## Curvularin. Part VII.<sup>1</sup> Some Acylations of 3,5-Dihydroxytoluene and its **Dimethyl Ether**

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3,5-Dihydroxytoluene is acylated in the 2-position by octanoyl chloride in the presence of aluminium chloride. In polyphosphoric acid it reacts with 7-oxo-octanoic acid and with crotonic acid to give the corresponding 4-acyl derivative and 7-hydroxy-2,5-dimethylchroman-4-one respectively. Under the same conditions 3,5-dimethoxytoluene and crotonic acid give the dioxobenzodipyran (V). Tin(IV) chloride effects the acylation of 3,5-dimethoxytoluene by crotonoyl chloride in the 2-position and by benzoyl chloride in the 2- and 6-positions.

The problems encountered when the acylation of methyl 3,5-dimethoxyphenylacetate was attempted with substituted octanoic acids or their acid chlorides were described in Part VI.<sup>1</sup> In connection with this work we have examined a number of acylations of the related compounds 3,5-dihydroxytoluene (orcinol) and 3,5-dimethoxytoluene.

3,5-Dihydroxytoluene reacted with octanoyl chloride in the presence of aluminium chloride to give a ketone which we formulate as the 2-octanoyl compound (I;  $R^1 = [CH_2]_6 Me$ ,  $R^2 = H$ ). It exhibits u.v. absorption very similar to that 2 of 2,4-dihydroxy-6-methylacetophenone (I;  $R^1 = Me$ ,  $R^2 = H$ ) and its n.m.r. spectrum shows the presence of two types of phenolic proton, one of which displays a chemical shift  $(\tau - 3.40)$  to low field characteristic<sup>3</sup> of an *o*-acylphenol. In contrast the treatment of 3,5-dihydroxytoluene with 7-oxo-octanoic acid<sup>4</sup> in polyphosphoric acid gave the 4-acyl derivative (II; R = H), the u.v. absorptions of the product and of its dimethyl ether (II; R = Me) resembling those of 2,6-dihydroxyacetophenone<sup>5</sup> and of 2,6-dimethoxyacetophenone<sup>6</sup> respectively. The n.m.r. spectrum of the dimethyl ether confirms the symmetrical substitution pattern of the aromatic nucleus. The two aromatic protons appear as a sharp singlet, as do the six methoxyprotons, and both signals display the 'ringing' associated with a single resonance. The hydroxy-protons of the dihydroxy-compound (II; R = H) also give rise to only

one sharp singlet, the chemical shift of which ( $\tau 0.15$ ) is close to the mean  $(\tau - 0.15)$  of the two signals given by the hydroxy-protons of the related 2-octanoyl compound (I;  $R^1 = [CH_2]_6 Me$ ,  $R^2 = H$ ). Each of the hydroxygroups of (II; R = H) can form a hydrogen-bond with the intervening carbonyl group only if this is suitably orientated and we conclude that the rotation of this group about the Ar-CO bond must be fast on the n.m.r. time scale. This results in the observed chemical shift for the hydroxy-protons being the average of the hydrogen-bonded and the non-bonded values.

Acylation of 3,5-dihydroxytoluene by crotonic acid in polyphosphoric acid occurred at C-2 and was accompanied by cyclisation, the product being the dimethylchromanone (III; R = Me). The i.r. and u.v. spectral properties of this closely resemble those of the monomethylchromanone (III; R = H) which was prepared in a similar manner from resorcinol. The n.m.r. spectra of these products show the expected couplings for the aliphatic protons. The chemical shifts of the hydroxyprotons  $(\tau - 0.23 \text{ and } - 0.44)$  are similar and confirm that the carbonyl group is located as shown in structure (III). The isomeric arrangement with the R and HO groups interchanged would show a hydroxy-proton signal below  $\tau - 2.0$  because intramolecular hydrogen-bonding between the hydroxy and carbonyl groups would then be possible.3

