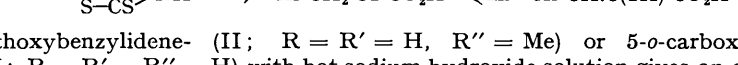
# 271. 1 : 2-*Dihydro*-2-*thianaphthalene Derivatives. Part I. Preparation and Reactions of* 1 : 2-*Dihydro*-1-*keto*-2-*thianaphthalenes.*

By D. J. Dijksman and G. T. Newbold.

Treatment of the rhodanine derivatives of *o*-carboxy-aldehydes and of an *o*-carboxy-ketone with sodium hydroxide gives 1 : 2-dihydro-1-keto-2-thianaphthalene-3-carboxylic acids which can be decarboxylated to 1 : 2-dihydro-1-keto-2-thianaphthalenes. The sulphur atom in these thianaphthalenes (benzothiopyrans) is readily eliminated by ammonia and primary amines with the formation of *iso*quinoline derivatives.

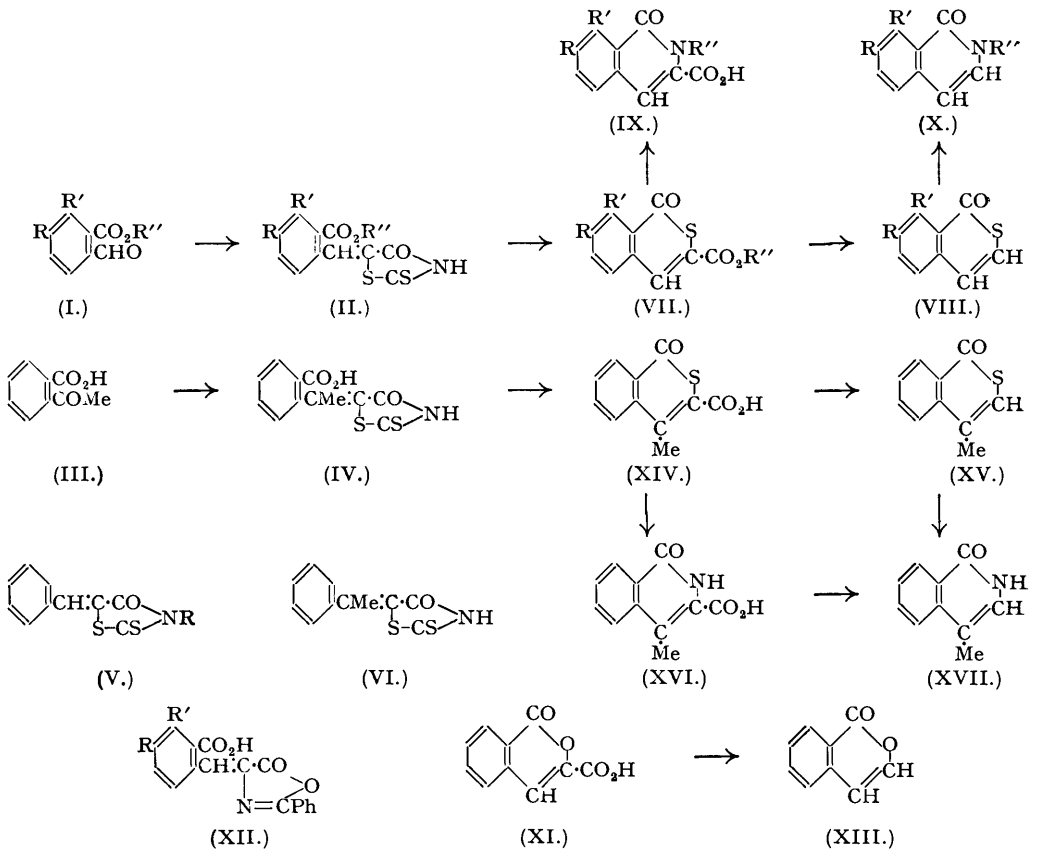
Though the condensation of rhodanine with aldehydes (Gränacher, *Helv. Chim. Acta*, 1922, **5**, 610, where references are given to earlier work; Gränacher, Gerö, Ofner, Klopfenstein, and Schlatter, *ibid.*, 1923, **6**, 458) and ketones (Brown, Bradsher, McCallum, and Potter, *J. Org. Chem.*, 1950, **15**, 174) has been extensively studied no record as far as we are aware exists of the condensation of *o*-carboxy-derivatives of aromatic aldehydes and ketones with rhodanine. We find that methyl phthalaldehydate (I; R = R′ = H, R″ = Me) and α-methyl opianate (I; R = R′ = OMe, R″ = Me) condense with rhodanine to give respectively 5-*o*-carbomethoxybenzylidene- (II; R = R′ = H, R″ = Me) and 5-(2′-carbomethoxy-3′ : 4′-dimethoxybenzylidene)-rhodanine (II; R = R′ = OMe, R″ = Me). Similarly phthaldehydic acid and 2-carboxyacetophenone (III) give the acids (II; R = R′ = R″ = H) and (IV) respectively; these products titrate to phenolphthalein as dibasic acids with sodium hydroxide, the second acidic function being present in the rhodanine moiety since we find that 5-benzylidene- (V; R = H) and 5-α-methylbenzylidene-rhodanine (VI) titrate sharply as monobasic acids under the same conditions. Holmberg (*J. pr. Chem.*, 1909, [ii], **79**, 266) determined the acidic strength of rhodanine as $K_a^{25}$ 3 × $10^{-6}$ and showed that it can be titrated with sodium hydroxide by using phenolphthalein as indicator; the acidity of its readily accessible condensation products with aldehydes and ketones gives a useful alternative method to the titration of carboxy- or sulpho-phenylhydrazones (Anchel and Schoenheimer, *J. Biol. Chem.*, 1936, **114**, 539; Willstätter, Schuppli, and Mayer, *Annalen*, 1919, **418**, 121) for the determination of the molecular weights of carbonyl compounds. 5-Benzylidenerhodanine (V; R = H) with diazomethane gave only the 3-methyl derivative (V; R = Me), which has been obtained by Andreasch and Zipser (*Monatsh.*, 1904, **25**, 167) by condensation of benzaldehyde with 3-methylrhodanine. The methylation behaviour suggests that the principal acidic centre in 5-benzylidenerhodanine is the imino-group and this is supported by the identical spectral absorptions of (V; R = H and Me).

