70.9; H, 5.4; N, 15.0; amino-N, 0.083. Found: C, 69.6; H, 5.5; N, 15.3; amino-N, 0.083.[3]

Poly-L-tryptophan differs in its solubility from the DL-polymer. It is soluble in dimethylformamide and pyridine, but insoluble in dioxane, acetone, butylamine, hot glacial acetic acid, methanol, ethanol and ethyl acetate.

An aqueous suspension of polytryptophan turns deep violet when treated with Hopkins–Cole reagent; it gives a positive ninhydrin reaction and a negative picric acid test.[11]

Hydrolysis of Polytryptophan.—Poly-DL-tryptophan (22.3 mg.) was dissolved in a mixture of dioxane (1 ml.), 4 *N* methanolic sodium methoxide (2 ml.) and water (0.2 ml.). Oxygen was removed by a stream of nitrogen and the hydrolysis carried out by heating in a sealed tube at 110–120° for 72 hours.

The amount of tryptophan in the hydrolysate was determined by its ultraviolet absorption[8] and colorimetrically.[12]

Anal. Calcd. for a hydrolysate of 100 mg. of poly-DL-tryptophan (*n* average 80): tryptophan, 109 mg. Found: tryptophan 105 mg. (ultraviolet absorption[8]); 107 mg. (colorimetric ninhydrin determination[12]).

Poly-L-tryptophan was hydrolyzed analogously to the DL-polymer; as it is insoluble in dioxane, pyridine was used instead. A quantitative yield of tryptophan was obtained also in this case.

A chromatographic analysis of the neutralized hydrolysate of poly-DL- and poly-L-tryptophan carried out as above yielded one spot with R_f 0.46 identical with that of authentic samples of DL- and L-tryptophan.

Acknowledgment.—This investigation was supported by a research grant (PHS G-3677) from the National Institutes of Health, Public Health Service.

(11) E. Abderhalden and E. Komm, *Z. physiol. Chem.*, **139**, 181 (1924).

(12) R. A. Boissonnas, *Helv. Chim. Acta*, **33**, 1975 (1950).

WEIZMANN INSTITUTE OF SCIENCE
REHOVOTH, ISRAEL

Nicotinyl and Isonicotinyl Hydrazones of Pyridoxal

BY PETER P. T. SAH

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Nicotinyl and isonicotinyl hydrazones of pyridoxal, two new compounds that show interesting biological properties,[1] may be prepared easily by the following procedure.

Pyridoxal hydrochloride (product of Nutritional Biochemicals Corporation, 2 g.) in water (20 ml.) was treated with isonicotinic acid hydrazide[2] or nicotinic acid hydrazide[3] (1.4 g.) in 50% ethanol (20 ml.). Sodium acetate (1 g.) in water (10 ml.) was then added and the reactants were heated on the steam-bath for 10 minutes and allowed to stand for 24 hours at room temperature. The crude crystalline product was recrystallized from a mixture of methanol and benzene (1:2). The yield of the purified product was between 2.4 and 2.6 g.

Equally satisfactory results were obtained by using an alternate procedure which consisted of heating equivalent amounts of the reactants in pyridine and removing the solvent by steam distillation with the addition of sodium acetate.

Pyridoxal isonicotinyl hydrazone forms pale-yellow, small prisms either from dilute ethanol or from a mixture of methanol and benzene, m.p. 261–262° dec. (cor.).

Anal. Calcd. for $C_{14}H_{14}O_3N_4$: C, 58.72; H, 4.94; N, 19.57. Found: C, 58.55; H, 5.03; N, 19.77.

Pyridoxal nicotinyl hydrazone forms practically colorless, fine needles from dilute ethanol or thick platelets from a mixture of methanol and benzene, m.p. 235–236° dec. (cor.).

Anal. Calcd. for $C_{14}H_{14}O_3N_4$: C, 58.72; H, 4.94; N, 19.57. Found: C, 58.68; H, 4.87; N, 19.63.

These two compounds are very slightly soluble in cold water, slightly soluble in cold methanol or ethanol but soluble in hot; soluble in cold 10% sodium hydroxide; very soluble in dilute mineral acids; but insoluble in benzene or petroleum ether. A mixture of methanol and petroleum ether may also be used for recrystallization. Quantitatively, pyridoxal nicotinyl hydrazone is considerably more soluble than pyridoxal isonicotinyl hydrazone in most of the solvents tested.

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UNIVERSITY OF CALIFORNIA
COLLEGE OF PHARMACY, SAN FRANCISCO
AND SCHOOL OF VETERINARY MEDICINE
DAVIS, CALIFORNIA

(1) Pyridoxal isonicotinyl hydrazone was found by W. B. Sutton of the Lilly Research Laboratories, Indianapolis, Indiana, to possess significant antitubercular activity *in vitro* as well as *in vivo*; its isomer, pyridoxal nicotinyl hydrazone, however, is much less active *in vitro* and inactive *in vivo*. Following this observation, both derivatives were found by Dr. Louis Greenberg of the University of California School of Medicine to be equal to pyridoxine in their vitamin B_6 activity. Recently, both were found by Dr. B. Freedlander of Mount Zion Hospital, San Francisco and Dr. A. Furst of Stanford University School of Medicine to show distinct activity against mammary cancer in mice and certain leukemia in mice. The details of these biological results will be reported by these investigators elsewhere.

