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PHENAZINES—VI

THE SYNTHESIS OF SOME 2-AMINOPHENAZINE AND 2-AMINOCARBOXYPHENAZINESULPHONAMIDES*

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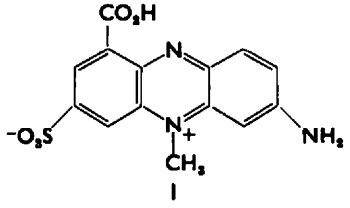
Abstract—7- and 8-aminophenazine-2-sulphonamides, 3- and 7-amino-9-carboxyphenazine-1-sulphonamides, and 8-amino -4- and -6-carboxyphenazine-2-sulphonamides have been synthesized from appropriate aminodiphenylamines by oxidative cyclization in boiling nitrobenzene.

THE structure of aeruginosin B, a red, crystalline pigment from a strain of *Pseudomonas aeruginosa* has recently been reported as being 2-amino-6-carboxy-10-methyl-8-sulphophenazinium betaine (I).[1] Part of the evidence came from a comparison of the



I

behaviour of the pigment with that of various 2-amino- and 2-aminocarboxyphenazinesulphonamides when heated with dilute acid. The synthesis of these model compounds are now reported.

The oxidative cyclization in boiling nitrobenzene of suitably substituted 2-aminodiphenylamines, a route which proved so valuable in the synthesis of the seven 2-aminophenazinecarboxylic acids,[2–4] has again been used. Although the synthesis of 8-aminophenazine-2-sulphonic acid by the reduction and cyclization of 2',4'-dinitrodiphenylamine-4-sulphonic acid[5] was first attempted, the method was precluded by the insolubility of the diaminodiphenylaminesulphonic acid in nitrobenzene, a difficulty which could not be overcome by the use, for example, of long chain quaternary ammonium salts of the acid. Therefore the synthesis of phenazines bearing a sulphamoyl group was considered in the belief that this group would have similar electronic effects to the sulphonic acid group (an essential requirement for the proposed hydrolytic studies) and yet, being much less polar, the intermediate aminodiphenylaminesulphonamides would be soluble in nitrobenzene. This approach was immediately successful. 2',4'-Diaminodiphenylamine-4-sulphonamide (II), prepared

* This paper is abstracted from the dissertation submitted by R. B. Herbert for the degree of Ph.D., University of Leeds, September, 1963.

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[1] R. B. Herbert and F. G. Holliman, *Proc. Chem. Soc.* 19 (1964).

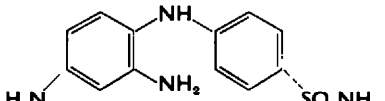
[2] F. G. Holliman, B. A. Jeffery and D. J. H. Brock, *Tetrahedron* 19, 1841 (1963).

[3] D. J. H. Brock and F. G. Holliman, *Tetrahedron* **19**, 1903 (1963).

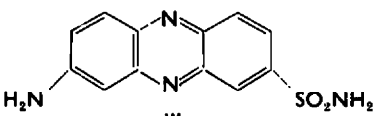
[4] D. J. H. Brock and F. G. Holliman, *Tetrahedron* **19**, 1911 (1963).

[5] J. Turner, DRP 152406 via *Chem. Zentr.* **11**, 273 (1904); J. Dobas, J. Pirkl and V. Hanousek, *Chem. listy* **51**, 1113 (1957); *Chem. Abstr.* **51**, 15505 (1957).

by the catalytic hydrogenation of the corresponding dinitro compound,[6] was smoothly cyclized to 8-aminophenazine-2-sulphonamide (III).

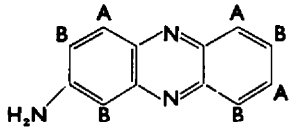


II

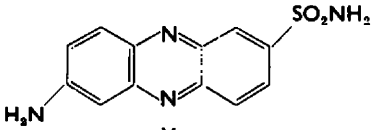


III

The seven 2-aminophenazinesulphonamides may be considered as falling into two groups (A and B, IV) according to whether the sulphamoyl group is conjugated with the 10- or the 5-nitrogen atom respectively. The synthesis of a representative of group A being accomplished, 7-aminophenazine-2-sulphonamide (V) was selected as a model from group B.



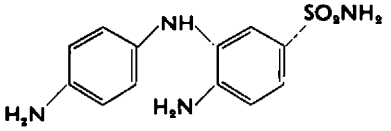
IV



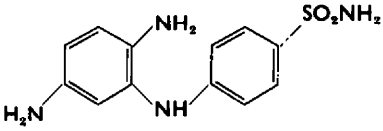
V

Of the two diphenylamines (VI and VII) which could give this phenazine unambiguously, 4',6-diaminodiphenylamine-3-sulphonamide (VI) was chosen as involving the shorter route.

It seemed unlikely that the halogen in 3-bromosulphanilamide[7] would be sufficiently reactive in an Ullmann condensation. This compound was therefore converted to 3-bromo-4-nitrobenzenesulphonamide by oxidation with hydrogen peroxide in acetic acid,[8] which is known to leave the sulphamoyl group unattacked.[9] As expected for a



VI



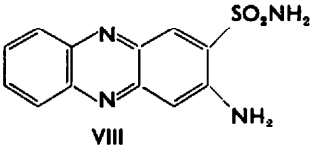
VII

compound with only one substituent *ortho* to the amino group,[10] some 2,2'-dibromoazoxybenzene-4,4'-disulphonamide was also produced. 3-Bromo-4-nitrobenzenesulphonamide was condensed with *p*-aminoacetanilide rather than *p*-phenylenediamine to avoid the risk of reductive dehalogenation in the Ullmann reaction.[11] Hydrolysis of the resultant 4'-acetamido-6-nitrodiphenylamine-3-sulphonamide was best achieved with acid rather than alkali, and catalytic hydrogenation followed by cyclization gave 7-aminophenazine-2-sulphonamide (V).

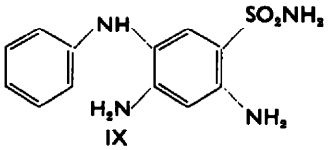
In both these syntheses, small amounts of 2-aminophenazine were isolated in addition to the required phenazines. As no attempt was made to isolate and purify the intermediate diaminodiphenylamines, it is possible that the sulphamoyl group was lost by hydrogenolysis rather than in the cyclization reaction; reductive loss of a sulphamoyl group has been reported,[12] but not under conditions of catalytic hydrogenation.

[6] H. Bräuniger and K. Spangenberg, *Pharmazie* **12**, 335 (1957).
[7] H. Wojahn, *Arch. Pharm.* **281**, 193 (1943).
[8] R. R. Holmes and R. P. Bayer, *J. Amer. Chem. Soc.* **82**, 3454 (1960).
[9] M. K. Seikel, *J. Amer. Chem. Soc.* **62**, 1214 (1940).
[10] K. M. Ibne-Rasa and J. O. Edwards, *J. Amer. Chem. Soc.* **84**, 763 (1962).
[11] A. A. Goldberg and W. Kelly, *J. Chem. Soc.* 102 (1946).
[12] S. Searles and S. Nukina, *Chem. Rev.* **59**, 1077 (1959).

