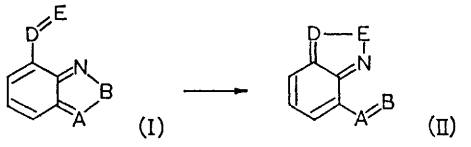
N-Oxides and Related Compounds. Part XXVIII.[1] 5-Amino- and 5-Hydroxy-benzofuroxans

By A. J. Boulton, P. B. Ghosh, and A. R. Katritzky

The synthesis is described of a variety of 5-substituted benzofuroxans and their precursors. Careful hydrolysis of 5-acetoxy- and 5-acylamino-benzofuroxan led to the isolation of 5-hydroxy- and 5-amino-benzofuroxan hydrochloride. The structures of these compounds are discussed.

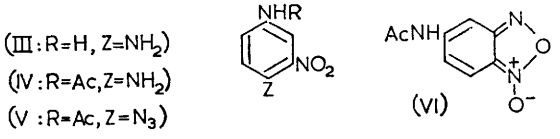
A PREVIOUS Paper [2] described a new class of heterocyclic rearrangements, (I) ⟶ (II). In connection with the preparation of compounds of type (I), we required benzofuroxans carrying strong electron-donor groups; we



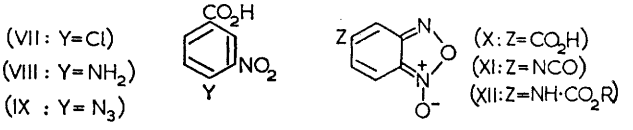
now record attempts to prepare amino- and hydroxybenzofuroxans.

5-Amino Series.—Green and Rowe [3] attempted to prepare 5-amino- and 5-acetamido-benzofuroxan by hypochlorite oxidation of nitro-1,4-diaminobenzene and 4-amino-3-nitroacetanilide. Our results (see below) indicate that under these conditions the acetamido-derivative would have been hydrolysed and the amino-compound degraded. Boyer *et al.* claimed [4] that 1,2-diamino-3-azido-4-nitrobenzene was transformed into a benzofuroxan on standing, but offered no evidence for the product other than a correct analysis; they later stated that no amino- or hydroxy-benzofuroxans were known.[5]

Monoacetylation of 1,4-diamino-2-nitrobenzene (III) afforded the monoacetyl derivative (IV) (previously [6] obtained by controlled hydrolysis of the diacetyl analogue), which was converted successively into the azide (V) and the benzofuroxan (VI).



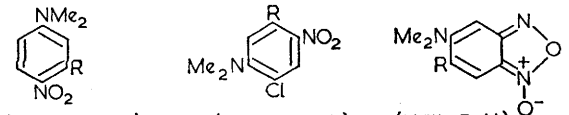
4-Amino-3-nitrobenzoic acid (VIII) [prepared from the 4-chloro-analogue (VII) and ammonia] was converted by way of diazotisation into 4-azido-3-nitrobenzoic acid (IX) which was pyrolysed in toluene without purification, to yield 5-carboxybenzofuroxan (X). Alternatively,



4-chloro-3-nitrobenzoic acid (VII) was treated with sodium azide in dimethyl sulphoxide, to give the 5-carboxybenzofuroxan as a surprisingly stable dimethyl sulphoxide complex which crystallised unchanged from light petroleum–ethyl acetate but which afforded the desired 5-carboxybenzofuroxan when heated or when treated with acid. 5-Carboxybenzofuroxan was converted successively into the acid chloride, acid azide, and isocyanate (XI). Heating of the acid azide in ethanol and in t-butyl alcohol yielded the corresponding ethyl

[1] Part XXVII, A. R. Katritzky, F. J. Swinbourne, and B. Ternai, *J. Chem. Soc.* (*B*), 1966, 235.
[2] A. J. Boulton, P. B. Ghosh, and A. R. Katritzky, *Angew. Chem.*, 1964, **19**, 816.
[3] A. G. Green and F. M. Rowe, *J. Chem. Soc.*, 1913, **103**, 2023.
[4] J. H. Boyer, R. S. Buriks, and V. Toggweiler, *J. Amer. Chem. Soc.*, 1960, **82**, 2213.
[5] J. H. Boyer, R. F. Reinisch, M. J. Danzig, G. A. Stoner, and F. Sahhar, *J. Amer. Chem. Soc.*, 1955, **77**, 5688.
[6] C. Bülow and E. Mann, *Ber.*, 1897, **30**, 981.

urethane (XII; R = Et) and t-butyl urethane (XII; R = Bu^t), respectively.



