

(20 g.) and 75 cc. of thionyl chloride were refluxed for 2 hours and the excess thionyl chloride was removed *in vacuo*. Benzene was added to the acid chloride hydrochloride and was then removed by distillation; this process was repeated several times. After the addition of 100 cc. of benzene, the mixture was cooled and 30 g. of  $\beta$ -diethylaminoethanol, dissolved in 50 cc., was added gradually. The mixture was refluxed for 6 hours, the precipitated diethylaminoethanol hydrochloride was removed by filtration and the solvent was distilled from the filtrate. The residue was washed with water, dissolved in ether, the solution was removed from the dried solution and the residue was distilled; b.p. 162–165° (1 mm.), yield 17 g. (54%).

The dihydrochloride precipitated when an ether solution of the ester was treated with hydrogen chloride; m.p. 193–195° after recrystallization from absolute ethanol.

*Anal.* Calcd. for  $C_{16}H_{22}O_2N_2Cl_2$ : N, 8.12; Cl, 20.54. Found: N, 8.13; Cl, 20.38.

After 12 hours, about one-half of the alcohol was distilled from a mixture of 2.7 g. of the ester base, 5 cc. of methyl bromide and 25 cc. of absolute ethanol. The methobromide precipitated after the addition of absolute ether; m.p. 177–179° after recrystallization from isopropyl alcohol; yield 2 g. (55%).

*Anal.* Calcd. for  $C_{17}H_{23}O_2N_2Br$ : N, 7.63; Br, 21.73. Found: N, 7.71; Br, 21.93.

**2-(1-Hydroxy)-propylamide of Quinoline-3-carboxylic Acid.**—The acid chloride hydrochloride, obtained from 20 g. of quinoline-3-carboxylic acid, was suspended in 200 cc. of benzene and added, gradually, to a cooled solution of 35 g. of 2-aminopropanol<sup>2</sup> in 200 cc. of benzene. After 12 hours the benzene layer was decanted from the precipitated oil. The oil was washed with water and then allowed to remain under 100 cc. of 10% sodium carbonate solution for 2 hours. The solidified material was dissolved in alcohol, the solution was treated with charcoal, filtered and the product was precipitated by the addition of ether; yield 16 g. (59%), m.p. 110–112°.

*Anal.* Calcd. for  $C_{13}H_{14}O_2N_2$ : N, 12.17. Found: N, 12.29.

The base was dissolved in absolute ethanol and the solution was treated with hydrogen chloride. The hydrochloride precipitated after the addition of ether; m.p. 189–190° after recrystallization from absolute ethanol.

*Anal.* Calcd. for  $C_{13}H_{15}O_2N_2Cl$ : N, 10.51; Cl, 13.29. Found: N, 10.32; Cl, 13.42.

**2-(1-Hydroxy)-butylamide of Quinoline-3-carboxylic Acid Hydrobromide.**—The base of this compound was prepared in the manner described above from the acid chloride hydrochloride, obtained from 15 g. of quinoline-3-carboxylic acid, mixed with 200 cc. of benzene and 31 g. of 2-aminobutanol<sup>3</sup> dissolved in 100 cc. of benzene. The crude product, which could not be purified by recrystallization, weighed 10 g. (48%). It was dissolved in the smallest possible amount of absolute ethanol and the solution was treated with hydrogen bromide. The salt precipitated after the addition of absolute ether; m.p. 165–167° after recrystallization from absolute ethanol.

*Anal.* Calcd. for  $C_{14}H_{17}O_2N_2Br$ : N, 8.62; Br, 24.58. Found: N, 8.51; Br, 24.48.

The hydrochloride proved to be hygroscopic.

**Ethyl Quinoline-3-carboxylate.**—The acid chloride hydrochloride, obtained from 10 g. of quinoline-3-carboxylic acid, was suspended in 20 cc. of benzene and added to 30 cc. of cooled absolute ethanol. The mixture was refluxed for 2 hours, the solvents were removed under reduced pressure, 10% sodium carbonate solution was added to the residue and the oily ester was extracted with ether. The solvent was removed from the dried solution; m.p. 68–69°<sup>4</sup> after recrystallization from petroleum ether (60–75°); yield 8 g. (68%).

**Ethyl Dihydroquinoline-3-carboxylate.**—Ethyl quinoline-3-carboxylate (12 g.), dissolved in a mixture of 25 cc. of acetic acid and 100 cc. of 95% ethanol, was hydrogenated under an initial pressure of 40 pounds in the presence of 0.2 g.

(2) F. F. Blicke, J. A. Faust, R. J. Wazynski and J. E. Gearien, *THIS JOURNAL*, **67**, 205 (1945). A part of the material was obtained from the Carbide and Carbon Chemicals Corporation.

(3) Purchased from the Commercial Solvents Corporation.

(4) Reference 1, m. p. 69–69.5°.

of platinum oxide catalyst. The solution rapidly absorbed 1.2 liters (0.05 mole) of hydrogen. Even after the addition of fresh catalyst, no further amount of hydrogen was absorbed. The mixture was filtered and the filtrate evaporated to dryness *in vacuo*. The residue was triturated with 10% sodium carbonate solution and the product was neutralized from isopropyl alcohol; m.p. 136–138°, yield 8 g. (66%).