In contrast, an attempt to synthesize 3-aminophenazine-2-sulphonamide (VIII)



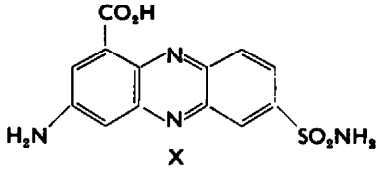
VIII



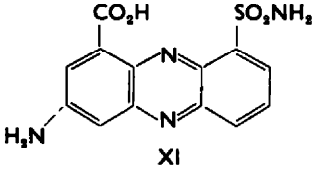
IX

by the cyclization of 4,6-diaminodiphenylamine-3-sulphonamide (IX) was frustrated by complete elimination of the sulphamoyl group and 2-aminophenazine was the only product isolated. This is reminiscent of the decarboxylation which ensued in an attempt to cyclize 4,6-diaminodiphenylamine-3-carboxylic acid, 2-aminophenazine again being the only product isolated.[3] 4,6-Dinitrodiphenylamine-3-sulphonamide, which hydrogenated to IX, was readily produced by the condensation of aniline with 3-chloro-4,6-dinitrobenzenesulphonamide. The synthesis of the latter by the action of ammonia on 3-chloro-4,6-dinitrobenzenesulphonyl chloride revealed an interesting displacement reaction, examples of which do not appear to have been previously reported; in addition to the sulphonamide (and some 3-amino-4,6-dinitrobenzenesulphonamide arising by the expected ammonolysis of the nuclear halogen), a small quantity of 3-chloro-4,6-dinitroaniline was isolated. The sulphonyl chloride was free from the sulphonic acid and was but slowly hydrolyzed. Furthermore, under the conditions of the reaction, 3-chloro-4,6-dinitrobenzenesulphonamide was shown to produce no more than a trace of 3-chloro-4,6-dinitroaniline. It therefore appears that some direct displacement of the sulphonyl chloride group must have occurred. We were, however, unable to detect any formation of 2,4-dinitroaniline from 2,4-dinitrobenzenesulphonyl chloride under similar conditions.

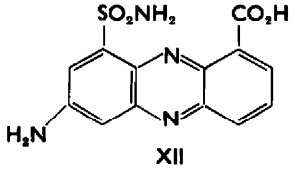
The nitrobenzene oxidative cyclization was also successful in the synthesis of some representative 2-aminocarboxyphenazinesulphonamides of which there are a total of 42 isomers. On the basis that the carboxyl group should be in the 4 or 6 position (according to IR evidence on aeruginosin B) and that, on evidence derived from the two aminophenazinesulphonamides, the sulphamoyl group should be in the 4, 6 or 8 positions (A positions, IV), we selected four compounds for synthesis, namely, 8-amino-6-carboxyphenazine-2-sulphonamide (X), 7-amino-9-carboxyphenazine-1-sulphonamide (XI), 3-amino-9-carboxyphenazine-1-sulphonamide (XII), and 8-amino-4-carboxyphenazine-2-sulphonamide (XIII).



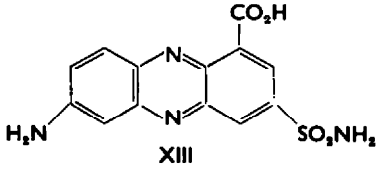
X



XI



XII



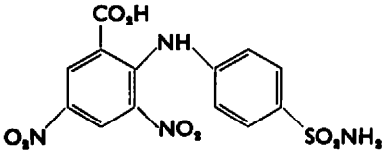
XIII

2-Bromo-3,5-dinitrobenzoic acid[13] readily condensed with sulphanilamide to give 2'-carboxy-4',6'-dinitrodiphenylamine-4-sulphonamide (XIV). Catalytic reduction

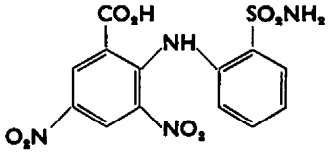
[13] J. Meisenheimer, P. Zimmermann and U. von Kummer, *Liebigs Ann.* **446**, 205 (1926).

of this compound (which, in common with the other similarly substituted diphenylamines mentioned below, was more slowly reduced than had previously been the experience for similar reactions) gave the diaminodiphenylamine which was cyclized, somewhat slowly, to 8-amino-6-carboxyphenazine-2-sulphonamide (X). This phenazine could only be isolated as an amorphous solid from the gel resulting on cooling a hot nitrobenzene solution.

A similar synthesis, employing orthanilamide in place of sulphanilamide, led to 7-amino-9-carboxyphenazine-1-sulphonamide (XI) *via* 2′-carboxy-4′,6′-dinitrodiphenylamine-2-sulphonamide (XV). The Ullmann condensation leading to this diphenylamine required much more vigorous conditions than in the previous case to the extent of a higher reaction temperature and a twelve-fold increase in the reaction time, a reflection of the *ortho* sulphamoyl group causing increased steric hindrance and inductive deactivation of the amino group. The cyclization resulted in partial elimination of the sulphamoyl group, a small amount of 3-aminophenazine-1-carboxylic acid accompanying the required phenazinesulphonamide (XI) which, in contrast to its isomer, was obtained crystalline.

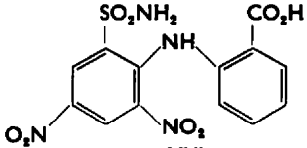


XIV



XV

3-Amino-9-carboxyphenazine-1-sulphonamide (XII) was to be synthesized by the usual method from 2′-carboxy-4,6-dinitrodiphenylamine-2-sulphonamide (XVI) which resulted from the Ullmann condensation of anthranilic acid with 2-chloro-3,5-dinitrobenzenesulphonamide. Although initial attempts to prepare the latter compound by nitration of 2-chloro-5-nitrobenzenesulphonamide[14] were unsuccessful, sodium 2-chloro-3,5-dinitrobenzenesulphonate[15] proved a useful starting material. In the sulphonyl chloride, produced by reaction with hot chlorosulphonic acid, the nuclear halogen is strongly activated by electron withdrawing groups and it proved impossible to make the corresponding sulphonamide by ammonolysis without some accompanying displacement of the nuclear halogen producing 2-amino-3,5-dinitrobenzenesulphonamide. Purification of the required 2-chloro-3,5-dinitrobenzenesulphonamide was difficult. However, it proved possible to proceed with the impure material: as had been the case with the other isomers, 2′-carboxy-4,6-dinitrodiphenylamine-2-sulphonamide (XVI) proved to be a relatively strong acid and it was precipitated as its sodium salt during the course of the Ullmann reaction in the presence of sodium acetate, thus providing an easy means of purification. Hydrogenation to the diaminodiphenylamine and oxidative cyclization thereof gave a crude product difficult to purify. Chromatography showed that the major component was probably

