Three New Diterpenes, 1,3-Dioxototarol, Isototarolenone, and 1-Oxo-3β-hydroxytotarol, from the Roots of *Juniperus chinensis* LINN.

Yueh-Hsiung KUO*[a,b] and Wen-Ching CHEN[a]

Department of Chemistry, National Taiwan University,[a] Taipei, Taiwan, R.O.C. and National Research Institute of Chinese Medicine,[b] Taipei Hsien, Taiwan, R.O.C. Received March 8, 1994; accepted May 11, 1994

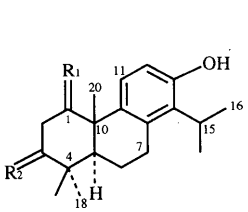
Six totarol derivatives were isolated from the extract of the root of *Juniperus chinensis* LINN. Three known components were identified as totarol, totarolone, and 7-oxototarol. The structures of three new totarol derivatives, 1,3-dioxototarol, isototarolenone, and 1-oxo-3β-hydroxytotarol, were elucidated on the basis of spectral data and chemical transformation.

Keywords *Juniperus chinensis*; root; 1,3-dioxototarol; isototarolenone; 1-oxo-3β-hydroxytotarol

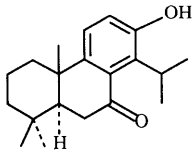
Juniperus chinensis LINN. (Cupressaceae) is a common ornamental tree[1] which contains biflavones, terpenes, and benzoquinones in its leaves[2] and heartwood.[3] There are ten species of *Juniperus* indigenous to Taiwan, among which *J. squamata* and *J. formosana* grow at an altitude of 2000—3000 m above sea level. We have conducted chemical studies of these two plants, and isolated twelve known compounds in addition to five new sesquiterpenes from *J. squamata*[4] and fifteen known compounds together with six new compounds from *J. formosana*.[5] In a continuation of our investigation in this area, we have investigated the methanol extract of the root of *J. chinensis* LINN. One new sesquiterpene (8α,12-dihydroxycedrane)[6] and one new diterpene (7β-hydroxysandaracopimaric acid)[7] were described in a previous report. We have now reinvestigated the same extract from the root of *J. chinenis* LINN. and isolated six totarol derivatives. Three known derivatives were identified as totarol (**1a**),[5] totarolone (**1b**)[8] and 7-oxototarol (**2**).[4] In this paper we described in detail the structure elucidation of the other three new totarol derivatives, 1,3-dioxototarol (**1c**), isototarolenone (**3a**), and 1-oxo-3β-hydroxytotarol (**1d**).

