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NEW PRENYLATED ISOFLAVONES AND A PRENYLATED DIHYDROFLAVONOL FROM *MILLETTIA PACHYCARPA**

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Key Word Index—*Millettia pachycarpa*; Leguminosae; Lotodoideae; prenylated isoflavones; prenylated dihydroflavonols; *Buddleia macrostachya*; Buddleiaceae; pectolinarigenin; salvigenin.

Abstract—Extraction of *Millettia pachycarpa* Benth. gave 5,7,4′-trihydroxy-6,8-diprenylisoflavone (**1a**), 5,7,4′-trihydroxy-6,3′-diprenylisoflavone (**2a**), 5,7,3′,4′-tetrahydroxy-6,8-diprenylisoflavone (**3a**) and (2*R*, 3*R*)-5,4′-dihydroxy-8-prenyl-6″,6″-dimethylpyrano[2″,3″:7,6]-dihydroflavonol (**4a**) whose structures were established by chemical transformations and spectroscopic means. Pectolinarigenin and salvigenin were isolated from *Buddleia macrostachya* Benth.

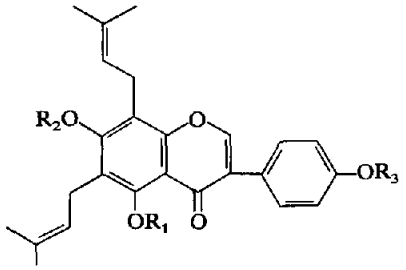
INTRODUCTION

Representatives of the large genus *Millettia* (Galegeae, Lotodoideae, Leguminosae) have yielded a variety of flavonoids [1–7]. We now report the isolation and structure determination of the prenylated isoflavones **1a**–**3a**, and the unusual prenylated dihydroflavonol **4a** from the aerial parts of *Millettia pachycarpa* Benth. **2a** and **4a** are new compounds. Syntheses of **1a** and **3a** were reported recently [8, 9] in the course of other work but they have not been isolated previously from a plant source. *Buddleia macrostachya* Benth. (Buddleiaceae) gave pectolinarigenin (**17a**) and salvigenin (**17b**).

RESULTS AND DISCUSSION

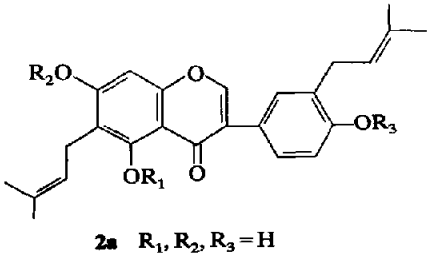
Compound **1a**, $C_{25}H_{26}O_5$, mp 142°, was a diprenylated 5,7,4′-trihydroxyisoflavone as shown by the 270 MHz ^{1}H NMR spectrum (chelated 5-hydroxyl, free 2,2′,3′,5′ and 6′ positions, characteristic signals of the two 3,3-dimethylallyl side chains) and the UV absorption. Its properties and the properties of the diacetate **1b** and the monomethyl ether **1c** suggested that the substance was identical with 6,8-diprenylgenistein, one of three substances obtained by nuclear prenylation of genistein [8]. This was confirmed by formic acid cyclization of **1a** to **5a** [10] and by cyclodehydrogenation [8] of **1a** to warangalone (scandenone, **6**) [11] and osajin (**7**) [12].

Compound **2a**, mp 120°, was an isomer of **1a**. Two of the hydroxyls were on ring A and attached to C-5 and C-7, with a 3,3-dimethylallyl group either at C-6



1a $R_1, R_2, R_3 = H$
1b $R_1, R_2, R_3 = Ac$
1c $R_1 = H$; $R_2, R_3 = Me$

or C-8 (UV and ^{1}H NMR spectra). Ring B was 3′,4′-disubstituted (^{1}H NMR) with preference given to prenylation at C-3′ and hydroxylation at C-4′ on biogenetic grounds and because of the chemical shifts of H-2′, H-5′ and H-6′ which were similar to those of **1a**. Methylation afforded a monomethyl ether **2c** and a dimethyl ether **2d**, both with free hydroxyls on C-5. Formic acid cyclization of **2a** afforded a bis-chromane derivative **8** whose formation located the lone methoxyl group of **2c** on C-7. Consequently the ring A



2a $R_1, R_2, R_3 = H$
2b $R_1, R_2, R_3 = Ac$
2c $R_1, R_3 = H$; $R_2 = Me$
2d $R_1 = H$; $R_2, R_3 = Me$

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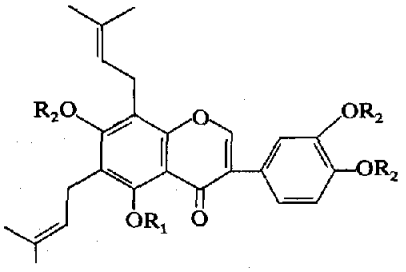
3,3-dimethyllallyl group of **2a** was on C-6. Two products obtained from formic acid cyclization and cyclodehydrogenation of **2a** were therefore **9** and **10a**, respectively. Final proof for the proposed structure was obtained by hydrolysis and oxidation (KOH–H_2O_2) of **8** which gave an acid **11** previously [11] obtained from cyclochandalone (**12**).

