CXXXII.—*The Conversion of* iso-β-*Naphthol Sulphide into* 2-*Naphthol* 1-*Sulphide.*

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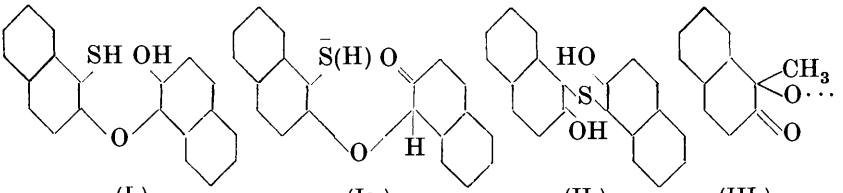
IT has been shown (J., 1930, 956) that *iso*-β-naphthol sulphide is (I), a thiol derived from 1 : 2′-dinaphthyl ether; the conversion of this substance into 2-naphthol 1-sulphide (II) thus appears as an

intramolecular change of a novel type and it accordingly merits further consideration.

Experiments are now described which were made with the view of defining the chief structural conditions controlling the change, and a brief discussion of the mechanism of the process is undertaken.

The conversion is effected by heat, either alone or in suitable solvents, and by alkalis. Experiments have been made to determine the extent and rate of the change in presence of various amounts and concentrations of alkali hydroxide; but, mainly on account of intractable by-products and the difficulty of estimating the two sulphides in the mixtures obtained, the data cannot be regarded as anything more than roughly approximate. Nevertheless from qualitative experiments and from these approximate data there is no doubt that the change is more actively promoted by stronger alkaline media than by weaker. For instance, it is comparatively rapid in aqueous alkali hydroxide and slow in ammonia or aqueous sodium carbonate, and pyridine appears to be without effect. Oxidation of the thiol has the noteworthy effect of restraining the change; the *iso*-sulphone (I, where SH is SO_2H; J., 1930, 1329) is stable in presence of warm aqueous alkali hydroxide and the formation of 2-naphthol-1-sulphone (II, where S is SO_2) from it has not been observed. These facts may be interpreted as showing that the negative condition of sulphur in the thiol is of fundamental importance; when this is enhanced by ionisation of the thiol in presence of alkali, the change is promoted, whereas a decrease of this state, as found in the sulphinic acid, restrains the process.



(I.) (Ia.) (II.) (III.)

Further information has been gained from the two isomeric monomethyl ethers of the *iso*-sulphide. It has been already recorded (J., 1930, 960) that the *S*-methyl ether (I, where SH is SMe), which is obtained from the zinc salt and methyl iodide, is stable in presence of warm aqueous alkali. This result is clearly to be anticipated and accords with the structure assigned to the *iso*-sulphide. The behaviour of the *O*-methyl ether (I, where OH is OMe) also has been examined. The disulphide derived from (I) yields the corresponding dimethoxy-sulphide when treated with diazomethane. It may be noted here that the improbable *C*-methyl

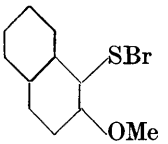
structure for this product of methylation cannot be accepted, since it involves the presence of the arrangement (III) which contains the structure of dehydro-1-methyl-2-naphthol (Pummerer and Cherbuliez, *Ber.*, 1914, **47**, 2979) and must accordingly yield 1-methyl-2-naphthol on reduction. The methylated disulphide has not the properties of a quinol associated with the dehydro-structure and on reduction it yields the required *O*-methyl ether of the thiol (I). It might be expected that this ether, having the unsubstituted thiol group of (I), would yield the monomethyl ether of (II) on treatment with alkali. The latter substance, being unknown, was synthesised, since a knowledge of its properties would facilitate recognition if it were formed; it was obtained by reaction of 1-bromothiol-2-methoxynaphthalene (IV) with 2-naphthol. This substance, however, could not be detected as the result of the action of warm aqueous alkali on the *O*-methyl ether in question; in fact the greater part of the latter was recovered unchanged.

