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ISOFLAVONOIDS FROM *CYCLOLOBIUM* SPECIES*

OTTO R. GOTTLIEB

Instituto de Química, Universidade de São Paulo

and

ALAÍDE BRAGA DE OLIVEIRA, TEREZINHA M. MACHADO GONÇALVES, GEOVANE G. DE OLIVEIRA and SEBASTIÃO A. PEREIRA

Instituto de Ciências Exatas, Universidade Federal de Minas Gerais, Belo Horizonte, Brasil

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Key Word Index—*Cyclolobium clausseni*; *Cyclolobium vecchii*; Leguminosae; isoflavans; isoflavanquinones.

Abstract—(3*R*)-Claussequinone (7-hydroxy-4′-methoxyisoflavanquinone) is the principal constituent of *Cyclolobium clausseni* Benth. and *C. vecchii* A. Samp. extracts. *C. clausseni* contains additionally (3*R*)-mucroquinone (7-hydroxy-8,4′-dimethoxyisoflavanquinone), (3*R*)-vestitol (7,2′-dihydroxy-4′-methoxyisoflavan), (3*R*)-α,α-dimethylallylcyclolobin [5′-(1,1-dimethylallyl)-7,3′,4′-trihydroxy-2′-methoxyisoflavan], biscyclolobin, 3′-hydroxyformononetin and isoliquiritigenin. The structural proposals for vestitol and claussequinone were confirmed by synthesis.

Dalbergia, *Machaerium* and *Cyclolobium* (Leguminosae-Lotoideae) are morphologically closely related [3]. Previous work on 25 *Dalbergia* and *Machaerium* species has shown that the affinities of the two genera extend to their chemical composition [4]. Only a few *Cyclolobium* species are known, all of very restricted geographical distribution; *C. clausseni* Benth., trivial name sucupira carim, and *C. vecchii* A. Samp. occur in the State of Minas Gerais.

The benzene extracts of the trunk wood of both species contain an orange pigment (**1a**), which gave a monoacetate (**1b**) and was named claussequinone after it was found that the compound is amenable to reduction to a quinol which, upon acetylation, gives a triacetate (**2a**). The structural analysis, involving UV, IR, PMR and MS, was confirmed by synthesis. 2,4-Dimethoxyphenylacetic acid [5], obtained by the Wilgerodt reaction [6] from 2,4-dimethoxyacetophenone, was condensed with resorcinol in $CHCl_3/BF_3$ [7] to 2,4-dihydroxyphenyl 2,4-dimethoxybenzyl ketone [8]. Application of the orthoformate method [7] to this deoxybenzoin led to 7-hydroxy-2′,4′-dimethoxyisoflavone (**3a**) [8], which was selectively demethylated by $AlCl_3$ in $C_6H_5NO_2$ [9] to 7,2′-dihydroxy-4′-methoxyisoflavone (**3b**) [8]. The catalytic reduction of isoflavans is not uniformly successful [10] and it was deemed necessary to test its applicability on several common isoflavones (**3c–f**). In these model reactions the hitherto undescribed (±)-7,3′,4′-trimethoxy- (**2b**), (±)-7-hydroxy-6,4′-dimethoxy- (**2c**) and (±)-7-hydroxy-4′-methoxy- (**2d**) isoflavans were prepared. Finally also the reduction of 7,2′-dihydroxy-4′-methoxyisoflavone was attempted, leading without difficulty to (±)-7,2′-dihydroxy-4′-methoxyisoflavan (**2e**) whose oxidation with Fremy's salt gave a compound, identical in all