1,3-Dioxototarol (**1c**) was obtained as needles from ethyl acetate and hexane, mp 231—232 °C. It was deduced to have the molecular formula $C_{20}H_{26}O_3$ on the basis of its elemental analysis and mass spectrum (MS) [M^+ peak at 314 (21%)]. It shows infrared (IR) absorption bands at 3447 (–OH), 3030, 1579, 1481 cm^{-1} (aromatic absorption), 1715, 1693 (two carbonyl), and 1380, 1370 (*gem*-dimethyl absorption). The proton nuclear magnetic resonance (^{1}H-NMR) spectrum (Table I) of 1,3-dioxototarol (**1c**) revealed that **1c** has an isopropyl group attached to a phenyl group [δ 1.33 (6H, d, J=6.9 Hz), 3.24 (1H, sep., J=6.9 Hz)], three singlet methyl groups (δ 1.24, 1.24, 1.34), two *ortho* phenyl protons [δ 6.59 and 7.28 (each 1H, d, J=8.7 Hz)], two geminal protons [δ 3.38, 3.75 (each 1H, d, J=18.2 Hz)] lying between two carbonyl groups, two benzylic protons [δ 2.67, 3.02 (each 1H, m)], and two geminal protons [δ 1.67, 2.00 (each 1H, m)], and a methine proton [δ 2.21 (dd, J=11.7, 2.0 Hz)]. Irradiation of the methine doublet of doublets at δ 2.21 (H-5) simplified the multiplets at δ 1.67 and 2.00, and irradiation of the multiplet at δ 1.67 caused (i) the doublet of doublets at δ 2.21 (H-5) to collapse to a doublet (J=2.0 Hz), and (ii) the multiplets at δ 2.00 (H-6), 2.67 and 3.02 (H-7) to become simpler. The result clearly indicated the presence of a $-CHCH_2CH_2-$ moiety. The carbon-13 nuclear magnetic resonance (^{13}C-NMR) spectrum of **1c** exhibits signals due to six aromatic carbons [δ 129.1, 114.2 (3° C; C-11, C-12), 131.5, 134.1, 153.1, 129.5 (40° C; C-8, C-9, C-13, C-14)], five methyl carbons [δ 20.3, 20.3, 22.7, 20.1, 28.7 (1° C; C-16, C-17, C-18, C-19, C-20)], three methylene carbons [δ 52.2, 19.8, 28.8 (2° C; C-2, C-6, C-7)], two methine carbons [δ 45.8, 27.6 (3° C; C-5, C-15)], two quaternary carbons [δ 47.2, 52.7 (4° C; C-4, C-10)], and two carbonyl carbons [δ 205.8, 210.8 (4° C; C-1, C-3)]. From the above physical evidence, the structure of **1c** can be assigned as a derivative of totarol (**1a**),[5] and differentiated by the presence of two extra carbonyl groups. The two carbonyl carbons exhibited signals at lower field than δ 200 ppm in the ^{13}C-NMR spectrum. The results revealed that two carbonyl carbons are isolated. One of them is located at C-1, since the chemical shift of H-11 (δ 7.28) in **1c** is lower than that of the corresponding proton (δ 6.98) in totarol (**1a**). The deshielding effect of a C-1 carbonyl group on H-11 has been observed between hinokiol (**4a**)[4] and 1-oxohinokiol (**4b**),[9] amounting to 0.37 ppm. The methylene protons of **1c** appeared at δ 3.38 and 3.75 with a larger coupling constant, indicating that they could be assigned to a methylene group between two carbonyl groups. By comparison of the ^{1}H-NMR data (Table I) of **1c** and **5a** (1,3-dioxototarol methyl ether),[10] the structure of **1c** can be assigned as 1,3-dioxototarol. The acetylation of **1c** with acetic anhydride in pyridine at room temperature for 40 h afforded **5b** (45%) and **6a** (55%). When reacted with *p*-toluenesulfonic acid in isopropenyl acetate at room temperature for 3 h, **1c** gave the same two products, **5b** (20%) and **6a** (80%), in a different yield ratio. Compound **5b** is a monoacetate [1756 cm^{-1}; δ 2.20 (3H, s)], and the two carbonyl groups are intact [1715, 1703 cm^{-1}; δ 3.38, 3.75 (each 1H, d, J=18.0 Hz), 6.86, 7.43 (each 1H, d, J=8.8 Hz)]. On the basis of the physical data, **6a** contained two acetates [1761 cm^{-1}; δ 2.24, 2.29 (each 3H, s)] and a conjugated enone [1675 cm^{-1}; δ 5.87 (1H, s)]. The phenyl protons at δ 6.87 and 7.50 (each 1H, d, J=8.5 Hz) revealed that the remaining carbonyl group is located at the C-1 position. In the reaction of **1c** with diazomethane in ether overnight, **6b** was obtained.

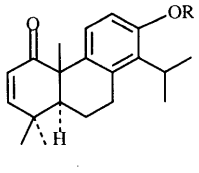
Dedicated to the memory of the late Professor Yau-Tang Lin.



