trimethylphenol in 9 cc. of 3.5% hydrochloric acid at 50° was treated with 0.35 cc. of acetic anhydride and with 0.30 g. of sodium acetate in 2.0 cc. of water. The precipitate was crystallized from water to give 0.58 g. (3.0 mmoles, 91%) of **2-acetamido-3,4,5-trimethylphenol** as colorless plates, m.p. 162–163°.

Anal. Calcd. for $C_{11}H_{15}NO_2$: C, 68.37; H, 7.82; N, 7.25. Found: C, 68.21; H, 7.88; N, 7.10.

The Aromatization of Isophorone Enol Acetate.—According to the procedure of Hagemeyer and Hull[17] 75 cc. (0.5 mole) of isophorone and 81.4 cc. (0.5 mole) of isopropenyl acetate[27] were refluxed under a helix-packed column until 40 cc. of acetone had been collected. The residue was rapidly distilled under reduced pressure to give 80.8 g. of crude isophorone enol acetate. Redistillation through a small Vigreux column gave 70.8 g. (0.392 mole, 78.4%) of **isophorone enol acetate**, b.p. 96° at 4 mm., saponification equivalent 180 (calcd., 181).

Bromination and aromatization in the manner described in a previous section gave a 34.8% yield of trimethylphenols.

Isophorone Dibromide.—According to the method of Baker,[16] the addition of bromine to isophorone in carbon tetrachloride at 7° gave a 76% yield of **isophorone dibromide**, dried in a continuously evacuated desiccator.

On keeping for 48 hours at room temperature in a beaker covered by a watch glass isophorone dibromide (56.5 g., 0.19 mole) decomposed to give 38 g. of a dark brown liquid. Distillation under reduced pressure gave 2 cc. of water, 5 cc. of a fraction b.p. 43–54° at 18 mm. (b.p. 119° in a micro b.p. tube) and 18 cc. (0.12 mole, 62%) of isophorone, b.p. 60° at 3 mm. (b.p. 211° in a micro b.p. tube).

A solution of 36 g. (0.13 mole) of isophorone dibromide in 160 cc. of 1,2,4-trichlorobenzene was refluxed for five hours. From the reaction mixture there was obtained in the manner described in a previous section 0.5 g. of phenols, m.p. 66–73°. Runs in which isophorone dibromide was heated in carbon tetrachloride (reflux) or in 2,4-lutidine (70°) gave no phenolic product.

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[27] A research sample from the Tennessee Eastman Co. is gratefully acknowledged.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE POLYTECHNIC INSTITUTE OF BROOKLYN]

The Aromatization and Rearrangement of Cyclic Ketones. IV. Substituted Acetanilides from Cyclohexenone Oximes[1]

BY F. MARSHALL BERINGER AND ISIDORE UGELOW

RECEIVED NOVEMBER 28, 1952

An improved method for the aromatization of cyclohexanone oximes when applied to 3-methyl-5-phenylcyclohexanone oxime gave 3-methyl-5-phenylacetanilide. Under similar conditions isophorone oxime gave 2,3,5- and 3,4,5-trimethylacetanilide while 3-phenyl-5,5-dimethylcyclohexanone oxime gave 2,3- and 3,4-dimethyl-5-phenylacetanilide. A possible mechanism for such reactions is discussed.

Over the past sixty years there have been scattered reports of the conversion of cyclohexenone oximes to anilines and their derivatives.[2] Thus the oximes of cyclohexenone[3] and of its 3-methyl,[4] 4-isopropyl,[5,6] 3,5-dimethyl[4,7] and 3-methyl-6-isopropyl[6] derivatives gave on treatment with acetic anhydride or acetyl chloride acetanilide and the corresponding alkyl derivatives. Yields were in general low or unreported. Related is the formation of carvacryl amine (from the oximes of carvenone,[8] carvone[6,9] and thujone[10]) and of amine derivatives of naphthalene,[11] quinoline[12] and thiophene.[13] The dehydration of isophorone oxime to 3,4,5-trimethylaniline on treatment with 20% hydrochloric acid at 170° is the only case in which rearrangement is said to accompany aromatization.[4,14]

The work presently reported had two aims. The first was to find satisfactory conditions for the conversion of cyclohexenone oximes to acetanilides. A second aim was the outgrowth of our previously reported investigations of the concurrent aromatization and rearrangements of isophorone[15,16] and of 3-phenyl-5,5-dimethylcyclohexenone[17] to trisubstituted phenols. Here we wished to see whether the oximes of these two cyclohexenones could be converted to the analogous trisubstituted acetanilides.

Our search for satisfactory reaction conditions was guided by two experimental facts and a working hypothesis for the mechanism. The facts were that hot acetic anhydride did not effect the aromatization of isophorone oxime, while addition of acetyl chloride to isophorone oxime caused a violent exo-

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[1] This paper, based largely on a thesis submitted by Isidore Ugelow in partial fulfillment of the requirements of the degree of Master of Science in Chemistry in the Graduate School of the Polytechnic Institute of Brooklyn in June, 1952, was presented in part at the 122nd meeting of the American Chemical Society, September 14 to 19, 1952, Atlantic City, N. J.