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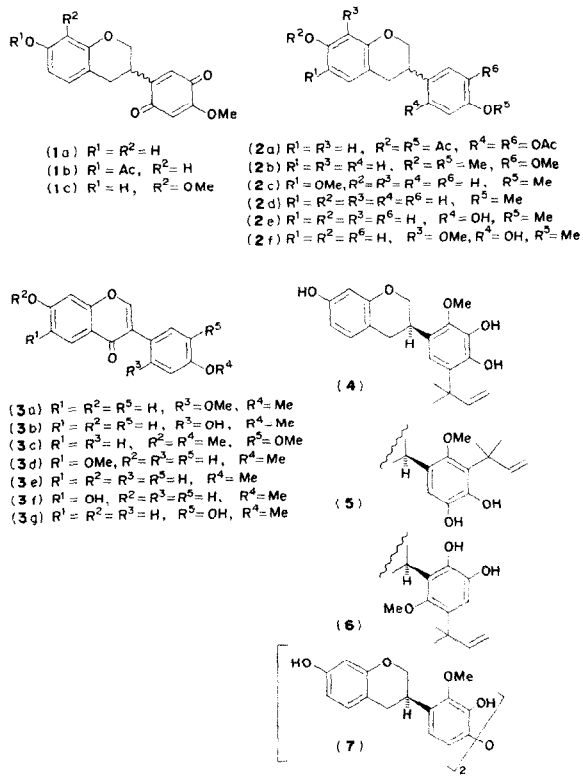
respects with natural claussequinone (**1a**), except for mp and optical activity. The synthetic material was, of course, inactive, while natural claussequinone showed a positive Cotton effect. (3*S*)-Claussequinone (**1a**), obtained by CrO_3/AcOH oxidation of (+)-7,2′-dihydroxy-4′-methoxyisoflavan, the (3*S*)-vestitol (**2e**) of *D. variabilis* Vog. [11] *D. ecastophyllum* (L.) Taub. [12] and *M. vestitum* Vog. [11], showed a negative Cotton effect [13]. The (3*R*)-configuration must, consequently, correspond to the claussequinone (**1a**) from *Cyclolobium*.

From the heartwood extract of *C. clausseni*, available in comparatively much larger quantity, an additional pigment was isolated. This was recognised as (3*R*)-mucroquinone (**1c**) by spectral data and direct comparison with (3*S*)-mucroquinone *ex M. mucronulatum* Mart. [11, 13]. Again, only the antipodal ORD curves of both derivatives were not coincident.

A priori, it would seem reasonable to consider **1a** and **1c** artifacts, produced by oxidation respectively of **2e** and **2f**. Although at least one of the required precursors, namely (3*R*)-vestitol (**2e**), was isolated from the *C. clausseni* extract, the presence of yellow pigments is consistent with the bright colour of the wood samples. (3*R*)-Vestitol was identified by comparison with the synthetic (±)-7,2′-dihydroxy-4′-methoxyisoflavan (**2e**), described above, as well as with natural (3*S*)-vestitol, differing from these products in the appropriate manner only with respect to the ORD curves.

Two additional isoflavan derivatives were obtained from the same source. They were characterized as such through inspection of their IR and UV spectra. The PMR spectrum of **4** confirmed this proposal through the characteristic signals due to the 5 protons of the heterocycle and revealed substitution by an α,α-dimethylallyl group. MS evidence shows that this, together with 2 hydroxyls and 1 methoxyl, can only be placed on ring B (retro-Diels–Alder fragment: *m/e* 234). Ring A is monohydroxylated (retro-Diels–Alder fragment: *m/e* 122) as shown in **4**, since a *meta*-split doublet is located at the high field PMR limit (τ 3·63, *d*, *J* 2·0 Hz) of the 3-proton system and must thus keep *ortho*-relations to two oxi-functions. The lone aromatic proton of ring B (τ 3·39, *s*) can only be placed *para* (or *ortho*) *meta*, *meta* to the oxi-functions. The *ortho*-alternatives



(**5**, **6**), however, can be safely disregarded. The hydroxyls, which form a catechol system (H_3BO_3 UV shift), are highly hindered, derivatization of the compound being very difficult, and must both be vicinal to substituents as in **4**. Furthermore, the pyridine induced solvent shift [14] of the ring B aromatic proton signal is very weak. The 3*R*-configuration can be attributed to α,α-dimethylallylcyclolobin (**4**) upon comparison of its ORD curve with published data [13].

Insolubility in the usual solvents prevented the measurement of a reasonable PMR spectrum for the additional isoflavan. The MS, however, showed that this must be a dehydrative dimer based on cyclolobin such as **7**. The molecular ion suffers two consecutive losses of ring-A fragments leading to $[M\text{-}122]^{+\cdot}$ and $[M\text{-}244]^{+\cdot}$ ions.