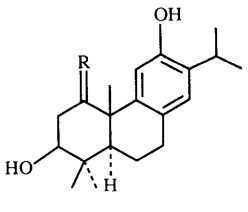
1a : $R_1=R_2=H_2$
1b : $R_1=H_2$, $R_2=O$
1c : $R_1=R_2=O$
1d : $R_1=O$, $R_2=\beta$-OH, α-H



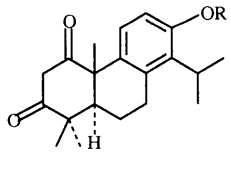
2



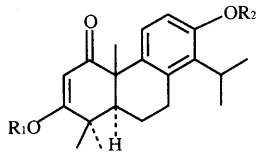
3a : R=H
3b : R=Ac



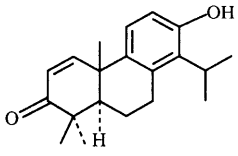
4a : $R=H_2$
4b : R=O



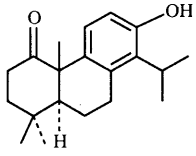
5a : R=Me
5b : R=Ac



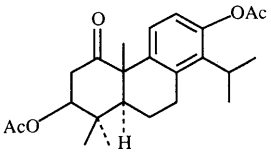
6a : $R_1=R_2=Ac$
6b : $R_1=Me$, $R_2=H$
6c : $R_1=R_2=Me$



7



8



9

TABLE I. ^{1}H-NMR Data for 1,3-Dioxototarol (**1c**), 1,3-Dioxototarol Methyl Ether (**5a**),[10] Isototarolenone (**3a**), Totarolenone (**7**), and 1-Oxo-3β-acetoxytotaryl Acetate (**9**) (300 MHz in $CDCl_3$)

H	1c	5a[a]	3a	7	9
1				7.53 d (10.3)	
2	3.38 d (18.2)	3.23 d (17.0)	5.88 d (10.0)	5.96 d (10.3)	
	3.75 d (18.2)	3.74 d (17.0)			
3			6.45 d (10.0)		4.92 dd (8.8, 4.6)
5	2.21 dd (11.7, 2.0)		1.92 dd (10.1, 2.4)	2.09 dd (12.4, 2.5)	
6	1.67 m, 2.00 m		1.65 m, 1.98 m	1.70 m, 2.00 m	
7	2.67 m, 3.02 m		2.70 m, 2.90 m	2.80 m, 2.90 m	
11	7.28 d (8.7)	7.35 d (9.0)	7.34 d (8.7)	7.13 d (8.4)	7.44 d (8.6)
12	6.59 d (8.7)	6.78 d (9.0)	6.59 d (8.7)	6.59 d (8.4)	6.79 d (8.6)
15	3.24 m (6.9)	3.21 m (7.0)	3.22 m (7.2)	3.27 m (7.0)	3.20 m (7.0)
16	1.33 d (6.9)	1.20 d (7.0)	1.31 d (7.2)	1.33 d (7.0)	1.20 d (7.0)
17	1.33 d (6.9)	1.20 d (7.0)	1.32 d (7.2)	1.34 d (7.0)	1.23 d (7.0)
18	1.24 s	1.17 s	1.14 s	1.16 s	1.07 s
19	1.24 s	1.28 s	1.16 s	1.19 s	1.07 s
20	1.34 s	1.32 s	1.53 s	1.38 s	1.57 s
–OMe		3.79			
–OAc					2.08 s, 2.29 s

Figures in parentheses are coupling constants. *a*) 60 MHz in $CDCl_3$.

Compound **6b** is a conjugated enol methyl ether [1665, 1639 cm^{-1}; δ 3.69 (3H, s), 5.25 (1H, s)] and the phenolic hydroxy group (3391 cm^{-1}) was intact. The treatment of **6b** with diazomethane in ether for a longer time afforded a dimethyl ether **6c** (mp 158—159 °C), which was also obtained from **5a**[10] by the same reaction.