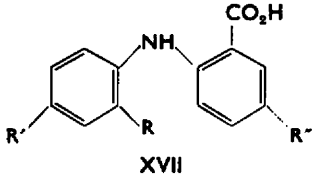


XVI

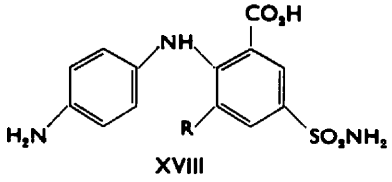
[14] A. R. Goldfarb and B. Berk, *J. Amer. Chem. Soc.* **65**, 738 (1943).
[15] F. Ullmann, *Liebigs Ann.* **366**, 111 (1909).

the required 3-amino-9-carboxyphenazine-1-sulphonamide (XII) but that this was contaminated with a brown impurity. It also seemed that some decarboxylation was taking place as a product was isolated which, having similar chromatographic, electrophoretic and light absorption properties to 7- and 8-aminophenazine-2-sulphonamides, was almost certainly 3-aminophenazine-1-sulphonamide. Accordingly, 2′-carboxy-4,6-dinitrodiphenylamine-2-sulphonamide (XVI) was converted to its methyl ester. This, by the usual procedure then gave the easily purified 3-amino-9-carbomethoxyphenazine-1-sulphonamide. Although the brown by-product of the cyclization of the free acid was now absent, some 3-aminophenazine-1-sulphonamide was again produced. It is unlikely that this arose through hydrolysis of the ester followed by decarboxylation of the free acid as no 3-amino-9-carboxyphenazine-1-sulphonamide was detected in the product. It thus seems that it is produced by a cyclization involving the amino group in direct displacement of the carbomethoxy group. Alkaline hydrolysis of the methyl ester gave 3-amino-9-carboxyphenazine-1-sulphonamide (XII), a crystalline solid with properties corresponding to those of the major product formed directly by the cyclization of the diphenylaminecarboxylic acid.

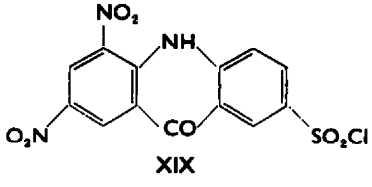
Of the four diphenylamines which can, theoretically, give 8-amino-4-carboxyphenazine-2-sulphonamide (XIII), two, 2′,4′-diamino-2-carboxydiphenylamine-4-sulphonamide (XVII, R = R′ = NH_2, R″ = SO_2NH_2) and 2,4′-diamino-6-carboxydiphenylamine-4-sulphonamide (XVIII, R = NH_2), should give it exclusive of any isomeric phenazine. Our first approach was via the former which seemed to be the easier to synthesize, but this proved not to be so. Attempted chlorosulphonation of anthranilic acid, its acetyl derivative or 2′,4′-dinitrodiphenylamine-2-carboxylic acid[16] (XVII, R = R′ = NO_2, R″ = H) failed; the diphenylamine underwent cyclization as well as substitution to give a dinitroacridonesulphonyl chloride, probably XIX. We therefore turned our attention to the second of the two diphenyl-



XVII



XVIII



XIX

amines (XVIII, R = NH_2). Although chlorosulphonation of 2-bromo-3-nitrobenzoic acid[17] was unsuccessful, sulphonation under vigorous conditions led to 4-bromo-3-carboxy-5-nitrobenzenesulphonic acid, isolated as its sodium salt. The same compound was produced, with improved yield, from *o*-bromobenzoic acid by sulphonation followed by nitration. Although neither sample gave a satisfactory analysis, the structure of the compound was clear since it arose by the two routes.

[16] F. Jourdan, *Ber. Dtsch. Chem. Ges.* **18**, 1448 (1885); G. Schroeter and O. Eisleb, *Liebigs Ann.* **367**, 114 (1909).

[17] F. C. Whitmore, P. J. Culhane and H. T. Neher, *Org. Synth.* Coll. Vol. I, 56; P. J. Culhane, *Ibid.* 125.

The corresponding sulphonyl chloride and amide were readily produced and an Ullmann reaction between 4-bromo-3-carboxy-5-nitrobenzenesulphonamide and *p*-aminoacetanilide gave a diphenylamine which, on acid hydrolysis, produced the required compound (XVIII, R = NO_2) isolated as its hydrochloride. This carboxylic acid proved to be relatively strong since the sodium salt was produced on attempted liberation of the free base with sodium acetate. Further, the methyl ester was readily hydrolysed, recrystallization from slightly wet butanol being sufficient to regenerate the acid. It was not surprising, therefore, that hydrogenation of the methyl ester followed by refluxing of the diaminodiphenylamine in nitrobenzene led to 2-amino-6-carboxyphenazine-8-sulphonamide rather than the methyl ester.

TABLE 1. ABSORPTION MAXIMA

Positions of substituents on phenazine			UV/visible Solution in 0·5N HCl λ_{max} mμ					IR (KCl disc) ν_{max} cm^{-1}						
								N—H Stretch				C = 0 Stretch	S = 0 Stretch Sym	S = 0 Stretch Asym
NH_2	CO_2H	SO_2NH_2												
7	—	2	238	292	365	377	532	3460	3350	3310	3230	—	1325	1160
6	—	2	237	296	365 (S)	376	521	3470	3310	3270	3185	—	1341	1155
8	6	2	238	292	375	383	553		3465	3360	3220	1720	1330	1158
7	9	1	233	286	372	385	541		3470	3370	3220	1708	1328	1156
3	9	1	234	285	370	385	553		3465	3370	3230	1715	1325	1155
3	9*	1	234	285	376	385	553		3455	3357	3232	1712	1332	1151
8	4	2	240	296	372	383	556		3425	3347	3240	1708	1342	1154

* CO_2Me. S, Shoulder,
UV/visible: Unicam SP 700 spectrophotometer.
IR: Perkin Elmer model 125 spectrophotometer.

Table 1 gives the absorption spectral data for the phenazines described above. The reactions of these model compounds with aqueous acid, which, together with other evidence, led to structure I for aeruginosin B, will be discussed in a later paper.

EXPERIMENTAL

M.ps are uncorrected. Chromatographic alumina was Woelm neutral which had been deactivated by stirring with methanol and subsequently dried at room temp in air. Chromatographic solvents were: A, butanol—conc HCl (4:1, saturated with water), B, butanol–acetic acid (4:1, saturated with water), C, butanol–pyridine–water (4:1:5, upper layer in trough and lower layer in tank).

2′,4′-Diaminodiphenylamine-4-sulphonamide (characterized as the diacetyl derivative)

2′,4′-Dinitrodiphenylamine-4-sulphonamide[6] (500 mg) in ethanol (50 cc) was hydrogenated (4 atm; 100 mg PtO_2) for 16 hr. The reaction mixture was filtered and triamine which had separated during the reduction was extracted from the residue with hot ethanol. The combined alcoholic solution and extracts were filtered and the solvent removed in N_2 under red. press. Acetic anhydride (25 cc) was added to the residue. The reaction mixture was warmed to dissolve the solid and stood overnight. The *diacetyl compound* which separated recrystallized (acetic anhydride) as white needles m.p. 213–214°. (Found: C, 52·6; H, 5·25; S, 8·6. $C_{16}H_{16}N_4O_4S$ requires: C, 53·0; H, 5·0; S, 8·85%).

