

Substitution Reactions of Benzo[*b*]thiophen Derivatives. Part IV.¹ Nitration of 3-Bromo-2-methylbenzo[*b*]thiophen and 2,3-Dimethylbenzo[*b*]thiophen

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Nitration of 3-bromo-2-methylbenzo[*b*]thiophen in a mixture of sulphuric and acetic acids gives 2-methyl-3-nitrobenzo[*b*]thiophen (44%), 3-bromo-2-methyl-6-nitrobenzo[*b*]thiophen (31%), and 3-bromo-2-methyl-4-nitrobenzo[*b*]thiophen (22%).

The nitration of 2,3-dimethylbenzo[*b*]thiophen in acetic acid is re-examined and the major products are shown to be 2,3-dimethyl-6-nitrobenzo[*b*]thiophen, 3-methyl-2-nitromethylbenzo[*b*]thiophen, 3-methylbenzo[*b*]thiophen-2-carbaldehyde, and 2,3-dimethyl-4-nitrobenzo[*b*]thiophen. The last compound was not reported in an earlier study by Bordwell and Cutshall. A minor product from the nitration reaction is now shown to be a bis-(*o*-substituted phenyl) disulphide (1), and its formation is rationalised in terms of a ring-opening reaction. The synthesis of a model compound, 3-nitro-3-phenylbutan-2-one, is reported and an attempt to synthesise the disulphide (1) is described.

THE previous papers in this series have been concerned mainly with the electrophilic substitution reactions of 2,3-disubstituted benzo[*b*]thiophen derivatives containing a 2-carboxy-^{1,2} or a 2-bromo-substituent.^{3,4} In an attempt to investigate how the substitution pattern is modified by the presence of an electron-donating 2-substituent we describe here the nitration of 3-bromo-2-methylbenzo[*b*]thiophen and of 2,3-dimethylbenzo[*b*]thiophen.

3-Bromo-2-methylbenzo[*b*]thiophen⁵ was obtained as the sole product from the bromination of 2-methylbenzo[*b*]thiophen. When treated with a mixture of fuming nitric acid, acetic acid, and sulphuric acid it gave a product which was separated chromatographically into three components. The first component [31% of the crude mixture (g.l.c.)] showed a splitting pattern in the n.m.r. spectrum consistent with the presence of either a 5- or a 6-nitro-substituent. The latter seemed the more probable since we had not previously obtained any 5-substituted compounds from the nitration of a range of 2,3-disubstituted benzo[*b*]thiophenes.¹⁻⁴ We therefore obtained the 1,1-dioxide of the nitration product by oxidation with hydrogen peroxide and acetic acid, and showed that it was identical with the

nitration product of 3-bromo-2-methylbenzo[*b*]thiophen 1,1-dioxide. As substituted benzo[*b*]thiophen 1,1-dioxides invariably undergo nitration in the 6-position regardless of the nature of the substituent,⁶ this affords adequate, though admittedly not rigorous, proof that the unknown nitration product is 3-bromo-2-methyl-6-nitrobenzo[*b*]thiophen.

The major component (44%) was identified as 2-methyl-3-nitrobenzo[*b*]thiophen by its molecular weight (mass spectrum), by a large anisotropic deshielding of 4-H by the 3-nitro-group in the n.m.r. spectrum, and by its identity with authentic material. The preparation of authentic 2-methyl-3-nitrobenzo[*b*]thiophen⁵ from the nitration of 2-methylbenzo[*b*]thiophen gave rise to at least two other products; these were not identified, but analogy with the results from this and previous studies suggests that they may be the 4- and 6-nitro-compounds. By-products are often formed by the electrophilic replacement of a 3-substituent during the substitution of certain benzo[*b*]thiophen derivatives. The high yield of replacement product in the present case is not unexpected in view of the fact that the reaction should be aided by the presence of an electron-donating *ortho*-methyl group. Further, Matsuki and

⁴ J. Cooper, D. F. Ewing, R. M. Scrowston, and R. Westwood, *J. Chem. Soc. (C)*, 1970, 1949.

⁵ D. A. Shirley, M. J. Danzig, and F. C. Canter, *J. Amer. Chem. Soc.*, 1953, **75**, 3278.

⁶ B. Iddon and R. M. Scrowston, *Adv. Heterocyclic Chem.*, 1970, **11**, 358.

¹ Part III, J. Cooper and R. M. Scrowston, *J. Chem. Soc. (C)*, 1971, 3405.

