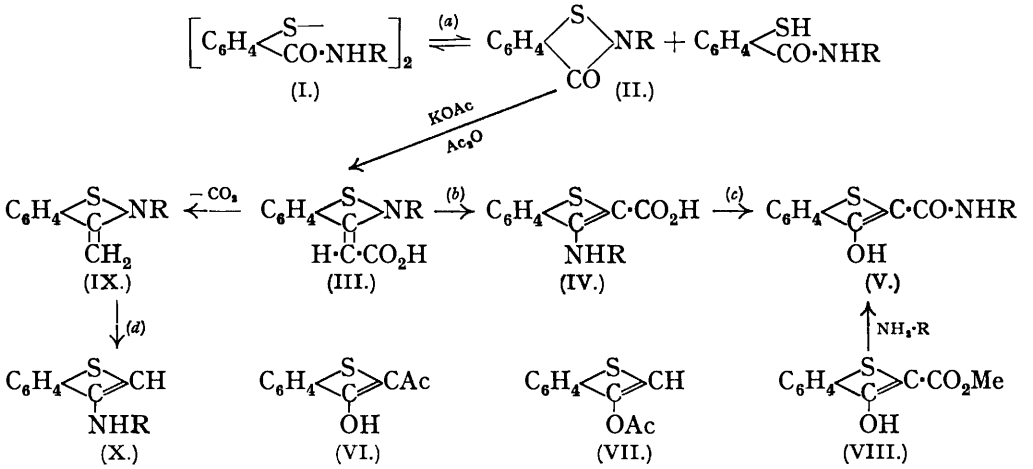
175. *The Dismutation of Some Disulphides. Part III. Molecular Rearrangements following Dismutation.*

By R. G. Bartlett and E. W. McClelland.

It has been shown (Part II; J., 1932, 2883) that 2 : 2′-dithiobenzamide (I; R = H) reacts with potassium acetate and acetic anhydride to give products identical with those obtained from the *iso*thiazole (II; R = H), namely, 3-hydroxy-2-acetyl-1-thionaphthen (VI), 3-acetoxy-1-thionaphthen (VII), and 3-acetamido-1-thionaphthen (X; R = Ac). The formation of these products has been attributed to the dismutation (*a*) of the disulphide and the subsequent reaction of the *iso*thiazole (II). The behaviour of some *N*-substituted *iso*thiazoles (II; R = Me, Et, Ph, or CH_2Ph) and of the corresponding dithiobenzamides (I; R = Me, Et, Ph, or CH_2Ph) with potassium acetate and acetic anhydride has now been investigated.

2-Keto-1-phenyl-1 : 2-dihydrobenz*iso*thiazole (II; R = Ph) gave the hydroxyacetyl- and the acetoxy-thionaphthen (VI and VII), together with a product which did not show the reactions of the expected aminothionaphthen (X; R = Ph). The analytical data for this product corresponded to those required by the acid (IV; R = Ph), but the substance gave a blue coloration with alcoholic ferric chloride, and formed an *acetyl* and a p-*toluenesulphonyl* derivative, both of which were insoluble in cold alkali. The acetyl derivative was also obtained directly by modified treatment of the crude condensation product. These properties excluded the structure (IV) and suggested that the substance was the isomeric *anilide* (V). This conclusion was confirmed by condensing the ester (VIII) with aniline, an identical material being obtained. Investigation of other *N*-substituted *iso*-thiazoles (II; R = Me, Et, or CH_2Ph) confirmed these results. With each the hydroxyacetyl- and acetoxy-thionaphthen (VI and VII) were obtained, together with compounds

identical with those resulting from the condensation of the ester (VIII) with the appropriate amines. The necessary *iso*thiazoles (II; R = Et or CH_2Ph) which had not previously been prepared were obtained by a modification of the method already described (McClelland and Gait, J., 1926, 921) and also from the corresponding 2 : 2′-dithiobenzamides by the method of Reissert and Manus (*Ber.*, 1928, **61**, 1308).



The formation of (V) is attributed to the sequence of intramolecular rearrangements (*b*) and (*c*), type (*b*) being analogous to the rearrangement of the alkylidenephthalides to diketohydrindenes (Gabriel and Neumann, *Ber.*, 1893, **26**, 951; compare Claisen, *Ber.*, 1896, **29**, 2931; Claisen and Haase, *Ber.*, 1903, **36**, 3674; Nathanson, *Ber.*, 1893, **26**, 2576; Bülow and Deseniss, *Ber.*, 1904, **37**, 4379). Intramolecular rearrangements analogous to (*c*) appear to be unknown, although the conversion of salicylanilide into acridone by way of phenylanthranilic acid (Pictet and Rubert, *Ber.*, 1896, **29**, 1189) may be regarded as the reversal of this type.

