

## Fungus Pigments

XVIII.\* The Structure of  
"Dihydroisothelephoric Acid Hexaacetate"

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The so called "dihydroisothelephoric acid hexaacetate", formed when thelephoric acid is boiled with acetic anhydride and sodium acetate, is shown to be 2,3,6,8,9-pentaacetoxy-12-(acetoxymethyl)-benzo[1,2-b;4,5-b']bisbenzofuran (5).

Some years ago the preparation of a compound termed "dihydroisothelephoric acid hexaacetate" was described.<sup>1</sup> It was formed when thelephoric acid (1) was boiled with acetic anhydride and sodium acetate for a long period of time. The structure 2 was tentatively proposed for this compound which, as the name implies, was assumed to be isomeric with thelephoric acid leucoacetate.

It was noted that the UV spectrum of "dihydroisothelephoric acid hexaacetate" is very similar to those of thelephoric acid leucoacetate and benzo[1,2-b;4,5-b']bisbenzofuran (3).<sup>1</sup> The proposal of structure 2 for "dihydroisothelephoric acid hexaacetate" was based on the assumption that the UV spectrum of the then unknown benzo[1,2-b;6,5-b']bisbenzofuran (4) would not differ much from that of 3. Stjernström<sup>2</sup> later synthesized 4 and its UV spec-

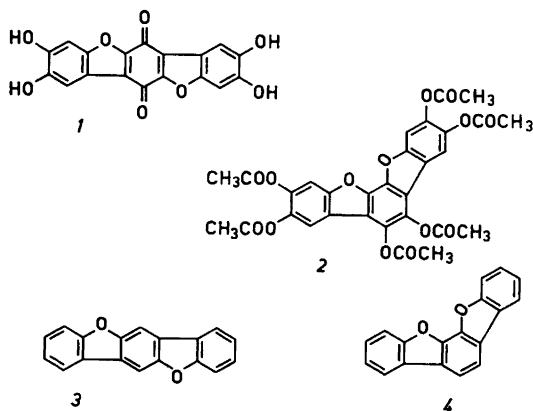


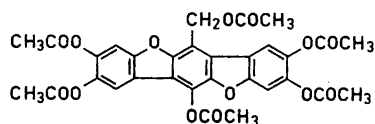
Table 1.

Position of the acetoxy groups	$m\mu$ (log $\epsilon$ )	$m\mu$ (log $\epsilon$ )	$m\mu$ (log $\epsilon$ )	Ref.
2,8	262 (4.33)	317 (4.77)	326 (4.65) • 334 (4.86)	This work
1,3,7,9	263 (4.28)	325 (4.80)	339 (4.80)	—»—
2,3,8,9	262 (4.29)	322 (4.73)	339 (4.88)	—»—
3,6,9,12	263 (4.22)	311 (4.84)	328 (4.86)	4
1,3,6,7,9,12	266 (4.04)	310 (4.75)	326 (4.73)	4
2,3,6,8,9,12	264 (4.17)	316 (4.72)	331 (4.60)	1
3,4,6,9,10,12	265 (4.10)	308 (4.78)	324 (4.77)	4
“Dihydroisothel- phoric acid hexa- acetate”	265 (4.17)	321 (4.78)	338 (4.84)	1

trum<sup>3</sup> differs so much from that of 3 that structure 2 is clearly untenable. A further objection that can be raised against 2 is that it does not readily explain the presence in the IR spectrum of “dihydroisothelphoric acid hexaacetate” of a maximum at 1748  $\text{cm}^{-1}$  in addition to the expected maximum at 1780  $\text{cm}^{-1}$  due to the phenolic acetates. The former is more in keeping with the presence of an aliphatic acetate. The fact that the formation of a compound isomeric with thelphoric acid leucoacetate requires reduction at some stage of the reaction has already been commented upon.<sup>1</sup>

A comparison of the UV spectra of “dihydroisothelphoric acid hexaacetate” with those of a number of acetoxy derivatives of benzo[1,2-b;4,5-b']bisbenzofuran reported in Table 1 shows clearly that there can be no doubt that “dihydroisothelphoric acid hexaacetate” is a derivative of benzo[1,2-b;4,5-b']bisbenzofuran.

Mainly based on mass and NMR spectra we now propose structure 5 for “dihydroisothelphoric acid hexaacetate” which hence should be named 2,3,6,8,9-pentaacetoxy-12-(acetoxymethyl)benzo[1,2-b;4,5-b']bisbenzofuran.



