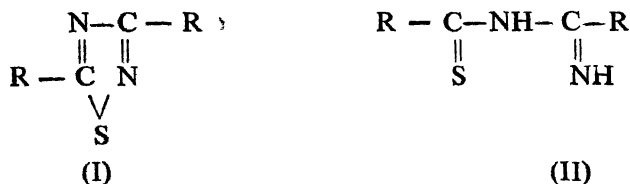


Oxidation of Thiobenzamide and 4 Methyl Thiobenzamide with Iodine

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Oxidation of thiobenzamide and 4-methyl thiobenzamide with iodine has been investigated. The pattern of the oxidation is found analogous to that of thiocarbamides.

The chemistry of the oxidation of thiocarbamides in relation to the structure of the various products and the mechanism of their formation has been investigated recently^{1,2,3}. The closely related thioamides, however, do not appear to have received as much attention excepting thiobenzamide where the final and penultimate products of oxidation *viz.* 3, 5 diphenyl-1, 2, 4-thiadiazole (I) and N benzimidyl thiobenzamide (II) only have been isolated. Products corresponding to a bis amidine disulphide and bis amidine sulphide formed in the oxidation of thiocarbamides do not appear to have been isolated.⁴



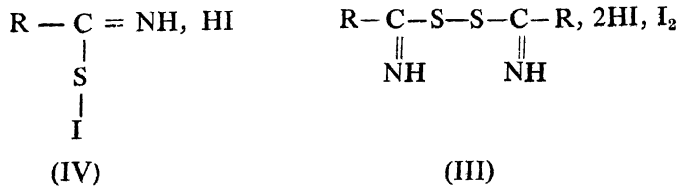
where R = phenyl, *p*-tolyl.

Reaction of thiobenzamide with iodine has been studied earlier by several workers^{5,6}. Hofmann⁵ as early as 1867 had observed that in an ethanolic medium with excess of iodine the thiadiazole (I) was obtained. In an alkaline medium, not like thiocarbamides, it is quantitatively oxidised into sulphate and the related amide.⁷ It is interesting to note that there are earlier reports in the literature to the effect that thiobenzamide was not oxidised by iodine.⁴ Oxidation of thiobenzamide and 4 methyl thiobenzamide now investigated has thrown further light on this subject and is reported in this paper.

On reaction with excess of iodine in solvents like benzene, chloroform and carbon tetrachloride a light, shining, crystalline, brown-grey product $\text{C}_{11}\text{H}_{14}\text{N}_2\text{S}_2\text{I}_4$ was

1. P. K. Srivastava, *Indian J. Chem.*, 1963, **1**, 432.
2. *Idem. Ibid*, 1963, **1**, 334.
3. *Idem. Ibid*, 1964, **2**, 154.
4. R. N. Hurd and G. DeLamater, *Chem. Rev.*, 1961, **61**, 45.
5. A. W. Hofmann, *Ber.*, 1869, **2**, 646.
6. H. Leo, *Ber.*, 1877, **10**, 2134.
7. H. Wajahn and E. Wenepe, *Arch. Pharm.*, 1952, **285**, 375.

obtained. It has been assigned the structure: bis-benzimino disulphide dihydriodide periodide (III). Since it failed to condense with thiosulphate, sulphite, benzyl mercaptan, thiobenzamide and thiocarbamide, the alternative sulphenyl iodide hydriodide structure (IV) is considered unlikely. 4-methyl thiobenzamide gave an analogous product

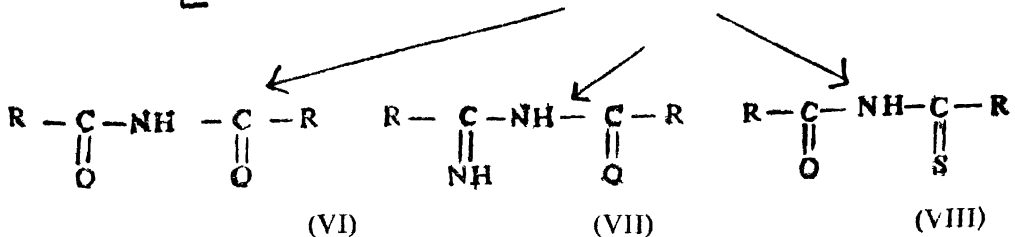
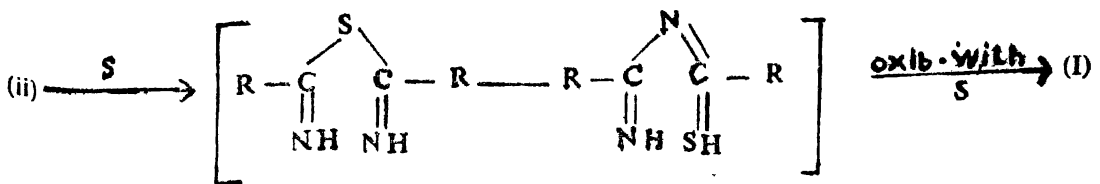
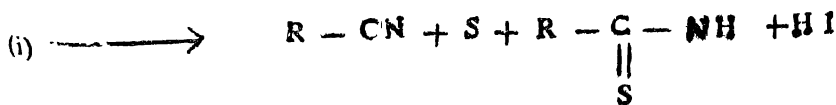


