of the solid had dissolved (20-30 min), after which the solution was cooled and acidified with hydrochloric acid, and the precipitated acid XIa was removed by filtration and dried. Recrystallization from acetic acid converted the product to anhydride XIb [5.6 g (83%)]. The yellow crystals had mp 219-221°C (dec.). IR spectrum: 1650, 1668 (quinone CO); 1718, 1785, and 1850 cm^{-1} (anhydride CO). PMR spectrum (in CF_3COOH): 3.98 (3H, s, NCH_3), 4.08 (3H, s, OCH_3), 7.25 (1H, s, =CH−CO), and 7.88 ppm (4H, m, 5, 6, 7, 8-H). Found: C 64.4; H 3.3; N 3.8%; M^+ (by mass spectroscopy) 337. $C_{18}H_{11}NO_6$. Calculated: C 64.1; H 3.3; N 4.2%; M 337.3.

1-Methyl-3-(cis-1,2-dicarbomethoxyvinyl)-2-methoxybenz[f]indole-4,9-dione (XIc). A mixture of 5 g (14.8 mmole) of XIb, 25 ml of thionyl chloride, and 0.2 ml of dimethylformamide (DMF) was refluxed for 2 h, after which it was evaporated to dryness in vacuo. Absolute methanol (20 ml) was added with cooling to the residue, and the mixture was refluxed for 1 h. It was then cooled, and the precipitated diester XIc was recrystallized from chloroform−methanol to give 5.2 g (91.5%) of pale-yellow needles with mp 161-162°C. IR spectrum: 1667 (quinone CO) and 1733 cm^{-1} (ester CO). PMR spectrum (in CF_3COOH): 4.00 (3H, s, NCH_3), 4.03 (3H, s, OCH_3), 4.07 (6H, broad s, $2OCH_3$), 6.88 (1H, s, =CH−CO), and 7.95 ppm (4H, m, 5, 6, 7, 8-H). Found: C 62.9; H 4.3; N 3.9%; M^+ (by mass spectrometry) 383. $C_{20}H_{15}NO_7$. Calculated: C 62.7; H 4.4; N 3.7%; M 383.3.

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REACTIONS OF 4-METHYL(CHLORO)SULFONYL-2,3,5,6-TETRABROMOPYRIDINES WITH NUCLEOPHILIC REAGENTS

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UDC 547.822.1.5.6'828

The $MeSO_2$ group is replaced in the reaction of 4-methylsulfonyltetrabromopyridine with small nucleophiles, whereas the Br atom in the 2 position is replaced in the reaction with bulky nucleophiles. Depending on the temperature conditions and the ratio of the reacting substances, 4-chlorosulfonyltetrabromopyridine reacts with primary amines to give either the corresponding amides or amines. It was established that the corresponding amines are formed when tetrabromopyridinesulfonic acid ω-hydroxyalkylamides are heated with triethylamine.

According to kinetic data, in nucleophilic substitution reactions the methylsulfonyl groups in nitrogen heterocycles are substituted considerably more rapidly than the halogen atoms [1], and hetaryl methyl sulfones are therefore valuable intermediates for all sorts of chemical transformations.

From this point of view it seemed of interest to study the reactions of 4-methylsulfonyl-2,3,5,6-tetrabromopyridine (I) with some nucleophilic reagents.

The presence of the strong electron-acceptor CH_3SO_2 group in I should activate the adjacent bromine atoms, and attack on the carbon atoms in the 2, 3, and 4 positions in sulfone I is therefore theoretically possible, depending on the nature of the nucleophile.

It was established that the CH_3SO_2 group is replaced exclusively in all cases when sulfone is heated even with excess ammonia, methylamine, sodium hydroxide, and sodium methoxide, and 4-amino, 4-methylamino, 4-hydroxy-, and 4-methoxy-2,3,5,6-tetrabromopyridine (IIa-d), respectively, are formed.

