to about *p*H 10 with concentrated ammonia solution and extracted with ethylene dichloride. The extract was washed with very dilute ammonia (*p*H 10) and dried a short time over Drierite. Before filtration the suspension was shaken with Norite. The filtered solution was then evaporated to dryness yielding the crude quinone (VIb) as a dark orange oil containing octyl alcohol.

For identification this oil was converted to the phenazine VIIIb. Half of the above product was dissolved in 2 ml. of acetic acid and treated with 0.20 g. of powdered *o*-phenylenediamine. The red solution was then warmed on the steam-bath for 15 minutes and allowed to stand at room temperature overnight. After it had been diluted with water, the solution was washed with petroleum ether to remove octyl alcohol. It was then treated with concentrated ammonia solution to bring the *p*H up to about 10 and extracted with ethylene dichloride. The fluorescent extract was washed with 1 *N* potassium hydroxide and dilute ammonia and finally shaken with Drierite and Norite. The residue obtained upon evaporation to dryness under reduced pressure was dissolved in absolute alcohol and treated with a few drops of 48% hydrobromic acid and a small volume of anhydrous ether. When the resulting turbid solution was cooled and scratched and seeded with the hydrobromide of VIIIb prepared from the oxidation product of Vb (see above), a red crystalline precipitate began to form. The suspension was allowed to stand in the refrigerator overnight and then treated with more ether before the product was filtered off. There was apparently a considerable quantity of impurity present since attempts to precipitate most of the salt resulted in the separation of an oil. The crystalline material was dissolved in hot absolute alcohol and reprecipitated by the addition of anhydrous ether. The red salt thus obtained from half of the original crude quinone weighed 0.06 g. (15% from VIIb). The micro melting point of this material was about 194°. After recrystallization from absolute alcohol and ether the melting point behavior showed the same changes as noted for the sample of the dihydrobromide dihydrate of 5-(5'-isopropylaminoamylamino)-pyrido[3,2-a]phenazine (VIIIb) prepared from Vb. The infrared and ultraviolet absorption spectra (Figs. 2 and 3) of the products from the two sources were very similar. It is quite probable that the slight differences between the two sets of curves are due to the presence of traces of impurities in the product obtained from VIIb.

**Treatment of Pentaquine (I) with Oxygen.**—A sample of pentaquine dihydrochloride was dissolved in water and treated with sodium bicarbonate solution and oxygen under conditions identical with those which led to the oxidation of demethylated pentaquine. After a few minutes much of the pentaquine precipitated from the solution but no other change was observed. At the end of the 4-hour reaction period a visual examination of the colors developed with diazotized sulfanilic acid indicated that one-third of the original pentaquine remained in solution and that no reaction had occurred. The precipitate was filtered off, washed and dissolved in alcohol. The alcohol solution was treated with concentrated hydrochloric acid and the hydrochloride of the base was precipitated with ether. The filtrate was made strongly alkaline and extracted with ethylene dichloride. The extract was washed, dried and evaporated to dryness and the residue was converted to the dihydrochloride. The hydrochlorides from both the precipitate and filtrate of the original reaction mixture melted only slightly below the melting point of pure pentaquine dihydrochloride and the melting points of mixtures with the latter were not depressed.

**Absorption Spectra.**[23]—The infrared spectra were measured by means of a Perkin–Elmer model 12C recording spectrometer with the pulverized samples suspended in mineral oil. The ultraviolet spectra were determined with a Beckman model DU quartz spectrophotometer, using approximately 0.1 *N* hydrochloric acid as the solvent.

(23) The authors wish to thank Dr. Robert Spurr and Mr. Richard Jewell for the infrared, and Mr. Everett Frazza for the ultraviolet spectra.

COLLEGE PARK, MD. RECEIVED AUGUST 9, 1950

---

[CONTRIBUTION NO. 216 FROM THE RESEARCH LABORATORIES OF HOFFMANN-LA ROCHE INC.]

