air and the adsorption of the stable argon from air is traced. Approximately 13% of the total argon present in air was found to be adsorbed.

In these studies with radioactive argon it has been found that the use of radioactive tracer for mixed gas adsorption is feasible and gives more consistent results than the conventional method. In cases where the chemical analysis of the gas mixture is difficult by ordinary means, the use of a radioactive tracer, if available, provides a convenient method for studying mixed adsorption. It is recognized that the technique described here using separate samples of silica gel for each experiment does not insure that the adsorbent has exactly the same adsorption properties in each experiment. Experiments in which the only variable was the sample of silica gel used showed this error to be of the order of 3%.

Acknowledgment.—The authors greatly appreciate the support given to this research by Professor Alpheus Smith and by Professor M. L. Pool. We also express our thanks to the Alumni Fund for a grant in aid for purchase of equipment.

Summary

1. An apparatus is described suitable for studying binary mixed gas adsorption in which one component is radioactive or contains radioactive atoms as a tracer. The apparatus is also suitable for certain mixed adsorption studies by conventional means. Simple adsorption isotherms were obtained for air, argon and carbon dioxide on silica gel at 25°.

2. Adsorption isotherms for radon in air, in argon and in carbon dioxide on silica gel at 25° were studied. The isotherm in air follows Henry's law and substantiates the Langmuir theory of mixed adsorption as applied to low concentrations. The adsorption of radon is slightly suppressed in carbon dioxide. The studies with radon in argon show that the adsorption of radon is enhanced in the presence of argon even though a very small fraction of the total surface of silica gel is covered by radon.

3. The heat of adsorption of radon in air and in argon was estimated from the data obtained to be of the order of magnitude of 9,000 calories per mole.

4. Methods are described for the use of radioactive argon to follow the adsorption of argon in mixtures with carbon dioxide and with air.

SYRACUSE, N. Y. RECEIVED JANUARY 2, 1948

NOTES

The Reduction of 6-Methyl-8-(4'-diethylamino-1'-methylbutylidene)-aminoquinoline

BY H. J. BARBER, D. H. O. JOHN AND W. R. WRAGG

The recent publication by Elderfield, *et al.*,[1] reporting a study of the synthesis of Plasmochin by the reductive condensation of 1-diethylaminopentanone-4 (I) with 6-methoxy-8-aminoquinoline (II), from which a satisfactory method did not ensue, is of considerable interest to us since we were concerned during the war with a similar process which gave Plasmochin in excellent yield. We wish therefore to record some additional data.

Early in our work we investigated a process revealed by Bergmann[2] for the reductive condensation of 6-methoxy-8-nitroquinoline with (I), following his conditions as closely as practicable (our palladium/barium sulfate catalyst was prepared by the method of Sabalitschka and Moses[3]), but we could not obtain any Plasmochin. A second Bergmann, patent[4] claims, but does not exemplify, the reductive condensation of (I) and (II).

Preparation of the Schiff base, 6-methoxy-8-(4'-diethylamino - 1' - methylbutylidene) - aminoquinoline (III), was accomplished by Elderfield, *et al.*,[1] by the interaction of (I) and (II) using ethylbenzene as an entrainer to remove water, but condensation under these conditions was slow and far from complete. The Schiff base may be obtained in almost quantitative yield using the diethyl ketal of (I), instead of (I) itself, (*cf.* van Shelven[5]) by the procedure described[6] for 6-methoxy - 8 - amino - 1,2,3,4 - tetrahydroquinoline (IV). The Schiff base, without distillation, could then be reduced in ethyl acetate solution at 60° and 450 lb. hydrogen pressure in the presence of a platinum/charcoal catalyst, but the results were not consistent. Considerable improvement was effected by using an Adams platinum oxide catalyst[7] at the same pressure but at room temperature. Reproducible results were obtained and an 80% over-all yield (calculated on (II)) of distilled Plasmochin base was obtained on a production scale.

In our experience the reduction is very susceptible to minor changes in materials, catalyst or

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[1] Elderfield, Kreysa, Dunn and Humphreys, THIS JOURNAL, **70**, 40 (1948).

[2] British Patent 547,302.

[3] Sabalitschka and Moses, *Ber.*, **60**, 800 (1927).

[4] British Patent 547,301.

[5] British Patent 388,087, Example 32.

[6] Barber and Wragg, *J. Chem. Soc.*, 610 (1946).

[7] John, *J. Soc. Chem. Ind.*, **63**, 256 (1944).

reaction conditions and unless hydrogenation proceeds rapidly and smoothly, by-products are formed. In one explanation of the imidazole formation observed in their reductive condensations of (I) and (II), Elderfield and Kreysa[8] suggest that on reduction of the Schiff base (III), saturation of the pyridine ring occurs before substantial reduction of the azomethine linkage. This clearly requires qualification since under conditions now reported the reverse is the case. However, the more drastic hydrogenation conditions and the different catalyst used by Elderfield, *et al.*, might have caused the reaction to follow the alternative course. That these latter conditions led to extensive nuclear reduction is in accord with our experience since we used similar conditions except for the solvent employed, for making tetrahydro-Plasmochin and (IV), the published yield and analysis[6] of which have been overlooked by Elderfield, *et al.*[8]

It is of interest to note that Andersag also reports a failure to achieve more than a few per cent. yield of Plasmochin by the aminoketone route.[9]

A considerable part of this experimental work was carried out by H. G. Thompson and A. C. Benzie.

(8) Elderfield and Kreysa, THIS JOURNAL, **70**, 44 (1948).

(9) I. G. Elberfeld, *Jahresberichte*, 1940 (B. I. O. S. 116), Appendix 2).

RESEARCH LABORATORIES
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RECEIVED MAY 1, 1948

The Preparation of 1-(*p*-Nitrophenyl)-1,3-butadiene

BY E. C. COYNER AND G. A. ROPP[1]

In the continuation of a study[2] on Diels–Alder reactions with 1-aryl-1,3-dienes, 1-(*p*-nitrophenyl)-1,3-butadiene and its adduct with maleic anhydride have been prepared and characterized.

The diene was synthesized in two steps by a modification of the procedure described in a review[3] of German war-time investigations on extensions of the Meerwein[4] reaction.

$$CH_2{=}CH{-}CH{=}CH_2 + ClN_2C_6H_4NO_2\text{-}p \longrightarrow ClCH_2{-}CH{=}CH{-}CH_2C_6H_4NO_2\text{-}p + N_2$$

$$ClCH_2{-}CH{=}CHCH_2C_6H_4NO_2\text{-}p + KOH \longrightarrow CH_2{=}CH{-}CH{=}CHC_6H_4NO_2\text{-}p + KCl + H_2O$$

The chlorobutene, obtained in the first step, may be distilled successfully in small quantities under high vacuum, but it was found that this operation could be omitted as well as the removal of impurities, chiefly *p*-nitrophenol, from the chlorobutene by steam distillation. Actually, inclusion of these operations, as described in the Germany report, give only very low yields of diene, whereas the abbreviated procedure given in detail below resulted in a yield of 61% of purified product based on *p*-nitroaniline. Furthermore, the product is described in the German report as an oil, but in this work 1-(*p*-nitrophenyl)-1,3-butadiene was found to crystallize in yellow needles, m. p. 78.0–78.8°. It reacts readily with maleic anhydride and has been kept at room temperature in dark bottles for several months with no apparent decomposition.

Studies are now underway on the reactions of 1-(*p*-nitrophenyl)-1,3-butadiene with unsymmetrical dienophiles.

Experimental

1-(*p*-Nitrophenyl)-4-chloro-2-butene.—Technical *p*-nitroaniline was recrystallized once from ethanol and 140 g. (one mole) was dissolved in a hot solution of 240 cc. concentrated hydrochloric acid and 100 cc. of water. The solution was stirred rapidly and cooled in an ice–salt-bath. After 100 g. of ice was added, a solution of 70 g. of sodium nitrite in 120 cc. of water was run in during one hour while the temperature was kept between −4 and +4.5°. Stirring was continued for an additional twenty minutes and the reaction mixture was filtered. The filtrate was kept at 0° while it was added over a period of ninety minutes to a well-stirred mixture of 1 liter of acetone, 80 g. of sodium acetate dissolved in 100 cc. of water, 30 g. of cupric chloride dissolved in 50 cc. of water, and 130 cc. of liquid butadiene. The reaction mixture was maintained at −3 to +5° by means of an ice–salt-bath during the addition and was then allowed to warm to room temperature. Stirring was continued for an additional sixteen hours. One liter of ether was then added to extract the oily product, and the ethereal solution was separated, washed four times with 1-liter portions of water and dried over anhydrous magnesium sulfate. Removal of the solvent on the steam-bath gave 187.5 g. (88.6%) of crude 1-(*p*-nitrophenyl)-4-chloro-2-butene as a dark brown oil.

1-(*p*-Nitrophenyl)-1,3-butadiene.—The crude chlorobutene was dissolved in a solution of 500 cc. of ligroin and 500 cc. of benzene and treated with 5 g. of activated charcoal under reflux for two hours. The charcoal was removed by filtration, the solvents were evaporated on the steam-bath and the residual oil was dissolved in 400 cc. of methanol. This solution was then stirred at 15–33° while a solution of 112 g. of potassium hydroxide in 600 cc. of methanol was added over thirty minutes. Stirring was continued for an additional five minutes and the precipitated light yellow crystalline diene was removed by filtration; it was washed thoroughly with water and dried in a vacuum desiccator to give 76.5 g. of product, m. p. 75.0–76.8. The methanolic filtrate was added to 1200 cc. of water to precipitate 41.5 g. of less pure, dark brown product, which upon recrystallization from 400 cc. of ligroin gave 30 g. of light yellow crystalline diene, m. p. 75.5–76.8°. The total yield of product, m. p. 75.0–76.8° is therefore 106.5 g. (61% based on *p*-nitroaniline). A highly purified sample, m.p. 78.0–78.8°, was prepared by repeated recrystallizations from ligroin and from methanol.

Anal. Calcd. for $C_{10}H_9O_2N$: C, 68.56; H, 5.18. Found: C, 68.44, 68.44; H, 5.07, 4.96.

Adduct with Maleic Anhydride, 3-(*p*-Nitrophenyl)-1,2,3,6-Tetrahydrophthalic Anhydride.—A mixture of one-hundredth mole quantities of 1-(*p*-nitrophenyl)-1,3-butadiene (1.75 g.) and maleic anhydride (0.98 g.) was heated at 70° for fifteen minutes, during which time the melt solidified. The solidified cake was then heated under reflux with 3 cc. of xylene for ten minutes and cooled to room temperature. The solid product was re-

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[1] Research Corporation Fellow.

[2] For a previous publication see Coyner and Ropp, THIS JOURNAL, **69**, 2231 (1947).

[3] Müller, "The Action of Aromatic Diazo Compounds on Aliphatic Unsaturated Compounds," PB 737, Office of Technical Services, Department of Commerce, Washington, D. C.

[4] Meerwein, Buchner and van Emster, *J. prakt. Chem.*, **152**, 237-266 (1939).

moved by filtration and recrystallized once from glacial acetic acid and three times from ethyl acetate to give pale yellow crystals, m. p. 170.9–172.0°.

Anal. Calcd. for $C_{14}H_{11}O_5N$: C, 61.54; H, 4.06. Found: C, 61.33, 61.60; H, 4.04, 3.99.

