[CONTRIBUTION NO 646 FROM THE RESEARCH LABORATORIES OF THE GOODYEAR TIRE AND RUBBER CO.]

The Preparation and Some Reactions of α-(ω-Cyanoethyl)-β-naphthol

BY A. F. HARDMAN

Hoesch[1] discovered that acetonitrile condenses with resorcinol in the presence of zinc chloride and hydrogen chloride to yield a compound which hydrolyzes to 2,4-dihydroxyacetophenone. Later Langley and Adams[2] attempting the same type of condensation with β-chloropropionitrile or acrylonitrile and resorcinol obtained not a ketone, but 2,4-dihydroxyphenylpropionic acid.

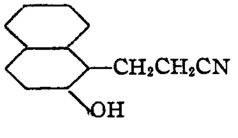
More recently, it was shown that various cyanoethyl aryl ethers are obtained by treating phenols with acrylonitrile in the presence of about 1% of metallic sodium as catalyst. This represents the usual reaction between acrylonitrile and a phenol.

It has now been found that β-naphthol and acrylonitrile in a solvent such as benzene condense in the presence of solid caustic soda. The caustic is used in equal or slightly more than equal molal quantities to the naphthol. Therefore, its function is not merely that of a catalyst. The product first obtained, as a viscous water-soluble layer under the organic solvent, is the sodium salt of α-(ω-cyanoethyl)-β-naphthol, from which the free naphthol is obtained by dissolution in water and acidification. This naphthol (I) is analogous to that obtained by Langley and Adams from resorcinol and acrylonitrile. However, resorcinol, treated with acrylonitrile and caustic under the conditions described, does not react. In fact, this reaction appears to be specific to β-naphthol; other phenols, including α-naphthol, failed to yield satisfactory products.

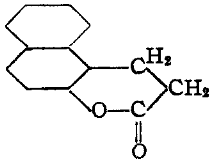
α-(ω-Cyanoethyl)-β-naphthol is readily hydrolyzed to the corresponding propionic acid which on heating forms a lactone (II).

The lactone reacts with ammonia and various amines to yield well-crystallized amides of 2-hydroxynaphthalenepropionic acid, and with alcohols to yield esters of the same acid. The esters cannot be distilled, but revert to lactones and free alcohols on heating.

α-(ω-Cyanoethyl)-β-naphthol also reacts like a typical nitrile to form amidines.



I



II

Experimental[3]

α-(ω-Cyanoethyl)-β-naphthol (1).—A mixture of 29 g. of β-naphthol, 12 g. of acrylonitrile, 50 cc. of benzene and 9 g. of sodium hydroxide pellets was refluxed. The mixture boiled vigorously at first, and the sodium hydroxide mostly went into solution. After about one-half hour the mixture began to separate into two layers. The heating was stopped after two hours, 100 cc. of cold water added and the water solution separated from the benzene, and acidified with acetic acid. The crude precipitate weighed 37 g. and after recrystallization from ethanol yielded white crystals melting at 142°.

Anal. Calcd. for $C_{13}H_{11}ON$: N, 7.1. Found: N, 6.85.

2-Hydroxy-1-naphthalenepropionic Acid.—A solution of 50 g. (I) in 222 g. of 10% aqueous sodium hydroxide was refluxed for eight hours, then cooled and stirred slowly into dilute hydrochloric acid. The crude 2-hydroxy-1-naphthalenepropionic acid melting at 115–117° weighed 54 g. and after recrystallization from benzene, melted at 121°.

Anal. Calcd. for $C_{13}H_{12}O_3$, neutral equivalent, 259. Found: neutral equivalent, 258.

Lactone of 2-Hydroxy-1-naphthalenepropionic Acid (II).—One hundred forty-three grams of crude acid, (m. p. 114–115°) was refluxed in 100 cc. of toluene under a water trap, until no more water collected, about one-half hour. The toluene was removed by distillation and the lactone distilled under 5 mm. pressure, coming over mostly between 210 and 220°. The viscous liquid, which weighed 115 g., crystallized after stirring and seeding. After recrystallization from benzene–petroleum ether, the lactone melted at 69–70°.