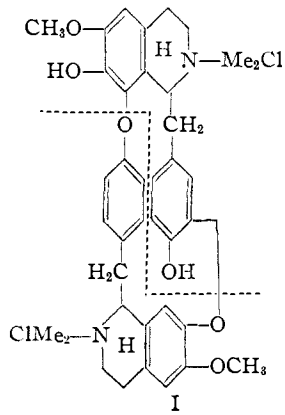
# The Synthesis of *dl*-Coclaurine

BY JACOB FINKELSTEIN

In the search for a curare-like acting substance the benzylisoquinoline portion of the *d*-tubocurarine chloride molecule was considered. A natural occurring compound of identical structure with such biological activity has been reported. To verify this the compound had to be synthesized. The greatest handicap to the conventional benzylisoquinoline synthesis has been the difficulty in obtaining the β-phenylethylamines. In this paper several methods were studied and conditions are described for the easy preparation of the desired amine in good yields. The compounds with possible biological significance were tested but found to be devoid of any curare-like activity at the dose levels tried.

With the establishment of *d*-tubocurarine chloride as a useful drug in medicine, much chemical research has been undertaken to find simpler active compounds. Among the investigations undertaken in these laboratories along these lines, consideration was given to the possible existence of an active fragment in the *d*-tubocurarine chloride molecule. When the King[1] formula for the alkaloid I is bisected, each half is represented by the structure of 1-(4-hydroxybenzyl)-6-methoxy-7-hydroxy-2,2-dimethyl-1,2,3,4-tetrahydroisoquinolinium chloride.

A closely related substance, 1-(4-hydroxybenzyl)-6-methoxy-7-hydroxy-1,2,3,4-tetrahydroisoquinoline or *d*-coclaurine, is known. This alkaloid was isolated in pure form by Kondo and Kondo[2] who also established its chemical constitution and structure by degradative methods. Since then no further work has been reported. Additional




I

interest in this active fragment idea was furnished from a report by Plugge[3] who tested extracts of the source of this alkaloid and found it to possess a weak and definite curare-like activity. The ex-

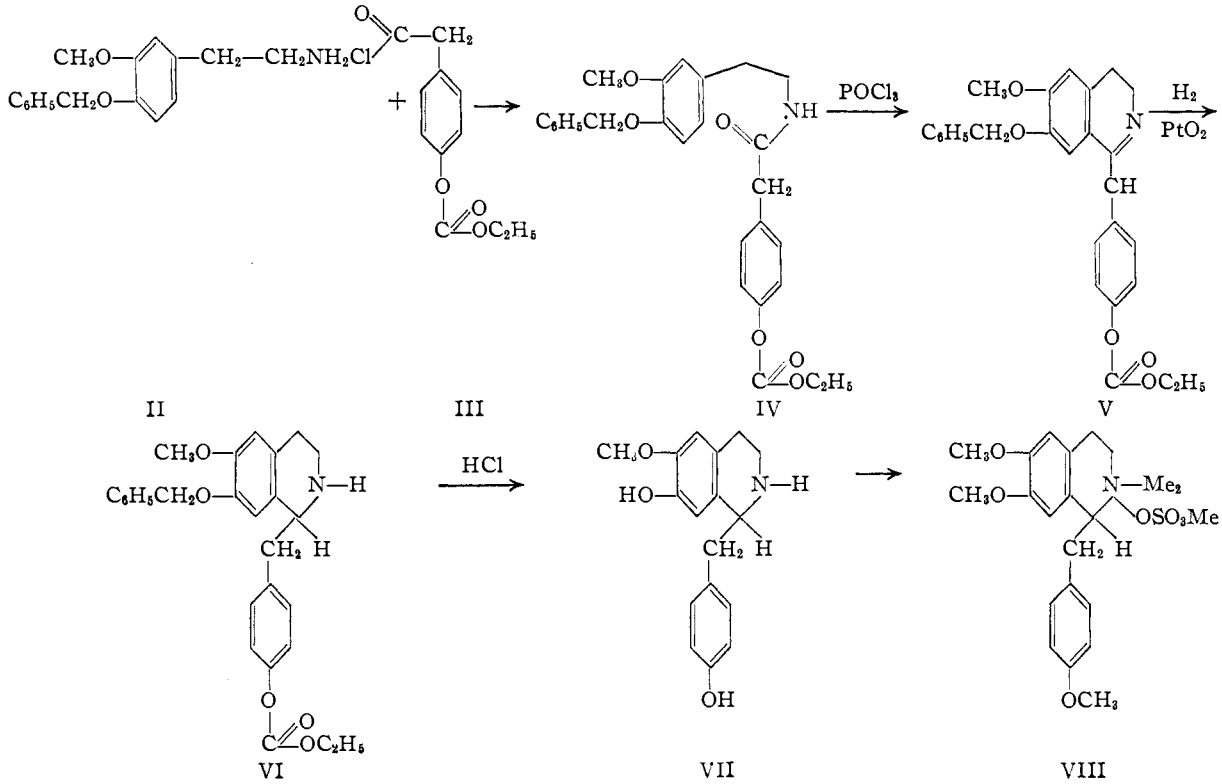
(1) King, *J. Chem. Soc.*, 265 (1949).