Condensation products of aromatic aldehydes with rhodanine have been used for the preparation of homologous acids (Julian and Sturgis, *J. Amer. Chem. Soc.*, 1935, **57**, 1126; Campbell and McKail, *J.*, 1948, 1251); the first step is hydrolysis to the β-aryl-α-thiopropionic acid by strong alkali (Gränacher, *loc. cit.*) :



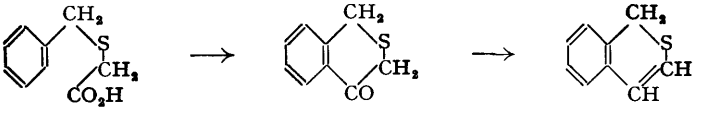
5-*o*-Carbomethoxybenzylidene- (II; R = R′ = H, R″ = Me) or 5-*o*-carboxybenzylidene-rhodanine (II; R = R′ = R″ = H) with hot sodium hydroxide solution gives an acidic product $C_{10}H_6O_3S$ which we formulate as 1 : 2-dihydro-1-keto-2-thianaphthalene-3-carboxylic acid (VII; R = R′ = R″ = H), formed by loss of water from the intermediate *o*-carboxy-α-thiolcinnamic acid tautomeric with the β-*o*-carboxyphenyl-α-thiopropionic acid. Support for this formula comes from the formation of 1 : 2-dihydro-1-keto*iso*quinoline-3-carboxylic acid (IX; R = R′ = R″ = H) by treatment of the compound $C_{10}H_6O_3S$ with ethanolic ammonia. The acid (IX; R = R′ = R″ = H) has been prepared by Bamberger and Kitschelt (*Ber.*, 1892, **25**, 1138) by reaction of *iso*coumarin-3-carboxylic acid (XI) with ammonia and by alkaline hydrolysis of 5-*o*-carbomethoxybenzylidene-2-phenyloxazol-4-one (cf. XII; R = R′ = H) (Bain, Perkin, and Robinson, *J.*, 1914, 2392); in the latter reaction the ready cyclisation of the intermediate α-amino-*o*-carboxycinnamic acid to the *iso*quinoline parallels our method of formation of 1 : 2-dihydro-1-keto-2-thianaphthalene-3-carboxylic acid. 1 : 2-Dihydro-1-keto-2-thianaphthalene-3-carboxylic acid reacts smoothly with methylamine, ethylamine, aniline, and benzylamine to give the corresponding *N*-substituted 1 : 2-dihydro-1-keto*iso*quinoline-3-carboxylic acids (IX; R = R′ = H, R″ = Me, Et, Ph, and $CH_2Ph$ respectively), the first

three of which have been similarly obtained from *iso*coumarin-3-carboxylic acid (Bamberger and Frew, *Ber.*, 1894, **27**, 198). Both the *iso*coumarin-acid (Bamberger and Kitschelt, *loc. cit.*;




Zinke, *ibid.*, p. 1493) and 1 : 2-dihydro-1-keto-2-thianaphthalene-3-carboxylic acid titrate normally with cold 0·1N-sodium hydroxide to phenolphthalein; heating them with excess of alkali, followed by hot back-titration, results in the uptake of two equivalents of alkali indicative of lactone ring opening.