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The reaction between *m*-dimethoxybenzene and crotonic acid in polyphosphoric acid gave the unsaturated ketone (IV;  $R^1 = CH:CHMe$ ,  $R^2 = Me$ ) in 70% yield. However the corresponding toluene derivative could not be isolated when 3,5-dimethoxytoluene was used in a similar reaction. Instead we obtained a compound



 $C_{15}H_{16}O_4$  which appears from its i.r. absorption to be a phenolic ester while its u.v. absorption resembles closely that of a polyalkylated benzene (e.g. 9-methyl-1,2,3,4,5,6,7,8-octahydroanthracene<sup>7</sup>). The simplicity of the n.m.r. spectrum establishes that the product is the linear dilactone (V) rather than the angular isomer (VI). The protons of the methyl groups at C-4 and C-6 appear as a doublet (6H) centred at  $\tau$  8.75 being coupled (J 7 Hz) with the C-4 and C-6 methine protons respectively. The latter are also coupled (J 4 Hz) with the methylene protons at C-3 and C-7 which give rise to the doublet (4H) centred at  $\tau$  7.24, and the methine protons themselves appear as the expected multiplet (2H) centred at  $\tau$  6.64. The remaining singlets at  $\tau$  7.68 (3H) and 3.32 (1H) correspond to the C-5 methyl protons and the C-10 proton respectively. The stereochemistry of the groups attached to C-4 and C-6 is not yet known. Polyphosphoric acid rarely causes the cleavage of an aromatic methoxy-group unless this enables cyclisation to take place.<sup>8</sup> Accordingly we consider that the initial step in the formation of the dilactone (V) involves the alkylation of 3.5-dimethoxytoluene at C-2 and C-6 by the crotonic acid-polyphosphoric acid complex. As a result

of the steric effects of the bulky new substituents the methoxy-groups are no longer fully conjugated with the aromatic ring and can undergo intramolecular O-acylation and concurrent demethylation with comparative ease.

The unsaturated ketone (I;  $R^1 = CH:CHMe$ ,  $R^2 =$ Me) was eventually obtained from the tin(IV) chloridecatalysed reaction between 3,5-dimethoxytoluene and crotonoyl chloride. Its u.v. absorption differs significantly from that <sup>9</sup> of the related ketone (IV;  $R^1 =$ CHC:HMe,  $R^2 = Me$ ) and we attribute the disappearance of the absorption maximum at 315 nm. to the lack of coplanarity in the cross-conjugated system resulting from the steric requirements of the two ortho-substituents. The poor yield (1.4%) appears to be due, in part, to the relative instability of crotonoyl chloride in the presence of tin(IV) chloride because, under the same conditions, benzoyl chloride, reacted with 3,5-dimethoxytoluene to give good yields of the benzoylated products (I;  $R^1 = Ph$ ,  $R^2 = Me$ ) and (VII; R = Me). The presence of two methoxy-proton signals in the n.m.r. spectrum of the monobenzoyl compound shows that the benzoyl group is in the 2- rather than the 4-position. The methoxy-protons of the dibenzoyl compound appear as one sharp, ringing signal which establishes the symmetrical arrangement of the benzoyl groups, in the 2- and 6-positions. The structures of these compounds were confirmed by their demethylation, with pyridine hydrochloride, to the corresponding phenols which have previously been described.<sup>10-12</sup>

The u.v. absorption of the 2,6-disubstituted benzophenone (I;  $R^1 = Ph$ ,  $R^2 = Me$ ) is quite unlike that <sup>13</sup> of the monosubstituted compound (IV;  $R^1 = Ph$ ,  $R^2 =$ Me) and resembles instead that of 2,6-dimethylbenzophenone.<sup>14</sup> This suggests that the two ortho-substituents cause considerable rotation of the benzoyl group relative to the second aromatic ring with the result that conjugation is greatly reduced. The same argument accounts for the u.v. absorption of the dibenzovl compound (VII; R =Me) in which, judging by the extinction coefficients, both benzoyl groups are largely unconjugated with the central aromatic nucleus. The u.v. absorptions of the phenols (I;  $R^1 = Ph$ ,  $R^2 = H$ ) and (VII; R = H) are very similar to those of the corresponding methyl ethers showing that hydrogen-bonding between the hydroxyl and carbonyl groups does not appreciably reduce the distortion of the twisted conjugated systems.