The biosynthesis of isoflavan derivatives should involve pterocarpan, isoflavone and chalcone intermediates [4], and the two latter classes are indeed represented in *C. clausseni* through 7,3′-dihydroxy-4′-methoxyisoflavone (**3g**) and isoliquiritigenin. The chalcone was previously isolated from *Dalbergia* and *Machaerium* species [12] and identified by direct comparison with an authentic

sample. The isoflavone (**3g**) gave a diacetate, which contributed to the spectral determination of its structure, and the known dimethyl ether (cabreuvin, **3c**) [15], identified by direct comparison with an authentic sample. 3'-Hydroxyformononetin (**3g**) was isolated previously from *Pterocarpus dalbergioides* [16] and subsequently also from *Machaerium vestitum* Vog., *Myroxylon peruiferum* L.f. and *M. balsamum* (L.) Harms [17].

EXPERIMENTAL

Isolation of the constituents of Cyclolobium clausseni. The trunk wood of a specimen collected in the vicinity of Pedro Leopoldo, Minas Gerais, and identified by the botanist A. Pereira Duarte, was separated into bark, heartwood and softwood. The ground heartwood (3·4 kg) was extracted successively with C_6H_6 and EtOH. The C_6H_6 extract (160 g) was extracted exhaustively with hot petrol (bp 60–80°). Chromatography on silica (1·4 kg) of the petrol insoluble portion (140 g) gave three main fractions with the indicated eluants: A_1 (C_6H_6–$CHCl_3$, 1:1), A_2 ($CHCl_3$) and A_3 ($CHCl_3$–MeOH, 19:1). A_1 (5·5 g) was chromatographed on silica (100 g). Crystallization of the C_6H_6–$CHCl_3$ (19:1) eluate from MeOH gave sitosterol (60 mg), while crystallization of the C_6H_6–$CHCl_3$ (1:3) eluate from MeOH afforded (3*R*)-**1a** (600 mg). Crystallization of A_2 (51·0 g) from MeOH gave (3*R*)-**1a** (600 mg). Crystallization of A_2 (51·0 g) from MeOH gave (3*R*)-**1a** (4·0 g). The filtered MeOH soln was evaporated and residue (47·0 g) was chromatographed on silica (500 g) yielding the following useful fractions with the indicated solvents: B_1 (C_6H_6–$CHCl_3$, 1:1), B_2, B_3 (C_6H_6–$CHCl_3$, 1:3), B_4 ($CHCl_3$), B_5 ($CHCl_3$–MeOH, 19:1). Crystallization of B_1 (6·3 g) from MeOH gave (3*R*)-**1a** (260 mg). The filtered MeOH soln was evaporated and the residue (6·0 g) was chromatographed on silica (120 g) giving the following useful fractions: C_1 (C_6H_6–$CHCl_3$ 1:3) and C_2 ($CHCl_3$). Crystallization of C_1 from MeOH gave (3*R*)-**1a** (104 mg). C_2 (1·8 g) was chromatographed twice on Sephadex LH-20 (MeOH) giving (3*R*)-**2e** (241 mg). B_2 (11·0 g) was chromatographed on silica (400 g). Crystallization of the $CHCl_3$–MeOH 19:1 eluate from EtOH gave **3g** (202 mg). The mother liquor was evaporated and residue (1·8 g) chromatographed on Sephadex LH-20 (MeOH). Intermediate fractions were recrystallized from EtOH giving **3g** (166 mg) and the later fractions yielded, after preparative TLC, isoliquiritigenin (10 mg). Crystallization of B_3 (11·2 g) from MeOH gave (3*R*)-**1a** (540 mg). The filtered MeOH soln was evaporated and residue (10·7 g) was chromatographed on silica (200 g). The $CHCl_3$ eluate (4·6 g) was crystallized from MeOH giving (3*R*)-**1a** (138 mg). Filtered MeOH soln was evaporated and residue (4·5 g) was chromatographed on Sephadex LH-20 (MeOH) yielding (3*R*)-**1c** (60 mg). B_4 (8·3 g) was chromatographed 2× on Sephadex LH-20 (MeOH) giving **4** (790 mg). Crystallization of B_5 (1·8 g) from MeOH gave **7** (17 mg). A_3 (4·6 g) was chromatographed on silica (100 g). Crystallization of the C_6H_6–$CHCl_3$ 1:1 eluate from EtOH yielded (3*R*)-**1a** (88 mg).