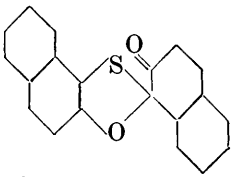
The behaviour of the *iso*-sulphide, like that of other 1-derivatives of 2-naphthol, as the ketonic tautomeride (Ia) is illustrated by the smooth formation of the cyclic quinol (V) from it by oxidation in presence of alkali or acid. This property suggests that the rearrangement concerns the ketonic tautomeride (Ia) and the suggestion appears all the more acceptable since it leads to a simple explanation of the inactivity of the *O*-methyl ether, in which conversion into this ketonic form is restrained.

In further considering the mechanism of the process, reference must be made to the hypothesis that (Ia) undergoes fission, yielding 1-thiol-2-naphthol or its ion and the quinonoid radical (compare Willstätter and Schuler, *Ber.*, 1928, **61**, 364), which reunite to form the 2-naphthol 1-sulphide (II). This suggestion has been abandoned for the following reasons. Picryl chloride and *1-thiol-2-acetoxynaphthalene* yield the *S*-picryl derivative (VI), which on mild alkaline treatment gives the characteristic dinitrothioxin (VII). The monopicryl derivative of the *iso*-sulphide obtained in the same way is evidently the *S*-picryl derivative (I, where SH is $S{\cdot}C_6H_2N_3O_6$), since it is not oxidised by iodine in presence of bicarbonate. If the hypothesis in question were correct, this substance also should yield with alkali the dinitrothioxin by way of the 1-*S*-picryl-2-naphthol at first liberated. Actually, no trace of the dinitrothioxin could be detected, picric acid and the sulphide (II) being formed after prolonged action.

Consequently this view appears untenable and the rearrangement is regarded as a direct displacement of the oxynaphthyl group from the α-carbon atom by the more highly negative thiol ion. This displacement is evidently due primarily to the positive character

of the α-carbon atom and is facilitated by an increase in this due to the tautomeric capacity of the system set up by the β-hydroxyl.

(IV.) 



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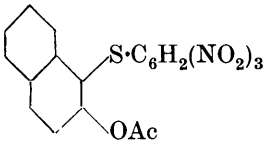
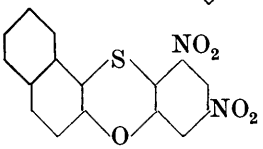
(VI.) 



(VII.)

In the *O*-methyl ether, not only is this tautomerism restrained but the insertion of the electron-repelling methyl group further lessens the positive effect at the α-position, with the result that the change is inhibited under the usual conditions. The inactivity of the *iso*-sulphone (I, where SH is SO_2H), in which the negative condition of the sulphur is diminished, also is simply explained. According to the interpretation now given, it is to be expected that insertion of a powerful electron-attracting group at the β-hydroxyl would tend to favour the change and, if the influence of this were sufficient, the lessened activity due to suppression of the tautomeric system might be compensated. Attempts to obtain the relevant *o*-picryl derivatives of the *iso*-sulphide (I) and sulphide (II) were unsuccessful; evidently these are unstable substances: but experiments support the requirements of theory by showing that the presence of picryl chloride in solution with the *iso*-sulphide remarkably assists the change in heated solvents.

Finally it must be mentioned that in surveying the views expressed it is important to recognise that the displacement is very greatly facilitated not only by the circumstance that the groups concerned co-exist in the same molecule but also by the favourable situation which they occupy with respect to one another. This intimate relation between the sulphur, oxygen, and α-carbon atoms is clearly shown by the quantitative formation of the cyclic quinol (V) when either the *iso*-sulphide (Ia) or 2-naphthol 1-sulphide is oxidised by alkaline ferricyanide or similar means.

EXPERIMENTAL.

Derivatives of 2-Naphthol 1-Sulphide and Disulphide.—Di-2-methoxy-1-naphthyl disulphide was obtained from the hydroxy-disulphide (1 mol.) by reaction with methyl sulphate (6 mols.) in presence of 2*N*-sodium hydroxide (10 mols.). After successive

purification from acetone and alcohol the substance (40% yield) formed yellow prisms, m. p. 20° (Found : C, 70·1 ; H, 5·2. $C_{22}H_{18}O_2S_2$ requires C, 69·8 ; H, 4·8%). The same material was obtained in somewhat better yield by reaction of the disulphide with diazomethane (2 mols.) in ether.

