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The Constituents of *Schizandra chinensis* Baill. IX.[1] The Cleavage of the Methylenedioxyl Moiety with Lead Tetraacetate in Benzene, and the Structure of Angeloylgomisin Q[2]

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A procedure for selective cleavage of the methylenedioxyl moiety with lead tetraacetate in dry benzene is described. Piperonylic acid methyl ester (**5**), 4-nitro-1,2-methylenedioxybenzene (**6**), 3,4-methylenedioxytoluene (**7**), 2,3-methylenedioxyanisole (**8**) and gomisin A (**9**) afforded protocatechuic acid (**12**), 4-nitrocatechol (**13**), 3,4-dihydroxytoluene (**14**), 2,3-dihydroxyanisole (**15**) and compound **16**, respectively.

The structure of angeloylgomisin Q isolated from the fruits of *Schizandra chinensis* Baill. (Schizandraceae), was elucidated as **1** by using the above reaction.

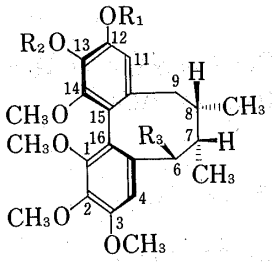
Keywords——cleavage of methylenedioxyl moiety; lead tetraacetate; *Schizandra chinensis* Baill.; Schizandraceae; dibenzocyclooctadiene; lignan; angeloylgomisin Q

The cleavage of the aromatic methylenedioxyl moiety has been extensively investigated because of the frequent occurrence of natural products which contain this functional group. Hydrogen iodide,[3] pyridine hydrochloride,[4] methyl magnesium iodide,[5] aluminum trichloride,[6] sodium hydroxide,[7] phosphorus pentachloride in dry benzene[8] and phosphoric acid–acetic acid in phenol[9] have been used as reagents. Recently, aluminum tribromide in ethanethiol,[10] sodium methoxide[11a] or sodium phenoxide[11b] in dimethylsulfoxide and boron trichloride in methylene chloride[12] have been used as reagents for the selective cleavage of the methylenedioxyl moiety.

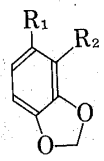
This paper deals with a selective and mild cleavage reaction of the methylenedioxyl moiety with lead tetraacetate [$Pb(OAc)_4$][13] in dry benzene, and also describes the structure elucidation of a new lignan, angeloylgomisin Q (**1**), isolated from the fruits of *Schizandra chinensis* Baill. (Schizandraceae) by using this reaction.

In the previous paper,[14] we reported that treatment of gomisin N (**2**) with $Pb(OAc)_4$ in AcOH gave 6β-acetoxygomisin N (acetylgomisin O, **3**), but treatment of **2** with the reagent in dry benzene gave an unexpected diphenol (**4**).[14] As further examples of the cleavage reaction of the methylenedioxyl moiety with this reagent, piperonylic acid methyl ester (**5**), 4-nitro-1,2-methylenedioxybenzene (**6**), 3,4-methylenedioxytoluene (**7**), 2,3-methylenedioxyanisole (**8**) and gomisin A (**9**) were also subjected to the reaction. The reaction conditions and yields of the corresponding diphenols are summarized in Table I.

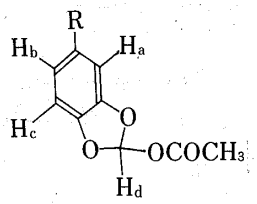
Among the above compounds, **7**, **8** and **9** smoothly afforded the corresponding diphenols, but **5** and **6**, with an electron-attracting group on the aromatic ring, afforded the unstable intermediates **10** and **11**, respectively. Compounds **10** and **11** show no methylenedioxyl signal, but show an acetoxyl signal (**10**: δ 2.13 and **11**: δ 2.15) and a deshielded proton signal (**10**: δ 7.75 and **11**: δ 7.80) in their proton magnetic resonance (^{1}H-NMR) spectra (in $CDCl_3$). These observations suggest that **10** and **11** might have orthoester type structures as shown in Chart 1. Treatment of **10** and **11** with 80% AcOH at room temperature gave protocatechuic acid methyl ester (**12**) and 4-nitrocatechol (**13**), respectively. The above results suggest that the reaction might proceed *via* displacement of a proton of the methylenedioxyl moiety by an acetoxyl group, followed by hydrolysis during separation of the products. As far as we know, this is the first report of cleavage of the methylenedioxyl moiety with $Pb(OAc)_4$. Among the above products, the diphenol (**16**) derived from gomisin A (**9**) gave schizandrin (**17**) on