[2] E. C. Horning has surveyed alicyclic-aromatic conversions in *Chem. Revs.*, **33**, 89 (1943).

[3] A. A. Kötz and T. Grethe, *J. prakt. Chem.*, [2] **80**, 500 (1909).

[4] L. Wolff, M. Gabler and F. Heyl, *Ann.*, **322**, 351 (1902).

[5] P. A. Berry, A. K. Macbeth and T. B. Swanson, *J. Chem. Soc.*, 986 (1937).

[6] R. G. Cooke and A. K. Macbeth, *ibid.*, 1593 (1937).

[7] An attempt to aromatize 3,5-dimethylcyclohexenone oxime by heating with palladium on charcoal was unsuccessful: E. C. Horning and M. G. Horning, THIS JOURNAL, **69**, 1907 (1947). For a successful application of this method see reference 13.

[8] Carvenone oxime hydrochloride gave carvacryl amine on dry distillation: O. Wallach, *Ber.*, **40**, 582 (1907).

[9] In the reported conversion of carvone oxime to carvacryl amine and carvacrol on heating with alcoholic sulfuric acid, reduction accompanied aromatization: O. Wallach, *Ann.*, **275**, 110 (1893). That a base-catalyzed mechanism for this reaction also exists is indicated by the formation of carvacryl amine from carvone oxime on treatment with potassium hydroxide at 230–240°: O. Wallach, *Ann.*, **279**, 366 (1894).

[10] F. W. Semmler, *Ber.*, **25**, 3352 (1892).

[11] G. Schroeter, *ibid.*, **63B**, 1308 (1930); H. E. Zaugg, M. Freifelder and B. W. Horrom, *J. Org. Chem.*, **15**, 1197 (1950).

[12] W. S. Johnson, E. L. Woroch and B. G. Buell, THIS JOURNAL, **71**, 1901 (1949).

[13] L. C. Cheney and J. R. Piening, *ibid.*, **67**, 729 (1945).

[14] Attempts in our laboratory to repeat this work gave isophorone but no amine.

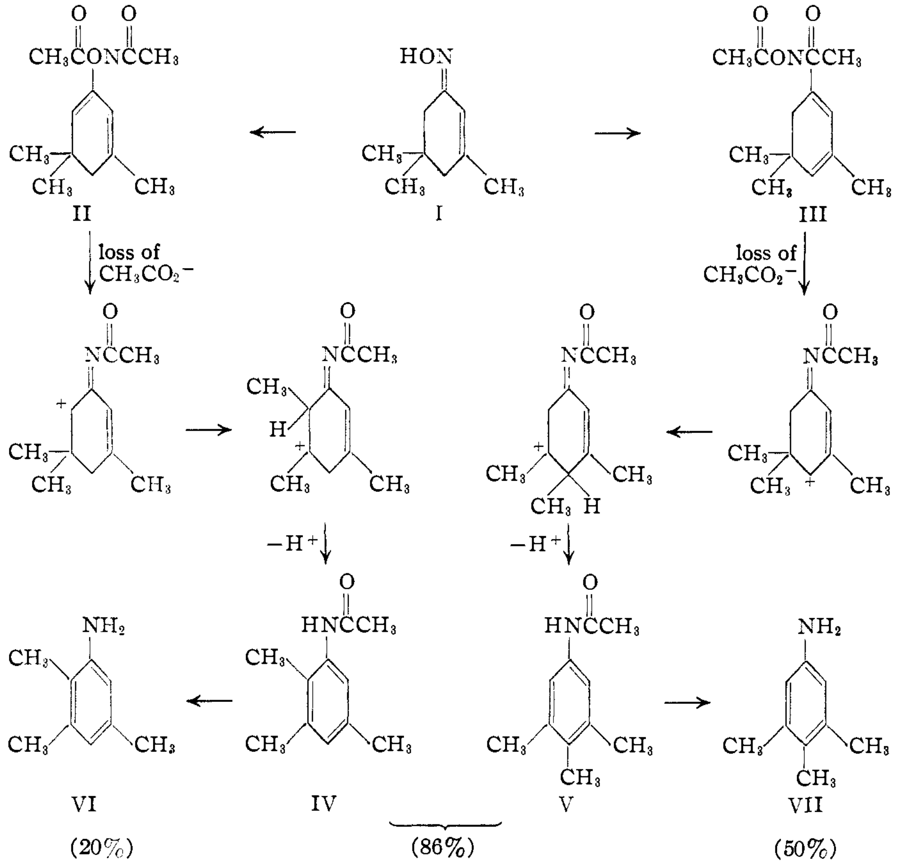
[15] W. von E. Doering and F. M. Beringer, THIS JOURNAL, **71**, 221 (1949).

[16] F. M. Beringer and E. J. Geering, *ibid.*, **75**, 2633 (1953).