Isototarolenone (**3a**), mp 179—180 °C, has the molecular formula $C_{20}H_{26}O_2$ on the basis of elementary analysis and MS [M^+, 298 (30%)]. It contained a conjugated ketone as indicated by the ultraviolet (UV) spectrum (λ_{max}^{MeOH} 230, 270 nm). Its IR spectrum exhibited a hydroxy absorption at 3409 cm^{-1}, a conjugated carbonyl absorption at 1669 cm^{-1}, and aromatic absorptions at 1600, 1585, and 1495 cm^{-1}. The ^{1}H-NMR spectrum (Table I) indicated the presence of three methyl groups [δ 1.14, 1.16, 1.53 (each s)], an isopropyl group attached to a benzene ring [δ 1.31, 1.32 (each 3H, d, J=7.2 Hz), 3.22 (1H, sep., J=7.2 Hz)], vicinal olefinic protons [δ 5.88, 6.45 (each 1H, d, J=10.0 Hz)], two *ortho* phenyl protons [δ 6.59, 7.34 (each 1H, d, J=8.7 Hz)], and a –$CHCH_2CH_2$– moiety as in **1c**. Based on the above ^{1}H-NMR data, **3a** is a derivative of totarol (**1a**) with an extra ketone and a conjugated double bond. But **3a** is different from totarolenone (**7**) by comparison of their physical data (the ^{1}H-NMR spectrum in Table I). The phenyl proton H-11 in **3a** shows a lower field shift than the corresponding proton in totarol (**1a**) by about 0.36 ppm, indicating that the carbonyl group is located at the C-1 position, and the H-1 in totarolenone (**7**) appeared at lower field at δ 7.53, which can be reasonably explained in terms of strong deshielding by the phenyl group. Therefore the structure of **3a** can be assigned as isototarolenone, as shown. The acetylation of **3a** gave a monoacetate (**3b**) [mp 65—66 °C; 1749, 1685 cm^{-1}; δ 2.32 (3H, s)]. Compound **3a** was reduced on catalytic hydrogenation (10% Pd–C in MeOH) to yield **8** [amorphous; 1706 cm^{-1}; δ 6.50, 7.94 (each 1H, d, J=8.5 Hz), signals of olefinic protons disappeared]. We tried to prepare compound **9** from **6a** by catalytic hydrogenation using the above-mentioned conditions, but we unexpectedly obtained **3b**, considered to be a deacetoxylated product formed from **9**. These results supported the view that **3a** is an isomer of totarolenone (**7**) with reversal of the enone function.

The third totarol derivative is 1-oxo-3β-hydroxytotarol (**1d**), characterized as its diacetate (**9**). Before acetylation, the original crude mixture showed no acetoxyl group by NMR spectral investigation. Compound **9** is an amorphous solid. MS m/z (%) 400 (M^+, 21) gave the molecular formula as $C_{24}H_{32}O_5$. The ^{1}H-NMR signals (Table I) of **9** showed it contains three singlet methyl groups, an isopropyl group attached to phenyl, one secondary alkyl acetoxyl group [1739 cm^{-1}; δ 2.08 (3H, s), 4.92 (1H, dd,

$J=8.8$, 4.6 Hz)], one phenyl acetoxyl group [1750 cm^{-1}; δ 2.29 (3H, s)], and two *ortho* phenyl protons [δ 6.79 (1H, d, $J=8.6$ Hz), 7.44 (1H, d, $J=8.6$ Hz)]. The latter signal appeared at lower field owing to the strong deshielding arising from the C-1 carbonyl (1715 cm^{-1}) anisotropic effect. The above result revealed that the structure of **9** is 1-oxototaryl acetate with an extra acetoxyl group. The acetoxyl group may be located at C-2, C-3 or C-7. We tried to convert the acetylation product to its original form, and let compound **9** react with NaOH in MeOH. But the resulting product was identical with isototarolenone (**3a**). The possibility that the acetoxyl group located at C-7 is excluded by this result. Therefore the acetoxyl group is positioned at C-3 in β-equatorial orientation, accounting for the proton signal at δ 4.92 with axial–axial and axial–equatorial coupling constants ($J=8.8$, 4.6 Hz). Thus we conclude that the compound from which **9** was obtained is 1-oxo-3β-hydroxytotarol (**1d**).