8-Aminophenazine-2-sulphonamide

2′,4′-Dinitrodiphenylamine-4-sulphonamide[6] (500 mg) was hydrogenated as above. The colourless ethanolic solution was filtered into nitrobenzene (50 cc) and the residue extracted with hot nitrobenzene (100 cc) and filtered. The ethanol was distilled from the combined ethanol–nitrobenzene

filtrates and the nitrobenzene solution then refluxed for 36 hr. Paper chromatography (solvent A) indicated the presence of one major component and other trace materials. The hot nitrobenzene solution was filtered and the volume reduced *in vacuo* (0·5 mm) on a steam bath until solid separated. The nitrobenzene was then boiled to dissolve this solid and allowed to cool. The dark red crystalline *8-aminophenazine-2-sulphonamide* which separated (124 mg) was chromatographically pure (solvent A). It did not melt below 330° (Kofler block). (Found: C, 53·2; H, 4·0; S, 11·5. $C_{12}H_{10}N_4O_2S$ requires: C, 52·5; H, 3·65; S, 11·7%).

The nitrobenzene mother liquors were introduced onto an alumina column (19 × 2·5 cm). The nitrobenzene was stripped off the column with benzene and, after washing the column with ether, a yellow band was eluted with 50% acetone in ether. Removal of the solvent left a red solid which at 160–165°/0·1 mm gave 1·6 mg of sublimate chromatographically identical (solvents A, B and C) to authentic 2-aminophenazine.

Elution of an orange band with 20% ethanol in acetone gave a further 62 mg of chromatographically pure 8-aminophenazine 2-sulphonamide (total yield 46%).

3-Bromo-4-nitrobenzenesulphonamide

Hydrogen peroxide (30% w/v, 60 cc) was added to a solution of 3-bromosulphanilamide[7] (11·5 g) in glacial acetic acid (200 cc) and conc. H_2SO_4 (4 cc) and the reaction mixture gently warmed with stirring. After being kept between 70 and 80° for 2 hr, the orange reaction mixture was allowed to cool and the yellow crystalline precipitate of *2,2'-dibromo-azoxybenzene-4,4'-disulphonamide* (3·7 g, 40%) was collected and recrystallized (dil. pyridine) to m.p. 286° d. (Found: C, 28·6; H, 1·7; N, 11·0; Br, 30·8. $C_{12}H_{10}Br_2N_4O_5S_2$ requires: C, 28·05; H, 1·95; N, 10·9; Br, 31·2%). IR spectrum (nujol mull): ν_{max} cm^{-1} 1340, 1160 (S = 0); 1285 (NO).

After removal of the azoxy compound, the volume of the filtrate was reduced *in vacuo*, the solution cooled and diluted with water. The yellow precipitate was collected and recrystallized (toluene) to give *3-bromo-4-nitrobenzenesulphonamide* (4·5 g, 45%) m.p. 136–138°. (Found: C, 25·85; H, 2·0; N, 10·05. $C_6H_5BrN_2O_4S$ requires: C, 25·6; H, 1·8; N, 9·95%).

4'-Acetamido-6-nitrodiphenylamine-3-sulphonamide

3-Bromo-4-nitrobenzenesulphonamide (3·25 g), *p*-aminoacetanilide (1·8 g) and potassium acetate (1·5 g) were ground together intimately. The mixture was fused at 130–135° (bath temp) for 3½ hr. After cooling, the dark melt was extracted into 1N NaOH. The dark red solution was stirred with charcoal, filtered and made acid with conc. HCl. The precipitate was collected and recrystallized (methanol) giving *4'-acetamido-6-nitrodiphenylamine-3-sulphonamide* (1·95 g, 48%) m.p. 132–134° (Found: C, 48·3; H, 3·65; N, 15·2; S, 8·6. $C_{14}H_{14}N_4O_6S$ requires: C, 48·0; H, 4·0; N, 16·0; S, 9·15%).

4'-Amino-6-nitrodiphenylamine-3-sulphonamide

A solution of 4'-acetamido-6-nitrodiphenylamine-3-sulphonamide (1·4 g) in 2·5N HCl (70 cc) was refluxed for 10 min. The boiling solution was treated with charcoal and filtered. The amine hydrochloride which separated on cooling was filtered off and sucked as dry as possible. The pH of a solution of the hydrochloride in water (50 ml) was slowly raised to 10 by the dropwise addition of 2N Na_2CO_3. The coppery crystalline precipitate of *4'-amino-6-nitrodiphenylamine-3-sulphonamide* (1·1 g, 90%) had m.p. 235–236°. Recrystallization (aqueous ethanol) failed to raise the m.p. (Found C, 47·05; H, 3·65; N, 18·5; S, 10·75. $C_{12}H_{12}N_4O_4S$ requires: C, 46·8; H, 3·90; N, 18·2; S, 10·4%).

4',6-Diaminodiphenylamine-3-sulphonamide (*characterized as the diacetyl derivative*)

4'-Amino-6-nitrodiphenylamine-3-sulphonamide was hydrogenated and the product acetylated as described above in the synthesis of the isomeric compound. The gummy *diacetyl compound* was recrystallized (95% ethanol) to m.p. 140–142°. (Found: C, 52·9; H, 5·35; N, 15·4. $C_{16}H_{16}N_4O_4S$ requires: C, 53·0; H, 5·0; N, 15·5%).

7-Aminophenazine-2-sulphonamide

4'-Amino-6-nitrodiphenylamine-3-sulphonamide (500 mg) was hydrogenated as before and the colourless ethanolic solution filtered into nitrobenzene (150 cc) the residue being washed with ethanol. After removal of the ethanol by distillation, the darkening nitrobenzene solution was refluxed for 24 hr. The solid which separated from the filtered and concentrated (under 0·5 mm press.) reaction

mixture was recrystallized (95% ethanol) giving *7-aminophenazine-2-sulphonamide* (111 mg) as dark red crystals, m.p. 287–289° (Kofler block), chromatographically pure and similar to 8-aminophenazine-2-sulphonamide (solvent A). (Found: C, 52·6; H, 3·85; N, 19·9; S, 11·4. $C_{12}H_{10}N_4O_2S$ requires: C, 52·5; H, 3·65; N, 20·4; S, 11·7%).

The ethanol mother liquors were taken to dryness and the residue dissolved in hot nitrobenzene. This nitrobenzene solution, together with the nitrobenzene reaction mother liquors, was introduced onto an alumina column (28 × 2·2 cm) and the nitrobenzene eluted with benzene. A yellow band, eluted with 20% acetone in ether, gave a red crystalline solid (2·6 mg) which was chromatographically identical (solvents A, B, C) to 2-aminophenazine.

An orange band was eluted with 20% ethanol in acetone and gave a further 83 mg of 7-aminophenazine-2-sulphonamide (total yield 44%).

