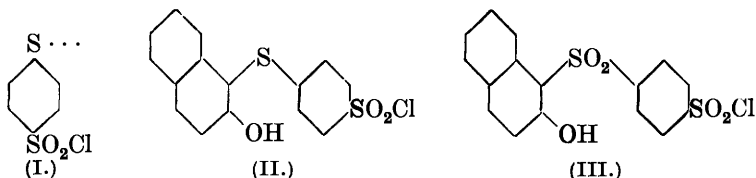


134. *The Rearrangement of Hydroxy-sulphones.* *Part II.*

By LEONARD ARTHUR WARREN and SAMUEL SMILES.

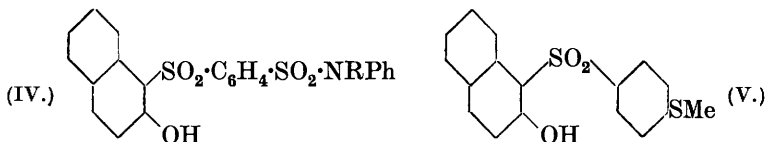
IN previous experiments (Levi, Rains, and Smiles, J., 1931, 3264) which were designed to test the validity of the explanation given to the rearrangement of 2-naphthol-1-sulphone (Warren and Smiles, J., 1931, 2207) it was shown that the *o*-phenolic ion was capable of displacing sulphonyl from an ortho-position with respect to the nitro-group in 2-hydroxy-2'-nitro-derivatives of diphenyl- or naphthylphenyl-sulphone, the sulphinic acids derived from the corresponding ethers being isolated. In the experiments now described, the study of this type of rearrangement has been continued by an examination of *o*-hydroxy-*p'*-sulphonyl sulphones (*e.g.*, IX).

The sulphonyl chloride (I) derived from diphenyl disulphide yielded on treatment with chlorine an active chlorothioli; this was



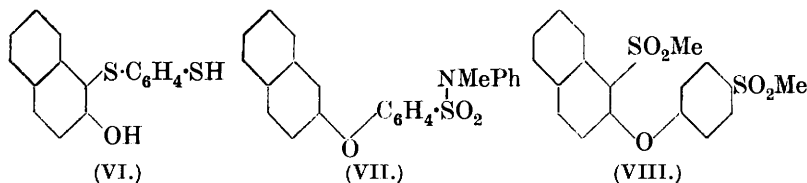
not isolated but by reaction with 2-naphthol in solution it yielded the *sulphide* (II), which was sufficiently stable in acetic acid to

endure oxidation to the *sulphone* (III). Similarly the *anilide* and *methylanilide* of (II) gave the *sulphones* (IV; R = H or Me). The *thiol* derived from (III) by reduction gave a zinc salt which was stable in the presence of acetic acid; with methyl iodide this salt yielded a *monomethyl* ether which was evidently (V), since it was not attacked by mild oxidising agents such as ferric chloride; more vigorous agents readily yielded the *disulphone* (IX). This disulphone was also obtained from (II) by selectively methylating the corresponding *thiol* (VI) by means of its zinc salt, the process being similar to that



available with other hydroxy-thiols such as "iso"-2-naphthol sulphide (Warren and Smiles, J., 1930, 960) for the preparation of their *S*-methyl ethers. Oxidation of this *S*-methyl ether of (VI) gave the disulphone (IX).

In the sulphones (IV; R = H or Me) and (IX) the intramolecular conditions regarded as favourable to the rearrangement are present. Accordingly, (X) may be expected to be formed from (IX), and the