(2) H. Meyer and J. Mally, *Monatsh.*, **33**, 393 (1912).

(3) Prepared by Dr. C. T. Peng of University of California College of Pharmacy according to the method described in the literature; "Beilsteins Handbuch der organischen Chemie," Bd. XXII, 41 (1935); Th. Curtius and E. Mohr, *Ber.*, **31**, 2493 (1898). It formed white, stout needles or rods from a mixture of benzene and dioxane, m.p. 163–164° (cor.).

A New Synthesis of Perfluoroaldehydes

BY OGDEN R. PIERCE AND THOMAS G. KANE

RECEIVED AUGUST 10, 1953

The preparation of perfluoroaldehydes has been described by reduction of the corresponding acid[1] or nitrile[2] with lithium aluminum hydride, by oxidative nitration of 1,1,1-trifluoropropane,[3] and by the Rosemund reduction of the corresponding acid chloride.[4] In this Laboratory it has been found that perfluoroaldehydes can be prepared by reduction of the corresponding perfluoroacid esters with lithium aluminum hydride at −70° in good yield (70–80%). The method employs a reverse addition technique and only small amounts of the by-product fluorine-containing alcohol are formed.

An explanation of the ready formation of aldehydes, in contrast to the usual alcohol formation from esters,[5] is not apparent at this time and is under investigation. Supporting work in this Laboratory has indicated that esters containing halogen atoms in the α- and β-positions will yield aldehydes on similar reductions. This would indicate that a strong inductive effect is a determining factor in the reaction mechanism.

(1) D. R. Husted and A. H. Ahlbrecht, THIS JOURNAL, **74**, 5422 (1952).

(2) A. L. Henne, R. L. Pelley and R. M. Alm, *ibid.*, **72**, 3370 (1950).

(3) H. Shechter and F. Conrad, *ibid.*, **72**, 3371 (1950).

(4) Central Research Department, Minnesota Mining and Manufacturing Co., private communication.

(5) W. G. Brown, "Reductions by Lithium Aluminum Hydride," in Adams, "Organic Reactions," Vol. VI, John Wiley and Sons, Inc., New York, N. Y., 1951, pp. 469–509.

Experimental

A typical experiment is described as follows: Ten grams of lithium aluminum hydride was weighed directly into a lead foil in a fume hood. The lead foil was folded in such a manner that it could be manipulated quickly into a closed package. The hydride was then pulverized using a hard rubber mallet. The finely powdered material was added directly to 300 ml. of anhydrous ether in a 500-ml., round-bottomed flask fitted with a condenser having a nitrogen gas inlet, stirrer and drying tube. The slurry was stirred for 1–2 hours and then the sludge was allowed to settle.

One mole of thoroughly dried ester in approximately one and a half times its volume of anhydrous ether was cooled to Dry Ice temperature in a one-liter, round-bottomed flask fitted with a stirrer, condenser and addition funnel having a pressure equalizing arm. The addition funnel was connected to a nitrogen cylinder. The hydride slurry was then decanted into the addition funnel, fresh ether was added to the sludge, and this solution was then added dropwise in entirety to the reaction mixture. The total time for hydride addition and reaction was limited to 3 hours. At this point, 25 ml. of 95% ethyl alcohol was added *via* the addition funnel and the reaction mixture was permitted to come to room temperature. The reaction mixture was then poured into a two-liter beaker containing crushed ice and enough concentrated sulfuric acid, approx. 75 ml., to give a clear ether layer. The aqueous layer was separated and extracted twice with ether. The combined ether portions were distilled to remove the ether and alcohol present. An equal volume of concentrated sulfuric acid was slowly added to the residue with vigorous stirring and the aldehyde was collected in a cooled receiver. Redistillation results in a pure product. The small quantity of fluorine-containing alcohol formed in these reactions is removed during the course of the initial distillation prior to dehydration of the aldehydrol. In one experiment, the amount of lithium aluminum hydride was doubled resulting in a slight increase in yield of aldehyde and also formation of a larger quantity of the corresponding alcohol.

The experimental results and physical properties are summarized in Table I.