where R = phenyl, *p*-tolyl.

The product (III) if kept dry was quite stable but decomposed to give complex products on reaction with various reagents.

On prolonged reaction with sulphur dioxide in an aq. medium to which considerable quantities of hydriodic acid had been added, it afforded a brownish solid which although it could not be purified, appeared to be the related disulphide dihydriodide as on reaction with alkali it precipitated elemental sulphur and formed small quantities of the thiadiazole (I) and on reaction with aq. potassium iodide it liberated iodine.⁸ Depending on the reagent, the disulphide dihydriodide periodide (III) as well as the above disulphide dihydriodide afforded in addition to elemental sulphur and thiadiazole (I), various other products *viz.* dibenzamide (VI), benzoyl benzimidine (VII), benzoyl thiobenzamide (VIII) and thiobenzamide. These can arise as follows:

(III)

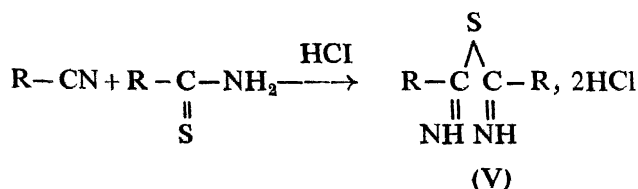


where R = phenyl, *p*-tolyl.

8. E. A. Werner, *J. Chem. Soc.*, 1912, 401, 2166, 2180.

Thus, the several products can be satisfactorily explained on the sequence of reactions (i) and (ii). But all attempts to isolate the benzimidyl sulphide (V) and N benzimidyl thiobenzamide (II) or the related dihydriodides, products analogous to which have been isolated from the oxidation products of thiocarbamides and which must have preceded the formation of the thiadiazole (I) in the present case too, proved unsuccessful.

The N-benzimidyl thiobenzamide (II) has been reported by Ishikawa⁹ and Chakravarti¹⁰ as an intermediate product in the sulphur monochloride and thionyl chloride oxidation of thiobenzamide to thiadiazole (I), but the bis-benzimidyl sulphide (V) or its hydrochloride do not appear to have been isolated or prepared so far. We were able to obtain it by the interaction of benzonitrile with thiobenzamide in dry ether in presence of hydrogen chloride.



where R=phenyl, *p* tolyl.

The sulphide V was very unstable and on contact with water, alkali, ethanol etc. decomposed quickly affording mainly benzoyl-thiobenzamide (VIII). On oxidation with ethanolic iodine it afforded the thiadiazole (I) as the principal product. These facts are suggestive of its being an intermediate in the oxidation of thiobenzamide to thiadiazole (I).

We were able to confirm the formation of II in the reactions reported by Ishikawa⁹ and Chakravarti¹⁰ but this product is very unstable and decomposes in various ways (*vide supra*).

From the evidence outlined above, it becomes evident that the overall scheme of the oxidation of thiobenzamide confirms to the general pattern shown by thiocarbamides but the various intermediates are far too unstable, probably, as the resonance stabilisation in these systems is far inferior as compared to that with thiocarbamide derivatives as indeed is evident from a general comparison of the reactions of thiocarbamides and thioamides.

E X P E R I M E N T A L

The thiobenzamide and 4-methyl thiobenzamide were prepared by the thiohydrolysis¹¹ of benzonitrile and 4-methyl benzonitrile respectively.

9. S. I. Ishikawa, *Sci. Papers Inst. Phys. Chem. Research (Tokyo)*, 1927, 7, 237.
10. G. C. Chakravarti, *J. Chem. Soc.*, 1923, 123, 964.
11. A. E. S. Fairfull, J. L. Lowe and D. A. Peak, *J. Chem. Soc.*, 1952, 752.