Reduction of this disulphide was easily effected by zinc dust in boiling acetic acid. Hydrochloric acid was added to the colourless mixture to dissolve zinc mercaptide ; addition of water to the cold solution yielded (95%) *1-thiol-2-methoxynaphthalene*, which formed plates, m. p. 68°, from alcohol (Found : C, 69·7 ; H, 5·3. $C_{11}H_{10}OS$ requires C, 69·5 ; H, 5·3%). The substance was converted into the disulphide by iodine in presence of bicarbonate and was further characterised by reaction with sodium chloroacetate. When an aqueous solution of these materials in excess of alkali was warmed (100°), reaction took place rapidly. The required *2-methoxy-1-naphthylthiolacetic acid*, $C_{10}H_6(OMe)\cdot S\cdot CH_2\cdot CO_2H$, separated from hot water in shining scales, m. p. 130°, which in water gave with ferric chloride a brown insoluble iron derivative (Found : C, 62·9 ; H, 5·0. $C_{13}H_{12}O_3S$ requires C, 62·9 ; H, 5·2%).

The monomethyl ether of 2-naphthol 1-sulphide,

$$C_{10}H_6(OMe)\cdot S\cdot C_{10}H_6\cdot OH.$$

A 10% solution of bromine (1 mol.) in carbon tetrachloride was added to a shaken mixture (4 : 1) of this solvent and di-2-methoxy-1-naphthyl disulphide (1 mol.). When formation of the red crystalline bromothiol was complete, a solution of 2-naphthol (2 mols.) in the warm solvent was added. The yellow oil remaining after the solvent had been evaporated solidified in contact with alcohol. The material was purified from acetic acid and had m. p. 155—156° (Found : C, 75·4 ; H, 5·0. $C_{21}H_{16}O_3S$ requires C, 75·9 ; H, 4·8%). The substance is insoluble in cold aqueous alkali and, unlike the corresponding dihydroxy-sulphide, gives no colour with ferric chloride in alcoholic solution.

Di-2-acetoxy-1-naphthyl disulphide, obtained from the hydroxy-disulphide, acetic anhydride, and a little sulphuric acid, formed pale yellow prisms, m. p. 200° (Found : C, 66·4 ; H, 4·3. $C_{24}H_{18}O_4S_2$ requires C, 66·4 ; H, 4·1%).

A solution of this disulphide in acetic acid (1 : 25) was rapidly attacked by zinc dust. When colourless, the solution was mixed with water ; the required *1-thiol-2-acetoxynaphthalene* then separated as an oil which solidified. This substance formed needles, m. p. 120°, from carbon tetrachloride (Found : C, 66·3 ; H, 4·9. $C_{12}H_{10}O_2S$ requires C, 66·1 ; H, 4·6%).

2-Hydroxy-1-naphthylthiolacetic acid, $C_{10}H_6(OH)\cdot S\cdot CH_2\cdot CO_2H$, was formed in almost theoretical yield when an aqueous solution of the

sodium salt of the acetoxy-thiol and sodium chloroacetate was boiled. It was liberated from the cooled solution (charcoal) and, after it had solidified, was purified from water, forming plates, m. p. 118°. It was not attacked by iodine in presence of bicarbonate and gave an intense green colour with ferric chloride in alcohol (Found : C, 61·5; H, 4·4. $C_{12}H_{10}O_3S$ requires C, 61·5; H, 4·3%).

Attempts to obtain the isomeric 1-thiol-2-naphthoxyacetic acid by reaction of the sodium salt of 2-naphthol 1-disulphide with sodium chloro- or bromo-acetate were unsuccessful. Instead of the desired product the thioglycollic acid derivative or the following disubstitution product of the thiol was usually obtained.

1-*Carboxymethylthiol*-2-*naphthoxyacetic acid*,

$$CO_2H\cdot CH_2\cdot S\cdot C_{10}H_6\cdot O\cdot CH_2\cdot CO_2H.$$

Alcohol containing the sodium salt of 2-naphthol 1-disulphide (1 mol.) and sodium bromoacetate (2 mols.) was boiled until reaction was complete. The viscous oil remaining after the solvent had been removed was extracted with boiling water; when mixed with aqueous barium hydroxide, the extracts furnished a sparingly soluble barium salt, from which the *acid* was obtained. This crystallised from hot water in needles, m. p. 161° (Found : C, 57·8; H, 4·2. $C_{14}H_{12}O_5S$ requires C, 57·5; H, 4·1%). It gave an insoluble yellow iron salt with aqueous ferric chloride.