Experimental

Melting points were determined on a Yanagimoto melting point apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer 983 G spectrometer. ^{1}H- and ^{13}C-NMR spectra were run on a Brucker AM 300 at 300 MHz and 75 MHz in the indicated solvent with tetramethylsilane (TMS) as an internal standard. Chemical shifts are given in δ-values and coupling constants (J) are given in hertz (Hz). Electron impact mass spectra (EIMS) and UV spectra were taken on JEOL JMS-100 and Hitachi U-3200 spectrometers, respectively.

Extration and Isolation The root of *Juniperus chinensis* LINN. (1.3 kg), crushed into small pieces, was extracted with methanol (50 l × 3). The combined extracts were evaporated *in vacuo* to give a residue, which was subsequently purified by repeated silica gel chromatography with a binary solvent system (hexane + ethyl acetate gradient) to give totarol (**1a**) (0.5 g), 7-oxototarol (**2**) (50 mg), totarolone (**1b**) (60 mg), 1,3-dioxototarol (**1c**) (80 mg), isototarolenone (**3a**) (10 mg), and 1-oxo-3β-acetoxytotaryl acetate (**9**) (9 mg) [purified by acetylation].

Totarol (**1a**): mp 132—133 °C, $[\alpha]_D^{22}$ +42.5 ($c=1.0$, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3521, 1538, 1487, 1383, 1370, 1268, 1171, 1105, 969, 905, 805. ^{1}H-NMR ($CDCl_3$) δ: 0.90, 0.93, 1.16 (each 3H, s), 1.30, 1.35 (each 3H, d, $J=6.8$ Hz), 2.21 (1H, br d, $J=12.8$ Hz, H_β-1), 3.28 (1H, m, $J=6.8$ Hz), 4.46 (1H, s, –OH), 6.50, 6.98 (each 1H, d, $J=8.4$ Hz).

7-Oxototarol (**2**): mp 294—296 °C, $[\alpha]_D^{18}$ +15.2 ($c=1.0$, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3219, 1642, 1585, 1484, 1310, 1279, 1091, 1059, 903, 870, 829. ^{1}H-NMR ($CDCl_3$) δ: 0.91, 1.01, 1.09 (each 3H, s), 1.32, 1.44 (each 3H, d, $J=7.1$ Hz), 2.19 (1H, br d, $J=12.0$ Hz, H_β-1), 3.75 (1H, m, $J=7.1$ Hz), 4.96 (1H, br s, –OH), 6.79, 7.03 (each 1H, d, $J=8.5$ Hz).

Totarolone (**1b**): mp 188—189 °C, $[\alpha]_D^{23}$ +101.4 ($c=1.0$, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3403, 3040, 1715, 1580, 1479, 1318, 1275, 1169, 1097, 979, 908, 808. ^{1}H-NMR ($CDCl_3$) δ: 1.06, 1.14, 1.27 (each 3H, s), 1.33 (6H, d, $J=6.9$ Hz), 2.50—2.80 (4H, m, H_β-1, H-2, H_α-7), 3.25 (1H, m, $J=6.9$ Hz), 4.68 (1H, br s), 6.53, 6.96 (each 1H, d, $J=8.4$ Hz).

1,3-Dioxototarol (**1c**): mp 231—232 °C, $[\alpha]_D^{20}$ +210° ($c=1.0$, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3447, 3030, 1715, 1693, 1579, 1481, 1389, 1280, 1190, 1093, 1050, 939, 831. MS m/z (%): 314 (M^+, 21), 286 (19), 271 (64), 243 (33), 229 (100), 201 (20), 159 (24), 145 (11). ^{1}H-NMR: Table I. *Anal.* Calcd for $C_{20}H_{26}O_3$: C, 76.40, H, 8.34. Found C, 76.51; H, 8.30.

