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A New Synthesis of Polyhydroxydihydroflavonols*

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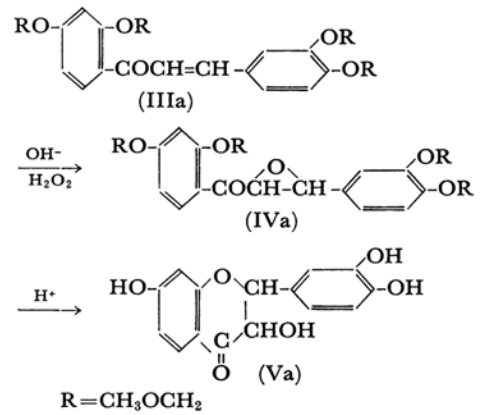
An alkaline hydrogen peroxide oxidation of chalcones with methoxymethoxyl groups in the 2′-position and in other positions gave the corresponding poly(methoxymethoxy)chalcone oxides; these were then, in turn, easily converted into polyhydroxydihydroflavonols, with a simultaneous splitting of all the *O*-methoxymethyl groups, by warming with acid. The general applicability of the new method was illustrated by the synthesis of the following hydroxydihydroflavonols: 3, 7-dihydroxy- (m. p. 170—171°C), 3, 4′-dihydroxy- (m. p. 214—216°C), 3, 4′-dihydroxy-3′-methoxy- (m. p. 217—218°C), 3, 4′, 7-trihydroxy- (m. p. 214—215°C), and 3, 3′, 4′, 7-tetrahydroxyflavanone (*dl*-fustin, m. p. 217—218°C). The first four new compounds were identified by converting them into known methyl ethers, while the last one was identified by comparing it with natural *dl*-fustin. Their structures were also confirmed by infrared and ultraviolet spectra.

The action of alkaline hydrogen peroxide on 2′-hydroxychalcones results in the formation of flavonols (3-hydroxyflavones)[1] or dihydroflavonols (3-hydroxyflavanones)[2], depending on the conditions employed. The course and mechanism of these reactions have been postulated by Geissman et al.[3] to involve an intermediary formation of the corresponding epoxides, which are immediately transformed into dihydroflavonols or aurones by the nucleophilic attack of the hydroxide or phenolate ions. The dihydroflavonols thus formed are readily oxidized in alkaline media into flavonols (the so-called Algar-Flynn-Oyamada reaction[4]); hence, the isolation of the former may be accomplished only under the appropriate conditions. Particularly polyhydroxychalcones, which carry one or more hydroxyl groups besides the 2′-hydroxyl group, often fail to give hydroxydihydroflavonols because of a further oxidation. Thus, only a few examples of the formation have been reported.[5]

The present authors have found that, from polyhydroxychalcones bearing one or more hydroxyl groups besides the 2′-hydroxyl one, the corresponding expoxides can be prepared by protecting all the hydroxyl groups by methoxymethylation during the course of the alkaline peroxide oxidation, and that the resulting poly(methoxymethoxy)chalcone oxides, when warmed with acid, readily cyclize to polyhydroxydihydroflavonols, with the simultaneous splitting of all *O*-methoxymethyl groups.

The general applicability of the new method will be illustrated by demonstrating the syntheses of the following hydroxydihydroflavonols: 3,3′,4′,7-tetrahydroxyflavanone (Va), 3,4′,7-trihydroxyflavanone (Vb), 3,4′-dihydroxy-3′-methoxyflavanone (Vc), 3,7′-dihydroxyflavanone(Vd), and 3,4′-dihydroxyflavanone (Ve).

The synthetic scheme of Va (*dl*-fustin), for example, is:



Of the above-mentioned compounds, the first one was identified by comparing it with the natural *dl*-fustin[6] obtained from the wood of *Rhus succedanea L.*, while the remaining four new compounds were identified by converting them into the known methyl ethers.[7-9] Their structures were also confirmed by infrared and ultraviolet spectra. Furthermore, these compounds gave a color reaction

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1) T. Oyamada, *J. Chem. Soc. Japan* (*Nippon Kwagaku Kwaishi*), **55**, 1256 (1934); This Bulletin, **10**, 182 (1935); J. Algar and J. P. Flynn, *Proc. Roy. Irish Imp. Acad.*, **B4**, 8 (1934).

