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Studies on the Constituents of Guang-Dou-Gen (the Root of *Sophora subprostrata* Chun et T. Chen). (6).[1] Isolation of Two New Flavanones

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Two new flavanones were isolated from Guang-Dou-Gen (the root of *Sophora subprostrata* Chun et T. Chen) and their structures were established from their spectral data and comparison with the corresponding synthesized derivatives as 4′,7-dihydroxy-6,8-bis(3-methyl-2-butenyl)flavanone (I), and 2-[(7′-hydroxy-2′,2′-dimethyl-2*H*-benzopyran)-6′-yl]-7-hydroxy-8-(3-methyl-2-butenyl)chroman-4-one (XI).

In previous papers, we reported the isolation and the structure elucidation of nine new flavonoids (sophoradin,[3a] sophoranone,[3a] sophoradochromene,[3b] sophoranochromene,[3b] and compound I,[3c] IV,[3c] VIII,[3c] and compound I,[1] VII[1]) as the constituents of the root of *Sophora subprostrata* Chun et T. Chen, a Chinese crude drug, Guang-Dou-Gen (広豆根).

Further studies on the constituents of this drug resulted in the isolation of two new flavanones I, and XI from the ether-soluble fraction of the methanolic extract. The present paper deals with the structure of these flavanones.

Compound (I) was obtained as colorless needles, mp 165.5°, M^+ 392, $C_{25}H_{28}O_4$, $[\alpha]_D^{22}$ −19.6° (EtOH). It gave the absorption bands of hydroxyl, conjugated carbonyl, and benzene ring in the infrared (IR) spectrum. The ultraviolet (UV) spectrum suggested the presence of a flavanone ring[4] (λ_{max}^{EtOH} nm: 284), and indicated the presence of a hydroxyl group in position 7, according to the significant bathochromic shift[4] ($\lambda_{max}^{EtOH-NaOH}$ nm: 355), but not the presence of a hydroxyl group in position 5, according to no bathochromic shift after the addition of aluminium chloride.[5a]

The nuclear magnetic resonance (NMR) spectrum of I exhibited the presence of two isoprenyl groups[1,3] [δ 1.62, 1.70 (each 6H, s, $(CH_3)_2\times2$), δ 3.20—3.45 (4H, m, Ar-C$\underline{H}_2$-CH=$\times2$), δ 5.00—5.50 (2H, m, Ar-CH$_2$-C$\underline{H}$=$\times2$)], two hydroxyl groups [δ 7.60—8.50 (2H, br, OH$\times2$; shifted to δ 7.47—8.32 at 48°)], aromatic protons [δ 7.47 (1H, s, C_5-H), δ 6.86 (2H, d, J=9.0 Hz, $C_{3'}$-H, and $C_{5'}$-H), δ 7.30 (2H, d, J=9.0 Hz, $C_{2'}$-H, and $C_{6'}$-H)], and C-2 proton [δ 5.00—5.50 (1H, m)], C-3 protons [δ 2.50—3.00 (2H, m)] in the flavanone ring.[1,3]

Alkali cleavage of I with 5% ethanolic potassium hydroxide gave a chalcone (II) (UV λ_{max}^{EtOH} nm: 370).[5b] In the UV spectrum of II, the significant bathochromic shift of 80 nm was observed after the addition of sodium ethoxide,[5b] indicating that a hydroxyl group must be in position 4.

1) Part 5: K. Kyogoku, K. Hatayama, K. Suzuki, S. Yokomori, K. Maejima, and M. Komatsu, *Chem. Pharm. Bull.* (Tokyo), **21**, 1436 (1973).
2) Location: *3-34-1, Takada, Toshima-ku, Tokyo, 171, Japan.*
3) *a*) M. Komatsu, T. Tomimori, K. Hatayama, and N. Mikuriya, *Chem. Pharm. Bull.* (Tokyo), **18**, 602 (1970); *b*) M. Komatsu, T. Tomimori, K. Hatayama, Y. Makiguchi, and N. Mikuriya, *ibid.*, **18**, 741 (1970); *c*) K. Kyogoku, K. Hatayama, S. Yokomori, M. Shio, and M. Komatsu, *ibid.*, **21**, 1192 (1973).
4) Y. Tomita, "Jikken Kagaku Koza, (Experimental Chemistry), *Suppl.* Vol.," Vol. 5, ed. by the Chemical Society of Japan, Maruzen Co., Ltd., Tokyo, 1966, pp. 940—942.
5) *a*) L. Jurd, "The Chemistry of Flavonoid Compound," ed. by T.A. Geissman, Pergamon Press, London, 1962, pp. 151—155; *b*) L. Jurd, *ibid.*, pp. 141—147; *c*) W.B. Whalley, *ibid.*, pp. 441—467.