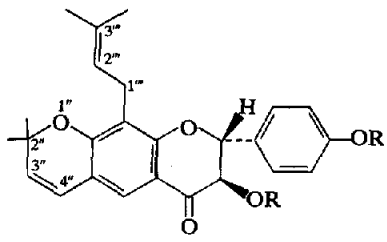
Compound **3a**, $C_{25}H_{26}O_6$, mp 155–156°, was a diprenylated isoflavone with four hydroxyls (formation of a tetraacetate **3b**) one of which was on C-5 (^{1}H NMR signal of chelated hydroxyl, formation of a trimethyl ether **3c** on treatment with diazomethane which retained the chelated hydroxyl group). Two hydroxyls were located on C-3′ and C-4′ as indicated by appropriate ^{1}H NMR signals and the UV spectrum in the presence of NaOMe [13]. The proposed distribution of functional groups was confirmed by formic acid cyclization which gave a product with a mp similar to dihydroisopomiferin **13a** [10]. The corresponding dimethyl ether **13b** was hydrolysed and oxidized (KOH–H_2O_2) to veratric acid, thus confirming the proposed structure. Also prepared was the tetrahydro derivative **14**. At this stage we noted the recent synthesis [9] of dihydroisopomiferin and its dimethyl ether. Direct comparison of our sample of **13b** with synthetic material established identity.



3a $R_1, R_2 = H$
3b $R_1 = H$: $R_2 = Ac$
3c $R_1 = H$; $R_2 = Me$

The fourth constituent of *M. pachycarpa*, although isomeric with **3a**, was clearly a dihydroxydihydroflavonol as evidenced in the ^{1}H NMR spectra of **4a** and **4b** by the characteristic AB system of H-2 and H-3 and in the spectrum of **4b** by the distinctive chemical shift of the acetate on C-3. A 3,3-dimethylchromene and a 3,3-dimethylallyl group were also present (^{1}H NMR). With a free hydroxyl on C-5 (signal at 11.37 ppm), ring A fully substituted, and positions 2′,3′,5′ and 6′ of ring B unoccupied (^{1}H NMR), the chromene ring had to be fused to ring A either angularly or linearly. That it was fused linearly was apparent from the upfield shift of H-4″ (Δδ 0.28 ppm) on acetylation of **4a** [14, 15]. This required attachment of the prenyl group to C-8 and the remaining hydroxyl group to C-4′ as in **4a** or vice versa, the latter possibility being quite implausible on biogenetic grounds.

The relative stereochemistry of **4a** (H-2, H-3 *trans*) was evident from the value of $J_{2,3}$ (12 Hz). The absolute stereochemistry is 2*R*,3*R* as illustrated because of the similarity of the CD curve in the n,π^* and π,π^* region to the CD curves of dihydroflavonols of



4a R = H
4b R = Ac

established absolute configuration [16]. The n,π^* extremum of **4a** was displaced to somewhat longer wavelength (348 nm) than usual, probably due to interaction with 3,3-dimethylchromene and prenyl residues as hydrogenation of **4a** resulted in **15a** whose CD curve exhibited a more normal long wavelength maximum near 320 nm. Deoxygenation of **15b** with Zn–HOAc gave **15c**. A reaction of some interest occurred on treatment of **4a** with 90% formic acid. This resulted in transformation to a compound whose spectral properties suggested the α-hydroxychalcone formula **16a** and which was characterized as a triacetate **16b**.

EXPERIMENTAL

Extraction of M. pachycarpa. Aerial parts (1.2 kg), collected in the Garmpani area of the Sibsagar District, Assam, India, on 24 May 1977, were extracted with $CHCl_3$ in a Soxhlet apparatus for 12 hr. Evapn of the solvent at red. pres. gave 16.5 g of residue which was dissolved in 500 ml MeOH containing 50 ml H_2O. Insoluble material was rejected. The soln was washed with petrol until the washings were almost colorless. Most of the MeOH was removed under red. pres. and the residue extracted with $CHCl_3$ (6× 200 ml). The washed and dried extract was evapd at red. pres. and the residue (8.4 g) was chromatographed over 400 g Si gel, 200 ml fractions being collected in the following order: 1–8 (C_6H_6), 9–15 (C_6H_6–EtOAc, 9:1), 17–24 (C_6H_6–EtOAc, 4:1), 25–32 (C_6H_6–EtOAc, 2:1), 33–40 (C_6H_6–EtOAc, 1:1), 41–48 (C_6H_6–EtOAc, 1:2), 49–55 (EtOAc), 55–62 (EtOAc–MeOH, 19:1).

Fractions 6–8 which showed a single spot on TLC (C_6H_6–EtOAc, 9:1) were combined to give 0.85 g of solid whose ^{1}H NMR spectrum showed it to be a 1:4 mixture of two substances which were eventually separated by PLC using the solvent system petrol (60–80°)–EtOAc (9:1) (two developments). The major component was **1a**, wt 0.56 g, mp 142° (from petrol–EtOAc), lit. mp 140° [8]; IR bands at 3490, 3350, 1650, and 1610 cm^{-1}; UV λ_{max}^{MeOH} 269 and 337 nm; ^{1}H NMR spectrum (270 MHz, $CDCl_3$): δ 13.08 (5-OH), 7.88 (H-2), 7.32*d* (*J* = 8 Hz, H-2′ and H-6′), 6.8*d* (*J* = 8 Hz, H-3′ and H-5′), 6.37 (–OH), 5.24 *m* (2H, vinyl protons), 3.46 *m* (4H, methylene protons), 1.83, 1.83, 1.77, 1.77 (Me's). (Calc. for $C_{25}H_{26}O_6$: C, 73.87; H, 6.45; MW, 406.1779. Found: C, 73.67; H, 6.28; MW(MS), 406.1760, 93.9%). Other major peaks in the high resolution MS were *m/e* (composition, %) 405 ($C_{25}H_{25}O_5$, 4.9), 404 ($C_{25}H_{24}O_5$, 8.5), 391 ($C_{24}H_{23}O_5$, 9.2), 389 ($C_{24}H_{21}O_5$, 16.2), 363 ($C_{22}H_{19}O_5$, 73.4), 351 $C_{21}H_{19}O_5$, 78.8), 349 ($C_{21}H_{17}O_5$, 19.4), 335 ($C_{20}H_{15}O_5$, 48.1), 307 ($C_{18}H_{11}O_5$, 63.5) and 295 ($C_{17}H_{11}O_5$, 100).

