stantaneously and completely oxidizes ethyl mercaptan to ethyl disulfide according to the equation

$$2RSH + Br_2 = R_2S_2 + 2HBr$$

The initial rate of disappearance of bromine as it reacts with ethyl mercaptan should then be interpreted readily in terms of the known rates of oxidation of ethyl disulfide in the presence of hydrogen ion. The results of experiments M-1 to M-6 shown by the lower curve in Fig. 1 indicate that the rate law $-dBr_2/dt = k[R_2S_2\cdot(Br_2)_2]$ is being followed fairly well, but that the initial specific rate does not increase with the liberated hydrogen ion as rapidly as might be expected. Apparently the hydrogen ions which are liberated throughout the carbon tetrachloride layer as hydrobromic acid are not as effective in increasing the initial reaction rate as are those originally introduced into the water layer.

Change in Rate with Surface of Carbon Tetrachloride Layer.—Since the carbon tetrachloride remained a contiguous layer throughout the experiments, the amount of surface per mole of intermediate was conveniently increased by decreasing the volume of the carbon tetrachloride. As the conical flasks used throughout the experiments were constructed so that they were nearly cylindrical in their lower parts, decreasing the volume of the carbon tetrachloride layer should result in an almost proportionate increase in contact area per mole. As indicated by the result of Expt. 8, decreasing the volume of the carbon tetrachloride from 67.7 to 35.0 cc. increased the experimental value of k from 0.020 (as previously determined) to 0.035. The two mercaptan experiments M-8 and M-9, when corrected for effect of hydrogen ion, also show an approximately proportionate increase in the value of k with a decrease in the total volume of the carbon tetrachloride. These results support the assumption that the rate determining reaction is one occurring at the boundary of the water and carbon tetrachloride layers.

Conclusion

The previous suggestion that the rate determining step in the oxidation of ethyl disulfide by bromine in this two phase system is initially the hydrolysis of an intermediate product at the surface of the carbon tetrachloride layer, and is finally the rate of diffusion of the intermediate from the carbon tetrachloride, is strengthened by the following observations:

1. The relationship between the initial specific rate and the initial hydrogen ion concentration.
2. The fact that initial rate of oxidation of ethyl mercaptan follows the same law as does that of the disulfide, except that the hydrogen ions liberated throughout the carbon tetrachloride layer are not completely available for accelerating the initial rate.
3. Increasing the amount of surface per mole of intermediate increases the initial rate of the reaction.

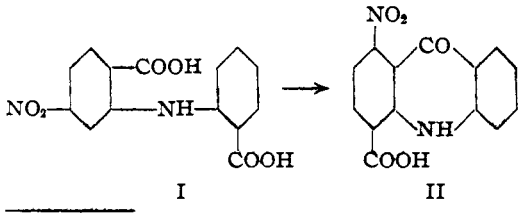
DAVIS, CALIF. RECEIVED DECEMBER 3, 1937

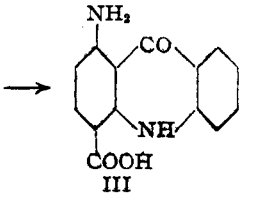
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF KITASATO INSTITUTE]

1-Aminoacridine-4-carboxylic Acid[1]

BY KONOMU MATSUMURA

In pursuance of a pharmacological investigation of amino-acridine carboxylic acids, 1-nitroacridone-4-carboxylic acid was synthesized according to the following scheme





In conformity with the expected behavior of a product of type II, the intermediary product in dilute alcoholic potassium hydroxide develops a deep orange yellow color. On reduction with stannous chloride, followed with decarboxylation, II yields an aminoacridone (m. p. 289–290°).

(1) Acknowledgment is due Prof. Hata for his interest in the work.

TABLE I

COMPARISON OF THE PROPERTIES OF SUBSTITUTED ACRIDONES

All compounds give a bluish-green color reaction with concd. sulfuric acid

Substituent	1-Amino- (pure)	1-Amino- (crude)	3-Amino-
Yellow crystal color	Intense	Intense	Light straw
M. p., °C.	289–290, uncorr. 299–300, corr.	285 Darkens at 283	295–296, uncorr.[a] 306–307, corr.
Fluorescence: Alcoholic solution	None or slight green		Intense violet
Fluorescence: Alc. soln. + trace HCl	No change	Weak green	Intense green
Fluorescence: Glacial HAc soln.	None	Weak green	Intense green
Soly. in Bz, $CHCl_3$, Et_2O	Moderate	Moderate	Prac. insoluble

(a) Albert and Linnell [*J. Chem. Soc.*, 1615 (1936)] give m. p. 301–303°, corr., and Tanasescu and Ramontianu [*Bull. soc. chim.*, [5] 1, 556 (1934)] give m. p. 292° for their specimens, respectively.

An attempt to identify the supposed 1-aminoacridone by comparison with an authentic sample failed because aminoacridones melt with decomposition; as a matter of fact, it was observed that an admixture of the substance in question with the 1- and 3-isomers caused no depression of the melting point in either case.

