496. *Syntheses of Flavones from* Lindera lucida

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Three flavones isolated from *Lindera lucida* have been shown by degradation and synthesis to be 5,6,7,8-tetramethoxyflavone, 5,6,7,8-tetramethoxy-3′,4′-methylenedioxyflavone and 5,7-dihydroxy-6,8-dimethoxy-3′,4′-methylenedioxyflavone (lucidin), respectively. The effect of sodium acetate on the ultraviolet absorptions of lucidin, 5,7-dihydroxy-6,8-dimethoxyflavone, and their corresponding 5-methyl ethers is discussed.

The discovery of two coloured cyclopentenedione derivatives from *Lindera pipericarpa* (Lauraceae) [1] prompted us to investigate related species of the same genus. In this Paper we report structural studies on, and total syntheses of, three flavones isolated from the ethereal extracts of the root of *Lindera lucida*. These substances were readily separated by their solubility differences in ether and chloroform, and possess the molecular formulæ $C_{18}H_{14}O_8$ (A), $C_{20}H_{18}O_8$ (B), and $C_{19}H_{18}O_6$ (C), respectively.

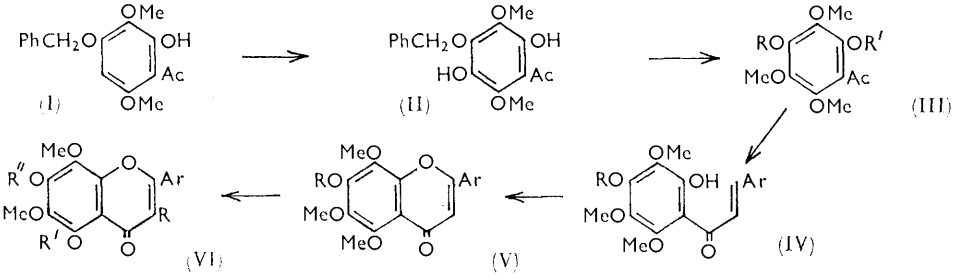
Flavone (A), a yellow solid for which the name lucidin is proposed, contains two phenolic hydrogens and two methoxyl groups. Its dimethyl ether is identical with flavone (B). The structure of flavone (B) is established as 5,6,7,8-tetramethoxy-3′,4′-methylenedioxyflavone (V; R = Me, Ar = 3,4-methylenedioxyphenyl) by alkaline hydrolysis to 3,4-methylenedioxyacetophenone, piperonylic acid, and 2-hydroxy-3,4,5,6-tetramethoxyacetophenone [2,3] (III; R = Me, R′ = H) and confirmed by its synthesis from the last compound and piperonal. Similar degradation of lucidin yields only 3,4-methylenedioxyacetophenone and piperonylic acid.

The positions of the two phenolic groups in lucidin were determined by spectroscopic measurements in the presence of complexing reagents and by colour tests.[4] The lack of

[1] A. K. Kiang, H. H. Lee, and K. Y. Sim, *J.*, 1962, 4338.
[2] G. H. Stout and V. F. Stout, *Tetrahedron*, 1961, **14**, 296.
[3] W. Baker, *J.*, 1941, 662.
[4] For references, see "The Chemistry of Flavonoid Compounds," ed. T. A. Geissman, Pergamon Press, New York, 1962, p. 75.