On methylation with dimethyl sulfate, I gave two dimethyl ethers, M^+ 420, one of which had a flavanone ring (III) [UV: λ_{max}^{EtOH} nm: 270. NMR: δ 3.67, 3.73 (each 3H, s, $OCH_3 \times 2$)], while the other had a chalcone ring (IV). Alkali cleavage of III gave the above-mentioned chalcone (IV) [UV λ_{max}^{EtOH} nm: 360. NMR: δ 7.32 (1H, d, J=15.0 Hz, C_α-H), δ 7.72 (1H, d, J=15.0 Hz, C_β-H)].

Treatment of resacetophenone (V) with 3,3-dimethylallyl bromide in alkali solution gave the mixture of VI,[3c,6,7,8] and VII,[3c,7] which were further treated with 3,3-dimethylallyl bromide to give VIII, which was converted to IX by methylation. Condensation of IX with *p*-methoxybenzaldehyde (X) in alkali solution[1] gave a chalcone, which was identified with IV derived from I by thin-layer chromatography (TLC) and by UV, IR and NMR spectra.

From these data, compound (I) was established as 4′,7-dihydroxy-6,8-bis(3-methyl-2-butenyl)flavanone. Since the specific optical rotation of I had a minus (−) sign, as in other natural flavanones,[5c] I most probably has an (*S*)- configuration at C-2.

Compound XI was obtained as a slight yellow viscous oil, M^+ 406. The UV spectrum (λ_{max}^{EtOH} nm: 286, $\lambda_{max}^{EtOH\text{-}NaOH}$ nm: 342) was characteristic of 7-hydroxyflavanone series,[4] and