[17] F. M. Beringer and I. Kuntz, *ibid.*, **73**, 364 (1951).

thermic reaction (possibly a Beckmann rearrangement[18]). The mechanistic hypothesis was that aromatization would proceed by way of an acid-catalyzed loss of acetate ion from an O-acetyl or an O,N-diacetylhydroxylamine (II, III), exemplified below with isophorone oxime (I).

2,3,5- AND 3,4,5-TRIMETHYLACETANILIDE FROM ISOPHORONE OXIME
POSSIBLE REACTION PATHS

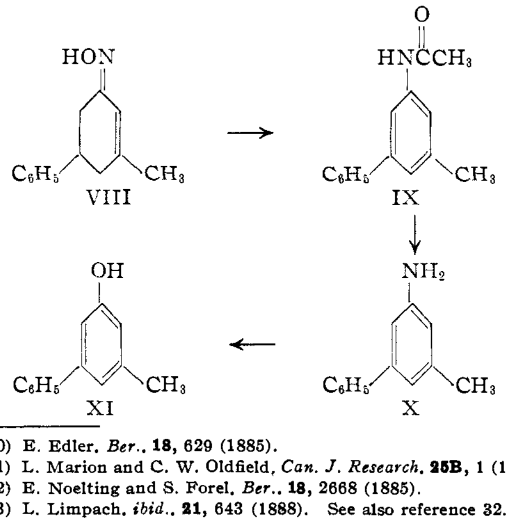


The aromatization of three cyclohexenone oximes was successfully carried out in a three-step procedure. After treatment with acetic anhydride and pyridine had formed the oxime acetate, acetyl chloride was added to the cold solution with the aim of forming the O,N-diacetylhydroxylamine. The solution was heated to about 65°. After about ten minutes an exothermic reaction started, finally under reflux. Heating on the steam-bath was followed by work-up by standard methods to give acetanilides in yields of 50, 86 and 75% of the theoretical from the oximes of 3-methyl-5-phenylcyclohexenone, isophorone and 3-phenyl-5,5-dimethylcyclohexenone.

The amide from 3-methyl-5-phenylcyclohexenone oxime (VIII) was shown to be 3-methyl-5-phenylacetanilide (IX) by hydrolysis to the previously unreported 3-methyl-5-phenylaniline (X), which in turn was converted to the known[19] 3-methyl-5-phenylphenol (XI) and its benzoate.

Hydrolysis of the mixed acetanilides (IV, V) from the aromatization of isophorone oxime (I) was followed by the separation of 2,3,5-trimethylaniline[20,21] (VI) in 20% yield and 3,4,5-trimethylaniline[22–24] (VII) in 50% yield providing a convenient route to this hitherto difficultly accessible compound. Previously reported derivatives were prepared to aid in the identification of the amines, while new derivatives were prepared for their fuller characterization.

The crude product from the aromatization of 3-phenyl-5,5-dimethylcyclohexenone oxime (XII) was converted to mixed aniline hydrochlorides in 74% of the theoretical yield. In this case only a part of the total yield was obtained as pure amines, 2,3-dimethyl-5-phenylaniline (XIII) being obtained in 18% yield while 3,4-dimethyl-5-phenylaniline (XIV) was obtained in 28% yield. Each of these amines was characterized by formation of acetyl and benzoyl derivatives. Further, each amine was converted to the corresponding phenol and its α-naphthylurethan. The phenol and α-naphthylurethan obtained from 3,4-dimethyl-5-phenylaniline proved identical to 3,4-dimethyl-5-phenylphenol (XV) and its α-naphthyl urethan prepared from 3-phenyl-5,5-dimethylcyclohexenone in a previous study[17] and prepared independently by an unequivocal method[17] not involving rear-



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(18) Recent work has allowed assignment of structures to the geometric isomers of the oximes of isophorone and 3-methyl-5-phenylcyclohexenone on the basis of the amides formed by Beckmann rearrangement: R. S. Montgomery and G. Dougherty, *J. Org. Chem.*, **17**, 823 (1952). The isomers of these oximes studied in the present work have the hydroxyl group *anti* to the olefinic double bond.

(19) V. Prelog, O. Metzler and O. Jeger, *Helv. Chim. Acta*, **30**, 675 (1947).

(20) E. Edler, *Ber.*, **18**, 629 (1885).

(21) L. Marion and C. W. Oldfield, *Can. J. Research*, **25B**, 1 (1947).

(22) E. Noelting and S. Forel, *Ber.*, **18**, 2668 (1885).

(23) L. Limpach, *ibid.*, **21**, 643 (1888). See also reference 32.

(24) V. M. Berezovskii, V. A. Kurdyukova and N. A. Preobrazhenskii, *Zhur. Obschei Khim.*, **21**, 1163 (1951); *C. A.*, **46**, 5006 (1952).

rangement. 2,3-Dimethyl-5-phenylaniline (XIII) is considered to have the structure assigned by analogy with 2,3,5-trimethylaniline, from isophorone oxime.