2) M. Murakami and D. K. Irie, *Proc. Imp. Acad.* (*Tokyo*), **11**, 229 (1935).

3) T. A. Geissman and D. K. Fukushima, *J. Am. Chem. Soc.*, **70**, 1686 (1948).

4) J. E. Gowan and T. S. Wheeler, "Name Index of Organic Reactions," Longmans, London (1962), p. 3.

5) J. M. Guider, T. H. Simpson and D. E. Thomas, *J. Chem. Soc.*, **1955**, 170; H. Pacheoco, *Compt. rend.*, **251**, 1077 (1960); L. Reichel and J. Steudel, *Ann.*, **553**, 83 (1942).

6) T. Oyamada, *J. Chem. Soc. Japan* (*Nippon Kwagaku Kwaishi*), **55**, 755 (1934); T. Oyamada, *Ann.*, **538**, 44 (1939).

7) T. Oyamada, *J. Chem. Soc. Japan* (*Nippon Kwagaku Kwaishi*). **64**, 334 (1943).

8) T. Oyamada, ibid., **64**, 336 (1943).

9) T. Oyamada, ibid., **64**, 372 (1943).

TABLE I. INFRARED AND ULTRAVIOLET SPECTRAL DATA FOR DIHYDROFLAVONOLS AND FLAVANONES

	3-Hydroxyflavanone		Flavanone	
	IR(KBr) CO cm^{-1}	UV λ_{max}^{EtOH} $m\mu$ (log ε)	IR(KBr) CO cm^{-1}	UV λ_{max}^{EtOH} $m\mu$ (log ε)
3′,4′,7-Trihydroxy-	1674	235 (4.19) 279 (4.17) 310 (3.84)	1662	234 (4.11) 277 (4.12) 308 (3.71)
4′,7-Dihydroxy-	1660	232 (4.19) 275 (4.13) 310 (3.83)	1649	229[a] (3.99) 279 (3.90) 312 (3.64)
4′-Hydroxy-3′-methoxy-	1677	232[a] (4.06) 250 (3.95) 281 (3.58) 315 (3.51)	1676	232[a] (4.03) 250 (3.97) 281 (3.57) 318 (3.56)
7-Hydroxy	1677	234[a] (3.92) 277 (4.07) 308 (3.88)	1650	234 (4.01) 278 (4.08) 312 (3.87)
4′-Hydroxy-	1688	230[a] (4.21) 253 (4.10) 317 (3.65)	1669	230[a] (4.06) 252 (4.02) 317 (3.57)

a Inflection

characteristic of flavonoid compounds when they were reduced with magnesium or zinc and hydrochloric acid, and they were readily oxidized, by air in the presence of alkali or acid, into the corresponding flavonols. This facile dehydrogenation is a common feature of dihydroflavonols with trans-configurations. The stereochemistry of these dihydroflavonols and the steric course of this reaction will be discussed elsewhere.

In Table I are collected the infrared spectral data of the carbonyl group in the hydroxydihydroflavonols and the corresponding flavanones bearing no 3-hydroxyl groups, along with their ultraviolet absorption maxima. An examination of the infrared spectra will indicate that the introduction of a 3-hydroxyl group in the flavanones results in a rise in the carbonyl frequency, due probably to an inductive effect of the hydroxyl group. On the other hand, as might be expected, the ultraviolet absorption maxima of the dihydroflavonols and the corresponding flavanones are essentially identical.

Experimental

All melting points are uncorrected.

2′-(Methoxymethoxy)acetophenone (Ia).—A mixture of sodium salt of 2′-hydroxyacetophenone (30.0 g.), monochlorodimethyl ether (15.3 g.), calcium oxide (10.5 g.), and dioxane (240 cc.) was heated while being stirred at 40—45°C for 3 hr. The mixture was then filtered, and the filtrate was poured into water. The ether extract of the oily product was washed with 2% aqueous sodium hydroxide, dried over anhydrous sodium sulfate, and evaporated to yield 35.0 g. (89%) of a colorless liquid (Ia); b. p. 114—116°C/8 mmHg (lit. b. p. 139—140°C/12.5 mmHg[10]); n_D^{24} 1.5144. IR liquid film): 2990(sh), 2950, 2910(sh), 2830, 2780, 1082, 923 (CH_3OCH_2O); 1676 (CO); 1362 cm^{-1} (CH_3CO). (Found: C, 66.64; H, 6.91. Calcd. for $C_{10}H_{12}O_3$: C, 66.65; H, 6.71%).