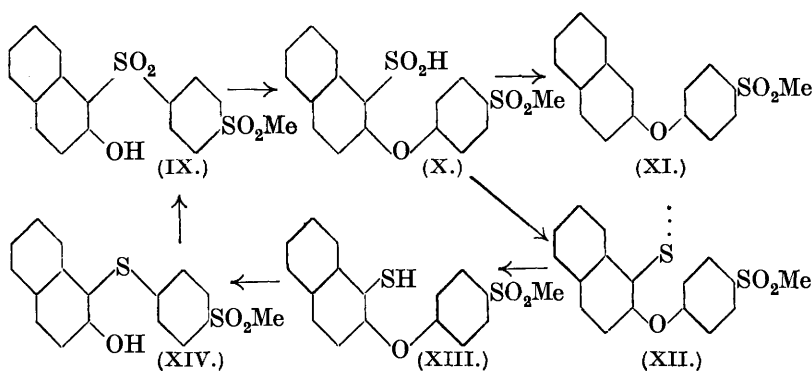


corresponding sulphonamides from (IV). These rearrangements may indeed be effected, but not under the relatively mild conditions sufficient with *o*-nitro-sulphones of analogous structure (Levi, Rains, and Smiles, *loc. cit.*); a considerably higher temperature is required (150°). Under this condition and in presence of 1 mol. of *N*-sodium hydroxide the naphthyl-1-sulphinic acids (*e.g.*, X) do not survive, but lose sulphur dioxide and yield the *ethers* (*e.g.*, XI from IX, and VII from IV) (compare the rearrangement of 2-naphthol-1-sulphones; Warren and Smiles, *loc. cit.*). The ether (XI) is identical with synthetic material obtained from potassium 2-naphthoxide and *p*-bromophenylmethylsulphone.

The 4-methylthiol (V) remains unaltered under conditions which effect the rearrangement of the 4-sulphonyl derivatives (*e.g.* IX). This contrast accords with current theory concerning the relative electronic displacements exerted by these substituents at the *p*-

carbon atom of the nucleus in which they occur and is forecast by the interpretation suggested for the rearrangement. The electronic condition generally ascribed to the sulphone group renders it difficult to suppose that these rearrangements involve a mechanism of the type which seemed available in the *o*-nitro-sulphones (Levi, Rains, and Smiles, *loc. cit.*), but the question whether the lessened activity of these *p*-sulphones is due to this circumstance or to the weaker positive character of the carbon atom from which the sulphone group is displaced or to both these factors must at present be left unanswered.

Experiments made to determine the influence of excess of alkali on these displacements showed that in the disulphone (IX) the change was not retarded and that, whilst the ether (XI) was usually formed in small amount, the sulphonic acid (X) survived. This acid was not isolated in the crystalline state, but it was characterised by (a) methylation, the product being different from the isomeric *methyl ether* of (IX), (b) conversion into the *disulphide* (XII), and



(c) conversion into the ether (XI) by oxidation, followed by hydrolysis of the 1-sulpho-group. Reduction of the disulphide (XII) gave the *thiol* (XIII). This substance provides intramolecular conditions similar to those obtaining in "*iso*"-2-naphthol sulphide (Warren and Smiles, J., 1931, 914) and accordingly, in presence of alkali, displacement of the oxido-group by the thiol ion occurs with formation of the *sulphide* (XIV), this retrograde change taking place rapidly at 90–100°. The product, an isomeride of (V), was identified by oxidation, which led to the original disulphone (IX).

Of the three sulphones now examined, the anilide (IV; R = H) is the only case in which rearrangement is strongly retarded by excess of alkali. This character has already been recorded with the change of 2-naphthol-1-sulphone (Warren and Smiles, J., 1931, 2209). If the few data at present available be admitted, it would seem that

the behaviour is due to the inclusion of alkali metal in the substituent before attack of the *p*- or *o*-carbon atom has taken place; in this circumstance a weakening of the positive character of the latter might be expected with a consequent adverse influence on the displacement.

The rearrangement of three different types of *o*-hydroxy-sulphone has now been described and in each of these the retrograde change of thiol-oxide to hydroxy-sulphide has been accomplished, but the present example is the first in which both the sulphinic acid and the thiol-oxide (*e.g.*, X and XIII) have been encountered while passing through the cycle (*e.g.*, IX \rightarrow X \rightarrow XIII \rightarrow XIV \rightarrow IX).

EXPERIMENTAL.

4-Chlorosulphonylphenyl-2-hydroxy-1-naphthyl Sulphide (II).—The yield of sulphonyl chloride obtained from potassium *p*-dithiobenzene-sulphonate by reaction with phosphoryl chloride (100°) was much improved by an increase in the proportion of the latter reagent (1 part salt : 2 parts POCl₃) compared with that recorded by Zincke and Frohneberg (*Ber.*, 1909, **42**, 2726). An agitated suspension of this sulphonyl chloride (I) (10 g.) in carbon tetrachloride (50 c.c.) was treated with dry chlorine until solution was complete. After removal of the excess of halogen, the chlorothiol separated in the crystalline state; 2-naphthol (7 g.) in warm carbon tetrachloride was then added to the stirred suspension. The desired product (15 g.), crystallised from benzene–light petroleum, had m. p. 160° (Found: C, 54.9; H, 3.3. C₁₆H₁₁O₃ClS₂ requires C, 54.8; H, 3.1%); it gave a green colour with alcoholic ferric chloride. The *anilide*, obtained from the sulphonyl chloride and warm aniline, crystallised from acetic acid in plates, m. p. 156° (Found: C, 65.1; H, 4.4. C₂₂H₁₇O₃NS₂ requires C, 64.9; H, 4.2%). The *methyl-anilide* formed needles, m. p. 115°, from alcohol (Found: C, 65.5; H, 4.7. C₂₃H₁₉O₃NS₂ requires C, 65.5; H, 4.5%).