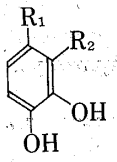
2 : $R_1+R_2=CH_2$, $R_3=H$
3 : $R_1+R_2=CH_2$, $R_3=OCOCH_3$
4 : $R_1=R_2=R_3=H$



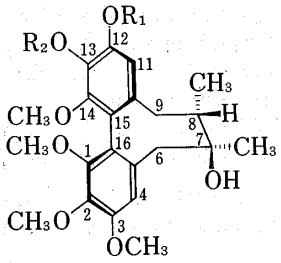
5 : $R_1=COOCH_3$, $R_2=H$
6 : $R_1=NO_2$, $R_2=H$
7 : $R_1=CH_3$, $R_2=H$
8 : $R_1=H$, $R_2=OCH_3$



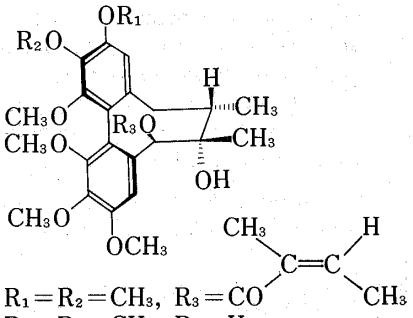
10 : $R=COOCH_3$
11 : $R=NO_2$



12 : $R_1=COOCH_3$, $R_2=H$
13 : $R_1=NO_2$, $R_2=H$
14 : $R_1=CH_3$, $R_2=H$
15 : $R_1=H$, $R_2=OCH_3$



9 : $R_1+R_2=CH_2$
16 : $R_1=R_2=H$
17 : $R_1=R_2=CH_3$



1 : $R_1=R_2=CH_3$, $R_3=CO$
18 : $R_1=R_2=CH_3$, $R_3=H$
19 : $R_1+R_2=CH_2$, $R_3=H$
20 : $R_1+R_2=CH_2$, $R_3=COCH_3$
21 : $R_1=R_2=H$, $R_3=COCH_3$
22 : $R_1=R_2=CH_3$, $R_3=COCH_3$

Chart 1

TABLE I. Cleavage of the Methylenedioxyl Moiety with $Pb(OAc)_4$

Starting material (mg)	Reaction conditions: $Pb(OAc)_4$ mg(mol eq)	Benzene ml	Temperature °C	Time h	Product (mg) mg(%)	Recovery of starting material mg(%)
5(180)	531(1.2)	8	60	20	**10**(44)→**12**, 32(19)	114(63)
6(177)	531(1.2)	8	60	7	**11**(2)	158(89)
6(177)	531(1.2)	8	70	7	**11**(15)→**13**, 6.8(4.4)	139(79)
6(177)	531(1.2)	8	80	7	**11**(10)	136(77)
7(105)	410(1.2)	6	60	7	**14**, 35(40)	14(13)
8(152)	531(1.2)	8	60	7	**15**, 35(25)	91(59)
9(150)	300(1.87)	5	50	7	**16**, 28(19)	49(32)
20 (84)	126(1.61)	4	50	8	**21**, 11.5(14)	16.5(20)

All products (**12**—**15**) gave the corresponding dimethyl ethers on treatment with $(CH_3)_2SO_4$ and K_2CO_3 in acetone.

methylation with $(CH_3)_2SO_4$ and K_2CO_3. Thus, the chemical correlation of gomisin A (**9**) with schizandrin (**17**) was accomplished.

Angeloylgomisin Q (**1**) was isolated as colorless prisms, $C_{29}H_{34}O_{10}$, mp 82.5—83.5°C, $[\alpha]_D^{24}$ −26.4° ($CHCl_3$) (yield 0.0047%). The ultraviolet (UV) spectrum [λ_{max}^{EtOH} nm (log ε): 220 (4.74), 250—251 (sh 4.17) and 285—286 (sh 3.45)], the infrared (IR) spectrum [ν_{max}^{KBr} cm^{-1}: 3500 (OH), 1700 (C=O), 1642 (C=C), 1596 and 1581 (aromatic)] and the ^1H-NMR spectrum (Table II) indicate that **1** is a dibenzocyclooctadiene lignan possessing six methoxyl groups on the aromatic rings, a tertiary methyl group attached to a carbon carrying a hydroxyl group (CH_3–$\overset{|}{C}$–OH), a secondary methyl group and an acyloxy benzylic methine. The signals

TABLE II. ^{1}H-NMR Spectral Data for **1**, **18**, **20**, **21** and **22** (δ in $CDCl_3$, 60 MHz)