The minor component was **2a**, yield 0.26 g, mp 120° from

C_6H_6–petrol, IR bands at 3600, 3400, 1640 and 1625 cm^{-1}; UV λ_{max}^{MeOH} 266 nm, with NaOAc 275 nm; ^1H NMR (60 MHz): δ 13.18 (5-OH), 7.82H, (H-2), 7.25*dd* (*J* = 8 Hz, H-6'), 7.2 (*J* = 2 Hz, H-6'), 6.85*d* (*J* = 8 Hz, H-5'), 6.38 (H-8), 5.38*t* (*J* = 7 Hz 2H, vinyl protons), 3.38 *m* (4H, methylenes), 1.82 (12H, 4×Me). (Calc. for $C_{25}H_{26}O_5$: MW, 406.1779. Found: MW(MS), 406.1781, 24.5%). Other significant peaks in the high resolution MS were at *m/e* (composition %), 389 ($C_{24}H_{21}O_5$, 29.7), 363 ($C_{22}H_{19}O_5$, 30.2), 351 ($C_{21}H_{19}O_5$, 100), 349 ($C_{21}H_{17}O_5$, 46.2), 335 ($C_{20}H_{15}O_5$, 12.7), 307 ($C_{18}H_{11}O_5$, 3.02), and 295 ($C_{17}H_{11}O_5$, 57.3).

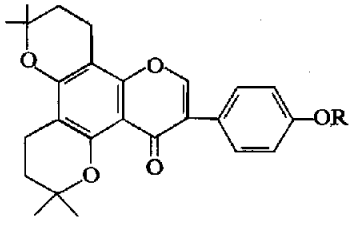
Fractions 12–18, wt 2.28 g, were a mixture (TLC, ^1H NMR) which was separated by column chromatography (Si gel, 300 g), 100 ml fractions being collected in the following order: 1–5 (petrol–EtOAc, 9:1), 6–10 (petrol–EtOAc, 8:1), 11–15 (petrol–EtOAc, 7:1), 16–20 (petrol–EtOAC, 6:1), 21–25 (petrol–EtOAc, 4:1), 26–30 (petrol–EtOAc, 2:1), 31–35 (petrol–EtOAc, 1:1), 36–40 (petrol–EtOAc, 1:2), 41–45 (petrol–EtOAc, 1:4), 46–50 (EtOAc) and 51–55 (EtOAc–MeOH, 19:1). Fractions 17–22 were combined and recrystallized from petrol–EtOAc to give 0.86 g of **3a**, mp 155–156°; lit. mp 156–157° [9], IR bands at 3525, 3300, 1690 cm^{-1}; UV λ_{max}^{MeOH} 270 nm, with NaOAc 285 nm, with NaOMe intensity of peak 270 nm reduced immediately (evidence for 3',4'-dihydroxy substitution [13]); ^1H NMR spectrum (270 MHz, $CDCl_3$): δ 12.91 (5-OH), 7.89 (H-2), 6.99*d* (*J* = 1.5 Hz, H-2'), 6.79 *m* (center of AB part of ABX where J_{AB} = 8, J_{AX} = 1.5 Hz, J_{BX} = 0 Hz, H-5' and H-6'), 6.4 (–OH), 5.24*t* and 5.21*t* (*J* = 8 Hz, vinyl protons), 3.48*d* (2H) and 3.45*d* (*J* = 6.5 Hz, 2H, methylene protons, 1.84, 1.84, 1.77 and 1.76 (4×Me). (Calc. for $C_{25}H_{26}O_6$: C, 71.07; H, 6.20; MW. 422.1728. Found: C, 71.02; H, 6.11%); MW(MS), 422.1715 base peak). Other significant peaks in the high resolution MS were at *m/e* (composition, %), 420 ($C_{25}H_{24}O_6$, 7.0), 407 ($C_{24}H_{23}O_6$, 7.1), 405 ($C_{24}H_{21}O_6$, 12.9), 379 ($C_{22}H_{21}O_6$, 12.8), 365 ($C_{21}H_{17}O_6$, 12.8), 351 ($C_{20}H_{15}O_6$, 48.0), 347 ($C_{21}H_{15}O_5$, 5.6), 323 ($C_{18}H_{11}O_6$, 47.7) and 311 ($C_{17}H_{11}O_6$, 89.8).