2-Hydroxy-1-naphthylphenylsulphone-4'-sulphonanilide (IV; R = H) separated in plates, m. p. 204° (4.5 g.), when a solution of the sulphide (5 g.) in acetic acid (25 c.c.) containing hydrogen peroxide (3.5 c.c.; 30%) was kept at 100° (1 hour). It gave a green colour with ferric chloride in alcohol (Found: C, 60.0; H, 4.1; N, 3.1. C₂₂H₁₇O₅NS₂ requires C, 60.1; H, 3.9; N, 3.2%).

2-Hydroxy-1-naphthylphenylsulphone-4'-sulphonmethylanilide (IV; R = Me), obtained similarly from the corresponding sulphide, formed plates, m. p. 181° (Found: C, 60.9; H, 4.3; S, 13.8. C₂₃H₁₉O₅NS₂ requires C, 60.9; H, 4.2; S, 14.1%).

2-Hydroxy-1-naphthylphenylsulphone-4'-sulphonyl Chloride (III).—A solution of the sulphide (II) (5 g.) in acetic acid (50 c.c.) contain-

ing hydrogen peroxide (5 c.c.; 30%) was warmed (100°). After a few minutes the sulfoxide partly separated, but rapidly dissolved when more hydrogen peroxide (2 c.c.) had been added; the required *sulphone* soon separated (*ca.* 5 mins.) (yield, 70%). It formed plates, m. p. 184° from acetic acid (Found: C, 50·2; H, 3·1. $C_{16}H_{11}O_5ClS_2$ requires C, 50·2; H, 2·9%). The substance gave a colourless solution in sulphuric acid (the sulfoxide gives an intensely green solution). It was further characterised by conversion into the anilide (IV; R = H) by reaction with warm aniline.

2-Hydroxy-1-naphthyl-4'-thiolphenylsulphone,
 $C_{10}H_6(OH) \cdot SO_2 \cdot C_6H_4 \cdot SH$.

—The sulphonyl chloride (III) (5 g.) was reduced in hot acetic acid (40 c.c.) with zinc dust and concentrated hydrochloric acid (10 c.c.), the excess of zinc removed, and the solution mixed with ice and water. The required *thiol* separated and was obtained from alcohol in plates, m. p. 129° (Found: C, 60·5; H, 3·8; S, 20·2. $C_{16}H_{12}O_3S_2$ requires C, 60·7; H, 3·8; S, 20·3%). With alcoholic ferric chloride it gave an intense green colour, which rapidly faded, the disulphide separating.

2-Hydroxy-1-naphthyl-4'-methylthiolphenylsulphone (V).—The zinc salt of the thiol was boiled with methyl alcohol and excess of methyl iodide until it dissolved. The greater portion of the solvent was then evaporated, and the solution mixed with water. The *methylthiol*, which separated, was obtained from acetic acid in plates, m. p. 151° (Found: C, 61·6; H, 4·3; S, 19·4. $C_{17}H_{14}O_3S_2$ requires C, 61·8; H, 4·2; S, 19·4%).

4-Thiolphenyl-2-hydroxy-1-naphthyl Sulphide (VI).—The sulphonyl chloride (II) (10 g.) in hot acetic acid (75 c.c.) was reduced with zinc dust and concentrated hydrochloric acid (25 c.c.) and the filtered solution mixed with water. The *thiol* obtained formed needles, m. p. 101°, from alcohol (Found: C, 67·3; H, 4·0. $C_{16}H_{12}OS_2$ requires C, 67·6; H, 4·2%). It gave a fugitive green colour with alcoholic ferric chloride.