1-Aminoacridone prepared by Ullmann's method[2] contains traces of 3-aminoacridone. However, as shown in the experimental part, recrystallization from appropriate solvents gave a pure product. As is evident from Table I, fluorescence and solubilities furnish reliable criteria in identifying the two isomers.

Experimental

5-Nitrodiphenylamine-2,2'-dicarboxylic Acid.—A mixture of *o*-chloro-*p*-nitrobenzoic acid (20 g.), anthranilic acid (20 g.), potassium carbonate (41.6 g.), copper (0.8 g.), and amyl alcohol (60 cc.) was heated in an oil-bath (160°) for five hours; yield 25 g. The product gives orange-yellow needles from nitrobenzene or alcohol, melting at 324–325° (dec.).

Anal. Calcd. for $C_{14}H_{10}O_6N_2$: C, 55.63; H, 3.11. Found: C, 55.88; H, 3.67.

1-Nitroacridone-4-carboxylic Acid.—A mixture of the preceding acid (31.5 g.), phosphorus pentachloride (52 g.) and nitrobenzene (300 g.) was warmed on a water-bath for one and one-half hours. On cooling, aluminum chloride (32 g.) (the aluminum chloride may be omitted)[3] was added and heating continued for three hours. The reaction product was dissolved in dilute sodium carbonate and precipitated with hydrochloric acid; yield 28.4 g. From alcohol it separates in yellow needles melting at 333° (dec.) and imparts an orange-yellow color to aqueous alcoholic potassium hydroxide. Decarboxylation was not observed to take place when this acid (0.2 g.) was heated in a glacial acetic acid (15 cc.)–hydrochloric acid (10%, 2 cc.) mixture at 100° for three hours.

Anal. Calcd. for $C_{14}H_8O_5N_2$: C, 59.15; H, 2.82; N, 9.86. Found: C, 59.36; H, 3.03; N, 9.72.

(2) Ullmann and Bader, *Ann.*, **355**, 332 (1907).

(3) Eisleb, *Medizin. und Chem.*, **III**, 51 (1936).

1-Nitroacridone-4-carboxylic Acid Chloride.—A mixture of 1-nitroacridone-4-carboxylic acid (0.5 g.), phosphorus pentachloride (0.8 g.) and phosphorus oxychloride (5 cc.) was heated at 110–120° for an hour. The acid chloride after precipitation with petroleum ether was poured into ice water and the solution was neutralized with sodium bicarbonate; yield 0.5 g. It forms yellow prismatic needles from benzene, m. p. 299° (dec.).

Anal. Calcd. for $C_{14}H_7O_4N_2Cl$: Cl, 11.74. Found: Cl, 10.89.

1-Aminoacridone-4-carboxylic Acid.—A mixture of 1-nitroacridone-4-carboxylic acid (8 g.), stannous chloride (24 g.), concd. hydrochloric acid (32 cc.) and glacial acetic acid (56 cc.) was triturated at room temperature for an hour, warmed at 70–80° for ten minutes, filtered on cooling and washed repeatedly with dilute hydrochloric acid (5%). The tin double salt was decomposed with warm dilute sodium carbonate (charcoal), filtered hot and precipitated with acetic acid; yield 6 g. Crystallized from alcohol, it forms lemon yellow needles (4.8 g.), m. p. 289–290°. It is moderately soluble in alcohol and ether but sparingly soluble in hot benzene and hot water and insoluble in dilute mineral acids. This product exhibits an intense green fluorescence in concd. sulfuric acid but none in glacial acetic acid or dilute alkaline solution.

Anal. Calcd. for $C_{14}H_{10}O_3N_2$: C, 66.14; H, 3.94. Found: C, 65.96; H, 3.88.

Decarboxylation of 1-Aminoacridone-4-carboxylic Acid.—A mixture of 1-aminoacridone-4-carboxylic acid (0.2 g.), acetic acid (33%, 15 cc.) and hydrochloric acid (10%, 1 cc.) was refluxed on a boiling water-bath for three hours. After the solution was made alkaline with dilute sodium hydroxide, the aminoacridone precipitated on cooling. Crystallized from 50% alcohol, then from benzene and finally from hot water, it forms lemon yellow needles, m. p. 289–290°. It melts at the same temperature as the parent carboxylic acid and there is no appreciable depression in m. p. on admixture of the two, but there is wide difference in behavior toward solvents.

Anal. Calcd. for $C_{13}H_{10}ON_2$: C, 74.29; H, 4.76; N, 13.33. Found: C, 74.31; H, 4.84; N, 13.37.