UNIVERSITY OF TENNESSEE
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RECEIVED MARCH 8, 1948

Hydroxyethylmorphine

BY WARNER W. CARLSON AND L. H. CRETCHER

The typical result of alkylating the phenolic hydroxyl of morphine has been found to be the production of codeine-like effects, almost regardless of the chemical nature of the alkylating group.[1] However, since no reference could be found to the preparation of a hydroxyalkyl ether derivative of morphine, the alkaloid was hydroxyethylated by the procedure previously developed for use with nitrogenous phenols.[2]

Toxicity of the derivative was determined by the subcutaneous (abdominal) injection of graded doses of the compound in white mice (17 to 19 g. weight range). The results are given in Table I, along with the values listed by Small and Eddy[1] for the parent alkaloid and its methyl and ethyl ethers. Introduction of the hydroxyethyl group was found to produce a marked decrease both in acute toxicity and convulsant action. Hydroxyethylmorphine also failed to elicit the Straub reaction or circus movements in the animals. In its actions the hydroxyethyl derivative resembles γ-isomorphine, which has an LD 50 of 2000 mg./kg. and does not produce the Straub reaction or circus movements in mice.[1]

TABLE I

ACUTE TOXICITY OF HYDROXYETHYLMORPHINE TO WHITE MICE

Substituent at position 3	LD 50 mg./kg., as free base	Convulsant action, mg./kg.	Straub reaction
HO—	531	531	Present
CH_3O—	241	161	Present
C_2H_5O—	136	122	Present
HOC_2H_4O—	2500	2500	Absent

A preliminary estimate of analgesic potency in white mice was made by the method of Woolfe and MacDonald,[3] morphine and codeine being used as reference compounds. The results are given in Table II, from which it is estimated that codeine is approximately 1/10, and hydroxyethylmorphine 1/15, as analgesic as the parent alkaloid.

Experimental

Hydroxyethylmorphine.—A mixture of 5.7 g. of morphine, 8.3 g. of potassium carbonate, and 100 g. of ethylene carbonate[2] (in excess as solvent) was heated with stirring for seventy-five minutes at 98°, cooled, and poured into an excess of cold aqueous alkali. The solution was extracted three times with 50-cc. portions of chloroform, the extracts united and the product extracted by 20 cc. of 0.1 *N* hydrochloric acid. The solution was made alkaline and the product again extracted into chloroform; because of the marked water solubility of the derivative, it was not feasible to wash the extract. The chloroform solution was evaporated to a sirup under reduced pressure, the residue dissolved in boiling absolute alcohol, and the solution cooled, hydroxyethylmorphine crystallizing. Recrystallized from the same solvent (30 cc. of alcohol per g. of compound) the derivative was obtained as colorless crystals; m. p. 190°; yield, 4.6 g.; $[\alpha]_D$ −124.8° (methanol).

TABLE II

ANALGESIC POTENCY OF HYDROXYETHYLMORPHINE

Drug	Dose, mg./kg., as free base	Animals showing analgesia, %	Av. time to develop analgesia minutes	Average duration of analgesia minutes
Morphine	10	100	14	29
	20	100	12	80
Codeine	50	60	14	31
	100	100	14	41
Hydroxy-ethylmorphine	50	66	12	32
	100	66	12	34
	150	100	10	38
	200	100	10	58

Anal. Calcd. for $C_{19}H_{23}NO_4$: C, 69.26; H, 7.04; N, 4.26. Found: C, 69.02; H, 7.08; N, 4.36.

DEPARTMENT OF RESEARCH IN PURE CHEMISTRY
MELLON INSTITUTE
PITTSBURGH, PA.

RECEIVED JANUARY 28, 1948

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[1] Small and Eddy, U. S. Public Health Reports, Supplement No. 138, U. S. Government Printing Office, Washington, D. C., 1938.

[2] Carlson and Cretcher, THIS JOURNAL, **69**, 1952 (1947).

[3] Woolfe and MacDonald, *J. Pharm. Exp. Therap.*, **80**, 300 (1944).

The Ultraviolet Absorption Spectra of 1,1′- and 2,2′-Binaphthyl

BY VERNON L. FRAMPTON, JOSEPH D. EDWARDS, JR., AND HENRY R. HENZE

In a very recent article concerning the ultraviolet absorption spectra of some naphthalene derivatives, Friedel, Orchin and Reggel[1] call attention in a footnote to differences between the spectra as determined by them for 1,1′- and 2,2′-binaphthyl and those noted previously by Adams and Kirkpatrick.[2] The significance of these data is such as to warrant this communication to confirm the location of the absorption maxima reported by Friedel, Orchin and Reggel, since, as they appear to us, the ultraviolet absorption spectra of 1,1′-binaphthyl and, especially, of 2,2′-binaphthyl were of fundamental importance in the selection by Adams, *et al.*, of a binaphthyl as the basic nucleus of gossypol.

1,1′-Binaphthyl has been resynthesized[3] by three different procedures, namely: (a) by the Wurtz–Fittig reaction[4] starting with 1-chloronaphthalene; (b) according to the method of Ull-

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[1] Friedel, Orchin and Reggel, THIS JOURNAL, **70**, 199 (1948); see footnote (10).

[2] Adams and Kirpatrick, *ibid.*, **60**, 2181 (1938).

[3] These experimental data are drawn from a thesis presented by Joseph Daniel Edwards, Jr., to the Faculty of the Graduate School of the University of Texas in partial fulfillment of the requirements for the Master of Arts degree, January, 1948.

[4] Rodd and Linch, *J. Chem. Soc.*, 2178 (1927).

mann[5] using 1-bromonaphthalene; (c) utilizing the Grignard reaction[6] with 1-bromonaphthalene. The melting points of the samples of 1,1′-binaphthyl[7] prepared by these procedures were 157.5, 157.2 and 157.5°, respectively; a mixture of the three preparations melted at 157.5°.

In Fig. 1 are presented the ultraviolet absorption spectra for these three samples, which were determined with a Beckman quartz spectrophotometer using 95% ethyl alcohol as solvent, together with the data[8] taken from the Fig. 2 published by Adams and Kirkpatrick.[2] In our Fig. 1 are included also data recorded still earlier by Pestemer and Cecelsky[9] using a hexane solution of 1,1′-binaphthyl. The low wave length absorption band which we report is at 220–224 millimicrons, which is in satisfactory agreement with the band at 226 millimicrons reported by Friedel, *et al.*,[1] but is in disagreement with the location of the absorption band at 238 millimicrons according to Adams and Kirkpatrick.

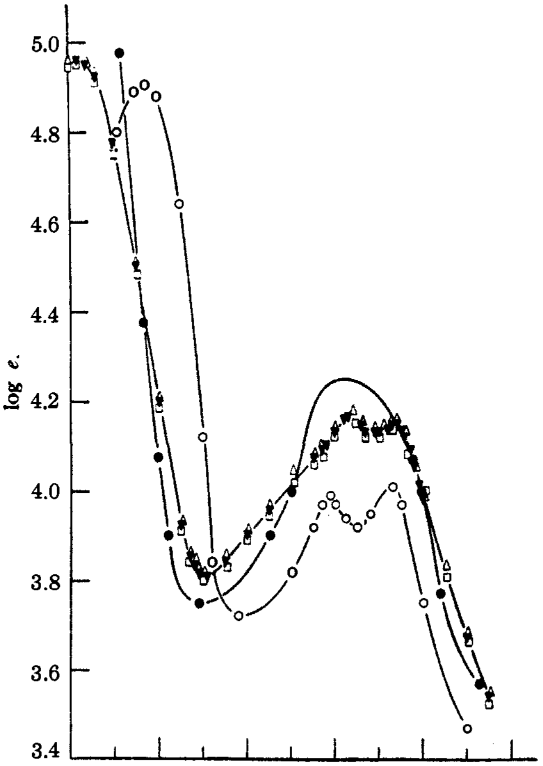

Fig. 1.—Ultraviolet absorption spectra for 1,1′-binaphthyl: ▼, 1,1′-binaphthyl prepared by the Wurtz–Fittig synthesis; △, Ullmann synthesis; □, Grignard synthesis; ○, data of Adams and Kirkpatrick; ●, data of Pestemer and Cecelsky.

2,2′-Binaphthyl,[10] melting at 187°, was synthesized through the Grignard reaction with 2-iodonaphthalene. The absorption spectrum for 2,2′-binaphthyl is presented in Fig. 2. In agreement with the findings of Friedel, *et al.*, a thorough investigation throughout the region 260–300 millimicrons did not yield evidence for the existence of an absorption maximum at 297 millimicrons, as reported by Adams and Kirkpatrick. Otherwise, the absorption spectra for 2,2′-binaphthyl are in reasonable agreement.

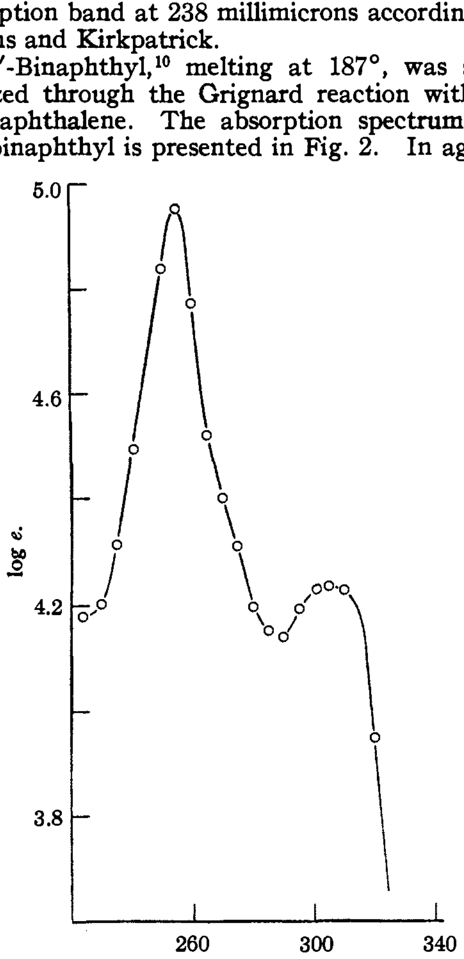

Fig. 2.—Ultraviolet absorption spectrum for 2,2′-binaphthyl.

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[5] Ullmann and Bielecki, *Ber.*, **34**, 2184 (1901).

[6] Sakellarios and Kyrimis, *ibid.*, **57**, 324 (1924).

[7] The melting point behavior is considerably influenced by the rate of heating. Samples can be shown to exhibit sintering at temperatures lower than the m. p. of 157.5° by very rapid heating. *Cf.* Orchin and Friedel, THIS JOURNAL, **68**, 573 (1946).

[8] These data were obtained using dioxane as solvent; however, identical data were reported utilizing ethyl alcohol as solvent.

[9] Pestemer and Cecelsky, *Monatsh.*, **59**, 119 (1932).

[10] Vesely and Stursa, *Coll. Czechoslov. Chem. Commun.*, **4**, 139 (1932), reported m. p. of 187° for a sample of 2,2′-binaphthyl obtained using lithium as the coupling agent.

THE COTTON RESEARCH COMMITTEE OF TEXAS
AUSTIN, TEXAS, AND
THE DEPARTMENT OF CHEMISTRY
THE UNIVERSITY OF TEXAS
AUSTIN, TEXAS

RECEIVED FEBRUARY 24, 1948

The Purification of Neopentane by Mercury Photosensitization[1]

BY B. DEB. DARWENT AND E. W. R. STEACIE

In a study of the mercury photosensitized reactions of neopentane it was found necessary to prepare extremely pure samples of that hydrocarbon. The Grignard reaction of tertiary butyl chloride with methylmagnesium chloride was used to produce the neopentane. The product was washed with 85 and 95% sulfuric acid and then photobrominated to ensure the complete removal of unsaturates, since isobutene is the most likely impurity. The residual bromine and any hydrogen bromide formed were removed by distilling the mixture through 40% potassium hydroxide (aqueous) and over solid potassium hydroxide. The resulting neopentane was finally purified by low temperature distillation in a column of conventional design. The distillate was assumed to be pure when the temperature remained constant at 9.6° for thirty to sixty minutes under total reflux. This "pure" neopentane was taken off in four consecutive fractions, the purity of which was checked by determining the vapor pressure–temperature relations of large samples over a wide range of temperature. No indications of impurity could be detected.