Sodium 3-chloro-4,6-dinitrobenzenesulphonate

Sodium sulphite (10·7 g) in water (200 cc) was added over 30 min to a rapidly stirred, refluxing solution of 1,5-dichloro-2,4-dinitrobenzene[18] (20·0 g) in ethanol (400 cc). The reaction mixture was stirred at reflux for a further 2 hr and allowed to cool. A small amount of unreacted dichloro compound was filtered off and the orange filtrate taken to dryness *in vacuo*. The residue was recrystallized twice (water) and the yellow *sodium 3-chloro-4,6-dinitrobenzenesulphonate* (16·6 g, 65%) dried at 100° over P_2O_5 *in vacuo*. It did not melt below 300°. (Found: C, 23·6; H, 0·45; S, 10·6. $C_6H_2ClN_2NaO_7S$ requires: C, 23·6; H, 0·65; S, 10·5%).

Sodium 4,6-dinitrodiphenylamine-3-sulphonate

A solution of sodium 3-chloro-4,6-dinitrobenzenesulphonate (900 mg), aniline (330 mg), and sodium acetate (370 mg) in ethanol (95%, 40 cc) was refluxed for 4 hr. The solvent was removed *in vacuo* and the residue recrystallized (absolute ethanol with a few drops of water) as yellow needles of *sodium 4,6-dinitrodiphenylamine-3-sulphonate* which turned red when alcohol free. (Found: C, 36·25; H, 2·8; N, 10·55; S, 8·45. $C_{12}H_8N_3NaO_7S.2H_2O$ requires: C, 36·25; H, 3·0; N, 10·6; S, 8·05%).

3-Chloro-4,6-dinitrobenzenesulphonyl chloride

Chlorosulphonic acid (30 cc) was added to dry sodium 3-chloro-4,6-dinitrobenzenesulphonate (10·0 g). The dark brown solution was heated with the exclusion of moisture at 96–98° for 4 hr and then allowed to cool. The reaction mixture was slowly added to a rapidly stirred ice-water mixture. The white solid which precipitated was collected, washed with water, and dried *in vacuo*. Recrystallization (dry pet. ether bp 100–120°) gave white needles of *3-chloro-4,6-dinitrobenzenesulphonyl chloride* (5·8 g, 59%) m.p. 116·5–117·5°. (Found: C, 24·3; H, 0·5; Cl, 23·7; S, 10·6. $C_6H_2Cl_2N_2O_6S$ requires: C, 24·0; H, 0·65; Cl, 23·6; S, 10·6%).

3-Chloro-4,6-dinitrobenzenesulphonamide

3-Chloro-4,6-dinitrobenzenesulphonyl chloride (510 mg) was shaken vigorously for 7 min with ammonia solution (Sp. gr. 0·88, 25 cc). The sulphonyl chloride dissolved completely and the yellow precipitate which formed (18 mg) was collected and recrystallized (95% ethanol). The m.p. (175–176°) and IR spectrum of the material were identical to those of 3-chloro-4,6-dinitroaniline prepared by the method of Fries and Roth.[19]

Evaporation of the orange ammoniacal filtrate to low volume, *in vacuo*, at first in the cold to remove as much ammonia as possible and finally with careful heating, gave a light yellow solid. Two recrystallizations from ethanol gave light yellow needles of *3-chloro-4,6-dinitrobenzenesulphonamide* (273 mg, 57%) m.p. 208–210°. (Found: C, 25·85; H, 1·05; N, 15·35. $C_6H_4ClN_3O_6S$ requires: C, 25·6; H, 1·4; N, 14·9%).

4,6-Dinitrodiphenylamine-3-sulphonamide

A solution of 3-chloro-4,6-dinitrobenzenesulphonamide (500 mg), aniline (400 mg), and sodium acetate (230 mg) in ethanol (15 cc) was refluxed for 7 hr. The hot, dark red solution was filtered and cooled to give long red needles of *4,6-dinitrodiphenylamine-3-sulphonamide* (308 mg; 52%) m.p.

[18] H. H. Hodgson, *J. Soc. Dyers and Col.* **42**, 3666 (1926).

[19] K. Fries and E. Roth, *Liebigs Ann.* **389**, 341 (1911).

216–218° unchanged by recrystallization (ethanol). (Found: C, 42·85; H, 3·05; S, 9·5. $C_{12}H_{10}N_4O_6S$ requires: C, 42·6; H, 2·95; S, 9·5%).

4,6-Diaminodiphenylamine-3-sulphonamide (characterized as the diacetyl derivative) and its oxidative cyclization

4,6-Dinitrodiphenylamine-3-sulphonamide was hydrogenated and the product acetylated in a similar way to that described for its isomers above. Two recrystallizations (95% ethanol) gave the *diacetyl derivative* as white needles m.p. 219–219·5°. (Found: C, 52·75; H, 5·3. $C_{16}H_{18}N_4O_6S$ requires: C, 53·0; H, 5·0%).

A further sample (140 mg) of the dinitrodiphenylamine was hydrogenated and the product refluxed in nitrobenzene in the usual way. Samples were removed after 1½, 3, 8 and 24 hr and chromatographed on paper (solvent A): the only product observed, apart from black insoluble material which remained at the origin, was 2-aminophenazine.

After 24 hr, the nitrobenzene solution was introduced onto an alumina column (26 × 2·5 cm). The nitrobenzene was eluted with benzene and the orange band eluted with 10% acetone in ether. The solvent was removed and the residue heated at 160–165° (0·1 mm) giving 15 mg (19%) of sublimate which proved identical to 2-aminophenazine by paper chromatography (solvents A, B and C) and IR spectrum (KCl disc).

2'-Carboxy-4',6'-dinitrodiphenylamine-4-sulphonamide

A solution of sulphanilamide (1·72 g), 2-bromo-3,5-dinitrobenzoic acid[18] (2·91 g) and sodium acetate (1·64 g) in ethanol (30 cc) was refluxed with stirring for 1 hr. The yellow sodium salt of the diphenylamine, which rapidly separated from the reaction mixture, was collected, washed with a little ethanol, and dissolved in water. Acidification with dil. HCl gave a yellow precipitate which was collected and recrystallized (ethanol aq) to give 2·4 g (63%) of *2'-carboxy-4',6'-dinitrodiphenylamine-4-sulphonamide* m.p. 275–276°. (Found: C, 39·7; H, 2·8; N, 14·3; S, 7·95. $C_{13}H_{10}N_4O_8S.\frac{1}{2}H_2O$ requires: C, 40·0; H, 2·8; N, 14·3; S, 8·2%).

2',4'-Diamino-6'-carboxydiphenylamine-4-sulphonamide

2'-Carboxy-4',6'-dinitrodiphenylamine-4-sulphonamide (500 mg) in absolute ethanol (50 cc) was hydrogenated (4 atm; 500 mg PtO_2) for 24 hr. The pale green solution was filtered and the residue extracted well with hot ethanol. The alcohol was removed from the combined filtrates in nitrogen under red. press. and the off-white residue recrystallized twice from water. *2',4'-Diamino-6'-carboxydiphenylamine-4-sulphonamide* decomposed on heating. (Found: C, 48·45; H, 4·35; S, 9·8. $C_{13}H_{14}N_4O_4S$ requires: C, 48·5; H, 4·35; S, 9·95%).