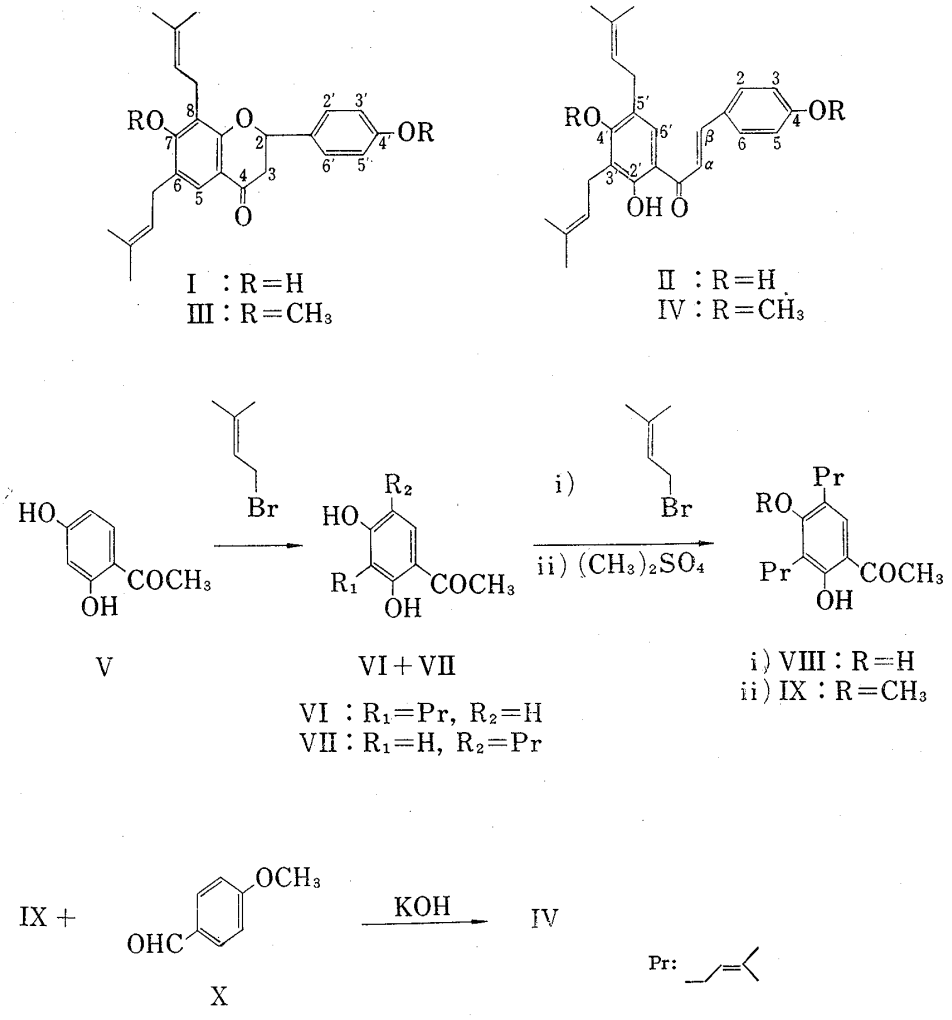


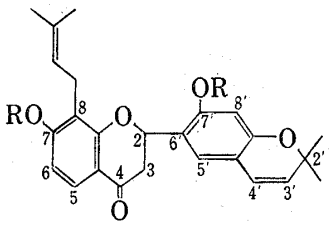
Chart 1

6) A.C. Jain, P. Lal, and T.R. Seshadri, *Indian J. Chem.*, **7**, 1072 (1969).
7) A.C. Jain, P. Lal, and T.R. Seshadri, *Tetrahedron*, **26**, 2631 (1970).
8) V.K. Bhalla, U. Ramdas Nayak, and Sukh Dev, *Tetrahedron Letters*, **1968**, 2401.

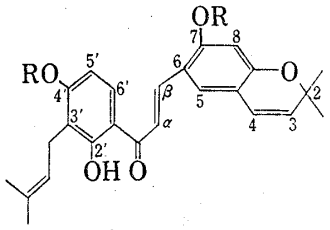
did not show the presence of any hydroxyl group in position 5, according to no bathochromic shift after the addition of aluminium chloride.[5a)]

The NMR spectrum of XI exhibited the presence of an isoprenyl group[1,3)] [δ 1.69 (6H, s, $=C(CH_3)_2$), δ 3.35 (2H, d, J=6.8 Hz, Ar-C$\underline{H}_2$-CH=), δ 5.18 (1H, t, J=6.8 Hz, Ar-CH$_2$-C$\underline{H}$=)], a 2′,2′-dimethylchromene ring[3b)] [δ 1.40 (6H, s, $-O-C(CH_3)_2-CH=CH-$), δ 5.43 (1H, d, J=9.8 Hz, $C_{3'}$-H), δ 6.18 (1H, d, J=9.8 Hz, $C_{4'}$-H)], aromatic protons [δ 6.34 (1H, s, $C_{8'}$-H), δ 6.52 (1H, d, J=8.3 Hz, C_6-H), δ 6.93 (1H, s, $C_{5'}$-H), δ 7.65 (1H, d, J=8.3 Hz, C_5-H)], and C-2 proton [δ 5.59 (1H, t, J=7.5 Hz)], C-3 protons [δ 2.94 (2H, d, J=7.5 Hz)] in the flavanone ring.[1,3)]

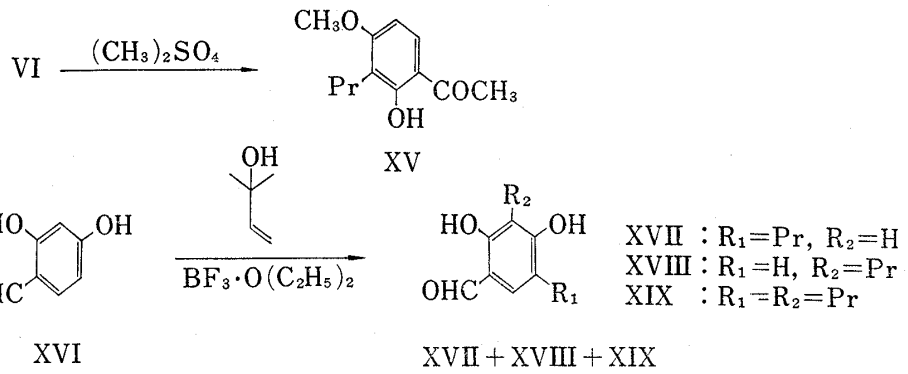
Alkali cleavage of XI with 5% ethanolic potassium hydroxide gave a chalcone (XII) (UV λ_{max}^{EtOH} nm: 397). On methylation with dimethyl sulfate, XI gave two dimethyl ethers, one of which had a flavanone ring (XIII) [UV λ_{max}^{EtOH} nm: 270. NMR: δ 3.72, 3.81 (each 3H, s, $OCH_3\times2$)], while the other had a chalcone ring (XIV) [NMR: δ 3.72, 3.81 (each 3H, s, $OCH_3\times2$), δ 7.35, 7.82 (each 1H, d, J=15.0 Hz, C_α-H, C_β-H)]. Alkali cleavage of XIII gave XIV.