It is interesting that under different acidic conditions cyclohexenone oximes may give either of two rearrangements: aromatization, as discussed in the present paper, and the Beckmann rearrangement.[25] Thus in a recent paper[18] Montgomery and Dougherty have reported a careful investigation of the Beckmann rearrangement (as the basis for the assignment of configuration to the isomeric oximes) of the oximes of two ketones used in the present work, isophorone and 3-methyl-5-phenylcyclohexenone. Schroeter[11] in his extensive study of ar-substituted α-tetralone oximes went further and investigated the effect of substituents and conditions on the nature of the rearrangement. It seems significant that while α-tetralone oxime was aromatized in 70% yield, 1,4-dimethyl-α-tetralone oxime under the same conditions gave the Beckmann rearrangement. Such an observation is rationalized by the mechanistic hypothesis presented earlier in this paper. The postulated O,N-diacetylhydroxylamine (compare II, III) and probably the O-acetylhydroxylamine would be prevented by the 1-methyl group from achieving the planarity necessary to transmit into the alicyclic ring the positive charge developing as the acetate group leaves.

Experimental[26]

Preparation of 2,3,5- and 3,4,5-Trimethylaniline (VI and VII) and Derivatives from Isophorone. Isophorone Oxime (I).—Redistilled isophorone (300 ml., 2.0 moles), 170 g. of 96–98% hydroxylamine hydrochloride, 170 ml. of dry pyridine and 200 ml. of methanol were shaken to give a pale yellow solution. After 24 hours the reaction mixture was poured slowly into 500 ml. of water with vigorous stirring, giving a faintly pink crystalline precipitate. Crushed ice (500 g.) was now added, and the mixture was stirred until the ice had melted. The precipitate was washed on a buchner funnel with 1500 ml. of water and dissolved in 300 ml. of hot hexane, allowing the water to be removed in a separatory funnel. The water layer was extracted with hexane, and the combined hexane solutions were dried while hot with anhydrous magnesium sulfate and cooled. Isophorone oxime (I), m.p. 77–78°, was obtained in three crops, 269.4 g. in all (87.9%). The m.p. of isophorone oxime has been frequently reported between 74 and 79.5°,[27] as 82°[28] and recently[18] as 78.2–78.5° for the isomer with the hydroxyl group *anti* to the olefinic double bond.

Anal. Calcd. for $C_9H_{15}NO$: C, 70.54; H, 9.87. Found: C, 70.66; H, 9.65.

2,3,5- and 3,4,5-Trimethylacetanilides (IV and V).—To a cold solution (refrigerated overnight) of 306.4 g. (2.0 moles) of isophorone oxime (I) in 1000 ml. of redistilled acetic anhydride and 161 ml. (2.0 moles) of pyridine in a 3-l. r.b. flask there was added 142 ml. (2.0 moles) of redistilled acetyl chloride in 100 ml. of acetic anhydride, with formation of a crystalline precipitate. Heating the reaction mixture by a water-bath at 65° gave a clear orange solution, which after ten minutes darkened with accompanying rise in temperature. After the solution had refluxed without external heating for about five minutes, the water-bath was heated to 100° for one hour. Water (1250 ml.) was now added through the condenser, care being taken to ensure thorough mixing after each addition. The reaction mixture was divided between two 2-l. erlenmeyer flasks, to each of which 500 ml. of hot water was then added. The flasks, in which crystallization had commenced, were refrigerated overnight. The precipitate was collected by filtration, washed thoroughly with water, then dried *in vacuo* at 105° to give 280.3 g. of mixed trimethylacetanilides, m.p. 130–145°. By concentration of the mother liquors to 500 ml. and adding to 500 g. of ice an oily mass was obtained, from which by crystallization from benzene and by sublimation there was obtained 26.1 g. of additional mixed trimethylacetanilides, m.p. 146–155°, for a combined yield of 306.4 g. (1.728 moles, 86.4% yield).

2,3,5- and 3,4,5-Trimethylaniline (VI and VII).—A suspension of the combined yield of mixed trimethylacetanilides in 200 ml. of concd. sulfuric acid and 800 ml. of water was refluxed for two hours after solution was effected, then cooled, made basic with concd. sodium hydroxide solution and cooled again at 5°. The aqueous layer was decanted from the solid trimethylaniline, which was transferred to a distilling flask. The aqueous layer was extracted with hexane and with ether, and the extracts were added to the distilling flask. The material (217 g.) distilling from 125 to 250° (mostly 242–248°) was collected.

Crystallization of the distillate of mixed trimethylaniline from 100 ml. of 28–38° petroleum ether gave 101.4 g. of 3,4,5-trimethylaniline (VII), m.p. 78–79.5°. Concentration of the mother liquor and washings gave a second crop of 14.6 g., m.p. 77–79°.

The 2,3,5- and 3,4,5-trimethylaniline in the mother liquors were now subjected to systematic fractional crystallization as the hydrochlorides from absolute ethanol. Regeneration from the hydrochlorides gave additional pure isomers plus oily fractions, which were purified by way of the easily formed and hydrolyzed trimethylformanilides. Altogether these procedures gave 55.0 g. of 2,3,5-trimethylaniline, m.p. 38–39°, and 19.1 g. of 3,4,5-trimethylaniline, m.p. 78–79°. Thus there was obtained altogether 135.1 g. (0.999 mole) of 3,4,5-trimethylaniline (VII) and 55.0 g. (0.407 mole) of 2,3,5-trimethylaniline (VI), a combined yield of trimethylanilines of 70.3% from isophorone oxime.