8-Amino-6-carboxyphenazine-2-sulphonamide

2'-Carboxy-4',6'-dinitrodiphenylamine-4-sulphonamide (500 mg) was hydrogenated as above. The pale green solution was filtered and the residue extracted with hot nitrobenzene (2 × 75 cc). The ethanol was distilled from the combined filtrate and extracts and the nitrobenzene reaction mixture then refluxed for 48 hr and filtered. The filtrate was taken to low volume *in vacuo* (0·1 mm) on a steam-bath and allowed to stand when it set to a gel. An amorphous solid was obtained from this gel by prolonged centrifugation and subsequent filtration. Attempts at crystallization were unsuccessful and purification was effected by precipitation as a gel by cooling hot solutions in nitrobenzene. After isolation as above, traces of nitrobenzene were removed by washing with ether and drying *in vacuo* (0·1 mm, 100°). 218 mg (54%) of amorphous *8-amino-6-carboxyphenazine-2-sulphonamide* were obtained; it did not melt below 330° (Kofler block). (Found: C, 49·55; H, 3·2; S, 10·25. $C_{13}H_{10}N_4O_4S$ requires: C, 49·0; H, 3·15; S, 10·1%). Paper chromatography showed that this product was contaminated with a trace of a violet material.

2'-Carboxy-4',6'-dinitrodiphenylamine-2-sulphonamide

A solution of orthanilamide[20] (1·72 g), 2-bromo-3,5-dinitrobenzoic acid[18] (2·91 g) and sodium acetate (2·05 g) in n-amyl alcohol (30 cc) was refluxed for 12 hr with stirring. The orange sodium salt of the diphenylamine separated during this time and, after cooling, was collected and dissolved in

[20] M. T. Bogert and A. Stull, Org. *Synth.* Coll. Vol. I, 220; E. Wertheim, ibid, Coll. Vol. II, 471. M. J. Taglianetti, *Anais faculdade farm. e ondontol Univ. Sao Paulo* **5** 17 (1947); *Chem. Abstr.* **42**, 2587 (1948).

hot water. The red aqueous solution was boiled to dispel any amyl alcohol and filtered. Acidification (HCl) of the cold filtrate gave a yellow precipitate which was collected and recrystallized (95% ethanol) to give 1·7 g (40%) of *2'-carboxy-4',6'-dinitrodiphenylamine-2-sulphonamide* m.p. 220–222° (softening 156–175°). (Found: C, 42·1; H, 3·7; N, 13·1; S, 7·7. $C_{13}H_{10}N_4O_8S.C_2H_5OH$ requires: C, 42·1; H, 3·75; N, 13·1; S, 7·5%).

7-Amino-9-carboxyphenazine-1-sulphonamide

2'-Carboxy-4',6'-dinitrodiphenylamine-2-sulphonamide (390 mg) was hydrogenated and the product oxidatively cyclized in a similar way to that described for its isomer above, the nitrobenzene solution being refluxed 44 hr. In this case the phenazine crystallized from the filtered, concentrated (0·5 mm press.) nitrobenzene reaction mixture. It was collected (120 mg, 41·5%) and recrystallized (nitrobenzene) to give the dark red *7-amino-9-carboxyphenazine-1-sulphonamide* which did not melt below 330° (Kofler block). (Found: C, 49·6; H, 3·2; N, 17·45; S, 9·65. $C_{13}H_{10}N_4O_4S$ requires: C, 49·0; H, 3·15; N, 17·6; S, 10·1%).

The nitrobenzene reaction mother liquors were extracted with 2N NaOH; the extracts were washed with ether, treated with charcoal and filtered. Acidification of the filtrate with glacial acetic acid gave a precipitate which was recrystallized from methanol to give 9·5 mg (4%) of 3-aminophenazine-1-carboxylic acid identified by comparison with an authentic sample by paper chromatography (solvents A, B, C) and IR spectra.

2-Chloro-3,5-dinitrobenzenesulphonyl chloride

A solution of sodium 2-chloro-3,5-dinitrobenzenesulphonate[15] (10 g, dried over P_2O_5 at 0·1 mm and 100°) in chlorosulphonic acid (50 cc) was stirred for 3 hr at 93°. The dark reaction mixture was allowed to cool and poured on ice. The white precipitate of *2-chloro-3,5-dinitrobenzenesulphonyl chloride* was filtered off, washed with a little water and dried *in vacuo*. Recrystallization of the product from dry ligroin (b.p. 100–120°) gave white flakes (5·4 g, 55%) m.p. 104–106°. (Found: C, 24·5; H, 1.0; Cl, 23·85; N, 9·3. $C_6H_2Cl_2N_2O_6S$ requires: C, 23·95; H, 0·7; Cl, 23·6; N, 9·3%).

2-Chloro-3,5-dinitrobenzenesulphonamide

2-Chloro-3,5-dinitrobenzenesulphonyl chloride (5·0 g) was shaken with aqueous ammonia (sp.gr. 0·88, 85 cc) for 2–3 min and filtered. The excess of ammonia was removed from the filtrate *in vacuo* in the cold. The yellow *2-chloro-3,5-dinitrobenzenesulphonamide* (3·9 g, 84%) which separated was collected. It had m.p. 198–209° and was not further purified; fractional crystallization (ethanol) failed to give any material with a sharp m.p.

2'-Carboxy-4,6-dinitrodiphenylamine-2-sulphonamine

A solution of crude 2-chloro-3,5-dinitrobenzenesulphonamide (3·9 g), anthranilic acid (1·9 g) and sodium acetate (2·9 g) in ethanol (100 cc) was refluxed with stirring for 4 hr. *2'-Carboxy-4,6-dinitrodiphenylamine-2-sulphonamide* soon began to separate as the sodium salt. On completion of the reaction, the red-orange precipitate was collected and dissolved in warm water. Acidification of the filtered solution (conc. HCl) gave 2·45 g of the free acid which was recrystallized (95% ethanol) to m.p. 287–288°. (Found: C, 41·1; H, 2·35; N, 15·05. $C_{13}H_{10}N_4O_8S$ requires: C, 40·8; H, 2·6; N, 14·7%).

4,6-Diamino-2'-carboxydiphenylamine-2-sulphonamide

2'-Carboxy-4,6-dinitrodiphenylamine-2-sulphonamide (206 mg) in ethanol (20 cc) was hydrogenated (4 atm, 206 mg PtO_2) for 24 hr. The colourless solution was filtered and the *triamine* which had separated during the reduction was extracted from the residue with hot ethanol. The combined filtered ethanolic solutions were taken to dryness in N_2 under red. press. The residue, recrystallized from water, had m.p. 233·5–234·5°. (Found: C, 48·7; H, 4·7; N, 17·5. $C_{13}H_{14}N_4O_4S$ requires: C, 48·5; H, 4·35; N, 17·4%).