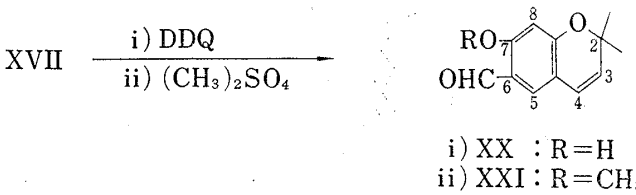


XI : R=H
XIII : R=CH_3



XII : R=H
XIV : R=CH_3





i) XX : R=H
ii) XXI : R=CH_3

XV + XXI $\xrightarrow{KOH}$ XIV

Pr: $-CH_2-CH=CH_2$

Chart 2

On methylation, VI gave XV. Treatment of 2,4-dihydroxybenzaldehyde (XVI) with 2-hydroxy-2-methyl-3-butene[9] in the presence of boron trifluoride etherate[9] gave a mixture of XVII, XVIII, and XIX. Cyclization of XVII was accomplished by the addition of 2,3-dicyano-5,6-dichloro-*p*-benzoquinone (DDQ)[10] in dioxane to produce XX. On methylation, XX gave XXI. Condensation of XV with XXI in alkali solution[1] gave a chalcone, which was identified with XIV derived from XI by TLC and by IR and NMR spectra.

From these data, compound (XI) was established as 2-(7′-hydroxy-2′,2′-dimethyl-2*H*-benzopyran)-6′-yl-7-hydroxy-8-(3-methyl-2-butenyl)chroman-4-one.

Experimental

All the melting points were uncorrected. IR spectra were measured using a JASCO DS-701 spectrophotometer. NMR spectra were taken at 60 MHz with TMS as an internal standard using a Hitachi Perkin-Elmer spectrometer (Model R-20). The chemical shifts were given in δ values. The unit (Hz) of coupling constant (J Hz) was abbreviated. The developing solvents of TLC were acetone–hexane (1: 1) (solv. 1), acetone–hexane (1: 4) (solv. 2).

Isolation of Compound I——Guang-Dou-Gen (50 kg) were extracted three times with boiling MeOH. The ether-soluble part (0.5 kg) of the MeOH extract was chromatographed on silica gel (50 kg) using acetone–hexane (1: 7) as an eluent, and the fraction containing I was checked by TLC [*Rf*: 0.48 (solv. 1)]. Then, this fraction was rechromatographed three times on silica gel, using acetone–hexane (1: 9), acetone–benzene (1: 30), AcOEt–benzene (1: 20), giving I (1.5 g).

Compound I——I was recrystallized from ether–benzene as colorless needles, mp 165.5°, M^+ 392. TLC (*Rf*): 0.48 (solv. 1). *Anal.* Calcd. for $C_{25}H_{28}O_4$: C, 76.50; H, 7.19. Found: C, 76.39; H, 7.00. $[\alpha]_D^{22}$ −19.6° (EtOH). UV λ_{max}^{EtOH} nm (log ε): 284 (4.14), $\lambda_{max}^{EtOH\text{-}AlCl_3}$ nm: 284, $\lambda_{max}^{EtOH\text{-}NaOH}$ nm: 355, $\lambda_{max}^{EtOH\text{-}AcONa}$ nm: 355. IR ν_{max}^{KBr} cm^{-1}: 3260 (OH), 1640 (conjugated CO), 1580 (aromatic C=C), 1375, 1360 (CH_3). NMR [$(CD_3)_2CO$]: 1.62, 1.70 (each 6H, s, $(CH_3)_2\times2$,) 2.50—3.00 (2H, m, C_3–H_2), 3.20—3.45 (4H, m, Ar–C$\underline{H}_2$–CH= ×2), 5.00—5.50 (3H, m, Ar–CH_2–C$\underline{H}$=×2, and C_2–H), 6.86 (2H, d, J=9.0, $C_{3'}$ –H, and $C_{5'}$ –H), 7.30 (2H, d, J=9.0, $C_{2'}$ –H, and $C_{6'}$ –H), 7.47 (1H, s, C_5 –H), 7.60—8.50 (2H, br, OH ×2; shifted to 7.47—8.32 at 48°).