(XIII: R=NO_2) (XIV: R=NH_2) (XV: R=N_3) (XVI: R=NH_2) (XVII: R=N_3) (XVIII: R=H) (XIX: R=Cl)

p-Dimethylaminoacetanilide on nitration afforded the 2-nitro-derivative, as reported by Hodgson and Crook,[7] but the method was unsuitable for large-scale work. An acceptable alternative route to 5-dimethylaminobenzofuroxan (XVIII) was found by directly heating *NN*-dimethyl-3,4-dinitroaniline (XIII) with sodium azide in dimethyl sulphoxide. Earlier, the same dinitro-compound had been converted successively into the 3-amino-*NN*-dimethyl-4-nitroaniline (XIV), and the 3-azido-analogue (XV), which was then pyrolysed to form (XVIII). Deoxygenation of this compound with trimethyl phosphite gave the corresponding 5-dimethylaminobenzofurazan.

1-Amino-4-chloro-5-dimethylamino-2-nitrobenzene (XVI) was prepared according to the literature[8] and then converted by way of diazotisation into the azide (XVII) which lost nitrogen when heated in glacial acetic acid, to form 6-chloro-5-dimethylaminobenzofuroxan (XIX).

Hydrolysis of 5-acylaminobenzofuroxans. Treatment of 5-acetamido-, 5-t-butoxycarbonylamino-, and 5-ethoxycarbonylamino-benzofuroxan with aqueous ethanolic hydrogen chloride gave purple-red solutions which slowly darkened on standing. Ultraviolet spectroscopic investigation of the reaction mixtures, and comparison with 5-dimethylaminobenzofuroxan, indicated that 5-aminobenzofuroxan was being formed in all cases (see Figure 1). Careful investigation of the reaction conditions led to the isolation of 5-aminobenzofuroxan hydrochloride, which could not be purified sufficiently for analysis, but was characterised by its ultraviolet spectrum (Figure 1) (see Experimental section). Attempts to isolate the free base failed. The pK_a values of 5-amino- and 5-dimethylamino-benzofuroxan were determined spectrophotometrically as 0·5 and 1·2, respectively. The pK_a of 5-acetamidobenzofuroxan could not be determined owing to hydrolysis, but complete protonation occurred only in the $H_0 \sim -10$ region.

Continued hydrolysis of the acylamino-derivative gave an ultraviolet spectrum similar to that from the hydrolysis of 5-acetoxybenzofuroxan, suggesting that conversion into the 5-hydroxy-compound was occurring.

Structure of 5-aminobenzofuroxan. The ultraviolet spectral evidence indicates that for 5-aminobenzofuroxan an amino (rather than an imino) structure predominates, both in the neutral molecule and in the cation, as for the 5-dimethylamino-derivative (see Figure 2). The relative importance of structures of type (XIX) and (XX) is presently under investigation for a variety of benzofuroxans, as is the general problem of the protonation of benzofuroxans. However, we have shown that the cation of 5-dimethylaminobenzofuroxan (and hence of the 5-amino-analogue) is not protonated on the exocyclic

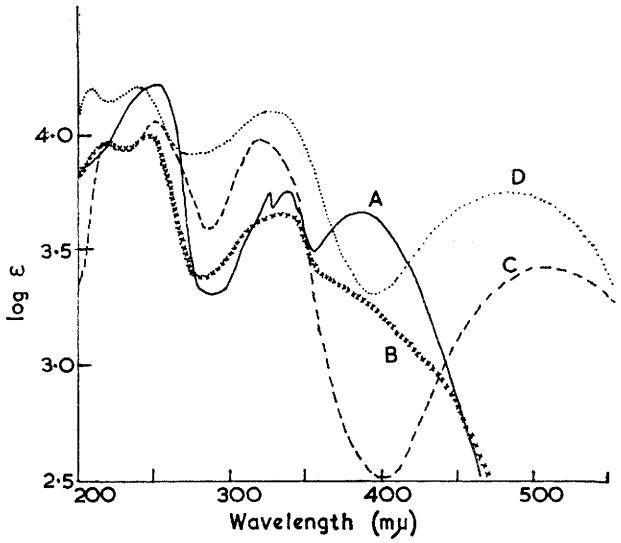


FIGURE 1 Ultraviolet spectra of (A) 5-acetamidobenzofuroxan in 50% aqueous ethanol, (B) 5-acetamidobenzofuroxan cation in aqueous sulphuric acid of H_0 — 10, (C) 5-aminobenzofuroxan cation in aqueous hydrochloric acid of H_0 — 2·1, and (D) 5-dimethylaminobenzofuroxan cation in aqueous hydrochloric acid of H_0 — 2·1