Fractions 24–31 of the second chromatogram were combined and recrystallized from petrol–EtOAc to give **4a**, wt 0.41 g, mp 80°, IR bands at 3575, 1640 and 1625 cm^{-1}; UV λ_{max}^{MeOH} 303.5 nm; CD curve (MeOH) $[\theta]_{318}$ +3900, $[\theta]_{290}$ −11 600, $[\theta]_{240}$ +10 600, $^-[\theta]_{225}$ +1000 (last reading); ^1H NMR (270 MHz, $CDCl_3$) δ 11.37 (5-OH), 7.41*d* (*J* = 8 Hz, H-2' and H-6'), 6.86*d* (*J* = 8 Hz, H-3' and H-5'), 6.63*d* (*J* = 10 Hz, H-4''), 5.51*d* (*J* = 10 Hz, H-3''), 5.11*t* (*J* = 7.5 Hz, J-2'''), 4.99*d* (*J* = 12 Hz, H-3), 4.49*d* (*J* = 12 Hz, H-2), 3.16*d* (*J* = 7.5 Hz, 2H, H-1'''), 1.63, 1.59 (vinyl Me's), 1.44, (6H, Me of pyran). (Calc. for $C_{25}H_{26}O_6$: MW, 422.1728. Found: MS(MS), 422.1711, 50.5%). Other significant peaks in the high resolution MS were at *m/e* (composition, %): 420 ($C_{25}H_{24}O_6$, 5.7), 407 ($C_{24}H_{23}O_6$, 57.4), 405 ($C_{24}H_{21}O_6$, 8.8), 391 ($C_{24}H_{23}O_4$, 5.0), 389 ($C_{24}H_{21}O_5$, 5.4), 379 ($C_{22}H_{19}O_6$, 2.4), 367 ($C_{21}H_{19}O_6$, 30.8), 365 ($C_{21}H_7O_6$, 4.1), 351 ($C_{20}H_{15}O_6$, 9.3), 335 ($C_{20}H_{15}O_5$, 4.8), 287 ($C_{17}H_{19}O_4$, 55.6), 285 ($C_{17}H_{17}O_4$, 11.7), 271 ($C_{16}H_{15}O_4$, 48.6), 260 ($C_{16}H_{20}O_3$, 9.2), 248 ($C_{16}H_{24}O_2$, 7.1), 245 ($C_{15}H_{17}O_3$, 48.1), 243 ($C_{15}H_{15}O_3$, 19.8) and 231 ($C_{13}H_{11}O_4$, 100).

Reactions of **1a**. Acetylation of 40 mg of **1a** (Ac_2O–Py) gave 38 mg of **1b**, mp 190° (petrol–EtOAc), lit. mp 190° [8], MW *m/e* 532 (M^+), 490, 448, 445, 441, 406, 393, 389, 379, 377, 363, 350, 335, 321, 307, 295; ^1H NMR (60 MHz): δ 7.95 (H-2), 7.50*d* (H-2' and H-6'), 7.18*d* (H-3' and H-5'), 5.18*t* and 5.05*t* (*J* = 8 Hz, vinylic protons), 3.3 *m* (4H, methylenes), 2.43, 2.37, 2.33 (Ac), 1.77 (12H, Me's).

Methylation of 30 mg of **1a** with excess CH_2N_2 gave 30 mg of **1c**, mp 84°, lit. mp 86° [8]; ^1H NMR (60 MHz): δ 13.0 (5-OH), 7.95 (H-2), 7.48*d* (*J* = 8 Hz, H-2' and H-6'), 7.0*d* (*J* = 8Hz, H-3' and H-5'), 5.25*t* (*J* = 7 Hz, 2H, vinyl protons), 3.86, 3.83, (OMe), 3.45 *m* (4H, methylenes), 1.8 (6H) and 1.7 (6H, Me); MS *m/e*: 434 (M^+), 419, 391, 379, 211 and 309.

Cyclization of 55 mg of **1a** in 3 ml 90% HCO_2H at 100° for 3 hr, dilution with H_2O, extraction with $CHCl_3$, evapn of the washed and dried extract and purification of the residue by TLC (EtOAc–C_6H_6, 1:6) gave 40 mg of **5a**, mp 285°, lit. mp 285° [10], ^1H NMR (60 MHz): δ 7.78 (H-2), 7.35*d* (H-2' and H-6'), 5.80*d* (H-3' and H-5'), 2.80 *m* (4H, methylenes), 1.33 (6H) and 1.3 (6H, Me); MS *m/e*: 406 (M^+), 391, 363, 351, 335, 307, 295 and 252. Methylation of 25 mg of **5a** with CH_2N_2 gave the mono Me ether, mp 194°, lit. mp 198° [17], ^1H NMR: δ 7.8 (H-2), 7.55*d* (*J* = 8 Hz, H-2' and H-6'), 6.96*d* (*J* = 8 Hz, H-3' and H-5'), 3.86 (OMe), 2.8 *m* (4H) and 1.9 *m* (4H, methylenes), 1.44 (12H, Me); MS *m/e*: 420 (M^+), 406, 379, 377, 365, 352, 349, 346, 323, 321, 309.

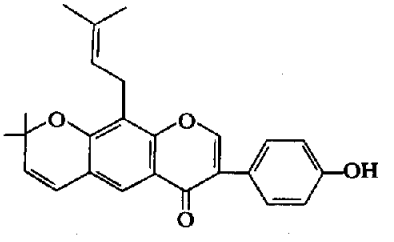


5a R = H
5b R = Me

Cyclodehydrogenation of 15 mg of **1a** with 30 mg DDQ [8] and chromatography of the crude product over Si gel gave in the C_6H_6–$CHCl_3$ (9:1) eluate 6 mg of warangalone (**6**), mp 162–164°, (from MeOH), lit. mp 160–163° [8], 163–165° [11], MW *m/e* 404 [M^+], 389, 351, 349 and 231. Further elution with C_6H_6–$CHCl_3$ (8:1) gave 3 mg of osajin (**7**) mp 188–190° (from petrol–EtOAc), lit. mp 190–192.5° [8, 12], MS *m/e*: 404 (M^+), 389, 351, 348, 333, 231 and 56.