Alkali Cleavage of I (Formation of II)——A mixture of I (15 mg) and 5% EtOH–KOH (30 ml) was refluxed for 30 min. After addition of H_2O (30 ml), EtOH was evaporated. The reaction mixture was acidified to pH 2 with dil. HCl, extracted with ether, and the ether layer was washed with H_2O, dried over Na_2SO_4. Evaporation of ether left a residue, which was chromatographed on silica gel using acetone–hexane (1: 30), giving a oily product (II). UV λ_{max}^{EtOH} nm: 370, $\lambda_{max}^{EtOH\text{-}NaOH}$ nm: 450.

Methylation of I (Formation of III and IV)——A mixture of I (73 mg), Me_2SO_4 (190 mg), anhyd. K_2CO_3 (540 mg), and acetone (7.5 ml) was refluxed for 3 hr, filtered, and the solvent was evaporated. H_2O was added to the residue which was extracted with ether. The ether layer was washed with H_2O and dried over Na_2SO_4. After evaporation of ether, the residue was chromatographed over silica gel with benzene–$CHCl_3$ (9: 1), next rechromatographed over silica gel with acetone–hexane (1: 30) giving two products.

The first product [TLC (*Rf*): 0.46 (solv. 2)] was obtained as a yellow oil (III). Yield: 34 mg, M^+ 420. UV λ_{max}^{EtOH} nm: 270. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1690 (conjugated CO), 1600 (aromatic C=C), 1375, 1360 (CH_3), 1340 (OCH_3). NMR (CCl_4): 1.60, 1.70 (12H, each s, $(CH_3)_2\times2$), 2.50—3.00 (2H, m, C_3 –H_2), 3.20 (4H, d, Ar–C$\underline{H}_2$–CH= ×2), 3.67, 3.73 (each 3H, s, OCH_3 ×2), 4.90—5.40 (3H, m, Ar–CH_2–C$\underline{H}$= ×2, and C_2–H), 6.77 (2H, d, J= 9.0, $C_{3'}$ –H, and $C_{5'}$ –H), 7.27 (2H, d, J=9.0, $C_{2'}$ –H, and $C_{6'}$ –H), 7.40 (1H, s, C_5 –H).

The second product [TLC (*Rf*): 0.53 (solv. 2)] was obtained as a yellow oil. The TLC and UV, IR, and NMR spectra of this product were identical with those of IV.

Alkali Cleavage of III (Formation of IV)——A mixture of III (84 mg) and 5% EtOH–KOH (6 ml) was allowed to stand for 17 hr at room temperature. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography using acetone–hexane (1: 40). Rechromatography was carried out on silica gel using benzene–$CHCl_3$ (10: 1), giving a yellow oil (IV). TLC (*Rf*): 0.53 (solv. 2). M^+ 420. UV λ_{max}^{EtOH} nm: 360. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 2900 (OH), 1635 (conjugated CO), 1600 (aromatic C=C), 1360 (CH_3). NMR (CCl_4): 1.65 (3H, s, CH_3), 1.76 (9H, s, CH_3, and $(CH_3)_2$), 3.15—3.40 (4H, m, Ar–C$\underline{H}_2$–CH= ×2), 3.70, 3.80 (each 3H, s, OCH_3 ×2), 5.00—5.50 (2H, m, Ar–CH_2–C$\underline{H}$= ×2), 6.82 (2H, d, J=9.0, C_3 –H, and C_5 –H), 7.32 (1H, d, J=15.0, Cα –H), 7.43 (1H, s, $C_{6'}$ –H), 7.48 (2H, d, J=9.0, C_2 –H, and C_6 –H), 7.72 (1H, d, J= 15.0, Cβ –H), 13.10 (1H, s, $C_{2'}$ –OH).

Isoprenylation of Resacetophenone (V) (Formation of VI and VII)——3,3-Dimethylallyl bromide (10 g) was added dropwise with stirring at room temperature, into V (10 g) in 6.7% KOH solution (42.8 ml), and

9) P.W. Austin and T.R. Seshadri, *Indian J. Chem.*, **6**, 412 (1968).
10) A.C. Jain and M.K. Zutshi, *Tetrahedron Letters*, **1971**, 3179.

the mixture was agitated for 3 hr. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography with acetone–hexane (1: 9) to elute VII, and VI in that order.