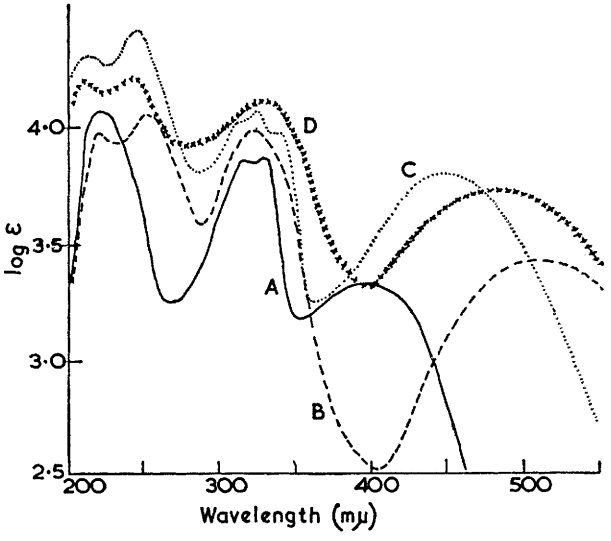


FIGURE 2 Ultraviolet spectra of (A) 5-aminobenzofuroxan neutral species in buffered aqueous solution of pH 2·5, (B) 5-aminobenzofuroxan cation in aqueous hydrochloric acid of H_0 — 2·1, (C) 5-dimethylaminobenzofuroxan neutral species in aqueous solution of pH 3·5, and (D) 5-dimethylaminobenzofuroxan cation in aqueous hydrochloric acid of H_0 — 2·1

nitrogen, because its ultraviolet spectrum does not resemble that of benzofuroxan itself (Figure 3). In contrast, the protonated form of 5-dimethylaminobenzofurazan (XXII) does resemble that of benzofurazan

[7] H. H. Hodgson and J. H. Crook, *J. Chem. Soc.*, 1932, 2976.
[8] I. Molnar, *Helv. Chim. Acta*, 1963, **46**, 1780.

(Figure 4), indicating protonation at the NMe_2 group in this instance.

5-Hydroxy Series.—Preparation of compounds. 5-Methoxybenzofuroxan is known;[9] attempts[10] by us

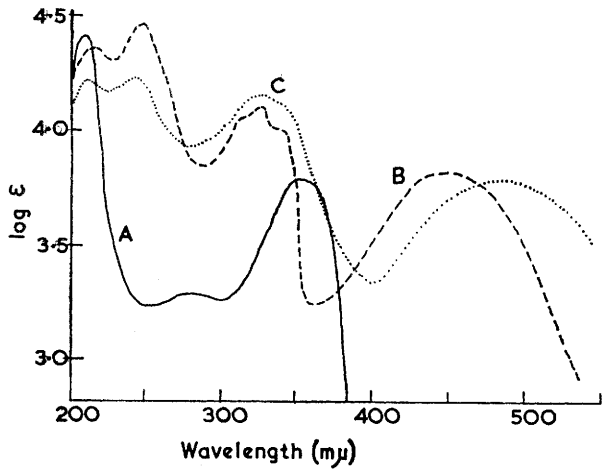


FIGURE 3 Ultraviolet spectra of (A) benzofuroxan in 50% aqueous ethanol, (B) 5-dimethylaminobenzofuroxan in 50% aqueous ethanol, and (C) 5-dimethylaminobenzofuroxan cation in aqueous hydrochloric acid of $H_0 - 2{\cdot}1$

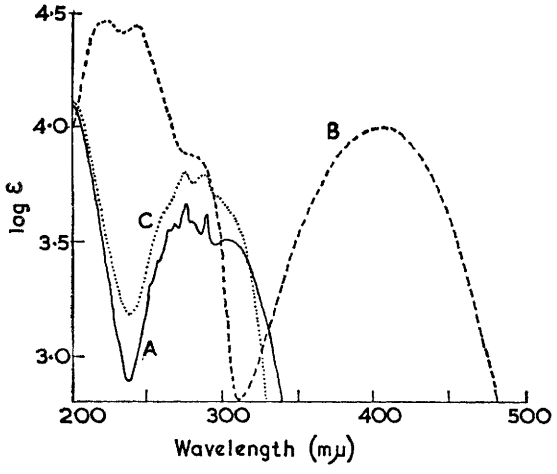
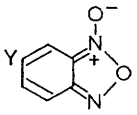
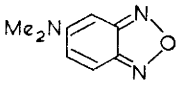


FIGURE 4 Ultraviolet spectra of (A) benzofurazan in water, (B) 5-dimethylaminobenzofurazan in water, and (C) 5-dimethylaminobenzofurazan cation in aqueous hydrochloric acid of $H_0 - 1$

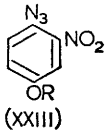
to demethylate with halogen acids (cf. the preparation of 5-hydroxybenzofurazan[11]), or with pyridine hydrochloride failed, evidently owing to the instability of 5-hydroxybenzofuroxan. A modification of Morgan and Porter's method[12] converted *o*-nitroaniline into 4-amino-3-nitrophenol which afforded the corresponding phenyl azide (XXIII; R = H). Pyrolysis of this azide gave a black tar instead of the expected 5-hydroxybenzofuroxan. However, the azide, after conversion into the acetyl derivative (XIII; R = Ac), lost nitrogen smoothly when heated in toluene, to yield 5-acetoxybenzofuroxan (XXIV; R = Ac).