Although 3,5-dihydroxytoluene is acylated by simple nitriles <sup>15</sup> in the Hoesch reaction it failed to react with methyl 6-cyanohexanoate in the presence of hydrogen chloride and zinc chloride. The cyanoester, which was prepared by standard procedures from 5-chloropentano-

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## EXPERIMENTAL

U.v. absorption spectra were measured for ethanolic solutions with Unicam SP 500 and Hilger 'Ultrascan' spectrophotometers. Unless otherwise stated, i.r. absorption spectra were obtained for KBr discs with Perkin-Elmer models 137 and 237 spectrophotometers, and n.m.r. spectra were measured for solutions in  $\text{CDCl}_3$  with a Varian Associates A-60 spectrometer (60 MHz) with tetramethylsilane ( $\tau$  10.0) as internal standard.

3,5-Dihydroxy-2-octanoyltoluene (I;  $R^1 = [CH_2]_6 Me$ ,  $R_2 =$ H).-Powdered anhydrous aluminium chloride (1.5 g.) was added slowly to a stirred mixture of octanoyl chloride<sup>1</sup> [from sodium octanoate (1.4 g.) and oxalyl chloride (2 ml.)], anhydrous 3,5-dihydroxytoluene (orcinol; 1 g.), and nitrobenzene (20 ml.) at 0°. Next day the mixture was added to ice and concentrated hydrochloric acid, shaken with ether, and the ethereal layer was steam-distilled. The residue was shaken with ether and the ethereal solution was washed with aqueous sodium hydrogen carbonate, dried (MgSO<sub>4</sub>), and evaporated, finally at  $100^{\circ}/0.2$  Torr. The residue (2 g.) on being heated at  $106^{\circ}$  (bath)/ $6 \times 10^{-5}$  Torr gave a waxy sublimate which crystallised from benzenelight petroleum (b.p. 60-80°) to give 3,5-dihydroxy-2-octanoyltoluene as plates (0.53 g., 26.5%), m.p. 90-91° (Found: C, 71.9; H, 8.9. C<sub>15</sub>H<sub>22</sub>O<sub>3</sub> requires C, 71.95; H,  $8{\cdot}85\%),\,\nu_{max.}$  (Nujol) 3400 (OH) and 1640 cm.<sup>-1</sup> (aryl ketone C=O);  $\lambda_{max}$  222 (log  $\epsilon$  4.08) and 279.5 (3.94);  $\lambda_{infl.}$  233 (log  $\epsilon$  3.88) and 313.5 nm. (3.61);  $\tau = 3.40$  (s, OH at C-3), 3.11 (s, OH at C-5), 3.74 (s, Ar-H at C-4 and C-6), 7.11 (t, J 7Hz, CO-CH<sub>2</sub>), 7.47 (s, ArCH<sub>3</sub>), 7.97-8.94 (m, [CH<sub>2</sub>]<sub>5</sub>), and 9.12 (t, J 5 Hz,  $\text{CH}_2$ -C $H_3$ ).

