aqueous layer was acidified at 10° with concentrated hydrochloric acid to give 6 g. of a pasty yellow solid. Recrystallization from 50% ethanol (charcoal) afforded 2.5 g. (0.011 mole, 45%) of yellow crystals, m.p. 167–168° (reported 163–165°, 164–166°,[2] 166–167°[5]).

β-(1-Naphthoyl)-acrylic Acid.—Using the procedure for the 2-naphthoyl isomer, starting with the same quantities of 1-naphthylglyoxal monohydrate[16] and malonic acid and crystallizing the yellow product finally from 50% ethanol, β-(1-naphthoyl)-acrylic acid was obtained in 53% yield, m.p. 148.5–149.5° (reported 145–147°, 148–149°[5]). No depression was observed on admixture with a sample prepared *via* the Friedel and Crafts reaction.[17]

β-(*m*-Nitrobenzoyl)-acrylic Acid.—At 10–15°, 7.0 g. (0.067 mole) of malonic acid was added gradually to a solution of 12 g. (0.067 mole) of *m*-nitrophenylglyoxal in 35 ml. of pyridine. After stirring for 15 minutes and standing for 20 hours, the mixture was cooled to 10–15° and to it was added 170 ml. of 5% aqueous sodium carbonate solution. While maintaining this temperature, the alkaline solution was extracted with four 150-ml. portions of benzene and then acidified with concentrated hydrochloric acid. Recrystallization of the crude product from 1.5 l. of 1.9% hydrochloric acid gave 3.4 g. (0.015 mole, 25%) of yellow β-(*m*-nitrobenzoyl)-acrylic acid, m.p. 190–191°.

Anal. Calcd. for $C_{10}H_7NO_5$: C, 54.30; H, 3.19; N, 6.33; neut. equiv., 221. Found: C, 54.45; H, 3.30; N, 6.45; neut. equiv., 221.

No depression was observed on admixture with a sample prepared by the direct nitration of β-benzoylacrylic acid.[8]

β-(*p*-Nitrobenzoyl)-acrylic Acid.—Using the procedure for the *m*-isomer and starting with 3.84 g. (0.019 mole) of *p*-nitrophenylglyoxal monohydrate, there was obtained 1.76 g. (0.0080 mole, 41%) of yellow product, m.p. 165.0–166.5° (from 1.9% hydrochloric acid).

Anal. Calcd. for $C_{10}H_7NO_5$: C, 54.30; H, 3.19; N, 6.33; neut. equiv., 221. Found: C, 54.29; H, 3.34; N, 6.37; neut. equiv., 222.

β-(*o*-Nitrobenzoyl)-acrylic Acid.—This material was prepared in the same manner as that for the other two isomers. Starting with the crude reaction product obtained by the oxidation of 6.5 g. (0.039 mole) of *o*-nitroacetophenone and 4.0 g. (0.039 mole) of malonic acid there was obtained 0.8 g. (0.0036 mole, 11%) of light yellow needles, m.p. 173.0–173.5° (from 1.9% hydrochloric acid).

Anal. Calcd. for $C_{10}H_7NO_5$: C, 54.30; H, 3.19; N, 6.33; neut. equiv., 221. Found: C, 54.38; H, 3.24; N, 6.48; neut. equiv., 222.

Acknowledgment.—The authors hereby express their appreciation to van Ameringen–Haebler, Inc., in whose laboratories this work was conducted, for the coöperation afforded them in the course of this research.

(17) This sample was kindly supplied by Dr. M. Goldman.

THE CHEMICAL LABORATORIES OF THE
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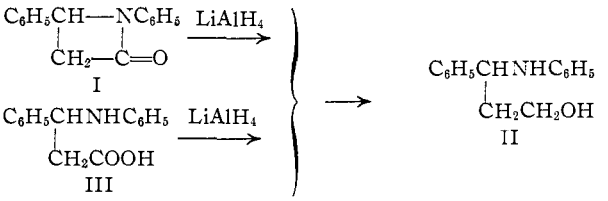
The Action of Lithium Aluminum Hydride on a β-Lactam[1]

BY MERRILL E. SPEETER AND WILLIAM H. MARONEY

RECEIVED MAY 12, 1954

The facile preparation of substituted pyrrolidines, piperidines and other polymethylenimines through the action of lithium aluminum hydride on the corresponding lactams has been reported by a number of investigators.[2–5] It thus appeared possible that relatively uninvestigated compounds of the azetidine series might be obtained through the action of lithium aluminum hydride on azetidinones (β-lactams). To test this possibility 1,4-diphenylazetidinone, which is readily obtainable through a Reformatsky reaction with benzalaniline,[6] was reduced with lithium aluminum hydride both in ether and in tetrahydrofuran solution. In these reductions no azetidine was produced as ring opening took place concurrent with the reduction of the carbonyl group and only 3-anilino-3-phenyl-1-propanol (II) could be isolated. This compound was obtained in 88% yield and a careful examination of the recrystallization mother liquors failed to yield any second product.