Compound VI[3c,6,7,8] was recrystallized from benzene to give colorless needles, mp 161°. TLC (*Rf*): 0.10 (solv. 2). Yield: 500 mg. *Anal.* Calcd. for $C_{13}H_{16}O_3$: C, 70.89; H, 7.32. Found: C, 71.16; H, 7.27. UV λ_{max}^{EtOH} nm: 287. IR ν_{max}^{KBr} cm^{-1}: 3120 (OH), 1620 (conjugated CO), 1588 (aromatic C=C), 1370 (CH_3). NMR [$(CD_3)_2CO$]: 1.62, 1.75 (each 3H, s, $(CH_3)_2$), 2.49 (3H, s, $COCH_3$), 3.32 (2H, d, J=6.0, Ar–$C\underline{H}_2$–CH=), 5.21 (1H, br, t, J=6.0, Ar–CH_2–C$\underline{H}$=), 6.41 (1H, d, J=9.0, C_5 –H), 7.53 (1H, d, J=9.0, C_6 –H), 9.11 (1H, br, s, C_4 –OH; shifted to 8.07 at 48°), 13.60 (1H, s, C_2 –OH).

Compound VII[3c,7] was recrystallized from benzene to give colorless needles, mp 160—162°. TLC (*Rf*): 0.20 (solv. 2). Yiled: 800 mg. *Anal.* Calcd. for $C_{13}H_{16}O_3$: C, 70.89; H, 7.32. Found: C, 70.84; H, 7.32. IR ν_{max}^{KBr} cm^{-1}: 3190 (OH), 1620 (conjugated CO), 1587 (aromatic C=C), 1377 (CH_3). NMR [$(CD_3)_2CO$]: 1.67 (6H, s, $(CH_3)_2$), 2.46 (3H, s, $COCH_3$), 3.19 (2H, d, J=7.5, Ar–$C\underline{H}_2$–CH=), 5.24 (1H, br, t, J=7.5, Ar–CH_2–C$\underline{H}$=), 6.28 (1H, s, C_3 –H), 7.50 (1H, s, C_6 –H), 9.30 (1H, br, s, C_4 –OH; shifted to 9.18 at 48°), 12.49 (1H, s, C_2 –OH).

Isoprenylation of the mixture of VI and VII (Formation of VIII)——3,3-Dimethylallyl bromide (1 g) was added dropwise, under agitation at room temperature, into the mixture of VI (45 mg) and VII (720 mg) in 6.7% NaOH solution (5.9 ml), and the mixture was refluxed for 3 hr. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography with acetone–hexane (1: 15) to give VIII.

VIII was recrystallized from ether–hexane to give colorless needles, mp 112°. $FeCl_3$ (+). TLC (*Rf*): 0.40 (solv. 2). Yield: 130 mg. *Anal.* Calcd. for $C_{18}H_{24}O_3$: C, 74.97; H, 8.39. Found: C, 74.68; H, 8.19. IR ν_{max}^{KBr} cm^{-1}: 3180 (OH), 1635 (conjugated CO). UV λ_{max}^{EtOH} nm (log ε): 285 (4.34), 328 (3.92). NMR [$(CD_3)_2CO$]: 1.64 (3H, s, CH_3), 1.73 (9H, s, CH_3, and $(CH_3)_2$), 2.51 (3H, s, $COCH_3$), 3.36 (4H, d, J=6.0, Ar–$C\underline{H}_2$–CH= ×2), 3.67, 3.74 (each 3H, s, OCH_3 ×2), 5.24 (2H, br, t, J=6.0, Ar–CH_2–C$\underline{H}$= ×2), 7.43 (1H, s, C_6 –H), 9.34 (1H, br, s, C_4 –OH), 12.90 (1H, s, C_2 –OH).

Methylation of VIII (Formation of IX)——A mixture of VIII (120 mg), Me_2SO_4 (140 mg), anhyd. K_2CO_3 (300 mg), and acetone (3 ml) was allowed to stand for 5 hr at room temperature. Then, the same procedures described for methylation of I were carried out till the chromatography giving a yellow oil (IX). Yield: 100 mg. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1635 (conjugated CO), 1370 (CH_3). NMR [$(CD_3)_2$ CO]: 1.64 (3H, s, CH_3), 1.73 (9H, s, CH_3, and $(CH_3)_2$), 2.56 (3H, s, $COCH_3$), 3.32 (4H, d, J=6.0, Ar–$C\underline{H}_2$–CH= ×2), 3.72 (3H, s, OCH_3), 5.10—5.30 (2H, m, Ar–CH_2–C$\underline{H}$= ×2), 7.54 (1H, s, C_6 –H), 12.63 (1H, s, C_2 –OH).

