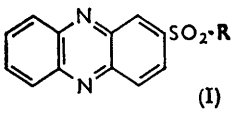
## 859. *Action of Arylsulphinic Acids on Phenazine and its Derivatives.*

By William Bradley and John D. Hannon.

The formation of 2-phenylsulphonylphenazine by reaction of phenazine with benzenesulphinic acid (Hinsberg and Himmelschein's reaction) has been confirmed and extended to the preparation of analogous sulphones from toluene-*p*-, *p*-chlorobenzene-, and 2,5-dichlorobenzene-sulphinic acid. 2,7-Diarylsulphonylphenazines are also formed in the reaction. The mechanism of the substitution has been established, and it has been found also that sulphinic acids replace a 2-chloro-substituent in phenazine without rearrangement.

After it had been shown that benzenesulphinic acid and *p*-benzoquinone reacted to form 2-phenylsulphonylquinol [1] Hinsberg and Himmelschein [2] discovered a similar reaction with phenazine. They considered the product to be 2-phenylsulphonylphenazine (I; R = Ph) on the ground that phenazine could be considered as having an *o*-quinonoid structure. This orientation has now been confirmed and a further study of the reaction

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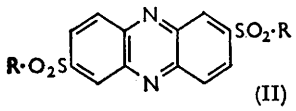



(II)

has shown that similar products (I) are formed with toluene-*p*-, *p*-chlorobenzene- and 2,5-dichlorobenzene-sulphinic acid and that the corresponding 2,7-diarylsulphones (II) are formed also.

The structures of the 2,7-derivatives were proved by obtaining the same compounds by reaction of the sulphinic acids with 2,7-dichlorophenazine [3] or its *N*-oxide. The monosulphones were proved to be 2-derivatives by converting one of them directly into the 2,7-derivative by further reaction with the sulphinic acid. In forming 2,7-diarylsulphonyl derivatives from 2,7-dichlorophenazine and sulphinic acids it is possible that the entering arylsulphonyl groups take the place of the chlorine atoms which are removed or of the hydrogens in the 3- and 8-position. Both kinds of reaction would lead to the same end-result. It was shown that the first alternative is correct, no vicinal substitution occurring, by deriving 2,7-diarylsulphonylphenazines from 2-arylsulphonyl-7-chlorophenazines by further action of sulphinic acids.

The reaction of benzenesulphinic acid (0·5 mol.) with phenazine (1 mol.) was carried out successfully in alcohol containing hydrochloric acid under reflux as described earlier,[2] but it was also observed that the reaction occurred at room temperature. Formation of a 2-monosulphonyl derivative occurred readily also with toluene-*p*-sulphinic and *p*-chlorobenzenesulphinic acid, and much more slowly also with 2,5-dichlorobenzenesulphinic acid.

When the proportion of benzenesulphinic acid was increased to 3 mol., both 2-phenylsulphonyl- and 2,7-diphenylsulphonyl-phenazine were formed, together with diphenyl sulphoxide. Toluene-*p*-, *p*-chlorobenzene-, and 2,7-dichlorobenzene-sulphinic acid (3 mol.) gave similarly mixtures of mono- and di-sulphones, but reaction with the last-named required 10 hours' refluxing.

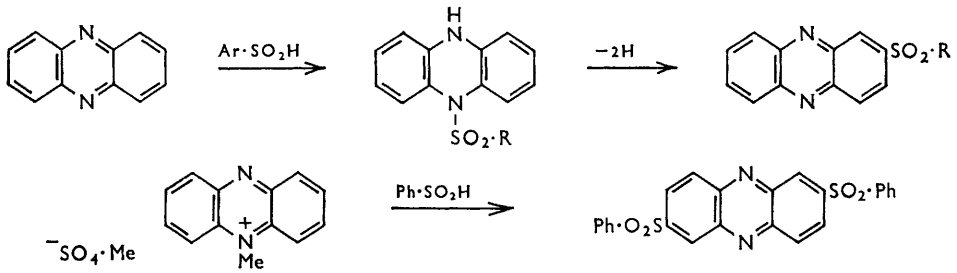
2-Chlorophenazine and benzenesulphinic acid (2 mol.) gave 2-chloro-7-phenylsulphonylphenazine. With benzenesulphinic acid (5 mol.) the same product was obtained, together with 2,7-diphenylsulphonylphenazine, the chlorine substituent having been replaced.

