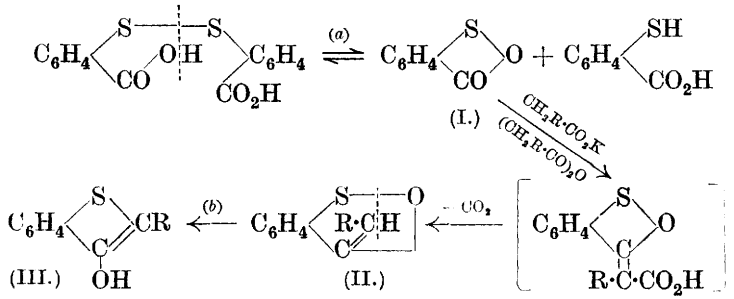
439. *The Dismutation of Some Disulphides. Part II.*

By J. L. D'Silva and E. W. McClelland.

It was suggested (Part I; J., 1930, 1095) that the presence of the complex O=(C)$_n$—S— in a disulphide tends to decrease the stability of the S–S link and favours dismutation. Consequently 2 : 2′-dithiobenzoic acid should exist in equilibrium with the sulphenic anhydride (I) and 2-thiolbenzoic acid under certain conditions. By analogy with phthalic anhydride the dismutation product (I) should yield a methylene compound (II) with acetic anhydride and potassium acetate; accordingly the interaction of 2 : 2′-dithiobenzoic acid with these reactants has now been investigated. The products isolated were 3-hydroxy-2-acetyl-1-thionaphthen (III; R = Ac) and an oil, evidently 3-acetoxy-1-thionaphthen, since it gave the characteristic reactions of this compound (compare McClelland and D'Silva, J., 1931, 2972). As these thionaphthens may be readily converted into thioindigotin, the foregoing process constitutes a new synthesis of this dye.

2 : 2′-Dithiobenzoic acid reacts also with propionic anhydride and sodium propionate. Here the only product isolated was 3-propionoxy-2-methyl-1-thionaphthen.

The formation of hydroxythionaphthens from 2 : 2′-dithiobenzoic acid in this way is accounted for by the intramolecular rearrangement (*b*), which is essentially of the same type as the dismutation (*a*) of the original disulphide and analogous to the rearrangement of alkylidenephthalides to diketohydrindenes (*Ber.*, 1893, **26**, 951, 2576; compare Claisen, *Ber.*, 1896, **29**, 2931; Claisen and Haase,

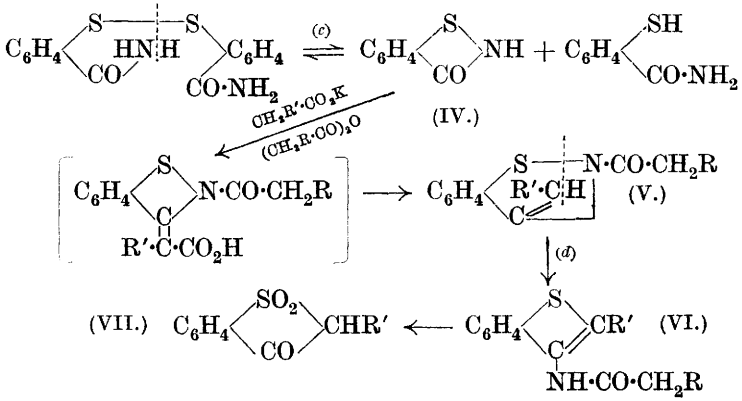


Ber., 1903, **36**, 3674; Bulow and Deseniss, *Ber.*, 1904, **37**, 4379 for similar rearrangements). The course of the reaction appears to be determined by the increasing stability of the bonds in the series S–S, S–O, S–C, which increases in the order given. Since the production of the methylene compound (II) is dependent on the initial dismutation of the disulphide, the formation of hydroxythionaphthens supports the dismutation hypothesis.