2'-Carbomethoxy-4,6-dinitrodiphenylamide

A solution of 2'-carboxy-4,6-dinitrodiphenylamine-2-sulphonamide (1·26 g) in anhydrous (30 cc) containing dry HCl was refluxed for 8 hr. The solution was filtered and allowed to cool, the solid which separated being collected. It was recrystallized (methanol) to give 980 mg (75%) of *2'-carbomethoxy-4,6-dinitrodiphenylamine-2-sulphonamide* as yellow needles m.p. 230·5–232·5°. (Found: C, 42·7; H, 3·05; N, 14·45; $C_{14}H_{12}N_4O_8S$ requires: C, 42·5; H, 3·05; N, 14·2%).

4,6-Diamino-2'-carbomethoxydiphenylamine-2-sulphonamide (characterized as the diacetyl derivative)

2'-Carbomethoxy-4,6-dinitrodiphenylamine-2-sulphonamide (100 mg) in ethanol (10 cc) was hydrogenated (4 atm, 100 mg PtO_2) for 24 hr. The colourless solution was filtered and the Pt residue washed with a little ethanol. The ethanol was removed from the filtrate in N_2 under red. press. Acetylation, as previously described for similar compounds, gave *4,6-diacetamido-2'-carbomethoxydiphenylamine-2-sulphonamide*, which recrystallized from 95% ethanol, m.p. 232–233°. (Found: C, 49·2; H, 5·0; N, 13·1; S, 7·35. $C_{18}H_{20}N_4O_6S.H_2O$ requires: C, 49·3; H, 5·05; N, 12·8; S, 7·3%).

3-Amino-9-carbomethoxyphenazine-1-sulphonamide

2'-Carbomethoxy-4,6-dinitrodiphenylamine-2-sulphonamide (500 mg) was hydrogenated as above and the diaminodiphenylamine cyclized in the usual manner, the nitrobenzene mixture being refluxed 65 hr. *3-Amino-9-carbomethoxyphenazine-1-sulphonamide* (71 mg) separated as dark red rods from the filtered, concentrated (0·5 mm press.) reaction mixture and was recrystallized from nitrobenzene to m.p. 276–277° (Kofler block). (Found: C, 51·05; H, 3·6; N, 17·3. $C_{14}H_{12}N_4O_4S$ requires: C, 50·6; H, 3·6; N, 16·9%). Paper chromatography (solvent A) gave a single spot.

The nitrobenzene reaction and recrystallization mother liquors were introduced onto an alumina column (58 × 2·3 cm). The nitrobenzene was eluted with benzene. 3-Amino-9-carbomethoxyphenazine-1-sulphonamide (39 mg) was eluted from the column with 10% ethanol in acetone. It was chromatographically pure (solvent A) and brought the total yield to the phenazine to 26%.

Another band, slightly more orange in colour, followed the band of 3-amino-9-carbomethoxyphenazine-1-sulphonamide too closely for complete separation. It was shown by paper chromatography (solvents A, B and C) to contain 3-amino-9-carbomethoxyphenazine-1-sulphonamide and a substance which behaved identically to 3-aminophenazine-1-sulphonamide (see the following experiment).

3-Amino-9-carboxyphenazine-1-sulphonamide

(i) *From 4,6-diamino-2'-carboxydiphenylamine-2-sulphonamide.* 2'-Carboxy-4,6-dinitrodiphenylamine-2-sulphonamide (360 mg) was hydrogenated as previously and the product was cyclized in boiling nitrobenzene solution (44 hr). Dark crystals of 3-amino-9-carboxyphenazine-1-sulphonamide (124 mg) separated from the filtered, concentrated (0·5 mm press.) nitrobenzene solution and were collected and washed free of nitrobenzene with ether. Paper chromatography (solvent A) showed it to be contaminated with a brown substance which was not removed by crystallization from nitrobenzene. A similarly impure product was also obtained when a sample of the isolated and purified 4,6-diamino-2'-carboxydiphenylamine-2-sulphonamide was oxidatively cyclized.

The nitrobenzene mother liquors were introduced onto an alumina column (22 × 2·5 cm). The nitrobenzene was stripped off with ether. Ethanol in acetone eluted on orange band. After evaporation of the solvent from the eluate the orange residue was recrystallized (acetone). Paper chromatography (solvents A, B) gave single spots which moved at a similar rate to 7- and 8-aminophenazine-2-sulphonamide. Electrophoresis on paper (pH 7; 7·5 v/cm; no movement), the IR spectrum (KCl disc: ν_{max} cm^{-1} 1320, 1150 (S = 0); no peak corresponding to a carboxylic acid) and UV/visible spectrum of a solution in 0·5N HCl (λ_{max}: 228, 280, 385, 390, 528 mμ) were also similar to those of 7- and 8-aminophenazine-2-sulphonamide. Thus, this compound is almost certainly 3-aminophenazine-1-sulphonamide.

(ii) *From 3-amino-9-carbomethoxyphenazine-1-sulphonamide.* 3-Amino-9-carbomethoxyphenazine-1-sulphonamide (50·5 mg) dissolved in 2N NaOH (5 cc) was kept in a boiling water-bath for 30 min. The red solution was diluted to 15 cc, filtered and cooled. The pH of the solution was reduced to 5 by the dropwise addition of glacial acetic acid. *3-Amino-9-carboxyphenazine-1-sulphonamide* separated as a dark red crystalline solid (46 mg, 95%), which did not melt below 330° (Kofler block) but which was chromatographically pure (solvent A). (Found: C, 49·45; H, 3·4; S, 10·45. $C_{13}H_{10}N_4O_4S$ requires: C, 49·0; H, 3·15; S, 10·1%).

Sodium 4-bromo-3-carboxy-5-nitrobenzenesulphonate

(i) *From 2-bromo-3-nitrobenzoic acid.* 2-Bromo-3-nitrobenzoic acid[17] (4·0 g) in 20% oleum (15 cc) was heated at 155–160° for 3 hr. The reaction mixture was cooled and added to a minimum of ice. The small amount of starting material which separated was filtered off and *sodium 4-bromo-3-carboxy-5-nitrobenzenesulphonate* was salted out from the filtrate by dissolving NaCl in the hot solution and

then allowing it to cool. The white crystalline precipitate did not melt below 300°. It failed to give a satisfactory analysis.

(ii) *From o-bromobenzoic acid.* *o*-Bromobenzoic acid (25 g) in 20% oleum (90 cc) was heated at 100° for 4 hr. Whilst keeping the temp of the solution below 40°, fuming HNO_3 (sp.gr. 1·5; 25 cc) was added. The reaction mixture was cautiously warmed to 98° and then kept in a boiling water-bath for 5 hr. It was allowed to cool, poured on ice and set aside overnight, after which the slight precipitate was filtered off and the crystalline sodium 4-bromo-3-carboxy-5-nitrobenzenesulphonate (39 g, 91%) was isolated as described above. Again, a satisfactory analysis could not be obtained but the IR spectrum (nujol mull) of this material was identical to that of the product in (i) above.