[1] Hinsberg, *Ber.*, 1894, **27**, 3259; 1895, **28**, 1315.
[2] Hinsberg and Himmelschein, *Ber.*, 1896, **29**, 2019.
[3] Pachter and Kloetzel, *J. Amer. Chem. Soc.*, 1952, **74**, 971; Vivian, *ibid.*, 1951, **73**, 457; Bamberger and Ham, *Annalen*, 1911, **382**, 82; Heller, Dietrich, and Reichardt, *J. prakt. Chem.*, 1928, **118**, 144.

The same products, together with diphenyl disulphoxide, resulted when 2-chlorophenazine 5-oxide was used. The structure of 2-chloro-7-phenylsulphonylphenazine was confirmed by a synthesis from *p*-aminodiphenyl sulphone and *p*-chloronitrobenzene.

2,7-Dichlorophenazine and benzenesulphinic acid gave 2,7-diphenylsulphonylphenazine. 2,7-Dichlorophenazine 5-oxide and 2,5-dichlorobenzenesulphinic acid gave 2,7-dichlorophenazine and 2,7-di-(2,5-dichlorophenylsulphonyl)phenazine. The formation of 2,7-dichlorophenazine from the corresponding *N*-oxide indicates that reduction of the oxide by the sulphinic acid occurs and this is doubtless the reason why substituted phenazines and their *N*-oxides give the same products on reaction with sulphinic acids.

Whilst phenazine and its derivatives undergo ready substitution by arylsulphonyl groups on being heated with free arylsulphinic acids there is no corresponding reaction when the sodium salts of the acids are used. It may be concluded that the introduction of arylsulphonyl groups does not proceed by simple substitution by a nucleophile, and this is confirmed by the resistance of phenazine to substitution by ammonia, aniline, sodium anilide, or potassium hydroxide. A more probable mechanism is addition of the sulphinic acids to the azine nucleus followed by nitrogen-to-carbon rearrangement of the




arylsulphonyl groups. This was supported by the observation that on being heated with benzenesulphinic acid (6 mol.) phenazine methosulphate gave 2,7-diphenylsulphonylphenazine. In this example simple nucleophilic substitution would have been expected to have given a 3,6-derivative.

There was no corresponding reaction with acridine.

## Experimental

Identifications claimed were confirmed by mixed melting points.

2-p-*Tolylsulphonylphenazine.*—Phenazine (1·0 g.) and toluene-*p*-sulphinic acid (0·48 g.) were dissolved in cold alcohol (50 ml.), and the solution was then acidified to litmus with hydrochloric acid and slowly heated to boiling. After 30 minutes' refluxing the colour became green and a yellow precipitate was formed. The suspension was cooled, and the solid *product* was collected and crystallised from alcohol as yellow plates (0·6 g.), m. p. 253—254° (Found: C, 68·4; H, 4·4; N, 8·7. $C_{19}H_{14}N_2O_2S$ requires C, 68·2; H, 4·2; N, 8·4%). The sulphone did not react with alcoholic ammonia at 170—180°, aniline under reflux, or sodium anilide in aniline at 50°. With toluene-*p*-sulphinic acid (1·0 g.) in boiling ethanol (50 ml.) for 12 hr. 2-*p*-tolylsulphonylphenazine (0·35 g.) gave 2,7-di-*p*-tolylsulphonylphenazine (0·4 g.), identical with the product discussed below.