2′, 4′-Bis(methoxymethoxy)acetophenone (Ib).—To a solution of resacetophenone (37.5 g.) in absolute ethanol (150 cc.) containing sodium ethoxide (metallic sodium: 12.0 g.) there was added, drop by drop, monochlorodimethyl ether (40.0 g.) under cooling; the mixture was then stirred at room temperature (20°C) for 20 min. After the solvent had been removed, the residue was poured into water. The ether extract of the oily product was washed with 2% aqueous sodium hydroxide, dried over anhydrous sodium sulfate, and evaporated to yield 20.0 g. (33%) of a colorless liquid (Ib); b. p. 184°C/12 mmHg (lit. b. p. 140—150°C/0.2 mmHg[11]); n_D^{15} 1.5274. IR (liquid film): 2990(sh), 2960, 2900, 2835, 2775(sh), 1084, 924 (CH_3OCH_2O); 1669 (CO); 1363 cm^{-1} (CH_3CO). (Found: C, 59.89; H, 6.74. Calcd. for $C_{12}H_{16}O_5$: C, 59.99; H, 6.71%).

4-(Methoxymethoxy)benzaldehyde (IIa).—To a stirred suspension of a finely-divided sodium (3.4 g.) in toluene (90 cc.), a solution of 4-hydroxybenzaldehyde (18.0 g.) in absolute ethanol (20 cc.) was added; the mixture was then refluxed with stirring in order to complete the salt-formation. After the alcohol had been removed by fractional distillation the suspension of the sodium salt in toluene was treated with monochlorodimethyl ether (120.0 g.) under cooling the precipitate disappeared. The resulting solution was washed with 2% aqueous sodium hydroxide, dried over anhydrous sodium sulfate, and evaporated to yield 12.5 g. (86%) of a colorless liquid (IIa); b. p. 147—149°C/22 mmHg

10) C. Eneback, *Soc. Sci. Fennica, Commentations Phys.-Math.*, **28** (10), 95 (1963); *Chem. Abstr.*, **60**, 7972 (1964).
11) A. Bellini and P. Venturella, *Ann. chim. (Rome)*, **48**, 111-24 (1948); *Chem. Abstr.*, **52**, 1641 (1958).

(lit. b. p. 152—153°C/21 mmHg[12]): n_D^{15} 1.5434. IR (liquid film): 2960, 2910, 2840, 2740, 1082, 923 (CH_3OCH_2O); 2840, 2740, 1962 cm^{-1} (CHO). (Found: C, 65.04; H, 6.10. Calcd. for $C_9H_{10}O_3$: C, 65.05; H, 6.07%).

3, 4-Bis(methoxymethoxy)benzaldehyde (IIb).—This product was obtained from protocatechualdehyde by the procedure used for Ib; yield, 46%; m. p. 59—60°C (lit. m. p. 60°C[12]). IR (KBr): 2980(sh), 2940, 2840, 2740, 1083, 918 (CH_3OCH_2O); 2840, 2740, 1676 cm^{-1} (CHO). (Found: C, 58.66; H, 6.41. Calcd. for $C_{11}H_{14}O_5$: C, 58.40; H, 6.24%).

3-Methoxy-4-(methoxymethoxy)benzaldehyde (IIc).—To a solution of the sodium salt of vanillin (15.3 g.) in dioxane (76 cc.), chlorodimethyl ether (5.6 g.) was added, drop by drop, under ice-cooling; the mixture was then heated at 70—80°C for 1.5 hr. and poured into water. The toluene extract of the product was washed with 2% aqueous sodium hydroxide, dried over anhydrous sodium sulfate, and evaporated to yield an oily residue which crystallized on standing. Recrystallization from ether gave 10.0 g. (49%) of colorless plates (IIc); m. p. 39.5—41.5°C (lit m. p. 39—40°C[13]). IR (liquid film): 2990(sh), 2950, 2900, 2830, 2740, 1083, 924 (CH_3OCH_2O): 2830, 2740, 1685 cm^{-1} (CHO).