Isolation of the constituents of C. vecchii. The ground heartwood (15 g) of a sample from the wood collection of the Rio de Janeiro Botanical Garden, supplied by the botanist A. de Mattos F°., was extracted successively with C_6H_6 and EtOH. The C_6H_6 ext. (1·2 g) was washed exhaustively with hot petrol (bp 60–80°). The residue was crystallized from MeOH giving (3*R*)-**1a** (8 mg).

(3R)-*Claussequinone* (*7-hydroxy-4'-methoxyisoflavanquinone*, **1a**). Orange plates, mp 189–194° dec. (Found: C, 67·17; H, 4·82. $C_{16}H_{14}O_5$ requires: C, 67·13; H, 4·93%). ν_{max}^{KBr} (per cm) 3480, 1665, 1645, 1623, 1602, 1587, 1510, 1450, 1150, 1112, 1030. λ_{max}^{EtOH} (nm): 266 (ε 14700); $\lambda_{max}^{EtOH+NaOH}$ (nm): 245, 293 infl. (ε 12800, 8200). MS (*m/e*): 286 (100%) M, 271 (13), 166 (17), 165 (17), 164 (53), 163 (13), 148 (17), 135 (50), 134 (25), 122 (55), 121 (15), 107 (12). PMR [$(CD_3)_2CO$, τ]: 3·12 (*d*, *J* 8·0 Hz, H-5), 3·52 (*d*, *J* 1·3 Hz, H-6'), 3·63 (*dd*, *J* 8·0, 2·0 Hz, H-6), 3·74 (*d*, *J* 2·0 Hz, H-8), 3·90 (*s*, H-3'), 5·62–6·02 (*m*, 2H-2, H-3), 6·22 (*s*, OMe), 6·80 (*s*, OH), 7·10–7·30 (*m*, 2H-4). ORD (EtOH, *c* 0·036 mg/ml, 250–285 nm; *c* 0·072 mg/ml, 285–340 nm; *c* 0·36 mg/ml, 340–400 nm; *c* 1·8 mg/ml, 458–625 nm): $[\phi]_{250}$ −3970, $[\phi]_{270}^{tr}$ −10330, $[\phi]_{310}$ −2740, $[\phi]_{340}^{pk}$ −790, $[\phi]_{370}^{tr}$ −5560, $[\phi]_{400}$ −3345, $[\phi]_{458}$ 0, $[\phi]_{475}^{pk}$ +175, $[\phi]_{515}$ 0, $[\phi]_{560}$ −50, $[\phi]_{625}$ −80. *Acetate* (**1b**). Yellow crystals, mp 158–161°. ν_{max}^{KBr} (per cm): 1760, 1675, 1650, 1610, 1500, 1220, 1150. PMR ($CDCl_3$, τ): 3·00 (*d*, *J* 8·5 Hz, H-5), 3·35–3·60 (*m*, H-6, H-8, H-6'), 4·05 (*s*, H-3'), 5·65–5·95 (*m*, 2H-2), 6·50–6·72 (*m*, H-3), 7·00–7·22 (*m*, 2H-4), 6·22 (*s*, OMe), 7·75 (*s*, COMe).

Reductive acetylation of (3R)-*claussequinone*. A soln of (3*R*)-claussequinone (80 mg) in $CHCl_3$ (10 ml) was stirred with aq. sodium dithionite; the organic layer was dried with Na_2SO_4 and added quickly to a mixture of Ac_2O (5 ml) and C_5H_5N (1 ml). The $CHCl_3$ was then removed under diminished pressure. After one night at room temp., H_2O was added. Extraction with $CHCl_3$ yielded a colourless oil whose crystallization from MeOH gave the quinol acetate (**2a**) as shining needles (EtOH), mp 147–149°. ν_{max}^{KBr} (per cm): 1758, 1625, 1592, 1513, 1502, 1374, 1220, 1148. PMR ($CDCl_3$, τ): 2·98 (*d*, *J* 8·5 Hz, H-5), 3·18 (*s*, H-2'), 3·32 (*s*, H-5'), 3·40 (*dd*, *J* 8·5, 2·0 Hz, H-6), 3·40 (*d*, *J* 2·0 Hz, H-8), 5·65–6·10 (*m*, 2H-2), 6·55–6·80 (*m*, H-3), 7·05–7·20 (*m*, 2H-4), 6·22 (*s*, OMe), 7·70 (*s*, COMe), 7·72 (*s*, COMe), 7·74 (*s*, COMe). MS (*m/e*): 414 (12%) M, 372 (34), 331 (21), 330 (100), 288 (42), 166 (84), 165 (89), 154 (13), 153 (20), 151 (11), 133 (13), 125 (32).