3,5-Dimethoxy-4-(7-oxo-octanoyl)toluene (II; R = Me). A mixture of anhydrous 3,5-dihydroxytoluene (0.57 g.), 7-oxo-octanoic acid 4 (0.95 g.), and polyphosphoric acid  $(82-85\% P_2O_5; 10 g.)$  was kept at  $60^\circ$  for 2 hr. with frequent stirring; it was then poured onto ice and shaken with ether. The ethereal layer was washed with aqueous sodium hydrogen carbonate, dried (MgSO<sub>4</sub>), and evaporated. The residual gummy solid (1.3 g.) on being crystallised first from benzene and then from ethanol-carbon tetrachloride-light petroleum (b.p. 60-80°) gave 3,5-dihydroxy-4-(7-oxo-octanoyl)toluene as pale yellow needles (0.21 g., 17.5%), m.p. 139.5-140.5° (Found: C, 68.2; H, 7.8.  $C_{15}H_{20}O_4$  requires C, 68·15; H, 7·65%),  $v_{max}$  3400 (OH), 1710 (alkyl ketone C=O), and 1625 cm.<sup>-1</sup> (aryl ketone C=O);  $\lambda_{max}$ 226.5 (log  $\varepsilon$  4.13), 275 (4.16), and 341 nm. (3.48);  $\tau$  0.15 (s, OH at C-3 and C-5), 3.77 (Ar-H at C-2 and C-6), 6.88 (t, J 7 Hz, CO-CH<sub>2</sub>), 7.51 (t, J 6 Hz, CO-CH<sub>2</sub>), 7.76 and 7.83 (both s, ArCH<sub>3</sub> and CO-CH<sub>3</sub>), and  $8\cdot 1$ -8.9 (m, CH<sub>2</sub>-[CH<sub>2</sub>]<sub>3</sub>- $CH_2$ ]. A mixture of the dihydroxy-compound (0.25 g.). dimethyl sulphate (0.5 g.), potassium carbonate (2.5 g.), and dry acetone (40 ml.) was boiled under reflux for 3 hr., poured into hot water, and extracted with ether. Evaporation of the ethereal solution and short-path (1 cm.) distillation of the residue at 100° (bath)/10-3 Torr gave 3,5-dimethoxy-4-(7-oxo-octanoyl)toluene (0.27 g.) as an oil (Found: C, 69.6; H, 8.2. C<sub>17</sub>H<sub>24</sub>O<sub>4</sub> requires C, 69.85; H,

8·25%),  $\nu_{max}$  (film) 1715br cm.<sup>-1</sup> (unresolved alkyl ketone and aryl ketone C=O);  $\lambda_{max}$  267·5 nm. (log  $\varepsilon$  3·59);  $\tau$  3·60 (s, Ar–H at C-2 and C-6), 6·24 (s, OCH<sub>3</sub> at C-3 and C-5), 7·05—7·60 (m, ArCO–CH<sub>2</sub> and CH<sub>2</sub>–Ac), 7·65 and 7·88 (both s, ArCH<sub>3</sub> and CO–CH<sub>3</sub>), and 8·00–8·90 (m, CH<sub>2</sub>–[CH<sub>2</sub>]<sub>3</sub>–CH<sub>2</sub>).

7-Hydroxy-2,5-dimethylchroman-4-one (III; R = Me). A mixture of anhydrous 3,5-dihydroxytoluene (2·0 g.), crotonic acid (2·0 g.), and polyphosphoric acid (70 g.) was stirred at 60° for 45 min. and poured onto ice. Extraction with ether afforded an oily solid which was triturated with benzene. Crystallisation of the residue from benzene gave 7-hydroxy-2,5-dimethylchroman-4-one (0·61 g., 20%) as needles, m.p. 173—173·5° (Found: C, 68·8; H, 6·2. C<sub>11</sub>H<sub>12</sub>O<sub>3</sub> requires C, 68·75; H, 6·3%),  $\nu_{max}$  3400 and ca. 3100br (OH), and 1644 cm.<sup>-1</sup> (aryl carbonyl C=O),  $\lambda_{max}$  230 (log  $\varepsilon$  4·02) and 281 (4·16);  $\lambda_{infl}$  306 nm. (log  $\varepsilon$  3·75);  $\tau$  (CD<sub>3</sub>SOCD<sub>3</sub>) --0·23br (OH), AB quartet centred at 3·74 and 3·81 (J 2 Hz, 6- and 8-H), 5·51 (m, 2-H), 7·49 (d, J 8 Hz, CH<sub>2</sub>-CH=), 7·53 (s, CH<sub>3</sub> at C-5), and 8·62 (d, J 6 Hz, CH<sub>3</sub> at C-2).