Bis-benzimino disulphide dihydriodide periodide (III):—When to a solution of thiobenzamide (1 g) in cold benzene (50 ml) were added a solution of iodine (2 g) in the same solvent and the mixture allowed to stand for 24 hr. shining, deep brown-grey, feathery light flakes separated. These were filtered and washed with warm benzene. No suitable solvent was found for recrystallisation. Yield 2.3 g. m.p. 165° d. Found: C 22.00, H 2.21, N 3.76, S 8.31, I 65.52%; m. eq. 201.4. $C_{14}H_{14}N_2S_2I_4$ requires C 21.4, H 1.7, N 3.5, S 8.1, I 64.9% m. eq. 195.5.

A similar product was obtained on reaction of iodine with 4-methyl thiobenzamide, m. p. 215° d. Found: C 24.17, H 2.42, N 3.25, S 8.22, I 63.14% m. eq. 204. $C_{16}H_{18}N_2S_2I_4$ requires C 23.70, H 2.22, N 3.45, S 7.90, I 62.71% m. eq. 202.5.

The product from thiobenzamide (1 g) when treated with hot water for a few minutes and filtered, left a residue of elemental sulphur and the filtrate on cooling deposited colourless needles (0.12 g). m. p. 148°. Found: N 6.68%; calculated for $C_{14}H_{11}NO_2$: N 6.20%. This was identified as dibenzamide by its undepressed m.m.p. with an authentic sample prepared by heating benzonitrile with benzoyl chloride in presence of aluminium chloride¹².

On reaction with aq. alkali, thiosulphate and bisulphite it discharged its colour and decomposed. Amongst the products of decomposition were found elemental sulphur, thiobenzamide, benzonitrile and the thiadiazole (I). In an aqueous medium it oxidised thiocarbamide to formamidine disulphide isolated and identified as picrate²⁰ (m.p. and m.m.p. 164°)

Bis-benzimino disulphide dihydriodide:—The brown grey product (2.5 g) described in the preceding experiment were suspended in a small quantity of dilute aq. hydriodic acid and sulphur dioxide passed, when a light brown coloured substance (0.8 g) was obtained. It was filtered and washed with carbon disulphide, m. p. 95.98°. Found: N 4.32, S 12.75, I 48.62% m. eq. 295. $C_{14}H_{14}N_2S_2I_2$ requires N 4.53, S 12.10, I 48.1% m. eq. 264.

The product was soluble in water but the aqueous solution decomposed rapidly. It liberated iodine from aq. potassium iodide and precipitated sulphur on treatment with cold dilute alkali.

A similar product was obtained on reaction of sulphur dioxide with Bis 4 methyl benzimino disulphide dihydriodide periodide. m.p. 135-138°. Found: N 4.55, S 12.02, I 45.14, m. eq. 240. $C_{16}H_{18}N_2S_2I_2$ requires N 5.03, S 11.50, I 45.61% m. eq. 278.

When bis-benzimine disulphide dihydriodide (1 g) was boiled with water for a few minutes and filtered hot, a brick red residue was left behind and the filtrate on cooling afforded a little thiobenzamide. The residue when treated with dilute aq. alkali mostly dissolved affording a pale yellow solution, which when acidified precipitated a deep-red compound (0.6 g). On crystallisation from methanol bright red crystals were

12. F. Kraft, *Ber.*, 1890, **23**, 2389.

obtained. m. p. 112°. Found: C 69.74, H 4.79, N 5.92, S 13.64%. m.eq. 245.6. Calculated for $C_{14}H_{11}NSO$, C 69.70, H 4.56, N 5.80, S 13.20%. m.eq. 241. It was identified as benzoyl thiobenzamide by observing its undepressed m.m.p. with an authentic sample prepared by the benzoylation of thiobenzamide¹³.

From bis 4-methyl benzimino disulphide dihydriodide a similar orange red product was obtained. m.p. 165°. Found: C 72.09, H 5.25, N 5.43, S 12.35% m.eq. 271.5. $C_{18}H_{15}NSO$ requires C 71.31, H 5.50, N 5.20, S 11.91%. m.eq. 269. It was identified as 4-methyl benzoyl 4-methyl thiobenzamide by its conversion into N-4-methyl benzoyl 4-methyl benzamidine (*vide infra*).