In Part II the formation of 3-acetamidothionaphthen (X; R = Ac) was attributed to decarboxylation (III ⟶ IX), followed by the rearrangement (*d*). It is now evident from the position of the CO·NHR group in the product (V) that rearrangement precedes decarboxylation.

The formation of 3-hydroxy-2-acetyl-1-thionaphthen in these condensations (compare McClelland, J., 1929, 1588; McClelland and D'Silva, J., 1931, 2972; Part II) provides interesting examples of carbon acetylation. In the structure (III) the presence of a twofold electronic source (S and N) 1 : 5 and 1 : 3 to the carbon which becomes acetylated might be expected to facilitate direct carbon acetylation at this stage. That direct carbon acetylation can be effected by means of acetic anhydride and potassium acetate appears probable from the work of Baker (J., 1933, 1384). The alternative to direct carbon acetylation at stage (III), namely, acetylation of the group in the 3-position at stage (IV) or (V), followed by migration and displacement of the group in the 2-position, cannot be excluded and is being investigated.

The reaction of the *N*-substituted 2 : 2′-dithiobenzamides (I) with potassium acetate and acetic anhydride was next investigated. 2 : 2′-Dithiobenzomethylamide (I; R = Me) with these reactants gave 3-hydroxy-2-acetyl-1-thionaphthen (VI), 3-acetoxy-1-thionaphthen (VII), and a small quantity of a material which gave the characteristic reactions of 3-*hydroxy*-2-*methylcarbamyl*-1-*thionaphthen* (V; R = Me). Similarly, 2 : 2′-*dithiobenzoethylamide* (I; R = Et) and 2 : 2′-*dithiobenzobenzylamide* (I; R = CH_2Ph) gave the two acetyloxythionaphthens (VI and VII) and small quantities of 3-*hydroxy*-2-*ethylcarbamyl*-1-*thionaphthen* (V; R = Et) and 3-*hydroxy*-2-*benzylcarbamyl*-1-*thionaphthen* (V; R = CH_2Ph) respectively. Unchanged material was recovered in these experiments. Pure specimens of these 2-substituted amides of 3-hydroxy-1-thionaphthen were not obtained in these reactions on account of the small quantities formed and the difficulty of purification, but

their presence was demonstrated by their characteristic reactions. 2 : 2′-Dithiobenzanilide (I; R = Ph) also reacted with potassium acetate and acetic anhydride, but less readily than the dithiobenzamides described above. The two acetyloxythionaphthens (VI and VII) were obtained, but the expected 3-hydroxy-2-phenylcarbamyl-1-thionaphthen (V; R = Ph) could not be detected among the products.

These experiments in which the dithiobenzamides and the corresponding *iso*thiazoles yield identical products with the same reactants under similar conditions support the hypothesis that the dithiobenzamides undergo dismutation. Moreover the behaviour of the phenyl amide (I; R = Ph) suggests that substitution of an aromatic nucleus for the amide hydrogen depresses the tendency to dismutation.

Experimental.

*Condensation of 2-Keto-1-phenyl-1 : 2-dihydrobenz*isothiazole (II; R = Ph) *with Acetic Anhydride and Potassium Acetate.*—The *iso*thiazole (3 g.) was heated with acetic anhydride (10 c.c.) and freshly fused potassium acetate (3 g.) under reflux for 30 minutes at 115—120°. The cooled product was diluted with water, heated at 100° for a short time, and distilled in steam. The distillate was extracted with ether, and the ethereal solution extracted with aqueous sodium hydroxide (2*N*). The alkaline extract (*a*) on acidification gave 3-hydroxy-2-acetyl-1-thionaphthen. The ethereal solution (*b*) was washed with water, dried over anhydrous sodium sulphate, and evaporated; the residual oil gave the characteristic reactions of 3-acetoxy-1-thionaphthen. The mother-liquor from the steam distillation was diluted with water. The material (A) which separated was washed with water by decantation and crystallised from alcohol, forming colourless needles, m. p. 231° (Found : C, 67·3; H, 4·2; N, 5·4. $C_{15}H_{11}O_2NS$ requires C, 67·0; H, 4·1; N, 5·2%). The material (A) was soluble in aqueous sodium carbonate and aqueous sodium hydroxide, giving solutions with a mauve fluorescence. Heated with acetic anhydride, it gave an *acetyl* derivative, colourless needles, m. p. 180°, from alcohol (Found : C, 65·5; H, 4·3. $C_{17}H_{13}O_3NS$ requires C, 65·6; H, 4·2%), which was also obtained in the primary condensation when the steam distillation was omitted. The p-*toluenesulphonyl* derivative, obtained by heating (A) (0·2 g.) and *p*-toluenesulphonyl chloride (0·25 g.) in pyridine for 30 mintues at 100° and precipitated on addition of 2*N*-hydrochloric acid, crystallised from acetic acid and finally from alcohol in colourless prisms, m. p. 166—167° (Found : C, 62·6; H, 4·5. $C_{22}H_{17}O_4NS_2$ requires C, 62·6; H, 4·0%).