The interaction of 2 : 2′-dithiobenzamide with acetic anhydride and potassium acetate was next investigated. The products were identical with those obtained when 2-keto-1 : 2-dihydrobenz*iso*thiazole (IV) was treated with these reagents, namely, 3-acetoxy-1-thionaphthen, 3-hydroxy-2-acetyl-1-thionaphthen, and the compound to which the formula (V; R, R′ = H) was assigned (McClelland, J., 1929, 1588). 2 : 2′-Dithiobenzamide also reacts with propionic anhydride and sodium propionate. Here the only product isolated was 3-propionoxy-2-methyl-1-thionaphthen, which, as previously shown (McClelland and D'Silva, *loc. cit.*), is also obtained by condensing 2-keto-1 : 2-dihydrobenz*iso*thiazole (IV) with these reagents. These results indicate that 2 : 2′-dithiobenzamide undergoes dismutation to 2-keto-1 : 2-dihydrobenz*iso*thiazole (IV) and 2-thiolbenzamide as shown (*c*) and affords an explanation of the fact that this amide on oxidation gives saccharin.

Since the methylene compound (II) undergoes intramolecular rearrangement, it was evident that the analogous compound to which the structure (V) had previously been assigned (McClelland, *loc. cit.*) might have the isomeric structure (VI) as a result of a similar intramolecular rearrangement. The structure (VI; R, R′ = H)

has been assigned to the product obtained by isomerisation of *o*-cyanophenylthioglycollic acid and subsequent treatment (Friedländer and Laske, *Annalen*, 1907, **351**, 419), and the more recent synthesis from 3-nitro-1-thionaphthen (Fries and Hemmecke,



Annalen, 1929, **470**, 1) leaves no doubt as to its structure. Comparison of our material with that from these sources established their identity. Thus the methylene compound (V) undergoes an intramolecular rearrangement (*d*) analogous to the dismutation (*c*) of the original disulphide, the course of the reaction being determined by the increasing stability of the series of bonds S–S, S–N, S–C, which increases in the order given.

During the study of the substance (VI; R, R′ = H), now identified as 3-acetamido-1-thionaphthen, its reactions were further investigated. On oxidation it yields the sulphone (VII; R′ = H). It reacts with nitric acid, giving a *nitro*-compound to which the formula (VI; R = H, R′ = NO_2) is assigned for the following reasons. Hydrolysis yields a product which is evidently the nitrothionaphthen (III; R = NO_2), since on reduction and subsequent oxidation thionaphthaquinone is obtained from it (compare *Ber.*, 1908, **41**, 228).

The result of this nitration suggested that the compound $C_{10}H_8ONBrS$ previously obtained (McClelland, *loc. cit.*) by bromination of 3-acetamidothionaphthen had the structure (VI; R = H, R′ = Br). Oxidation of this bromo-derivative gave a product, from which 2 : 2-dibromo-3-keto-2 : 3-dihydrothionaphthen 1-dioxide was isolated, thus confirming that bromination had taken place in the 2-position. The formation of this dibromo-compound from the monobromo-compound is evidently due to the instability of the monobromo-sulphone and the ease of formation of the dibromo-

compound which has been noted previously (Smiles and Cohen, J., 1930, 408).

By treatment of 2-keto-1 : 2-dihydrobenz*iso*thiazole with propionic anhydride and sodium propionate McClelland and D'Silva (*loc. cit.*) obtained a substance $C_{12}H_{13}ONS$ which they suggested might be a homologue of the substance now identified as 3-acetamidothionaphthen. Hydrolysis of this material gives 3-hydroxy-2-methyl-1-thionaphthen (III; R = Me), identified as the bis-compound. It is oxidised by hydrogen peroxide to a sulphone, evidently 3-propionamido-2-methyl-1-thionaphthen 1-dioxide (VI; R, R′ = Me, S = SO_2), since on hydrolysis it gives the sulphone (VII; R′ = Me). On treatment with bromine it gives a monobromo-derivative. It is thus evident that the compound has the structure (VI; R, R′ = Me) and results by intramolecular change (*d*) of the primary product (V; R, R′ = Me).