Preliminary experiments showed that the rates of the mercury photosensitized reaction of different samples, though surprisingly low, were very variable. Samples of the unreacted and of the "partially decomposed" neopentane were analyzed by the mass spectrometer with the following results:

Sample	Percentages					
	A	B	C	D	E	F
Neopentane	96.4	99.6	99.9	100	100	100
n-Pentane	1.1	..	...	...	...	...
Dimethylcyclopropane	1.6	0.4	trace	...	...	...
C_6 hydrocarbons	1	..	...	...	...	...

in which Sample A was the "pure" unreacted neopentane and B to F were "partially decomposed" samples. It was stated by the analyst that samples D, E and F were "apparently of the same purity as the neopentane used for calibrating as obtained from Dr. F. D. Rossini, National Bureau of Standards, Standard Sample No. 299–5s. It is certified to be 99.96% pure; impurity 0.04 ± 0.02%."

Accordingly a large sample of crude (undistilled) neopentane (about 30 liters of gas) was subjected to prolonged mercury sensitization by circulating a mixture of gaseous neopentane and mercury through a quartz vessel illuminated by a low pressure mercury lamp, the radiation from which consisted largely of the unreversed 2537 Å. line, for seventy to eighty hours, roughly distilled into 5 fractions and analyzed on the mass spectrometer. The results were:

Fraction no.	Percentages				
	1	2	3	4	5
Neopentane	99 (8)[a]	99 (7)[a]	99 (6)[a]	99 (4)[a]	99 (0)[a]
Hexane	0.2	0.3	0.4	0.6	1.0

[a] The figures in parentheses are uncertain.

Hence, in the absence of very efficient fractionation, mercury photosensitization is an efficient method of obtaining neopentane of high purity. This method of purification is possible only because neopentane is remarkably resistant to attack by Hg($^3P_1$) atoms whereas the impurities react readily to give, ultimately, heavy polymers and non-condensable gases (hydrogen and methane) which are easily separated from the unreacted neopentane.

The Grignard reaction was carried out by Dr. A. Cambron and Mr. R. A. B. Bannard of these laboratories, and the mass spectrometer analyses by Dr. Fred L. Mohler of the National Bureau of Standards, Washington, D. C., to whom our thanks are due. The laboratory assistance of Mr. J. R. Pilon is gratefully acknowledged.

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DIVISION OF CHEMISTRY
NATIONAL RESEARCH LABORATORIES
OTTAWA, ONTARIO
RECEIVED MARCH 19, 1948

The Reduction of *p*-Hydroxyformanilide by Lithium Aluminum Hydride to N-Methyl-*p*-aminophenol

BY JACOB EHRLICH

This reduction of an anilide to a secondary amine proceeds smoothly in tetrahydrofuran as solvent. The method is applicable to various amides using diethyl ether or tetrahydrofuran as solvent, to be reported in a later communication.

Experimental

A solution of 1.9 g. (0.05 mole)[1] of lithium aluminum hydride in 36 cc. of anhydrous tetrahydrofuran[2] was prepared in a 3-neck conical flask provided with sealed stirrer, thermometer, reflux condenser, hopper[3] and calcium chloride guard-tube.[4] The solution was brought to 20–25° and 2.75 g. (0.02 mole) of *p*-hydroxyformanilide was added in small portions during thirty minutes, cooling externally with ice-water to maintain this temperature. The hopper was flushed with 4 cc. of tetrahydrofuran and the charge stirred twenty minutes more at 20–25°. Dur-

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[1] Assuming only one labile hydrogen (phenolic) in 1 mole of *p*-hydroxyformamilide, then 0.25 mole of $LiAlH_4$ would be destroyed prior to any reduction. The reduction of the formyl radical would consume a further 0.5 mole of $LiAlH_4$, making a 4:3 molar ratio of anilide:$LiAlH_4$. If the amido hydrogen is also labile, the ratio becomes 1:1. If the formyl hydrogen is labile, the ratio becomes 4:5. However, these calculations are only of academic interest, for the 0.02:0.05 molar ratio was arrived at empirically. If less $LiAlH_4$ is employed, the yield drops proportionally.

[2] The tetrahydrofuran was obtained from E. I. du Pont de Nemours and Co. This was rendered water and peroxide free by storing 500 cc. in an amber bottle over 75 g. of flake sodium hydroxide for two weeks, occasionally shaking. The clear, colorless supernatant liquor was decanted (from now discolored solids) for use in the reductions without further purification. On dissolving the $LiAlH_4$ in the tetrahydrofuran the heat of solution will raise the temperature to about 50°.

[3] Similar in construction (but smaller capacity) to that described by Swift and Billman, *Ind. Eng. Chem., Anal. Ed.*, **17**, 600 (1945). However, this may be omitted and the same results obtained by using a removable rubber stopper.

[4] In various reductions no special precautions, except the exclusion of atmospheric moisture, were employed, and no uncontrolled or explosive reaction was observed. However, as an added precaution, it would be desirable to conduct the reaction under an atmosphere of dry nitrogen.

ing this period a thin slush formed. The temperature was then raised to 63–66° and maintained for ten minutes. The pale pink slurry was then chilled to 20–25°, 77 cc.[5] of 3 N hydrochloric acid added *cautiously* from a dropping funnel (ice-water cooling as required), resulting in a pale slightly cloudy solution.

The charge then was steam-distilled (about 90 cc. distillate) to remove the solvent, digested while hot with 0.3 g. of Norit and 0.2 g. of Filter-Cel and filtered with suction. The colorless filtrate was cooled to 0–5°, 10 cc. of concentrated hydrochloric acid added, then titrated at this temperature with molar sodium nitrite solution to a strong blue streak (ten minutes end-point) on starch-iodide paper. Almost the theoretical amount was required. During the titration pale yellow nitrosamine needles separated. The crystals were filtered with suction, washed with water and dried at 55°; yield 2.66 g., m. p. 134–135°. The filtrate, on extraction with ether, yielded an additional 0.12 g.; total yield 92%.

On recrystallizing the combined crops from 10% ethanol, in the presence of a little Norit, the m. p. was raised to 135.5°, identical with purified N-nitroso-N-methyl-*p*-aminophenol prepared from photographic Metol as shown by mixed m. p.

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[5] The first 20 cc. of 3 N hydrochloric acid must be fed very slowly, dropwise. During this period the main heat effect is evident and the bulk of the hydrogen gas evolved (by decomposition of the excess lithium aluminum hydride). Thereafter the balance may be added faster. Prior to the acid addition the calcium chloride tube is removed (*versus* any back pressure) and the flask vented to the hood.

CONTRIBUTION FROM THE
EHRLICH LABORATORY
BEVERLY HILLS, CALIFORNIA RECEIVED JANUARY 31, 1948

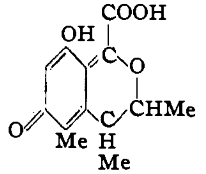
The Constitution of Citrinin

BY T. S. GORE, T. B. PANSE AND K. VENKATARAMAN

The structures originally assigned[1] to citrinin (I) and its degradation products (II) and (III) are untenable in the light of their behavior towards diazonium salts.[2] Cram[3] has now shown by synthesis and direct comparison that (III) is 4-methyl-5-ethylresorcinol, a conclusion at which we had arrived by circumstantial evidence. The 2,4 and 4,6-compounds were ruled out by the ability of (III) to form disazo dyes. Comparison of the absorption spectra and the color reactions of the bis-benzeneazo derivative of (III) with those of 2,4- and 4,6-bis-benzeneazoresorcinol and a series of analogous dyes showed that (III) is 5-methyl-4-ethylresorcinol (IV) or 4-methyl-5-ethylresorcinol (V). The absorption curves for 2,4-bis-benzeneazoresorcinol, 2,6-bis-benzeneazo-5-methyl-4-ethyl resorcinol and the bis-benzeneazo derivative of (III) had a well-defined, high intensity band in the visible region ($\lambda_{\max.} \backsim 415$ mμ; $\epsilon_{\max.} \backsim 60{,}000$). 4,6-bis-Benzeneazoresorcinol and 4,6-bis-benzeneazo-2-ethylresorcinol exhibited a band of relatively low intensity in the visible region ($\lambda_{\max.} \backsim 415$ mμ; $\epsilon_{\max.} \backsim 20{,}000$) and absorption maxima in the near ultraviolet ($\lambda_{\max.} \backsim 340$ mμ; $\epsilon_{\max.}$ 36,000).

Shah and Robinson's synthesis[4] of (IV) was repeated, and it was found to melt at 79–82° (Shah and Robinson, m. p. 75–80°), while (III) as a monohydrate melts at 68–69°, and after dehydration at 98–99°; the m. p. of (III) was considerably depressed by admixture with (IV). Cram[3] has quoted us erroneously as reporting a m. p. of 65–70° for (III). The bis-benzeneazo derivatives of (III) and (IV) melted, respectively, at 171° and 188°, and the mixed m. p. was lower. It followed therefore that (III) is 4-methyl-5-ethylresorcinol. However, this is in conflict with the observation of Hetherington and Raistrick[1] that neither of the acids obtained by oxidation of the dimethyl ether of (III) gave the anthrachrysone reaction. We prepared 3,5-dimethoxy-2-methylbenzoic acid (VII) by the methylation of the corresponding α-resorcylic acid,[5] and found that it readily gave a bordeaux-red color on warming with sulfuric acid (the anthrachrysone reaction); Cram has recorded that the acid (VI) synthesized by him corresponds in its properties to one of Hetherington and Raistrick's acids. The m. p. (157–158°) reported for (VI) by Cram is in agreement with ours, while Hetherington and Raistrick's two acids melted at 142–146° and 98–99°.

From the formulation of (III) as 4-methyl-5-ethylresorcinol, the properties of (II), including the formation of (III) from (II) by alkali fusion, are fully explained by the structure 4-methyl-5-(1-methyl-2-hydroxy)-propyl-resorcinol, proposed



by Cram. The experimental results of Hetherington and Raistrick[1] and the behaviour of citrinin towards diazonium salts[2] would then agree with the above constitution for citrinin.

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[1] Raistrick, Robinson, *et al.*, *Phil. Trans. Roy. Soc.*, **B220**, 269, 297 (1931).

[2] Gore, *et al.*, *Nature*, **157**, 333 (1946).

[3] Cram, THIS JOURNAL, **70**, 440 (1948).

[4] Shah and Robinson, *J. Chem. Soc.*, 1491 (1934).

[5] Woodward and Reed, THIS JOURNAL, **65**, 1569 (1943).

DEPARTMENT OF CHEMICAL TECHNOLOGY
THE UNIVERSITY
BOMBAY, INDIA
RECEIVED APRIL 17, 1948

The Employment of Sodium Hydride as a Condensing Agent

BY NATHAN GREEN AND F. B. LAFORGE

Sodium hydride is now being produced on a large scale, and its advantages as a catalyst in various organic reactions have been indicated by Hansley and Carlisle.[1] Its use in this Laboratory in the preparation of ethyl β-oxocaprylate, ethyl β-carbethoxy-α-oxo-enanthate, and 5-carbethoxydihydrocinerone has been described in previous articles.[2,3] We have since employed this reagent in

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[1] Hansley and Carlisle, *Chem. Eng. News*, **23**, 1332 (1945).

[2] Soloway and LaForge, THIS JOURNAL, **69**, 2677 (1947).

[3] LaForge and Soloway, *ibid.*, **69**, 2932 (1947).

the preparation of carbethoxy derivatives of other ketones, and of their substitution products, for Claisen condensations of alkyl esters with ketones, and for cyclizations of the Dieckman type. It probably could be used with advantage for many reactions where powdered sodium or sodium ethylate is usually employed. We are therefore presenting some observations which we have made in the use of this catalyst in these reactions.

The reaction of ketones with ethyl carbonate starts promptly when the finely ground catalyst is employed, but with the coarser material there is a considerable lag, or occasionally the reaction may not start at all. Since at present sodium hydride is supplied only in the coarser size, which is easier and less hazardous to handle but less reactive, it is generally necessary to reduce the particle size by some means of grinding.