appreciable change in the ultraviolet absorption of lucidin on the addition of boric acid–sodium acetate [5] (Table 1) and the negative reactions with *p*-benzoquinone and *o*-dinitrobenzene in alkali indicate the absence of *o*- or *p*-dihydroxy groups. The considerable bathochromic shifts observed in ethanolic aluminium chloride [6] on the other hand, suggest the presence of a 5-hydroxy group and therefore lead to structure (VI; R = R′ = R″ = H, Ar = 3,4-methylenedioxyphenyl) for lucidin. Chemical evidence in favour of a 5-hydroxy group in lucidin is based on its reaction with diazomethane which gives a monomethylated product (VI; R = R′ = H, R″ = Me, Ar = 3,4-methylenedioxyphenyl), consistent with the reported resistance of chelated 5-hydroxy groups to methylation by diazomethane.[7] The structure of the monomethyl ether is further supported by the change in its spectral data on addition of aluminium chloride and by the fact that it is also obtained from the treatment of lucidin dimethyl ether with anhydrous aluminium chloride, a reagent known to demethylate readily a 3- or 5-methoxyl group in the flavone nucleus.[8] The presence of a 7-hydroxyl group is usually indicated by the pronounced bathochromic shift (8—20 mμ) of the low-wavelength band (Band II) in the ultraviolet absorption of the flavonoid compound on addition of fused sodium acetate.[9] This behaviour has been ascribed to the fact that Band II is associated mainly with absorption in the A ring, and sodium acetate is sufficiently basic to ionise the relatively more acidic 7-hydroxyl group. Unexpectedly, the position of Band II in the ultraviolet absorption of lucidin remains unaffected in ethanolic sodium acetate solution.

Although three other 5,7-dihydroxy-6,8-dimethoxyflavonoid compounds are known to date,* the structure of one of them, erianthin [10] (VI; R = OMe, R′ = R″ = H, Ar = 3,4-dimethoxyphenyl) is still doubtful [11] while the structures of the other two, sudachitin [12] (VI; R = R′ = R″ = H, Ar = 3-methoxy-4-hydroxyphenyl), and demethoxysudachitin [13] (VI; R = R′ = R″ = H, Ar = 4-hydroxyphenyl), have only recently been confirmed by the syntheses of their ethyl ethers. No spectral studies on any of them, however, have yet been reported. The anomalous ultraviolet absorption of lucidin in the presence of sodium acetate therefore led us to undertake its total synthesis as the unequivocal proof of its structure. The synthetic scheme is outlined.



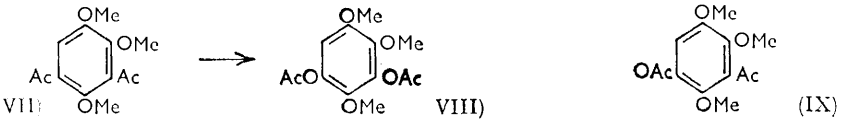
The unambiguity of the synthesis is demonstrated by the fact that the benzyl ether (III; R = R′ = $PhCH_2$) of the fully substituted hydroxyketone (III; R = $PhCH_2$,

* For the isolation and structural studies of two new 5,7-dihydroxy-6,8-dimethoxyflavonoid compounds, see B. Gentili and R. M. Horowitz, *Tetrahedron*, 1964, **20**, 2313.

[5] L. Jurd, *Arch. Biochem. Biophys.*, 1956, **63**, 376.
[6] T. Swain, *Chem. and Ind.*, 1954, 1480; R. M. Horowitz, *J. Amer. Chem. Soc.*, 1957, **79**, 6561.
[7] R. Robinson and K. F. Tseng, *J.*, 1938, 1004.
[8] K. Venkataraman and G. K. Bharadwaj, *Current. Sci.* (*India*), 1933, **2**, 50.
[9] For references, see L. Jurd, ref. 4, pp. 122, 147.
[10] P. K. Bose and P. Dutt, *J. Indian Chem. Soc.*, 1940, **17**, 45.
[11] T. R. Seshadri and K. Venkateswarlu, *Proc. Indian Acad. Sci.*, 1946, **23***A*, 192.
[12] T. Horie, M. Masumra, and S. Okumura, *J. Chem. Soc. Japan*, 1962, **83**, 468 (*Chem. Abs.*, 1963, **59**, 1576).
[13] T. Horie, H. Shimoo, M. Masumra, and S. Okumura, *J. Chem. Soc. Japan*, 1962, **83**, 602 (*Chem. Abs.*, 1963, **59**, 6346).

R′ = H) is identical with the methylated product of 4,6-dibenzyloxy-2-hydroxy-3,5-dimethoxy-acetophenone obtained from the alkaline hydrolysis of lucidin dibenzyl ether (VI; R = H, R′ = R″ = $PhCH_2$, Ar = 3,4-methylenedioxyphenyl).