1 : 2-Dihydro-4-keto-2-thianaphthalene has been prepared by cyclisation of benzylthioacetic acid (Lesser and Mehrlander, *Ber.*, 1923, **56**, 1642; von Braun and Weissbach, *ibid.*,



1929, **62**, 2416). Reduction of 1 : 2-dihydro-4-keto-2-thianaphthalene then led to 1 : 2-dihydro-2-thianaphthalene. No reference to 1-keto-derivatives of the latter compound appears in the literature to our knowledge. We have prepared 1 : 2-dihydro-1-keto-2-thianaphthalene (VIII; R = R′ = H) by decarboxylation of (VII; R = R′ = R″ = H); it has m. p. 78—79° and is similar in properties to *iso*coumarin (XIII) (m. p. 47°) (Bamberger and Frew, *loc. cit.*). Reaction of (VIII; R = R′ = H) with ammonia gives 1 : 2-dihydro-1-keto*iso*quinoline (X; R = R′ = R″ = H) as does similar treatment of (XIII) (Bamberger and Frew, *loc. cit.*). Unlike *iso*coumarin, 1 : 2-dihydro-1-keto-2-thianaphthalene does not reduce Fehling's solution.

5-(2′-Carbomethoxy-3′ : 4′-dimethoxybenzylidene)rhodanine (II; R = R′ = OMe, R″ = Me), when heated with sodium hydroxide, gives 1 : 2-dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid (VII; R = R′ = OMe, R″ = H) which readily forms a methyl ester with diazomethane. Partial demethylation of the acid by constant-boiling hydrobromic

acid gives a monomethyl compound which we formulate as the 8-hydroxy-7-methoxy-compound (VII; R = OMe, R′ = OH, R″ = H) since opianic acid under similar conditions gives 2-formyl-6-hydroxy-5-methoxybenzoic acid (I; R = OMe, R′ = OH, R″ = H) (Wegscheider, *Monatsh.*, 1882, **3**, 356, 790; Liebermann, *Ber.*, 1896, **29**, 2030; Schorigin, Issaguljanz, and Below, *ibid.*, 1931, **64**, 274). 1 : 2-Dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid can be decarboxylated in very low yield to give (VIII; R = R′ = OMe), and with ethanolic ammonia gives 1 : 2-dihydro-1-keto-7 : 8-dimethoxy*iso*quinoline-3-carboxylic acid (IX; R = R′ = OMe, R″ = H) identical with that prepared by Bain, Perkin, and Robinson (*loc. cit.*) by the oxazolone route from (XII; R = R′ = OMe). Reaction of (VII; R = R′ = OMe, R″ = H) with methylamine and ethylamine gives respectively the 2-methyl (IX; R = R′ = OMe, R″ = Me) and 2-ethyl (IX; R = R′ = OMe, R″ = Et) derivative of the *iso*quinoline-acid.

5-(*o*-Carboxy-α-methylbenzylidene)rhodanine (IV) is converted by alkali into 1 : 2-dihydro-1-keto-4-methyl-2-thianaphthalene-3-carboxylic acid (XIV) which readily forms 1 : 2-dihydro-1-keto-4-methyl*iso*quinoline-3-carboxylic acid (XVI) when heated with ethanolic ammonia. Decarboxylation of (XIV) proceeds smoothly with the formation of 1 : 2-dihydro-1-keto-4-methyl-2-thianaphthalene (XV), which with ammonia gives 1 : 2-dihydro-1-keto-4-methyl-*iso*quinoline (XVII) identical with the decarboxylation product of (XVI).

When the manuscript of this paper was complete, the communication of Kamal, Robertson, and Tittensor (*J.*, 1950, 3375) appeared, describing the conversion of 5-(6′-carbomethoxy-2′ : 4′-dimethoxybenzylidene)rhodanine into 1 : 2-dihydro-1-keto-5 : 7-dimethoxy-2-thianaphthalene-3-carboxylic acid by the method we have recorded above.

## Experimental.

*Rhodanine Condensation Products.*—The method is exemplified by the preparation of 5-(2′-carbomethoxy-3′ : 4′-dimethoxybenzylidene)rhodanine. α-Methyl opianate (Bain, Perkin, and Robinson, *loc. cit.*; 10·0 g.) and rhodanine (6·0 g.) were dissolved in hot glacial acetic acid (30 c.c.), and powdered fused sodium acetate (12·0 g.) was added. After 30 minutes' heating under reflux dissolution was complete and the reaction mixture was poured into water (500 c.c.). The precipitated solid was crystallised from ethanol, giving 5-(*2′-carbomethoxy-3′ : 4′-dimethoxybenzylidene)rhodanine* (11·4 g., 75%) as yellow prisms, m. p. 191—193° (Found: C, 49·7; H, 4·2; N, 3·7; S, 18·4. $C_{14}H_{13}O_5NS_2$ requires C, 49·5; H, 3·9; N, 4·1; S, 18·9%). Light absorption in ethanol: Max. at 2610 (ε = 9100), 2850 (ε = 9900), 3020 (ε = 7900), 3100 (ε = 7400), and 3870 A. (ε = 37000).