Benzoyl thiobenzamide (1 g) was suspended in dilute aq. ammonia (25 ml) and the mixture allowed to stand for 24 hr., when colourless needles (0.5 g) separated. M.p. 101°. (reported, m.p. 101°¹⁸). Found: N 13.05%. Calculated for $C_{14}H_{12}N_2O$, N 12.51%. It did not show any depression in m.m.p. with the authentic sample prepared by the benzoylation of benzamidine.¹⁴

From 4-methylbenzoyl 4-methylthiobenzamide on reaction with ammonia an analogous product was obtained, m.p. 145° (reported, m.p. 145°¹⁵). Found: N 11.42%. Calculated for $C_{16}H_{16}N_2O$, N 11.11%.

Bis benzimino sulphide dihydrochloride (V):—An ethereal solution of thiobenzamide (2 g) and benzonitrile (2 ml) were cooled in a freezing mixture and hydrogen chloride passed when a pale yellow solid separated. It was found highly hygroscopic and on reaction with water, alcohol and alkali formed benzoyl thiobenzamide. M.p. 45-50°. Found: N 8.34, S 9.75% m.eq. 159. $C_{14}H_{12}N_2S$, 2HCl requires N 8.90, S 10.21% m.eq. 156.5.

From 4-methyl benzonitrile and corresponding thioamide a similar pale yellow product was obtained which rapidly changed to orange yellow. M.p. 155°. Found: N 8.53, S 9.71% m.eq. 176.5. $C_{16}H_{16}N_2S$, 2HCl requires N 8.21, S 9.38% m.eq. 170.5.

Lomerisation of Bis-benzimino sulphide dihydrochloride (V) into N-benzimidyl thiobenzamide (II) hydrochloride:—Bis benzimino sulphide dihydrochloride (4 g) were suspended in dry ether saturated with hydrogen chloride and allowed to stand surrounded with ice and protected with a guard tube for 24 hrs. On filtration and washing with ether a red product was obtained (2.2 g), m.p. 68-70°. Found: N 9.5, S 11.01%, m.eq. 273.4. $C_{14}H_{12}N_2S$, HCl requires N 10.14, S 11.5%. m.eq. 276.5. Free base, m.p. 75°. The base was identified as N-benzimidyl thiobenzamide (II) by observing undepressed m.m.p. with an authentic sample prepared by the action of sulphur monochloride with thiobenzamide.¹⁹

13. Tochtermann, *Chem. Zentr.*, 1905, II, 407.

14. H. Gillman and A.H. Blat, *Organic Synthesis Collective Volume I*, p. 6.

15. F. Kraft and H. Karstens, *Ber.*, 1892, **25**, 454.

16. U. Fr. Klein, *Ber.*, 1878, **11**, 764.

17. S. Ishikawa, *Sci. Papers Inst. Phys. Chem. Res. (Tokyo)*, 1927, **7**, 271.

18. A.W. Hoffmann and S. Gabriel, *Ber.*, 1892, **25**, 1578.

19. S. Ishikawa, *Sci. Papers Inst. Phys. Chem. Res. (Tokyo)*, 1925, **3**, 147.

20. R. H. Sahasrabudhey, *This Journal*, 1951, **28**, 309.

From 4-methyl benzimidyl sulphide dihydrochloride a similar orange yellow coloured product was obtained m.p. 160° (reported m.p. 160°¹⁶). Found: N 9.00, S 10.35% m.eq. 307.8. Calculated for C₁₆H₁₆N₂S, HCl N 9.19, S 10.50%. m.eq. 304.5. Free base, m.p. 108°.

Oxidation of N-benzimidyl thiobenzamide hydrochloride with alcoholic iodine: formation of 3,5-diphenyl 1,2,4-thiadiazole (I):—N benzimidyl thiobenzamide hydrochloride (1 g) was dissolved in methanol (25 ml) and methanolic iodine was added gradually with stirring until the colour of iodine persisted. On basification with ammonia a colourless product (0.7 g), m.p. 91° was obtained. This was identified as 3,5-diphenyl 1,2,4-thiadiazole.¹⁷

A similar product was obtained by the oxidation of 4-methyl benzimidyl 4-methylthiobenzamide, m.p. 128° (reported m.p. 128°⁹). It did not show depression in m.p. when mixed with an authentic sample prepared by the direct oxidation of 4-methyl thiobenzamide with alcoholic iodine.

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