(2) Kondo and Kondo, *J. prakt. Chem.*, **126**, 24-52 (1930).

(3) Plugge, *Arch. expil. path. Pharmakol.*, **32**, 266 (1893).

tracts exerted a general paralyzing action. The attack was principally at the neuromuscular junction of the motor nerves as shown by experiments in frogs. In view of the facts that curariform activity has been associated with quaternary salts; that coclaurine is a secondary base; and that the frog method is not now considered an adequate method of screening for tubocurarine-like activity, a re-evaluation of the drug seemed advisable. Therefore, we synthesized *dl*-coclaurine and its quaternized methylated derivative.

The synthesis was achieved in the following manner, employing such easily removable blocking groups as benzyl and carbethoxy




The benzyl ether of vanillin, prepared according to the information furnished by Professor Alfred Burger,[3a] was treated with nitromethane by the improved method of Lange and Hambourger[4] who claimed a 97% yield of 3-methoxy-4-benzyloxy-ω-nitrostyrene I. In our hands the yield was 60%. The reduction of this nitrostyrene I to 3-methoxy-4-benzyloxy-β-phenethylamine II required considerable study. The hitherto studied methods of reduction, chemical, catalytic or electrolytic, left much to be desired. Kobayashi[5] reported the synthesis of this compound by first reducing the nitrostyrene I with zinc dust in an alcoholic solution of acetic acid at 5–10° to the oxime which in turn was reduced with sodium amalgam at 30–50° to the amine, but did not report his yield. Späth,[6] *et al.*, referred to a similar procedure employed by Burger[3a] for the synthesis of this compound in an over-all yield of 20%. Thus, it became imperative to investigate other methods for preparing this compound.

The Reichert[7] method of preparing β-phenethylamine derivatives from nitrostyrenes was tried with success. The nitrostyrene was hydrogenated in pyridine with palladium to the corresponding aldoxime which was then reduced in alcohol containing oxalic acid by means of hydrogen and platinum. Upon decomposing the resultant oxalate, the desired amine II was obtained in 27% over-all yield. At the conclusion of this experiment, Nystrom and Brown[8] published their elegant method of reduction with lithium aluminum hydride. Included among the types of compounds successfully reduced by them with this new reagent was β-nitrostyrene to β-phenylethylamine in 60% yield. When this method was applied to the nitrostyrene I, the yield was over 70% of II. It was found that the intermediate oxime, as prepared by the Reichert procedure, when treated with lithium aluminum hydride gave the same product. Recently, similar reductions have been reported by Hamlin and Weston[9] and Ramirez and Burger.[10]

For the acid chloride III, the carbethoxy was selected as the blocking group. The *p*-hydroxyphenylacetic acid[11] was carbethoxylated and converted to the chloride III which reacted with II to form the amide IV. The amide was treated with phosphorus oxychloride in the usual manner, and the dihydroisoquinoline V was isolated as its hydrochloride. When V was reduced at 25–50°

(3a) Private communication from Prof. Burger, University of Virginia.
(4) Lange and Hambourger, THIS JOURNAL, **53**, 3865 (1931).
(5) Kobayashi, *Chem. Centr.*, **99**, I, 1026–1028 (1928).
(6) Späth, Orechoff and Kuffner, *Ber.*, **67**, 1214 (1934).
(7) Reichert, German Patent 629,313, April, 1936.
(8) Nystrom and Brown, THIS JOURNAL, **70**, 3738 (1948).
(9) Hamlin and Weston, *ibid.*, **71**, 2210 (1949).
(10) Ramirez and Burger, *ibid.*, **72**, 2781 (1950).
(11) The Dow Chemical Co., Midland, Mich.

under one to ten atmospheres of pressure, the tetrahydroisoquinoline VI was obtained as a crystalline hydrochloride. Upon heating VI with 20% hydrochloric acid on the steam-bath, both blocking groups were removed and the *dl*-coclaurine hydrochloride VII crystallized out of the warm reaction mixture. A higher over-all yield of 80% of *dl*-coclaurine hydrochloride can be directly obtained from V if the resinous material obtained by removing the solvent after reduction is treated with 20% hydrochloric acid.