2-Hydroxy-1-naphthyl-4'-methanesulphonylphenylsulphone (IX).—

(a) The zinc salt obtained from the thiol (VI) (8 g.) and zinc acetate in alcohol was suspended in boiling methyl alcohol (80 c.c.) and methyl iodide (10 c.c.); it dissolved after 3 hours. The solvent was removed, and the residue repeatedly extracted with hot water. The colourless viscous *S*-methyl ether of (VI) was treated in hot (100°) acetic acid (50 c.c.) with an excess of hydrogen peroxide (30%; 15 c.c.) for $\frac{3}{4}$ hour and, the oxidation being incomplete, again with hydrogen peroxide (5 c.c.) for $\frac{1}{2}$ hour. The *disulphone* (7 g.) crystallised from the cooled and agitated liquid; recrystallised from acetic acid, it formed needles, m. p. 190°.

(b) The same substance, m. p. 190° , was readily obtained when the corresponding methylthiol (V) was oxidised with hydrogen peroxide in the usual manner (Found : C, 56.2; H, 4.0; S, 17.8. $C_{17}H_{14}O_5S_2$ requires C, 56.35; H, 3.9; S, 17.7%). The yellow sodium derivative was sparingly soluble in excess of aqueous alkali hydroxide.

2-Methoxy-1-naphthyl-4'-methanesulphonylphenylsulphone, formed from (IX) by reaction with methyl sulphate in presence of warm alkali hydroxide, crystallised from acetic acid in plates, m. p. 176° (Found : C, 57.7; H, 4.4. $C_{18}H_{16}O_5S_2$ requires C, 57.4; H, 4.3%).

The Rearrangement of the Disulphones (IV; R = H or Me) and (IX).—At 100° , none of the disulphones was affected by *N*-sodium hydroxide. When heated with 1 mol. of *N*-sodium hydroxide at 150° for 2 hours, the three disulphones gave sodium sulphite and approximately 50% yields of the respective ethers (e.g., VII and XI); more than this can hardly be expected, since the sulphurous acid formed liberates half the naphthol from its sodium salt before this has undergone the change. With excess of alkali, the anilide (IV; R = H) behaved exceptionally, whereas the methylanilide (IV; R = Me) and the methylsulphone (IX) gave very little sulphite and good yields of the sulphinic acids.

Reaction of the methylanilide with alkali hydroxide. (a) The product obtained (2 hours; 150°) from the methylanilide (1 g.) and *N*-sodium hydroxide (1 mol.) was treated with warm dilute sulphuric acid until liberation of sulphur dioxide was complete. A solution of the viscous mass in a little warm alcohol was mixed with excess of 2*N*-sodium hydroxide. The solution when acidified yielded the original anilide (0.4 g.). The solid insoluble in the aqueous alkali was *4-methylanilinosulphonylphenyl 2-naphthyl ether* (VII), which crystallised from alcohol in needles, m. p. 125° (Found : C, 71.0; H, 4.6; N, 3.6. $C_{23}H_{19}O_3NS$ requires C, 70.95; H, 4.9; N, 3.6%).

(b) In presence of 2 mols. of *N*-sodium hydroxide the methylanilide (1 g.) gave 0.9 g. of the ether (VII), and none of the original substance could be detected in the product.

(c) The product from the action of 8 mols. of *N*-sodium hydroxide on the methylanilide (1 g.) also yielded this ether (0.5 g.). None of the original anilide was isolated, but a considerable quantity of a viscous material, evidently a sulphinic acid (e.g., X), was obtained which could not be closely characterised. Nevertheless it is clear from these comparative experiments that the rearrangement of the methylanilide is not retarded by excess of dilute alkali.

Reaction of the anilide (IV; R = H) with alkali hydroxide. (a) The product from 1 g. of the anilide and 1 mol. of *N*-sodium hydroxide

oxide contained sulphite and a viscous material, from which the original anilide (0.4—0.5 g.) was isolated together with a resinous material. The latter evidently consisted mainly of the ether related to (VII), since on methylation in presence of alkali it yielded that substance (0.3 g.; m. p. 124—125°).

(b) With 2 mols. of *N*-sodium hydroxide, only 0.1 g. of the anilide was recovered, and 0.6 g. of the ether (VII) was isolated after methylation of the remainder of the product.

(c) After treatment with 8 mols. of *N*-sodium hydroxide at 150° (2 hours), 0.9 g. of the original anilide (1 g.) was recovered unchanged. It is thus evident that the rearrangement of this anilide is inhibited by excess of alkali hydroxide.