The 2,3,5-trimethylaniline was obtained by crystallization from petroleum ether as needles, m.p. 38–39°; reported 36°[20] and 39°.[21]

Anal. Calcd. for $C_9H_{13}N$: C, 79.95; H, 9.69; N, 10.36. Found: C, 80.30; H, 9.81; N, 10.22.

The 3,4,5-trimethylaniline was obtained by crystallization from heptane as needles, m.p. 78.5–79°; reported 67–68°,[23] 75°,[24] 76–77°[25] and 79–80°.[5]

Anal. Calcd. for $C_9H_{13}N$: C, 79.95; H, 9.69; N, 10.36. Found: C, 80.04; H, 9.84; N, 10.10.

Derivatives of 2,3,5-Trimethylaniline.—2,3,5-Trimethylformanilide was obtained from methanol as needles, m.p 132.5–133°; reported[22] 135.5°.

Anal. Calcd. for $C_{10}H_{13}NO$: C, 73.58; H, 8.03. Found C, 73.87; H, 7.93.

2,3,5-Trimethylacetanilide (IV) was obtained from methanol as needles, m.p. 171.5–172°.

N-(2,3,5-Trimethylphenyl)-*p*-toluenesulfonamide, prepared by the Schotten–Baumann procedure, was obtained from methanol as cottony needles, m.p. 146–146.5°.

Anal. Calcd. for $C_{16}H_{19}NO_2S$: C, 66.40; H, 6.62; N, 4.84. Found: C, 66.18; H, 6.67; N, 4.91.

2,3,5-Trimethyl-4,6-dibromoaniline, prepared by bromination in acetic acid, was obtained from heptane as needles, m.p. 169–169.5°.

Anal. Calcd. for $C_9H_{11}Br_2N$: C, 36.89; H, 3.78; Br, 54.55; N, 4.78. Found: C, 37.11; H, 3.53; Br, 54.69; N, 4.69.

Derivatives of 3,4,5-Trimethylaniline.—3,4,5-Trimethylformanilide was obtained from heptane as crystals, m.p. 99–100°; reported[23] 98.5°.

Anal. Calcd. for $C_{10}H_{13}NO$: C, 73.58; H, 8.03; N, 8.58. Found: C, 73.71; H, 8.20; N, 8.66.

3,4,5-Trimethylacetanilide was obtained from methanol as crystals, m.p. 171.5–172°; reported 163–164°[22] and 164.5°.[23]

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[25] Bruymor Jones has surveyed the Beckmann rearrangement in *Chem. Revs.*, **35**, 335 (1944).

[26] Melting points were taken in a modified Hershberg apparatus. Microanalyses were performed by Dr. Weiler and Dr. Strauss, 164 Banbury Road, Oxford, England.

[27] Beilstein, "Handbuch der Organischen Chemie," Fourth Ed., Vol. VII, Springer-Verlag, Berlin, Germany, Main Work, p. 65; First Supp., p. 56; Second Supp., p. 65.

[28] R. C. Morris and A. V. Snider, U. S. Patent 2,462,009 (Feb. 14, 1949).

N-(3,4,5-Trimethylphenyl)-*p*-toluenesulfonamide, prepared by the Schotten–Baumann procedure, was obtained from methanol and chloroform–hexane as hexagonal prisms, m.p. 155.5–156°.

Anal. Calcd. for $C_{16}H_{19}NO_2S$: C, 66.40; H, 6.62; N, 4.84. Found: C, 66.10; H, 6.58; N, 4.62.

3,4,5-Trimethyl-2,6-dibromoaniline, prepared by the bromination of 3,4,5-trimethylaniline in acetic acid–1:3 hydrochloric acid, was crystallized from heptane and from ethanol to give needles, m.p. 162.5–163.5°.

Anal. Calcd. for $C_9H_{11}Br_2N$: C, 36.89; H, 3.78; N, 4.78. Found: C, 36.83; H, 3.66; N, 4.77.

Diazotization of 3,4,5-trimethyl-2,6-dibromoaniline in hydrobromic acid suspension and addition of excess cuprous bromide were followed by heating the solution to 100°. The product was removed and washed with water. After passage in a benzene solution through an alumina column **1,2,3-trimethyl-4,5,6-tribromobenzene** (tribromohemimellitene) was obtained as colorless crystals, m.p. 241–243°: reported 241°[29] and 245°.[30]

Anal. Calcd. for $C_9H_9Br_3$: C, 30.28; H, 2.54. Found: C, 30.65; H, 2.64.

3,4,5-Trimethylphenol, prepared by heating a solution of diazotized 3,4,5-trimethylaniline in 1:1 aqueous sulfuric acid, was recrystallized from heptane to give needles, m.p. 107–108°; reported[15,16,31] 106 to 109.5°.