A laboratory apparatus for this purpose has been designed by V. L. Hansley[4] in which reactions are carried out in a revolving closed cylinder containing steel balls. Since this rather expensive equipment will not be generally available, we have employed the same principle in connection with the usual glass apparatus. When several ceramic spheres about 13 mm. in diameter are placed in the reaction flask with the solvent and the ethyl carbonate, and rolled slowly over the catalyst with a glass paddle stirrer for about thirty minutes, the particle size of the sodium hydride is reduced sufficiently so that the reaction starts soon on addition of a small quantity of the ketone. Care should be taken not to add very much of the ketone until the reaction, which is observed by the evolution of hydrogen, has definitely started. When the experiment is performed in this manner, the yield in the case of ethyl β-oxocaprylate is usually 80 to 85% of the theoretical.

In the preparation of sodium derivatives of β-keto esters the reaction starts at once regardless of the physical state of the sodium hydride, and the addition of the ester is regulated according to the rate of evolution of hydrogen. The solvent is generally anhydrous ether. Dioxane, in which most sodium enolates are soluble, is sometimes used.

Alcohol-free sodium alcoholates are conveniently prepared by dropping a slight excess of the alcohol on sodium hydride covered with benzene and, after refluxing, distilling off the solvent until it is alcohol-free, as shown by measurement of the refractive index. Sodium hydride dissolves more readily than sodium lumps or wire.

The following examples illustrate the employment of sodium hydride in reactions referred to above.[5]

Ethyl-3-oxo-6-octenoate[6] was prepared from 58 g. (2.4 moles) of sodium hydride covered with 300 ml. of dry ether and 283 g. (2.4 moles) of ethyl carbonate in a nitrogen atmosphere by dropping 136 g. (1.2 moles) of 5-heptene-2-one into the stirred suspension over a period of five hours. More ether was added as the contents of the flask thickened. Acetic acid was added in quantity equivalent to the sodium hydride diluted with ice and water, and the reaction product was isolated from the ethereal solution by removing first the ether and then the excess ethyl carbonate in vacuum: b. p. 110–120° (10 mm.), n^{25}_{D} 1.4460, yield 188 g. (85%).

Anal. Calcd. for $C_{10}H_{16}O_3$: C, 65.19; H, 8.76. Found: C, 64.67; H, 8.80.

2,4-Nonanedione.—A mixture of 28.8 g. (0.2 mole) of ethyl caproate and 12.7 g. (0.22 mole) of dry acetone was added to 4.8 g. (0.2 mole) of sodium hydride covered with 10 ml. of dry ether. The evolution of hydrogen started after refluxing for several minutes, and more ether was added as solid material separated. Refluxing was continued for one hour. Ice and water containing a suitable quantity of sulfuric acid were added, and the reaction product was isolated from the ethereal solution and distilled from a modified Claisen flask: b. p. 94–98° (11 mm.), n^{25}_{D} 1.4222, yield 16.8 g. (54%).

2,5-Dioxo-1,4-cyclohexandicarboxylic Acid Diethyl Ester.—The Dieckman cyclization between two molecules of ethyl succinate occurs smoothly on addition of the ester to two equivalents of sodium hydride covered with a small quantity of ether and refluxing until the evolution of hydrogen has ceased. Upon addition of dilute acid the reaction product separates in crystalline form on removal of the ether and it can be recrystallized from ethanol (m. p. 130–131°).

Ethyl β-Carbethoxy-γ-oxo-pelargonate.—To 4.8 g. (0.2 mole) of sodium hydride covered with 100 ml. of ether, 37.2 g. (0.2 mole) of ethyl β-oxocaprylate was slowly added with stirring, more ether being added as the contents of the flask thickened. It was refluxed for thirty minutes, after which 37 g. (0.22 mole) ofe thyl bromoacetate was added dropwise at a rate to cause gentle refluxing of the ether. The reaction was completed by further refluxing for thirty minutes, after which the separated sodium bromide was dissolved by addition of water containing 5% of sulfuric acid. The ethereal layer was washed and dried and the solvent removed. The residue was distilled on a modified Claisen flask: b. p. 133–136° (0.4 mm.), n^{25}_{D} 1.4388. The yield was 46 g. (84.5%).

Anal. Calcd. for $C_{14}H_{24}O_5$: C_2H_5O, 32.4. Found: C_2H_5O, 33.0.

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AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
BELTSVILLE, MARYLAND
RECEIVED MARCH 10, 1948

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[4] Private communication from V. L. Hansley of E. I. du Pont de Nemours and Co., Niagara Falls, N. Y.

[5] We wish to express our appreciation to the E. I. du Pont de Nemours and Co. for donating the sodium hydride we employed in this and previous work.

[6] Prepared in collaboration with S. B. Soloway.

The Action of Copper Sulfate on the Phenylosazones of the Sugars. VI.[1] Gentiobiose Phenylosotriazole[2]

BY W. T. HASKINS, RAYMOND M. HANN AND C. S. HUDSON

In continuation of the investigation of the conversion of the sugar phenylosazones to the corresponding phenylosotriazoles through the action of copper sulfate, we have prepared the phenylosotriazole of gentiobiose. This phenylosotriazole differs from those described in the previous articles in that its crystals contain one molecular equivalent of ethanol which is tenaciously retained at ordinary temperatures even in moderately high

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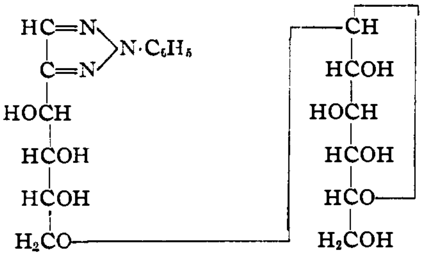
[1] Number V was published in THIS JOURNAL, 69, 1461 (1947).

[2] Presented in part before the Division of Sugar Chemistry and Technology at the Chicago meeting of the American Chemical Society, April 19-23, 1948.

vacuum but is eliminated *in vacuo* at elevated temperatures. It is also unique in that its heptaacetate and heptabenzoate crystallize readily whereas, among the other disaccharide phenylosotriazoles investigated, only one crystalline acyl derivative has been obtained (cellobiose phenylosotriazole heptaacetate). Acid hydrolysis of gentiobiose phenylosotriazole produces a high yield (93%) of D-glucose phenylosotriazole and D-glucose (65%) as expected from the accompanying formula.



Gentiobiose Phenylosotriazole

We are indebted to Mr. Charles A. Kinser and Mrs. Betty Mount for the microchemical analyses.

Experimental

Gentiobiose Phenylosotriazole.—To a suspension of 10 g. of gentiobiose phenylosazone[3] in 900 ml. of boiling water was added a hot solution of 5.3 g. (1.1 molecular equivalents) of copper sulfate pentahydrate in 100 ml. of water. Solution of the phenylosazone took place rapidly and after refluxing for thirty minutes the solution was cooled, filtered, and the excess copper removed from the filtrate as the sulfide; the copper-free solution was neutralized with 10 g. of barium carbonate and following filtration, concentrated *in vacuo* to a thick reddish sirup. The sirup was dried by successive evaporations with three 25-ml. portions of absolute alcohol, and dissolved in 25 ml. of warm absolute alcohol, filtered to remove a small amount of inorganic contaminant and diluted with 35 ml. of ether; upon scratching, the product separated as somewhat gelatinous flocs which were recovered by filtration and washed with cold absolute alcohol and ether; yield 5.3 g. An additional 1.2 g. of product was obtained by concentration of the mother liquor; total yield 6.5 g. (71%). The material was recrystallized from 5 parts of absolute alcohol forming minute needles which melted at 91–93°[4] with foaming and rotated −34.3° in aqueous solution (*c*, 0.83). Analyses showed that the material contained one molecular equivalent of ethanol of crystallization which was retained tenaciously *in vacuo* at temperatures below the sintering point; at 97° *in vacuo* the alcohol was removed leaving an amorphous glassy material of no definite melting point; its analysis corresponded closely to that of an unsolvated disaccharide phenylosotriazole. The crystalline alcoholate was readily soluble in water, pyridine and hot alcohol and sparingly soluble in ether, acetone, ethyl acetate and cold alcohol. Upon separating from solution in impure form it shows a marked tendency to form gelatinous precipitates rather than discrete crystals.

Anal. Calcd. for $C_{18}H_{25}N_3O_9 \cdot C_2H_5OH$: C, 50.73; H, 6.60; loss on drying, 9.7. Found: C, 50.94; H, 6.39; loss on drying, 9.5.

Anal. (of the alcohol-free amorphous material). Calcd. for $C_{18}H_{25}N_3O_9$: C, 50.58; H, 5.90. Found: C, 50.56; H, 5.99.

On refluxing 1.2 g. of the crystalline alcoholate with 50 ml. of 0.5 *N* hydrochloric acid for six hours and chilling the solution, a 93% yield of D-glucose phenylosotriazole (m. p. 195–196°) was obtained and the concentrated aqueous mother liquor, after neutralization with silver carbonate, yielded 65% of D-glucose ($[\alpha]^{20}_D$ +52.5°).

Gentiobiose Phenylosotriazole Heptaacetate.—A solution of 1.0 g. of gentiobiose phenylosotriazole monoalcoholate in a mixture of 8 ml. of acetic anhydride and 0.25 g. of fused sodium acetate was heated on the steam bath for two hours, cooled, and poured into ice water; the crystalline heptaacetate (1.6 g., quantitative) was recrystallized from 10 parts of alcohol and formed clumps of very fine needles melting at 144–146° and rotating −28.1° in chloroform solution (*c*, 0.84). It was readily soluble in chloroform, acetone–ether and warm alcohol and nearly insoluble in water and hexane.

Anal. Calcd. for $C_{32}H_{39}N_3O_{16}$: C, 53.26; H, 5.45; CH_3CO, 41.8. Found: C, 53.53; H, 5.62; CH_3CO, 41.6.

Gentiobiose Phenylosotriazole Heptabenzoate.—To a solution of 0.5 g. of gentiobiose phenylosotriazole monoalcoholate in 5 ml. of pyridine was added 2 ml. of benzoyl chloride; after standing at 25° for twenty-four hours the mixture was poured into ice water and the gummy precipitate washed by decantation with dilute sodium bicarbonate solution and water. The damp precipitate was digested on the steam-bath with 25 ml. of alcohol when spontaneous crystallization occurred; the cooled mixture was filtered and washed with alcohol yielding 1.2 g. (quantitative) of the heptabenzoate. The compound was recrystallized by dissolving it in 10 parts of chloroform and adding 20 parts of hexane or 50 parts of absolute alcohol; it crystallized as fine, short needles melting at 122–123° and rotating +1.5° in chloroform solution (*c*, 0.88). It is soluble in chloroform, ether, acetone and pyridine and sparingly soluble in water, hexane and hot alcohol.

Anal. Calcd. for $C_{67}H_{53}N_3O_{16}$: C, 69.60; H, 4.62; C_6H_5CO, 63.6. Found: C, 69.40; H, 4.57; C_6H_5CO, 63.3.

CONTRIBUTION FROM THE
FEDERAL SECURITY AGENCY
PUBLIC HEALTH SERVICE
NATIONAL INSTITUTE OF HEALTH
EXPERIMENTAL BIOLOGY AND
MEDICINE INSTITUTE
CHEMISTRY LABORATORY
BETHESDA, MARYLAND

RECEIVED MAY 3, 1948

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[3] Berlin, THIS JOURNAL, 48, 1107 (1926).

[4] The melting points were made with the stem of the thermometer fully immersed in the heated bath. The rotations are specific rotations $[\alpha]^{20}_D$; the tube length was 4 dm. and *c* is the concentration in grams in 100 ml. of solution. All the crystalline compounds were recrystallized to constant m.p. and rotation.

The Separation of Iodine-131 from Tellurium

BY MILTON LEVY, ALBERT S. KESTON AND SIDNEY UDENFRIEND

The irradiated unit[1] supplied by the U. S. Atomic Energy Commission as a source of I^{131} contains 50 g. of tellurium. The chromic or nitric acid oxidations such as have been used in working up cyclotron targets proved cumbersome in the case of the pile units because of the large amount of tellurium. The following method based on fusion with sodium hydroxide has proven rapid and reliable.