Condensation of IX and *p*-methoxybenzaldehyde (X) (Formation of IV)——To a mixture of IX (100 mg) and (X) (70 mg) in EtOH (2 ml), 50% KOH solution (1 g) was added, and the mixture was allowed to stand for 48 hr at room temperature, and agitated for 1 hr at 40°. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography with acetone–hexane (1: 30). Next, repeated re-chromatography over silica gel with acetone–hexane (1: 100) and benzene gave a yellow oily product. Yield: 26 mg. The TLC and UV, IR, and NMR spectra of this product were identical with those of IV.

Isolation of Compound XI——The ether-soluble part (0.3 kg) of the MeOH extract described for isolation of compound I was chromatographed on silica gel (30 kg) using acetone–hexane (1: 7) as an eluent, and the fraction containing XI was checked by TLC [*Rf*: 0.43 (solv. 1)]. Then, this fraction was rechromatographed repeatedly on silica gel, using benzene–isopropyl ether (5: 1), hexane–acetone (96: 4), hexane–acetone (5: 1), $CHCl_3$–MeOH (99: 1), giving XI (0.3 g).

Compound XI——XI was obtained as a slight yellow viscous oil (unsuccessful to crystallize from recrystallization). TLC (*Rf*): 0.43 (solv. 1). M^+ 406. UV λ_{max}^{EtOH} nm: 286, $\lambda_{max}^{EtOH\text{-}AlCl_3}$ nm: 286, $\lambda_{max}^{EtOH\text{-}NaOH}$ nm: 342. NMR ($CDCl_3$): 1.40 (6H, s, $^{-O}_{=}\!\!\times\!^{CH_3}_{CH_3}$), 1.69 (6H, s, $=\!\langle^{CH_3}_{CH_3}$), 2.94 (2H, d, J=7.5, C_3 –H_2), 3.35 (2H, d, J=6.8, Ar–$C\underline{H}_2$–CH=), 5.18 (1H, t, J=6.8, Ar–CH_2–C$\underline{H}$=), 5.43 (1H, d, J=9.8, $C_{3'}$ –H), 5.59 (1H, t, J=7.5, C_2 –H), 6.18 (1H, d, J=9.8, $C_{4'}$ –H), 6.34 (1H, s, $C_{8'}$ –H), 6.52 (1H, d, J=8.3, C_6 –H), 6.93 (1H, s, $C_{5'}$ –H), 7.65 (1H, d, J=8.3, C_5 –H).

Alkali Cleavage of XI (Formation of XII)——A mixture of XI (12 mg) and 5% EtOH–KOH (2.5 ml) was allowed to stand for 10 hr at room temperature. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography with acetone–hexane (1: 30), giving a slight yellow oil (XII). UV λ_{max}^{EtOH} nm: 397.

Methylation of XI (Formation of XIII and XIV)——A mixture of XI (100 mg), Me_2SO_4 (200 mg), anhyd. K_2CO_3 (600 mg), and acetone (10 ml) was refluxed for 2 hr. Then, the same procedures described for methylation of I were carried out till the chromatography with acetone–hexane (1: 30), to elute XIV, and XIII in that order.

The first product [TLC (*Rf*): 0.80 (benzene)] was obtained as a yellow oil (XIV). IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1640 (conjugated CO), 1500 (aromatic C=C), 1180, 1125 (OCH_3). NMR (CCl_4): 1.39 (6H, s, CH_3 ×2), 1.61, 1.72 (each 3H, s, $=\!\langle^{CH_3}_{CH_3}$), 3.22 (2H, d, J=7.5, Ar–$C\underline{H}_2$–CH=), 3.72, 3.81 (each 3H, s, OCH_3 ×2), 5.10 (1H, t, J=7.5, Ar–CH_2–C$\underline{H}$=), 5.38, 6.12 (each 1H, d, J=9.8, C_3 –H, C_4 –H), 6.19 (1H, s, C_8 –H), 6.26, 7.52 (each 1H, d, J=9.0, $C_{5'}$ –H, $C_{6'}$ –H), 7.03 (1H, s, C_5 –H), 7.35, 7.82 (each 1H, d, J=15.0, C_α –H, C_β –H), 13.47 (1H, s, $C_{2'}$ –OH).

The second product was obtained as a yellow oil (XIII). UV λ_{max}^{EtOH} nm: 270. IR $\nu_{max}^{CCl_4}$ cm^{-1}: 1690 (conjugated CO), 1605 (aromatic C=C), 1375, 1360 (CH_3), 1340 (OCH_3). NMR (CCl_4): 3.72, 3.81 (each 3H, s, $OCH_3 \times 2$).