4-Bromo-3-carboxy-5-nitrobenzenesulphonyl chloride

Dry sodium 4-bromo-3-carboxy-5-nitrobenzenesulphonate (5·0 g) in chlorosulphonic acid (20 cc) was heated at 96–98° for 3 hr. After cooling, the reaction mixture was cautiously poured into a rapidly stirred ice-water mixture. The white precipitate was collected and dried over P_2O_5. Recrystallization (dry toluene) gave 2·5 g (58%) of *4-bromo-3-carboxy-5-nitrobenzenesulphonyl chloride* as white needles m.p. 197–199°. (Found: C, 24·65; H, 0·65; S, 9·05. $C_7H_2ClNO_6S$ requires: C, 24·4; H, 0·85; S, 9·3).

4-Bromo-3-carboxy-5-nitrobenzenesulphonamide

4-Bromo-3-carboxy-5-nitrobenzenesulphonyl chloride (8·8 g) was added portionwise to a stirred solution of ammonia (sp.gr. 0·88, 50 cc). On completion of the addition the reaction mixture was filtered and the ammonia removed from the filtrate *in vacuo* with the minimum of heating. The precipitate produced on acidification of the solution with conc. HCl was collected and recrystallized from water to give *4-bromo-3-carboxy-5-nitrobenzenesulphonamide* (6·6 g, 80%) as cream needles m.p. 218–221°. (Found: C, 25·75; H, 1·4; N, 8·7. $C_7H_3BrN_2O_6S$ requires: C, 25·8; H, 1·55; N, 8·6%).

4'-Acetamido-2-carboxy-6-nitrodiphenylamine-4-sulphonamide

A solution of 4-bromo-3-carboxy-5-nitrobenzenesulphonamide (6·5 g), *p*-amino-acetanilide (3·0 g) and sodium acetate (4·1 g) in ethanol (50 cc) was refluxed for 4 hr. The deep red reaction mixture was taken to dryness *in vacuo*. The residue was dissolved in water and the solution filtered. The orange solid which precipitated on acidification of the filtrate with conc. HCl was collected and recrystallized (dil. acetic acid); 5·6 g (68%) of *4'-acetamido-2-carboxy-6-nitrodiphenylamine-4-sulphonamide* m.p. 250–251° were obtained. (Found: C, 43·9; H, 3·8; N, 13·6. $C_{15}H_{14}N_4O_7S.H_2O$ requires: C, 43·8; H, 4·05; N, 13·6%).

4'-Amino-2-carboxy-6-nitrodiphenylamine-4-sulphonamide hydrochloride

4'-Acetamido-2-carboxy-6-nitrodiphenylamine-4-sulphonamide (5·6 g) in 2N HCl (750 cc) was refluxed for 1 hr. The reaction mixture was filtered and the volume reduced to 250 cc. The yellow *4'-amino-2-carboxy-6-nitrodiphenylamine-4-sulphonamide hydrochloride* which crystallized out (4·0 g, 68%) was collected and recrystallized from dil. HCl. (Found: C, 40·25; H, 3·3; N, 13·8. $C_{13}H_{12}ClN_4O_6S$ requires: C, 40·2; H, 3·35; N, 14·4%).

4'-Amino-2-carbomethoxy-6-nitrodiphenylamine-4-sulphonamide and the corresponding carboxylic acid

A solution of 4'-amino-2-carboxy-6-nitrodiphenylamine-4-sulphonamide hydrochloride (500 mg) in methanol (20 cc) containing dry HCl was refluxed for 8 hr. The methanol was removed *in vacuo* and the residue dissolved in cold water. The solution was filtered and *4'-amino-2-carbomethoxy-6-nitrodiphenylamine-4-sulphonamide* (350 mg, 66%) was precipitated from the filtrate by addition of sodium acetate aq. It was not recrystallized and had m.p. 193·5–196·5°. (Found: C, 45·4; H, 4·0; N, 15·5. $C_{14}H_{14}N_4O_6S$ requires: C, 45·9; H, 3·85; N, 15·3%).

Attempted recrystallization from bench butanol resulted in the crystallization of the corresponding acid, *4'-amino-2-carboxy-6-nitrodiphenylamine-4-sulphonamide* m.p. 268–270°. (Found: C, 48·45; H, 4·35; S, 9·8. $C_{13}H_{14}N_4O_6S$ requires: C, 48·5; H, 4·35; S, 9·95%). The hydrochloride of this material had an IR spectrum identical to that of the 4'-amino-2-carboxy-6-nitrodiphenylamine-4-sulphonamide hydrochloride described above.

8-Amino-4-carboxyphenazine-2-sulphonamide

4'-Amino-2-carbomethoxy-6-nitrodiphenylamine-4-sulphonamide (300 mg) was hydrogenated and the product cyclized in boiling nitrobenzene (60 hr). The reaction mixture was filtered, cooled and introduced onto an alumina column (2·5 × 45 cm). The nitrobenzene was eluted with benzene. After washing the column well with ether, acetone, ethanol and water which removed unidentified trace materials, *8-amino-4-carboxyphenazine-2-sulphonamide* was eluted with 1% pyridine aq. The eluate was concentrated to 15 cc *in vacuo* and the 8-amino-4-carboxyphenazine-2-sulphonamide (34 mg, 14%), which separated as the pyridine distilled off, was collected and washed with water. It did not melt below 330° (Kofler block). (Found: C, 48·9; H, 3·35; S, 9·5. $C_{13}H_{10}N_4O_4S$ requires: C, 49·0; H, 3·15; S, 10·1%).

5,7-Dinitroacridone-2-sulphonyl chloride

Chlorosulphonic acid (25 ml) was added slowly to dry 2',4'-dinitrodiphenylamine-2-carboxylic acid[16] (10·5 g). There was a vigorous effervescence and the temp rose to about 70°. The dark red reaction mixture was maintained in an oil bath at 110° (bath temp) for 1 hr and then allowed to cool. The excess chlorosulphonic acid was decomposed on ice and the yellow precipitate of *5,7-dinitroacridone-2-sulphonyl chloride* collected (12·2 g, 92%). The m.p. of 272–276° dec (m.p. tube inserted in the heating block at 260°) was not improved by recrystallization (dry toluene). (Found: C, 40·25; H, 1·4; Cl, 9·65. $C_{13}H_6ClN_3O_7S$ requires: C, 40·7; H, 1·55; Cl, 9·25%). IR spectrum (KCl disc): ν_{max} cm^{-1} 1660 (C = 0); 1370, 1160 (S = 0).

5,7-Dinitroacridone-2-sulphonamide

When conc. NH_4OH (sp.gr. 0·88, 60 cc) was added rapidly to 5,7-dinitroacridone-2-sulphonyl chloride (2·0 g), the reaction was rapid and exothermic. Excess of ammonia was removed *in vacuo* after 5 min and the reaction mixture made acid with dil. HCl. The yellow precipitate (1·8 g, 95%) of *5,7-dinitroacridone-2-sulphonamide* was collected and recrystallized from dil. acetic acid; it did not melt below 300°. (Found: C, 43·05; H, 2·35; S, 8·85. $C_{13}H_8N_4O_7S$ requires: C, 42·9; H, 2·2; S, 8·85%). IR spectrum (KCl disc.): ν_{max} cm^{-1} 1650 (C = 0); 1330, 1160 (S = 0).