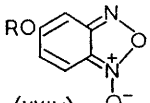
(XX : Y=NMe_2)
(XXI : Y=OR)



(XXII)



(XXIII)



(XXIV)

Hydrolysis of 5-acetoxybenzofuroxan. The hydrogen chloride catalysed hydrolysis of 5-acetoxybenzofuroxan was followed spectrophotometrically and conditions were found[10] under which a curve closely similar to that for 5-methoxybenzofuroxan was obtained (further heating under the hydrolytic conditions caused further spectral changes, the nature of which has not yet been elucidated). Using corresponding preparative conditions, it was possible to isolate 5-hydroxybenzofuroxan as the hydrochloride and as the free base; although these derivatives were too unstable for analysis, they could be characterised by infrared spectra (see Experimental section), and by ultraviolet spectroscopy (Figures 5 and 6).

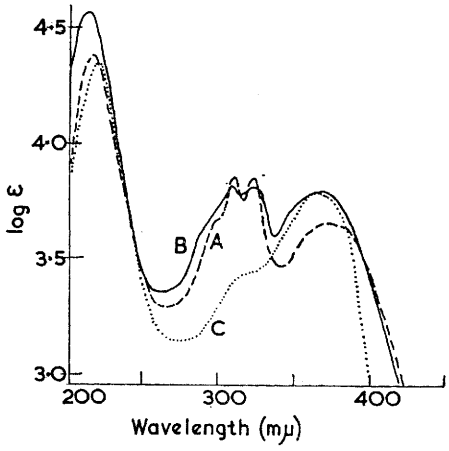


FIGURE 5 Ultraviolet spectra of (A) 5-methoxybenzofuroxan in 50% aqueous ethanol, (B) 5-hydroxybenzofuroxan in 50% aqueous ethanol, and (C) 5-acetoxybenzofuroxan in 50% aqueous ethanol

The pK_a of 5-hydroxybenzofuroxan as an acid was determined spectrophotometrically to be $6{\cdot}75 \pm 0{\cdot}1$ (cf. 5-hydroxybenzofurazan,[11] $pK_a = 7{\cdot}28$). Its pK_a as a base was also found spectrophotometrically as *ca.* $-0{\cdot}9$; hydrochloric acid solutions were used, as decomposition occurred in sulphuric acid.

[9] J. F. Gaughran, J. P. Picard, and J. V. R. Kaufman, *J. Amer. Chem. Soc.*, 1954, **76**, 2233.
[10] For full details see P. B. Ghosh, Ph.D. Thesis, University of East Anglia, 1966.
[11] D. Dal Monte and E. Sandri, *Ann. Chim.* (*Italy*), 1964, **54**, 486.
[12] G. T. Morgan and J. T. Porter, *J. Chem. Soc.*, 1915, **107**, 653.

Tautomeric structure of 5-hydroxybenzofuroxan. The major tautomeric possibilities for the structure of 5-hydroxybenzofuroxan neutral molecule are shown in (XXI and XXIV; R = H) and (XXV)—(XXIX).

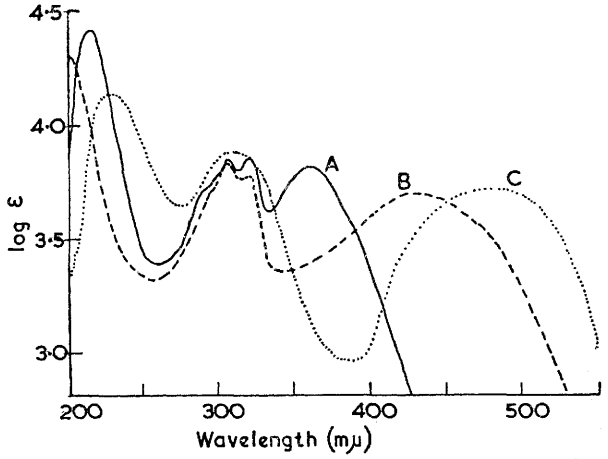
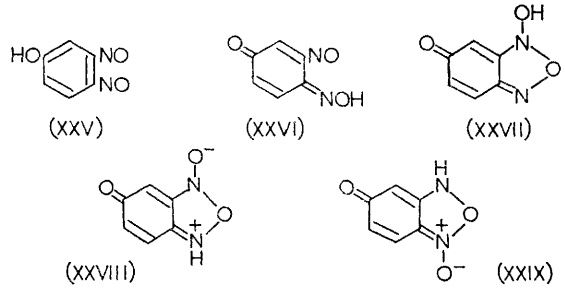


FIGURE 6 Ultraviolet spectra of (A) 5-hydroxybenzofuroxan neutral species in buffered aqueous solution of pH 5·0, (B) anion in buffered aqueous solution of pH 12·3, and (C) cation in aqueous hydrochloric acid of $H_0 - 3$

However, as the ultraviolet spectra resemble that of 5-methoxybenzofuroxan so closely, it is probable that the tautomeric composition of the two compounds is also similar. 5-Methoxybenzofuroxan has been shown [13] to exist in forms (XXI; R = Me) and (XXIV; R = Me) in a ratio of *ca.* 2 : 1, and we believe that forms (XXI and XXIV; R = H) contribute to 5-hydroxybenzofuroxan in a similar manner.