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The mass spectrum of “dihydroisothelphoric acid hexaacetate” is particularly instructive when compared with the mass spectrum of thelphoric acid leucoacetate. The last mentioned is very simple, consisting of peaks at  $m/e$  606, 564, 522, 480, 438, 396, 354, and 43. The peaks at higher mass numbers represent the series  $M^+ - n \times 42$  ( $\text{CH}_2\text{CO}$ ), where  $n = 0-6$ . These losses of  $\text{CH}_2\text{CO}$  are consecutive single step fragmentations as shown by the appearance of metastable peaks at  $m/e$  525, 483, 441.5, 400, 358, and 316.5. The peak at  $m/e$  43, which is the base peak, represents of course  $\text{CH}_3\text{CO}^+$ .

The mass spectrum of “dihydroisothelphoric acid hexaacetate” (Fig. 1) is more complicated.

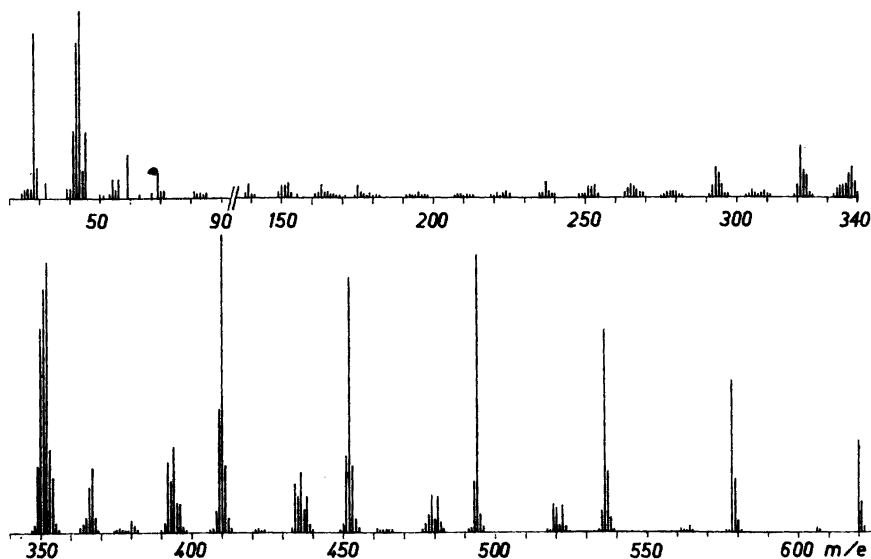


Fig. 1. The mass spectrum of „dihydroisothalephoric acid hexaacetate” (2,3,6,8,9-penta-acetoxy-12-(acetoxymethyl)benzo[1,2-b;4,5-b']bisbenzofuran(5)).

The molecular peak occurs at  $m/e$  620 and the compound is thus not isomeric with thalephoric acid leucoacetate. There are again peaks corresponding to fragments  $M^+ - n \times 42$  ( $m/e$  578, 536, 494, 452, 410, and 368), but the peak for  $n = 6$  ( $m/e$  368) is in this case very weak. Instead there is a strong peak at  $m/e$  351 corresponding to  $M^+ - 5(\text{CH}_2\text{CO}) - \text{CH}_3\text{COO}$ , which shows that one of the acetoxy groups is of a different type than the others. The peak at  $m/e$  351 is actually the last member in a series  $M^+ - 59 - n \times 42$  ( $n = 0-5$ ) ( $m/e$  561, 519, 477, 435, 393, and 351) where the last peak is by far the strongest.

The preferential fragmentation thus appears to be loss of the five aromatic acetoxy groups as  $\text{CH}_2\text{CO}$  one after another, followed by elimination of  $\text{CH}_3\text{COO}$ . This sequence is supported by the occurrence of appropriate metastable peaks at  $m/e$  539, 497, 455.5, 413.5, 372, and 300.5.

That the molecular peak at  $m/e$  620 corresponds to the formula  $\text{C}_{31}\text{H}_{24}\text{O}_{11}$  was confirmed by investigation of the peak at  $m/e$  452 under high resolution giving the value 452.0733. The theoretical value for  $\text{C}_{31}\text{H}_{24}\text{O}_{14} - 4(\text{CH}_2\text{CO}) = \text{C}_{23}\text{H}_{16}\text{O}_{10}$  is 452.0743. The analytical data reported earlier<sup>1</sup> fit this formula well. (Found: C 59.70; H 3.72;  $\text{CH}_3\text{CO}$  41.4.  $\text{C}_{31}\text{H}_{24}\text{O}_{14}$  requires C 60.00; H 3.87; 6  $\text{CH}_3\text{CO}$  41.6).