Isototarolenone (**3a**): mp 179—180 °C, $[\alpha]_D^{23}$ +1.6 ($c=0.26$, $CHCl_3$). UV λ_{max}^{MeOH} nm ($\log\varepsilon$): 230 (4.01), 270 (3.41). IR ν_{max}^{KBr} cm^{-1}: 3409, 1669, 1600, 1585, 1495, 1260, 1100, 1029, 802. MS m/z (%): 298 (M^+, 30), 202 (100), 189 (15), 159 (20), 121 (30). ^{1}H-NMR: Table I. *Anal.* Calcd for $C_{20}H_{26}O_2$: C, 80.49, H. 8.78. Found C, 80.13; H, 8.80.

1-Oxo-3β-acetoxytotaryl Acetate (**9**): Amorphous, $[\alpha]_D^{25}$ +175.6 ($c=0.2$, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 1752, 1739, 1715, 1600, 1236, 1199, 1076, 1031, 975, 932, 875. MS m/z (%): 400 (M^+, 21), 358 (M^+, 95), 255 (52), 243 (100), 229 (13), 202 (47), 159 (32). ^{1}H-NMR: Table I.

Acetylation of 1,3-Dioxototarol (1c) 1,3-Dioxototarol (**1c**) (30 mg) was allowed to react with Ac_2O (1 ml) and pyridine (1 ml) at room temperature for 40 h. Usual work-up gave a monoacetate (**5b**) (15 mg) [amorphous: IR ν_{max}^{KBr} cm^{-1}: 1756, 1715, 1703, 1608, 1368, 1215, 1108, 1053. ^{1}H-NMR ($CDCl_3$) δ: 1.23 (6H, s, H-18, H-19), 1.25 (6H, s), 1.35 (3H, s, H-20), 2.20 (3H, s), 3.21 (1H, m, $J=7.0$ Hz), 3.38, 3.75 (each 1H, d, $J=18.0$ Hz), 6.86, 7.43 (each 1H, d, $J=8.8$ Hz)] and a diacetate (**6a**) (20 mg) [amorphous; IR ν_{max}^{KBr} cm^{-1}: 3040, 1761, 1675, 1610, 1367, 1198, 1108, 1069, 1011. ^{1}H-NMR ($CDCl_3$) δ: 1.20 (6H, d, $J=7.0$ Hz), 1.23, 1.25, 1.59 (each 3H, s, H-18, H-19, H-20), 2.24, 2.29 (3H, s, $-OCOCH_3$), 3.20 (1H, m, $J=7.0$ Hz), 5.87 (1H, s, H-2), 6.87, 7.50 (each 1H, d, $J=8.5$ Hz)]. 1,3-Dioxototarol (**1c**) (30 mg) and *p*-toluenesulfonic acid (30 mg) were dissolved in 2 ml of isopropenyl acetate. The reaction mixture was stirred at ambient temperature for 3 h. After usual treatment, the reaction mixture yielded a monoacetate (**5b**) (8 mg) and a diacetate (**6a**) (24 mg).

Methylation of 1,3-Dioxototarol (1c) Excess diazomethane in ether was added dropwise to a solution of 1,3-dioxototarol (**1c**) (15 mg) in ether (3 ml), and the reaction mixture was left to stand overnight. The yellow reaction solution was evaporated and the residue was submitted to chromatography on silica gel, affording **6b** (6 mg) [amorphous; IR ν_{max}^{KBr} cm^{-1}: 3391, 1665, 1639, 1603, 1356, 1281, 1200, 1110, 1075, 908, 816. ^{1}H-NMR ($CDCl_3$) δ: 1.21 (6H, s), 1.29 (6H, d, $J=6.8$ Hz), 1.50 (3H, s, H-20), 3.22 (1H, m, $J=6.8$ Hz), 3.69 (3H, s, $-OCH_3$), 5.29 (1H, s, H-2), 6.60, 7.50 (each 1H, d, $J=8.5$ Hz)]. Excess diazomethane was allowed to react with compound **6b** (6 mg) in 3 ml of ether for 3 d at room temperature to afford the dimethyl ether product **6c** (3 mg) (mp 158—159 °C).[10]