The *dl*-coclaurine hydrochloride thus prepared is a hydrate. When dried at elevated temperatures *in vacuo*, the water of crystallization is not completely removed, and a hemi-hydrate is obtained. This property of the alkaloid was not recorded by Kondo and Kondo,[2] probably because their only reported analysis of the hydrochloride is for chlorine, which is not too critical. The completely methylated quaternary salt VIII was prepared from *dl*-coclaurine and methyl sulfate.

Both compounds, *dl*-coclaurine hydrochloride and its methylated quaternary salt, were tested by Dr. L. O. Randall, of the Pharmacology Division of these laboratories. He could not detect any effect of either substance up to a dose of one mg. on neuromuscular transmission in dogs.

**Acknowledgment.**—The author wishes to express his thanks to Dr. Al Steyermark and his associates for performing the microanalyses herein reported and to Mr. Richard Terracino for his technical assistance.

## Experimental

***p*-Carbethoxyhydroxyphenylacetic Acid.**—To a stirred solution of 5.1 g. of *p*-hydroxyphenylacetic acid in 66.6 cc. of 1 *N* NaOH, 4 g. of ethyl chlorocarbonate was added. The mixture warmed up slightly as the ethyl carbonate reacted. After 10 minutes, the reaction mixture was acidified with dilute hydrochloric acid to precipitate the acid. The compound was purified by recrystallization from benzene–ligroin (b.p. 60–72°); yield 5.85 g. or 78%; m.p. 80–83°.

*Anal.* Calcd. for $C_{11}H_{12}O_5$: C, 58.90; H, 5.40. Found: C, 59.02; H, 5.65.

***p*-Carbethoxyhydroxyphenylacetyl Chloride III.**—To 25 g. of the above acid under a reflux condenser, 18 g. of thionyl chloride was added. A vigorous reaction took place accompanied by refluxing as the acid went into solution. When the reaction subsided, it was warmed for one-half hour on the steam-bath. The excess thionyl chloride was then removed by heating *in vacuo*. The resultant oily acid chloride was used at once.

**Benzylvanillin.**[3]—"To a solution of 50 g. of vanillin in 200 cc. of ethanol was added a solution of 18.5 g. of potassium hydroxide in 50 cc. of water. To the clear solution 45 g. of benzyl chloride was added. The mixture became hot and settled to a semi-solid mass which was dissolved by vigorous shaking and warming on a steam-bath. After heating another 4 hours, the ethanol was distilled *in vacuo*, and the sirupy residue was poured into alkaline water. The insoluble oil solidified soon. The solid was filtered, washed with alkaline water, and dried in air. From the alkaline filtrate some vanillin was recovered by acidification and could be recycled; yield 70 g."

**3-Methoxy-4-benzyloxy-ω-nitrostyrene.**—This compound was prepared as by Lange and Hambourger[4] in 60% yield.

**3-Methoxy-4-benzyloxyphenylacetaldehyde Oxime.**—A solution of 14.2 g. of ω-(3-methoxy-4-benzyloxy)-nitrostyrene in 75 cc. of pyridine containing 5.0 g. of 3% Pd–C was hydrogenated at 45–50° under 100 lb. pressure. After reduction, filtration and concentration *in vacuo* from a water-bath, the residual oil was diluted with water and acidified with dilute sulfuric acid. The gummy material thus produced crystallized upon scratching. After two recrystallizations from alcohol with decolorization by charcoal, the product was obtained colorless; m.p. 113–114°.

*Anal.* Calcd. for $C_{16}H_{17}NO_3$: N, 5.16. Found: N, 5.15.