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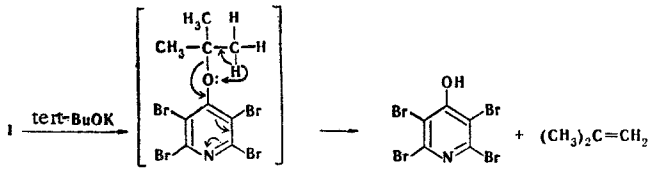
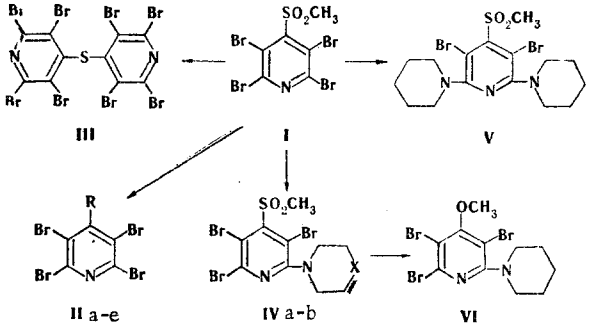
The reaction of sulfone I with potassium tert-butoxide leads to the formation of product IIc rather than to 4-tert-butoxytetrabromopyridine. The probable mechanism of the reaction apparently consists in the initial formation of unstable 4-tert-butoxytetrabromopyridine, in which, owing to the shift of the electron density toward the electron-acceptor tetrabromopyridyl residue, the C–H and C–O bonds are cleaved synchronously, and a proton migrates to the oxygen atom. The isobutylene liberated in the reaction was identified in the form of the corresponding dibromide.



4-Mercapto-2,3,5,6-tetrabromopyridine (IIe) was obtained in the reaction of sulfone I with sodium hydrosulfide at a reagent ratio of 1:2.5. The use of equimolar amounts of these compounds leads to bis(2,3,5,6-tetrabromo-4-pyridyl) sulfide (III), which is also formed in the reaction of sulfone I and pentabromopyridine with the sodium salt of IIe.

In the case of alicyclic amines the reaction with sulfone I proceeds in two directions. In contrast to 4-methylsulfonyltetrachloropyridine [2], replacement of only one bromine atom rather than the CH_3SO_2 group to give, respectively, 2-morpholino(piperidino)-4-methylsulfonyl-3,5,6-tribromopyridines (IVa,b) occurs when twofold amounts of morpholine or piperidine are used. The use of a fourfold amount of piperidine leads to 2,6-dipiperidine-4-methylsulfonyl-3,5-dibromopyridine (V). The position of the piperidine and morpholine

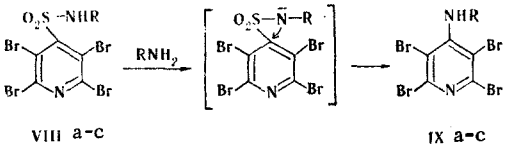


IIa R–NH_2; b R=$NHCH_3$; c R–OH; d R=OCH_3; e R=SH; IVa X=O; b X=CH_2

residues in the ring was proved by conversion of IVb to the known [3] 2-piperidino-4-methoxy-3,5,6-tribromopyridine (VI) by heating it to 160°C with sodium methoxide in methanol. The stability of the CH_3SO_2 group in sulfone I under the influence of alicyclic amines is probably due to steric hindrance, which makes it difficult for the ring nitrogen atom to approach the carbon atom in the 4 position. The inert character of the bromine atoms in the 3 and 5 positions is evidently explained by the fact that these atoms are bulky substituents and force the CH_3SO_2 group out of the plane of the π-electron system of the pyridine ring along the S–C_4 bond and thereby interfere with its mesomeric effect (–M) on this system. One may, nevertheless, assume that the CH_3SO_2 group retains its meta-orienting effect owing to the negative inductive effect, which has a substantial influence on the increased lability of the bromine atom in the 2 position.