Rearrangement of the methylsulphone (IX). (a) With 1 mol. of *N*-sodium hydroxide at 150° (2 hours). The aqueous liquor contained sulphite. When aqueous alkali (2*N*) was added to a solution of the viscous product in a little alcohol, a solution of the original material (0.2 g.) was obtained; the insoluble crystalline material was 4-methanesulphonylphenyl 2-naphthyl ether (XI), which formed plates, m. p. 104°, from alcohol (Found: C, 68.5; H, 4.9; S, 10.9. $C_{17}H_{14}O_3S$ requires C, 68.5; H, 4.7; S, 10.7%). This ether was synthesised by evaporating a solution of 2-naphthol (10 g.) and potassium hydroxide (3.5 g.) in a little water in an atmosphere of nitrogen, heating the dry residue with 4-bromophenylmethylsulphone (10 g.) and a little copper powder at 230° for 2½ hours, dissolving the cold mass in alcohol (charcoal), and adding aqueous alkali until a solid began to separate; this, after repeated crystallisation from methyl alcohol (charcoal), formed plates, m. p. 104°, alone or mixed with the above ether (XI).

(b) With 2 and 8 mols. of *N*-sodium hydroxide at 150° (2 hours). The product in each case contained merely traces of sulphite and neither the original sulphone (IX) nor the ether (XI), and was evidently 4-methanesulphonylphenyl 1-sulphino-2-naphthyl ether (X) for the reasons given in the theoretical part. It gave the usual colour reaction of sulphinic acids in sulphuric acid with anisole, and when treated in methyl alcohol with methyl sulphate and potassium hydroxide yielded 4-methanesulphonylphenyl 1-sulphinomethoxy-2-naphthyl ether (VIII), which crystallised from acetic acid in needles, m. p. 189° (Found: C, 57.5; H, 4.2; S, 16.7. $C_{18}H_{16}O_5S_2$ requires C, 57.45; H, 4.3; S, 17.0%); a mixture of these with the methyl ether (m. p. 176°) of (IX) melted at 153—166°.

Conversion of the sulphinic acid (X) into the ether (XI) was effected by a slight excess of warm aqueous alkaline potassium permanganate: the filtered solution was mixed with cold dilute

sulphuric acid, again filtered, and concentrated (100°), more sulphuric acid being added if necessary; the ether (XI), which separated as a liquid and solidified on treatment with cold aqueous alkali, had m. p. and mixed m. p. 104° after crystallisation from alcohol.

2-(4'-*Methanesulphonylphenoxy*)-1-naphthyl disulphide (XII), obtained from the sulphinic acid (X) by the usual method of reduction in hot acetic acid with hydrogen iodide in presence of a little sulphur dioxide, formed pale yellow needles, m. p. 218° , from acetic acid (Found: C, 62.0; H, 4.2; S, 19.2; *M*, 690. $C_{34}H_{26}O_6S_4$ requires C, 62.0; H, 4.0; S, 19.5%; *M*, 658).

2-(4'-*Methanesulphonylphenoxy*)-1-naphthylthiol (XIII).—The disulphide (XII) was reduced in hot acetic acid with zinc dust, hydrochloric acid added to decompose the zinc salt of the thiol, and the filtered solution cooled and mixed with water. The thiol, which separated, crystallised from alcohol in plates, m. p. 146° (Found: C, 61.8; H, 4.4. $C_{17}H_{14}O_3S_2$ requires C, 61.8; H, 4.2%). It gave Rheinboldt's reaction for aromatic thiols and was converted into the disulphide by oxidation.

4-*Methanesulphonylphenyl-2-hydroxy-1-naphthyl Sulphide* (XIV).—When the colourless solution of the thiol (XIII) in aqueous sodium hydroxide (2*N*) was heated (100° ; $\frac{1}{2}$ hour), it became yellow. The sulphide (XIV), liberated in the usual manner, formed prisms, m. p. 189° , from acetic acid (Found: C, 61.9; H, 4.3; S, 19.2. $C_{17}H_{14}O_3S_2$ requires C, 61.8; H, 4.2; S, 19.4%). With alcoholic ferric chloride, it gave a green colour, whereas the thiol (XIII) remained colourless. The sulphide (2 g.) was oxidised by hydrogen peroxide (30%; 4 c.c.) in acetic acid at 100° ($\frac{1}{2}$ hour). When the liquid was cooled, the product separated; after purification from acetic acid, it had m. p. 190° , alone or mixed with the disulphide (IX). A mixture of the product with the sulphide (XIV) (m. p. 189°) melted at 160 — 170° .