An alternative route to the key intermediate (III; R = $PhCH_2$, R′ = H) was suggested by the recent report that the reaction of 1,3-diacetyl-2,4,5-trimethoxybenzene (VII) with peracetic acid (22—28%) gave 2,4,5-trimethoxyresorcinol diacetate (VIII), m. p. 76—77°, in 90% yield.[14] Since the diketone (VII) is readily obtainable from *p*-benzoquinone in three steps,[15] and further conversion of (VIII) to (III; R = $PhCH_2$, R′ = H) would



involve only two or three known reactions, the reported high yield of (VIII) makes this synthetic approach appear to be equally attractive. However, in our hands, peracetic acid (18% by weight) oxidation of (VII) under essentially the same conditions as that reported gave in 30% yield a compound $C_{13}H_{16}O_6$, m. p. 77·5—78·5° whose infrared spectrum shows strong absorptions at 1778 (vinyl ester) and 1708 cm.$^{-1}$, and is assigned the new

TABLE 1

Absorption spectra of flavones in various solutions

$\lambda_{max.}$ is given in mμ, with log ε in parenthesis

Flavone	95% EtOH	0·02M NaOEt	EtOH–NaOAc	EtOH–H_3BO_3–NaOAc	EtOH–$AlCl_3$	EtOH–HCl
5,7-Dihydroxy-6,8-dimethoxy-3′,4′-methylenedioxyflavone (Lucidin)	285 (4·29) 343 (4·26)	240 (4·35) 285 (4·32) 317 (4·07) 384 (3·94)	238 285 317 384	229 (inf.) 285 330 345 (inf.)	233 (inf.) 252 (inf.) 295 320 (inf.)	243 (inf., 4·20) 284 (4·24) 344 (4·31)
7-Hydroxy-5,6,8-trimethoxy-3′,4′-methylenedioxyflavone	238 (inf., 4·33) 274 (4·19) 330 (4·29)	279 (4·34) 322 (4·12) 375 (4·15)	236 279 318 373		245 271 332	245 (4·32) 271 (4·18) 330 (4·39)
7-Hydroxy-5,6,8-trimethoxyflavone	246 (inf., 4·30) 271 (4·45) 313 (4·18)	242 (4·26) 277 (4·41) 373 (3·94)	244 277 370		270 314	270 (4·45) 313 (4·21)
5,7-Dihydroxy-6,8-dimethoxyflavone	252 (inf., 4·18) 277—283 (4·48) 323 (3·88)	250 (4·16) 270 (4·37) 286 (4·34) 384 (3·98)	247 271 285 381	252 (inf.) 275 282 380	256 298 340 410	252 (inf., 4·12) 281 (4·49) 324 (4·05)
7-Hydroxy-5,8-dimethoxyflavone	272 (4·53) 320 (inf., 3·94)	243 (4·30) 283 (4·55) 373 (3·91)	243 282 373			272 (4·53) 320 (inf., 3·96)
5-Hydroxy-6,7,8-trimethoxy-3′,4′-methylenedioxyflavone	256 (4·18) 284 (4·23) 343 (4·33)				262 295 359	
5-Hydroxy-6,7,8-trimethoxyflavone	282 (4·52) 316 (inf., 4·05)				301 334	
5,6,7,8-Tetramethoxy-3′,4′-methylenedioxyflavone	251 (4·37) 271 (inf., 4·24) 335 (4·42)					
7-Benzyloxy-5,6,8-trimethoxy-3′,4′-methylenedioxyflavone	251 (4·31) 271 (4·20) 335 (4·35)					
5,6,7,8-Tetramethoxyflavone	271 (4·52) 305 (4·26)					
7-Benzyloxy-5,6,8-trimethoxyflavone	271 (4·62) 305 (4·34)					

[14] A. Ballio and L. Almirante, *Ann. Chim.* (*Italy*), 1951, **41**, 421 (*Chem. Abs.*, 1952, **46**, 2518).
[15] M. Healey and R. Robinson, *J.*, 1934, 1625.

structure (IX), since the latter absorption is suggestive of a hindered alkyl aryl ketone. This is based on the infrared spectrum of the diketone (VII) which shows two bands at 1710 and 1680 cm.$^{-1}$, and may be interpreted as due to the absorption of the hindered alkyl aryl carbonyl at position 3 and the normal aryl carbonyl at position 1. The poor yield of the rearrangement discouraged further attempts along this synthetic approach.