These experiments and many others of a similar type show the instability of the dithio-system in 2-naphthol 1-disulphide even under mildly alkaline conditions.

1-*Thiopicryl*-2-*methoxynaphthalene*, $C_{10}H_6(OMe)\cdot S\cdot C_6H_2(NO_2)_3$. When picryl chloride (1 mol.) was warmed with an alcoholic solution (30 : 1) of 1-thiol-2-methoxynaphthalene, it dissolved and separation of the required *product* began. This crystallised from hot alcohol or acetic acid in orange plates, m. p. 183°; these, when kept, became deep red without change in m. p. (Found : C, 50·5; H, 3·1. $C_{17}H_{11}O_7N_3S$ requires C, 50·9; H, 2·7%). The substance was not attacked by hydrochloric acid in warm acetic acid but was hydrolysed by sodium hydroxide in warm aqueous alcohol.

1-*Thiopicryl*-2-*acetoxynaphthalene*, $C_{10}H_6(O\cdot CO\cdot CH_3)\cdot S\cdot C_6H_2(NO_2)_3$, separated (yield, 90%) when pyridine was added to alcohol which contained picryl chloride (1 mol.) and 1-thiol-2-acetoxynaphthalene (1 mol.). It crystallised from acetic acid in yellow needles, which decomposed violently at 191° (Found : C, 50·0; N, 9·8. $C_{18}H_{11}O_8N_3S$ requires C, 50·3; N, 9·8%). When aqueous sodium hydroxide was added to a warm alcoholic solution of this substance, 9 : 11-dinitrobenz-αβ-naphthathioxin (VII) (this vol., p. 721) separated (90%) in red needles, m. p. 300° (Found : N, 8·5. Calc. : N, 8·2%).

Attempts to obtain a picryl derivative from 2-naphthol 1-sulphide

by reaction with picryl chloride either in presence of pyridine or alone in solvents were unsuccessful. An orange *additive compound*, m. p. 182—184°, was obtained by cooling a concentrated solution of these materials in acetic acid, but it was readily resolved into the components by excess of warm solvent [Found: N, 7·4. $C_{20}H_{14}O_2S,C_6H_2(NO_2)_3\cdot OH$ requires N, 7·7%].

Derivatives of iso-2-*Naphthol Sulphide* (I).—*2'-Methoxy-1-dithio-1 : 2'-dinaphthyl ether* (compare I, where OH is OMe). Dry ether (200 c.c.) containing the disulphide (10 g.) derived from the *iso*-sulphide was mixed with an ethereal solution of diazomethane obtained from nitrosomethylurethane (10 c.c.). The *product* (7 g.), which gradually (12 hours) separated from the yellow solution, crystallised from ethyl acetate in yellow prisms, m. p. 107° (decomp.), containing a molecular proportion of the solvent [Found: C, 73·9; H, 5·1. $(C_{21}H_{15}O_2S)_2,C_4H_8O_2$ requires C, 73·6; H, 5·1%], which was removed at 110°/5 mm. (Found: loss, 11·2. Calc.: loss, 11·7%); the orange crystalline material then had m. p. 128° [Found: C, 76·4; H, 4·5. $(C_{21}H_{15}O_2S)_2$ requires C, 76·1; H, 4·5%]. Also when crystallised from benzene, the substance (m. p. 122—123°, decomp.) retained solvent [Found: C, 77·6; H, 5·0. $(C_{21}H_{15}O_2S)_2,C_6H_6$ requires C, 77·8; H, 4·8%], which was only slowly lost at 110°.

2'-Methoxy-1-thiol-1 : 2'-dinaphthyl ether (I, where OH is OMe). Zinc dust was added to a suspension of the disulphide in a hot mixture of acetic and hydrochloric acids until reduction was complete. When the solution was mixed with water, the required *thiol* separated as a viscous oil; this solidified in contact with alcohol and, purified from that solvent, formed needles, m. p. 112° (Found: C, 76·2; H, 4·9. $C_{21}H_{16}O_2S$ requires C, 75·9; H, 4·8%). Oxidation of the substance gave the original disulphide. It was further identified by complete methylation (methyl sulphate) in aqueous alkali; the product, purified from ether–chloroform, had m. p. 177—178° and was identical with the product from the dimethyl ether of the *iso*-sulphide previously described (J., 1930, 961).