The structure of protonated 5-hydroxybenzofuroxan, and of the protonated form of other benzofuroxans, is still under investigation.

EXPERIMENTAL

Melting points were taken on a Kofler hot-stage microscope.

4-Amino-3-nitroacetanilide (IV).— 1,4-Diamino-2-nitrobenzene (Aldrich Chemical Co.) (1·53 g.) was heated for 15 min. at 100° in acetic acid (50 c.c.) containing acetic anhydride (1·02 g.) and sulphuric acid (*ca.* 0·2 c.c.). The cooled solution was poured on to ice, and the precipitate crystallised three times from ethanol (charcoal), to give yellow needles of the amine (1·75 g., 88%), m. p. 211·5—212° (lit.,[6] 189°). It crystallised from aqueous acetone as orange plates (Found: C, 49·2; H, 5·0; N, 21·8. Calc. for $C_8H_9N_3O_3$: C, 49·2; H, 4·7; N, 21·3%).

4-Azido-3-nitroacetanilide (V).— 4-Amino-3-nitroacetanilide (9·75 g.) in glacial acetic acid (200 c.c.) was diazotised by addition at 0° to stirred nitrosylsulphuric acid, formed from sodium nitrite (4 g.) and 36N-sulphuric acid (75 c.c.). After 15 min. stirring the mixture was poured on to ice (200 g.), and the clear solution added to a stirred solution of sodium azide (15 g.) in water (100 c.c.). The precipitate obtained crystallised from methanol, to give the *azide* (9·0 g., 82%) as white needles, m. p. 115° (Found: C, 43·7; H, 3·2; N, 31·5. $C_8H_7N_5O_3$ requires C, 43·4; H, 3·2; N, 31·7%), $\nu_{max.}$ 2120 (N_3), 1680 cm.$^{-1}$ (CO).

5-Acetamidobenzofuroxan (VI).—The azide (V) (5·0 g.) was refluxed in acetic acid (50 c.c.) until evolution of nitrogen ceased (*ca.* 30 min.). Water (*ca.* 15 c.c.) was added at 100° until a slight turbidity persisted. Cooling then gave the *5-acetamidobenzofuroxan* (13·9 g., 90%), yellow needles (from ethanol), m. p. 177—179° (Found: C, 49·9; H, 3·5; N, 22·0. $C_8H_7N_3O_3$ requires C, 49·8; H, 3·7; N, 21·8%). $\nu_{max.}$ 3240 (NH); 1685 (C=O); 1605, 1560, 1540 cm.$^{-1}$ (benzofuroxan ring).

4-Amino-3-nitrobenzoic Acid (VIII).—4-Chloro-3-nitrobenzoic acid (VII) (27 g.) was heated for 3 hr. at 130—135° with 0·880 ammonia (100 c.c.) (sealed tube). Addition of hydrochloric acid to the cooled mixture liberated the acid, which was washed with water. It crystallised from aqueous ethanol (1 : 1) as yellow needles (16·5 g., 63%), m. p. 282—284° (lit.,[14] 284°).

4-Azido-3-nitrobenzoic Acid (IX).—Sodium nitrite (3·6 g.) in conc. sulphuric acid (50 c.c.) was added at 0° to the amine (VIII) (9·1 g.) in glacial acetic acid (100 c.c.) and conc. sulphuric acid (100 c.c.). After stirring for 1½ hr. the whole was poured on to ice (200 g.). The filtered solution was added with stirring to sodium azide (15 g.) in water (100 c.c.); 4-azido-3-nitrobenzoic acid (7·0 g., 67%), m. p. 83—84° was precipitated. This was used in the next stage without purification.

Benzofuroxan-5-carboxylic Acid (X).—(a) *From 4-azido-3-nitrobenzoic acid.* The azido-acid (7·0 g.) was refluxed for ½ hr. in toluene (100 c.c.). Solvent (*ca.* 70 c.c.) was then distilled off. The cold residue deposited the *5-carboxylic acid* (4·0 g., 70%), pale yellow prisms (from toluene), m. p. 128—129° (Found: C, 46·5; H, 2·3; N, 15·7. $C_7H_4N_2O_4$ requires C, 46·7; H, 2·2; N, 15·6%). $\nu_{max.}$ 1685 (C=O); 1610, 1585, 1540 cm.$^{-1}$ (benzofuroxan ring).