*Anal.* Calcd. for  $C_{12}H_{13}O_2N$ : C, 70.91; H, 6.45; N, 6.88; mol. wt., 203. Found: C, 70.76; H, 6.25; N, 7.10; mol. wt., 207.

**Dihydroquinoline-3-carboxylic Acid.**—A mixture of 4 g. of the ester, 2 g. of potassium hydroxide and 25 cc. of 95% ethanol was refluxed for 4 hours. After removal of the alcohol, the residue was dissolved in water and the product was precipitated by the addition of acetic acid; m.p. 172° dec. after recrystallization from absolute ethanol; yield 3 g. (85%).

*Anal.* Calcd. for  $C_{10}H_9O_2N$ : N, 8.00. Found: N, 8.01.

**Dihydroquinoline-3-carboxamide.**—A mixture of 7.0 g. of ethyl dihydroquinoline-3-carboxylate, 25 cc. of 95% ethanol and 8.3 g. of an 85% aqueous solution of hydrazine hydrate was refluxed for 12 hours. After removal of the alcohol, the residue was triturated with 5 cc. of water and then was recrystallized from isopropyl alcohol; the hydrazide melted at 190–192°; yield 5.9 g. (89%).

The hydrazide (1.9 g.) was dissolved in a mixture of 10 cc. of acetic acid and 3 cc. of water, the solution was cooled to –5°, stirred and 0.76 g. of sodium nitrite was added in small portions. The solution was stirred for 15 minutes and during this time the yellow azide precipitated. It was filtered and washed free from acetic acid with ether. The azide decomposed rather violently at 134°; yield 1.6 g. (80%).

The azide (2 g.) was suspended in 250 cc. of ether and 5 cc. of 28% ammonia water was added. The mixture was stirred for 12 hours. The precipitated amide weighed 0.6 g. (42%); m.p. 180–182°.

*Anal.* Calcd. for  $C_{10}H_{10}ON_2$ : N, 16.02. Found: N, 15.84.

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## Polarographic Study of Some Propylpyridonium Salts

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Pyridine, substituted pyridines, pyridine analogs, and many heterocyclic nitrogen compounds can be characterized and determined by polarography. This method most generally is applied to synthetic materials, but can often be adapted to naturally occurring products. A review article by Wawzonek<sup>3</sup> indicates the significance of the many polarographic investigations on heterocyclic nitrogen compounds. Pyridine and related amine materials are seen to give catalytic hydrogen waves which are attributed to the "onium" salts formed by hydrolysis.<sup>4,5</sup> Tompkins and Schmidt<sup>6</sup> have shown that "true" *one* electron reversible reduction waves

(1) North American Aviation, Inc., Atomic Energy Research Department, Box 309, Downey, California.

(2) Work described herein was from a thesis submitted by P. A. O'Donovan to the University of Portland in partial fulfillment of the requirements for the Degree of Master of Science.

(3) S. Wawzonek, *Anal. Chem.*, **21**, 61 (1949).

(4) E. Knobloch, *Collection Czechoslov. Chem. Commun.*, **12**, 407 (1947).

(5) P. C. Tompkins and C. L. A. Schmidt, *J. Biol. Chem.*, **143**, 643 (1942).

(6) P. C. Tompkins and C. L. A. Schmidt, *Univ. of Calif. Pub. Physiol.*, **5**, 221, 229, 237, 247 (1943).

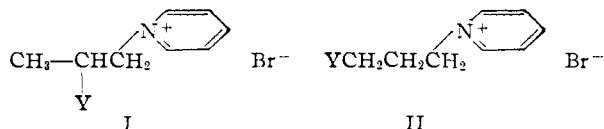
TABLE I  
HALF-WAVE POTENTIALS IN VOLTS vs. S.C.E. OF SUBSTITUTED PROPYLPYRIDONIUM SALTS

Salt	Aq. pH 7	Aq. pH 8	Aq. 0.05 M KOH	Aq. 0.05 M KNO <sub>3</sub>	0.05 M LiCl in ethanol	0.02 M TEAB <sup>a</sup> in 90.5% dioxane
<i>n</i> -Propyl bromide	-1.38	-1.36	-1.37	-1.37, -1.43 <sup>b</sup>	-1.29	-1.15
Isopropyl bromide			-1.40	-1.37, -1.43 <sup>b</sup>		-1.20
$\beta$ -OH bromide	-1.36	-1.36	-1.37	-1.42		-1.23
$\beta$ -Cl bromide	-1.22	-1.24	-1.23	-1.24, -1.40, <sup>b</sup> -1.72 <sup>c</sup>		-1.10
$\beta$ -Br bromide	-1.34	-1.33	-1.33	-1.33, -1.43, <sup>b</sup> -1.66 <sup>c</sup>		-1.15
$\beta$ -I bromide		-1.40	-1.39	-1.42	-0.19, <sup>c</sup> -1.35	
$\gamma$ -OH bromide	-1.28	-1.28	-1.30	-1.28, -1.42 <sup>b</sup>		-1.16
$\gamma$ -Cl chloride	-1.12	-1.12	-1.13	-1.13		-1.03
$\gamma$ -Br bromide	-1.18	-1.17	-1.18	-1.18, -1.38, <sup>b</sup> -1.70 <sup>c</sup>		-1.10
$\gamma$ -I iodide	-1.20	-1.19	-1.20	-1.23, -1.60 <sup>c</sup>		-0.96