Synthesis of A (3-*Hydroxy-2-phenylcarbamyl-1-thionaphthen*) (V; R = Ph).—Methyl 3-hydroxy-1-thionaphthen-2-carboxylate (*Annalen*, 1912, **393**, 338; 1907, **351**, 407) (0·35 g.) was refluxed with aniline (1·5 c.c.) for 30 mintues. The material which separated on cooling was washed with ether and crystallised from acetic acid; it had m. p. 230°, alone or mixed with (A), and gave identical colour reactions.

*Condensation of 2-Keto-1-methyl-1 : 2-dihydrobenz*isothiazole (II; R = Me) *with Acetic Anhydride and Potassium Acetate.*—The *iso*thiazole (*Ber.*, 1928, **61**, 1308) (2 g.), acetic anhydride (10 c.c.), and potassium acetate (3·2 g.) were heated for 30 minutes at 125—130°. The mixture was treated as in the previous condensation. Solutions (*a*) and (*b*) gave the same products as before. The residue from the steam distillation was boiled with acetic acid (charcoal). The material which separated from the filtered solution on cooling crystallised from methyl alcohol in needles, m. p. 122—123°, which were invariably pale red owing to oxidation to thioindigotin [Found : S, 14·7% (Schoeller)]. Its identity with 3-*hydroxy-2-methylcarbamyl-1-thionaphthen* (V; R = Me) was proved by synthesis: Methyl 3-hydroxy-1-thionaphthen-2-carboxylate (1·5 g.) was heated with methyl-alcoholic methylamine (10 c.c. of 10% approx.) in a sealed tube for 1 hour at 180°; the material precipitated by 2*N*-hydrochloric acid was rapidly crystallised from methyl alcohol and then had m. p. 125—126° alone or mixed with the preceding specimen (Found : C, 57·9; H, 4·1. $C_{10}H_9O_2NS$ requires C, 57·9; H, 4·4; S, 15·4%). Both specimens gave the same blue coloration with alcoholic ferric chloride and mauve fluorescence in alkali.

2 : 2′-*Dithiobenzoethylamide* (I; R = Et).—Dry ethylamine was passed into a suspension of 2 : 2′-dithiobenzoyl chloride (5 g.) in dry benzene (30 c.c.), and the solid was collected, boiled with water, and crystallised from alcohol, forming colourless prisms, m. p. 203° (Found : C, 60·0; H, 5·6. $C_{18}H_{20}O_2N_2S_2$ requires C, 60·0; H, 5·6%).

2-*Keto-1-ethyl-1 : 2-dihydrobenz*isothiazole (II; R = Et).—(i) 2 : 2′-Dithiobenzoethylamide (2 g.) was ground to a paste with carbon tetrachloride and bromine (0·4 c.c.). The solid was collected, dissolved in boiling acetic acid, and poured into excess of 2*N*-sodium hydroxide, and the oil obtained was extracted and dried in ether, recovered, and distilled under reduced pressure,

giving a solid which crystallised from aqueous alcohol in colourless needles, m. p. 118—120°. (ii) A chlorinated solution of 2 : 2'-dithiobenzoyl chloride (10 g.) in carbon tetrachloride (compare J., 1926, 921) was stirred into a solution of ethylamine (4 g.) in pyridine (30 c.c.) and the product was cooled, acidified with 2*N*-hydrochloric acid, and heated till free from carbon tetrachloride. Extraction with ether gave the required material [Found : C, 59·6; H, 5·2 (Schoeller). C_9H_9ONS requires C, 60·3; H, 5·0%]. A solution of the iso*thiazole* (1 g.) in acetic acid (10 c.c.) containing hydrogen peroxide (5 c.c. of 30%), heated for 1 hour at 100° and diluted with water, gave a material which crystallised from alcohol in colourless needles, m. p. 92—94° (*N*-ethyl-*o*-benzoic sulphinide has m. p. 94°).

Condensation of 2-*Keto*-1-*ethyl*-1 : 2-*dihydrobenz*iso*thiazole* (II; R = Et) *with Acetic Anhydride and Potassium Acetate.*—The *iso*thiazole (2 g.), acetic anhydride (10 c.c.), and potassium acetate (2 g.) were heated for 45 minutes at 120—125°, and the product treated as before. Solutions (*a*) and (*b*) again gave the same two products. The residue from the steam distillation was extracted in ether, recovered and heated with aqueous ammonium carbonate. From the filtered and acidified solution, ether extracted 3-*hydroxy*-2-*ethylcarbamyl*-1-*thionaphthen* (V; R = Et), which crystallised from aqueous alcohol in colourless needles, m. p. 135°, gave an intense blue coloration with alcoholic ferric chloride and a mauve fluorescence in alkaline solution, and was synthesised from methyl 3-hydroxy-1-thionaphthen-2-carboxylate (2 g.), ethylamine (1 g.), and ethyl alcohol (10 c.c.) at 180° (1 hour) (Found : C, 59·9; H, 4·8. $C_{11}H_{11}O_2NS$ requires C, 59·7; H, 5·0%).