**β-(3-Methoxy-4-benzyloxy)-phenethylamine II.**—A solution of 15 g. of the above oxime in 200 cc. of warm, absolute alcohol was mixed with a solution of 6.9 g. of oxalic acid in 200 cc. of alcohol with 100 mg. of $PtO_2$. The reduction was performed at 50 ± 5° and 100 lb. pressure. After cooling, the white, insoluble, crystalline salt was filtered and extracted with several portions of boiling water. When the combined water extracts were cooled, the pure oxalate crystallized, m.p. 156–157°, from alcohol.

*Anal.* Calcd. for $C_{16}H_{19}NO_2 \cdot C_2H_2O_4 \cdot H_2O$: C, 59.20; H, 5.75; N, 3.84. Found: C, 58.70; H, 6.23; N, 4.19.

The oxalate was stirred with an excess of 5% potassium hydroxide solution, and the oil thus produced was extracted with ether. After washing, drying and concentrating, the base crystallized. It distilled at 1 mm. between 180–182° and crystallized on standing at room temperature; over-all yield 27%.

*Anal.* Calcd. for $C_{16}H_{19}O_2N$: C, 74.70; H, 7.44; N, 5.44. Found: C, 74.43; H, 7.36; N, 5.47.

**β-(3-Methoxy-4-benzyloxy)-phenethylamine II by Reduction of Nitrostyrene with $LiAlH_4$.**—In an atmosphere of dry nitrogen, 12 g. of lithium aluminum hydroxide was suspended in 250 cc. of tetrahydrofuran, previously dried and distilled over lithium aluminum hydride. While stirring, a solution of 28.5 g. of the nitrostyrene in 250 cc. of purified tetrahydrofuran was added dropwise at such a rate that the refluxing did not become too vigorous. After the addition, the reaction was completed by stirring for an additional hour. Then, while cooling, water was slowly added with stirring to decompose the excess reagent, and the complex was treated with 125 cc. of 30% sodium hydroxide. The tetrahydrofuran layer was separated and concentrated on the steam-bath. The residual oil was taken up in ether, washed three times with water and dried over potassium carbonate. After distilling off the ether, the product was distilled *in vacuo*, collecting the fraction 188–196° at 2 mm. The yellowish oil soon crystallized; yield 18.9 g. or 73.6%.

**N-(3-Methoxy-4-benzyloxyphenethyl)-4-carbethoxy-hydroxyphenylacetamide IV.**—A solution of 4-carbethoxyphenylacetyl chloride (from 20.6 g. of acid) dissolved in 50 cc. of dimethoxytetraglycol was added dropwise to a stirring mixture of 7.4 g. of sodium hydroxide in 25 cc. of water and 17.7 g. of β-(3-methoxy-4-benzyloxy)-phenethylamine in 50 cc. of dimethoxytetraglycol at approximately 16°. The temperature slowly rose to 35°. The reaction mixture was poured into 500 cc. of cold water, and the medium was adjusted to *p*H 10 by the addition of a few drops of alkali. Upon stirring, the oil which was first formed crystallized. At first it was recrystallized from benzene and then from ethyl acetate; m.p. 101–102°; yield 29.5 g. or 92.5%.

*Anal.* Calcd. for $C_{27}H_{39}NO_6$: C, 69.96; H, 6.31; N, 3.02. Found: C, 70.12; H, 6.10; N, 3.01.

**1-(4-Carbethoxyhydroxybenzyl)-6-methoxy-7-benzyloxy 3,4-dihydroisoquinoline Hydrochloride.**—A mixture of 5 g. of the above amide, 1.6 g. of phosphorus oxychloride in 40 cc. of dry toluene was refluxed for one-half hour and concentrated *in vacuo* from a water-bath to dryness. The yellow solid was treated with alcohol and heated on the steam-bath to effect solution. Upon cooling, the product was obtained crystalline; m.p. 195–196°; yield 4.5 g. or 86.6%; dried *in vacuo* at 120°.

*Anal.* Calcd. for $C_{27}H_{27}NO_5 \cdot HCl$: C, 67.30; H, 5.86; N, 2.91. Found: C, 67.66; H, 5.56; N, 2.77.