² J. Cooper and R. M. Scrowston, *J.C.S. Perkin I* in the press.

³ J. Cooper and R. M. Scrowston, *J. Chem. Soc. (C)*, 1971, 3052.

Ito⁷ have shown that although 3-bromo-2-methylbenzo[*b*]thiophen gives the 6-acetyl compound (94%) when treated with acetyl chloride and aluminium chloride in nitrobenzene at 0°, it gives mainly the 3-acetyl compound (80%) when the temperature is raised to 10°.

The third component (22%) was readily identified as 3-bromo-2-methyl-4-nitrobenzo[*b*]thiophen from its n.m.r. spectrum. Although the coupling pattern was consistent with the presence of either a 4- or a 7-nitro-group the signals appeared at rather high field, suggesting that the nitro-group was not exerting its full mesomeric effect. We have shown previously⁴ that this effect occurs only for 4-nitrobenzo[*b*]thiophens, in which the nitro-group is twisted out of coplanarity with the benzene ring by steric interaction with the bulky 3-substituent.

Finally, 3-bromo-2-methylbenzo[*b*]thiophen was treated with an excess of nitric acid in acetic anhydride and the major product was isolated by preparative t.l.c. It was easily identified as 2-methyl-3,6-dinitrobenzo[*b*]thiophen by the absence of a bromine isotope pattern from the mass spectrum and by the large anisotropic deshielding of 4-H by the 3-nitro-group in the n.m.r. spectrum.

The nitration of 2,3-dimethylbenzo[*b*]thiophen with nitric acid in acetic anhydride at 0° has been reported previously by Bordwell and Cutshall,⁸ who obtained 2,3-dimethyl-6-nitrobenzo[*b*]thiophen (10%), 3-methyl-2-nitromethylbenzo[*b*]thiophen (33%), 3-methylbenzo[*b*]thiophen-2-carbaldehyde (6%), a small amount of unidentified crystalline material, and a large amount of polymeric material. The yields quoted were obtained by weighing fractions eluted from a chromatographic column, and are probably not very accurate. In connection with the present study we repeated the nitration reaction under conditions which gave less polymeric material and obtained an accurate analysis of the resulting mixture by a combination of n.m.r. spectroscopy and g.l.c. (see Table and the footnotes

Nitration products of 2,3-dimethylbenzo[*b*]thiophen^a

Benzo[<i>b</i>]thiophen derivative	<i>R_t</i> /min	% of mixture
Starting material	2.0	0.3
3-Me, 2-CHO [compound (D)]	11.7	15 ^b
3-Me, 2-CH ₂ NO ₂ [compound (C)]	11.7	45 ^b
2,3-diMe, 4-NO ₂ [compound (A)]	14.6	14
2,3-diMe, 6-NO ₂ [compound (B)]	26.85	14
Disulphide (1) [compound (E)]		10 ^c

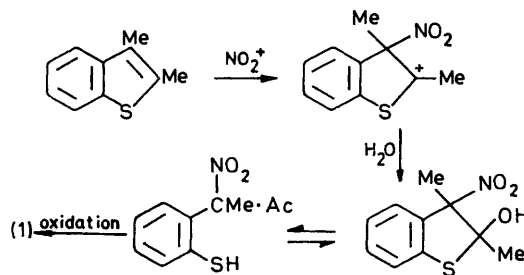
^a Mixture analysed by g.l.c. ^b Because of identical *R_t* values the relative proportions were estimated from peak areas in the n.m.r. spectrum of the mixture. ^c Too involatile for g.l.c.; estimated from material recovered from the mixture.

thereto). Nitration with a mixture of nitric, sulphuric, and acetic acid at 25° gave intractable tars, but with nitric acid and acetic acid at 25° a clean product was obtained and little starting material remained. Five

crystalline components (A—E) were obtained, of which (B), (C), and (D) respectively had m.p.s corresponding to those⁸ of 2,3-dimethyl-6-nitrobenzo[*b*]thiophen, 3-methyl-2-nitromethylbenzo[*b*]thiophen, and 3-methylbenzo[*b*]thiophen-2-carbaldehyde. The structural assignments made by Bordwell and Cutshall⁸ were confirmed in each case from the n.m.r. spectrum.

Compound (A) was identified as 2,3-dimethyl-4-nitrobenzo[*b*]thiophen from the n.m.r. spectrum, from which there was clear evidence of the type just described for the out-of plane twisting of the nitro-group. It is interesting that Bordwell and Cutshall's⁸ nitration procedure evidently did not give any of the 4-nitro-compound.