The following derivatives were prepared analogously: 2-p-*Chlorophenylsulphonylphenazine* (0·2 g.), m. p. 235° (Found: C, 60·6; H, 3·3; Cl, 10·4; S, 9·2. $C_{18}H_{11}ClN_2O_2S$ requires C, 61·0; H, 3·2; Cl, 10·0; S, 9·1%), from phenazine (1·0 g.) and *p*-chlorobenzenesulphinic acid (0·48 g.). 2-(2,5-*Dichlorophenylsulphonyl*)*phenazine* (0·18 g.), m. p. 205—206° (Found: C, 55·2; H, 2·6; S, 8·5. $C_{18}H_{10}Cl_2N_2O_2S$ requires C, 55·5; H, 2·6; S, 8·2%), from phenazine (1·0 g.) and 2,5-dichlorobenzenesulphinic acid (0·58 g.) after 18 hours' refluxing.

2-Phenylsulphonylphenazine (0·5 g.), m. p. 247° (Found: C, 67·2; H, 3·7; S, 9·5. Calc. for $C_{18}H_{12}N_2O_2S$: C, 67·5; H, 3·7; S, 10·0%), from phenazine (0·9 g.) and benzenesulphinic

acid (0·36 g.) after heating at 30—40° during 10 min. (green solution) and then refluxing for 10 min. longer. The same derivative (0·2 g.) was formed when the reactants were shaken at room temperature for 20 hr. 2-Phenylsulphonylphenazine is insoluble in water but dissolves in concentrated hydrochloric acid with a yellow colour. It was recovered unaltered after being heated at 100° with 40% sodium hydroxide. There was no reaction when phenazine was refluxed in ethanol with sodium benzenesulphinate.

2,7-*Diphenylsulphonylphenazine*.—Phenazine (1·16 g.) and benzenesulphinic acid (2·7 g.) were dissolved in alcohol (50 ml.), acidified to litmus with hydrochloric acid, and then refluxed for 40 min. A yellow precipitate (A) was formed and this was collected from the hot suspension. The cooled filtrate gave a further precipitate of 2-phenylsulphonylphenazine, and after this had been collected the filtrate obtained was concentrated to 10 ml. and then cooled; diphenyl disulphoxide (0·8 g.), m. p. 45° (from alcohol), was obtained as colourless crystals.

Fraction (A) was extracted with ethanol (800 ml.) under reflux. A part dissolved leaving a residue. The soluble fraction was 2-phenylsulphonylphenazine (total yield, 0·5 g.), m. p. 246—247° after crystallisation from acetic acid. The ethanol-insoluble residue, crystallised from *o*-dichlorobenzene, gave 2,7-*diphenylsulphonylphenazine* (0·4 g.), m. p. 334—335° (Found: C, 62·1; H, 3·7; S, 13·5. $C_{24}H_{16}N_2O_4S_2$ requires C, 62·6; H, 3·5; S, 13·8%).

The same derivative (0·35 g.) was formed when 2,7-dichlorophenazine (0·4 g.) and benzenesulphinic acid (2·0 g.) were heated in ethanol (20 ml.) at 130—140° for 18 hr.

2,7-*Di*-p-*tolylsulphonylphenazine* (0·8 g.), m. p. 349—350° (Found: C, 64·2; H, 4·2; S, 13·5. $C_{26}H_{20}N_2O_4S_2$ requires C, 64·0; H, 4·1; S, 13·1%), was obtained analogously, together with 2-*p*-tolylsulphonylphenazine (0·26 g.) by reaction of phenazine (1·0 g.) with toluene-*p*-sulphinic acid (2·6 g.).