(3R)-*Mucroquinone* (*7-hydroxy-8,4'-dimethoxyisoflavanquinone*, **1c**) orange crystals, mp 169–172° dec. (Found: C, 64·23; H, 5·16. $C_{17}H_{16}O_6$ requires: C 64·56; 5·10%). ν_{max}^{KBr} (per cm): 3500, 1672, 1645, 1602, 1500, 1477, 1212, 1180, 1045. λ_{max}^{EtOH} (nm): 266 (ε 13800); $\lambda_{max}^{EtOH+NaOH}$ (nm): 245, 290 (ε 11900, 7800). PMR [$(CD_3)_2CO$, τ]: 3·38 (*d*, *J* 8·0 Hz, H-5), 3·52 (*d*, *J* 1·0 Hz, H-6'), 3·65 (*d*, *J* 8·0 Hz, H-6), 3·98 (*s*, H-3'), 5·70–6·05 (*m*, 2H-2), 6·20 (*s*, OMe), 6·28 (*s*, OMe), 6·50–6·80 (*m*, H-3), 7·05–7·25 (*m*, 2H-4), 7·25 (*s*, OH). MS (*m/e*): 316 (68%) M; 301 (9), 286 (14), 166 (34), 165 (33), 164 (100), 163 (13), 154 (14), 153 (90), 152 (16), 151 (19), 149 (14), 137 (16), 135 (64), 134 (28), 133 (20), 123 (24), 122 (14), 109 (11), 107 (11). ORD (MeOH, c 0·43 mg/ml, 230–455 nm): $[\phi]_{230}$ −735, $[\phi]_{250}$ −6615, $[\phi]_{261}$ −10280, $[\phi]_{270}$ −6615, $[\phi]_{282}$ −1470, $[\phi]_{290}^{pk}$ −735, $[\phi]_{310}^{tr}$ −1470, $[\phi]_{330}$ −735, $[\phi]_{345}^{pk}$ −370, $[\phi]_{385}^{tr}$ −1470, $[\phi]_{430}$ −735, $[\phi]_{455}$ 0.

(3R)-*Vestitol* (**2e**). Colourless needles, mp 154–157° (lit [5] mp 156°). (Found: C, 70·60; H, 5·95. $C_{16}H_{16}O_4$ requires: C, 70·58; H, 5·92%). ν_{max}^{KBr} (per cm): 3350, 1625, 1600, 1525, 1508, 1148, 1123, 1035. λ_{max}^{EtOH} (nm): 225, 283 (ε 16000, 7400); $\lambda_{max}^{EtOH+NaOH}$ (nm): 240, 297 (ε 14400, 9200). PMR [$(CD_3)_2CO$, τ]: 1·55 (*s*, OH), 1·98 (*s*, OH), 3·00 (*d*, *J* 8·0 Hz, H-5), 3·10 (*d*, *J* 9·0 Hz, H-6'), 3·53 and 3·70 (*d*, *J* 2·0 Hz, H-8, H-3'), 3·5–3·7 (*m*, H-6, H-5'), 5·6–6·2 (*m*, 2H-2), 6·30 (*s*, OMe), 6·5–6·8 (*m*, H-3), 7·18 (*d*, *J* 7·0 Hz, 2H-4). MS (*m/e*): 272 (37%) M, 151 (10), 150 (100), 149 (11), 138 (22), 137 (34), 135 (15), 123 (11). ORD (EtOH, *c* 0·588 mg/ml, 238–400 nm): $[\phi]_{238}$ −8790, $[\phi]_{250}$ −3700, $[\phi]_{260}$ −3240, $[\phi]_{272}^{tr}$ −4625, $[\phi]_{282}$ −2310, $[\phi]_{288}$ 0, $[\phi]_{291}^{pk}$ +925, $[\phi]_{308}$ 0, $[\phi]_{310}$ −460, $[\phi]_{330}^{tr}$ −925, $[\phi]_{400}$ −460.