An independent synthesis of II was desired and this was accomplished through the lithium aluminum hydride reduction of the acid III.[7] Only a poor yield of II was obtained in this reduction, but it might be expected that III would yield a highly insoluble complex with lithium aluminum hydride which would reduce with difficulty.

The formation of carbinols in the lithium aluminum hydride reduction of cyclic amides rarely has been reported. Morrison, Long and Königstein[8] treated 4-methyl-2,2-diphenyl-3-morpholone with lithium aluminum hydride and in addition to the expected morpholine derivative isolated 3-hydroxy-4-methyl-2,2-diphenylmorpholine.[9]

Experimental

Lithium Aluminum Hydride Reduction of 1,3-Diphenylazetidinone.—A solution of 33 g. (0.15 mole) of 1,4-diphenylazetidinone was prepared in 400 ml. of dry tetrahydrofuran. This solution was added with stirring to 6.4 g. (0.17 mole) of lithium aluminum hydride dissolved in 350 ml. of tetrahydrofuran. A moderately exothermic reaction was observed during the addition. The mixture was concentrated to a volume of 200 ml., after the addition and the cooled solution diluted with 500 ml. of ether. Excess lithium aluminum hydride was destroyed with ether–alcohol and several hundred ml. of 10% sodium hydroxide was added with vigorous stirring. The ether layer was decanted and the alkali layer agitated with several 200-ml. portions of ether. The combined ether solutions were washed with water, dried over potassium carbonate and concentrated. The remaining oil crystallized and after two recrystallizations from toluene the material melted at 87–88°. The product weighed 28 g. and an additional 2 g. was obtained from the

(1) Abstracted from a senior research paper submitted by W. H. Maroney to Kalamazoo College in partial fulfillment of the requirements for the A.B. degree.

(2) P. Karrer and P. Portmann, *Helv. Chim. Acta*, **31**, 2088 (1948).

(3) R. B. Moffett, *J. Org. Chem.*, **14**, 862 (1949).

(4) L. Ruzicka, M. Kobelt, O. Häfliger and V. Prelog, *Helv. Chim. Acta*, **32**, 544 (1949).

(5) See also the review "Reductions by Lithium Aluminum Hydrides," by W. G. Brown, "Organic Reactions," Vol. VI, John Wiley and Sons, Inc., New York, N. Y., 1951, Chapter 10.

(6) H. Gilman and M. E. Speeter, THIS JOURNAL, **65**, 2255 (1943).

(7) H. T. Clarke, J. R. Johnson and R. Robinson, editors, "The Chemistry of Penicillin," Princeton University Press, Princeton, N. J., 1948, p. 977.

(8) A. L. Morrison, R. F. Long and M. Königstein, *J. Chem. Soc.*, 952 (1951).

(9) The referee has pointed out the work of A. Stoll, A. Hofmann and T. Petrzilka, *Helv. Chim. Acta*, **34**, 1544 (1951), which indicates that carbinols have been obtained from some lithium aluminum hydride reductions in the ergot alkaloid field. Also, A. Mustafa, *J. Chem. Soc.*, 2435 (1952), isolated arylsulfonylaminocarbinols from the $LiAlH_4$ reduction of N,N'-diaryl-α-sulfonyldianthranilides.

mother liquors (yield 88%). The infrared spectrum[10] of the material showed no carbonyl absorption but did indicate strong NH/OH absorption. Analytical data established the product to be 3-anilino-3-phenyl-1-propanol.

A similar reduction using ether as a solvent in place of tetrahydrofuran also gave the amino alcohol, yield 64%.

Anal. Calcd. for $C_{15}H_{17}NO$: C, 79.26; H, 7.54; N, 6.15. Found: C, 79.51, 79.70; H, 7.37, 7.30; N, 6.24, 6.00.

A portion of the amino alcohol was refluxed in benzene for two hours with excess phenyl isocyanate. The benzene was distilled and the solid recrystallized from toluene. The phenylurea-phenylurethan of II melted at 166–167.5°.

Anal. Calcd. for $C_{29}H_{27}N_3O_3$: C, 74.82; H, 5.84; N, 9.02. Found: C, 74.85, 74.85; H, 5.79, 5.65; N, 9.14, 9.31.

Lithium Aluminum Hydride Reduction of β-Phenyl-β-Anilinopropionic Acid.—To a solution of 1.14 g. (0.03 mole) of lithium aluminum hydride in 150 ml. of dry ether was added 7.78 g. of β-phenyl-β-anilinopropionic acid[7] in 140 ml. of tetrahydrofuran and a vigorous exothermic reaction observed. After standing at room temperature for 18 hours the mixture was hydrolyzed with wet ether and 10% aqueous sodium hydroxide. The ether tetrahydrofuran layer was decanted, washed with water and concentrated. The oil remaining did not crystallize so it was taken into toluene, washed with alkali to remove unreduced acid, dried, concentrated to a small volume and cooled. The crystals which separated were recrystallized from toluene and melted at 87–88°. The melting point of this product when mixed with the material from the lactam reduction was not depressed.