The structure of flavone (C) was shown to be 5,6,7,8-tetramethoxyflavone (V; R = Me, Ar = Ph) by alkaline degradation to benzoic acid, acetophenone and 2-hydroxy-3,4,5,6-tetramethoxyacetophenone (III; R = Me, R′ = H). Although this flavone has not hitherto been found to occur in nature, its synthesis from (III; R = R′ = Me) has been reported by Murti, Rao, and Seshadri,[16] and is confirmed in the present work.

Reaction of the flavone (V; R = Me, Ar = Ph) with anhydrous aluminium chloride gave the corresponding 5-hydroxy derivative (VI; R = R′ = H, R″ = Me, Ar = Ph).

The failure of sodium acetate to affect the position of Band II in the ultraviolet absorption of lucidin has been mentioned earlier. Examination of available data [9] indicates that 7-hydroxyflavonoid compounds which show a bathochromic shift of Band II in the presence of sodium acetate are either those that have both the 6- and the 8-positions unsubstituted or those that have only one substituent adjacent to the 7-hydroxyl group. It should be of interest therefore to investigate whether the spectral behaviour of lucidin towards weak base is general for flavones with 7-hydroxyl groups located in a fully oxygenated ring A. Accordingly, lucidin 5-methyl ether (VI; R = R″ = H, R′ = Me, Ar = 3,4-methylenedioxyphenyl), 5,7-dihydroxy-6,8-dimethoxyflavone (VI; R = R′ = R″ = H, Ar = Ph) and its 5-methyl ether (V; R = H, Ar = Ph) were prepared and their ultraviolet absorptions studied in various solutions. As can be seen from Table 1, the effect of sodium acetate or even sodium ethoxide on the position of Band II of these flavones appears to be irregular, ranging from no change in the case of lucidin to a bathochromic shift of 6 mμ in the case of flavone (V; R = H, Ar = Ph). In contrast, Band II of the known 7-hydroxy-5,8-dimethoxyflavone [17] is shifted 10 mμ towards longer wavelength in the same solution. It may thus be inferred that this spectral method of detecting a 7-hydroxy group with sodium acetate is of limited value when applied to flavonoid compounds which possess a fully oxygenated ring A.

Experimental

Melting points were taken on a Kofler micro-hot-stage apparatus. Unless otherwise stated infrared spectra were determined in carbon tetrachloride solutions with a Hilger H800 spectrophotometer, and ultraviolet spectra were measured in ethanolic solutions with a Hilger Uvispek. Microanalyses were by Dr. W. Zimmerman (Melbourne) and Mrs. H. K. Tong (Singapore).

Isolation of Lucidin, Lucidin Dimethyl Ether and 5,6,7,8-Tetramethoxyflavone.—Ground root of *Lindera lucida* (4·0 kg.) was extracted continuously with ether (10 l.) for 72 hr. The ethereal extracts were concentrated to 3 l. and filtered to remove insoluble solids (75 g.), which upon washing with chloroform (4 × 150 ml.) left a yellow powder (25 g.), soluble with difficulty in most organic solvents. After two crystallisations from glacial acetic acid, *lucidin* was obtained in bright yellow needles, m. p. 255—257° (Found: C, 60·5, 60·7; H, 4·3, 4·15; O, 35·3; active H, 0·12; OMe, 16·7. $C_{18}H_{14}O_8$ requires C, 60·3; H, 3·9; O, 35·7; 2H, 0·56; 2OMe, 17·3%); $\nu_{max.}$ (Nujol) 1592 and 1655 cm.$^{-1}$. The following derivatives were prepared: *diacetate*, m. p. 142—144° (Found: C, 59·6; H, 4·4. $C_{22}H_{18}O_{10}$ requires C, 59·7; H, 4·1%); dimethyl ether, m. p. and mixed m. p. 171—172°; *diethyl ether*, m. p. 140—141° (Found: C, 63·6; H, 5·4. $C_{22}H_{22}O_8$ requires C, 63·8; H, 5·35%); *dibenzyl ether*, m. p. 131—133° (Found: C, 71·5; H, 5·0. $C_{32}H_{26}O_8$ requires C, 71·4; H, 4·9%).

