the preparation of this compound afforded only the dihydro compound X or unchanged starting material.

Anal. Calcd. for $C_7H_9BrO_6S$: C, 27.92; H, 3.01. Found: C, 27.86, 28.10, 27.88; H, 3.21, 3.12, 3.25.

Ultraviolet Absorption Spectra.—The spectra were determined in purified dioxane with a Beckman Quartz Spectrophotometer, Model DU, using an approximately constant spectral band width of *ca.* 1 $m\mu$. *p*-Benzoquinone (Eastman practical grade) was purified by recrystallization from water and subsequent sublimation at 100°; m. p. 114–115°. 1,4-Thiapyrone-1-dioxide and 2,3-dihydro-1,4-thiapyrone-1-dioxide were both recrystallized from acetic acid and then sublimed *in vacuo* at temperatures slightly below their melting points; the sublimed samples melted at 174–175° and 147–148°, respectively. The wave lengths and extinction coefficients at the absorption maxima are summarized in Table I.

Summary

An improved procedure for the synthesis of 1,4-thiapyrone-1-dioxide, a sulfonyl analog of *p*-benzoquinone, has been described, and the addition reactions of this compound with hydrogen, hydrogen bromide, bromine and butadiene have been investigated. A number of new thiapyrone derivatives have been prepared and characterized. The ultraviolet absorption spectra of 1,4-thiapyrone-1-dioxide and 2,3-dihydro-1,4-thiapyrone-1-dioxide have been determined and compared with the spectrum of *p*-benzoquinone.

PHILADELPHIA, PENNSYLVANIA

RECEIVED DECEMBER 19, 1947

[A CONTRIBUTION OF THE CHEMICAL LABORATORY OF CLARK UNIVERSITY]

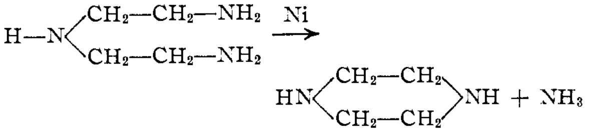
Preparation of Piperazine[1]

BY WILLIAM B. MARTIN AND ARTHUR E. MARTELL

The formation of secondary amines from primary amines by catalytic deamination has been mentioned by Adkins in the case of the formation of dibenzylamine from benzylamine. Also, C. W. Hoerr, *et al.*,[2] have recently prepared secondary aliphatic amines by the same method.

Kyrides[3] has described the preparation of piperazine from ethylenediamine and diethylenetriamine by the same method. The reaction was carried out without solvent at high temperatures (about 235°) in an autoclave. No yields were reported. This reaction has been subjected to considerable investigation in this Laboratory, and it seemed desirable at this time to report on the investigation to supplement the disclosures of the Kyrides patent.

Diethylenetriamine was heated with Raney nickel under various experimental conditions. The results of these experiments are tabulated below. In all cases ammonia was evolved and piperazine was formed according to the reaction



A temperature of about 150° or somewhat higher was found to be most suitable for the reaction. When a low-boiling solvent such as xylene or toluene was used at atmospheric pressure, the reaction proceeded very slowly and little piperazine was obtained. The reaction seemed to be endothermic, and an increase of the rate of heating at atmospheric pressure merely resulted in a more rapid evolution of ammonia. After the reaction had proceeded for a while the temperature would gradually rise to the reflux point of the solvent.

Allowing the ammonia to escape from the reaction mixture does not tend to improve the yield of piperazine. The yields are in general somewhat higher when the reaction is carried out in an autoclave. This may have been due in part to the loss of piperazine through volatilization in the escaping ammonia, since the vapor pressure of piperazine, even at room temperature, is fairly high. At any rate, the reaction does not approach a state of equilibrium. In all cases in which the ammonia was not allowed to escape, very little unreacted diethylenetriamine was isolated. As a further test, piperazine was treated with several molar proportions of alcoholic ammonia in an autoclave at 150° for ten hours in the presence of Raney nickel catalyst. No diethylenetriamine or ethylenediamine was obtained, and substantially all the piperazine was recovered by fractional distillation.

In all the reactions attempted some high-boiling fractions and viscous high molecular weight residues were obtained. These were evidently mixtures of higher "polyalkylene polyamines" which probably resulted from linear deamination of diethylenetriamine to form tetraethylenepentamine and higher homologs. The use of solvent is important in cutting down intermolecular condensation and in improving the yield of piperazine. This was also found to be the case by Pollard, *et al.*,[4] in the preparation of piperazine by the catalytic dehydration of hydroxyethylethylenediamine. In general, the use of a solvent decreased the formation of high boiling tarry residues. Of the solvents employed, moderately high boiling hydrocarbons gave the best results.

Similar results were obtained when the experi-

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(1) Adkins, "Reactions of Hydrogen," The University of Wisconsin Press, Madison, Wis., 1937, p. 55.

(2) C. W. Hoerr, *et al.*, *J. Org Chem.*, **9**, 201–210 (1944).

(3) Kyrides, U. S. Patent 2,267,686, December 23, 1941.