2′, 3, 4, 4′-Tetrakis(methoxymethoxy)chalcone (IIIa).—To a solution of Ib (3.2 g.) and IIb (3.0 g.) in methanol (40 cc.) 50% aqueous sodium hydroxide (25.0 g.) was added; the mixture was then allowed to stand at room temperature overnight. The reaction mixture was poured into water, and the precipitate formed was collected and recrystallized from ligroin to give 3.0 g. (50%) of pale yellow needles (IIIa); m. p. 69—70°C. IR(KBr): 2990(sh), 2930(sh), 2900, 2830, 2800(sh), 1072, 918 (CH_3OCH_2O); 1640 cm^{-1} (CO).

Found: C, 61.98; H, 6.51. Calcd. for $C_{23}H_{28}O_9$: C, 61.59; H, 9.30%.

The Hydrolysis of IIIa with Hydrochloric Acid.—To a solution of IIIa (1.0 g.) in ethanol (20 cc.), 12 N hydrochloric acid (10 cc.) was added; the solution was then left at room temperature for 40 min. The reaction mixture was poured into water and the precipitate was collected and recrystallized from ethanol to give 0.15 g. of yellow crystals, m. p. 215—216°C. No depression of the melting point was observed on admixture with an authentic sample of butin.

2′, 4, 4′-Tris(methoxymethoxy)chalcone (IIIb).—IIIb was obtained from Ib and IIa by the procedure described above. Yield, 90%; pale yellow needles; m. p. 47—48°C (*n*-hexane - carbon tetrachloride). IR (KBr): 2990, 2960, 2900, 2830, 2795(sh), 1077, 928 (CH_3OCH_2O); 1650 cm^{-1} (CO).

Found: C, 64.69; H, 6.38. Calcd. for $C_{21}H_{24}O_7$; C, 64.93: H, 6.24%.

2′, 4-Bis(methoxymethoxy)-3-methoxychalcone (IIIc).—IIIc was obtained from Ia and IIc by the procedure described above. Yield, 67%; colorless needles; m. p. 64—64.5°C. IR(KBr): 2965, 2910, 2825, 2790(sh), 1080, 917 (CH_3OCH_2O); 1648 cm^{-1} (CO).

Found: C, 67.03; H, 6.34. Calcd. for $C_{20}H_{22}O_6$: C, 67.02; H, 6.20%.

2′, 4′-Bis(methoxymethoxy)chalcone (IIId).—IIId was obtained from Ib and benzaldehyde by the procedure described above, except that the oily product was extracted with ether. The removal of the ether gave a pale yellow oil (IIId), which was used in the subsequent epoxidation without further purification. Yield, 80%; pale yellow liquid: n_D^{18} 1.5978. IR (liquid film): 3005, 2950, 2900, 2830, 2780(sh), 1080, 926 (CH_3OCH_2O); 1662 cm^{-1} (CO).

2′, 4-Bis(methoxymethoxy)chalcone (IIIe).—IIIe was obtained from Ia and IIa by the procedure used for making IIId. Yield, 95%; pale yellow liquid; n_D^{12} 1.6067. This was used without further purification. IR (liquid film): 2990, 2940, 2900, 2835, 2780(sh), 1082, 924 (CH_3OCH_2O); 1660—1640 cm^{-1} (doublet) (CO).

2′, 3, 4, 4′-Tetrakis(methoxymethoxy)chalcone Oxide (IVa).—To a solution of IIIa (3.0 g.) in methanol (160 cc.) there were adedd 15% aqueous hydrogen peroxide (9 cc.) and then 16% aqueous sodium hydroxide (15.0 g.) under cooling. The mixture was then allowed to stand in a refrigerator over night. The colorless precipitate formed was collected by filtration and recrystallized from carbon tetrachloride to give 1.5 g. (48%) of colorless needles (IVa), m. p. 77—79°C. A further amount (about 1.1 g.) of this compound was recovered from the filtrate by diluting it with water. IR (KBr): 2970, 2945, 2920, 2830, 2805, 1071, 924 (CH_3OCH_2O); 1678 (CO); 896 cm^{-1} (C—O).