The combined chloroform washings were passed through a column of alumina (120 g.) and concentrated, yielding *lucidin dimethyl ether* (30 g.) as needles, m. p. 163—168°, raised to 171—172° after five crystallisations from methanol (Found: C, 62·4; H, 4·9; O, 33·2; OMe, 30·5. $C_{20}H_{18}O_8$ requires C, 62·2; H, 4·7; O, 33·1; 4OMe, 32·2%), $\nu_{max.}$ 1648 cm.$^{-1}$.

Extraction of the ethereal filtrate with 2% aqueous sodium hydroxide (5 × 100 ml.) and

[16] V. V. S. Murti, K. V. Rao, and T. S. Seshadri, *Proc. Indian Acad. Sci.*, 1947, **26***A*, 182.
[17] R. C. Shah, C. R. Mehta, and T. S. Wheeler, *J.*, 1938, 1555.

acidification of the extracts gave a further amount of *lucidin* (5 g.). The neutral ether solution was evaporated and a portion (30 g.) of the residue (142 g.) dissolved in benzene and adsorbed on alumina (150 g.). Elution with benzene and evaporation of the solvent gave a solid mixture, m. p. 96—107°, from which 5,6,7,8-*tetramethoxyflavone* (15 g.), m. p. 112—113° (lit.,[16] m. p. 117—118° for a synthetic specimen) was obtained by fractional recrystallisation from aqueous methanol (Found: C, 66·5; H, 5·5; O, 28·2; OMe, 34·0. $C_{19}H_{18}O_6$ requires C, 66·7; H, 5·3; O, 28·0; 4OMe, 36·1%), $\nu_{max.}$ 1650 and 690 cm.$^{-1}$.

Further continuous extraction of the ground root with methanol (10 l.) for 48 hr. yielded another crop of lucidin (20 g.).

5-*Hydroxy*-6,7,8-*trimethoxy*-3′,4′-*methylenedioxyflavone*.—(a) *From lucidin*. Excess ethereal diazomethane was added to a suspension of lucidin (0·4 g.) in ether (150 ml.). After 48 hr. at 28° the solvent was evaporated and the *product* crystallised from ethanol as yellow needles, softened at 185°, m. p. 188—189° (Found: C, 61·6; H, 4·6. $C_{19}H_{16}O_8$ requires C, 61·3; H, 4·3%), $\nu_{max.}$ ($CHCl_3$) 1650 and 1605 cm.$^{-1}$. The monomethyl ether gives a dark green colour with ferric chloride but is insoluble in 5% aqueous sodium hydroxide. The *acetyl derivative* had m. p. 123—125° (Found: C, 61·1; H, 4·6. $C_{21}H_{18}O_9$ requires C, 60·9; H, 4·4%).

(b) *From reaction of lucidin dimethyl ether with anhydrous aluminium chloride*. Anhydrous aluminium chloride (2 g.) was added to a cooled solution of lucidin dimethyl ether (0·3 g.) in dry ether (50 ml.). After 24 hr. at 28°, the mixture was decomposed with ice–water and the solvent evaporated to give the *product* (0·18 g.), m. p. and mixed m. p. with the above sample 188—190°.

Similar hydrolysis could be achieved by refluxing lucidin dimethyl ether in concentrated hydrochloric acid and acetic acid (1 : 1) for 2 hr.

5-*Hydroxy*-6,7,8-*trimethoxyflavone*.—Hydrolysis of 5,6,7,8-tetramethoxyflavone by methods described under (b) above gave the 5-*hydroxy derivative* as light yellow needles from petroleum, m. p. 100—102° (Found: C, 65·9; H, 5·0. $C_{18}H_{16}O_6$ requires C, 65·85; H, 4·9%), $\nu_{max.}$ 1655 and 1612 cm.$^{-1}$, *acetyl derivative*, m. p. 101—103° (Found: C, 65·2; H, 5·0. $C_{20}H_{18}O_7$ requires C, 64·9; H, 4·9%).