Compound (E) had a m.p. identical to that reported for the unidentified crystalline material in the earlier work.⁸ Its i.r. spectrum showed a carbonyl absorption at 1725 cm⁻¹, similar to that shown by an aliphatic ketone with an electron-withdrawing α -substituent^{9a} and bands at 1545 and 1360 cm⁻¹, which were assigned to a tertiary nitro-group.^{9b} The n.m.r. spectrum [in (CD₃)₂SO] showed two methyl singlets (δ 2.07 and 2.17 p.p.m.) and a typical ABCD splitting pattern due to a 1,2-disubstituted benzene ring; there was no aldehyde signal. The mass spectrum showed a molecular ion peak at *m/e* 448, corresponding to C₂₀H₂₀N₂O₆S₂, and significant fragment ions at *m/e* 418 (*M* - NO, *m*^{*} 390), 402 (*M* - NO₂, *m*^{*} 386.5), 356 (402 - NO₂, *m*^{*} 315), 313 (356 - Ac, *m*^{*} 275), 271 (313 - CH₂CO, *m*^{*} 234.5), 178 (symmetrical cleavage of 356), 135 (178 - Ac, *m*^{*} 102.5), and 91 (135 - CS, *m*^{*} 61.5). These data suggested that (E) was the disulphide (1), which could arise from 2,3-dimethylbenzo[*b*]thiophen by the mechanism shown. In support of this structure,



the keto-group was reduced by diborane to give an oily hydroxy-compound.

We next attempted to synthesise the disulphide (1), but in order to determine the best route we decided first to prepare the model compound, 3-nitro-3-phenylbutan-2-one (2). Methylation of phenylacetone with methyl iodide and sodium hydroxide is reported¹⁰ to yield 3-phenylbutan-2-one (3), but we found that this reaction gave a 1 : 1 mixture of the monomethyl compound (3) and the dimethyl compound (4). However, the required ketone (3) was obtained in >95% purity by methylation of phenylacetone with ethereal

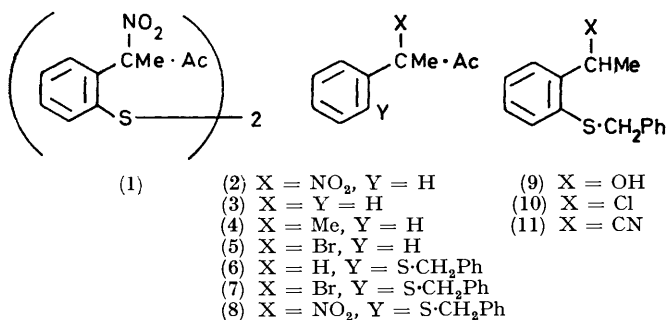
⁷ Y. Matsuki and I. Ito, *J. Chem. Soc. Japan*, 1967, **88**, 751.

⁸ F. G. Bordwell and T. W. Cutshall, *J. Org. Chem.*, 1964, **29**, 2020.

⁹ (a) L. J. Bellamy, 'The Infra-red Spectra of Complex Molecules,' 2nd edn., Methuen, London, 1958, p. 132; (b) p. 299.

¹⁰ U.S.P. 2,644,843/1953 (*Chem. Abs.*, 1954, **48**, 6466).

methyl iodide in the presence of sodamide. It then reacted with bromine to give 3-bromo-3-phenylbutan-2-one (5) in high yield. Treatment of the bromo-compound (5) with sodium nitrite in dimethyl sulphoxide



in the presence of phloroglucinol (a nitrite ester scavenger) gave 3-nitro-3-phenylbutan-2-one (2) (67%), the i.r., n.m.r., and mass spectra of which were similar to those of the disulphide (1). Although alkyl halides and α -bromo-esters¹¹ are converted into the corresponding nitro-compounds by reaction with sodium nitrite under the conditions just described, we believe that this is the first example of the preparation of an α -nitro-ketone by this method.