Treatment of diazotized 3,4,5-trimethylaniline with aqueous sodium iodide followed by the usual work-up gave **3,4,5-trimethyliodobenzene** (5-iodohemimellitene), m.p. 34–35°; reported[32] 35°.

Anal. Calcd. for $C_9H_{11}I$: C, 43.92; H, 4.51; I, 51.57. Found: C, 44.18; H, 4.67; I, 51.5.

Carbonation of the Grignard reagent from 3,4,5-trimethyliodobenzene gave in small yield **3,4,5-trimethylbenzoic acid**, crystals from aqueous acetic acid, m.p. 218–219°; reported[33] 215–216°.

Preparation of 3-Methyl-5-phenylaniline and Derivatives from 3-Methyl-5-phenylcyclohexenone. 3-Methyl-5-phenylcyclohexenone Oxime (VIII).—3-Methyl-5-phenylcyclohexenone,[5,18,34] m.p. 36–37°, was obtained in 44% yield from ethyl α,α-diacetyl-β-phenylglutarate[34] according to the procedure of Horning and Field.[35] 3-Methyl-5-phenylcyclohexenone (30.0 g., 0.161 mole), hydroxylamine hydrochloride (11.7 g., 0.168 mole), pyridine (13.5 ml., 0.168 mole) and sufficient methanol to give complete solution were mixed and allowed to stand for 24 hours. The solid precipitated by the addition of water was crystallized from aqueous methanol to give 31 g. (95%) of **3-methyl-5-phenylcyclohexenone oxime (VIII)**, m.p. 121–122°; reported, 115°[5] and recently[18] as 120.2–121.2° for the isomer with the hydroxyl group *anti* to the olefinic double bond.

Anal. Calcd. for $C_{13}H_{15}NO$: C, 77.58; H, 7.50; N, 6.96. Found: C, 77.15; H, 7.22; N, 6.82.

3-Methyl-5-phenylacetanilide (IX).—A solution of 14.39 g. (0.0715 mole) of 3-methyl-5-phenylcyclohexenone oxime in 50 cc. of acetic anhydride and 6 cc. of pyridine was refluxed for 30 minutes and then cooled. Acetyl chloride (15 ml.) was added, and the mixture was again refluxed for 30 minutes. Hydrolysis and neutralization with ammonium hydroxide gave a precipitate which was collected, dried and crystallized from benzene to give 8.0 g. (50%) of **3-methyl-5-phenylacetanilide (IX)**, cottony needles of m.p. 165.5–167°.

Anal. Calcd. for $C_{15}H_{15}NO$: C, 79.96; H, 6.70; N, 6.22. Found: C, 79.89; H, 6.63; N, 6.29.

3-Methyl-5-phenylaniline (X).—A suspension of 2.50 g. (0.0111 mole) of 3-methyl-5-phenylacetanilide in 70 ml. of 1:1 hydrochloric acid was refluxed for one hour and then cooled to give light tan needles of the hydrochloride of 3-methyl-5-phenylaniline. Treatment with alkali liberated the free amine as a solid, which was decolorized with charcoal in methanol and then crystallized from aqueous methanol to give 1.6 (0.0088 mole, 79%) of **3-methyl-5-phenylaniline (X)** as needles, m.p. 80–82°.

Anal. Calcd. for $C_{13}H_{13}N$: C, 85.21; H, 7.15; N, 7.64. Found: C, 85.20; H, 7.04; N, 7.89.

Treatment of 3-methyl-5-phenylaniline with benzoyl chloride in hot benzene gave **N-benzoyl-3-methyl-5-phenylaniline**, pearly needles from benzene, m.p. 142–143°.

Anal. Calcd. for $C_{20}H_{17}NO$: C, 83.59; H, 5.96; N, 4.87. Found: C, 83.87; H, 6.06; N, 4.83.

3-Methyl-5-phenylacetanilide (2.4 g., 0.0106 mole) was converted to the amine sulfate by refluxing 20% sulfuric acid. Without isolation this amine sulfate was diazotized in the usual way and then heated to 50°. The separated red-brown oil was collected by extraction with benzene and removal of the solvent. After removal of non-phenolic materials, it was possible to induce crystallization, giving 0.9 g. (0.0047 mole, 44%) of **3-methyl-5-phenylphenol (XI)** as light needles, which after sublimation were colorless and had a m.p. of 56–58°; reported[36] 56°.

Anal. Calcd. for $C_{13}H_{12}O$: C, 84.75; H, 6.57. Found: C, 85.00; H, 6.31.

3-Methyl-5-phenylphenyl benzoate, prepared from the phenol by a Schotten–Baumann reaction with benzoyl chloride, had a m.p. of 97–98°; reported[36] 98°.

Anal. Calcd. for $C_{20}H_{16}O_2$: C, 83.31; H, 5.59. Found: C, 83.38; H, 5.83.