5-o-*Carbomethoxybenzylidenerhodanine*, prepared from methyl phthalaldehydate in 60% yield, formed pale yellow needles (from ethanol), m. p. 215—216° (Found: C, 51·6; H, 3·5; N, 5·0; S, 22·3. $C_{12}H_9O_3NS_2$ requires C, 51·6; H, 3·2; N, 5·0; S, 23·0%). Light absorption in ethanol: Max. at 2610 (ε = 8800), 2780 (ε = 7600), and 3610 A. (ε = 27000).

5-o-*Carboxybenzylidenerhodanine*, prepared from phthalaldehydic acid in 74% yield, separated from aqueous ethanol as yellow needles, m. p. 265—266° (Found: C, 49·7; H, 3·0%; equiv., 134. $C_{11}H_7O_3NS_2$ requires C, 49·8; H, 2·7%; equiv., 132·5). Light absorption in ethanol: Max. at 2590 (ε = 7900), 2830 (ε = 8000) and 3600 A. (ε = 25200).

5-(o-*Carboxy-α-methylbenzylidene)rhodanine* was prepared from *o*-carboxyacetophenone [prepared by Gabriel and Michael's method, *Ber.*, 1877, **10**, 1554, by heating phthaloylacetic acid (14 g.) in water (70 c.c.) at 200° for 4 hours; yield 5·5 g., 45%; m. p. 114—115°] by the method described and crystallised from aqueous methanol as yellow needles, m. p. 192—194° (31% yield) (Found: C, 52·0; H, 3·7%; equiv., 141·5. $C_{12}H_9O_3NS_2$ requires C, 51·6; H, 3·2%; equiv., 139·5). Light absorption in ethanol: Max. at 2270 (ε = 8400), 2560 (ε = 8000), 2950 (ε = 11400), and 3460 A. (ε = 3300).

5-α-Methylbenzylidenerhodanine, prepared from acetophenone by the above method in 25% yield, separated from methanol as yellow needles, m. p. 166—167° (Brown, Bradsher, McCallum, and Potter, *J. Org. Chem.*, 1950, **15**, 174, give m. p. 165—166° for this compound prepared by condensation of acetophenone with rhodanine in the presence of ammonium chloride in aqueous ammonia) (Found: C, 56·2; H, 3·9%; equiv., 233. Calc. for $C_{11}H_9ONS_2$: C, 56·1; H, 3·9%; equiv., 235). Light absorption in ethanol: Max. at 2780 (ε = 9300) and 3530 A. (ε = 28500).

5-Benzylidenerhodanine, prepared by the method of Gränacher, Gerö, Ofner, Klopfenstein, and Schlatter (*loc. cit.*) (Found: equiv., 224. Calc. for $C_{10}H_7ONS_2$: equiv., 221), had light absorption in ethanol: Maxima at 2720 (ε = 10000) and 3740 A. (ε = 44000).

3-*Methylrhodanine* (cf. Andreasch and Zipser, *loc. cit.*).—Methyl *iso*thiocyanate (7·3 g.; *Org. Synth.*, **21**, 81) and mercaptoacetic acid (11·0 g.) in ethanol (20 c.c.) and water (10 c.c.) were refluxed for 2½ hours. Water (10 c.c.) was then added, the solution cooled, and the crystalline product collected (15·5 g.; m. p. 72—72·5; Andreasch and Zipser, *loc. cit.*, record m. p. 72°).

5-*Benzylidene*-3-*methylrhodanine.*—(*a*) Under the conditions prescribed by Andreasch and Zipser (*loc. cit.*) a very low yield was obtained. The following procedure is satisfactory. Benzaldehyde (3·0 g.), 3-methylrhodanine (3·8 g.), and fused sodium acetate (5·0 g.) were heated under reflux in acetic acid (15 c.c.) for 15 minutes. The hot solution from which solid had separated was poured into water and the product collected (4·5 g., 61%; m. p. 169°). 5-Benzylidene-3-methylrhodanine separated from methanol as light yellow needles, m. p. 169—170° (lit., m. p. 169°). Light absorption in ethanol: Max. at 2720 (ε = 12000) and 3750 A. (ε = 38000).