Reactions of **2a**. Acetylation of 35 mg of **2a** with Ac_2O–Py at room temp. for 72 hr followed by the usual work-up gave 32 mg of **2b** as a gum which had ^1H NMR signals (60 MHz) at δ 7.85 (H-2), 7.6–7*c* (4H, overlapping signals of OH- H-2', H-5' and H-6'), 5.2*t* and 5.0*t* (*J* = 6.5 Hz, vinyl protons), 3.35*d* (*J* = 6.5 Hz, 4H each, methylenes), 2.45, 2.38, 2.35 (Ac), 1.8*br* (12H, Me's); MS *m/e*: 532 (M^+), 490, 448, 435, 431, 406, 393, 389, 387, 363, 351, 349, 321, 307 and 295.

Methylation of 25 mg of **2a** with excess CH_2N_2 gave a mixture of **2c** and **2d** which was separated by TLC. Mono Me ether **2c**, yield 20 mg, was a gum which exhibited ^1H NMR signals at δ 12.94 (5-OH), 7.8 (H-2), 7.2 *m* (H-2' and H-6'), 6.8*d* (*J* = 9 Hz, H-5'), 6.38 (H-8), 5.3*t* and 5.2*t* (*J* = 7 Hz,



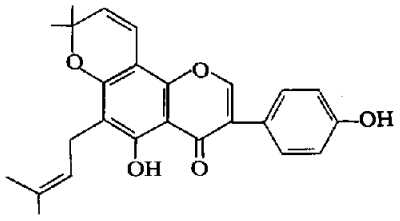
6 (warangalone)

vinylic protons), 3.9 (OMe), 3.35*d* (J=7 Hz, 4H, methylenes), 1.8 (12H, Me); MS *m/e*: 420 (M^+), 403, 377, 365 and 309. Di Me ether **2d**, yield 5 mg, also was a gum which exhibited ^{1}H NMR signals at δ 7.8 (H-2), 7.3*d*–7.0*c* (H-2′, H-5′ and H-6′), 6.4 (H-8), 5.3*t* (J=7 Hz, 2H, vinylic protons), 3.9 and 3.85 (OMe), 3.35*d* (J=7 Hz, 4H, methylenes), 1.8 (12 H, Me's), MS *m/e*: 434 (M^+), 391 and 379.

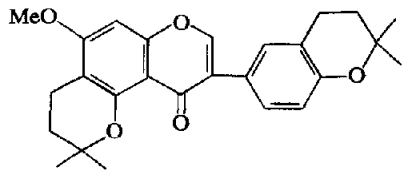
Cyclization of 20 mg of **2c** with 2 ml 90% HCO_2H in the manner described in the previous section gave **8**, mp 140° (dec.), which had ^{1}H NMR signals (60 MHz) at δ 7.7 (H-2), 7.22 *m* (H-2′ and H-6′), 6.75*d* (J=9 Hz, H-5′) 6.35 (H-8), 3.9 (OMe), 2.8 *m* and 1.8 *m* (4H each, methylenes), 1.43 (6H) and 1.37 (6H, Me); MS *m/e* 420 (M^+), 318, 403, 377, 365, 364, 363, 349, 347, 321 and 309. To a soln of 50 mg of **8** in 7 ml EtOH and 5 ml 12% aq. NaOH was added 1 ml 30% H_2O_2 with stirring. Stirring was continued while 3 portions of 1.5 ml each of H_2O_2 were added over 4.5 hr. The mixture was allowed to stand at room temp. for 60 hr, diluted with H_2O and extracted with Et_2O. The layer was acidified with dil H_2SO_4 and extracted with Et_2O; the Et_2O layer was extracted with 3×50 ml of 10% $NaHCO_3$ and the latter again extracted with Et_2O. Acidification of the basic layer followed by extraction with Et_2O gave, after evapn of the washed and dried Et_2O layer, 18 mg of **11**, mp 175°, lit. mp 176° [18], 180° [11]; ^{1}H NMR ($CDCl_3$) δ 9.67 (–COOH), 7.8 *m* (H-2′ and H-6′), 6.8*d* (J=9 Hz, H-5′) 2.85 *m* (2H, benzylic H), 1.85 *m* (2H, methylene) and 1.37 (6H, Me); MS *m/e* 206 (M^+).

Cyclization of 45 mg of **2a** with 2 ml 90% HCO_2H in the manner described in the previous section gave 35 mg of **9** after purification by TLC (C_6H_6–EtOAc, 9:1), mp 148° (from petrol–EtOAc); ^{1}H NMR (270 MHz): δ 13.2 (5-OH), 7.8 (H-2), 7.22*d* (J=2 Hz) and 7.2*dd* (J=8 Hz, 2, H-2′ and H-6′ superimposed), 6.48*d* (J=8 Hz, H-5′), 6.32 (H-8), 2.82*t* and 2.72*t* (2H each, benzylic methylenes), 1.83 *m* (4H, methylenes), 1.38 and 1.36 (6H each, Me). (Calc. for $C_{25}H_{26}O_5$: MW, 406.1719. Found: MW(MS), 406.1738, 100%). Other major peaks in the high resolution MS were at *m/e* (composition %): 391 ($C_{24}H_{23}O_5$, 3.0), 363 ($C_{22}H_{19}O_5$, 8.9), 351 ($C_{21}H_{19}O_5$, 42.1), 307 ($C_{18}H_{11}O_5$, 6.9) and 295 ($C_{17}H_{11}O_5$, 19.5).