Phenazine (1·0 g.) and *p*-chlorobenzenesulphinic acid (2·88 g.) gave 2-*p*-chlorophenylsulphonylphenazine (0·2 g.) and 2,7-*di*-p-*chlorophenylsulphonylphenazine* (0·95 g.), m. p. 355° (Found: N, 5·3; Cl, 13·8; S, 12·3. $C_{24}H_{14}Cl_2N_2O_4S_2$ requires N, 5·3; Cl, 13·4; S, 12·1%). This derivative was very sparingly soluble in chlorobenzene or dichlorobenzene; it crystallised from 1,2,4-trichlorobenzene.

Analogously, phenazine (1·0 g.) and 2,5-dichlorobenzenesulphinic acid (3·2 g.) gave, after 10 hours' refluxing in acidified ethanol, 2-(2,5-dichlorophenylsulphonyl)phenazine (0·2 g.) and 2,7-*di*-(2,5-*dichlorophenylsulphonyl*)*phenazine* (1·5 g.), m. p. 309—310° (Found: C, 47·9; H, 2·2; N, 4·5; S, 10·4. $C_{24}H_{12}Cl_4N_2O_4S_2$ requires C, 48·2; H, 2·0; N, 4·7; S, 10·7%), much more easily soluble than the other 2,7-disulphones prepared but crystallising readily from acetic acid.

2-*Chloro*-7-*phenylsulphonylphenazine*.—2-Chlorophenazine (0·66 g.) and benzenesulphinic acid (0·8 g.) were refluxed for 20 hr. in ethanol (50 ml.), then cooled and kept for 12 hr. The precipitate which was formed was crystallised from toluene and this afforded yellow plates (0·9 g.), m. p. 272° (Found: C, 61·3; H, 3·4; N, 8·3; S, 8·9; Cl, 9·9. $C_{18}H_{11}ClN_2O_2S$ requires C, 61·1; H, 3·1; N, 8·0; S, 9·0; Cl, 10·0%), which consisted of 2-*chloro*-7-*phenylsulphonylphenazine*.

When the proportion of benzenesulphinic acid was increased to 2·8 g., the products were 2-chloro-7-phenylsulphonylphenazine (0·45 g.) and 2,7-diphenylsulphonylphenazine (0·55 g.). The last was identical with the disulphone prepared directly from phenazine and benzenesulphinic acid.

On being heated with benzenesulphinic acid (1·0 g.) in ethanol (30 ml.) at 130—140° for 17 hr., 2-chloro-7-phenylsulphonylphenazine (0·5 g.) afforded a brown precipitate. This was collected and extracted with toluene. The yellow residue (0·3 g.) which resulted crystallised from *o*-dichlorobenzene. 2,7-Di(phenylsulphonyl)phenazine, m. p. 333—334° (Found: S, 13·8%), was obtained, identical with the derivative prepared directly from phenazine.

*Reactions with* 2-*Chloro-*, 2,7-*Dichloro-*, *and* 2-*Chloro*-7-*phenylsulphonyl-phenazine* 5-*Oxide*.—(*a*) 2-Chlorophenazine 5-oxide (1·0 g.) and benzenesulphinic acid (1·2 g.), refluxed in ethanol (50 ml.) for 20 hr., afforded 2-chloro-7-phenylsulphonylphenazine (0·85 g.), identical with the derivatives prepared from benzenesulphinic acid and 2-chlorophenazine.

(*b*) 2-Chlorophenazine 5-oxide (1·0 g.) and benzenesulphinic acid (3·0 g.), heated in ethanol (20 ml.) for 18 hr. at 130—140°, afforded a precipitate (1·15 g.) on being cooled. Extraction of this with toluene gave 2-chloro-7-phenylsulphonylphenazine (0·3 g.) and a residue which was further crystallised from *o*-dichlorobenzene to give 2,7-diphenylsulphonylphenazine (0·6 g.), m. p. 334—335° (Found: C, 62·1; H, 3·5; S, 13·7%), identical with the derivative

prepared from phenazine, 2,7-dichlorophenazine, or 2-chloro-7-phenylsulphonylphenazine. The alcoholic filtrate which remained when the 1·15 g. of precipitate had been removed was evaporated and the residue so obtained was crystallised from aqueous ethanol; diphenyl disulphoxide (0·8 g.), m. p. 45°, was obtained.