Alkali Cleavage of XIII (Formation of XIV)——A mixture of XIII (75 mg) and 5% EtOH–KOH (5.5 ml) was refluxed for 3 hr. Then, the same procedures described for alkali cleavage of I were carried out, giving a yellow oil. The TLC and UV, IR and NMR spectra of this product were identical with those of XIV.

Methylation of VI (Formation of XV)——A mixture of VI (1.5 g), Me_2SO_4 (3 g), anhyd. K_2CO_3 (6.7 g), and acetone (30 ml) was refluxed for 30 min. Then, the same procedures described for methylation of I were carried out till the chromatography with acetone–hexane (1: 30), giving a yellow oil (XV). IR ν_{max}^{Nujol} cm^{-1}; 1624 (CO), 1500 (aromatic C=C). NMR ($CDCl_3$): 1.64, 1.76 (each 3H, s, $=\langle^{CH_3}_{CH_3}$), 2.47 (3H, s, $COCH_3$), 3.30 (2H, d, J=7.2, Ar–C<u>H</u>$_2$–CH=), 3.80 (3H, s, OCH_3), 5.13 (1H, t, J=7.2, Ar–CH_2–C<u>H</u>=), 6.35, 7.42 (each 1H, d, J=9.0, C_5–H, and C_6–H), 11.63 (1H, s, C_2–OH).

Isoprenylation of XVI (Formation of XVII, XVIII, and XIX)——To a solution of XVI (10 g) in dioxane (70 ml), 47% $BF_3 \cdot O(C_2H_5)_2$ (3 ml) was dropped. Next, to this solution, 2-hydroxy-2-methyl-3-butene (4.9 g) in dioxane (50 ml) was dropped, and allowed to stand for 2 hr at room temperature. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography with benzene, giving XVII (2.36 g), XVIII[9] (606 mg), and XIX[9] (465 mg).

XVII was obtained as colorless plates, sublimated at 115°. IR ν_{max}^{KBr} cm^{-1}: 3220 (OH), 1627 (CO), 1508 (aromatic C=C). NMR [$(CD_3)_2CO$]: 1.70 (6H, s, $=\langle^{CH_3}_{CH_3}$), 3.22 (2H, d, J=7.5, Ar–C<u>H</u>$_2$–CH=), 5.29 (1H, t, J=7.5, Ar–CH_2–C<u>H</u>=), 6.33 (1H, s, C_3–H), 7.33 (1H, s, C_6–H), 9.65 (1H, s, CHO), 11.25 (1H, br, OH).

Conversion of XVII to XX——To a solution of XVII (207 mg) in dioxane (3 ml), DDQ (273 mg) in dioxane (7 ml) was added dropwise, and allowed to stand for 40 min at room temperature. Then, the same procedures described for methylation of I were carried out till the chromatography with benzene, giving colorless plates (XX), mp 95.5—98.5°. Yield: 68.8%. IR ν_{max}^{KBr} cm^{-1}: 1620 (CHO), 1593 (aromatic C=C). NMR [$(CD_3)_2CO$]: 1.44 (6H, s, $CH_3 \times 2$), 5.69 (1H, d, J=9.8, C_3–H), 6.23 (1H, s, C_8–H), 6.35 (1H, d, J=9.8, C_4–H), 7.23 (1H, s, C_5–H), 9.72 (1H, s, CHO), 11.43 (1H, s, OH).

Methylation of XX (Formation of XXI)——A mixture of XX (450 mg), Me_2SO_4 (900 mg), anhyd. K_2CO_3 (3.2 g), and acetone (35 ml) was refluxed for 1 hr. Then, the same procedures described for methylation of I were carried out till the chromatography with benzene, giving a crystalline substance (XXI). IR ν_{max}^{KBr} cm^{-1}: 1666 (CHO), 1603 (aromatic C=C). NMR ($CDCl_3$): 1.45 (6H, s, $CH_3 \times 2$), 3.84 (3H, s, OCH_3), 5.52, 6.23 (each 1H, d, J=9.8, C_3–H, and C_4–H), 6.33 (1H, s, C_8–H), 7.46 (1H, s, C_5–H), 10.22 (1H, s, CHO).

Condensation of XV and XXI (Formation of XIV)——To a mixture of XV (517 mg) and XXI (402 mg) in EtOH (6 ml), 50% KOH solution (2 ml) was added, and the mixture was agitated for 1.5 hr at 65°. Then, the same procedures described for alkali cleavage of I were carried out till the chromatography with benzene–CCl_4 (1: 1), giving a yellow oil. The TLC and IR and NMR spectra of this product were identical with those of XIV.

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