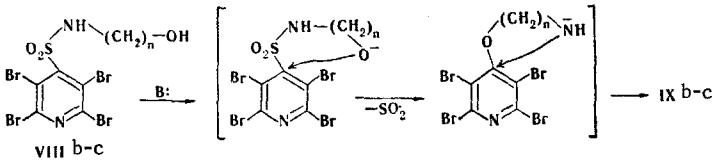
We also studied some nucleophilic substitution reactions for 2,3,5,6-tetrabromopyridine-4-sulfonyl chloride (VII). In contrast to sulfone I, a new electrophilic center, viz., the sulfur atom, develops in sulfonyl chloride VII. Depending on the temperature conditions and the nature of the nucleophile, the reaction with sulfonyl chloride VII is realized either at the sulfur atom of the sulfonyl group or at the carbon atoms in the 2 and 4 positions. Thus, according to the results of thin-layer chromatography (TLC), 2,3,5,6-tetrabromopyridine-4-sulfonic acid n-butyl, β-hydroxyethyl-, and γ-hydroxypropylamides (VIIIa-c) are formed exclusively by the action of even excess n-butylamine, ethanolamine, and propanolamine at –70°C on sulfonyl chloride VII. At 20°C a fourfold excess of the amines indicated above leads to the formation of 4-butyl-, 4-β-hydroxyethyl-, and 4-γ-hydroxypropylamino-2,3,5,6-tetrabromopyridines (IXa-c). The mechanism of the latter reaction consists in the initial formation of amides VIIIa-c, which can subsequently be converted to amines IXa-c

via various mechanisms: a) as a result of intermolecular attack by the amine directly on the electrophilic carbon atom in the 4 position; b) as a result of an S_Ni rearrangement, which consists in detachment of a proton from the amide group with subsequent intramolecular attack by the nitrogen anion on the carbon atom in the 4 position through a three-membered ring:



VIII a-c IX a-c

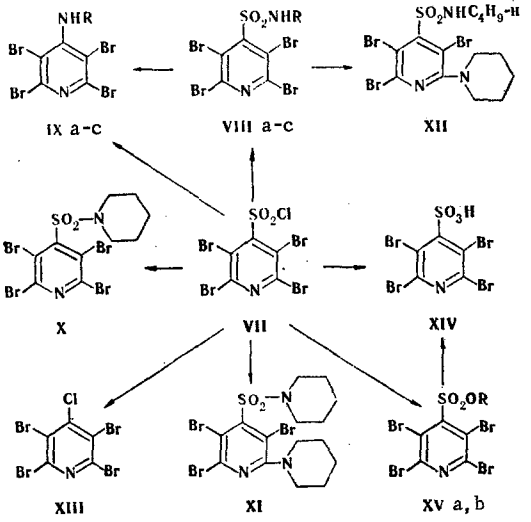
c) in the case of amides VIIIb and VIIIc as a result of a possible double Smiles rearrangement, which also leads to amines IXb and IXc:



VIII b-c IX b-c

The latter two mechanisms are less likely, since amides VIIIa-c are not converted to amines IXa-c under the influence of triethylamine at 20°C. However, an increase in the temperature to 80°C promotes the conversion of amides VIIIb and VIIIc to amines IXb and IXc. Amide VIIIa is not converted to amine IXa under these conditions. Thus in this case a double Smiles rearrangement is undoubtedly realized for amides VIIIb and VIIIc; according to the data from the UV spectra, the rate of rearrangement of amide VIIIc is lower by a factor of 33 than the rate for amide VIIIb. This is evidently explained by the fact that in the case of amide VIIIc the rearrangement proceeds through the less favorable seven-membered ring, whereas in the case of amide VIIIb it proceeds through the more favorable six-membered ring.

4-(Piperidinosulfonyl)-2,3,5,6-tetrabromopyridine (X) was obtained in the reaction of sulfonyl chloride VII with a twofold amount of piperidine. The excess piperidine does not replace the sulfonamido group but leads to the formation of 4-(piperidinosulfonyl)-2-piperidino-3,5,6-tribromopyridine (XI). Replacement of the bromine atom in the 2 position to give 2-piperidino-3,5,6-tribromopiperidine-4-sulfonic acid n-butylamide (XII) also takes place in the reaction of piperidine with amide VIIIa; this additionally confirms the presence of steric hindrance created by the bromine atoms in the 3 and 5 positions.