The tellurium powder is transferred to a 100-ml. Pyrex kjeldahl flask (through a powder funnel) containing 5 g. of sodium hydroxide pellets. The

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[1] Catalog item No. 37, "Radioisotopes," Catalog No. 2, revised September, 1947, U. S. Atomic Energy Commission, Oak Ridge, Tenn.

mixture is shaken and heated gently to drive out water and then to a dull red (above 452°, the m. p. of tellurium). The mixture is held at this high temperature for about five minutes with occasional shaking during the progress of heating. The flask is allowed to cool somewhat and then plunged into 100 ml. of water in a large mortar. The flask breaks and both it and the solid contents are coarsely powdered with a pestle. The aqueous layer with suspended tellurium is transferred to a liter erlenmeyer flask with suction and the residue in the mortar extracted with several 50-ml. portions of hot water until only minor amounts of radioactive materials are being transferred. The extracts and washings are heated to boiling to coagulate the precipitate. The solution is cooled and filtered to remove tellurium.

The remainder of the isolation requires an all-glass-standard taper distilling apparatus consisting of a 500-ml. flask, an adapter with addition tube, an adapter and condenser and a receiving adapter arranged to dip into a receiving solution. The filtered alkaline extract is run into the distilling flask, which contains a few boiling stones, and evaporated to a volume of about 50 ml. The distillate contains no radioactive material and is discarded. A concentrated solution of potassium permanganate is added in excess to oxidize all iodine in the alkaline solution to iodate. The receiving flask is changed to one containing a dilute solution of sodium sulfite and sodium carbonate (about 1 mg. of each in several ml. of water). The delivery tip is covered by this solution. Fifty ml. of concentrated sulfuric acid is added through the addition tube. Care is necessary because of the heat developed. After the sulfuric acid has been added, 1 g. of oxalic acid dissolved in a minimal amount of hot water is added. The iodate is reduced to iodine. The mixture is now distilled until substantially all of the radioactivity has collected in the receiver where the iodine is converted to iodide. The solution of iodide containing some carbonate, sulfite and sulfate is used directly in most of our work.

The tellurium residue when dissolved in nitric acid containing a small amount of chloride ion, gave, in the presence of excess dissolving silver, a silver chloride precipitate which contained relatively little radioactivity. When unirradiated tellurium to which I^{131} has been added is dissolved in this way, substantially all the radioactivity is coprecipitated with the silver chloride. Portions of the irradiated tellurium gave large amounts of I^{131} in the silver chloride precipitate. Since the tellurium residue from the pile unit contained little I^{131} and all other fractions except the final product contained not more than 10% of the radioactivity of the final product, we believe the yield to be 85–95% of the I^{131} originally present.

The exposures of the operators (two) during the working up of a unit by the method is minimized by the use of lead bricks, long handled tongs and rapid handling of materials. On pocket ionization chambers 0.04–0.06 roentgen was registered on the day of processing a unit. This is well below the allowed maximum of 0.1 roentgen per day. Film badges[2] worn during the week including the day of the preparation showed less than ten per cent. of the permitted maximum exposure for the week.

The irradiated tellurium units used in this investigation were supplied by the Clinton Laboratories and obtained on allocation from the U. S. Atomic Energy Commission.

This work was supported by a grant from the American Cancer Society, recommended by the Committee on Growth of the National Research Council.

[2] Film Badge Service, Tracerlab, Inc., Boston, Mass.

DEPARTMENT OF CHEMISTRY
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NEW YORK 16, N. Y.

RECEIVED MARCH 11, 1948

Preparation of *t*-Butylamine

BY D. E. PEARSON, J. F. BAXTER AND K. N. CARTER

Tertiary butylamine has been made by the hydrogenation of 2,2-dimethylethylenimine[1] and by the reaction of *t*-butylmagnesium chloride and methoxyamine.[2] Simple hydrolysis of the readily obtainable *t*-butylurea (E. K.) with aqueous alkali is too slow for satisfactory use. Smith and Emerson[3] accomplished the hydrolysis indirectly by reaction with phthalic anhydride and subsequent hydrolysis of the resulting phthalimide. It has now been found that the amine is readily prepared from *t*-butylurea by saponification in aqueous ethylene glycol solution. The procedure shown has been checked according to "Organic Syntheses" recommendations.

$$(CH_3)_3CHNHCONH_2 + 2NaOH \longrightarrow (CH_3)_3CNH_2 + NH_3 + Na_2CO_3$$

Procedure

A 1-liter round-bottomed, S. T. flask was equipped with an upright condenser, and a glass tubing was led from the top of the condenser to a small flask immersed in ice-water. The trap was unnecessary, if sufficiently cold water was used in the condenser. The flask was charged with sodium hydroxide (60 g., 1.5 moles) dissolved in 75 cc. of water, *t*-butylurea (70 g., 0.6 mole) and 225 cc. of ethylene glycol (practical grade), and the mixture refluxed for four hours. The liquid temperature was 115° when refluxing started and fell to 86° at the end. The *t*-butylurea gradually dissolved, and a gelatinous mass of sodium carbonate was formed. Shorter reflux gave lower yields; longer periods gave no increase. Lower concentrations of ethylene glycol gave proportionately lower yields. The flask was then cooled, equipped for distillation and the fraction boiling at 40–60° was collected in an ice-cooled receiver. The crude amine, including any in the trap, weighed 37–39 g. It was dried with 5–7 g. of solid sodium hydroxide. If a lower, aqueous

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(1) Karabinos and Serijan, THIS JOURNAL, **67**, 1856 (1945); Campbell, Sommers and Campbell, *ibid.*, **68**, 140 (1946).

(2) Jones, *J. Chem. Soc.*, 781 (1946).

(3) Smith and Emerson, THIS JOURNAL, **67**, 1862 (1945).

layer formed, it was removed in a small separatory funnel, and the amine was redried with fresh sodium hydroxide for eight to ten hours. The filtered amine was then distilled through a short, Vigreux column into an ice-cooled receiver equipped with a soda-lime tube. The yield was 31–34 g. (71–78%), b. p. 44–46°, m. w. 73 by glass electrode titration. Double quantities also were used with no significant change in yields. It is suggested that the procedure, with obvious modifications in details, is probably applicable to the preparation of *t*-amylamine from *t*-amylurea.

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Colored Complexes of Tungsten Hexafluoride with Organic Compounds

BY HOMER F. PRIEST AND WALTER C. SCHUMB

It was observed in the course of a study of the reduction of tungsten hexafluoride by organic compounds that when the hexafluoride was dissolved in certain of these compounds deep colors were produced. Apparatus was devised in which tungsten hexafluoride could be added as liquid to a sample of the organic liquid, an atmosphere of dry air being maintained above the solution. Solutions were also prepared quantitatively by distilling the pure hexafluoride into a known weight of organic solvent contained in weighed cylindrical comparison tubes for a Coleman spectrophotometer (Model 14). The tubes could be sealed off and reweighed so as to obtain the weight of added fluoride. Spectrometric traces were made, all values being obtained by use of the potentiometer drum rather than by direct galvanometer deflection.

The tungsten hexafluoride had been prepared from metallic tungsten and fluorine, followed by redistillation to eliminate any WOF_4 which might be present. Analysis of the hexafluoride showed it to be better than 99% pure. The organic solvents employed were of carefully selected purity; thus, analytical reagent grade, thiophene-free benzene; reagent grade acetone, toluene, *sym*-tetrachloroethane, ethyl alcohol and diethyl ether; Eastman Kodak Co. pure grade cyclohexane, cyclohexanone, and *n*-decane; dioxane free from unsaturated compounds. Most of the liquids were dried over anhydrous calcium sulfate and redistilled.

A summary of the qualitative observations made on the solution of tungsten hexafluoride in the different organic solvents is shown in Table I.

TABLE I

EFFECT OF DISSOLVING TUNGSTEN HEXAFLUORIDE IN ORGANIC LIQUIDS

Solvent	Color of solution	Effect of cooling to −78°	Effect of dilution	Remarks
Benzene	Red	White crystals	Orange–yellow	
Toluene	Red	None	Orange–yellow	Color retained when frozen
Acetone	Red	None	Orange	Color intensified on standing
Cyclohexanone	Red	None	Orange	Some intensification on standing
Ethyl alcohol	None	White crystals		
Carbon tetrachloride	None	White crystals		
sym-Tetrachloroethane	None	Solidified		
n-Decane	None	Solidified		
Cyclohexane	None	Solidified		
Diethylcarbitol	Violet–brown	None	Brown	
Diethyl ether	Violet–brown	None	Brown	
Dioxane	Pale red	White solid	Orange	Some crystals deposited

From these results it appears that the presence of certain functional groups in the solvents employed results in similar colors; thus the colors in benzene and toluene are similar, as are those in diethylcarbitol and diethyl ether. Ketones, such as acetone and cyclohexanone, give similar colors which intensify on standing and may be due to polymerization of the ketone rather than to the formation of a complex with the hexafluoride. Chlorinated solvents and hydrocarbons containing no functional groups give no colors. Alcohol also gives no color, but it is to be expected that alcoholysis of the hexafluoride could interfere with complex formation.

Because of the intense color given by benzene, a quantitative study was made of this solvent. At concentrations above 0.04 molar the color appeared to remain stable for several weeks. Solutions were made up at three concentrations of tungsten hexafluoride, 0.048, 0.118 and 0.121 molar, and the optical densities of these solutions were measured at 520, 550, 560 and 570 μ. A plot of optical density *vs.* concentration of tungsten hexafluoride gave straight lines, indicating that the colored material follows Beer's law, and that the concentration of the colored complex is directly proportional to the tungsten hexafluoride concentration. By absorption measurements carried out on four solutions of tungsten hexafluoride and benzene in carbon tetrachloride, results were obtained which led to the conclusion that the concentration of the colored complex also varies directly as the benzene concentration, from which fact it is concluded that the complex contains one molecule of benzene per molecule of the hexafluoride, $WF_6 \cdot C_6H_6$.

It has been noted previously by others,[1] as well

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(1) See, for example, Fischer, *Z. anorg. Chem.*, **81**, 170 (1930); Kalischer, "Zur Kenntnis der Halogenide des höherwertigen Wolframs und Molybdäns," Berlin, 1902; Roscoe, *Ann*. **162**, 351 (1872).

as by ourselves, that colored solutions are also formed by tungsten hexachloride in various solvents; but we feel that the two cases are not comparable, for the following reasons. (1) Tungsten hexachloride itself has a blood-red color, so that solutions in various solvents showing a red, brown, or yellow color are reasonably to be expected, whereas tungsten hexafluoride itself is colorless. (2) The red solution of the hexafluoride in benzene freezes to a colorless crystalline solid, which on warming regains its color. (3) If the hexafluoride were reduced by solvent to lower valences of tungsten, the solution could not be expected to follow Beer's law, as was found to be the case. Furthermore, the colored solution of the hexafluoride in benzene remained unaltered for weeks, indicating lack of reaction, whereas the hexachloride solutions change gradually, owing to reduction of the tungsten.

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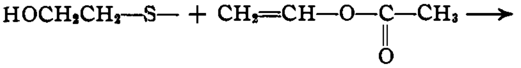
RECEIVED MARCH 11, 1948

Thiodiglycol Monoacetate by the Photochemical Addition of Mercaptoethanol to Vinyl Acetate

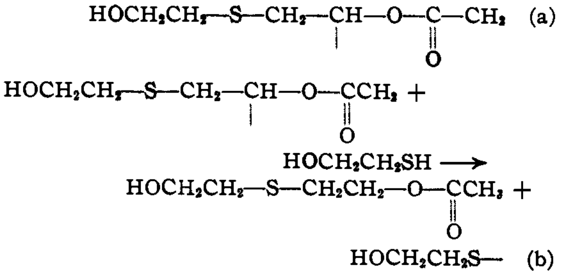
BY WALTER H. C. RUEGGEBERG, JACOB CHERNACK, IRA M. ROSE AND E. EMMET REID

The photochemical addition of mercaptans to olefins has been studied in this Laboratory[1] for several years. Recently, the photoaddition of ethanolmercaptan to vinyl chloride yielding 2-chloroethyl-2-hydroxyethyl sulfide (semi-mustard) was reported by Fuson and Ziegler[2] and from this Laboratory.[3] Inasmuch as the monoacetate of thiodiglycol has not been reported previously in the literature to the best of our knowledge, it appeared worthwhile to synthesize this half-ester through the photochemical addition of ethanolmercaptan to vinyl acetate.