Alkaline Degradation of (*a*) *Lucidin Dimethyl Ether*.—A mixture of lucidin dimethyl ether (4·0 g.), 20% aqueous potassium hydroxide (20 ml.), and ethanol (80 ml.) was refluxed under nitrogen for 17 hr. The resulting brown solution was diluted with water (300 ml.) and extracted with ether (3 × 100 ml.). Evaporation of the ethereal extracts gave 3,4-methylenedioxyacetophenone (0·4 g.), m. p. 85—87° (lit.,[18] m. p. 87—88°), identified by its semicarbazone, m. p. 240—241° (lit.,[18] m. p. 241—242°), and by oxidation with sodium hypoiodite to piperonylic acid, m. p. and mixed m. p. with authentic material 228—230°. The aqueous alkaline solution was acidified and extracted with ether (5 × 80 ml.). The ethereal extracts were shaken with saturated aqueous sodium hydrogen carbonate (3 × 50 ml.) and dried ($MgSO_4$). Acidification of the sodium hydrogen carbonate extracts yielded piperonylic acid (1·2 g.). Evaporation of the ethereal solution followed by short-path distillation gave 2-hydroxy-3,4,5,6-tetramethoxyacetophenone (1·6 g.) as a light orange oil, b. p. 130° (bath)/0·2 mm. (Found: C, 56·5; H, 6·3; OMe, 46·9; C–Me, 5·6. Calc. for $C_{12}H_{16}O_6$: C, 56·2; H, 6·3; 4OMe, 48·4; 1C–Me, 5·9%), $\lambda_{max.}$ 282 (log ε 4·04) and 348 (log ε 3·42) mμ [Stout and Stout [2] report $\lambda_{max.}$ 282 (log ε 4·02) and 348 (log ε 3·42) mμ]. The 2,4-*dinitrophenylhydrazone derivative* had m. p. 168—170° (Found: C, 49·5; H, 4·7; N, 12·4. $C_{18}H_{20}N_4O_9$ requires C, 49·5; H, 4·6; N, 12·8%); the *O*-methyl derivative had b. p. 110—120° (bath)/0·2 mm. and m. p. 40—41° (lit.,[3] m. p. 43°).

(b) *Lucidin Dibenzyl Ether*.—Lucidin dibenzyl ether (3·5 g.) was hydrolysed with 10% aqueous ethanolic potassium hydroxide (150 ml.) and worked up as described in (a). Piperonylic acid (0·8 g.) and 3,4-methylenedioxyacetophenone (0·6 g.) were isolated from the acidic and neutral fractions, respectively. The phenolic fraction yielded 4,6-*dibenzyloxy*-2-*hydroxy*-3,5-*dimethoxyacetophenone* as a yellow oil, b. p. 160—180° (bath)/0·2 mm., which crystallised on standing, m. p. 86—87° (Found: C, 70·7; H, 6·1. $C_{24}H_{24}O_6$ requires C, 70·6; H, 5·9%). The O-*methyl derivative* had m. p. 61—62·5° after crystallisation from aqueous methanol (Found: C, 71·3; H, 6·5. $C_{25}H_{26}O_6$ requires C, 71·1; H, 6·2%), $\nu_{max.}$ 1705 cm.$^{-1}$.

(c) *Lucidin*.—Similar hydrolysis of lucidin (2·5 g.) afforded only 3,4-methylenedioxyacetophenone (0·47 g.) and piperonylic acid (0·48 g.). No phenolic product was isolated.

(d) 5,6,7,8-*Tetramethoxyflavone*.—A solution of the flavone (3 g.) in 10% aqueous ethanolic potassium hydroxide (80 ml.) was refluxed for 20 hr. and worked up as described in (a). The

[16] F. Mauthner, *J. prakt. Chem.*, 1927, **116** 321.

neutral fraction afforded acetophenone (0·36 g.). The acidic and phenolic fractions yielded benzoic acid (0·8 g.) and 2-hydroxy-3,4,5,6-tetramethoxyacetophenone (1·2 g.), respectively.