An attempted synthesis of the disulphide (1) by an analogous route started from *o*-(benzylthio)acetophenone,¹² borohydride reduction of which gave the alcohol (9), which was then converted *via* the chloro-compound (10) into the nitrile (11). This reacted with methylmagnesium iodide in benzene to give 3-(*o*-benzylthiophenyl)butan-2-one (6) in good yield. Yields from this reaction were considerably higher than when ether was used as solvent, probably because the Grignard reagent reacts less readily with the acidic α -hydrogen of the nitrile in the relatively non-polar benzene solution. Bromination of the ketone (6) gave the expected bromo-compound (7); its structure was confirmed by the absence of a methine proton signal from the n.m.r. spectrum. Compounds [(10), (11), (6), and (7)] were all oils, but the purity of each was checked carefully by chromatographic and spectroscopic methods. It was hoped that the bromo-compound (7) would give the corresponding nitro-compound (8) on treatment with sodium nitrite in dimethyl sulphoxide. Removal of the benzyl group and oxidation of the resulting thiol should then give the required disulphide (1). However, several attempts to replace the bromine atom in (7) by the nitro-group gave back starting material, and the synthesis by this route was discontinued. Nevertheless we consider that the spectroscopic data for the model compound (2) are sufficient to justify the proposed structure (1) for the product from the nitration.

The results of the substitution reactions described above will be correlated in a later paper with those obtained for other 2,3-disubstituted benzo[*b*]thiophenes.¹⁻⁴

¹¹ N. Kornblum, *Org. Reactions*, 1962, **12**, 101.

¹² M. S. El Shanta, Ph.D. Thesis, University of Hull, 1969.

EXPERIMENTAL

For general experimental directions see refs. 3 and 4.

3-Bromo-2-methylbenzo[*b*]thiophen was prepared⁵ by the bromination of 2-methylbenzo[*b*]thiophen. Two crystallisations from ethanol gave material of 99.5% purity (g.l.c.), m.p. 41–42° (lit.,⁵ 42–42.5°), *R_t* 43.5 min.

Prepared⁸ (88%) by the cyclisation of 3-(phenylthio)butan-2-one with phosphorous pentoxide in polyphosphoric acid at 120°, 2,3-dimethylbenzo[*b*]thiophen had b.p. 81–83° at 0.4 mmHg (lit.,⁸ 96–98° at 1.5 mmHg), *R_t* 2.0 min.

*Nitration of 3-Bromo-2-methylbenzo[*b*]thiophen.*—A solution of fuming nitric acid (*d* 1.5; 2.7 ml, 0.066 mol) in glacial acetic acid (10 ml) was added dropwise during 20 min to a stirred solution of 3-bromo-2-methylbenzo[*b*]thiophen (11.3 g, 0.05 mol) in acetic acid (100 ml) and concentrated sulphuric acid (10 ml). Stirring was continued for 4 h at room temperature, then the mixture was poured into water and extracted with ether. The washed (NaHCO₃) and dried ethereal extracts were evaporated to give semi-solid orange material (11.5 g), a portion (5.0 g) of which was chromatographed on silica gel. Elution with light petroleum–benzene (9:1) gave (a) 3-bromo-2-methyl-6-nitrobenzo[*b*]thiophen (0.9 g) as pale yellow needles, m.p. 137–138° (from ethanol) (Found: C, 39.75; H, 2.1; Br, 29.2; N, 5.0%; *M*, 271. C₉H₆BrNO₂S requires C, 39.7; H, 2.2; Br, 29.35; N, 5.15%; *M*, 271), ν_{max} 1515 and 1338 (NO₂) cm⁻¹, δ 2.61 (s, Me), 7.77 (dd, 4-H), 8.24 (dd, 5-H), and 8.64 (dd, 7-H) p.p.m. (*J*_{4,5} 9.0, *J*_{4,7} 0.5, *J*_{5,7} 2.1 Hz), *R_t* 29.15 min. Oxidation with hydrogen peroxide (28% w/v) in acetic acid gave the 1,1-dioxide as plates, m.p. 179.5–180.5° (from ethanol) (Found: C, 35.75; H, 1.95; N, 4.4. C₉H₆BrNO₂S requires C, 35.55; H, 2.0; N, 4.6%; ν_{max} 1530, 1350 (NO₂), 1320, and 1175 (SO₂) cm⁻¹; (b) 2-methyl-3-nitrobenzo[*b*]thiophen (1.4 g), which crystallised from ethanol as pale yellow needles, m.p. 97–98° (lit.,⁵ 98–98.5°) (Found: C, 55.85; H, 3.45; N, 7.35%; *M*, 193. Calc. for C₉H₇NO₂S: C, 55.95; H, 3.65; N, 7.25%; *M*, 193), ν_{max} 1535 and 1340 (NO₂) cm⁻¹, δ 2.91 (s, Me) p.p.m., *R_t* 8.35 min, identical with authentic⁵ material; (c) 3-bromo-2-methyl-4-nitrobenzo[*b*]thiophen (0.6 g), which formed pale yellow needles, m.p. 120–121.5° (from ethanol) (Found: C, 39.7; H, 2.1; Br, 29.1; N, 5.3%; *M*, 271), ν_{max} 1530 and 1370 (NO₂) cm⁻¹, δ 2.57 (s, Me), 7.59 (dd, 5-H), 7.37 (dd, 6-H), and 7.91 (dd, 7-H) p.p.m. (*J*_{5,6} = *J*_{6,7} 7.7, *J*_{5,7} 1.3 Hz), *R_t* 41.1 min.