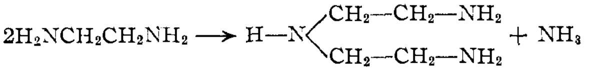
(4) Pollard, *et al.*, U. S. Patent 2,400,022, May 7, 1946.

TABLE I

YIELDS OF PIPERAZINE UNDER VARIOUS REACTION CONDITIONS

Reagent	G.	Solvent	Temperature, °C.	Time, hr.	Yield of piperazine, g.	Yield %
Diethylenetriamine	103	None	Reflux.	10	46	53
Diethylenetriamine		Tetrahydronaphthalene	Reflux	12	53	62
Diethylenetriamine		None	150, autoclave	8	33	38
Diethylenetriamine		Dipentene	160, autoclave	8	63	73
Diethylenetriamine		Xylene	Reflux	7	15	17
Diethylenetriamine		Dioxane	160, autoclave	7	28	32
Ethylenediamine	60	Tetrahydronaphthalene	150, autoclave	6	17	39

ments were repeated using ethylenediamine instead of diethylenetriamine. The formation of piperazine from ethylenediamine probably resulted through preliminary formation of diethylenetriamine which then condensed to form piperazine as described above.



$$2H_2NCH_2CH_2NH_2 \longrightarrow H{-}N\left\langle\begin{matrix}CH_2{-}CH_2{-}NH_2\\CH_2{-}CH_2{-}NH_2\end{matrix}\right. + NH_3$$

The piperazine was isolated as white crystals upon distillation and was identified in each case as the dibenzoyl derivative.

Experimental

The experimental conditions are summarized in Table I. Ethylenediamine and diethylenetriamine were purified by drying the commercial material over potassium hydroxide pellets and subsequent fractional distillation. Ethylenediamine was collected between 117 and 119°, while the diethylenetriamine used distilled from 83 to 86° at 3 mm. pressure. All solvents were dried and purified by distillation with the exception of dioxane which was first refluxed with sodium and aniline and then distilled. In each of the reactions listed in Table I, 10 g. of Raney nickel was used.

The reaction mixture was fractionally distilled in each case to remove solvent and separate the products. The piperazine was isolated as colorless prisms, all samples melting within a few degrees of 100°. In each case the dibenzoyl derivative was prepared. The melting points of the dibenzoyl derivatives of each reaction product ranged from 193 to 195°. In all cases, a mixed melting point with an authentic sample of dibenzoylpiperazine showed no depression.

Acknowledgment.—The authors express their appreciation to the F. C. Bersworth Laboratories of Framingham, Massachusetts, for supplying the materials used in this investigation.

Summary

Experimental conditions for the preparation of piperazine by catalytic deamination of diethylenetriamine and of ethylenediamine are described.

WORCESTER 3, MASS. RECEIVED OCTOBER 2, 1947

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, OREGON STATE COLLEGE]

Pyrimidine. II. Amino Alcohols Derived from Pyrimidine[1]

BY RAY A. CLARKE AND BERT E. CHRISTENSEN

This laboratory has previously synthesized[2] a number of amino alcohols with this substituent in the 5 position of pyrimidine nucleus, by the application of the Mannich reaction to various 5-acetylpyrimidines.

The usual methods for the preparation of such compounds involve the Mannich reaction on the acetyl derivative or the coupling of the bromomethyl ketone with the desired amine. The bromomethyl ketones are prepared either by direct bromination of the acetyl derivative or by means of the Arndt–Eistert reaction. Whenever possible, this latter method is preferable since it utilizes the acid rather than the less common acetyl derivative of the desired nucleus. Furthermore, there is less possibility of brominating other positions in the molecule and hence fewer separations and characterization problems.

Several 4-pyrimidinecarboxylic acid derivatives have been reported.[3,4,5] In this laboratory, 5-methyl-6-oxo-2-phenyl-4-pyrimidinecarboxylic acid was prepared in 50 to 60% yield from sodio diethyloxalpropionate and benzamidine. The acid in this instance was obtained directly in contrast to the diethyl oxalacetate condensation described by both Pinner[3] and Rappeport.[4]

5 - Methyl - 6 - oxo - 2 - phenyl - 4 - pyrimidinecarboxylic acid I was readily converted through the series of intermediates, 6-chloro-5-methyl-2-phenylpyrimidine-4-carbonyl chloride II → 4-bromoacetyl - 6 - chloro - 5 - methyl - 2 - phenylpyrimidine III → 4-(2-diethylamino-1-oxoethyl)-6-chloro-5-methyl-2-phenylpyrimidine hydrochloride IV to the amino alcohol, 4-(2-diethylamino-

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(1) The work described in this paper was made possible by a grant in aid from the Research Corporation. Published with the approval of the Monograph Publications Committee, Oregon State College, as Research Paper No. 121, School of Science, Department of Chemistry.

(2) Bruce Graham, A. M. Griffith, C. S. Pease and B. E. Christensen, THIS JOURNAL, **67**, 1294 (1945).

(3) A. Pinner, *Ber.*, **22**, 2615 (1889).

(4) T. Rappeport, *Ber.*, **34**, 1986 (1901).

(5) T. B. Johnson and K. G. Mackenzie, *Am. Chem. J.*, **42**, 365 (1909).