4-Benzyloxy-2-hydroxy-3,6-dimethoxyacetophenone.—Benzylation of 2,4-dihydroxy-3,6-dimethoxyacetophenone [19a] (5·0 g.) according to the procedure described by Geissman [19b] gave a crude product which was suspended in ether (150 ml.) and extracted with 5% aqueous sodium hydroxide (4 × 40 ml.). Acidification of the alkaline extracts, collection of the product, and recrystallisation from ethanol yielded the pure product (4·8 g.), m. p. 110—112° (lit.,[19b] m. p. 109—110°), $\nu_{max.}$ 1618 and 1600 cm.$^{-1}$. The neutral ethereal solution gave *2,4-dibenzyloxy-3,6-dimethoxyacetophenone* (90 mg.) which crystallised from cyclohexane as plates, m. p. 88·5—89·5° (Found: C, 73·4; H, 6·3. $C_{24}H_{24}O_5$ requires C, 73·45; H, 6·2%), $\nu_{max.}$ 1701 cm.$^{-1}$.

4-Benzyloxy-2,5-dihydroxy-3,6-dimethoxyacetophenone.—Elbs persulphate oxidation [20] of the preceding hydroxyacetophenone (5·0 g.) was by essentially the procedure described for the oxidation of the analogous α-methoxy-compound.[21] The *product* was obtained as an oil (2·41 g.) which solidified slowly at 5° and was purified by sublimation at 120—150° (bath)/0·2 mm., m. p. 59—61° (Found: C, 64·1; H, 5·9; OMe, 19·3. $C_{17}H_{18}O_6$ requires C, 64·1; H, 5·7; 2OMe, 19·5%), $\nu_{max.}$ 3520, 1623, and 694 cm.$^{-1}$. The *diacetate* had m. p. 81—82° (Found: C, 63·0; H, 5·7. $C_{21}H_{22}O_7$ requires C, 62·7; H, 5·5%).

4-Benzyloxy-2-hydroxy-3,5,6-trimethoxyacetophenone.—Methylation of the preceding dihydroxy compound (0·5 g.) with methyl sulphate (0·19 g.) and anhydrous potassium carbonate (2·0 g.) in petroleum (b. p. 40—60°; 60 ml.) gave a mixture of products which was separated by extraction with aqueous sodium hydroxide (5%). The *monomethylated product* was obtained as an oil (365 mg.) which slowly crystallised, m. p. 35—36° (Found: C, 65·1; H, 6·2; OMe, 29·6. $C_{18}H_{20}O_6$ requires C, 65·05; H, 6·1; 3OMe, 28·0%), $\lambda_{max.}$ 1625 and 1590(sh) cm.$^{-1}$. The *O*-benzyl derivative had m. p. and mixed m. p. 61—62·5°. The neutral material after chromatography on alumina gave *4-benzyloxy-2,3,5,6-tetramethoxyacetophenone*, rods, m. p. 68—69° from petroleum (b. p. 40—60°) (Found: C, 66·0; H, 6·6. $C_{19}H_{22}O_6$ requires C, 65·9; H, 6·4%), $\nu_{max.}$ 1709 cm.$^{-1}$.

Peracetic Acid Oxidation of 1,3-Diacetyl-2,4,5-trimethoxybenzene.—A solution of the diketone (VII) [15] (4·4 g.) and toluene-*p*-sulphonic acid (1·2 g.) in peracetic acid (18% by weight in acetic acid, 25 ml.) was heated at 60—65° for 3 hr. and then left at 28° for 15 hr. After dilution with

TABLE 2

Data for chalcones (IV) and flavones (V)