VIII, IX a R=C_4H_9-n; b R=$(CH_2)_2OH$; c R=$(CH_2)_3OH$; XV a R=CH_3; b R=C_6H_5

Sulfonyl chloride VII remains unchanged after prolonged treatment with water; treatment with 35% HCl leads to the formation of 2,3,5,6-tetrabromo-4-chloropyridine (XIII). Sodium hydroxide readily converts sulfonyl chloride VII to 2,3,5,6-tetrabromopyridine-4-sulfonic acid (XIV). Acid XIV is unexpectedly obtained in the reaction of sulfonyl chloride VII with sodium methoxide in methanol at 20°C. The reaction evidently leads

TABLE 1. Characteristics of the Synthesized Compounds

Compound	mp, °C	IR Spectrum, cm^{-1}	Found, %			Empirical formula	Calc., %			Yield, %
			N	Br	S		N	Br	S	
III	260[a]		—	78,4	3,9	$C_{10}Br_8N_2S$	—	78,0	3,9	99
IVa	125—126[b]	1160, 1335 (SO_2)	5,9	50,4	—	$C_{10}H_{11}Br_3N_2O_3S$	5,9	50,0	—	84
IVb	129—131[c]	1160, 1335 (SO_2)	—	50,4	6,7	$C_{11}H_{13}Br_3N_2O_2S$	—	50,3	6,7	82
V	105[c]	1160, 1340 (SO_2)	8,5	33,0	—	$C_{16}H_{23}Br_2N_3O_2S$	8,7	33,2	—	91
VIIIa	130—132[c]	1170, 1340 (SO_2); 3295 (NH)	—	60,0	6,2	$C_9H_{10}Br_4N_2O_2S$	—	60,3	6,1	80
VIIIb	160—162[d]	1170, 1345 (SO_2); 3140—3180 (NH); 3530—3550 (OH)	—	61,9	6,2	$C_7H_6Br_4N_2O_3S$	—	61,7	6,2	89
VIIIc	145—146[e]		—	60,2	6,0	$C_8H_8Br_4N_2O_3S$	—	60,1	6,0	86
IXa	41—42[e]	3230 (NH)	6,1	68,9	—	$C_9H_{10}Br_4N_2$	6,0	68,6	—	88
IXb	154—156[d]		6,3	70,6	—	$C_7H_6Br_4N_2O$	6,2	70,4	—	90
IXc	114—115[d]		5,9	68,4	—	$C_8H_8Br_4N_2O$	6,0	68,3	—	88
X	133—134[b]	1170, 1340 (SO_2)	—	59,2	6,0	$C_{10}H_{10}Br_4N_2O_2S$	—	59,0	5,9	87
XI	116—118[c]	1165, 1340 (SO_2)	—	43,8	6,0	$C_{15}H_{20}Br_3N_3O_2S$	—	43,9	5,9	94
XII	100—102[c]	1170, 1340 (SO_2); 3300 (NH)	7,6	45,0	6,0	$C_{14}H_{20}Br_3N_3O_2S$	7,8	44,9	6,0	89
XVa	226—228		—	65,5	6,6	$C_6H_3Br_4NO_3S$	—	65,4	6,6	59
XVb	160—162[e]		2,6	—	—	$C_{11}H_5Br_4NO_3S$ [f]	2,5	—	—	54

a) From aqueous dioxane. b) From methanol. c) From heptane. d) From aqueous methanol. e) From benzene and heptane. f) Found: C 24.2; H 0.9%. Calculated: C 24.0; H 0.9%.

initially to methyl 2,3,5,6-tetrabromopyridine-4-sulfonate (XVa), which, being a strong alkylating agent, reacts with the alcohol to give dimethyl ether and acid XIV. Ester XVa is formed in the reaction of sulfonyl chloride VII with sodium methoxide in methanol at −5°C, while phenyl 2,3,5,6-tetrabromopyridine-4-sulfonate (XVb) is formed by reaction of sulfonyl chloride VII with phenol in aqueous sodium hydroxide. Acid XIV was isolated by treatment of ester XVa with methanol at room temperature. The characteristics of the synthesized compounds are presented in Table 1.

EXPERIMENTAL

The IR spectra of KBr pellets of the compounds were recorded with a UR-20 spectrometer. The UV spectra of solutions of the compounds in ethanol were obtained with a Specord UV-vis spectrophotometer. The characteristics of the synthesized compounds are presented in Table 1. The purity of the products was verified by means of TLC on Silufol UV-254.