7-Hydroxy-2-methylchroman-4-one (III; R = H).—A similar reaction between resorcinol (2·0 g.), crotonic acid (2·0 g.), and polyphosphoric acid (105 g.) gave 7-hydroxy-2-methylchroman-4-one (0·75 g., 23%) which crystallised from benzene as needles, m.p. 179—180° (lit.,<sup>16</sup> m.p. 177°), v<sub>max.</sub> 3420 and ca. 3100br (OH), and 1650 cm.<sup>-1</sup> (aryl carbonyl C=O);  $\lambda_{max.}$  238 (log  $\varepsilon$  3·99), 279 (4·13), and 314 nm. (3·90);  $\tau$  (CD<sub>3</sub>SOCD<sub>3</sub>) —0·44br (OH), 2·37 (d, J 8 Hz, 5-H), 3·52 (d × d, J 8, 2·3 Hz, 6-H), 3·68 (d, J 2·3 Hz, 8-H), 5·42 (m, 2-H), 7·43 (d, J 8 Hz, CH<sub>2</sub>–CH=), and 8·60 (d, J 6 Hz; CH<sub>3</sub>–CH=).

1-(2,4-Dimethoxyphenyl)but-2-en-1-one (IV;  $R^1 = CH:CHMe$ ,  $R^2 = Me$ ).—A similar reaction between *m*-dimethoxybenzene (2·0 g.), crotonic acid (2·0 g.), and polyphosphoric acid (100 g.) at 70° gave 1-(2,4-dimethoxyphenyl)but-2-en-1-one (2·1 g., 70%) as an oil, b.p. 120—125°/0·3 Torr, identical (i.r. and u.v. absorption) with an authentic specimen.<sup>9</sup>

2,8-Dioxo-3,4,6,7-tetrahydro-4,5,6-trimethylbenzo-[1,2-b; 5,4-b']dipyran (V).—A similar reaction between 3,5-dimethoxytoluene (8 g.), crotonic acid (8 g.), and polyphosphoric acid (200 g.) gave an oily product which, after having been washed with aqueous M-sodium hydroxide and triturated with benzene, crystallised from a mixture of benzene, light petroleum (b.p. 60—80°), and chloroform to give the *benzodipyran* (2·4 g., 20%) as plates, m.p. 254—255° (Found: C, 69·2; H, 6·4. C<sub>15</sub>H<sub>16</sub>O<sub>4</sub> requires C, 69·2; H, 6·2%), v<sub>max.</sub> 1782 cm.<sup>-1</sup> (phenolic ester C=O);  $\lambda_{max.}$  226·5 (log  $\varepsilon$  3·91), 272·5 (2·68), and 282 nm. (2·68).

1-(2,4-Dimethoxy-6-methylphenyl)but-2-en-1-one (I;  $R^1 = CH$ :CHMe,  $R^2 = Me$ ).—A solution of anhydrous tin(IV) chloride (11 g.) in dry benzene (10 ml.) was added slowly to a swirled solution of 3,5-dimethoxytoluene (5 g.) and crotonoyl chloride (4 g.) in the same solvent (20 ml.) at 0° and the mixture was kept for 1.5 hr. at 0°. Next day it was added to ice and concentrated hydrochloric acid, shaken with ether, and the ethereal extract was washed with aqueous M-sodium hydroxide, dried (MgSO<sub>4</sub>), and evaporated. Distillation of the dark residue under reduced pressure gave an oil b.p. 130—132°/0·5 Torr which crystal-lised (charcoal) from light petroleum (b.p. 60—80°) to give

<sup>18</sup> J. H. Richards, A. Robertson, and J. Ward, J. Chem. Soc., 1948, 1610.

the butenone (0·1 g., 1·4%) as needles, m.p. 113—114° (Found: C, 70·6; H, 7·3; OMe, 28·1%. C<sub>13</sub>H<sub>16</sub>O<sub>3</sub> requires C, 70·9; H, 7·3; OMe, 28·15%),  $\nu_{max}$  1660 cm.<sup>-1</sup> (aryl alkenyl ketone C=O);  $\lambda_{max}$  238 (log  $\epsilon$  4·17) and 281 nm. (3·84).