3'-Hydroxyformononetin (**3g**). Mp 228–231° and 240–242° (lit [15] mp 245–247°). PMR (CF_3COOH, τ): 1·28 (*s*, H-2), 1·52 (*dd*, *J* 8·5, 1·5 Hz, H-5), 2·49 (*dd*, *J* 8·5, 3·0 Hz, H-6), 2·59 (*d*, *J* 3·0 Hz, H-8), 2·86 (*s*, H-2', H-5', H-6'), 5·94 (*s*, OMe). MS (*m/e*) 284 (100%) M, 283 (18), 269 (18), 241 (13), 213 (13), 137 (28), 126 (18), 112 (26), 105 (20). Other data, as well as data for *acetate*, identical to data from lit [16].

α,α-Dimethylallylcyclolobin [(3R)-7,3',4'-*trihydroxy*-2'-*methoxy*-5'-(1,1-*dimethylallyl*)-*isoflavan*, **4**]. Needles, mp 76–79°. (Found: C, 70·60; H, 6·75. $C_{21}H_{24}O_5$ requires: C, 70·79; H, 6·79%). ν_{max}^{KBr} (per cm): 3375, 1660, 1625, 1590, 1600, 1550, 1155, 1120, 1060, 1028. λ_{max}^{EtOH} (nm): 219, 285 (ε 9300, 2300); $\lambda_{max}^{EtOH+NaOH}$ (nm): 231, 296 (ε 10700, 3900); $\lambda_{max}^{EtOH+NaOAc+H_3BO_3}$ (nm): 229, 285 (ε 9600, 3700); $\lambda_{max}^{EtOH+AlCl_3}$ (nm): 219, 284, 302, 355 (ε 9500, 3800). PMR ($CDCl_3$, 100 MHz, τ): 3·08 (*d*, *J* 9·0 Hz, H-5), 3·39 (*s*, H-6'), 3·60 (*dd*, *J* 9·0, 2·0 Hz, H-6), 3·63 (*d*, *J* 2·0 Hz, H-8), 3·90 (*dd*, *J* 18·0, 10·0 Hz, H-β), 4·30 (*s*, OH), 5·02 (*dd*, *J* 18·0, 2·0 Hz, H-γ), 5·04 (*dd*, *J* 10·0, 2·0 Hz, H-γ), 5·66 (*dd*, *J* 10·0, 3·5 Hz, H-2), 5·93 (*t*, *J* 10·0 Hz, H-2), 6·25 (*s*, OMe), 6·3–6·6 (*m*, H-3), 6·8–7·2 (*m*, 2H-4), 8·60 (*s*, 2Me); (C_5D_5N, 100 MHz, τ): 2·95 (*d*, *J* 8·0 Hz, H-5), 3·14 (*s*, H-6'), 3·16 (*dd*, *J* 8·0, 2·0 Hz, H-6), 3·06 (*d*, *J* 2·0 Hz, H-8), 3·66 (*dd*, *J* 18·0, 10·0 Hz, H-β), 4·7–5·0 (*m*, 2H-γ), 5·44 (*dd*, *J* 10·0, 3·0 Hz, H-2eq), 6·70 (*t*, *J* 10·0 Hz, H-2ax), 6·06 (*s*, OMe), 6·2–6·5 (*m*, H-3), 6·5–7·1 (*m*, H-4), 8·40 (*s*, 2Me). MS (*m/e*): 356 (100%) M, 234 (37), 233 (25), 153 (23), 149 (37), 122 (71). ORD (EtOH, *c* 0·02 mg/ml, 240–360 nm): $[\phi]_{240}$ −24920, $[\phi]_{250}$ −8900, $[\phi]_{275}$ 0, $[\phi]_{300}^{pk}$ + 19580, $[\phi]_{320}$ +10680, $[\phi]_{360}$ +3560.

Bis-cyclolobin (**7**). Mp 220–223°. ν_{max}^{KBr} (per cm): 3450, 1623, 1603. λ_{max}^{EtOH} (nm): 220 inf., 285 (ε 55800, 16700); $\lambda_{max}^{EtOH+NaOH}$ (nm): 244 inf., 297 (ε 33400, 21700). MS (*m/e*): 558·1890 (100%) M [$C_{32}H_{30}O_9$ requires 558·1890], 436·1520 (30) [$C_{25}H_{24}O_7$ requires 436·1522], 314·1155 (34) [$C_{18}H_{18}O_5$ requires 314·1154], 149 (19), 123 (50). ORD (EtOH, *c* 0·02 mg/ml, 240–360 nm): $[\phi]_{240}$ −55800, $[\phi]_{280}$ −33480, $[\phi]_{297}$ −1390, $[\phi]_{305}$ −11160, $[\phi]_{320}$ −6970, $[\phi]_{360}$ −2790.