Preparation of 2,3- and 3,4-Dimethyl-5-phenylaniline from 3-Phenyl-5,5-dimethylcyclohexenone. 3-Phenyl-5,5-dimethylcyclohexenone Oxime (XII).—Twenty-one grams (0.105 mole) of 3-phenyl-5,5-dimethylcyclohexenone,[17,37] 8.8 g. (0.127 mole) of hydroxylamine hydrochloride and 12 cc. of pyridine were dissolved in a minimum of methanol, and the clear solution was allowed to stand overnight. The colorless needles of oxime were removed by filtration. Addition of water (incipient turbidity) to the filtrate gave a second crop of oxime, the combined yield being 21.7 g. (0.101 mole, 96%) of 3-phenyl-5,5-dimethylcyclohexenone oxime, m.p 154–156°; reported 156–157°[37] and 160–161.3°.[17]

2,3- and 3,4-Dimethyl-5-phenylaniline (XIII, XIV) from 3-Phenyl-5,5-dimethylcyclohexenone Oxime.—A solution of 30.2 g. (0.14 mole) of 3-phenyl-5,5-dimethylcyclohexenone oxime in 125 cc. of acetic anhydride and 14 cc. of pyridine was refluxed for 45 minutes, cooled, treated with 35 cc. of acetyl chloride, and refluxed for an additional 45 minutes. Addition of water precipitated an oil which slowly changed to a tan solid. A suspension of this solid in 600 cc. of 1:1 hydrochloric acid was refluxed for one hour and then cooled to give 24.2 g. (0.104 mole, 74.3%) of tan needles of the **hydrochlorides of 2,3- and 3,4-dimethyl-5-phenylaniline**.

Partial separation of this material into the isomers was effected by crystallization of the hydrochlorides (from benzene–methanol) and of the free amines (from petroleum ether). On the basis of the free amines, there were obtained 5.06 g. (0.0257 mole, 18.4%) of **2,3-dimethyl-5-phenylaniline (XII)** and 7.58 g. (0.0385 mole, 27.5%) of **3,4-dimethyl-5-phenylaniline (XIV)**.

2,3-Dimethyl-5-phenylacetanilide.—A sample of the crude hydrochloride of 2,3-dimethyl-5-phenylaniline was converted with hot acetic anhydride to 2,3-dimethyl-5-phenylacetanilide, m.p. 135–137°, after crystallization from benzene.

Anal. Calcd. for $C_{16}H_{17}NO$: C, 80.30; H, 7.16; N, 5.86. Found: C, 80.10; H, 7.02; N, 6.20.

2,3-Dimethyl-5-phenylaniline (XIII).—Acid hydrolysis of 2,3-dimethyl-5-phenylacetanilide, liberation of the free amine from the separated amine hydrochloride, and crystallization of the product from petroleum ether (27–38°) gave 2,3-dimethyl-5-phenylaniline, m.p. 41–42°.

Anal. Calcd. for $C_{14}H_{15}N$: C, 85.23; H, 7.66; N, 7.10. Found: C, 85.21; H, 7.46; N, 7.30.

2,3-Dimethyl-5-phenylphenol.—Diazotization of 2,3-dimethyl-5-phenylaniline and hydrolysis with hot 40% sul-

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furic acid gave in the usual way a black crude phenol. Two treatments of this material in benzene solution with charcoal gave, in turn, a gray, waxy solid, which was sublimed to give 2,3-dimethyl-5-phenylphenol as colorless needles of m.p. 51–52°.

Anal. Calcd. for $C_{14}H_{14}O$: C, 84.81; H, 7.11. Found: C, 84.74; H, 6.94.

α-Naphthylurethan of 2,3-Dimethyl-5-phenylphenol.—Heating a mixture of 2,3-dimethyl-5-phenylphenol with α-naphthyl isocyanate and a catalytic amount of pyridine gave crude α-naphthylurethan of 2,3-dimethyl-5-phenylphenol. One crystallization from heptane gave pale yellow crystals, m.p. 135–136°.

Anal. Calcd. for $C_{25}H_{21}NO_2$: C, 81.72; H, 5.76; N, 3.81. Found: C, 81.55; H, 5.81; N, 3.53.

3,4-Dimethyl-5-phenylacetanilide.—A sample of the crude hydrochloride of 3,4-dimethyl-5-phenylaniline was converted with hot acetic anhydride to 3,4-dimethyl-5-phenylacetanilide, m.p. 167–168.3°, after crystallization from dilute acetic acid.

Anal. Calcd. for $C_{16}H_{17}NO$: C, 80.30; H, 7.16; N, 5.86. Found: C, 80.28; H, 7.19; N, 5.82.

3,4-Dimethyl-5-phenylaniline (XIV).—Acid hydrolysis of 3,4-dimethyl-5-phenylacetanilide and liberation of the free amine from the separated amine hydrochloride gave a waxy solid. This was crystallized from dilute methanol to give 3,4-dimethyl-5-phenylaniline as colorless needles, m.p. 71–72°.

Anal. Calcd. for $C_{14}H_{15}N$: C, 85.23; H, 7.66; N, 7.10. Found: C, 85.28; H, 7.73; N, 7.11.