2-Hydroxy-1-naphthalenepropionamide.—Dry ammonia was bubbled through a solution of 20 g. of the lactone (II) in 200 cc. benzene. The solution became warm and in a few minutes crystals began to separate. After saturation, the mixture was allowed to stand overnight, then filtered, and the crystals washed with benzene. The yield was 21 g. of fine, white crystals melting with decomposition at 171–172°.

Anal. Calcd. for $C_{13}H_{13}O_2N$: N, 6.52. Found: N, 6.46.

2-Hydroxy-1-naphthalene-N-cyclohexyl-propionamide.—Twenty grams of the lactone (II) was dissolved in 50 cc. of benzene and 10 g. of cyclohexylamine was added. The solution became warm on adding the amine, and in a short time crystals began to separate. After standing overnight, the fine white crystals were filtered off and washed with benzene. The yield was 28 g.; m. p. 172–173°.

Anal. Calcd. for $C_{19}H_{23}O_2N$: N, 4.72. Found: N, 4.81.

Table I below lists a number of other substituted amides which have been prepared by heating the lactone and the amine in an appropriate solvent.

TABLE I

Amine	Amide		
	M. p., °C.	Nitrogen, % Calcd.	Nitrogen, % Found
Diethylamine	124	5.17	5.26
Monoethanolamine	142–143	5.40	5.14
Ethylenediamine	188	6.14	5.87
Aniline	173–174	4.81	4.48
p-Aminophenol	142–143	4.56	4.32
α-Naphthylamine	205–206	4.11	4.06
β-Naphthylamine	193–194	4.11	3.91
p,p'-Diaminodiphenylmethane	207	4.71	4.68

Methyl 2-Hydroxy-1-naphthalenepropionate.—A solution of 20 g. of the lactone (II) in 50 cc. of methanol to which

---

[1] Hoesch, *Ber.*, **48**, 1122 (1915).

[2] Langley and Adams, THIS JOURNAL, **44**, 2326 (1922).

[3] The melting points reported are uncorrected.

a pinch of sodium methylate was added was refluxed for one-half hour. On cooling, 16 g. of the ester precipitated. After recrystallization from methanol, the product melted at 122–123°.

Anal. Calcd. for $C_{14}H_{14}O_3$: sapn. equiv., 244. Found: sapn. equiv., 245.

2-Hydroxy-1-naphthalenepropio-N,N'-diphenylamidine.—One hundred grams of (I) was refluxed with 125 g. of aniline. Ammonia came off rapidly at first, then more and more slowly. After eight hours 86% of the theoretical ammonia had been driven off. The mixture was cooled and stirred into 400 cc. of ethanol and allowed to stand overnight. The product, which was removed by filtration and washed with ethanol weighed 123 g. and melted at 147°. After recrystallization from xylene, it melted at 150–151°.

Anal. Calcd. for $C_{25}H_{22}ON_2$: N, 7.64. Found: N, 7.87.

It has been discovered in preliminary tests that the 2-hydroxy-1-naphthalenepropionic acid is moderately effective as a root growth promoter when applied to chrysanthemum cuttings and is of some value as a spray material to reduce premature apple drop. It is hoped that this publication will stimulate investigation by others in various fields of possible utility.

Acknowledgment.—The author is indebted to Miss Marion Treiber for assistance in preparing a number of the amides tabulated above.

Summary

1. A new reaction is described in which α-(ω-cyanoethyl)-β-naphthol is obtained in excellent yield from acrylonitrile and β-naphthol.

2. Derivatives prepared from α-(ω-cyano-ethyl)-β-naphthol include 2-hydroxy-1-naphthalenepropionic acid, its methyl ester, various amides and the N,N'-diphenylamidine.