(b) *Directly from 4-chloro-3-nitrobenzoic acid.* The chloro-acid (VII) (2·0 g.) and sodium azide (0·69 g.) were heated at 100° for 15 min. in dimethyl sulphoxide (25 c.c.). The cooled mixture was poured into water (100 c.c.); a yellow oil was deposited and was extracted with benzene. Removal of the benzene and two crystallisations from ethyl acetate–light petroleum (1 : 2) gave the *dimethyl sulphoxide complex* of benzofuroxan-5-carboxylic acid (1·3 g., 50%) as yellow prisms, m. p. 81·5—82° (Found: C, 41·8; H, 4·0; N, 10·9; S, 12·6. $C_9H_{10}N_2O_5S$ requires C, 42·0; H, 3·9; N, 10·9; S, 12·4%), $\nu_{max.}$ 1687 (C=O); 1617, 1590, 1530 (benzofuroxan ring); 1030 cm.$^{-1}$ (S–O). N.m.r.: singlet (τ 7·2) in $CHCl_3$ (dimethyl sulphoxide); ABC pattern (τ_A ~1·75, τ_B ~2·05, τ_C ~2·25).

The complex was decomposed by heating to 120°/20 mm. in a sublimation apparatus. Dimethyl sulphoxide collected on the cold finger and a residue of benzofuroxan-5-carboxylic

[13] B. Wallis, unpublished work.
[14] F. Ullmann and F. Mauther, *Ber.*, 1903, **36**, 4032.

acid was identified by comparison with authentic material. Alternatively, acidification of a solution of the complex in water precipitates the acid.

Benzofuroxancarbonyl Chloride.—The 5-carboxylic acid (10 g.) was refluxed for 2 hr. in toluene (100 c.c.) and thionyl chloride (50 c.c.). Excess of thionyl chloride and toluene were removed at 80°/20 mm. The *product* (9·5 g., 90%) crystallised from hexane as bright yellow prisms, m. p. 54—54·5° (Found: C, 42·3; H, 1·4; N, 14·0. $C_7H_3ClN_2O_3$ requires C, 42·2; H, 1·6; N, 14·1%). $\nu_{max.}$ 1760 (C=O); 1620, 1600, 1540 cm.$^{-1}$ (benzofuroxan ring).

5-*Azidocarbonylbenzofuroxan*.—The acid chloride (9·0 g.) in acetone (100 c.c.) was mixed with sodium azide (5·0 g.) in water (25 c.c.) and kept for 0·5 hr. at 35—40°. Addition of water (100 c.c.) precipitated the *azide* (9·0 g., 91%) which crystallised from aqueous acetone (1 : 1) as yellow needles, m. p. 90—92° (Found: C, 41·2; H, 1·8; N, 34·0. $C_7H_3N_5O_3$ requires C, 41·1; H, 1·5; N, 34·1%), $\nu_{max.}$ 2270 (N_3), 1630 cm.$^{-1}$ (C=O).

5-*Isocyanatobenzofuroxan* (XI).—The acid azide (1·0 g.) was refluxed (2 hr.) in dry toluene (50 c.c.). Removal of solvent at 80°/20 mm. and crystallisation of the residue from benzene gave the *isocyanate* (0·6 g., 70%) as orange-yellow plates, m. p. 180° (decomp.) (Found: C, 47·3; H, 2·6. $C_7H_3N_3O_3$ requires C, 47·5; H, 1·7%), $\nu_{max.}$ 2270 cm.$^{-1}$ (NCO).

5-*Ethoxycarbonylaminobenzofuroxan* (XII; R = Et).—The acid azide (0·5 g.) was refluxed for 1 hr. in absolute ethanol (50 c.c.). Addition of water (50 c.c.) precipitated the *ethyl urethane* (0·5 g., 70%), yellow needles (from benzene), m. p. 116—117° (Found: C, 48·3; H, 4·1. $C_9H_9N_3O_4$ requires C, 48·4; H, 4·4%). $\nu_{max.}$ 1720 (C=O); 1620, 1590, 1540 cm.$^{-1}$ (benzofuroxan ring).

5-*t-Butoxycarbonylaminobenzofuroxan* (XII; R = Bu^t).—Prepared as for the ethyl analogue, the *t-butyl urethane* (90%) crystallised from aqueous acetone as pale yellow needles, m. p. 155—156° (Found: C, 52·7; H, 5·2; N, 16·8. $C_{11}H_{13}N_3O_4$ requires C, 52·6; H, 5·2; N, 16·7%).