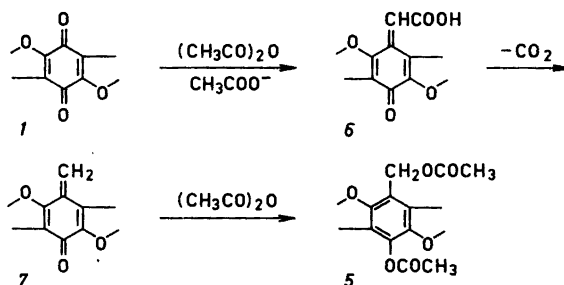
The NMR spectrum with singlet peaks at  $\tau$  2.11 (1 H), 2.27 (1 H), 2.48 (1 H), 2.50 (1 H), 4.13 (2 H), 7.38 (3 H), 7.62 (12 H), and 7.86 (3 H) is in complete agreement with structure 5. The possibility that the two peaks at 2.48 and 2.50 in the aromatic region are the central peaks of an AB-quartet, where the outer peaks are lost in the noise, can be dismissed by a comparison of the spectra run at 60 and 100 Mc. The separation of the peaks are 1 cps at 60 Mc and 1.7 cps at 100 Mc, thus directly proportional to the field strength as re-

quired for uncoupled signals. There are furthermore no sign of any outer peaks even when the spectrum was rerun 431 times with the aid of a time averaging computer.

The peak at  $\tau$  4.13 is ascribed to be benzylic protons. This value is slightly lower than that usually found for benzylic acetates, but is evidently due to deshielding by the lateral aromatic rings. The same deshielding shifts the signals of one of the aromatic acetoxy groups to  $\tau$  7.38. The signal at  $\tau$  7.86 is that of the aliphatic acetoxy.

The evidence cited above clearly demonstrates that in "dihydroisothelphoric acid hexaacetate" there is a benzo[1,2-*b*; 4,5-*b'*] bisbenzofuran system to which are attached five acetoxy groups and one acetoxymethyl group, but their positions cannot be unequivocally established. However, structure 5 is the only one which can be formed from thelphoric acid (1) by a reasonable sequence of reactions.

We consider this reaction to be a Perkin reaction at one of the quinone carbonyl groups leading to 6, which then loses carbon dioxide giving 7, whereafter acetic anhydride adds to the quinone methide. The sequence of the two last steps can also be reversed.



A similar mechanism has also been proposed for the reaction between 9,10-phenanthrene quinone and acetic anhydride.<sup>5</sup> Further examples of nucleophilic addition to the carbonyl group of a quinone are found in the addition of acetone to a variety of quinones in the presence of a base.<sup>6-10</sup>

Whether the reaction described here is specific to thelphoric acid or has a greater generality is under investigation.

#### EXPERIMENTAL

The UV spectra have been obtained from dioxane solutions on a Beckman DK-2 instrument and the IR spectra from KBr-discs on a Perkin Elmer 237 instrument unless stated otherwise. The NMR spectra have been taken in deuteriochloroform with Varian A-60 and HA-100 instruments using the Varian C-1024 Time Averaging Computer. The mass spectra have been taken on an A. E. I. MS-9 instrument. The melting points were taken in a capillary melting point apparatus (Townson & Merces Ltd.) and are corrected. The analyses have been performed by Dr. A. Bernhardt, Mülheim, Germany.

*2,8-Diacetoxybenzo[1,2-*b*; 4,5-*b'*]bisbenzofuran*. 2,5,2',5',2'',5''-Hexamethoxy-*p*-terphenyl<sup>11</sup> (320 mg) was refluxed for 69 h with 40 % hydrobromic acid in a nitrogen atmosphere. The precipitated phenol was acetylated with acetic anhydride and a drop of pyridine. Yield 240 mg, m.p. 317–319° after recrystallisation from acetic acid. (Found: C 70.20; H 3.88. C<sub>22</sub>H<sub>14</sub>O<sub>8</sub> requires: C 70.58; H 3.77). UV spectrum:  $\lambda_{\max}$  262(4.33), 305sh(4.40), 317(4.77), 326(4.65), 334(4.86) m $\mu$  (log  $\epsilon$ );  $\lambda_{\min}$  255(3.98), 269(3.38), 323(4.63), 329(4.62)

$m\mu$  (log  $\epsilon$ ). IR maxima (PE 125): 1756s, 1626w, 1602w, 1480s, 1438s, 1368s, 1354w, 1316m, 1240s, 1220s, 1202s, 1176m, 1152s, 1138s, 1112s, 1040w, 1014m, 932m, 890m, 850s, 810m, 784m, 734w, 696w, 672w, 612w  $\text{cm}^{-1}$ .