	M. p.	Formula	Reqd. (%) C	Reqd. (%) H	Found (%) C	Found (%) H
IV; R = CH_3, Ar = Ph	B. p. 158—180° (bath)/0·1 mm.	$C_{19}H_{20}O_6$	66·3	5·85	66·0	6·1
IV; R = $PhCH_2$, Ar = Ph	Red oil [a]	$C_{25}H_{24}O_6$	71·4	5·75	71·6	5·9
IV; R = Me, Ar = 3,4-CH_2O_2:C_6H_3	124—126°	$C_{20}H_{20}O_8$	61·85	5·2	61·9	5·5
IV; R = $PhCH_2$, Ar = 3,4-CH_2O_2:C_6H_3	130·5—131·5	$C_{26}H_{24}O_8$	67·2	5·2	67·0	5·5
V; R = $PhCH_2$, Ar = Ph	144—145	$C_{25}H_{22}O_6$	71·8	5·3	71·8	5·5
V; R = H, Ar = Ph [b]	186—188	$C_{15}H_{16}O_6$	65·9	4·9	66·2	5·2
V; R = $PhCH_2$, Ar = 3,4-CH_2O_2:C_6H_3	186—187	$C_{26}H_{22}O_8$	67·5	4·8	67·3	5·3
V; R = H, Ar = 3,4-CH_2O_2:C_6H_3 [b]	232—233	$C_{19}H_{16}O_8$	61·3	4·3	61·4	4·6

[a] Purified by chromatography on alumina with benzene as eluent. [b] These flavones give a negative test with ferric chloride but are soluble in aqueous sodium hydroxide.

ice–water (200 ml.), the mixture was extracted with benzene (5 × 50 ml.). The benzene extracts were washed with aqueous saturated sodium hydrogen carbonate, water, and dried ($MgSO_4$). Evaporation of the solvent gave *3-acetoxy-2,5,6-trimethoxyacetophenone* (1·4 g.), m. p. 77·5—78·5° (from ethanol) (Found: C, 58·4; H, 6·3. $C_{13}H_{16}O_6$ requires C, 58·2; H, 6·0%), $\nu_{max.}$ 1778 and 1708 cm.$^{-1}$.

Preparation of Chalcones and Flavones.—The chalcones listed in Table 2 were prepared by a standard method involving the condensation of benzaldehyde or piperonal with the appropriate 2-hydroxy-ketone in ethanolic sodium hydroxide solution. The flavones were obtained from the corresponding chalcones by oxidative cyclisation with selenium dioxide in pentan-1-ol.

[19] (*a*) T. A. Geissman and T. G. Halsall, *J. Amer. Chem. Soc.*, 1951, **73**, 1282; (*b*) T. A. Geissman, *ibid.*, p., 3514.

[20] K. V. Rao and T. R. Seshadri, *Proc. Indian Acad. Sci.*, 1947, **25***A*, 417, 444; T. R. Seshadri, *ibid.*, 1948, **28***A*, 1.

[21] V. D. N. Sastri and T. R. Seshadri, *Proc. Indian Acad. Sci.*, 1946, **24***A*, 238.

Not included in the Table are the data for 5,6,7,8-tetramethoxyflavone and 5,6,7,8-tetramethoxy-3′,4′-methylenedioxyflavone. Removal of benzyl groups to give 7-hydroxyflavones was accomplished by hydrogenolysis over 30% palladium–charcoal in tetrahydrofuran solution containing a trace of hydrochloric acid.

5,7-*Dihydroxy*-6,8-*dimethoxyflavone*.—A solution of 7-benzyloxy-5,6,8-trimethoxyflavone (96 mg.) in acetic acid (4 ml.) and concentrated hydrochloric acid (4 ml.) was refluxed for 2 hr. and diluted with water (25 ml.). The product (60 mg.) was collected and crystallised from aqueous methanol as yellow needles, m. p. 235—237° (Found: C, 65·2; H, 4·9. $C_{17}H_{14}O_6$ requires C, 65·0; H, 4·5%), $\nu_{max.}$ ($CHCl_3$) 3490, 1652, and 1590 cm.$^{-1}$.

5,7-*Dihydroxy*-6,8-*dimethoxy*-3′,4′-*methylenedioxyflavone* (*Lucidin*).—Hydrolysis of 7-benzyloxy-5,6,8-trimethoxy-3′,4′-methylenedioxyflavone under similar conditions gave lucidin, m. p. and mixed m. p. 225—257°.

We thank Professors R. L. Huang and W. B. Whalley for helpful discussions, and the Chief Research Officer, Forest Research Institute, Kepong, for collection of plant material.

UNIVERSITY OF MALAYA, KUALA LUMPUR. [*Received, August 5th*, 1964.]