3-*Azido*-NN-*dimethyl*-4-*nitroaniline* (XV).— *NN*-Dimethyl-3,4-dinitroaniline (XIII) (Aldrich Chemical Co.) was converted into 3-amino-*NN*-dimethyl-4-nitroaniline (XIV) following van Romberg.[15] This material (5·2 g.) was diazotised in conc. hydrochloric acid (25 c.c.) by addition of sodium nitrite (2·3 g.) in water (10 c.c.) and treated with sodium azide (5·0 g.) in water (50 c.c.), to yield the *azido-compound* (5·5 g., 93%) which crystallised from ether–acetone (6 : 1) as golden-yellow needles, m. p. 82—83° (decomp.) (Found: C, 45·9; H, 4·7; N, 34·2. $C_8H_9N_5O_2$ requires C, 46·3; H, 4·4; N, 33·8%), $\nu_{max.}$ 2160 cm.$^{-1}$ (N_3).

5-*Dimethylaminobenzofuroxan* (XVIII).—(a) *From* 3-*azido*-NN-*dimethyl*-4-*nitroaniline*. The azido-compound (XV) (3 g.) was refluxed for 1 hr. in toluene (50 c.c.). Removal of solvent and crystallisation (charcoal) from ethyl acetate–light petroleum (1 : 1) gave the *dimethylaminobenzofuroxan* (2·3 g., 88%) as orange-yellow needles, m. p. 123—124° (Found: C, 53·5; H, 5·0; N, 23·7. $C_8H_9N_3O_2$ requires C, 53·6; H, 5·1; N, 23·5%), $\nu_{max.}$ 1615, 1600, 1580 cm.$^{-1}$ (benzofuroxan ring).

(b) *Directly from* NN-*dimethyl*-3,4-*dinitroaniline*. The dinitro-compound (XIII) (10·5 g.) and sodium azide (3·3 g.) were heated at 100° for 30 min. in dimethyl sulphoxide (100 c.c.). The temperature was then raised to *ca.* 160° for 5 min., the mixture was cooled, and water (100 c.c.) added. The yellow precipitate crystallised from ethyl acetate–light petroleum (2 : 1), giving the benzofuroxan (7·0 g., 84%), m. p. 123—124°, identical with a specimen prepared by method (a).

5-*Dimethylaminobenzofurazan* (XXII).—The dimethylaminobenzofuroxan (0·4 g.) was refluxed for 30 min. in ethanol (20 c.c.) containing trimethyl phosphite (1 c.c.). The *product* was steam-distilled over as a pale yellow oil which solidified on cooling, and crystallised from aqueous ethanol as yellow needles (0·2 g., 55%), m. p. 97—98° (Found: C, 58·8; H, 5·9. $C_8H_9N_3O$ requires C, 58·9; H, 5·6%).

1-*Azido*-4-*chloro*-5-*dimethylamino*-2-*nitrobenzene* (XVII).—4-Chloro-5-dimethylamino-2-nitroaniline [8] (XVI) (9·4 g.) in conc. hydrochloric acid (50 c.c.) was stirred at 0°, and sodium nitrite (3·5 g.) in water (30 c.c.) added. The diazonium solution was added (vigorous stirring) to sodium azide (10 g.) in water (100 c.c.). The precipitated *azide* (10 g., 95%) was crystallised twice from ethanol, and formed yellow needles, m. p. 97—99° (decomp.) (Found: C, 40·3; H, 3·3; N, 29·4. $C_8H_8ClN_5O_2$ requires C, 40·0; H, 3·3; N, 29·1%), $\nu_{max.}$ 2120 cm.$^{-1}$ (N_3).

6-*Chloro*-5-*dimethylaminobenzofuroxan* (XIX).— The azide (XVII) (10 g.) was refluxed for 1 hr. in glacial acetic acid (50 c.c.). Water (*ca.* 30 c.c.) was then added to the hot solution until it became turbid. The *product* separated on cooling; orange-yellow needles (from ethanol) (8·6 g., 95%), m. p. 99·5—100° (Found: C, 44·9; H, 3·7; N, 20·4. $C_8H_8ClN_3O_2$ requires C, 45·0; H, 3·8; N, 19·9%).

Hydrolysis of 5-*Aminobenzofuroxan Derivatives*.—5-*Acetamidobenzofuroxan*. 5-Acetamidobenzofuroxan (0·2 g.) was heated at 45° for 24 hr. in ethanol (50 c.c.) and 12N-aqueous hydrochloric acid (50 c.c.). The volume was reduced (*ca.* 20 c.c.) at 40°/10 mm. 5-*Aminobenzofuroxan hydrochloride* separated as purple crystals on standing. Attempts to purify this further for analysis resulted in decomposition.