(*b*) 5-Benzylidenerhodanine (0·5 g.), suspended in methanol (10 c.c.), was treated with ethereal diazomethane (50 c.c., from 5 g. of nitrosomethylurea). Dissolution was rapidly effected with gas evolution, followed by separation of crystals. The solution was concentrated and the solid separated, having m. p. 162—164° (210 mg.). Crystallisation from methanol gave the 3-methyl derivative as light yellow needles, m. p. 169—170° undepressed by preparation (*a*) (Found : C, 56·2; H, 4·2. Calc. for $C_{11}H_9ONS_2$ : C, 56·1; H, 3·9%).

1 : 2-*Dihydro*-1-*keto*-2-*thianaphthalene*-3-*carboxylic Acids*.—The carboxy- or carbomethoxy-rhodanine (0·01 mole) was heated with aqueous sodium hydroxide (20 c.c. ; 15%) for 30 minutes, the cooled solution poured into an excess of dilute hydrochloric acid, and the product collected. In this way 5-(2′-carbomethoxy-3′ : 4′-dimethoxybenzylidene)rhodanine gave 1 : 2-*dihydro*-1-*keto*-7 : 8-*dimethoxy*-2-*thianaphthalene*-3-*carboxylic acid* (75%) as yellow needles, m. p. 257—258° (from ethanol) (Found : C, 54·3; H, 4·0; S, 12·3%; equiv., 264. $C_{12}H_{10}O_5S$ requires C, 54·1; H, 3·8; S, 12·0%; equiv., 266). Light absorption in ethanol : Max. at 2460 (ε = 29500), 3320 (ε = 14600), 3700 (ε = 11300), and 3880 A. (ε = 10000). The *methyl* ester prepared by ethereal diazomethane separated from ethanol as light yellow laths, m. p. 152—153° (Found : C, 55·5; H, 4·4. $C_{13}H_{12}O_5S$ requires C, 55·7; H, 4·3%).

5-*o*-Carbomethoxybenzylidenerhodanine similarly gave 1 : 2-*dihydro*-1-*keto*-2-*thianaphthalene*-3-*carboxylic acid* (82%) prisms (from aqueous ethanol), m. p. 261—263° (Found : C, 58·6; H, 2·8%; equiv., 205. $C_{10}H_6O_3S$ requires C, 58·2; H, 2·9%; equiv., 206), also obtained from 5-*o*-carboxybenzylidenerhodanine as prisms (80% yield) (from aqueous ethanol), m. p. 261—263° undepressed by the foregoing preparation (Found : C, 58·5; H, 3·1%). Light absorption in ethanol : Max. at 2220 (ε = 29000), 2750 (ε = 5000), 3000 (ε = 7100), 3120 (ε = 7800), and 3470 (ε = 7600), inflection at 2450 A. (ε = 18500). The *methyl* ester, prepared by diazomethane, formed fine needles, m. p. 138—139°, from ethanol (Found : C, 59·9; H, 3·6. $C_{11}H_8O_3S$ requires C, 60·0; H, 3·7%).

5-(2′-Carboxy-α-methylbenzylidene)rhodanine gave 1 : 2-*dihydro*-1-*keto*-4-*methyl*-2-*thianaphthalene*-3-*carboxylic acid* (60%), needles, m. p. 243—245° [from ethyl acetate–light petroleum (b. p. 60—80°)] (Found : C, 60·1; H, 3·7%; equiv., 217. $C_{11}H_8O_3S$ requires C, 60·0; H, 3·7%; equiv., 220); light absorption in ethanol : Max. at 2480 (ε = 22400), 3000 (ε = 6300), and 3610 A. (ε = 4800). It forms a *methyl* ester which separates from methanol as fine felted needles, m. p. 152—154° (Found : C, 61·7; H, 4·3. $C_{12}H_{10}O_3S$ requires C, 61·5; H, 4·3%).

1 : 2-*Dihydro*-8-*hydroxy*-1-*keto*-7-*methoxy*-2-*thianaphthalene*-3-*carboxylic Acid*.—1 : 2-Dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid (0·5 g.) was heated under reflux with constant-boiling hydrobromic acid (20 c.c.) during 3 hours. The cooled reaction mixture was filtered and the *product* (95% yield) crystallised from ethanol as needles, m. p. 304—305° (Found : C, 52·6; H, 3·5. $C_{11}H_8O_5S$ requires C, 52·4; H, 3·2%). An ethanolic solution of the compound gave a dark olive-green colour with aqueous ferric chloride.