1-Aminoacridine-4-carboxylic Acid.—To a warm solution of 1-aminoacridone-4-carboxylic acid (0.8 g.) in sodium carbonate (1 g.) and water (40 cc.), sodium amalgam (5%, 8 g.) was added. The mixture was warmed in a water-bath for a half hour with shaking and bubbling in of carbon di-

oxide. The reduction product was precipitated from the filtered and cooled solution with acetic acid. After boiling in alcohol in the presence of animal charcoal, crystallization was effected by concentrating the solvent; yield 0.5 g.

On recrystallization from alcohol the amino acid separated in long orange-yellow needles melting at 273–274° (dec.) with sintering at 268°.

It is easily soluble in dilute sodium hydroxide, moderately in alcohol, chloroform, ether and hot water but difficultly soluble in hot benzene. The solution in concd. sulfuric acid shows green fluorescence.

Anal. Calcd. for $C_{14}H_{10}O_2N_2$: C, 70.59; H, 4.20. Found: C, 70.36; H, 4.37.

The monohydrochloride gives black-violet leaflets from dilute hydrochloric acid, decomposing at 245–250°. It is soluble in alcohol and water with violet-red color.

Anal. Calcd. for $C_{14}H_{10}O_2N_2 \cdot HCl \cdot {}^1/_2H_2O$: C, 59.26; H, 4.23. Found: C, 59.27; H, 4.77.

Summary

5-Nitrodiphenylamine-2,2′-dicarboxylic acid, on ring closure, yields 1-nitroacridone-4-carboxylic acid as a chief product.

TOKYO, JAPAN RECEIVED SEPTEMBER 27, 1937

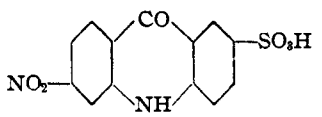
[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF KITASATO INSTITUTE]

Sulfonation of 6-Nitroacridone

BY KONOMU MATSUMURA

6-Nitroacridone-2-sulfonic acid, I can be prepared by the action of fuming sulfuric acid on the

I



corresponding nitroacridone. Contrary to expectation, the sodium salt of this new acid yields with phosphorus oxychloride or pentachloride the corresponding acridone sulfonyl chloride, while sodium acridone-2-sulfonate is converted to 9-chloroacridine-2-sulfonyl chloride.[1]

The assumed 2-position of the sulfonic acid group in I was confirmed as follows:

II. Acridone-2-sulfonic acid was prepared from the nitroacridone sulfonic acid by reduction of the nitro group, followed by removal of the amino group through diazotizing. The product so obtained, on admixture with an authentic sample,[1] showed no depression in melting point.

III. Synthesis of 6-nitroacridone-2-sulfonic acid was effected as follows: *p*-nitro-*o*-chlorobenzoic acid was condensed with sulfanilic acid by the method of Polaczek,[2] the reaction product was treated with phosphorus oxychloride and the resultant acridone sulfonyl chloride was hydrolyzed to the corresponding sulfonic acid.

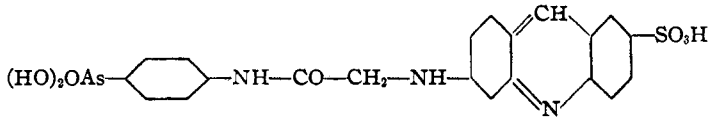
IV. The same nitroacridonesulfonic acid was synthesized by the interaction of 5-nitrodiphenylamine-2-carboxylic acid and fuming sulfuric acid.

(1) Matsumura, THIS JOURNAL, **57**, 1535 (1935).

(2) Polaczek, *Roczniki Chem.*, **15**, 565 (1935); *Chem. Zentr.*, **108**, 2355 (1936).

The identity of preparations I, III and IV was established by the constant melting point of admixed samples.

By the interaction of sodium ω-chloroacetaminophenyl-*p*-arsinate and sodium 6-aminoacridine-2-sulfonate, 6-arsacetinylaminoacridine-2-sulfonic acid (V) was made.



V

This compound was shown to be trypanocidally ineffective when tested with recurrent fever on mice.[3]

Experimental

Sodium 6-Nitroacridone-2-sulfonate.—6-Nitroacridone (20 g.) in fuming sulfuric acid (20%, 100 g.) was allowed to stand at room temperature for several hours until a sample dissolved completely in water, the mixture was poured into ice water, sodium hydroxide (21 g. in 500 cc. of water) was added and the sodium salt was precipitated from the filtered solution with hydrochloric acid (yield 27.7 g. or 97.2%).

Crystallized from water, it forms yellow needles with two moles of water, being unaltered at 360°. It is readily soluble in hot dilute sodium carbonate and cold dilute sodium hydroxide with red color but almost insoluble in alcohol, dilute hydrochloric acid or salt solution.

Anal. Calcd. for $C_{13}H_7O_5N_2SNa$: C, 45.61; H, 2.05; Na, 6.73. Found: C, 45.03; H, 2.55; Na, 6.62.

6-Nitroacridone-2-sulfonic Acid.—Prepared from its sodium salt through the barium salt, it crystallized from

(3) I am indebted to Dr. Yamamoto of this Institute for the biological test.