Experimental.

Condensation of 2 : 2′-*Dithiobenzoic Acid with Acetic Anhydride and Potassium Acetate.*—The acid (10 g.) was heated with Ac_2O (150 c.c.) and freshly fused AcOK (16 g.) under reflux for 2 hr. at 120—125°. The cooled product was diluted with H_2O, heated at 100° for a short time, and distilled in steam. The distillate was extracted with Et_2O, and the ethereal solution extracted with NaOH aq. The alkaline extract (a) on acidification gave 3-hydroxy-2-acetyl-1-thionaphthen (1·9 g.). The ethereal solution (b) was washed with H_2O, dried over Na_2SO_4, and evaporated. The residual oil (2 g.) gave 3-hydroxy-1-thionaphthen on hydrolysis, and reacted with NHPh·NH_2 in AcOH to give thionaphthindole and with NH_2Ph to give NHPhAc. Semicarbazone, m. p. 234—235° (decomp.).

Condensation of 2 : 2′-*Dithiobenzoic Acid with Propionic Anhydride and Sodium Propionate.*—The acid (5 g.) was heated with $(Et{\cdot}CO)_2O$ (30 c.c.) and $Et{\cdot}CO_2Na$ (8 g.) at 150° for 1½ hr. The mixture was treated as in the preceding expt. The residual oil (1·2 g.) obtained by evaporation of the ethereal solution (b) solidified on inoculation with a crystal of 3-propionoxy-2-methyl-1-thionaphthen. After purification from aq. EtOH it had m. p. 75—76°, alone or mixed with this compound.

Condensation of 2 : 2′-*Dithiobenzamide with Acetic Anhydride and Potassium Acetate.*—The amide (5 g.) was heated with Ac_2O (60 c.c.) and AcOK (6·8 g.) at 125° for 30 min. The mixture was treated as in the previous expts. 3-Hydroxy-2-acetyl-1-thionaphthen was obtained by acidification of the alkaline extract (a). The residual oil (1·2 g.) from the ethereal solution (b) gave the characteristic reactions of 3-acetoxy-1-thionaphthen. The mother-liquor from the steam-distillation was concentrated, and the solid which separated warmed with 2*N*-NaOH. Purified from aq. EtOH, it had m. p. 168—170°, alone or mixed with 3-acetamido-1-thionaphthen.

Condensation of 2 : 2′-*Dithiobenzamide with Propionic Anhydride and Sodium Propionate.*—The amide (10 g.) was heated with $(Et{\cdot}CO)_2O$ (30 c.c.) and $Et{\cdot}CO_2Na$ (8 g.) for ¾ hr. at 145—150°. The product (3·4 g.) from the ethereal solution (b) after purification from aq. EtOH had m. p. 75—76°, alone or mixed with authentic 3-propionoxy-2-methyl-1-thionaphthen.

Oxidation of 3-*Acetamido*-1-*thionaphthen*.—A solution of 3-acetamido-1-thionaphthen (0·5 g.) in AcOH (5 c.c.) and H_2O_2 (5 c.c.; 90/100 vol.) was heated for 1 hr. at 100°. The material isolated by dilution and concn., after crystn. from H_2O, had m. p. 135°, alone or mixed with authentic 3-hydroxy-1-thionaphthen 1-dioxide.

2-*Nitro*-3-*acetamido*-1-*thionaphthen* (VI; R = H, R′ = NO_2).—3-Acetamido-1-thionaphthen (1 g.) in H_2O (30 c.c.) and conc. HNO_3 (4 c.c.) was heated for ½ hr. at 100°. The *product* was washed with H_2O, dried and crystallised from EtOH (charcoal), forming yellow needles, m. p. 205—206° (Found: C, 50·7; H, 3·8; S, 13·6. $C_{10}H_8O_3N_2S$ requires C, 50·8; H, 3·4; S, 13·6%).