(10) We wish to thank Dr. J. L. Johnson and associates of the Upjohn Department of Physics for the infrared data and Mr. W. A. Struck and associates of the Upjohn Analytical Chemistry Laboratory for the analytical data.

THE RESEARCH LABORATORIES
THE UPJOHN COMPANY AND THE
DEPARTMENT OF CHEMISTRY
KALAMAZOO COLLEGE
KALAMAZOO, MICHIGAN

The Preparation of Crystalline *dl*-Pantothenamide

BY MAYNETTE VERNSTEN, W. C. BRAATEN AND M. B. MOORE

RECEIVED MAY 29, 1954

Previous attempts in these laboratories to produce a solid form of pantothenamide led to the discovery of pantothenamide–calcium chloride double salt.[1] Although Wieland, *et al.*,[2] recently have described the synthesis of oily *d*-pantothenamide by another method, it was found here that the addition of pure β-alanine amide to *dl*-pantolactone provides a method of obtaining pure solid *dl*-pantothenamide. Optical crystallographic and X-ray diffraction characteristics proved the crystalline nature of this solid.

Experimental[3]

β-Alanine Amide.—β-Alanine amide hydrochloride (1.54 g., 0.023 mole) prepared from cyanoacetamide by the method of Carlson[4] was slurried in water with the hydroxyl form of IRA 400 resin[5] to remove the chloride ion. The resulting solution was lyophilized to yield the β-alanine amide free base which is hygroscopic and rapidly absorbs carbon dioxide from the air.

***dl*-Pantothenamide.**—β-Alanine amide (0.7 g., 0.0079 mole) and *dl*-pantolactone (1.03 g., 0.0079 mole) were mixed in a flask protected by a soda lime drying tube and then warmed in hot water until the two solids liquefied. After standing at room temperature for three days the clear colorless oil was dissolved in 50 ml. of absolute alcohol, filtered through sintered glass and dried *in vacuo* for two days at 50°. The resulting gummy residue was stirred several times with dry ether and it then crystallized, m.p. 97–100°, 1.5 g. (88%). A sample of this material was dried *in vacuo* at 56°, m.p. 106–108°.

Anal. Calcd. for $C_8H_{18}N_2O_4$: C, 49.52; H, 8.31; N, 12.83. Found: C, 49.07; H, 8.32; N, 12.99.

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ABBOTT LABORATORIES
NORTH CHICAGO, ILLINOIS

(1) M. B. Moore, U. S. Patent 2,369,839 (1945).

(2) T. Wieland, E. A. Miller and G. Dieckelmann, *Ber.*, **85**, 1035 (1952).

(3) Melting points are corrected.

(4) G. H. Carlson, U. S. Patent 2,354,909 (1944).

(5) Rohm and Haas Company.

cis- and *trans*-γ-Halo-α,β-epoxy Ketones. Reactions with Aniline

BY HARRY H. WASSERMAN AND JOYCE B. BROUS[1]

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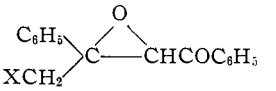
In previous articles[2,3] the reactions of various organic bases with the isomeric γ-halo-α,β-epoxy ketones of general structure I were described. Based on these reactions, conclusions were drawn with

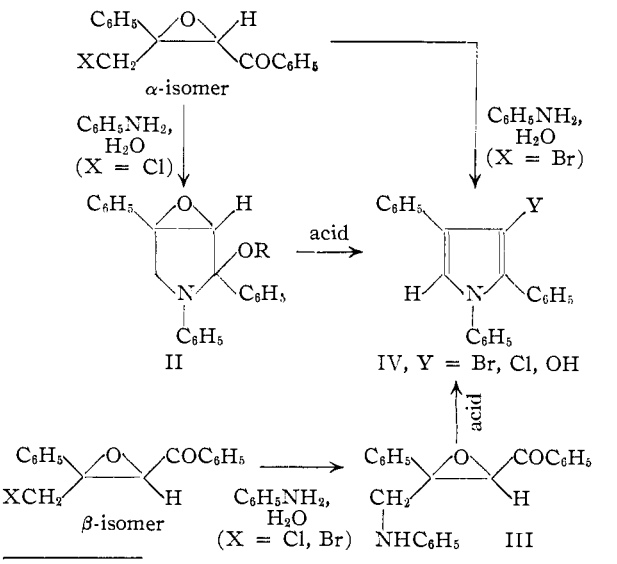


I, X = Cl, Br

respect to the configurations of these so-called halodiphenacyls, namely, that the α-isomers have a *trans* arrangement of phenyl and benzoyl groupings and the β-isomers, the *cis* configuration.

The reactions with aniline–water mixtures in the β-series, as summarized in Chart I, led only to a monoanilino derivative III, which could be converted to a pyrrole IV only by a second-stage treat-

CHART I



(1) Abstracted from a dissertation by J. B. Brous presented to the faculty of Yale University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 1954.

(2) H. H. Wasserman and J. B. Brous, *J. Org. Chem.*, **19**, 515 (1954).

(3) C. L. Stevens and V. J. Traynelis, *ibid.*, **19**, 533 (1954).