*2,4,6,2',5',2'',4'',6''-Octamethoxy-p-terphenyl*. 1,4-Diiodo-2,5-dimethoxybenzene (1.8 g), 1-iodo-2,4,6-trimethoxybenzene (10.8 g) and copperbronze (25 g) were thoroughly mixed and heated in an oil bath to 240° when reaction started. The temperature was then raised to 270° during 20 min. The products from two such runs were combined and extracted with chloroform in a Soxhlet apparatus. The residue after evaporation of the chloroform was fractionally distilled under vacuum. The first fraction, b.p. 210–240°/4 mm, consisted of 2,4,6,2',4',6'-hexamethoxybiphenyl, m.p. 149–153° after recrystallisation from light petroleum (lit.<sup>12</sup> m.p. 156°). A second fraction, b.p. 240–270°/1.5 mm was discarded. The third fraction (1.5 g), b.p. 260–300°/1 mm solidified on cooling and was recrystallised from butanol, m.p. 267–269°. (Found: C 65.38; H 6.31.  $\text{C}_{26}\text{H}_{30}\text{O}_8$  requires C 66.37; H 6.43). UV spectrum:  $\lambda_{\text{max}}$  259(4.29), 302(4.16)  $m\mu$  (log  $\epsilon$ );  $\lambda_{\text{min}}$  249(4.24), 282(3.95)  $m\mu$  (log  $\epsilon$ ). IR maxima: 3020m, 2938s, 2840s, 1604s, 1590s, 1522m, 1462s, 1438w, 1416m, 1386s, 1336s, 1300w, 1272m, 1210s, 1188m, 1158s, 1152m, 1126s, 1068m, 1044s, 1036m, 1020m, 950s, 922w, 862s, 820s, 790m, 780m, 744w, 716w, 650m, 636w  $\text{cm}^{-1}$ .

*1,3,7,9-Tetraacetoxybenzo [1,2-b;4,5-b'] bisbenzofuran*. 2,4,6,2',5',2'',4'',6''-Octamethoxy-p-terphenyl (300 mg) was refluxed in 40 % hydrogen bromide in a nitrogen atmosphere for 69 h. Water was then added and the precipitate boiled with acetic anhydride and two drops of pyridine. The acetylation product (185 mg) was recrystallised first from acetic acid and then from dioxane. M.p. 318–320° (decomp.). (Found: C 62.25; H 3.85.  $\text{C}_{26}\text{H}_{18}\text{O}_{10}$  requires: C 63.67; H 3.70). UV spectrum:  $\lambda_{\text{max}}$  231(4.75), 263(4.28), 300sh(4.40), 311(4.73), 321sh(4.76), 325(4.80), 339(4.80)  $m\mu$  (log  $\epsilon$ );  $\lambda_{\text{min}}$  259(4.13), 273(3.69), 316(4.69), 335(4.57)  $m\mu$  (log  $\epsilon$ ). IR maxima: 1770s, 1636m, 1606m, 1516m, 1464w, 1440s, 1424m, 1374s, 1350m, 1332m, 1308m, 1196s, 1146m, 1118s, 1060s, 1018m, 1010m, 986m, 906s, 882w, 868m, 850w, 838m, 812m, 766m, 754w, 722w, 696m  $\text{cm}^{-1}$ .

*2,3,8,9-Tetraacetoxybenzo [1,2-b;4,5-b'] bisbenzofuran*. 2,4,5,2',5',2'',4'',5''-Octamethoxy-p-terphenyl<sup>13</sup> (160 mg) was demethylated and acetylated as described above for the isomeric compound. Yield 130 mg, m.p. 335–336° after recrystallisation from acetic acid. (Found: C 63.34; H 3.70.  $\text{C}_{26}\text{H}_{18}\text{O}_{10}$  requires C 63.67; H 3.70). UV-spectrum:  $\lambda_{\text{max}}$  229sh(4.63), 262(4.29), 309sh(4.43), 322(4.73), 339(4.88)  $m\mu$  (log  $\epsilon$ );  $\lambda_{\text{min}}$  256(4.03), 273(3.39), 329(4.64)  $m\mu$  (log  $\epsilon$ ). IR maxima: 1770s, 1512w, 1464s, 1448m, 1430m, 1372s, 1350w, 1314m, 1294m, 1200s, 1158s, 1148s, 1116s, 1042w, 1014m, 990w, 912m, 898m, 874m, 860w, 850m, 812m, 794w, 738w, 716w, 678w, 666w  $\text{cm}^{-1}$ .

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