4-*Amino*-3-*nitrophenol*. *o*-Nitroaniline (100 g.) was diazotised by the general procedure of ref. 16, and the clear diazonium solution added at 0° with stirring to sodium azide (50 g.) in water (200 c.c.). The pale yellow azide separated and was washed thoroughly with water (it is essential to wash out any excess of sodium azide). The air-dried azide (110 g., 90%) is suitable for the next stage. Recrystallisation from methylene chloride gave *o*-nitrophenyl azide, m. p. 50—52° (lit.,[17] 53°).

o-Nitrophenyl azide (100 g.) was added portionwise to 30N-sulphuric acid (300 c.c.) at 70—75° with vigorous shaking. The temperature rose spontaneously and decomposition commenced at 85—90°. The rate of addition of material was such that 85—90° was maintained (near the end of the addition some cooling was necessary). On keeping for 12 hr., 4-amino-3-nitrophenol hydrogen sulphate separated (70 g., 75%). It was washed with light petroleum (b. p. 60—80°)–alcohol mixture (1 : 2) and was suitable for the next stage. Basification and recrystallisation from benzene gave the free base, m. p. 147—148° (lit.,[12] 144°).

4-*Azido*-3-*nitrophenol* (XXIII; R = H).—The hydrogen sulphate salt (25·1 g.) obtained above in hot water (200 c.c.) was rapidly cooled and treated with 36N-sulphuric acid (50 c.c.). Sodium nitrite (9 g.) in water (50 c.c.) was then added at 0° with shaking, and the whole added (stirring) to sodium azide (10 g.) in water (100 c.c.) (nitrogen evolution). After ½ hr., ice (200 g.) and sodium chloride (15 g.) were added to precipitate the *azide* (14 g., 48%), sufficiently pure for

[15] P. van Romberg, *Rec. Trav. chim.*, 1923, **42**, 804.
[16] H. H. Hodgson and J. Walker, *J. Chem. Soc.*, 1933, 1620.
[17] E. Noelting and O. Michel, *Ber.*, 1893, **26**, 87.

conversion into the *O*-acetyl derivative. Recrystallisation of a sample from benzene–hexane gave material of m. p. 95—97° (decomp. 98°) (Found: C, 40·0; H, 2·2; N, 31·7. $C_6H_4N_4O_3$ requires C, 40·0; H, 2·2; N, 31·1%). $\nu_{max.}$ 3420 (OH); 2130 (N_3); 1530, 1360 cm.$^{-1}$ (NO_2).

4-*Azido*-3-*nitrophenyl acetate* (XXIII; R = Ac). 36N-Sulphuric acid (0·2 c.c.) was added to the azido-phenol (14 g.) in acetic anhydride (50 c.c.) at 0°. The dark solution was cautiously warmed to 40° to complete the reaction. After 15 min. at 40°, addition to crushed ice (200 g.) precipitated the *acetate* (15 g., 88%) which after two crystallisations from hexane–benzene (10 : 1) formed white needles, m. p. 75—76° (decomp. 80°) (Found: C, 43·8; H, 2·8; N, 24·8. $C_8H_6N_4O_4$ requires C, 43·3; H, 2·7; N, 25·2%), $\nu_{max.}$ 2100 (N_3); 1750 (CO); 1530 cm.$^{-1}$ (NO_2).

5-*Acetoxybenzofuroxan* (XXIV; R = Ac). 4-Azido-3-nitrophenyl acetate (10 g.) was refluxed in toluene (100 c.c.) for 2 hr. The dark solution was treated with charcoal and most of the solvent removed at 80°/20 mm. Addition of light petroleum (25 c.c.) and cooling gave 5-*acetoxybenzofuroxan* (6·5 g., 75%) as pale yellow plates which separated from ethyl acetate–light petroleum (2 : 1), m. p. 66—67° (Found: C, 49·4; H, 3·3; N, 14·4. $C_8H_6N_2O$ requires C, 49·5; H, 3·9; N, 14·4%). $\nu_{max.}$ 1750 (CO); 1620, 1590, 1540 cm.$^{-1}$ (benzofuroxan ring).

5-*Hydroxybenzofuroxan* (XXIV; R = H). (*a*) 5-Acetoxybenzofuroxan (0·5 g.) was heated in ethanol (50 c.c.) and N-hydrochloric acid (50 c.c.) for 12 hr. at 40°. Solvent evaporation at 50°/10 mm. gave red crystals of 5-hydroxybenzofuroxan hydrochloride which were recrystallised cautiously from ethanol. Shaking of the hydrochloride with water gave the free *base* as yellow powder, m. p. 140° (decomp.). Attempts to crystallise or purify this material by chromatography resulted in decomposition.

(*b*) Hydrogen chloride gas was passed into a solution of the acetoxy-compound in ethanol for 5 min. Removal of solvent now gave the hydrochloride as above. This procedure is advantageous in that it requires less heating to remove solvent. $\nu_{max.}$ 3440 (OH); 1630, 1585, 1550 cm.$^{-1}$ (benzofuroxan).

This work was carried out during the tenure (by P. B. G.) of a Science Research Council Studentship.

School of Chemical Sciences,
University of East Anglia, Norwich.

[5/1240 *Received, November 18th*, 1965]