7. D. R. Dalton, J. B. Hendricson, and D. Jones, Chem. Commun., 591 (1966).
8. A. J. Gordon and R. A. Ford, Chemist's Companion: A Handbook of Practical Data, Techniques, and References, Wiley-Interscience, New York (1973).
9. N. L. Sergovskaya, Yu. S. Tsizin, and S. A. Chernyak, Khim. Geterotsikl. Soedin., No. 6, 803 (1984).

BROMINATION OF QUINOLINE IN THE PRESENCE OF SOME LEWIS ACIDS

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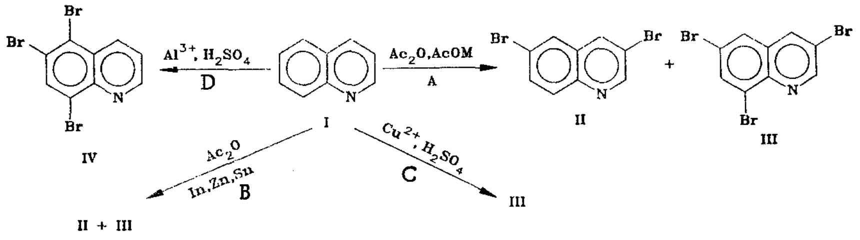
Data on the bromination of quinoline in acetic anhydride and in the presence of salts of p and d elements are presented. High catalytic activity of the investigated salts, particularly the salts of p elements, was demonstrated. An unexpected orientation of the bromination of quinoline in 94% sulfuric acid in the presence of copper sulfate was discovered.

Halogenation is considered to be one of the most thoroughly investigated reactions in the monoazine series [1]. However, some aspects of the catalysis of this reaction by salts of p and d elements of the Mendeleev periodic system have not been adequately studied. In particular, in [2] one of us demonstrated the high activation of pyridine to bromination in complexes for elements with p orbitals (Zn, Sn, Sb, Te, etc.), although such activation of a ligand is not obvious from the generally accepted concept [3-5]. Because of the possible d_π–p_π interaction (π back bonding), one might have expected, from the same concept, a somewhat different orientation of the bromination of quinoline with salts of d elements than in the case of its catalysis with silver sulfate [6].

In order to shed some light on the problems enumerated above, it was necessary to conduct additional investigations in the case of the bromination of quinoline in complexes with salts of p and d elements. It is known that the yields of bromoquinolines by known methods are rather low [6-8], although they are of practical interest as potential inhibitors of the nitrification of nitrogen fertilizers [9].

In the present communication we present data on the bromination of quinoline in acetic anhydride and in the presence of Al, In, Sn (p elements), Cu, Zn (d elements), and Na, Co, Ni, Cu, Ag, Zn, Ba, Pb, and other acetates. The role of acetic anhydride and acetates is evidently determined in the generation and facilitation of the addition of the AcO^-Br^+ bromo cation in the intermediate 1,4-dihydroquinoline [10] as a function of the degree of valence of the metal, the positive charge, the ability to coordinate at the ring nitrogen atom of quinoline, and other factors. The general method is similar to that described in [11] for the bromination of quinoline N-oxide. Exclusively 3,6-dibromo-substitution products are formed under the conditions in [11].



M=Na, Co, Ni, Cu, Zn, Ag, Ba, Pb

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We have observed that the bromination of quinoline (I) by method A in the presence of metals leads to dibromoquinoline II and tribromoquinoline III in high yields. The overall yield of II and III when AcONa is used is 64%. However, when sodium acetate is replaced by barium acetate, the yield of quinoline II is 17%, and the yield of tribromo derivative III is 42%. When cobalt acetate is used, the yields of the indicated quinolines are 25% and 22%, respectively.

In the bromination of quinoline in acetic anhydride in the presence of sodium nitrate and nitrite the overall yield of di- and tribromides II and III reaches 15%, whereas the yields of II and III reach 22-57% in the presence of indium, zinc, tetravalent tin, and other salts (method B). The selection of $NaNO_2$ and $NaNO_3$ was determined by the necessity to demonstrate the effectiveness of the catalysts in the indicated reaction.

An unexpected result was obtained in the bromination of quinoline in 94% sulfuric acid. As expected, exclusively the benzene ring undergoes bromination in the presence of the nontransition p element aluminum sulfate (method C). In the presence of a salt of a transition d element, viz., copper sulfate (method D), the pyridine ring also undergoes bromination, and tribromo derivative IV is formed. The observed anomalous bromination of quinoline in a strongly acidic medium in the presence of copper sulfate may evidently serve as an experimental confirmation of the possible interaction of the d electrons of copper sulfate with the π electrons of quinoline (d_π–p_π conjugation). The direction of bromination of quinoline, as in the halogenation of the neutral molecule in a slightly acidic medium [7, 8], can be explained by a decrease, as a consequence of this, in the formal positive charge on the nitrogen atom of the quinolinium cation. The quinoline–bromine ratio and the reaction time were selected in such a way that the reaction would be shifted maximally to favor the production of tribromoquinolines.

The structures of the II-IV obtained were proved by the fact that the TLC data and the data from the IR spectra at 700-4000 cm^{-1} were identical to the data for samples with genuine structures and by the lack of melting-point depressions for mixtures with genuine samples obtained by known methods [6, 7].