Found: C, 59,74; H, 6.19; Calcd. for $C_{23}H_{28}O_{10}$: C, 59.47; H, 6.09%.

2′, 4, 4′-Tris(methoxymethoxy)chalcone Oxide (IVb), 2′, 4-Bis(methoxymethoxy)-3-methoxychalcone Oxide (IVc), 2′, 4′-Bis(methoxymethoxy)-chalcone Oxide (IVd), and 2′, 4-Bis(methoxymethoxy)chalcone Oxide (IVe).—IVb, IVc, IVd, and IVe were obtained from IIIb, IIIc, IIId, and IIIe respectively by the procedure described above for IVa.

IVb.—Yield, 76%; colorless needles; m. p. 95—96°C (carbon tetrachloride). IR (KBr): 3000, 2960, 2930(sh), 2830, 2800(sh), 1076, 910 (CH_3OCH_2O); 1681 (CO); 889 cm^{-1} (C—C).

Found: C, 62.67; H, 5.65. Calcd. for $C_{21}H_{24}O_8$: C, 62.36; H, 5.99%.

IVc.—Yield, 67%; liquid, n_D^{15} 1.6633. Attempts to crystallize the oily product (IVc) were unsuccessful. Thus, its elementary analysis gave no satisfactory results, although the infrared spectrum exhibited the expected bands as follows: IR (liquid film): 2990(sh), 2960, 2900(sh), 2820, 2780(sh), 1084, 924 (CH_3OCH_2O); 1679 (CO); 898 cm^{-1} (C—C).

IVd.—Yield, 68%; colorless needles; m.p. 61.5—62°C (carbon tetrachloride). IR(KBr): 2960, 2900, 2830, 2780(sh), 1086, 926 (CH_3OCH_2O); 1675 (CO); 898 cm^{-1} (C—C).

Found: C, 66.01; H, 5.93. Calcd, for $C_{19}H_{20}O_6$: C, 66.26; H, 5.86%.

IVe.—Yield, 79%; colorless prisms; m. p. 59—60°C (carbon tetrachloride). IR(KBr): 2991, 2970(sh), 2825(sh), 2785, 1084, 927 (CH_3OCH_2O); 1686 (CO); 890 cm^{-1} (C—C).

Found: C, 66.24; H, 6.29. Calcd. for $C_{19}H_{20}O_6$: C, 66.26; H, 5.86%.

3, 3′, 4′, 7-Tetrahydroxyflavanone (Va, *dl*-fustin).—A mixture of IVa (1.0 g.), methanol (10 cc.) and 12 N

12) H. Baum, D. R. Pat. 209608 (1909).

13) K. Freudenberg and H. G. Müller, *Ann.*, **584**, 40 (1953).

hydrochloric acid (3 cc.) was refluxed for 5 min. The reaction mixture was then diluted with water (about 20 cc.), and the methanol was removed at a temperature below 40°C in vacuo. The precipitate which had separated on cooling was collected and recrystallized from water to give 0.5 g. (80%) of colorless plates (Va), m. p. 217—218°C; this substance showed no melting point depression on admixture with an authentic sample of *dl*-fustin.[6] The infrared and ultraviolet spectra of Va were identical with those of the natural substance

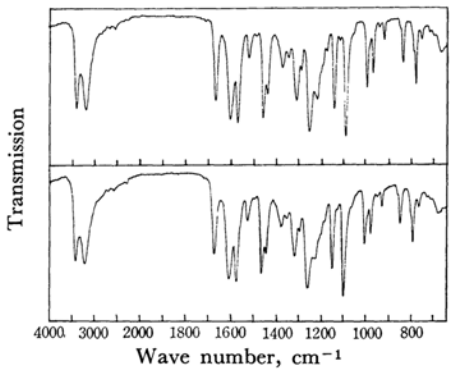

Fig. 1. The infrared spectra of natural (upper) and synthetic fustin (Va) (lower).

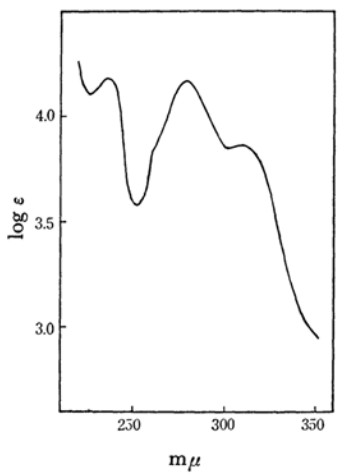

Fig. 2. The ultraviolet spectrum of synthetic fustin (Va) in ethanol.