Cyclodehydrogenation of 40 mg of **2a** with 100 mg of DDQ in 10 ml of dry C_6H_6 for 2 hr at reflux, filtration and column chromatography of the crude product over Si gel furnished 25 mg of **10a**, mp 142° (from EtOAc-petrol); ^{1}H NMR: δ 13.23 (5-OH), 7.85 (H-2), 7.3 *m* (H-2′ and H-6′), 6.9*d* (J=8 Hz, H-5′), 6.8*d* (J=10 Hz, H-4‴), 6.45 (J=10 Hz, H-4″), 6.4 (H-8), 5.7*d* (J=10 Hz, H-3″ and H-3‴) and 1.53 (12H, Me); MS *m/e* 402 (M^+), 387, 373, 357, 338, 309 and 295. Acetylation of **10a** (Ac_2O–Py) furnished **10b** as a gum which had ^{1}H NMR signals at 7.8 (H-2), 7.12 *m* (H-2′ and H-6′), 6.3*d* (J=10 Hz, H-4″), 6.6*c* (H-4‴, H-8 and H-5′), 5.8*d* (J=10 Hz, H-3′ and H-3‴), 2.45 (Ac), 1.5 (6H) and 1.45 (6H, Me); MS *m/e* 444 (M^+), 429, 402, 387, 371, 345, 259 and 186.

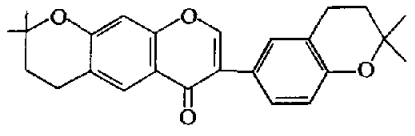


7 (osajin)



8

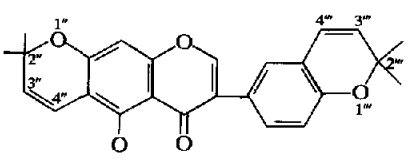
Reactions of **3a**. Acetylation of 40 mg of **3a** (Ac_2O–Py) at room temp. gave 35 mg of **3b**, mp 132° (from petrol–EtOAc), which had ^{1}H NMR signals at δ 12.84 (5-OH) 7.95 (H-2), 7.4*c* (H-2′, H-5′ and H-6′), 5.15*t* (J=6.5 Hz, two vinyl H), 3.35*d* (J=6.5 Hz, four methylene H), 2.35, 2.3 (Ac), 1.73 (6H) and 1.66 (6H, Me); MS *m/e*: 548 (M^+), 506, 493, 489, 463, 451, 449, 447, 422, 421, 407, 395, 393, 391, 379, 365, 353, 337, 325, 324, 323, 310, 295, 281, 279, 268, 267 and 253. Methylation of 15 ml of **3a** with CH_2N_2 furnished 30 mg of **3c** as a gum which had ^{1}H NMR signals at 13.03 (5-OH), 7.95 (H-2)), 7.10*c* (H-2′, H-5′ and H-6′), 5.3*t* (J=6.5 Hz, two vinyl H), 3.9 (6H), and 3.85 (3H, OMe), 3.5 *m* (four methylene H), 1.8 (6H) and 1.7 (6H, Me); MS *m/e*: 464 (M^+), 450, 433, 432, 421, 419, 407, 395, 379, 365, 361, 351, 339, 337, 327, 325, 298, 282, 269, 255 and 233.



9

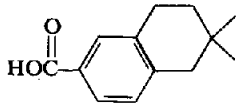
Low pressure hydrogenation of 30 mg of **3a** in 15 ml of EtOAc (100 mg 10% Pd–C) for 1 hr gave 30 mg of **14** as a gum which had ^{1}H NMR signals at 12.9 (5-OH), 7.85 (H-2), 6.85*c* (H-2′, H-5′ and H-6′). 2.6 *m* (4H, benzylic H), 1.4–1.8*c* (6H, methylene and methine H) and 0.95*d* (J=6 Hz, 12H, Me); MS *m/e*: 426 (M^+), 383, 369, 316, 313, 270, 252, 250, 235, 233, 217 and 203.

Cyclization of 50 mg of **3a** with 90% HCO_2H followed by the usual work-up gave dihydroisopomiferin (**13a**), mp 260°, lit. mp 262–263° [9], 264–265° [10], which exhibited the reported ^{1}H NMR [9]; MS *m/e*: 422 (M^+), 407, 391, 361, 35, 399, 232, 311, 307, 295 and 287. The diMe ether **13b** melted at 212° (from petrol–EtOAc), lit. mp 207.5–209.5° [10], 213–214° [9]: mmp with an authentic sample supplied by Professor Jain 212°; ^{1}H NMR spectrum as reported [9]; MS *m/e* 450 (M^+), 436, 419, 407, 395, 381, 379, 351, 339, 310, 295, 279, 252 and 250. Hydrolysis of 80 mg of **13b** in 7 ml EtOH with 5 ml 15% aq. KOH and addition of 5 ml 30% H_2O_2 in small portions over 5hr with stirring followed by 48 hr at room temp., dilution with H_2O, removal of neutral material by extraction with Et_2O, acidification, Et_2O extraction, washing and drying of the Et_2O extract, evapn and crystallization of the residue from Et_2O gave 12 mg of veratric acid, mp 178°, identical with an authentic sample.