4-Amino-2,3,5,6-tetrabromopyridine (IIa). Dry ammonia was passed into a solution of 0.47 g (1 mmole) of sulfone I [4] in 20 ml of ethanol at 20°C for 2 h, after which the solvent was removed by vacuum distillation to give 0.36 g (88%) of a product with mp 236-238°C (dec., from ethanol) [mp 237-239°C (dec.) [3]].

4-Methylamino-2,3,5,6-tetrabromopyridine (IIb). A mixture of 0.95 g (2 mmole) of sulfone I, 2 ml of 25% aqueous methylamine, and 40 ml of ethanol was refluxed for 10 min, after which the ethanol was removed by vacuum distillation to give 0.85 g (94%) of a product with mp 146-147°C (from methanol) (mp 145°C [3]).

4-Hydroxy-2,3,5,6-tetrabromopyridine (IIc). A) A mixture of 0.31 g (0.6 mmole) of sulfone I, 0.09 g (1.5 mmole) of KOH, and 15 ml of water was refluxed for 7 h, after which the mixture was acidified with hydrochloric acid and worked up to give 0.25 g (95%) of a product with mp 256-257°C (from acetic acid) (mp 257-258°C [5]).

B) A mixture of 0.47 g (1 mmole) of sulfone I, 0.17 g (1.5 mmole) of tert-BuOK, and 25 ml of tert-butanol was refluxed for 40 min, during which the isobutene was trapped with a solution of bromine in CCl_4. The butanol was removed by vacuum distillation, and the residue was treated with 20 ml of water. The resulting solution was filtered, and the filtrate was acidified with hydrochloric acid and worked up to give 0.34 g (80.7%) of a product with mp 256-257°C.

4-Methoxy-2,3,5,6-tetrabromopyridine (IId). A mixture of 0.31 g (0.6 mmole) of sulfone I, 0.034 g (0.62 mmole) of sodium methoxide, and 10 ml of absolute methanol was refluxed for 1 h, after which the methanol was removed by distillation, and the precipitate was washed with water to give 0.25 g (89%) of a product with mp 143°C (from benzene with petroleum ether) (mp 143-144°C [6]).

4-Mercapto-2,3,5,6-tetrabromopyridine (IIe). A mixture of 0.47 g (1 mmole) of sulfone I, 0.14 g (2.5 mmole) of sodium hydrosulfide, and 20 ml of absolute ethanol was refluxed for 2 h, after which it was worked up to give 0.42 g (99%) of a product with mp 189-190°C (from propanol) (mp 189-190°C [4]).

Bis(2,3,5,6-tetrabromo-4-pyridyl) Sulfide (III). A) A mixture of 1.18 g (2.5 mmole) of sulfone I, 0.14 g (2.5 mmole) of sodium hydrosulfide, and 70 ml of absolute ethanol was refluxed for 2 h, after which it was poured into 100 ml of water, and the resulting precipitate was removed by filtration to give 0.72 g (70%) of product. Acidification of the filtrate with hydrochloric acid yielded 0.31 g (28%) of mercaptan IIe with mp 189-190°C (from propanol).

B) A mixture of 0.14 g (0.3 mmole) of sulfone I, 0.15 g (0.33 mmole) of the sodium salt of mercaptan IIa, and 15 ml of absolute ethanol was refluxed for 1.5 h, after which the mixture was worked up as in method A to give 0.24 g (99%) of product.

C) A mixture of 0.24 g (0.5 mmole) of pentabromopyridine, 0.25 g (0.55 mmole) of the sodium salt of mercaptan IIe, and 10 ml of dimethylformamide (DMF) was refluxed for 8 h, after which the mixture was worked up as in method A to give 0.41 g (99%) of product.

2-Morpholino-4-methylsulfonyl-3,5,6-tribromopyridine (IVa). A mixture of 0.47 g (1 mmole) of sulfone I, 0.17 g (2 mmole) of morpholine, and 15 ml of ethanol was refluxed for 2 h, after which the ethanol was removed by vacuum distillation, and the residue was treated with hydrochloric acid and extracted with benzene (three 10-ml portions). The extract was dried over calcium chloride and worked up to give 0.4 g of product.

2-Piperidino-4-methylsulfonyl-3,5,6-tribromopyridine (IVb). This compound was similarly obtained from sulfone I and piperidine.