After a solution of the *O*-methyl ether (2 g.) in excess of *N*-sodium hydroxide had been boiled (¼ hour), the ether was recovered (1·65 g.) unchanged together with a little of the corresponding disulphide. The presence of the monomethyl ether of 2-naphthol 1-sulphide could not be detected. For comparison, it may be added that the *iso*-sulphide (2 g.), treated under comparable conditions with alkali hydroxide, readily gave 2-naphthol 1-sulphide (1·9 g.).

The following data are added to show the influence of various amounts of alkali and different times of reaction on the extent of this change. Solutions of the *iso*-sulphide (1 g.) in *n*-propyl alcohol (25 c.c.) containing various amounts of *N*-sodium hydroxide were

kept at 15° or 100° for the times stated; the amount of 2-naphthol 1-sulphide isolated in each case is shown in the right-hand column.

Mols. NaOH.	Temp.	Time.	Naphthol sulphide isolated.
1	100°	10 mins.	0·9 g.
¼	100	10 mins.	none
¼	100	2 hrs.	0·4
¼	100	4 ,,	0·55
⅛	100	8 ,,	0·47
4	15	20 ,,	0·55
2	15	24 ,,	0·42

S-*Picryl derivative of the* iso-*sulphide* (compare I). Pyridine (8 c.c.) which contained the *iso*-sulphide (3 g.) and picryl chloride (2·3 g.) was cooled and shaken until the latter dissolved and was replaced by a red crystalline material. The mixture was treated with water, the *product* being isolated in the usual manner. It crystallised from hot acetic acid in orange plates, m. p. 134° (Found: N, 8·0; S, 5·9. $C_{26}H_{15}O_8N_3S$ requires N, 7·9; S, 6·0%). The substance did not react with iodine in ethereal solution in presence of sodium bicarbonate, and was hydrolysed by excess of warm 2*N*-sodium hydroxide.

The *acetyl* derivative, prepared with acetic anhydride, formed shining red leaflets, m. p. 225°, from acetic acid (Found: N, 7·4. $C_{28}H_{17}O_9N_3S$ requires N, 7·4%). This *S*-picryl derivative may also be obtained, though in poor yield, from the *iso*-sulphide and picryl chloride in warm solvents; but under these conditions it is accompanied by 2-naphthol 1-sulphide (II) formed by isomeric change: the latter may occur either as the additive compound with picryl chloride (m. p. 182—184°) or in the free state according to the conditions of experiment. The following experiments illustrate this conversion.

(*a*) Picryl chloride (0·78 g.) was added to a concentrated solution of the *iso*-sulphide (1 g.) in hot acetic acid and the mixture was kept at 100° (1 min.) and then rapidly cooled; 2-naphthol 1-sulphide (0·45 g.) separated in a pure condition (m. p. 218°).

(*b*) Picryl chloride (0·78 g.) was added to a hot solution of the *iso*-sulphide (1 g.) in alcohol (10 c.c.). The solution was boiled (½ min.) and quickly cooled; the additive compound of picryl chloride and 2-naphthol 1-sulphide (0·4 g.) then separated. The *S*-picryl derivative of the *iso*-sulphide was obtained from the mother-liquor.

In comparison, experiments in the same solvents without picryl chloride are recorded.

(*c*) Acetic acid (5 c.c.) containing the *iso*-sulphide (1 g.) was boiled (1 min.) and cooled. The *iso*-sulphide (0·84 g.) separated unchanged (m. p. 155—156°).

(*d*) Alcohol (10 c.c.) which contained the *iso*-sulphide (1 g.) was boiled (3 mins.). The *iso*-sulphide separated from the cooled solution (0·57 g.; m. p. 156·5—157°).

From these experiments the accelerating influence of picryl chloride on the change is evident. This effect is not obtained with picric acid or hydrogen chloride. In conclusion the following experiment is recorded to illustrate the slow conversion by heat in acetic acid. A solution of the *iso*-sulphide (1 g.) in acetic acid (12 c.c.) was boiled (2 hrs.). When the brown liquid was cooled, 2-naphthol 1-sulphide (0·34 g.; m. p. 216—218°) separated.

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