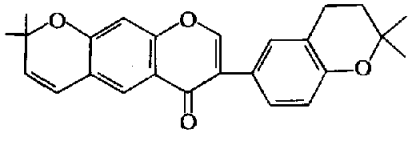


10a R=H
10b R=Ac

Reactions of **4a**. Acetylation of 25 mg of **4a** (Ac_2O–Py) at room temp. for 72 hr and recrystallization of the crude product from petrol–EtOAc gave **4b**, mp 102°, which had ^1H NMR signals at δ 7.3*d* (*J* = 8 Hz, H-2′ and H-6′), 7.0*d* (H-3′ and H-5′), 6.35*d* (*J* = 10 Hz, H-4″), 5.6*d* (*J* = 10 Hz, H-3″), 5.0–5.5 (H-2 and H-3), 2.4, 2.3 and 2.0 (Ac), 1.6 (6H, vinyl methyls), 1.45 (6H, Me); MS *m/e*: 548 (M^+), 506, 491, 461, 451, 433, 391, 374 and 313.

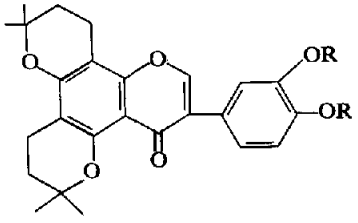


11



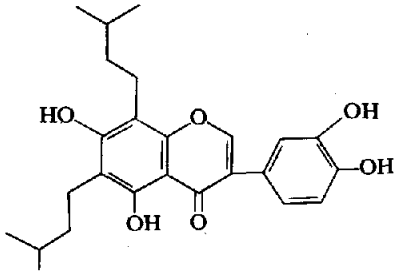
12

Hydrogenation of 100 mg of **4a** in 25 ml EtOAc (100 mg 10% Pd–C) gave **15a** after TLC (EtOAc–C_6H_6, 1:9), mp 155° (from petrol –EtOAc); CD curve (MeOH) $[\theta]_{318}+8400$, $[\theta]_{287}-23\,000$, $[\theta]_{230}+7600$; $[\theta]_{288}+7300$ (last reading); ^1H NMR signals (270 MHz) at 11.37 (5-OH), 7.4*d* (*J* = 8 Hz, H-2′ and H-6′), 6.87*d* (*J* = 8 Hz, H-3′ and H-5′), 4.49*d* (*J* = 12 Hz, H-3), 4.46*d* (*J* = 12 Hz, H-2), 2.67*t* (*J* = 6 Hz, 2H, H-4″), 2.5*t* (*J* = 6 Hz, 2H, H-1‴), 1.81*t* (*J* = 6 Hz, 2H, H-3″), 1.49*m* (H-3‴), 1.3*m* (2H, H-2‴), 1.37 (6H, methyls of chroman), 0.86*d* (*J* = 7 Hz, 6H, Me's of side chain). (Calcd. for $C_{25}H_{30}O_6$: MW, 426.2041. Found MW(MS), 426.2013, 59.3%). Other significant peaks in the high resolution MS were at *m/e* (composition %): 424 ($C_{25}H_{28}O_6$, 1.6), 397 ($C_{24}H_{29}O_5$, 10.6), 369 ($C_{21}H_{21}O_6$, 22.5), 353 ($C_{21}H_{21}O_5$, 10.7), 319 ($C_{18}H_{21}O_5$, 7.6), 313 ($C_{17}H_{13}O_6$, 6.1), 291 ($C_{17}H_{23}O_4$, 100) 264 ($C_{16}H_{24}O_3$, 64.7), 235 ($C_{13}H_{15}O_4$, 40.7) 234 ($C_{13}H_{14}O_4$, 26.7) and 233 ($C_{13}H_{13}O_{11}$, 28.3).



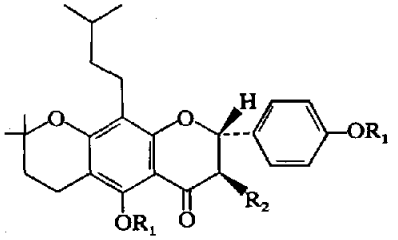
13a R = H
13b R = Me

Acetylation of 40 mg of **15a** with Ac_2O and 1 drop of conc H_2SO_4 for 18 hr followed by the usual work-up gave 40 mg of **15b** as a gum which had ^1H NMR signals at 7.5*d* (*J* = 8 Hz, H-2′ and H-6′), 7.2*d* (*J* = 8 Hz, H-3′ and H-5′), 5.7*d* (*J* = 12 Hz, H-3), 5.3*d* (*J* = 12 Hz, H-2), 2.45, 2.35, 2.05 (Ac), 1.8–2.8 (methylenes and methines), 1.37 (6H, Me of chroman) and 0.95*d* (*J* = 7 Hz, 6H Me's of side chain); MS *m/e*: 552 (M^+), 510, 453, 450, 411, 408, 384, 383, 346, 307, 204, 291, 285 and 239. Reduction of 50 mg of **15b** in 3.5 ml of HOAc and 1.5 ml H_2O with 0.2 g Zn dust at 100° for 4 hr, dilution with H_2O, extraction with $CHCl_3$, evapn of the washed and dried extract and recrystallization from petrol–EtOAc gave 20 mg



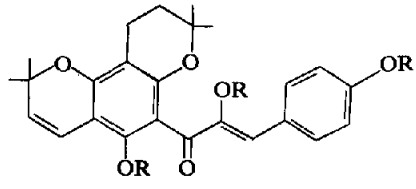
14

of **15c**, mp 130°: ^1H NMR: δ 7.25*d* (*J* = 8 Hz, H-2′ and H-6′), 6.8*d* (*J* = 8 Hz, H-2′ and H-5′), 5.2*dd* (*J* = 12, 3 Hz, H-2), 2.6–1.6 (11H), 1.33 (6H, pyran Me), and 0.9*d* (*J* = 7 Hz, 6H, side chain Me's); MS *m/e*: 452 (M^+), 410, 353, 297, 285, 284, 264, 256, 213, 199 and 185.