2,6-Dipiperidino-4-methylsulfonyl-3,5-dibromopyridine (V). A mixture of 1.18 g (2.5 mmole) of sulfone I, 0.93 g (11 mmole) of piperidine, and 60 ml of ethanol was refluxed for 6 h, after which the product was isolated as in the preparation of Va. The yield was 1.1 g.

2-Piperidino-4-methoxy-3,5,6-tribromopyridine (VI). A mixture of 0.38 g (0.79) of IVb, 43 mg (0.79 mmole) of sodium methoxide, and 50 ml of methanol was heated in an ampul at 150-160°C for 18 h, after which the methanol was removed by distillation, and the residue was washed with water and extracted with benzene (three 15-ml portions). The extract was dried over calcium chloride, a large amount of the benzene was removed by distillation, and the residue was chromatographed with a column filled with aluminum oxide [elution with benzene–petroleum ether (4:1)] to give 0.2 g (58%) of a product with mp 79-80°C (mp 81°C [3]).

2,3,5,6-Tetrabromopyridine-4-sulfonic Acid n-Butylamide (VIIIa). A) A solution of 0.15 g (2 mmole) of n-butylamine in 5 ml of ethanol was added dropwise at −70°C to a solution of 0.49 g (1 mmole) of sulfonyl chloride VII in 20 ml of absolute ethanol, and the mixture was maintained at −70°C for 1 h. It was then treated with 30 ml of 1% HCl, and the acidic mixture was extracted with benzene (three 10-ml portions). The extract was dried over calcium chloride and worked up to give 0.42 g of product.

B) A 0.18-g (2.4 mmole) sample of n-butylamine was added to a solution of 0.6 g (1.2 mmole) of sulfonyl chloride VII in 20 ml of benzene, and the mixture was maintained at 20°C for 6 h. The benzene was removed by vacuum distillation, and the residue was washed with 1% HCl. The yield was 0.56 g (87%).

2,3,5,6-Tetrabromopyridine-4-sulfonic Acid β-Hydroxyethylamide (VIIIb). A) A solution of 0.22 g (3.6 mmole) of ethanolamine in 5 ml of ethanol was added dropwise at −70°C to a solution of 0.6 g (1.2 mmole) of sulfonyl chloride VII in 25 ml of absolute ethanol, and the mixture was maintained at this temperature for 1 h. It was then treated with 40 ml of 1% HCl and worked up to give 0.56 g of product. UV spectrum, λ_{max} (log ε): 222 (4.35) and 320 nm (3.85).

B) A 0.1-g (1.62 mmole) sample of ethanolamine was added to a solution of 0.41 g (0.81 mmole) of sulfonyl chloride VII in 20 ml of dioxane, and the mixture was maintained at 20°C for 3 h. The dioxane was then removed by distillation, and the residue was washed with 1% HCl. The yield was 0.38 g (90%).

2,3,5,6-Tetrabromopyridine-4-sulfonic Acid γ-Hydroxypropylamide (VIIIc). This compound was similarly obtained from sulfonyl chloride VII and 3-aminopropyl alcohol by methods A (in 83% yield) and B (in 86% yield). UV spectrum, λ_{max} (log ε): 222 (4.48) and 320 nm (3.86).

4-n-Butylamino-2,3,5,6-tetrabromopyridine (IXa). A) A 0.35-g (4.8 mmole) sample of n-butylamine was added to a solution of 0.6 g (1.21 mmole) of sulfonyl chloride VII in 20 ml of dioxane, and the mixture was stirred at 20°C for 15 h. The dioxane was removed by distillation, and the residue was treated with 1% HCl and extracted with benzene (three 15-ml portions). The extract was dried over calcium chloride and worked up to give 0.5 g of product.

B) An 83-ml (1.13 mmole) sample of n-butylamine was added to a solution of 0.3 g (0.56 mmole) of amide VIIIa in 10 ml of ethanol, and the mixture was maintained at 20°C for 10 h. The ethanol was then removed by vacuum distillation to give 0.24 g (91%) of product.

4-β-Hydroxyethylamino-2,3,5,6-tetrabromopyridine (IXb). A) This compound was similarly obtained from sulfonyl chloride VII and ethanolamine by method A for the synthesis of amine IXa. UV spectrum. λ_{max} (log ε): 234 nm (4.47).