1 : 2-*Dihydro*-1-*keto*-2-*thianaphthalene*.—1 : 2-Dihydro-1-keto-2-thianaphthalene-3-carboxylic acid (500 mg.) was heated at 330° for 10 minutes in a sublimation apparatus at atmospheric pressure. Sublimation was then carried out at 150°/0·5 mm. The sublimate was dissolved in ether and the ethereal solution washed with 2N-sodium hydroxide, then with water, and dried ($Na_2SO_4$). The alkaline washings on acidification gave unchanged acid (100 mg.). The ethereal extract was evaporated and the residue sublimed at 100°/0·5 mm., to give a yellow sublimate (230 mg., 41%), m. p. 77—78°. Two crystallisations from light petroleum (b. p. 60—80°) gave 1 : 2-*dihydro*-1-*keto*-2-*thianaphthalene* as needles, m. p. 78—79° (Found : C, 66·6; H, 3·7. $C_9H_6OS$ requires C, 66·7; H, 3·7%). Light absorption in ethanol : Max. at 2130 (ε = 26300), 2430 (ε = 26000), 2650 (ε = 5400), 2850 (ε = 5000), and 3450 A. (ε = 4300). This substance is insoluble in water and soluble in the common organic solvents with the exception of light petroleum ; it dissolves in warm 2N-potassium hydroxide to give a colourless solution and does not reduce Fehling's solution on prolonged boiling.

1 : 2-*Dihydro*-1-*keto*-4-*methyl*-2-*thianaphthalene*.—1 : 2-Dihydro-1-keto-4-methyl-2-thianaphthalene-3-carboxylic acid (150 mg.) was heated at 310—315° for 10 minutes, then treated as in the last experiment, and the neutral fraction sublimed at 100°/0·5 mm. The pale yellow solid (80 mg.) had m. p. 71—74° ; it was dissolved in light petroleum (b. p. 60—80°) (25 c.c.) and adsorbed on a column (1 × 7 cm.) of alumina (Grade III). The column was washed with the same solvent (50 c.c.), evaporation of the combined eluates giving a negligible residue. Elution with benzene (50 c.c.) gave 60 mg. of crystalline material, m. p. 75—77°, still retaining a slight yellow colour not removed by crystallisation from light petroleum (b. p. 60—80°) from which the material separated as fine needles. A colourless product was obtained by two sublimations at 80°/0·5 mm., only the first two-thirds of the material being sublimed. 1 : 2-*Dihydro*-1-*keto*-4-*methyl*-2-*thianaphthalene* obtained in this way had m. p. 75—77° (Found : C, 68·4; H, 4·6. $C_{10}H_8OS$ requires C, 68·1; H, 4·5%). Yellow material gave consistently high C values. Light absorption in ethanol : Max. at 2170 (ε = 29000), 2470 (ε = 25000), 2680 (ε = 5500), 2870 (ε = 5000), 2990 (ε = 5000), and 3510 A. (ε = 4500).

1 : 2-*Dihydro*-1-*keto*-7 : 8-*dimethoxy*-2-*thianaphthalene*.—1 : 2-Dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid (0·65 g.) was heated at 330° for 5 minutes at atmospheric pressure. The sublimate and residue were extracted with chloroform, and the extract was washed once with 2N-potassium hydroxide, then once with water, and dried ($Na_2SO_4$). The extract was evaporated and the residue sublimed at 180°/0·1 mm., to give a yellow gummy sublimate (65 mg.). This was dissolved in dry benzene (10 c.c.) and adsorbed on a column of alumina (Grade II ; 1 × 7 cm.). The column was washed with benzene–ether (1 : 1 ; 50 c.c.) and the eluate evaporated to give an almost colourless solid A (20 mg.). Further elution with the same solvent (50 c.c.) and evaporation of the eluate gave a solid B (15 mg.). Elution of the column with ether gave a negligible residue. Solid A, m. p. 85—90°, was sublimed at 100°/0·5 mm. and the sublimate crystallised from light petroleum (b. p. 80—100°) from which 1 : 2-*dihydro*-1-*keto*-7 : 8-*dimethoxy*-2-*thianaphthalene* separated as small needles, m. p. 92—94° (Found : C, 59·3; H, 4·6. $C_{11}H_{10}O_3S$ requires C, 59·5; H, 4·5%). Light absorption in ethanol : Max. at 2440 (ε = 20000), 2900 (ε = 4400), and 3800 A. (ε = 2200). Solid B, m. p. 148—150°, crystallised

from light petroleum (b. p. 80—100°) as fine needles, m. p. 152° (Found : C, 54·6; H, 4·2%). A mixture of the latter compound and 1 : 2-dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene could be separated by sublimation at 100°/0·5 mm., only the latter subliming.