(Figs. 1 and 2). Color reactions: magnesium - hydrochloric acid, orange red; zinc — hydrochloric acid, orange red; ferric chloride, green. IR(KBr): 3400, 3200, 1018 (OH); 1674 cm^{-1} (CO). UV λ_{max}^{EtOH} mμ (log ε): 235 (4.19), 279 (4.17), 310 (3.84). (Found: C, 62.61; H, 4.38. Calcd. for $C_{15}H_{12}O_6$: C, 62.50; H, 4.16%).

Tetraacetate: m. p. 148—149°C (lit. m. p. 150—151°C[6]). IR (KBr): 1752 (acetate CO); 1707 cm^{-1} (CO).

3', 4', 7-Trimethyl Ether: m. p. 140—140.5°C (lit. m. p. 143—144°C[6]). IR(KBr): 3450, 998 (OH); 3000—2900 (triplet), 2835 (CH_3O); 1679 cm^{-1} (CO).

3, 4', 7-Trihydroxyflavanone (Vb), 3, 4'-Dihydroxy-3'-methoxyflavanone (Vc), 3, 7-Dihydroxyflavanone (Vd), and 3, 4'-Dihydroxyflavanone (Ve). —Vb, Vc, Vd, and Ve were prepared from IVb, IVc, IVd, and IVe respectively by a slight modification of the procedure described above. The precipitate which had separated on the addition of water was collected and recrystallized from the appropriate solvents.

Vb.—Yield, 63%; colorless fine crystals; m. p. 214—215°C (ethanol). Color reactions: magnesium - hydrochloric acid, reddish violet; zinc - hydrochloric acid, reddish violet; phloroglucinol - hydrochloric acid, reddish violet; ferric chloride, none. IR (KBr): 3250 (broad), 1005 (OH); 1660 cm^{-1} (CO). UV λ_{max}^{EtOH} mμ (log ε): 232 (4.19), 275 (4.13), 310 (3.83).

Found: C, 66.17; H, 4.78. Calcd. for $C_{15}H_{12}O_5$: C, 66.17; H, 4.44%.

Triacetate: m. p. 149—150.5°C. IR (KBr): 1750 (acetate CO); 1707 cm^{-1} (CO).

Found: C, 63.19; H, 4.75. Calcd. for $C_{21}H_{18}O_8$: C, 63.31; H, 4.56%.

4', 7-Dimethyl Ether: m. p. 130—131°C (lit. m. p. 124—126°C[8]). IR (KBr): 3450, 1007 (OH); 3000—2900 (triplet), 2840 (CH_3O); 1683 cm^{-1} (CO).

The Oxidation of Vb to 3, 4', 7-Trihydroxyflavone (VIb). —A mixture of Vb (0.1 g.), 16% aqueous sodium hydroxide (4 cc.), and methanol (3 cc.) was warmed on a water bath for 10 min. The reaction mixture was then poured into water, and the precipitate formed was collected and recrystallized from ethanol to give VIb as yellow crystals, m. p. 296—297°C (lit. m. p. 302°C[14]).

Vc.—Yield, 45%; colorless needles; m. p. 217—218°C (ethyl acetate). Color reactions: magnesium - hydrochloric acid, reddish orange; zinc - hydrochloric acid, reddish orange; phloroglucinol - hydrochloric acid, violet; ferric chloride, none. IR(KBr): 3460, 1009 (OH); 1677 cm^{-1} (CO). UV λ_{max}^{EtOH} mμ (log ε): 232[a](4.06), 250(3.95), 281(3.58), 315(3.51).

Found: C, 67.10; H, 4.99. Calcd. for $C_{16}H_{14}O_5$: C, 67.12; H, 4.94%.

Diacetate: m. p. 144—145°C. IR (KBr): 1750 (acetate CO): 1699 cm^{-1} (CO).

Found: C, 65.07; H, 5.19. Calcd. for $C_{20}H_{18}O_7$: C, 64.85; H, 4.91%.