2-Benzoyl- and 2,6-Dibenzoyl-3,5-dimethoxytoluene (I;  $R^1 = Ph$ ,  $R^2 = Me$ ) and (VII; R = Me).—A similar reaction between 3,5-dimethoxytoluene (5 g.), benzoyl chloride (4.6 g.), and tin(IV) chloride (10.7 g.) in dry benzene (60 ml.) gave an oily solid (9 g.). This crystallised from a mixture of benzene and light petroleum (b.p. 60-80°) to give 2,6-dibenzoyl-3,5-dimethoxytoluene (2 g., 33.8%) as rods, m.p.  $165-166^{\circ}$  [Found (by mass spectrometry): M, 360; (M - 1), 359·1282. C<sub>23</sub>H<sub>20</sub>O<sub>4</sub> requires M, 360; C<sub>23</sub>H<sub>19</sub>O<sub>4</sub> requires M, 359.1283], mass spectrum m/e 360 [96%;  $(M)^{+}$ ], 359 [100%;  $(M - H)^{+}$ ], 343 [14%;  $(M - OH)^{+}$ ], 283 [38%;  $(M - C_6H_5)^+$ ], 105 [83%;  $(C_6H_5CO)^+$ ], and 77 [51%;  $(C_6H_5)^+$ ],  $v_{max}$  (CCl<sub>4</sub>) 1685 cm.<sup>-1</sup> (aryl carbonyl C=O);  $\lambda_{\max} 251 \ (\log \epsilon 4.54), \ \lambda_{\inf I.} 281 \ (3.81), \ 306 \ (3.53), \ and \ 338 \ nm.$  $(\overline{3.01})$ ;  $\tau 2.00-2.80$  (m, C<sub>6</sub>H<sub>5</sub>-CO at C-2 and C-6), 3.52 (s, Ar-H at C-4), 6.28 (s, OCH<sub>3</sub> at C-3 and C-5), and 8.08 (s, Ar-CH<sub>3</sub>). Evaporation of the mother-liquor and distillation of the residue under reduced pressure gave 2-benzoyl-3,5-dimethoxytoluene (3 g., 35.8%) as an oil b.p. 168-170°/ 0.2 Torr which solidified and then had m.p. 56-58° (Found: C, 74·7; H, 6·4.  $C_{16}H_{16}O_3$  requires C, 75·0; H, 6·3%),  $\nu_{max}$ . (CCl<sub>4</sub>) 1685 cm.<sup>-1</sup> (aryl carbonyl C=O);  $\lambda_{max}$  249.5 (log  $\varepsilon$  4.22) and 282 (3.58);  $\lambda_{infl}$  229.5 (log  $\varepsilon$  4.05), 290 (3.52), 307 (3·34), and 345 nm. (2·82);  $\tau$  2·00–2·80 (m, C<sub>6</sub>H<sub>5</sub>–CO), 3.61 (s, Ar-H at C-4 and C-6), 6.17 and 6.37 (both s, OCH<sub>3</sub> at C-3 and C-5), and 7.86 (s,  $ArCH_3$ ).

Demethylation Experiments.—(a) A mixture of 2-benzoyl-3,5-dimethoxytoluene (0.88 g.) and dry pyridine hydrochloride (2.64 g.) was heated at 196° for 2 hr., cooled, and added to aqueous sodium hydroxide, which was shaken with ether. The aqueous layer was acidified and extracted with ether. Evaporation of the dried (MgSO<sub>4</sub>) ethereal layer gave a glass (0.75 g.) which crystallised from aqueous ethanol (charcoal) to give 2-benzoyl-3,5-dihydroxytoluene (0.1 g., 12.8%), m.p. 140.5—142.5° (lit.,<sup>10,11</sup> m.p. 138°, 141°) (Found: C, 73.8; H, 5.2. Calc. for C<sub>14</sub>H<sub>12</sub>O<sub>3</sub>: C, 73.65; H, 5.3%),  $v_{max}$ . (Nujol) 3320 and 3240br (OH), and 1655 cm.<sup>-1</sup> (aryl carbonyl C=O);  $\lambda_{max}$ . 229 (log  $\varepsilon$  4.05), 251 (4.18), and 285 (3.62);  $\lambda_{infl}$ . 302 (log  $\varepsilon$  3.56) and 338 nm. (3.37).