1 : 2-*Dihydro*-1-*keto*-7 : 8-*dimethoxy*isoquinoline-3-*carboxylic Acid.*—1 : 2-Dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid (0·5 g.) in ethanolic ammonia (20 c.c.; saturated at 0°) was heated at 130° for 2½ hours. On cooling, the solid (0·45 g.) which separated was dissolved in water (1 c.c.) and the solution made acid to Congo-red with dilute hydrochloric acid. The precipitated *iso*quinoline-acid (0·40 g., 86%) crystallised from ethanol as fine needles, m. p. 256—257° undepressed by a sample of m. p. 257—258° prepared according to Bain, Perkin, and Robinson (*loc. cit.*) (Found : C, 58·1; H, 4·3; N, 5·7. Calc. for $C_{12}H_{11}O_5N$ : C, 57·8; H, 4·4; N, 5·6%). Light absorption in ethanol : Max. at 2210 (ε = 26000), 3120 (ε = 16500), 3400 (ε = 11300), and 3450 A. (ε = 11300).

1 : 2-*Dihydro*-1-*keto*isoquinoline-3-*carboxylic Acid.*—By the above mothod 1 : 2-dihydro-1-keto-2-thianaphthalene-3-carboxylic acid gave 1 : 2-dihydro-1-keto*iso*quinoline-3-carboxylic acid (90%) as fine needles (from ethanol), m. p. 326—328° undepressed by an authentic specimen (Bain, Perkin, and Robinson, *loc. cit.*) of the same m. p. (these authors and Bamberger and Kitschelt, *loc. cit.*, give m. p. 320°) (Found : C, 63·6; H, 3·3. Calc. for $C_{10}H_7O_3N$ : C, 63·5; H, 3·7%). Light absorption in ethanol : Max. at 2240 (ε = 18600), 3010 (ε = 12500), and 3220 (ε = 8800), inflections at 2480 (ε = 8800) and 3360 A. (ε = 5600).

1 : 2-*Dihydro*-1-*keto*-4-*methyl*isoquinoline-3-*carboxylic Acid.*—This *acid* was obtained similarly (85%) as small needles, m. p. 335—336° (from ethanol) (Found : C, 65·5; H, 4·7. $C_{11}H_9O_3N$ requires C, 65·0; H, 4·5%). Light absorption in ethanol : Max. at 2120 (ε = 20500), 2270 (ε = 14500), 2540 (ε = 5900), and 3070 (ε = 12200), inflection at 3250 A. (ε = 8200).

1 : 2-*Dihydro*-1-*keto*-7 : 8-*dimethoxy*-2-*methyl*isoquinoline-3-*carboxylic Acid.*—1 : 2-Dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid (0·5 g.) was heated at 130° with aqueous methylamine (20 c.c.; 40%) and ethanol (20 c.c.) for 2 hours. The reaction mixture was concentrated and made acid (Congo-red) with dilute hydrochloric acid to give 1 : 2-*dihydro*-1-*keto*-7 : 8-*dimethoxy*-2-*methyl*isoquinoline-3-*carboxylic acid monohydrate* (0·35 g., 72%) which crystallised from water as needles, m. p. 198—199° (Found : C, 55·1; H, 5·5. $C_{13}H_{13}O_5N,H_2O$ requires C, 55·5; H, 5·4%). Light absorption in ethanol : Max. at 2230 (ε = 39000), 3050 (ε = 12400), and 3460 A. (ε = 8500).

1 : 2-Dihydro-1-keto-2-methyl*iso*quinoline-3-carboxylic acid was obtained similarly (80%) from 1 : 2-dihydro-1-keto-2-thianaphthalene-3-carboxylic acid as fine needles (from water), m. p. 238—240° (Bamberger and Frew, *loc. cit.*, give m. p. 238°) (Found : C, 65·2; H, 4·1. Calc. for $C_{11}H_9O_3N$ : C, 65·0; H, 4·5%). Light absorption in ethanol : Max. at 2240 (ε = 17000) and 2950 (ε = 10000), inflection at 3280 A. (ε = 8200).

2-*Ethyl*-1 : 2-*dihydro*-1-*keto*-7 : 8-*dimethoxy*isoquinoline-3-*carboxylic Acid.*—Reaction of 1 : 2-dihydro-1-keto-7 : 8-dimethoxy-2-thianaphthalene-3-carboxylic acid with ethylamine as above gave this *acid monohydrate* (70%) as pale yellow needles (from water), m. p. 128—130° (Found : C, 57·4; H, 5·4. $C_{14}H_{15}O_5N,H_2O$ requires C, 56·9; H, 5·8%). When this was dried at 70°/0·1 mm. the m. p. rose to *ca.* 160° and the specimen became gummy. Light absorption in ethanol : Max. at 2200 (ε = 33200), 3020 (ε = 11500) and 3500 A. (ε = 7700).