3', 4'-Dimethyl Ether: m. p. 155—157°C (lit. m. p. 155—157°C[8]). IR (KBr): 3450, 1005 (OH); 3000—2900 (triplet), 2840 (CH_3O); 1692 cm^{-1} (CO).

Vd.—Yield, 75%; colorless needles; m. p. 170—171°C (ethanol). Color reactions: magnesium - hydrochloric acid, reddish orange; zinc - hydrochloric acid, red; phloroglucinol - hydrochloric acid, orange; ferric chloride, none. IR(KBr): 3395, 3165, 1010 (OH); 1677 cm^{-1} (CO). UV λ_{max}^{EtOH} mμ (log ε): 234[a](3.92), 277-(4.07), 308(3.88).

Found: C, 69.66; H, 5.06. Calcd. for $C_{15}H_{12}O_4$: C, 70.30; H, 4.73%.

Diacetate: m. p. 129.5—130°C. IR (KBr): 1752 (acetate CO); 1700 cm^{-1} (CO).

Found: C, 66.95; H, 4.99. Calcd. for $C_{19}H_{16}O_6$: C, 67.04; H, 4.75%.

7-Methyl Ether: m. p. 148—149°C (lit. m. p. 146—147°C,[9] 149—150°C[10]). IR(KBr): 3450, 1012 (OH); 3000—2900 (triplet), 2840 (CH_3O); 1682 cm^{-1} (CO).

The Oxidation of Vd to 3, 7-Dihydroxyflavone (VId).—A

14) S. Yamaguchi, *J. Chem. Soc. Japan, Pure Chem. Sec.* (*Nippon Kagaku Zasshi*), **84**, 148 (1963).

mixture of Vd (0.05 g.), 2 N sulfuric acid (5 cc.), and methanol (2 cc.) was heated on a water bath for 15 hr. under reflux, while a gentle stream of air was passed into the flask. The work-up of the reaction product gave VId as pale yellow crystals, m. p. 251—252°C, which was identical with the sample prepared from 2', 4'-dihydroxychalcone by the Algar-Flynn-Oyamada method.

Ve.—Yield, 45%; colorless needles; m. p. 214—216°C (methanol). Color reactions: magnesium - hydrochloric acid, red; zinc - hydrochloric acid, reddish orange; phloroglucinol - hydrochloric acid, red; ferric chloride, none. IR(KBr): 3390, 1006 (OH); 1688 cm^{-1} (CO). UV λ_{max}^{EtOH} mμ (log ε): 230[a](4.21), 253(4.10), 317(3.65).

Found: C, 70.03; H, 5.03. Calcd. for $C_{15}H_{12}O_4$: C, 70.30; H, 4.73%.

Diacetate: m. p. 164.5—165.5°C. IR(KBr): 1742 (acetate CO); 1694 cm^{-1} (CO).

Found: C, 67.29; H, 4.99. Calcd. for $C_{19}H_{16}O_6$: C, 67.04; H, 4.75%.

4'-Methyl Ether: m. p. 171—172°C (lit. m. p. 172—174°C[7]). IR(KBr): 3450, 1003 (OH); 3000—2900 (triplet), 2840 (CH_3O); 1690 cm^{-1} (CO).

The Oxidation of Ve to 3, 4'-Dihydroxyflavone (VIe).—This oxidation was effected essentially by the method described above for Va. VIe was obtained as yellow needles, m. p. 266—268°C; it was identical with the sample prepared from 2', 4-dihydroxychalcone by the Algar-Flynn-Oyamada method.

As has been described above, except for *dl*-fustin, the hydroxydihydroflavonols obtained here, which contain a free 4'-, 7-hydroxyl, or 4', 7-dihydroxyl grouping, gave no color reaction with ferric chloride (carried out by the addition of aqueous ferric chloride to aqueous alcohol solutions of these compounds). This is not too surprising, for this observation is in agreement with that made by Briggs and Locker[15] in hydroxyflavones containing a similar hydroxyl grouping.

All of the above acetates were prepared by treating them with acetic anhydride and pyridine; all of the above methyl ethers were prepared by refluxing them with dimethyl sulfate and anhydrous potassium carbonate in an acetone solution.

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15) L. H. Briggs and R. H. Locker, *J. Chem. Soc.*, **1951**, 3136.