15a R_1 = H; R_2 = OH
15b R_1 = Ac; R_2 = OAc
15c R_1, R_2 = H

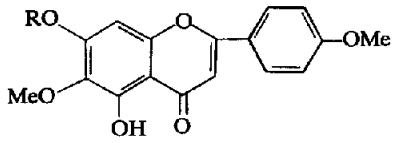
Cyclization of 35 mg of **4a** with 90% HCO_2H and work-up as described earlier followed by TLC of the crude product (C_6H_6–EtOAc, 4:1) gave 25 mg of **16a** as a gum which had ^1H NMR (60 MHz, $CDCl_3$) δ 11.4 (chelated OH), 7.4–6.7*c* (6H, vinyl H, H-2′, H-3′, H-5′, H-6′, H-4″), 5.5*d* (*J* = 10 Hz, H-3″), 2.6–1.8 (4H, methylenes), 1.5 (6H, Me's on chromene) and 1.23 (6H, Me's on chroman ring): MS *m/e*: 422 (M+), 407, 357, 343, 325, 324, 297, 295, 231, 229, 228, 215 and 189. Acetylation of 25 mg of **16a** (Ac_2O–Py, 72 hr) furnished 25 mg of triacetate **16b**, mp 95° (EtOAc–petrol)



16a R = H
16b R = Ac

which had ^1H NMR (60 MHz, $CDCl_3$): δ 7.5–6.8*c* (6H, vinyl H, H-2′, H-3′, H-5′, H-6′, H-4″), 5.5*d* (*J* = 10 Hz, H-3″), 2.3, 2.2, 1.98 (Ac), 1.35 (6H) and 1.2 ppm (6H, Me's); MS *m/e*: 548 (M^+), 506, 464, 422, 238 and 220.

Extraction of Buddleia macrostachya. Aerial parts of *B. macrostachya* Benth. (1.2 kg), collected in the Khari Hills, Shillong, India on 28 June 1977, were extracted with $CHCl_3$. The extract was worked up as described for *M. pachycarpa*. Column chromatography of the crude gum, wt 10.5 g, over Si gel gave two flavonoids which were identified as pectolinarigenin (**17a**), wt 220 mg, and salvigenin (**17b**), wt 80 mg, by comparison with authentic samples. Pectolinarigenin was also converted to **17b** by methylation with CH_2N_2.



17a R = H
17b R = Me

Acknowledgements—We wish to thank Mr. L. C. Rabha for collection and identification of plant material, Dr. K. P. Madhusudaman for MS and Mr. R. C. Das for ^{1}H NMR spectra, as well as Professor A. C. Jain for a sample of dihydroisopomiferin-3',4'-dimethyl ether.

REFERENCES

1. Harborne, J. B., Boulter, D. and Turner, B. L. (eds.) (1971) *Chemotaxonomy of the Leguminosae.* Academic Press, London and New York.
2. Harborne, J. B., Mabry, T. J. and Mabry, H. (eds.) (1975) *The Flavonoids.* Chapman & Hall, London.
3. Kahn, N. and Zaman, A. (1974) *Tetrahedron* **30,** 2811.
4. Gupta, R. K. and Krishnamurty, M. (1976) *Phytochemistry* **15,** 1795, 2011.
5. Gupta, R. K. and Krishnamurty, M. (1977) *Phytochemistry* **16,** 293.
6. Desai, H. K., Gawad, D. H., Joshi, B. S., Parthasarathy, P. C., Ravindranath, K. R., Saindane, M. T., Sidhaye, A. R. and Viswanathan, N. (1977) *Indian J. Chem.* **15b,** 291.
7. Raji, K. V. S. and Srimanaruyana, G. (1978) *Phytochemistry* **17,** 1065.
8. Jain, A. C. and Sharma, B. N. (1974) *J. Org. Chem.* **39,** 2215.
9. Jain, A. C., Tuli, D. K. and Gupta, R. C. (1978) *J. Org. Chem.* **43,** 3446.
10. Wolfrom, M. L., Harris, W. D., Johnson, G. F., Mahan, J. E., Moffet, S. M. and Wildi, B. S. (1946) *J. Am. Chem. Soc.* **68,** 406.
11. Falshaw, C. P., Harmer, R. A., Ollis, W. D., Wheeler, R. E., Laliths, V. R. and Subba Rao, N. W. (1969) *J. Chem. Soc. C* 374.
12. Wolfrom, M. L. and Wildi, B. S. (1946) *J. Am. Chem. Soc.* **68,** 406.
13. Mabry, T. J., Markham, K. R. and Thomas, M. B. (1970) *The Systematic Identification of Flavonoids.* Springer, New York.
14. Shabbir, M., Zaman, A., Crombie, L., Tuck, B. and Whiting, D. A. (1968) *J. Chem. Soc. C* 1899.
15. Shabbir, M. and Zaman, A. (1970) *Tetrahedron* **26,** 5041.
16. Gaffield, W. (1970) *Tetrahedron* **26,** 4093.
17. Jain, A. C., Lal, P. and Seshadri, T. R. (1970) *Tetrahedron* **26,** 1977.
18. Lauer, A. M. and Moe, O. (1943) *J. Am. Chem. Soc.* **65,** 289.