*Nitration of 3-Bromo-2-methylbenzo[*b*]thiophen 1,1-Dioxide.*—Treatment of 3-bromo-2-methylbenzo[*b*]thiophen with an excess of a mixture of hydrogen peroxide and acetic acid gave the 1,1-dioxide (88%) as colourless plates, m.p. 190–191° (from ethanol) (Found: C, 41.5; H, 2.5; Br, 31.0. C₉H₆BrO₂S requires C, 41.7; H, 2.7; Br, 30.8%), ν_{max} 1296 and 1170 (SO₂) cm⁻¹.

The 1,1-dioxide (1.0 g) was added portionwise with stirring to fuming nitric acid (*d* 1.5; 5 ml). The temperature was kept at –5° during the addition, then the mixture was stirred at room temperature for 4 h, and poured into water. Extraction with benzene gave an oily yellow product (0.9 g), which crystallised from benzene to give 3-bromo-2-methyl-6-nitrobenzo[*b*]thiophen 1,1-dioxide (0.25 g, 21%), m.p. 179–180°, identical with the 1,1-dioxide of the product from the nitration reaction. Evaporation of the mother liquors from the crystallisation gave yellow material, the i.r. spectrum of which was determined

with the aid of the wedge technique,¹³ in order to eliminate the bands due to the 1,1-dioxide. The resulting spectrum showed ν_{\max} 1736 (C=O), 1544, and 1336 (NO₂) cm⁻¹, but attempts to purify the carbonyl compound were unsuccessful.

2-Methyl-3,6-dinitrobenzo[b]thiophen.—A solution of fuming nitric acid (*d* 1.5; 3 ml) in acetic acid (3 ml) was added dropwise during 20 min to a cold (0°), stirred solution of 3-bromo-2-methylbenzo[b]thiophen (2.25 g, 0.01 mol) in acetic anhydride (15 ml). Stirring was continued for 20 min at 0° and for 8 h at room temperature, then the mixture was poured into water. The resulting yellow solid (2 g) was filtered off and a portion (0.4 g) of it was subjected to preparative t.l.c. The major product formed yellow crystals (0.1 g), m.p. 169—171° (from ethanol) (Found: C, 45.1; H, 2.4; N, 11.4%; *M*, 238. C₉H₆N₂O₄S requires C, 45.35; H, 2.55; N, 11.75%; *M*, 238), ν_{\max} 1512 and 1340 (NO₂) cm⁻¹, δ 3.01 (s, Me), 8.60 (dd, 4-H), 8.37 (dd, 5-H), and 8.69 (dd, 7-H) p.p.m. (*J*_{4,5} 9.0, *J*_{4,7} 0.4, *J*_{5,7} 1.8 Hz).

Nitration of 2,3-Dimethylbenzo[b]thiophen.—Fuming nitric acid (*d* 1.5; 3 ml) was added to a stirred solution of 2,3-dimethylbenzo[b]thiophen (1.62 g, 0.01 mol) in acetic acid (20 ml) and the mixture was stirred at room temperature for a total of 10 h. It was then poured into water and extracted with ether. Compound (E) (0.12 g) was undissolved by the ether extraction, and was filtered off. The dried ethereal solution was evaporated to give semi-solid orange material (1.35 g), which was chromatographed on silica gel. Compounds (A—F) and a further quantity (30 mg) of (E) were eluted successively with light petroleum [for (A), (B), and (C)], light petroleum—chloroform (4 : 1) [for (D)], and chloroform [for (E)].