It was soon learned, however, that the reaction rate depended strongly upon the purity of vinyl acetate used. Thus, for example, when freshly distilled vinyl acetate was mixed with mercaptoethanol, the mixture warmed up immediately. Titration of the residual mercaptan with iodine in methanol solution showed that 80% of the mercaptan had reacted after the first hour. On the other hand, if stabilized vinyl acetate (Eastman Kodak Co., practical grade) is employed in the process, no reaction is observed until the mixture is irradiated from an S-4, 100 watt mercury vapor lamp (General Electric Co.) in the presence of 1% of diphenyl disulfide, as catalyst.



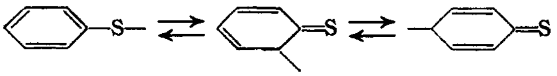
$$HOCH_2CH_2—S— + CH_2{=}CH—O—\underset{\underset{O}{\|}}{C}—CH_3 \longrightarrow$$



$$HOCH_2CH_2—S—CH_2—\underset{|}{C}H—O—\underset{\underset{O}{\|}}{C}—CH_3 \quad (a)$$

$$HOCH_2CH_2—S—CH_2—\underset{|}{C}H—O—\underset{\underset{O}{\|}}{C}CH_3 + HOCH_2CH_2SH \longrightarrow HOCH_2CH_2—S—CH_2CH_2—O—\underset{\underset{O}{\|}}{C}CH_3 + HOCH_2CH_2S— \quad (b)$$

Although disulfides such as diamyl disulfide are known to accelerate the photoaddition of mercaptoethanol to vinyl chloride,[3] it has been shown that diphenyl disulfide is a catalyst superior to aliphatic disulfides in this type of reaction.[1] Two reasons for this behavior may be cited. First, diphenyl disulfide absorbs light more strongly than dialkyl disulfides in the visible and near ultraviolet regions of the spectrum,[1] indicating that free radicals are more easily obtained; secondly, the stabilizing influence of resonance on the thiophenyl radicals should prolong their lives thus increasing reaction probability. The three resonance forms of the thiophenyl radicals may be represented by the following equilibria



In the disulfide-free reaction, the primary dissociation is that of the splitting of the S—H bond

$$HOCH_2CH_2SH + h\nu \longrightarrow HOCH_2CH_2—S— + H—$$

This reaction is then followed by a chain mechanism given by equations (a) and (b), above.

Thiodiglycol monoacetate, so prepared, is a water white liquid resembling thiodiglycol itself in odor and having the physical properties listed in Table I. It is soluble in water, benzene, carbon tetrachloride, chloroform, ethyl ether and acetone but insoluble in hexane or cyclohexane.

TABLE I

SOME PHYSICAL PROPERTIES OF THIODIGLYCOL MONOACETATE[a]

Temp., °C.	Density, g./ml.	Refractive index n_D^T	Molar refractivity[b] found	Viscosity, centipoises
9.5	1.1671	....	...	26.96
10	1.1666	1.4916	40.81	...
20	1.1576	1.4879	40.87	...
25	1.1531	....	...	12.43
30	1.1485	1.4841	40.92	...
35.8	1.1433	....	...	8.22
		Mean	40.87	

[a] Surface tension at 28.9°, 41.2 dynes/cm. (du Noüy method). [b] The calculated value of the molecular refractivity is 40.78.

Experimental

Photosynthesis in the Absence of Catalysts.—Mercaptoethanol, 33.2 g., obtained from the Carbide and Carbon Chemicals Corporation was added slowly to 92.4 g. of freshly distilled, unstabilized vinyl acetate, originally obtained from Eastman Kodak Company. Immediately upon mixing, an exothermic reaction ensued. After

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[1] Rueggeberg, *et al.*, reports on file at the Army Chemical Center; not currently available in the published literature.

[2] Fuson and Ziegler, *J. Org. Chem.*, **11**, 510 (1946).

[3] Rueggeberg, Cook and Reid, *ibid.*, **13**, 110 (1948).

standing one hour, an iodimetric titration of the reaction mixture in methanol indicated that about 80% of the mercaptan had undergone reaction. The mixture was allowed to stand at room temperature for one week prior to being distilled. Distillation of the product resulted in the recovery of unused mercaptoethanol and vinyl acetate and a residue yield of crude thiodiglycol monoacetate weighing 54.4 g. This material on distillation boiled at 137–138° at 8 mm.; yield of distilled product, 51%. *Anal.* Calcd. for $C_6H_{12}O_3S$: S, 19.5. Found: S, 19.2.

Photosynthesis in Presence of Diphenyl Disulfide.—Vinyl acetate, 90 g., (practical grade, stabilized) obtained from the Eastman Kodak Company was mixed with 78 g. of mercaptoethanol obtained from the Carbide and Carbon Chemicals Corporation. No reaction ensued. These reagents together with 0.8 g. of diphenyl disulfide (1% of the mercaptan used) were placed in a 300-ml. Pyrex test-tube and suspended in a water-bath at 20–25°. An S-4, 100-watt mercury vapor lamp was also suspended under water and placed 11 cm. from the center of the test-tube. On turning on the light the temperature of the reaction mixture rose from 22 to 34° receding slowly after about one hour of irradiation. Irradiation was continued for an additional two hours and subsequently, the reaction product was distilled. After two distillations 72 g. of a product was obtained boiling at 147.7 to 148° at 13–14 mm.

Anal. Calcd. for $C_6H_{12}O_3S$: C, 43.9; H, 7.4; S, 19.5. Found: C, 43.7; H, 7.4; S, 19.9.

Acknowledgment.—The authors are indebted to Messrs. N. Beitsch, S. Sass, E. A. Green and B. Zeffert for having performed the analytical and physical work presented in this paper.

CHEMICAL CORPS TECHNICAL COMMAND
ARMY CHEMICAL CENTER, MARYLAND
RECEIVED JANUARY 14, 1948

Preparation of Vanillonitrile and Vanillic Acid from Vanillin

BY CONRAD SCHUERCH, JR.

The acid catalyzed condensation of hydrazoic acid with aldehydes is included in the more general Schmidt reaction,[1] and in the case of acetaldehyde, benzaldehyde and *m*-nitrobenzaldehyde, results in the corresponding nitriles and N-substituted formyl derivatives.

$$\text{I.}\quad RCHO + HN_3 \xrightarrow{H^+} RC{\equiv}N + H_2O + N_2$$

$$\text{II.}\quad RCHO + HN_3 \xrightarrow{H^+} RNH{-}CHO + N_2$$

Vanillin has now been found to react readily in the presence of sulfuric acid according to equation I, and crystalline vanillonitrile has been easily isolated in a yield of about 70%. The formanilide, which was presumably formed at the same time according to equation II, did not interfere appreciably in the purification of the nitrile. When the original reaction mixture was diluted with water and boiled, hydrolysis of the nitrile occurred and almost pure vanillic acid crystallized in more than 70% yield from the liquors. This observation is of interest because vanillic acid is not readily available by the direct oxidation of vanillin, and because Pearl's catalytic oxidation with silver oxide[2] was found to be somewhat sensitive to obscure differences in the experimental conditions. Substitution of veratraldehyde for the vanillin used in the condensation with hydrazoic acid resulted in more than an 80% yield of crystalline veratric acid, and a small amount of 4-aminoveratrole (equation II) was also isolated from the hydrolysate.

As would be expected from the known reactions of ketones and the mechanism recently proposed for the Schmidt reaction[3,4,5,6] vanillin reacted with hydrazoic acid in the presence of reagents such as a dioxane solution of hydrogen chloride, that are milder than sulfuric acid. Although it is probable that a proper choice of solvent would give a homogeneous system and a smooth condensation with much smaller quantities of acid than those now used, the decrease might well alter the relative amounts of the products formed.[1]

Acknowledgment.—The author wishes to express his gratitude to Professor C. B. Purves for his kind interest and assistance in this and related work.

Vanillonitrile and Vanillic Acid.—One hundred grams (0.658 mole) of pure vanillin was dissolved completely in 375 ml. of concentrated reagent grade sulfuric acid kept at 0–10° in a 2-liter 3-necked flask, with mercury-sealed stirrer, condenser, thermometer and gas exit tube attached. Powdered sodium azide (45 g., 0.69 mole), contained in a small flask attached to the reaction vessel by means of a rubber connector, was added to the red solution at 0–11° over a period of one and one-half hours. The cooling bath was removed and the mixture was stirred for another half hour. The flask was again chilled and about 900 ml. of distilled water was added cautiously from a separatory funnel without allowing the temperature to rise above 18°. This addition caused the nitrile to separate as a yellow solid which completely filled the aqueous layer. When desired, the nitrile could be extracted with ether, and isolated after washing the extract with small amounts of sodium bisulfite and sodium bicarbonate solutions. The yield from smaller quantities of reactants was about 70% and most of the product melted at 87.5–88.3°; m. p. 89–90° is the recorded value for vanillonitrile.[7]

When vanillic acid was required, the original reaction mixture was diluted with 900 ml. of water as already described. The stirrer and thermometer were then removed and washed with 100 ml. of water which was added to the reaction flask, and the mixture boiled gently under reflux. Crystals of vanillic acid appeared after two and one-half hours, and after three hours of boiling the mixture was allowed to cool overnight. The crystals were filtered with suction under an efficient hood, washed five times with a total volume of 1700 ml. of distilled water and dried: yield of vanillic acid 81.5 g. or 73.8%; m. p., 201–203°; and neutralization equivalent (by electrometric titration to *p*H 7), 171. Calcd. for vanillic acid, neut. equiv., 168. Decolorization and recrystallization from water gave beautiful needles but raised the m. p. only slowly. A melting point of 208–210° was obtained,

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(1) R. Adams, "Organic Reactions," Vol. 3, John Wiley and Sons, New York, N. Y., 1947, article by H. Wolfe, The Schmidt Reaction, p. 307.

(2) Pearl, THIS JOURNAL, **68**, 429 (1946).

(3) Sanford, Blair, Arroya and Sherk, *ibid.*, **67**, 1941 (1945).

(4) Smith, *ibid.*, **70**, 320 (1948).

(5) (a) Newman, Organic Chemistry Symposium, Boston, Mass., 1947; (b) Newman and Gildenhorn, THIS JOURNAL, **70**, 317 (1948).

(6) Schuerch and Huntress, presented at the 112th Meeting of the American Chemical Society in New York, N. Y., September, 1947.

(7) Rupe, *Ber.*, **30**, 2449 (1898).

however, by extracting the crude crystals once with absolute ether in a Soxhlet apparatus. A mixed melting point with authentic vanillic acid[8] with the recorded m. p. 208–210°[8] was undepressed.

Veratric Acid and 4-Aminoveratrole.—The condensation of veratraldehyde 27.6 g., sodium azide 12.5 g. and concentrated sulfuric acid 118 ml. was essentially as described above but the time of hydrolysis was somewhat longer. Slightly discolored veratric acid, 25.4 g. or 84%, separated from the reaction mixture. One recrystallization from water and ethanol gave a pure product with the recorded[9] m. p. 179–181°. Extraction of the acid mother liquor with benzene gave less than 1 g. of oily crystals. The acidic solution was made strongly alkaline and extracted again with benzene. Evaporation of this extract and distillation of the residue under reduced pressure yielded 1.6 g. of colorless crystals that darkened in air. Their melting point of 87–88° agreed with that reported for 4-aminoveratrole.[10]

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(8) Misani and Bogert, *J. Org. Chem.*, **10**, 355 (1945).

(9) Goldschmiedt, *Monatsh.*, **6**, 379 (1885).