2-Ethyl-1 : 2-dihydro-1-keto*iso*quinoline-3-carboxylic acid was analogously obtained as small prisms, m. p. 200—201° (from water) (Bamberger and Frew, *loc. cit.*, give m. p. 202°) (Found : C, 66·6; H, 5·0. Calc. for $C_{12}H_{11}O_3N$ : C, 66·3; H, 5·1%). Light absorption in ethanol : Max. at 2220 (ε = 18800) and 2980 (ε = 8600), inflection at 3270 A. (ε = 6300).

1 : 2-*Dihydro*-1-*keto*-2-*phenyl*isoquinoline-3-*carboxylic Acid.*—1 : 2-Dihydro-1-keto-2-thianaphthalene-3-carboxylic acid and boiling aniline gave 1 : 2-dihydro-1-keto-2-phenyl*iso*quinoline-3-carboxylic acid (85%) as small prisms (from aqueous ethanol), m. p. 272—273° (cf. Bamberger and Frew, *loc. cit.*, whose preparation from *iso*coumarin-3-carboxylic acid had m. p. 265°) (Found : C, 72·6; H, 3·9. Calc. for $C_{16}H_{11}O_3N$ : C, 72·4; H, 4·2%).

2-*Benzyl*-1 : 2-*dihydro*-1-*keto*isoquinoline-3-*carboxylic Acid.*—1 : 2-Dihydro-1-keto-2-thianaphthalene-3-carboxylic acid (0·4 g.) was heated under reflux with benzylamine (5 c.c.) for 30 minutes. The cooled reaction mixture was poured into excess of dilute hydrochloric acid, and the precipitate (0·45 g.) collected. Crystallisation from aqueous ethanol gave 2-*benzyl*-1 : 2-*dihydro*-1-*keto*isoquinoline-3-*carboxylic acid* as small laths, m. p. 223—224° (Found : C, 73·1; H, 4·7. $C_{17}H_{13}O_3N$ requires C, 73·1; H, 4·7%). Light absorption in ethanol : Max. at 2060 (ε = 39000), 3010 (ε = 11500), and 3260 (ε = 6500), inflection at 2230 A. (ε = 26000).

1 : 2-*Dihydro*-1-*keto*-4-*methyl*isoquinoline.—(*a*) 1 : 2-Dihydro-1-keto-4-methyl-2-thianaphthalene (100 mg.) was heated with methanolic ammonia (15 c.c.; saturated at 0°) at 130° for 2 hours. The reaction mixture was evaporated to dryness and the residue crystallised from water from which 1 : 2-*dihydro*-1-*keto*-4-*methyl*isoquinoline (60 mg., 61%) separated as fine needles, m. p. 173—174° (Found : C, 75·7; H, 5·5. $C_{10}H_9ON$ requires C, 75·45; H, 5·7%). Light absorption in ethanol : Max. at 2250 (ε = 16200), 2850 (ε = 8900), and 3310 A. (ε = 5400).

(*b*) 1 : 2-Dihydro-1-keto-4-methyl*iso*quinoline-3-carboxylic acid (10 mg.) was heated to 340—350° until effervescence ceased and the residue was sublimed at 120°/$10^{-5}$ mm. The sublimate (2 mg.) crystallised from water as fine needles, m. p. 172—173° alone or mixed with preparation (*a*).

1 : 2-*Dihydro*-1-*keto*isoquinoline(iso*Quinol*-1-*one*).—(*a*) 1 : 2-Dihydro-1-keto-2-thianaphthalene (100 mg.) was treated as in (*a*) in the previous experiment, to give 1 : 2-dihydro-1-keto*iso*quinoline (75 mg., 84%) as needles (from aqueous ethanol), m. p. 209° (Bamberger and Kitschelt, *loc. cit.*, give m. p. 208°) (Found : C, 75·0; H, 4·5. Calc. for $C_9H_7ON$ : C, 74·5; H, 4·85%). Light absorption in ethanol : Max. at 2800 (ε = 9300) and 3240 A. (ε = 4900); Ewing and Steel, *J. Amer. Chem. Soc.*, 1946, **68**, 2181, give maxima at 2800 (ε = 8000) and 3250 A. (ε = 4500).

(*b*) 1 : 2-Dihydro-1-keto*iso*quinoline-3-carboxylic acid, when heated to 350°, gave 1 : 2-dihydro-1-keto*iso*quinoline as needles (from aqueous ethanol), m. p. 209—210° undepressed by preparation (*a*) (Found: C, 74·65; H, 4·5%).

The authors gratefully acknowledge their indebtedness to Professor F. S. Spring for his constant encouragement and thank Messrs. T. and H. Smith Ltd. for the gift of opianic acid.

THE ROYAL TECHNICAL COLLEGE, GLASGOW. [*Received, January 10th,* 1951.]