Acetylation of Isototarolenone (3a) Acetylation of **3a** (5 mg) in the same way as mentioned above (Ac_2O/pyridine) yielded **3b** (6 mg). mp 65—66 °C (needles from MeOH); IR ν_{max}^{KBr} cm^{-1}: 1749, 1685, 1370, 1226, 1200. ^{1}H-NMR ($CDCl_3$) δ: 1.18, 1.20, 1.58 (each 3H, s), 1.23, 1.27 (each 3H, d, $J=6.9$ Hz), 2.32 (3H, s, $-OCOCH_3$), 3.25 (1H, m, $J=6.9$ Hz), 5.91, 6.49 (each 1H, d, $J=10.0$ Hz), 6.89, 7.53 (each 1H, d, $J=8.8$ Hz).

Catalytic Hydrogenation of 3a Compound **3a** (5 mg) was dissolved in 3 ml of MeOH, then 5 mg of 5% Pd–C suspended in 3 ml of MeOH was added and the mixture was saturated with H_2. After 5 h, the catalyst was removed by filtration and washed several times with MeOH. After purification, the combined filtrate yielded **8** (4 mg): amorphous; IR ν_{max}^{KBr} cm^{-1}: 3401, 1706, 1582, 1365, 1260, 1033, 1099, 906, 802. ^{1}H-NMR ($CDCl_3$) δ: 0.90, 0.90, 1.20 (each 3H), 1.31, 1.33 (each 3H, d, $J=6.8$ Hz), 3.30 (1H, m, $J=6.8$ Hz), 4.50 (1H, br s, –OH), 6.50, 7.94 (each 1H, d, $J=8.5$ Hz).

Catalytic Hydrogenation of 6a Compound **6a** (10 mg) was dissolved in 5 ml of MeOH, then 10 mg of 5% Pd–C suspended in 5 ml of MeOH was added and the mixture was saturated with H_2. After 10 h, treatment as mentioned above yielded **3b** (5 mg).

Deacetylation of 9 A solution of **9** (6 mg) and NaOH (2 mg) in 3 ml of MeOH was left to stand overnight at room temprature, then poured into 30 ml of water. After purification it gave compound **3a** (3 mg).

Acknowledgement This research was supported by the National Science Council of R.O.C.

References

1) S. S. Ying, "Coloured Illustrated Flora of Taiwan," Vol. 1, National Taiwan University, Taipei, 1978, p. 1020.
2) T. Sawada, *Yakugaku Zasshi*, **78**, 1020 (1958).
3) C. Piol, J. Runeberg, *Acta Chem. Scand.*, **14**, 353 (1960).
4) Y. H. Kuo, I. C. Yang, C. S. Chen, Y. T. Lin, *J. Chin. Chem. Soc.*, **34**, 125 (1987).
5) Y. H. Kuo, T. R. Wu, M. C. Cheng, Y. Wang, *Chem. Pharm. Bull.*, **38**, 3195 (1990).
6) Y. H. Kuo, W. C. Chen, *J. Chem. Res.* (S), **1992**, 382.
7) Y. H. Kuo, W. C. Chen, *Chem. Express*, **7**, 833 (1992).
8) Y. L. Chow, H. Erdtman, *Acta Chem. Scand.*, **16**, 1305 (1962).
9) J. M. Fang, S. T. Jan, Y. S. Cheng, *Phytochemistry*, **26**, 853 (1987).
10) L. Mangoni, M. Belardini, *Tetrahedron Lett.*, **1964**, 2643.