AKRON, OHIO RECEIVED NOVEMBER 26, 1947

[CONTRIBUTION FROM THE NOYES CHEMICAL LABORATORY, UNIVERSITY OF ILLINOIS]

A New Synthesis of Atranol (2,6-Dihydroxy-4-methylbenzaldehyde) and the Corresponding Cinnamic Acid

BY ROGER ADAMS AND JEAN MATHIEU

In experiments designed to prepare products suitable for the synthesis of natural tetrahydrocannabinol,[1] techniques for certain reactions were developed which may be of general interest. A new synthesis of atranol was also discovered. The compounds desired are 2,6-dihydroxy-4-*n*-amylcinnamic acid and its ester. This preliminary work, however, has involved the synthesis of the corresponding 4-methyl derivatives, since orcinol is a much more readily accessible substance than olivetol (3,5-dihydroxy-*n*-amylbenzene).

Orcinol dimethyl ether can be formylated (I) in the position between the methoxyls by treating lithium orcinol dimethyl ether with methylformanilide.[1b] Demethylation of this product was attained only after an exhaustive study of different reagents. Anhydrous aluminum bromide proved successful and a 70% yield of 2,6-dihydroxy-4-methylbenzaldehyde (II) resulted. This product is known as atranol. It was first isolated by degradation of atranorin, a product occurring in various lichens, and its structure was determined by oxidation to *p*-orsellinic acid.[2] It has been synthesized by Pfau in low yields by the introduction of an aldehyde group into ethyl 2,4-dihydroxy-6-methylbenzoate (orcinol carboxylic ester), followed by saponification and decarboxylation.[3] The new method offers a much simpler and more satisfactory procedure. Anhydrous aluminum chloride under similar conditions gives primarily resins, although in very small runs (0.1 g.), a 30% yield of atranol could be isolated. With benzene as a solvent, aluminum chloride causes demethylation of only one methoxyl with formation of 2-hydroxy-6-methoxy-4-methylbenzaldehyde (atranol monomethyl ether). This compound has been described by Asahina,[4] who found it in the pyrolysate of stictinic acid and synthesized it from atranol.

Although atranol dimethyl ether (I) condenses with malonic acid in presence of piperidine with formation of an almost quantitative yield of the corresponding cinnamic acid,[1b] the unmethylated product, atranol(II), did not react similarly under the same conditions. The conversion of substituted aromatic aldehydes to the cinnamic acids by the Knoevenagel reaction has been exhaustively studied. In general the yields are excellent but previous investigators have noted the abnormally low yields of products when *o*- or *p*-hydroxybenzaldehydes were subjected to condensation under conditions entirely suitable to other substituted benzaldehydes.[5] The conditions found most satisfactory for the condensation of salicylaldehyde with malonic acid[5b] were (a) the use of a small amount of pyridine as catalyst resulting in a yield of 51% of 3-carboxycoumarin or (b) heating at 80° followed by twenty-four hours at room temperature in presence of trace amounts of a variety of tertiary bases such as lutidine, quinoline, etc. (methylacridine[1c] proved to be the best) resulting in a 66–77% yield of product. An explanation of the difficulty in the condensation of *o*- and *p*-hydroxybenzaldehydes was suggested by

---

[1] (a) Adams, McPhee, Carlin and Wicks, THIS JOURNAL, **65**, 356 (1943); (b) Adams and Carlin, *ibid.*, **65**, 360 (1943).

[2] Pfau, *Helv. Chim. Acta*, **9**, 650 (1926).

[3] Pfau, *ibid.*, **16**, 282 (1933).

[4] Asahina, *Ber.*, **66**, 943 (1933).

[5] (a) Dutt, *J. Indian Chem. Soc.*, **1**, 297 (1925); **9**, 309 (1932); (b) Kurien and Pandja, *ibid.*, **11**, 823 (1934); (c) *Proc. Indian Acad. Sci.*, **1A**, 440 (1935).