Isoliquiritigenin (4,2',4'-*trihydroxychalcone*). Yellow crystals, mp and mmp with a synthetic sample 201–204°. M found and required: 256.

Synthesis of 7,2'-*dihydroxy*-4'-*methoxyisoflavone* (**3b**). A mixt. of 2,4-dimethoxyacetophenone (36·8 g), morpholine (17 ml) and sulphur (6·54 g) was kept under reflux (7 hr). The crude morpholide (47·2 g, 83%), a tan oil, was hydrolyzed (10% aq. KOH, 450 ml) to 2,4-*dimethoxyphenylacetic acid* (16·8 g, 65%), mp and lit [5] mp 106–108°. ν_{max}^{KBr} 2600, 1712, 1620, 1592, 1510, 1270, 1210, 1035, 822. PMR ($CDCl_3$, τ): −3·70 (*s*, COCH), 2·97 (*d*, *J* 8·5 Hz, H-6'), 3·60 (*dd*, *J* 8·5, 2·5 Hz, H-5'), 3·56 (*d*, *J* 2·5 Hz, H-3'), 6·27 (*s*, 2OMe), 6·47 (*s*, CH_2). MS (*m/e*): 196 M, 152, 151, 121, 91. A soln of 2,4-dimethoxyphenylacetic acid (11·8 g) in $CHCl_3$ (EtOH free) (140 ml) was satd with BF_3. Resorcinol (16·5 g) was added and the mixt. left at room temp. for 3 days. Working up [7] gave 2',4'-*dihydroxyphenyl*-2,4-*dimethoxybenzylketone* (7·6 g, 40%), mp 154–156° (lit [8] mp 154°). ν_{max}^{KBr} (per cm): 3250, 1630, 1605, 1585, 1505. RMP ($CDCl_3$, τ): −2·80 (*s*, OH), 2·22 (*d*, *J* 8·0 Hz, H-6'), 2·85 (*d*, 9 Hz, H-6), 3·4–3·7 (*m*, H-3, H-5, H-3', H-5'), 5·80 (*s*, CH_2), 6·20 (*s*, 2OMe). MS (*m/e*): 288 (50%) M, 152 (43), 151 (96), 138 (11), 137 (100), 121 (42), 91 (20). To a soln of 2,4-dihydroxyphenyl-2,4-dimethoxybenzyl ketone (6·5 g) in dry pyridine (20 ml) ethyl orthoformate (65 ml) [7] and piperidine (3·2 ml) were added. The mixt. was heated under reflux (11 hr), received on ice and dil. HCl and extracted with AcOEt, giving **3a** (5·2 g, 78%), mp and lit [8] mp 265–267°. ν_{max}^{KBr} (per cm): 3200, 1627, 1610, 1590, 1570, 1502, 1310, 1270, 1160. RMP (CF_3COOH, τ): 1·24 (*s*, H-2), 1·50 (*d*, *J* 9·0 Hz, H-6'), 3·1–3·3 (*m*, H-3', H-5'), 5·98 (*s*, OMe), 6·02 (*s*, OMe). MS (*m/e*): 298 (78), M, 265 (31), 164 (12), 163 (33), 136 (36), 118 (28), 107 (24). To a soln of **3a** (3·5 g) in nitrobenzene (30 ml) was added. The mixt. was heated on a steam-bath (1 hr), cooled and worked up as described [9] giving **3b** (2·5 g, 73%), mp and lit [8] mp 212–215°. ν_{max}^{KBr} (per cm): 3305, 1625, 1570, 1508, 1240, 830. RMP [$(CD_3)_2CO$, τ]: 1·77 (*s*, H-2), 1·85 (*d*, *J* 8·0 Hz, H-5), 2·78 (*dd*, *J* 8·0, 2·5 Hz, H-6), 2·96 (*d*, *J* 8·0 Hz, H-6'), 3·00 (*d*, *J* 2·0 Hz, H-8), 3·40 (*d*, *J* 2·0 Hz, H-3'), 3·42 (*dd*, *J* 8·0, 2·0 Hz, H-5'), 6·20 (*s*, OMe).