2 : 2'-*Dithiobenzobenzylamide*, obtained from benzylamine (5 g.) and a suspension of 2 : 2'-dithiobenzoyl chloride (5 g.) in benzene (50 c.c.), was boiled with water and crystallised from acetic acid, forming colourless needles, m. p. 206° (Found : C, 69·4; H, 5·0. $C_{28}H_{24}O_2N_2S_2$ requires C, 69·4; H, 5·0%).

2-*Keto*-1-*benzyl*-1 : 2-*dihydrobenz*iso*thiazole* (II; R = CH_2Ph).—This was prepared by the two methods used in the case of the corresponding ethyl compound : (i) 2 : 2'-dithiobenzobenzylamide (1 g.) and bromine (0·15 c.c.) in carbon tetrachloride; (ii) a chlorinated solution of 2 : 2'-dithiobenzoyl chloride (15 g.) in carbon tetrachloride and a solution of benzylamine (10 g.) in pyridine (25 c.c.). Both specimens crystallised from methyl alcohol in colourless needles, m. p. 89° alone or mixed (Found : C, 69·7; H, 4·4. $C_{14}H_{11}ONS$ requires C, 69·7; H, 4·6%), and when heated (2 g.) in acetic acid (50 c.c.) with hydrogen peroxide (10 c.c. of 30%) for 1 hour at 100° gave a substance, m. p. 110—112° (*N*-benzyl-*o*-benzoic sulphinide has m. p. 111°).

Condensation of 2-*Keto*-1-*benzyl*-1 : 2-*dihydrobenz*iso*thiazole* (II; R = Ch_2Ph) *with Acetic Anhydride and Potassium Acetate.*—The *iso*thiazole (1 g.), acetic anhydride (7 c.c.), and potassium acetate (1 g.) were heated for 1 hour at 125—130°. Solutions (*a*) and (*b*) again contained the same two substances. The residue after the steam distillation was boiled with 2*N*-ammonium carbonate (charcoal), and from the filtered and acidified solution a material (B) was obtained which crystallised from aqueous alcohol in colourless needles, m. p. 130—131·5°, gave the usual colour reactions in alcoholic ferric chloride and in alkaline solution, and was synthesised by the following method.

Synthesis of 3-*Hydroxy*-2-*benzylcarbamyl*-1-*thionaphthen* (V; R = CH_2Ph).—Methyl 3-hydroxy-1-thionaphthen-2-carboxylate (2 g.) and benzylamine (2·5 g.) were heated for 12 hours at 100°, the product dissolved in ether, the solution washed with 2*N*-hydrochloric acid and shaken with 2*N*-sodium hydroxide, and the oil which separated shaken with ether and 2*N*-hydrochloric acid. The ethereal solution was dried over anhydrous sodium sulphate and evaporated; the residue crystallised from alcohol in colourless needles, m. p. 134°, and 133° when mixed with (B), and gave identical reactions (Found : C, 67·9; H, 4·8. $C_{16}H_{13}O_2NS$ requires C, 67·8; H, 4·6%). The *acetyl* derivative, prepared with boiling acetic anhydride, crystallised from acetic acid in colourless needles, m. p. 148° (Found : C, 66·6; H, 4·8. $C_{18}H_{15}O_3NS$ requires C, 66·5; H, 4·6%).

Reaction of the Substituted 2 : 2'-*Dithiobenzamides with Acetic Anhydride and Potassium Acetate.*—(i) 2 : 2'-Dithiobenzomethylamide (I; R = Me) (4 g.), acetic anhydride (25 c.c.), and potassium acetate (5 g.) were heated for 1 hour at 125—130°. (ii) 2 : 2'-Dithiobenzoethylamide (I; R = Et) (1 g.), potassium acetate (1 g.), and acetic anhydride (12 c.c.) were similarly heated. (iii) 2 : 2'-Dithiobenzobenzylamide (I; R = CH_2Ph) was similarly treated. (iv) 2 : 2'-Dithiobenzanilide (I; R = Ph) (5 g.), potassium acetate (5 g.), and acetic anhydride (30 c.c.) were heated for 45 minutes at 125—130° and also refluxed for 4½ hours. In each case the mixture was treated as in the *iso*thiazole condensations. The products obtained are mentioned on p. 819.

KING'S COLLEGE, LONDON. [*Received, March 3rd,* 1934.]