(10) Buck and Ide in "Organic Syntheses," Coll. Vol. II, John Wiley and Sons, New York, N. Y., 1943, p. 44.

DIVISION OF INDUSTRIAL AND CELLULOSE CHEMISTRY
MCGILL UNIVERSITY
MONTREAL, CANADA

RECEIVED MARCH 9, 1948

[CONTRIBUTION FROM THE STEELE CHEMICAL LABORATORY OF DARTMOUTH COLLEGE, AND THE CHEMISTRY DEPARTMENT OF THE UNIVERSITY OF MICHIGAN]

8-Amino-2,4-Dimethylquinoline[1]

BY WYMAN R. VAUGHAN[2]

As a consequence of the tremendous recent interest in the derivatives of 8-aminoquinoline as antimalarial drugs it was found desirable to develop a satisfactory synthesis for 8-amino-2,4-dimethylquinoline. The present procedure was found to be a rapid and efficient method for the preparation of this substance, one of its advantages being that it obviates any extensive purification of the intermediate 8-nitro-2,4-dimethylquinoline.

Experimental

8-Nitro-2,4-dimethylquinoline.—One mole (157 g., 150 ml.) of 2,4-dimethylquinoline[3] was cooled to 0° and treated with 250 ml. of concentrated sulfuric acid which was added as rapidly as possible with good mechanical stirring. The resulting solution was then cooled to 0° and treated with a solution of 115 g. of potassium nitrate in 300 ml. of concentrated sulfuric acid with vigorous mechanical stirring, the temperature being maintained between 0 and 5° by means of an ice–salt-bath. When all of the nitrating solution had been added, the mixture was stirred for an additional fifteen minutes without cooling and then was poured onto 2500 g. of cracked ice. The resulting mixture was treated with 1500 ml. of concentrated ammonia and diluted to 6 l. with cold water, cooled to room temperature and filtered. The filter cake was placed in a 2-l. beaker with 1 l. of cold water and stirred vigorously until a uniformly fine suspension was obtained. It was then filtered with good suction, and the moist filter cake was recrystallized from 1 l. of 95% ethanol using norit and a heated funnel: yield 113–115 g. (51–67%), m. p. 115–125°.[4] This impure product is a mixture of 8-nitro-2,4-dimethylquinoline with one or more isomers. A second isomer, m. p. 109.6–110.1° cor., was isolated from the mother liquors from the recrystallization of the major product, but the structure of this substance has not as yet been determined.

Anal. Calcd. for $C_{11}H_{10}O_2N_2$: N, 13.86. Found: N, 14.0.

In view of the work of Price, Velzen and Guthrie[5] who isolated 6-nitro-2,4-dimethylquinoline, it would appear that this substance is either 5- or 7-nitro-2,4-dimethylquinoline, probably the former in view of the well-known resistance of the 7-position in quinoline toward nitration.[6]

8-Amino-2,4-dimethylquinoline.—A solution of 101 g. (0.5 mole) of 8-nitro-2,4-dimethylquinoline (m. p. 115–125°) in 375 ml. of concentrated hydrochloric acid was added from a dropping funnel to a well-stirred solution of 375 g. of stannous chloride dihydrate in 136 ml. of concentrated hydrochloric acid, the temperature being maintained at 40–50° by means of an ice-bath. Near the end of the reduction a yellow precipitate appeared. After complete addition of the nitro compound to the reducing solution there was added 2000 g. of cracked ice and a cooled solution of 850 g. of potassium hydroxide in 1 l. of water. The resulting mixture was vigorously stirred for 30 minutes and then filtered, and the residue was washed in the funnel with three portions of cold water totaling 1 l. The filter cake was pressed dry and then was dissolved in 1 l. of water containing 50 ml. of concentrated hydrochloric acid. In order to effect solution the mixture was boiled and then was treated at the boiling temperature with a liberal quantity of norit and filtered through a steam-heated funnel. Upon cooling there separated from the filtrate a mass of golden yellow needles, 71–87 g.[7] This product was dissolved in 500 ml. of boiling water, and the resulting solution was treated with 30 ml. of concentrated ammonia. The 8-amino-2,4-dimethylquinoline separated as an oil which solidified upon rapid cooling with continuous agitation. The mixture was allowed to stand for 30 minutes at room temperature, and then it was filtered: yield 51–61 g. (59–71%), m. p. 86–90°. If a very pure product is desired, the initial product may be recrystallized directly from 70–90° ligroin (10 ml. per g.) or converted to the hydrochloride, which is readily recrystallized from water. Highly purified 8-amino-2,4-dimethylquinoline is a colorless crystalline substance, m. p. 93.7–94.2° cor.[8]

Anal. Calcd. for $C_{11}H_{12}N_2$: N, 16.27. Found: N, 16.3, 16.23.

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(1) Part of the work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Dartmouth College.

(2) Present address: Department of Chemistry, University of Michigan, Ann Arbor, Michigan.

(3) Vaughan, "Organic Syntheses," Vol. 28, in preparation; *cf.* Craig, THIS JOURNAL, **60**, 1458 (1938).

(4) Repeated recrystallization of a portion of this product from ethanol-water and finally from 95% ethanol yielded a very pure 8-nitro-2,4-dimethylquinoline, m. p. 147-147.5°. Price, Velzen and Guthrie give 149.5-150° cor., *cf.* ref. 5.

(5) Price, Velzen and Guthrie, *J. Org. Chem.*, **12**, 203 (1947).

(6) Bacharach, Haut and Caroline, *Rec. trav. chim.*, **52**, 413 (1933); *cf.* ref. 8.

(7) The hydrochloride thus obtained appears to be a dihydrate which loses some of its water of hydration upon standing in a dry atmosphere.

(8) Roberts and Turner, *J. Chem. Soc.*, 1856 (1927), give 89-92°.

ANN ARBOR, MICHIGAN

RECEIVED DECEMBER 23, 1947

Some 2,3-Dialkylpyridines and their Derivatives[1]

BY HENRY M. WOODBURN AND MAX HELLMANN

Our extension of Elderfield's work[2] on 2,3-dimethylpyridine to the synthesis of other 2,3-dialkylpyridines was interrupted by the war, and

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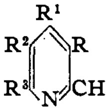
(1) From the M.A. thesis of Max Hellmann, University of Buffalo, June, 1947.

(2) Elderfield and Tracy, *J. Org. Chem.*, **6**, 54 (1941).

TABLE I

PROPERTIES OF 2-METHYL-3-ALKYLPYRIDINE DERIVATIVES



R	R¹	R²	R³	M. p., °C.	B. p.,[a] °C.	Formula	Analyses, % Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found
n-C_3H_7	OH	CO_2Et	OH	192–193		$C_{12}H_{17}O_4N$	60.2	59.7	7.18	7.15
n-C_4H_9	OH	CO_2Et	OH	182–184		$C_{13}H_{19}O_4N$	61.6	61.9	7.57	7.41
n-C_3H_7	OH	H	OH	330–332 dec.		$C_9H_{13}O_2N$	64.6	64.5	7.84	7.73
n-C_4H_9	OH	H	OH	348–350 dec.		$C_{10}H_{15}O_2N$	66.3	66.0	8.34	8.38
n-C_3H_7	Cl	H	Cl		259	$C_9H_{11}Cl_2N$	Cl 34.7	34.6		
n-C_4H_9	Cl	H	Cl		275	$C_{10}H_{13}Cl_2N$	Cl 32.5	32.1		
n-C_3H_7	H	H	H	130–131[b]	200–201	$C_{15}H_{16}N_4O_7$[c]	49.5	49.8	4.44	4.46
n-C_4H_9	H	H	H	124–125[b]	222–223	$C_{16}H_{18}N_4O_7$[c]	50.8	50.5	4.80	4.92

[a] Corrected. [b] M. p. of the picrate. [c] Formula and analysis of the picrate.

shortly after its resumption the appearance of an abstract of a paper by Wibaut and Kooyman[3] made it inadvisable to proceed further along those lines. The applicability of the reaction scheme having been proved, we wish to report the synthesis and properties of 2-methyl-3-n-propylpyridine and of 2-methyl-3-n-butylpyridine together with those of certain intermediates used in their preparation.

Ethyl α-n-butyl β-aminocrotonate, for which no literature reference was found, was prepared from ethyl α-n-butylacetoacetate, ammonia and ammonium nitrate. It had a melting point of 41–42° and a boiling point of 116–118° (10 mm.).

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(3) Wibaut and Kooyman, *Rec. Trav. Chim.*, **63**, 231 (1944); *C. A.*, **41**, 450a (1947).

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF BUFFALO
BUFFALO, NEW YORK

RECEIVED FEBRUARY 26, 1948

Products of the Interaction of Potassium Dihydrogenphosphide and n-Heptyl Bromide in Liquid Ammonia

BY GEORGE W. WATT AND R. C. THOMPSON, JR.

Alkali and alkaline earth metal dihydrogenphosphides prepared by the reaction between phosphine and solutions of these metals in liquid ammonia[1,2] continue to find application in the synthesis of derivatives of phosphine.[3]

Several years ago we studied several reactions of potassium dihydrogenphosphide in liquid ammonia and since further work is not anticipated it seems worth while to report the synthesis of n-heptylphosphine and its conversion to a product believed to be n-heptyl-phosphonous acid.

Phosphine was prepared by the action of sodium hydroxide solution on phosphonium iodide and dried over potassium hydroxide pellets. The dry gas was led into a solution of 2.7 g. of potassium in approximately 100 ml. of anhydrous liquid ammonia (contained in a flask provided with a stirrer and reflux condenser) until the characteristic blue color of the potassium solution was discharged. All reactants were protected from contact with the atmosphere. n-Heptyl bromide (11.9 g.) was added to the resulting pale yellow solution of potassium dihydrogen phosphide and the reaction mixture was stirred for two hours at −33.5°. The ammonia was evaporated and the residual liquid was removed in an atmosphere of carbon dioxide, extracted with 2 N hydrochloric acid solution, and the acid-insoluble fraction was distilled in an atmosphere of carbon dioxide to provide 6 ml. of a clear liquid, b. p., 73–74° at 30 mm. Boiling point determinations using capillary tubes gave consistently a value of 169.5°. This is a reasonable value for the boiling point of the anticipated n-heptylphosphine[4] which was apparently the primary reaction product. Despite precautions taken to avoid atmospheric oxidation while handling samples for analysis, this product was oxidized to a substance having an analytical composition corresponding to n-heptylphosphonous acid.

Anal. Calcd. for $C_7H_{17}PO_2$: C, 51.19; H, 10.44; P, 18.89. Found: C, 50.91; H, 10.48; P, 19.10.

This substance gave a negative test for halogen, exploded upon contact with fuming nitric acid, and was soluble in glacial acetic acid. Upon exposure to the atmosphere for several hours, it was further oxidized to a viscous liquid that boiled above 225°.

With potassium dihydrogenphosphide in liquid ammonia at −33.5°, bromo and iodobenzene react slowly, and ammonium chloroacetate reacts more rapidly to form products that have not been identified.

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(1) Joannis, *Compt. rend.*, **119**, 557 (1894); *Ann. chim. phys.*, [8] **7**, 101 (1906).

(2) Legoux, *Compt. rend.*, **207**, 634 (1938); **209**, 47 (1939); *Bull. soc. chim.*, [5] **7**, 545 (1940); *Ann. chim.*, **17**, 100 (1942).

(3) Knunyants and Sterlin, *Compt. rend. acad. sci. U. R. S. S.*, **56**, 49 (1947).

(4) For n-octylphosphine, Möslinger [*Ann.*, **185**, 65 (1877)] has reported b. p., 184–187°.

DEPARTMENT OF CHEMISTRY
THE UNIVERSITY OF TEXAS
AUSTIN 12, TEXAS

RECEIVED FEBRUARY 24, 1948

Reduction Products of m-Nitrostyrene

BY RICHARD H. WILEY AND NEWTON R. SMITH

The reduction of m-nitrostyrene to 3,3′-divinylazobenzene and to 2,2′-divinylbenzidine has been reported by Komppa.[1] These and two additional products, 3,3′-divinylazoxybenzene and 3,3′-divinylhydrazobenzene have been prepared in this study. Analytical data for these compounds are collected in Table I. The customary reagents were used for the transformations as described in

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(1) Komppa, Inaugural Dissertation, Helsingfors, *Ber.*, **26**, Ref. 677 (1893).