TABLE I

Product	B.p., °C.	Yield, %	2,4-Dinitrophenylhydrazone m.p., °C.
CF_3CHO[a]	−18	71	149
C_2F_5CHO[a]	1.5	75	129[d]
C_3F_7CHO[a]	28	76	106.5
$C_7F_{15}CHO$[b]	122	70	94.5[c]

[a] Physical properties in good agreement with those reported by D. R. Husted and A. H. Ahlbrecht, THIS JOURNAL, **74**, 5422 (1952). [b] Not reported previously, $n^{20}D$ 1.2913. *Anal.* Calcd. for $C_8HF_{15}O$: C, 24.12; H, 0.25; F, 71.61. Found: C, 24.24; H, 0.42; F, 71.02. [c] Melting point of aldehydrol. *Anal.* Calcd. for $C_8H_3F_{15}O$: C, 23.08; H, 0.72. Found: C, 23.08; H, 0.74. [d] E. T. McBee, O. R. Pierce and J. F. Higgins, THIS JOURNAL, **74**, 1387 (1952); reported value 128.5°.

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DEPARTMENT OF CHEMISTRY
PURDUE UNIVERSITY
LAFAYETTE, INDIANA

N-Acetylation of the Hexosamines

BY SAUL ROSEMAN[1] AND JULIO LUDOWIEG

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Due to the divergence in physical constants reported by various workers for N-acetylglucosamine (2-acetamido-2-deoxy-D-glucose) and for N-acetylchondrosamine (2-acetamido-2-deoxy-D-galactose), a new method for the preparation of these substances was investigated.

In contrast to the usual procedure (treatment of the hexosamine hydrochloride with silver acetate and acetic anhydride in dry methanol), it was found that N-acetylation could be performed by treating a cold, neutral, *aqueous* solution of the sugar with acetic anhydride. Adequate control of *p*H could be attained by the use of sodium bicarbonate, sodium hydroxide, barium hydroxide, etc., but the most convenient preparative method was by the use of a basic ion-exchange resin such as Dowex-1, carbonate form.[2]

In the course of this work, it became necessary to prepare galactosamine hydrochloride (2-amino-2-deoxy-D-galactose hydrochloride) in quantity. The difficulty of this preparation has been noted.[3] A procedure based upon the use of a cationic exchange resin was developed which yielded pure chrondrosamine hydrochloride from the commercially available, inexpensive, crude chondroitin sulfate.

The acetylation proceeds quantitatively under certain conditions, and application of this technique at a microgram level can be used for determination of the individual hexosamines in a mixture. Details of the analytical technique will be described elsewhere.

Experimental[4]

D-Galactosamine Hydrochloride.—Chondroitin powder, Wilson Laboratories,[5] (100 g.) was shaken mechanically for 12 hours with 1 l. of water, and the dark solution was passed through a column containing 600 ml. of Amberlite IR-120, barium form. The effluent and washings were concentrated to 900 ml. and the solution was refluxed for 12 hours after the addition of 450 ml. of concentrated hydrochloric acid. The mixture was treated with 15 g. of Norit A, cooled, shaken mechanically with 1 l. of Dowex-1, carbonate form[6] and then passed through a column containing 500 ml. of Dowex-1, carbonate form. The effluent was acidified with acetic acid and concentrated to dryness *in vacuo*. Fractionation of the residue was accomplished by dissolving it in 26 ml. of water, transferring the solution to the top of a 350-ml. column of Dowex-50, hydrogen form (200–400 mesh)[6] and eluting with 0.05 *N* hydrochloric acid solution at a flow rate of about 5 ml. per minute. The fractions (500 ml. each) were tested with Benedict solution and positive tests were obtained in fractions 1 and 8–11. Fraction 1 was brown in color and the reducing substances were presumably neutral decomposition products. Fractions 8–11 were combined and concentrated to dryness yielding a pale yellow or colorless sirup. Occasionally, when the chondroitin powder was of unusually poor quality, the sirup was quite dark and it was refractionated by means of the ion-exchange resin. Crys-

(1) The Rackham Arthritis Research Unit, University of Michigan, Ann Arbor, Michigan.

(2) The hydroxyl form of the resin cannot be used for reasons previously described: S. Roseman, R. H. Abeles and A. Dorfman, *Arch. Biochem. Biophys.*, **36**, 232 (1952).

(3) A. B. Foster and M. Stacey in "Advances in Carbohydrate Chemistry," Vol. 7, Academic Press, Inc., New York, N. Y., 1952, p. 280; S. Gardell, *Acta Chem. Scand.*, **5**, 195 (1951).

(4) All m.p.'s are corrected.

(5) Supplied through the courtesy of Dr. David Klein; a mixture of crude chondroitin sulfate salts.

(6) Dowex-1 and Dowex-50 were supplied by the National Aluminate Corp., Chicago, 38, Ill. Amberlite IR-120 was supplied by the Rohm and Haas Co., Resinous Products Division, Washington Square, Philadelphia, Pa. Dowex-1, or Nalcite SBR, is a strong basic resin of the quaternary ammonium type with 3 methyl groups per N atom. It is prepared from polymerized styrene crosslinked with divinylbenzene. Dowex-50, or Nalcite HCR, is a strong cationic exchange resin—a monofunctional, sulfonated, copolymer of styrene and divinylbenzene. Amberlite-120 is similar in properties to Dowex-50.