**1-(Carbethoxyhydroxybenzyl)-6-methoxy-7-benzyloxy-3,4-dihydroisoquinoline Methiodide.**—In an atmosphere of nitrogen, 2.85 g. of the above dihydro hydrochloride was suspended in 25 cc. of absolute alcohol. While stirring, a solution of 0.136 g. of sodium in 5 cc. of absolute alcohol was added. After 15 minutes stirring, 2.0 g. of methyl iodide was added; the mixture refluxed for 3.5 hours and filtered. The filtrate was set at 0° and deposited a non-crystalline, yellow precipitate; m.p. 93–169°. Three crystallizations from a proportionately large amount of alcohol raised the melting point to 168–169° dec. This seriously reduced the yield.

*Anal.* Calcd. for $C_{28}H_{30}NIO_5$: C, 57.23; H, 5.15; N, 2.38. Found: C, 57.37; H, 4.95; N, 2.72.

**1-(Carbethoxyhydroxybenzyl)-6-methoxy-7-benzyloxy-1,2,3,4-tetrahydroisoquinoline VI.**—A suspension of 2.28 g. of the above dihydro compound in 50 cc. of absolute alcohol and 50 mg. of $PtO_2$ were shaken at room temperature under 25 lb. pressure of hydrogen for 1.5 hours, *i.e.*, until no more hydrogen was absorbed. After filtering, the solution no longer possessed the original blue fluorescence. Upon concentration to a small volume, a non-crystalline precipitate was obtained by the addition of ether. The compound was dissolved in water, made alkaline with dilute sodium hydroxide, and the oil extracted with ether. After drying, the solution was saturated with dry hydrogen chloride, and a gummy product was produced. It was dissolved in benzene and diluted with ligroin (b.p. 60–72°) until turbid. After several days at room temperature, the compound slowly crystallized; m.p. 156–166°. It was recrystallized from ethanol–ether; m.p. 162–165°.

*Anal.* Calcd. for $C_{27}H_{30}NO_5Cl$: C, 67.00; H, 6.25; N, 2.90. Found: C, 67.19; H, 5.76; N, 2.94.

The yield was low due to losses during the above crystallization.

***dl*-Coclaurine Hydrochloride VII.**—One gram of the above compound was warmed on the steam-bath with 20 cc. of 20% hydrochloric acid. After one-half hour, the material had dissolved, and the equivalent amount of carbon dioxide was collected. While warming was continued, colorless crystals appeared. After cooling, they were filtered off. The product was recrystallized from water; m.p. 251–254° dec.; dried *in vacuo* over phosphorus pentoxide; m.p. 259–261°.

*Anal.* Calcd. for $C_{17}H_{20}NO_3Cl\cdot H_2O$: C, 60.09; H, 6.40. Found: C, 60.07; H, 6.41.

Dried *in vacuo* at 120° over $P_2O_5$; m.p. 250–252°.

*Anal.* Calcd. for $C_{17}H_{20}NO_3Cl\cdot{}^1/_2H_2O$: C, 61.72; H, 6.53; Cl, 10.72. Found: C, 61.67; H, 6.40; Cl, 10.71.

**DL-Coclaurine Hydrochloride without Isolating the Intermediate Tetrahydroisoquinoline.**—A solution of 11.4 g. of 1-(4-carbethoxyhydroxybenzyl)-6-methoxy-7-benzyloxy-3,4-dihydroisoquinoline hydrochloride was prepared in 200 cc. of absolute alcohol with slight warming. After adding 100 mg. of $PtO_2$, it was reduced at 25° and 185 lb. pressure of hydrogen until one mole equivalent was absorbed. The clear solution was filtered and concentrated to dryness. To the resinous material obtained, 200 cc. of 20% hydrochloric acid was added, and the mixture warmed on the steam-bath for approximately 1 hour when crystals started to appear. The solution was filtered rapidly and the filtrate cooled. The colorless crystals were collected and dried; yield 6.1 g. or 80%.

**DL-Tetramethylcoclaurine Methylsulfate VIII.**—A solution of 2.2 g. of *dl*-coclaurine hydrochloride was treated with 33.0 cc. of *N* NaOH and 5.94 g. of methyl sulfate and warmed on the steam-bath. Within 10 minutes the two layers disappeared. The treatment of alkali and dimethylsulfate was repeated twice and cooled. The solution was extracted with ether which was discarded and then three times with chloroform. The chloroform extract was dried and blown down *in vacuo* to a small volume. The oily residue was treated with a small amount of alcohol and ethyl acetate and again blown down *in vacuo*, yielding colorless crystals. Recrystallization was effected from a mixture of alcohol–ethyl acetate; m.p. 174–174.5°; yield 2.2 g.