(b) A similar reaction between 2,6-dibenzoyl-3,5-dimethoxytoluene (0.5 g.) and pyridine hydrochloride (1.5 g.) gave 2,6-dibenzoyl-3,5-dihydroxytoluene (0·1 g., 21·7%) as needles, m.p. 213—214° (lit.,<sup>12</sup> m.p. 211°) (Found: C, 75·9; H, 5·1. Calc. for C<sub>21</sub>H<sub>16</sub>O<sub>4</sub>: C, 75·9; H, 4·85%),  $\nu_{max}$  (Nujol) 3430 and 3210 (OH), 1670 and 1645 cm.<sup>-1</sup> (aryl carbonyl C=O);  $\lambda_{max}$  252 (log  $\varepsilon$  4·54), and 284 (3·86);  $\lambda_{infl}$ . 315 (log  $\varepsilon$  3·60) and 338 nm. (3·44).

Methyl 6-Cyanohexanoate.-Ethyl acetoacetate (112 g.) was added to a stirred ethanolic solution of sodium ethoxide [from sodium (18.9 g.) and anhydrous ethanol (550 ml.)] followed, after 0.5 hr., by 5-chloropentanonitrile 17 (96.5 g.). The mixture was stirred overnight, boiled under reflux for 48 hr., and filtered. Evaporation of the solvent gave an oil which was stirred with aqueous 5M-sodium hydroxide for 4 hr. and the mixture was then extracted with ether to remove unchanged 5-chloropentanonitrile (30.5 g.). The aqueous solution was adjusted to pH 2 with concentrated hydrochloric acid and boiled under reflux for 1 hr. Extraction with ether gave 6-cyanohexanoic acid (20 g., 25%) as an oil, b.p. 138-140°/0·4 Torr (lit., 18 b.p. 158-160°/3 Torr),  $v_{max.}$  (film) ca. 3100br (carboxyl OH), 2260 (nitrile), and 1710 cm.<sup>-1</sup> (carboxyl C=O), which formed an S-benzylisothiouronium salt, m.p. 150.5-151° (decomp.) (Found: C, 58.5; H, 7.0; N, 13.4. C<sub>15</sub>H<sub>21</sub>N<sub>3</sub>O<sub>2</sub>S requires C, 58.6; H, 6.9; N, 13.65%), and which on being treated with an excess of ethereal diazomethane gave methyl 6-cyanohexanoate as an oil (22 g.), b.p. 64-65°/0.01 Torr (lit., 19 b.p. 86-91°/0.4 Torr) (Found: C, 62.1; H, 8.5. Calc. for C<sub>8</sub>H<sub>13</sub>NO<sub>2</sub>: C, 61.9; H, 8.45%),  $\nu_{max}$  (film) 2250 (nitrile) and 1740 cm.<sup>-1</sup> (ester C=O).

4-(6-Carboxyhexanoyl)resorcinol (IV;  $R^1 = [CH_2]_5CO_2H$ ,  $R^2 = H$ ).—Dry hydrogen chloride was passed rapidly for 3 hr. into a mixture of resorcinol (1·2 g.), methyl 6-cyanohexanoate (1·9 g.), anhydrous zinc chloride (2·7 g.), and dry ether (30 ml.) at 0°. The mixture was kept at 0° overnight and the resulting red oil was collected and boiled with water (30 ml.) for 0·5 hr. The solid which separated on cooling crystallised (charcoal) from aqueous ethanol to give 4-(6-carboxyhexanoyl)resorcinol as plates (0·56 g., 20·4%), m.p. 131—131·5° (Found: C, 61·7; H, 6·3. C<sub>13</sub>H<sub>16</sub>O<sub>5</sub> requires C, 61·9; H, 6·4%),  $v_{max}$  (Nujol) 3375 and 3300 (OH), 1710 (carboxyl C = O), and 1640 cm.<sup>-1</sup> (aryl carbonyl C = O);  $\lambda_{max}$  233 (log  $\varepsilon$  3·92), 279 (4·17), and 315 nm. (3·88).

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