<sup>a</sup> Tetraethylammonium bromide. <sup>b</sup> Catalytic waves. <sup>c</sup> These waves are assumed to be halogen reduction waves.

are obtained with quaternary nitrogen salts such as methylpyridonium salts and trigonelline.

In the present investigation, the polarographic properties of a series of beta (I) and gamma (II)



substituted propylpyridonium halides were studied in relationship to structural variation. Recently reported<sup>7</sup> dissociation constants for these same isomeric pyridonium salts bear consideration in correlating structure and electron distribution within the propylpyridonium ion-molecule.

#### Experimental

The polarographic equipment, materials and characteristics were the same as described in previous reports from this Laboratory.<sup>8,9</sup> All measurements were at a drop-time equal to 3.00 sec. and at 25.00  $\pm$  0.05°. The "m" value for the capillary was 2.00 mg. per second.

$m^2/s^2 = 1.907 \text{ mg.}^2/\text{sec.}^{-1/2}$  (open circuit) at  $h = 64 \text{ cm.}$

Preparation of the various pyridonium salts was described recently.<sup>7</sup> The aqueous buffer solutions containing 0.05 M potassium dihydrogen phosphate with different concentrations of sodium hydroxide were made according to directions given by Britton.<sup>10</sup> Gelatin was found to be an excellent maximum suppressor in the aqueous solutions. It was employed at concentrations 0.01-0.05%. The use of a maximum suppressor generally made it possible to ascertain the catalytic hydrogen waves with greater certainty. Methyl cellulose was used as a suppressor at concentrations 0.1 to 0.2% in the alcohol solutions. Minimum quantities of suppressor were employed so that diffusion currents were not materially altered. A satisfactory maximum suppressor was not found for the polarographic waves in dioxane. Maxima obtained in these cases did not prevent accurate evaluation of the half-wave potentials. Dioxane used was purified by distillation from sodium.

#### Results and Discussion

The  $E_{1/2}$  values (Table I) obtained for all of the pyridonium salts were unaffected, within experimental error, by the nature of the buffered or unbuffered aqueous solutions employed. Diffusion current was found to be directly proportional to concentration, and half-wave potential values were found to be unaffected by concentration change

(7) E. L. Colichman, W. R. Vanderzanden and S. K. Liu, *THIS JOURNAL*, **74**, 1953 (1952).

(8) E. L. Colichman, *ibid.*, **74**, 722 (1952).

(9) E. L. Colichman and H. P. Maffei, *ibid.*, **74**, 2744 (1952).

(10) H. T. S. Britton, "Hydrogen Ions," Vol. I, D. Van Nostrand Co., New York, N. Y., 1943, p. 306.

over the range investigated,  $5 \times 10^{-4}$  to  $5 \times 10^{-3}$  M, for the various pyridonium salts tested in both aqueous and non-aqueous solutions.

In all the aqueous solutions investigated slope analyses data (values  $0.059 \pm 0.002$ ) indicated that all pyridonium salts are reduced at the dropping mercury cathode by a one electron reversible reaction. Slope values equal to 0.10 and greater showed that these pyridonium salts are irreversibly reduced in dioxane solutions. Lower half-wave potentials were observed in dioxane.

It is seen (Table I) that a particular substituent group has a more pronounced influence in lowering the half-wave potential when in the gamma position as compared to when it is in the beta position. This greater enhancement in the ease of polarographic reduction by the gamma substituted salts is apparently related to the smaller dissociation constants found for these pyridonium salts.<sup>7</sup> It thus seems that polarographic properties as well as dissociation constant data<sup>7</sup> both indicate the probability that field effects rather than static inductive or direct resonance effects cause the unique influence noted with the gamma substituted salts. A previous communication<sup>7</sup> from this Laboratory indicates the possible nature of the field effect in these cases.

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#### Reactions of Long-chain Amines. I. Preparation of 4-Alkylmorpholines and 4,4-Dialkylmorpholinium Chlorides<sup>1</sup>

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Long-chain 4-alkylmorpholines (I) have previously been prepared by alkylation of morpholine<sup>2</sup> or by catalytic dehydration of N,N-bis-(2-hydroxyethyl)-alkylamines.<sup>3</sup> We have found that they may also be prepared by the reactions of the corre-

(1) Paper No. 160, Journal Series, General Mills, Inc., Research Department.

(2) J. B. Niederl, H. W. Salzberg and J. J. Shatynski, *THIS JOURNAL*, **70**, 618 (1948).

(3) R. A. Reck, U. S. Patent 2,597,260, May 20, 1952.