3,4-Dimethyl-5-phenylphenol (XV).—A solution of diazotized 3,4-dimethyl-5-phenylaniline in dilute sulfuric acid was slowly added to boiling 40% sulfuric acid, and the reaction mixture was boiled for ten minutes. Extraction of the cooled reaction mixture with ether gave, after removal of the solvent, crude 3,4-dimethyl-5-phenylphenol. Sublimation gave colorless needles of 3,4-dimethyl-5-phenylphenol, m.p. 106.5–107.5°, with no depression of m.p. on admixture with an authentic sample (Beringer and Kuntz, ref. 17). The ultraviolet absorption spectra of the two samples of the phenol were superimposable.

Anal. Calcd. for $C_{14}H_{14}O$: C, 84.81; H, 7.11. Found: C, 84.88; H, 6.93.

α-Naphthylurethan of 3,4-Dimethyl-5-phenylphenol.—Heating a mixture of 3,4-dimethyl-5-phenylphenol with α-naphthyl isocyanate and a catalytic amount of pyridine gave crude α-naphthylurethan of 3,4-dimethyl-5-phenylphenol. This was crystallized twice from heptane to give colorless needles, m.p. 171–172°; reported[18] 171–172°. Admixture with an authentic sample[18] of this urethan showed no depression of the m p.

Anal. Calcd. for $C_{25}H_{21}NO_2$: C, 81.72; H, 5.76; N, 3.81. Found: C, 81.63; H, 5.60; N, 3.60.

BROOKLYN 2, N. Y.

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY, GEORGIA INSTITUTE OF TECHNOLOGY]

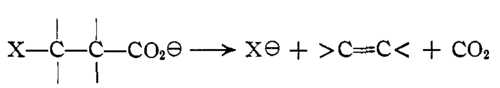
The Stereochemistry and Mechanism of the Transformation of Cinnamic Acid Dibromide to β-Bromostyrene[1]

BY ERLING GROVENSTEIN, JR., AND DONALD E. LEE

RECEIVED DECEMBER 17, 1952

The sodium salt of *trans*-cinnamic acid dibromide in absolute ethanol has been found to give β-bromostyrene which consists predominantly of the *cis* isomer, while in water predominantly the *trans* isomer results. Possible mechanisms for these reactions are considered and it is concluded that in absolute ethanol *trans* elimination of the elements of carbon dioxide and bromide ion occurs in a concerted process somewhat analogous to the bimolecular elimination reaction (E2) of alkyl halides. In water there appears to be a preliminary ionization followed by decarboxylation, a process which recalls the unimolecular elimination reaction (E1) of alkyl halides. The effect of substituents upon the stereochemistry, rate and product composition of analogous decarboxylative eliminations is discussed and found to be in general agreement with these mechanistic considerations. Dufraisse's synthesis of *cis*-β-bromostyrene is discussed.

The preparation of olefins from the salts of β-halo acids may be expressed by the equation



$$X{-}\overset{|}{\underset{|}{C}}{-}\overset{|}{\underset{|}{C}}{-}CO_2^{\ominus} \longrightarrow X^{\ominus} + {>}C{=}C{<} + CO_2$$

One of the oldest known examples of this reaction is the transformation of cinnamic acid dibromide[2] to β-bromostyrene in boiling water or, frequently at lower temperature, in aqueous sodium carbonate. It seemed to us that such elimination reactions[3] might resemble elimination reactions of alkyl halides. One method of comparison would be by study of stereochemical interrelationships between products and reactants.

In 1904 Pfeiffer,[4] in his interesting repudiation of the van't Hoff–Wislicenus theory of *cis* elimination and *cis* addition, proposed that carbon dioxide and halide ion are eliminated from β-halo acids in the *trans* sense. Pfeiffer's theory does not seem to have received appreciable attention. In part, at least, this is due to the fact that diastereoisomeric β-halo acids have been reported in a number of cases to give the same olefin. Thus Liebermann[5] reported that the β-bromostyrene obtained from *cis*-cinnamic acid dibromide, m.p. 91–93°, in aqueous solution was about the same as that from *trans*-cinnamic acid dibromide, m.p. 200° (dec.). K. v. Auwers[6] has confirmed the observations of Liebermann and in addition reports that *trans*-cinnamic acid dibromide yields the same product when treated with alcoholic potassium acetate solution. Since these results are in opposition to Pfeiffer's theory and since Dufraisse[7] reports that *cis*- and *trans*-β-bromostyrene are readily isomerized by light, we have undertaken a repetition of the work of Liebermann and v. Auwers with respect to *trans*-cinnamic acid dibromide.

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(1) Presented in part before the Division of Organic Chemistry, American Chemical Society. Atlantic City. N. J., Sept. 16, 1952.

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(3) It will be convenient to designate eliminations in which carbon dioxide and halide ion are lost as "decarboxylative eliminations." This term seems to have been used first in connection with an apparently similar reaction by E. J. Corey and G. Fraenkel, paper before the Division of Organic Chemistry. American Chemical Society. Sept. 16. 1952.

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