*Anal.* Calcd. for $C_{22}H_{31}O_7NS$: C, 58.27; H, 6.89; N, 3.09. Found: C, 58.13; H, 6.80; N, 3.26.

NUTLEY, N. J. RECEIVED AUGUST 3, 1950

---

[CONTRIBUTION FROM THE IPATIEFF HIGH PRESSURE AND CATALYTIC LABORATORY, DEPARTMENT OF CHEMISTRY, NORTHWESTERN UNIVERSITY]

# Study in the Terpene Series. X. Isomerization Accompanying Hydrogenolysis of Alcohols

BY V. N. IPATIEFF, W. W. THOMPSON[1] AND HERMAN PINES

Cyclopentylmethanol, 1-cyclopentylethanol, 2-cyclopentylethanol and cyclohexylmethanol, undergo ring expansion or contraction when subjected to hydrogenolysis in the presence of a nickel–alumina catalyst. Cyclohexanol and 2-cyclopentyl-2-propanol undergo hydrogenolysis to the corresponding hydrocarbons. 3,3-Dimethyl-2-butanol formed a mixture of 2,2- and 2,3-dimethylbutane on hydrogenolysis in the presence of nickel–alumina catalyst. 3,3-Dimethylbutanol under similar conditions yielded as the main products of reaction 2,2-dimethylbutane, neopentane and isopentane. The hydrogenolysis of 3,3-dimethylbutanol in the presence of either nickel–kieselguhr or Raney nickel yielded neopentane.

The hydrogenolysis of the oxygen to carbon bond in primary and secondary alcohols proceeds with difficulty in the presence of nickel–kieselguhr or copper oxide–chromium oxide catalyst except when the hydroxyl group is activated by the presence of a phenyl, furyl, pyrryl and other groups.[2]

The hydrogenolysis of aliphatic primary alcohols in the presence of a nickel–kieselguhr catalyst or in the presence of finely divided nickel is usually accompanied by the splitting of a carbon–carbon bond, which results in the formation of a paraffin having one carbon less than the parent alcohol,[3,4]; a similar reaction occurs even in the absence of hydrogen.[5,6]

In the present study a nickel–alumina catalyst has been used for the hydrogenolysis of alcohols; this catalyst has been shown previously to reduce ketones and alcohols of the terpene series to hydrogenated terpenic hydrocarbons.[7] In some cases the hydrogenolysis was accompanied by isomerization, *e.g.*, fenchyl alcohol was converted to isobornylane, isoborneol to isocamphane.

The present investigation was undertaken in order to determine whether a nickel–alumina catalyst could be applied for converting some monocyclic terpenic alcohols to the corresponding hydrocarbons without causing a skeletal rearrangement to occur. For that reason compounds having structures similar to those of the terpenes have been used in this study.

It was observed that when a primary or secondary alcohol having the hydroxy group adjacent to a five or six membered ring was subjected to hydrogenolysis using the nickel–alumina catalyst (com-

(1) Universal Oil Products Company Predoctorate Fellow 1946–1947. E. I. du Pont de Nemours and Company, Wilmington, Delaware.

(2) H. Adkins, "Reactions of Hydrogen with Organic Compounds over Copper-Chromium Oxide and Nickel Catalysts," the University of Wisconsin Press, Madison, Wisconsin, 1937.

(3) J. Böeseken and G. H. Van Senden, *Rec. trav. chim.*, **32**, 23 (1913).

(4) B. Wojcik and H. Adkins, THIS JOURNAL, **55**, 1293 (1933).

(5) H. Gault, L. Palfray and P. Hsu, *Compt. rend.*, **209**, 999 (1939).

(6) V. N. Ipatieff, G. S. Monroe, L. E. Fischer and E. E. Meisinger, *Ind. Eng. Chem.*, **41**, 1802 (1949).

(7) (a) V. N. Ipatieff and Matov, *Ber.*, **45**, 3205 (1912); (b) V. N. Ipatieff, "Catalytic Reactions at High Pressures and Temperatures," the Macmillan Company, New York, 1936, p. 340; (c) V. N. Ipatieff and H. Pines, THIS JOURNAL, **67**, 1931 (1945).