Synthesis of (±)-*isoflavans* (**2b**–**e**). 7,2'-Dihydroxy-4',methoxyisoflavone (**3b**), cabreuvin (**3c**), afrormosin (**3d**), formononetin (**3e**) and texasin (**3f**) in AcOH contg. 10% Pd/C were hydrogenated at 100° and atm. pres. The (±)-isoflavans, after purification by silica column chromatography, were obtained in the following yields: **2e** 78%, **2b** 92%, **2c** 58%, and **2d** 26%. Texasin (**3f**) led to a mixture from which no pure compound could be obtained. (±)-7,3',4'-*Trimethoxyisoflavan* (**2b**). Mp 107–108° (M found and required 300). ν_{max}^{KBr} (per cm): 1612, 1578, 1502, 1461, 1242, 1149, 1120, 1026. λ_{max}^{EtOH} (nm): 230, 281, 288 inf. (ε 28500, 20000, 18000). RMP ($CDCl_3$, τ): 3·00 (*d*, *J* 8·0 Hz, H-5), 3·1–3·2 (*m*, H-2', H-5', H-6'), 3·48 (*dd*, *J* 8·0, 2·5 Hz, H-6), 3·52 (*d*, *J* 2·5 Hz, H-8), 5·4–6·0 (*m*, 2H-2), 6·15 (*s*, 2 OMe), 6·24 (*s*, OMe), 6·7–7·0 (*m*, H-3, 2H-4). MS (*m/e*): 300 (35%) M, 164 (100), 149 (21), 121 (10). (±)-7-*Hydroxy*-6,4'-*dimethoxyisoflavan* (**2c**). Mp 127–129° (M found and required 286). ν_{max}^{KBr} (per cm): 3410, 1622, 1602, 1504, 1285, 1248, 1150, 1041, 825. λ_{max}^{EtOH} (nm): 238, 280 inf. 291, 294 (ε 26300, 12000, 14500, 15000). RMP ($CDCl_3$, τ): 2·75 (*s*, H-5), 2·82 (*d*, *J* 8·5 Hz, H-2', H-6'), 3·08 (*d*, *J* 8·5 Hz, H-3', H-5'), 3·48 (*s*, H-8), 5·6–6·0 (*m*, 2H-2), 6·18 (*s*, OMe), 6·20 (*s*, OMe), 6·8–7·2 (*m*, H-3, 2H-4). MS (*m/e*): 286(68%)M, 165(24), 164(24), 134(100). (±)-7-*Hydroxy*-4'-*methoxyisoflavan* (**2d**). Mp 139–141°. (M found and required 256). ν_{max}^{KBr} (per cm): 3240, 1623, 1600, 1505, 1462, 1155, 1025, 846. λ_{max}^{EtOH} (nm): 230, 283 inf. 289, 294 inf. (ε 24800, 15000, 16000, 10200). RMP ($CDCl_3$, τ): 2·85 (*d*, *J* 8·5 Hz, H-2', H-6'), 3·18 (*d*, *J* 8·5 Hz, H-3', H-5'), 3·10 (*d*, *J* 7·0 Hz, H-5), 3·60 (*dd*, *J* 7·0, 2·0 Hz, H-6), 3·65 (*d*, *J* 2·0 Hz, H-8), 5·6–6·1 (*m*, 2H-2), 6·22 (*s*, OMe), 6·7–7·2 (*m*, H-3, 2H-4). MS (*m/e*): 256 (14%) M, 134 (100), 121 (32), 120 (12). (±)-7,2'-*Dihydroxy*-4'-*methoxyisoflavan* (**2e**). All data, except mp 171–173° and ORD curve, as given for (3*R*)-vestitol.

Synthesis of (±)-*claussequinone* (**1a**). To a soln of (±)-vestitol (**2e**) (44 mg) in MeOH (4 ml), H_2O (10 ml), aq. N NaOAc soln (0·4 ml) and Fremy's salt (320 mg) were added. The mixt. was stirred until the violet colour had disappeared. The reaction product was purified by column chromatography (SiO_2, C_6H_6–$CHCl_3$ 1:1) to give **1a** (22 mg, 46%). All data, except mp 197–205° dec. and ORD curve, as given for (3*R*)-claussequinone.

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