B) A 0.16-g (1.58 mmole) sample of triethylamine was added to a solution of 0.4 g (0.77 mmole) of amide VIIIb in 15 ml of ethanol, and the mixture was refluxed for 50 min. The product was isolated as in the preparation of amine IXa. The yield was 0.22 g (63%).

4-γ-Hydroxypropylamino-2,3,5,6-tetrabromopyridine (IXc). A) This compound was obtained from sulfonyl chloride VII and 3-aminopropyl alcohol by method A for the synthesis of amine IXa. UV spectrum, λ_{max} (log ε): 234 nm (4.57).

B) This compound was obtained in 61% yield from amide VIIIc after 28 h by method B for the synthesis of amine IXa.

4-Piperidinosulfonyl-2,3,5,6-tetrabromopyridine (X). This compound was obtained from sulfonyl chloride VII and piperidine by method A for the preparation of amide VIIIa.

4-Piperidinosulfonyl-2-piperidino-3,5,6-tribromopyridine (XI). A 0.28-g (3.3 mmole) sample of piperidine was added to a solution of 0.4 g (0.8 mmole) of sulfonyl chloride VII in 20 ml of benzene, and the mixture was maintained at 20°C for 20 h. The benzene was then removed by vacuum distillation, and the residue was washed with 1% HCl. The yield was 0.42 g.

2-Piperidino-3,5,6-tribromopyridine-4-sulfonic Acid n-Butylamide (XII). A 96-mg (1.12 mmole) sample of piperidine was added to a solution of 0.3 g (0.56 mmole) of amide VIIIa in 15 ml of benzene, and the mixture was maintained at 20°C for 16 h. The benzene was then removed by distillation, and the residue was washed with 1% HCl. The yield was 0.27 g.

2,3,5,6-Tetrabromo-4-chloropyridine (XIII). A) A mixture of 0.2 g (0.4 mmole) of sulfonyl chloride VII in 20 ml of concentrated HCl was stirred at 20°C for 70 h, and the resulting precipitate was removed by filtration to give 0.17 g (97%) of a product with mp 158-159°C (from heptane) (mp 159-161°C [4]).

2,3,5,6-Tetrabromopyridine-4-sulfonic Acid (XIV). A) A 0.2-g (0.4 mmole) sample of sulfonyl chloride VII was stirred in 30 ml of 1% NaOH for 1.5 h. Acid XIV was identified in the form of the benzylthiuronium salt. The yield of product with mp 208-209°C (from aqueous methanol) was 0.18 g (80%) (mp 207-208°C [4]).

B) A mixture of 0.2 g (0.4 mmole) of sulfonyl chloride VII in 20 ml of methanol was maintained at 20°C for 16 h, after which the methanol was removed by vacuum distillation, and the residue was treated with water. The yield of the benzylthiuronium salt of acid XIV was 0.19 g (73%). The use of triethylamine also gave acid XIV.

C) A solution of 44 mg (0.8 mmole) of sodium methoxide in 5 ml of methanol was added to a solution of 0.4 g (0.8 mmole) of sulfonyl chloride VII in anhydrous methanol, and the mixture was maintained at 20°C for 6 h. The yield of acid XIV was 0.35 g (93%).

D) The acid was obtained from ester XVa and methanol by a method similar to method B. The yield was quantitative.

Methyl 2,3,5,6-Tetrabromopyridine-4-sulfonate (XVa). A solution of 66 mg (1.2 mmole) of sodium methoxide was added at −5°C to a solution of 0.6 g (1.2 mmole) of sulfonyl chloride VII in 15 ml of anhydrous methanol, and the mixture was allowed to stand for 10 min. The resulting precipitate was removed by filtration and washed with water. The yield was 0.35 g.

Phenyl 2,3,5,6-Tetrabromopyridine-4-sulfonate (XVb). A mixture of 0.6 g (1.2 mmole) of sulfonyl chloride VII, 0.23 g (2.4 mmole) of phenol, 0.2 g (5 mmole) of sodium hydroxide, and 25 ml of water was stirred at 20°C for 16 h. The yield was 0.36 g.

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