2-*Nitro*-3-*hydroxy*-1-*thionaphthen*.—2-Nitro-3-acetamido-1-thionaphthen (1 g.) was refluxed for 1 hr. with 2*N*-NaOH (30 c.c.). The cooled solution was acidified with HCl aq., and the ppt. dried. The product separated from aq. EtOH in orange plates, m. p. 104—105° (decomp.) (Found: C, 49·5; H, 2·7; N, 7·0; *M*, 192. $C_8H_5O_3NS$ requires C, 49·2; H, 2·6; N, 7·2%; *M*, 195). 2-*Nitro*-3-*hydroxy*-1-*thionaphthen* gives a wine-red coloration with alc. $FeCl_3$ and gives with NaOH aq. a *sodium* salt (Found: Na, 10·0. $C_8H_4O_3NSNa$ requires Na, 10·6%).

To 2-nitro-3-hydroxy-1-thionaphthen (0·5 g.), suspended in HCl aq. (15 c.c.; equal vols. of conc. HCl and H_2O), Fe filings were added and the mixture was heated for a few min. $FeCl_3$ was added to the filtered liquid, and the mixture heated. The material which separated on cooling gave a hydrazone on treatment with $NHPh{\cdot}NH_2$ in AcOH, which after recrystn. from EtOH had m. p. 164—165°, alone or mixed with thionaphthaquinonephenylhydrazone.

Oxidation of $C_{10}H_8ONBrS$.—The bromo-compound (2 g.) in AcOH (10 c.c.) containing H_2O_2 (4 c.c., 90/100 vol.) was heated for 1 hr. at 100°. The product obtained on diln. with H_2O, after several recrystns. from C_6H_6–ligroin, had m. p. 146°, alone or mixed with authentic 2 : 2-dibromo-3-keto-2 : 3-dihydro-thionaphthen 1-dioxide (Found: Br, 46·6. Calc. for $C_8H_4O_3Br_2S$: Br, 47·0%).

Investigation of $C_{12}H_{13}ONS$ (VI; R, R′ = Me).—(a) *Hydrolysis*. The compound (1 g.) was refluxed with 2*N*-HCl (20 c.c.) for 1 hr. and steam-distilled. Et_2O extracted from the distillate an oil which, dissolved in aq.-alc. NaOH and oxidised with $K_3Fe(CN)_6$, gave a product which after recrystn. from EtOH had m. p. 150—151°, alone or mixed with 2 : 2′-bis-(3-hydroxy-2-methyl-1-thionaphthen).

(b) *Oxidation*. The compound (0·3 g.) was heated in AcOH (4 c.c.), to which had been added H_2O_2 (1 c.c., 90/100 vol., and 1 c.c. H_2O), for 1 hr. at 100°. The material pptd. by addition of H_2O crystallised from C_6H_6 in colourless needles, m. p. 173° (Found: C, 57·1; H, 5·1; S, 12·8. $C_{12}H_{12}O_3NS$ requires C, 57·3; H, 5·2; S, 12·8%). The *sulphone* on hydrolysis with 2*N*-HCl at 100° for ½ hr. gave 3-hydroxy-2-methyl-1-thionaphthen 1-dioxide.

(c) *Bromination*. A solution of the compound (1 g.) in $CHCl_3$ (10 c.c.) containing Br (0·73 g.; 1 mol.) was set aside for 2 days. After removal of $CHCl_3$ the *product* crystallised from EtOH (charcoal) in colourless needles, m. p. 195—196° (Found: Br, 27·4. $C_{12}H_{12}ONBrS$ requires Br, 26·8%).

We thank the Department of Scientific and Industrial Research for a grant to one of us (J. L. D'S.).

KING'S COLLEGE, LONDON. [*Received, October 24th*, 1932.]