There was no reaction when 2-chlorophenazine 5-oxide was heated with sodium benzenesulphinate in alcohol at 140° for 18 hr.

(*c*) 2,7-Dichlorophenazine 5-oxide (1·0 g.), dissolved in benzene (30 ml.), was mixed with benzenesulphinic acid (1·08 g.) in ethanol (30 ml.) and refluxed for 18 hr. The solution so obtained was filtered; the filtrate afforded 2,7-dichlorophenazine (0·8 g.), m. p. 265° (Found: C, 58·2; H, 2·7; Cl, 28·4. Calc. for $C_{12}H_6Cl_2N_2$: C, 57·8; H, 2·4; Cl, 28·5%), and benzenesulphonic acid (0·9 g.).

(*d*) 2,7-Dichlorophenazine 5-oxide (1·0 g.) and benzenesulphinic acid (3·2 g.), heated at 130—140° for 20 hr. in ethanol (30 ml.), afforded a suspension from which the solid was collected; the filtrate afforded diphenyl disulphoxide (1·1 g.). Extraction of the solid with toluene gave a solution from which 2,7-dichlorophenazine (0·15 g.) was obtained; the insoluble part (0·7 g.) was further crystallised from *o*-dichlorobenzene, giving 2,7-diphenylsulphonylphenazine (0·65 g.), m. p. 335°, identical with the derivative prepared from phenazine and benzenesulphinic acid.

2,7-Dichlorophenazine 5-oxide did not react with sodium benzenesulphinate in ethanol at 140—150° during 20 hr.

(*e*) In a similar experiment 2,7-dichlorophenazine 5-oxide (0·5 g.) and 2,5-dichlorobenzenesulphinic acid (1·6 g.) gave 2,7-dichlorophenazine (0·2 g.) and 2,7-di-(2,5-dichlorophenylsulphonyl)phenazine (0·35 g.), m. p. 309° (Found: N, 4·3; S, 10·4%), identical with the derivative prepared from phenazine and 2,5-dichlorobenzenesulphinic acid.

(*f*) *2-Chloro-7-phenylsulphonylphenazine 5-Oxide.*—*p*-Aminodiphenyl sulphone (5 g.), *p*-chloronitrobenzene (8 g.), and potassium hydroxide (8 g.) were refluxed with stirring in benzene (25 ml.) for 18 hr. The suspension which was formed was added to water (50 ml.) and then filtered. The residue (2 g.) was extracted with benzene (charcoal), and the extract evaporated to 15 ml. A precipitate (0·3 g.) was formed which on being crystallised from benzene gave golden-yellow needles (0·17 g.) of *2-chloro-7-phenylsulphonylphenazine 5-oxide*, m. p. 210° (Found: N, 7·2. $C_{18}H_{11}O_3N_2SCl$ requires N, 7·5%).

This oxide (0·1 g.) was heated with benzenesulphinic acid (0·4 g.) in a sealed tube at 140—150° for 18 hr. A yellow product was formed which on being crystallised from *o*-dichlorobenzene gave 2,7-diphenylsulphonylphenazine (0·03 g.), m. p. 335°, not depressed in m. p. by the disulphone prepared from 2,7-dichlorophenazine 5-oxide and an excess of benzenesulphinic acid.

*Reaction of 5-Methylphenazinium Methosulphate and Benzenesulphinic Acid.*—The methosulphate (0·6 g.) and sulphinic acid (1·8 g.) were refluxed for 1 hr. in ethanol (50 ml.). A precipitate was formed and this was collected from the hot suspension. After being dried and crystallised from *o*-dichlorobenzene it was identified as 2,7-diphenylsulphonylphenazine (0·35 g.), m. p. 335°.

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