EXPERIMENTAL

The IR spectra of mineral oil suspensions and KBr pellets of the compounds were recorded with a UR-10 spectrometer. The samples of 3,6-dibromo- and 3,6,8-tribromoquinolines were obtained by the methods in [6, 7] and were purified by sublimation *in vacuo* or by crystallization from alcohol. The purity and individuality of the compounds was monitored by data from TLC and the IR spectra.

Bromination of Quinoline. A) A 31-g (0.2 mole) sample of bromine was added to a mixture of 12.9 g (0.1 mole) of quinoline, 16 g (0.2 mole) of sodium acetate, and 13 ml of acetic anhydride in 50 ml of $CHCl_3$ (CCl_4), and the mixture was heated to the point at which it began to boil gently (70°C) and maintained at this temperature for 3 h. It was then cooled, made alkaline to pH 10, and extracted with $CHCl_3$. The solvent was removed by distillation, and the residue was extracted with ether. Workup of the ether solutions gave 7.2 g (25%) of dibromo derivative II with mp 129-130°C (alcohol) (mp 127-128.5°C [7]). From the residue after extraction with ether by recrystallization from acetone we obtained 14.1 g (39%) of tribromoquinoline III with mp 168-170°C (mp 169-171°C [7]). According to data from TLC and the IR spectra, the products were identical to samples with genuine structures.

B) A 31-g (0.2 mole) sample of bromine was added to a mixture of 12.9 g (0.1 mole) of quinoline, 16 g (0.2 mole) of $NaNO_2$, 5 g (0.02 mole) of $InCl_3$, and 13 ml of Ac_2O in 50 ml of $CHCl_3$ (CCl_4), and the reaction mixture was heated to the point at which it began to boil gently and was maintained at this temperature for 3 h. It was then cooled, made alkaline to pH 10, and extracted with chloroform. The solvent was removed by distillation, and the residue was extracted with ether. Workup of the ether solutions gave 3.0 g (17.0%) of dibromoquinoline II with mp 129-130°C. Workup of the residue after extraction with ether gave 14.5 g (40%) of tribromoquinoline III with mp 168-170°C. No melting-point depressions were observed for mixtures of II and III with samples with genuine structures. According to data from TLC and the IR spectra the products that we obtained were identical to genuine samples.

The yields of II and III when sodium nitrite was used in the reaction were, respectively, 24% and 43%. In the presence of $ZnCl_2$ and $SnCl_4$ catalysts, the yields of II are 33% and 22%, respectively. The yield of III was less than 1%. The yield of dibromoquinoline II was 15% in the bromination of quinoline under conditions similar to those in method A without the use of a catalyst.

C) A 32-g (0.2 mole) sample of bromine was added with cooling (0-5°C) and stirring in the course of 0.5 h to a mixture of 40 g (0.31 mole) of quinoline and 10 g (0.06 mole) of $CuSO_4$ in 100 ml of 94% H_2SO_4, and the reaction mixture was maintained at this temperature for 1.5-2 h. It was then poured over crushed ice, and the aqueous mixture was made alkaline to pH 10. The unchanged quinoline was removed by steam distillation, and the residue was acidified to pH 2. The resulting precipitate was removed by filtration, washed with water, and dried to give 9.1 g (19%) of tribromoquinoline III. No melting-point depression was observed for a mixing of the product with a sample with a genuine structure [7]. According to the data from TLC and the IR spectra, the product was identical to the genuine sample.

D) A 32-g (0.2 mole) sample of bromine was added with cooling (0-5°C) in the course of 0.5 h to a mixture of 40 g (0.31 mole) of quinoline and 10 g (0.03 mole) of $Al_2(SO_4)_3$ in 100 ml of 94% H_2SO_4, after which the reaction mixture was stirred for 2 h. It was then poured over ice, and the aqueous mixture was worked up as indicated above to give 8.1 g (58%) of tribromoquinoline IV with mp 161-162°C (acetone). No melting-point depression was observed for a mixture of this product with a sample with a genuine structure [6]. According to data from TLC and the IR spectra, the product was identical to the genuine sample.

LITERATURE CITED

1. Zh. I. Aksel'rod and V. M. Berezovskii, Usp. Khim., 39, 1337 (1970).
2. R. E. Lokhov, S. S. Lokhova, N. M. Gaidarova, and L. I. Belen'kii, Khim. Geterotsikl. Soedin., No. 9, 1236 (1981).
3. O. J. Johnson, J. Res. Inst. Catal. Hokkaido Univ., 28, No. 3, 215 (1980).
4. V. I. Minkin, B. Ya. Simkin, and R. M. Minyaev, Theory of Molecular Structure [in Russian], Vyssh. Shkola, Moscow (1979), p. 188.
5. K. Masters, Homogeneous Catalysis by Transition Metals [Russian translation], Mir, Moscow (1983), p. 13.
6. P. B. D. Mare, M. Kiamerd-din, and J. H. Ridd, J. Chem. Soc., 561 (1960).
7. J. J. Eisch, J. Org. Chem., 27, 1318 (1962).
8. J. J. Eisch, Adv. Heterocycl. Chem., 7, 1 (1967).
9. P. M. Smirnov, N. A. Torina, and S. D. Bazilevich, Agrokhimiya, No. 1, 16 (1979).
10. M. J. S. Dewar and P. M. Maitlis, J. Chem. Soc., 944 (1957).
11. M. Hamana and M. Yamaraki, Chem. Pharm. Bull. (Tokyo), 9, 414 (1961); Chem. Abstr., 55, 247 (1961).