2,3-Dimethyl-4-nitrobenzo[b]thiophen [compound (A)] formed pale yellow needles (0.1 g), m.p. 61—62° (from ethanol) (Found: C, 57.9; H, 4.1; N, 7.1%; *M*, 207. C₁₀H₈NO₂S requires C, 57.95; H, 4.4; N, 6.75%; *M*, 207), ν_{\max} 1523 and 1360 (NO₂) cm⁻¹, δ 2.18, 2.50 (s, Me), 7.59 (dd, 5-H), 7.28 (dd, 6-H), and 7.89 (dd, 7-H) p.p.m. (*J*_{5,6} 7.7, *J*_{5,7} 1.1, *J*_{6,7} 7.8 Hz), *R*_t 14.6 min.

2,3-Dimethyl-6-nitrobenzo[b]thiophen [compound (B)] crystallised from ethanol as yellow needles (0.12 g), m.p. 123—124° (lit.,⁸ 124—125°), ν_{\max} 1510 and 1330 (NO₂) cm⁻¹; δ 2.32, 2.53 (s, Me), 7.62 (dd, 4-H), 8.17 (dd, 5-H), and 8.62 (dd, 7-H) p.p.m. (*J*_{4,5} 8.9, *J*_{4,7} 0.5, *J*_{5,7} 2.1 Hz), *R*_t 26.85 min.

3-Methyl-2-nitromethylbenzo[b]thiophen [compound (C)] was obtained as needles (0.65 g), m.p. 98—99° (lit.,⁸ 103—104°), ν_{\max} 1550 and 1370 (NO₂) cm⁻¹, δ 2.45 (s, Me) and 5.65 (s, CH₂) p.p.m., *R*_t 11.7 min.

3-Methylbenzo[b]thiophen-2-carbaldehyde [compound (D)] formed yellow needles (0.12 g), m.p. 86—87° (lit.,⁸ 88—89°), ν_{\max} 1655 (C=O) cm⁻¹, δ 2.73 (s, Me) and 10.30 (s, CHO) p.p.m., *R*_t 11.7 min.

The **disulphide (1)** [compound (E)] crystallised from dimethylformamide as white needles, m.p. 159—160° (Found: C, 53.6; H, 4.4; N, 6.4%; *M*, 448.0708; *M* — NO₂, 402.0824; *M* — 2NO₂, 356.0897. C₂₀H₂₀N₂O₆S₂ requires C, 53.55; H, 4.5; N, 6.25%; *M*, 448.0763; *M* — NO₂, 402.0833; *M* — 2NO₂, 356.0904), see text for spectral data.

Diborane Reduction of Compound (1).—Diborane (5 mol. equiv.) was passed into a cooled (0°), stirred solution of compound (1) (0.45 g) in dry tetrahydrofuran (50 ml), then the mixture was kept for 12 h at room temperature.

Water was added and the product was obtained by ether extraction as a pale yellow oil (0.45 g), ν_{\max} 3000—3700 (OH), 1543, and 1342 (NO₂) cm⁻¹.

3-Phenylbutan-2-one (3).—Finely powdered sodamide (7.8 g) was added portionwise to a vigorously stirred solution of phenylacetone (26.8 g) and methyl iodide (28.6 g) in dry ether (400 ml). The mixture was stirred for 12 h at room temperature, then heated under reflux for 8 h, poured into water, and extracted with ether. The product (22.9 g, 76%) was obtained as a colourless oil, b.p. 139—140° at 50 mmHg (lit.,¹⁰ 105—110° at 22 mmHg), ν_{\max} 1710 (C=O) cm⁻¹, δ 2.08 (s, Ac), 1.45 (d, Me), and 3.79 (q, CH) p.p.m. (*J* 7 Hz).

3-Bromo-3-phenylbutan-2-one (5).—Bromine (10.8 g) was added to a cooled solution of the foregoing ketone (10 g) in ether (50 ml). After 30 min the solution was washed, dried, and evaporated, to give the bromo-compound (14.8 g) as a pale yellow oil (Found: *M*, 226. C₁₀H₁₁BrO requires *M*, 226), ν_{\max} 1713 (C=O) cm⁻¹, δ 2.10 (s, Me) and 2.20 (s, Ac) p.p.m. It was used in the next stage without further purification.