TABLE I

REDUCTION PRODUCTS OF *m*-NITROSTYRENE

Compound	Yield, %	Color	M. p., °C., cor.	Empirical formula	Analyses, % Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found	Nitrogen Calcd.	Nitrogen Found
3,3′-Divinylazoxybenzene	78	Yellow	39.5–41	$C_{16}H_{14}N_2O$	76.78	76.81	5.64	5.65	11.20	11.30
3,3′-Divinylazobenzene	81.5	Orange	84	$C_{16}H_{14}N_2$	82.02	82.21	6.02	6.16	11.96	11.87
3,3′-Divinylhydrazobenzene	74.5	Faint yellow	96.5-97	$C_{16}H_{16}N_2$	81.32	81.14	6.81	6.92	11.86	11.87
2,2′-Divinylbenzidine	30	White	123	$C_{16}H_{16}N_2$	81.32	81.06	6.81	6.92	11.86	12.10
3-Aminostyrene hydrochloride polymer	84	Brown	Dec.	$C_8H_{10}NCl$	...	...	..	..	9.00	9.17

the experimental part. The azoxy compound was formed with zinc and ammonium chloride instead of the hydroxylamine usually obtained with this reagent. Polymeric products were obtained in the reduction of nitro to amino with zinc and hydrochloric acid; of nitro to azo with stannous chloride; of azoxy to azo with iron filings; and of azo to hydrazo with zinc and alcoholic sodium hydroxide. The azoxy compound polymerized on heating with benzoyl peroxide and the benzidine and azo compounds on heating without catalyst. The hydrazo compound decomposed on heating with benzoyl peroxide apparently without polymerization.

Experimental

Yields, physical properties, and analyses for the following products are listed in Table I.

m-**Nitrostyrene** was prepared by the decarboxylation of *m*-nitrocinnamic acid by a procedure similar to that previously attempted.[2] A mixture of 20 g. of *m*-nitrocinnamic acid (E. K. Co.), 75 ml. of quinoline, and 3 g. of copper powder were heated at 185–190° so as to produce a steady evolution of carbon dioxide. After one and one-half hours of heating the mixture was acidified with 50% excess 3 *N* hydrochloric acid and steam distilled. The distillate was extracted with chloroform and the combined extracts were dried over anhydrous sodium sulfate. After distilling off the chloroform, the residue was fractionated from a modified Claisen flask to give 9.3 g., 60% of the theoretical amount, of *m*-nitrostyrene, b. p. 90–96° (3.5 mm.), $n^{20}\text{D}$ 1.5836. Refractionation through a partial take-off column, 0.75 × 8 in. packed with Fenske rings gave a center cut, b. p. 96° (3.5 mm.), $n^{20}\text{D}$ 1.5830. With larger quantities longer reaction times were required and lower yields were obtained than in the above experiment.

3,3′-Divinylazoxybenzene was prepared by the reduction of *m*-nitrostyrene with sodium methoxide in methanol[3] or by reduction with zinc and ammonium chloride in aqueous ethanol.[4] Heating the fused solid at 80° with 0.5% benzoyl peroxide gave an insoluble, infusible polymer.

3,3′-Divinylazobenzene.—To 0.68 g. of 3,3′-divinylhydrazobenzene in 75 ml. of ethanol was added 10 g. of ferric chloride hexahydrate in 25 ml. of hot water. After fifteen minutes water was slowly added to precipitate the azo compound which was twice recrystallized from alcohol–water. Oxidation with sodium hypobromite or air in alcoholic sodium hydroxide also converted the hydrazo to the azo compound. Attempts to convert the azoxy to the azo compound by heating with iron filings gave polymeric products. The sample analyzed melted at 84° (cor.); Komppa[1] reported a m. p. of 38°. Heating at 110° for twenty-four hours gave an insoluble polymer which decomposed before melting when heated.

3,3′-Divinylhydrazobenzene was prepared by zinc and alcoholic sodium hydroxide reduction[5] of *m*-nitrostyrene. Attempts to reduce the azo to hydrazo compound with zinc and alcoholic sodium hydroxide gave only a polymer. On heating a mixture of solid the hydrazo compound and 0.5% benzoyl peroxide to 110° decomposition without apparent polymerization occurred.

2,2′-Divinylbenzidine was prepared in 30% yield by treating 3,3′-divinylhydrazobenzene with concd. hydrochloric acid in ether,[6] m. p. 123° (cor.); reported[1] m. p. 124°. Heating to 135° converted the benzidine to an infusible, insoluble polymer.

m-**Aminostyrene Polymer.**—Reduction of *m*-nitrostyrene with zinc and hydrochloric acid gave a polymer which was precipitated as the hydrochloride on addition of excess hydrochloric acid to its aqueous acid solution.

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[2] Walling and Wolfstirn, THIS JOURNAL, **69**, 852 (1947).

[3] Sudborough and James, "Practical Organic Chemistry," D. Van Nostrand and Company, New York, N. Y., 1934, p. 252.

[4] Sudborough and James, *ibid.*, p. 253.

[5] Gattermann-Wieland, "Laboratory Methods of Organic Chemistry," The Macmillan Company, New York, N. Y., 1932, p. 174.

[6] Gattermann-Wieland, *ibid.*, p. 176.

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p-Alkoxybenzyl Grignard Reagents

BY M. G. VAN CAMPEN, DONALD F. MEISNER[1] AND STANLEY M. PARMERTER[2]

The alkoxybenzylmagnesium halides are valuable intermediates in the synthesis of stilbene derivatives particularly in the study of synthetic estrogenic agents. However, the general impression exists that these Grignard reagents cannot be prepared. This impression is probably due to the fact that in attempts to form the Grignard from such halides as *p*-methoxybenzyl chloride by the usual procedure, a nearly quantitative yield of the *p*,*p*′-dialkoxybibenzyl is obtained. By using a modification of the method reported by Gilman[3] for the preparation of allyl Grignard reagents, it is possible to prepare *p*-alkoxybenzylmagnesium chlorides in acceptable yields. This is accomplished primarily by the use of a large excess of magnesium powder and slow addition of a dilute ether solution of the benzyl halide to the magnesium. Using the following general procedure 90% yields of *p*-methoxybenzylmagnesium chloride and *p*-benzyloxybenzylmagnesium chloride are consistently obtained.

Procedure.—A mixture of 2 to 2.5 g. atoms of magnesium turnings and 2 to 2.5 g. atoms of magnesium

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[1] Present address: C. J. Patterson Co., Kansas City 2, Missouri.

[2] Present address: Eastman Kodak Research Laboratories. Rochester, New York.

[3] Gilman and McGlumphy, *Bull. soc. chim.*, [4] **43**, 1322 (1928).

powder is vigorously stirred under 1 liter of refluxing anhydrous ether. One mole of the alkoxybenzyl halide dissolved in 1 l. of ether is added over a two to five hour interval. The resulting Grignard reagent is then filtered through glass cotton to remove the finely divided magnesium powder, which if not removed usually reacts with objectionable vigor during the ultimate decomposition with water or dilute acid. The yield is estimated by the usual acidimetric titration.

RESEARCH LABORATORIES OF
THE WM. S. MERRELL COMPANY
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COMMUNICATIONS TO THE EDITOR

CHEMICAL REACTIONS IN MOVING BOUNDARY SYSTEMS OF WEAK ELECTROLYTES

Sir:

In moving boundary systems containing partially neutralized weak acids or bases there exists the possibility of chemical reactions at the moving boundary which cause the mobility calculated from the boundary velocity and the conductivity of the leading solution to be lower than the ionic mobility.[1] This is illustrated by experiments 2 and 3 in which the indicator electrolyte is a salt of weak acid (cacodylic acid) having a higher *pK* than the leading weak electrolyte (acetic acid). The following reaction goes to completion to the right at the moving boundary so that none of the acetic acid remains behind that boundary.

$$\mathrm{Cac^- + HOAc \rightleftharpoons HCac + OAc^-} \quad K_{25^\circ} = 25 \quad (1)$$

The concentration of the sodium acetate is 0.05 *N* (at 0°) in all experiments, and it has been shown that the concentration and *p*H of the indicator electrolyte (α solution) is unimportant over a wide range.

The moving boundary equation[2] cannot be applied to acetate ion in the presence of acetic acid, but a term may be added for the acetic acid as follows so that the moving boundary equation for acetate constituent becomes

$$T^{\gamma}_{\mathrm{OAc^-}} = V^{\beta\gamma}(C^{\gamma}_{\mathrm{OAc^-}} + C^{\gamma}_{\mathrm{HOAc}}) = \frac{u^{\gamma}_{\mathrm{OAc^-}}\, C^{\gamma}_{\mathrm{OAc^-}}}{\kappa^{\gamma}\, 1000/F} \quad (2)^{3}$$

From equation (2) we see that the mobility, u, calculated from the boundary velocity in this case is the "constituent" mobility. The acetate ion mobility, $u^{\gamma}_{\mathrm{OAc^-}}$

$$u = V^{\beta\gamma}\kappa^{\gamma}\,\frac{1000}{\mathrm{F}} = u^{\gamma}_{\mathrm{OAc^-}}\,\frac{(C^{\gamma}_{\mathrm{OAc^-}})}{(C^{\gamma}_{\mathrm{OAc^-}} + C^{\gamma}_{\mathrm{HOAc}})} \quad (3)$$

calculated from the constituent mobility obtained in experiments 2 and 3 by using equation (3) are -17.62×10^{-5} and -17.55×10^{-5} in agreement with the average value, -17.53×10^{-5}, obtained in experiments 1 and 4.

However, in systems containing weak electrolytes the constituent mobility is not always obtained as illustrated by experiment 5. Whether or not a chemical reaction takes place depends upon the *pK* and relative mobility of the indicator ion. In this experiment the mobility calculated is slightly lower than the ionic mobility because the acetate ion does not disappear in the $\beta\gamma$ boundary, owing to the slight dissociation of the acetic acid left behind the moving boundary.

Since proteins and buffers used in electrophoresis are weak electrolytes, reactions such as the above occur and must be considered in the quantitative interpretation of electrophoretic patterns.

TABLE I[a]

	Moving Boundary System[b]				$u \times 10^5$
	γ		β	α	(0° C.)
(1)	NaOAc(0.05)	←	NaCac	: : NaCac	−17.47
(2)	NaOAc(0.05), HOAc(0.05)	←	NaCac, HCac	: : NaCac	− 8.81
(3)	NaOAc(0.05), HOAc(0.01)	←	NaCac, HCac	: : NaCac	− 5.85
(4)	NaOAc(0.05)	←	NaT	: : NaT	−17.59
(5)	NaOAc(0.05), HOAc(0.05)	←	NaT, HOAc	: : NaT	−16.54

[a] OAc, acetate; Cac, cacodylate; T, trichloroacetate. [b] The conventions recommended by Longsworth, THIS JOURNAL, **67**, 1109 (1945), are used.

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J. C. NICHOL

RECEIVED MAY 25, 1948

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[1] Dr. Harry Svensson, Institutes of Physical and Biological Chemistry, Upsala, Sweden, has independently recognized this fact in work initiated in September, 1946 (*Acta Chem. Scand.*, in press), personal communication.

[2] Weber, *Sitzungsber. Akad. Wissensch. Berlin*, 936 (1897); Svensson, *Ark. Kem. Min. Geol.*, **17A**, No. 14 (1943); Longsworth, THIS JOURNAL, **67**, 1109 (1945).

[3] The symbols have the meanings used by Longsworth ($C_{\mathrm{OAc^-}}$ is taken as negative).

SYNTHESIS OF DL-THREONINE

Sir:

The structure α-amino-β-hydroxy-*n*-butyric acid contains two dissimilar asymmetric carbon atoms and hence exists as four optical isomers and