3-Nitro-3-phenylbutan-2-one (2).—3-Bromo-3-phenylbutan-2-one (5.6 g) was added with stirring to a cooled (15°) solution of sodium nitrite (1.8 g), phloroglucinol (3.2 g), and urea (1 g) in dimethyl sulphoxide (50 ml). The mixture was stirred for 4 h at room temperature, then poured into water, and extracted with ether. The washed (aqueous 1% NaOH, H₂O) and dried ethereal solution was evaporated, to give pale yellow needles (3.9 g, 67%), m.p. 67—68° (from light petroleum) (Found: C, 62.05; H, 5.75; N, 7.55%; *M*, 193. C₁₀H₁₁NO₃ requires C, 62.15; H, 5.75; N, 7.25%; *M*, 193), ν_{\max} 1720 (C=O), 1542, and 1352 (NO₂) cm⁻¹, δ 2.16 (s, Me) and 2.20 (s, Ac) p.p.m.

1-(*o*-Benzylthiophenyl)ethanol (9).—A solution of sodium borohydride (1.5 g) and sodium hydroxide (0.4 g) in water (5 ml) was added dropwise to a hot (70°), stirred solution of *o*-(benzylthio)acetophenone¹² (3.7 g) in ethanol (100 ml), and the mixture was kept at 70° for 5 h. Most of the ethanol was then distilled off, water was added, and the product was extracted with ether. It formed white needles (3.3 g, 88%), m.p. 48—49° (from light petroleum) (Found: C, 73.5; H, 6.5; S, 13.1. C₁₅H₁₆OS requires C, 73.7; H, 6.6; S, 13.1%), ν_{\max} 3400 (OH) cm⁻¹, δ 1.34 (d, Me) and 5.15 (q, CH) p.p.m. (*J* 7.5 Hz).

2-(*o*-Benzylthiophenyl)propionitrile (11).—Treatment of the alcohol (9) with thionyl chloride gave 1-(*o*-benzylthiophenyl)ethyl chloride (10) as a yellow oil, which was used without further purification.

A mixture of the chloro-compound (10) (30 g), sodium cyanide (9.2 g), acetone (150 ml), and water (100 ml) was heated under reflux for 24 h, then most of the acetone was distilled off, and the product was extracted with benzene. The dried benzene solution was filtered through a column of alumina, then evaporated and distilled. The product was obtained as a pale yellow oil (25 g, 86%), b.p. 161—163° at 0.4 mmHg (Found: C, 75.95; H, 6.0; N, 5.55%; *M*, 253. C₁₆H₁₅NS requires C, 75.85; H, 5.95; N, 5.5%; *M*, 253), ν_{\max} 2240 (CN) cm⁻¹, δ 1.38 (d, Me) and 4.36 (q, CH) p.p.m. (*J* 7.0 Hz).

3-(*o*-Benzylthiophenyl)butan-2-one (6).—Benzene (100 ml) was added to a solution of methylmagnesium iodide [from magnesium (3 g) and methyl iodide (17.2 g)] in ether (25 ml), then most of the ether was distilled off, and the

¹³ H. McCormick, E. L. Deeley, and J. Tadayon, *Nature*, 1965, 207, 474.

resulting solution was added under nitrogen to a stirred solution of the nitrile (11) (10 g) in benzene (25 ml). The mixture was heated under reflux for 8 h, then poured into dilute hydrochloric acid. The benzene layer was separated, dried and evaporated, to yield a yellow oil, which was purified *via* its Girard derivative. Distillation gave a colourless, viscous *oil* (6.9 g, 65%), b.p. 157—159° at 0.4 mmHg, ν_{\max} 1712 (C=O) cm^{-1} , δ 1.90 (s, Ac), 1.22 (d, Me), and 4.37 (q, CH) p.p.m. (J 7.0 Hz).

The 2,4-dinitrophenylhydrazone had m.p. 134—135° (from ethanol) (Found: C, 61.6; H, 5.15; N, 12.45. $\text{C}_{23}\text{H}_{22}\text{N}_4\text{O}_4\text{S}$ requires C, 61.3; H, 4.95; N, 12.45%).

3-Bromo-3-(*o*-benzylthiophenyl)butan-2-one (7).—Treat-

ment of the ketone (6) with bromine in ether under the conditions already described for compound (5) gave a pale yellow *oil* (90%) (Found: M , 348. $\text{C}_{17}\text{H}_{17}\text{BrOS}$ requires M , 348), ν_{\max} 1710 (C=O) cm^{-1} , δ 2.17 (s, Ac) and 2.43 (s, Me). It was recovered unchanged after treatment with sodium nitrite in dimethyl sulphoxide.

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