Compd.	4-H, s 11-H, s	OCH_2O s	OCH_3 s	6α-H s	$COCH_3$ s	9α-H dd (J=Hz)	9β-H dd (J=Hz)	HO[c]–C[(7)]–CH_3 s s	H–C[(8)]–CH_3[d] m d (J=Hz)	
1[a]	6.80 5.53	—	3.52, 3.55, 3.82, 3.87, 3.88(×2)	5.77	—	2.25 (Center) (2H, m)		1.57	1.30	1.87	1.17 (7)
18[a]	6.62 6.58	—	3.63, 3.72, 3.88, 3.92 (×3)	4.57, d[b] J=11 Hz	—	2.38 (13.5/8)	2.12 (13.5/2)	1.65	1.40	1.65	1.15 (7)
20	6.73 6.50	5.93	3.57, 3.85, 3.88, 3.92	5.63	1.63	2.38 (13.5/9)	2.07 (13.5/1)	1.57	1.28	1.78	1.11 (7)
21	6.75 6.65	5.53 (2H, s, 2×OH[c])	3.31, 3.53, 3.93(×2)	5.68	1.60	2.20 (Center) (2H, m)		1.32	1.32	1.92	1.12 (7)
22	6.72 6.55	—	3.57, 3.70, 3.87, 3.93 (×3)	5.65	1.58	2.22 (Center) (2H, m)		1.72	1.30	1.87	1.13 (7)

a) Other signals: **1**, $CH_3{}^{\beta}_{H}{>}C{=}C{<}^{\alpha}_{CH_3}CO-$: 1.30 (3H, m, α-CH_3), 1.80 (3H, dq, J=7/1 Hz, β-CH_3), 5.95 (1H, qq, J=7/1 Hz, β-H).
18: 1.65 (1H, d, J=11 Hz, OH, D_2O exchangeable).
b) Singlet after addition of D_2O.
c) Hydroxyl signals were confirmed by addition of D_2O.
d) Confirmed by decoupling experiments.
e) s=singlet, d=doublet, q=quartet, m=multiplet.

at δ 1.30 (3H, m, overlapped with the tertiary methyl), 1.80 (3H, dq, J=7/1 Hz) and 5.95 (1H, qq, J=7/1 Hz) in the ^{1}H-NMR spectrum (in $CDCl_3$) as well as the strong peaks at m/z 83 (base peak) and m/z 55 in the mass spectrum indicate the presence of an angeloyl group in **1**.

On hydrolysis with 3% ethanolic potassium hydroxide, **1** afforded an acid and a diol (**18**), named gomisin Q. The former was identified as a mixture of angelic acid and tiglic acid by gas liquid chromatography (GLC) (see "Experimental").[15] The latter was obtained as colorless needles, $C_{24}H_{32}O_8$, mp 191—193°C, $[\alpha]_D^{22}$ −106° ($CHCl_3$). The upfield shift of a benzylic methine signal (δ 4.57) assignable to the $C_{(6)}$-proton in the ^{1}H-NMR spectrum of **18**, compared with that of **1** (δ 5.77), shows that the angeloyl group in **1** is linked to the $C_{(6)}$-hydroxyl group. In addition, on the basis of comparisons of the ^{13}C-NMR (see "Experimental") and ^{1}H-NMR spectra of **18** with those of deangeloylgomisin B (**19**)[16] (Table II), it was assumed that the methylenedioxyl moiety at the C-12 and -13 positions in **19** is replaced by two methoxyl groups in **18**. The structure of **18** was confirmed by the correlation with **19** as described below.

Treatment of acetyldeangeloylgomisin B (**20**) with $Pb(OAc)_4$ in dry benzene afforded a diphenol (**21**) [^{1}H-NMR (δ in $CDCl_3$): 5.53 (2H, s, 2×phenolic OH), no methylenedioxyl signal], methylation of which with $(CH_3)_2SO_4$ and K_2CO_3 in dry acetone gave compound **22** [^{1}H-NMR (δ in $CDCl_3$): 3.57 (3H, s), 3.70 (3H, s), 3.87 (3H, s), 3.93 (9H, s) (6×OCH_3)]. Hydrolysis of **22** afforded **18**, colorless needles, $C_{24}H_{32}O_8$, mp 190—192.5°C, $[\alpha]_D^{23}$ −96.5° ($CHCl_3$), which was identified as gomisin Q (**18**) by direct comparison (IR, mixed mp, ^{1}H-NMR and $[\alpha]_D$). The structure of angeloylgomisin Q was thus elucidated as **1**.

Experimental

All melting points were determined on a Yanagimoto micromelting point apparatus (a hot-stage type) and are uncorrected. The UV spectra were recorded with a Hitachi 624 digital spectrophotometer and the IR spectra with a Hitachi EPI-G2 machine. The ^{1}H-NMR spectra were recorded with a Varian T-60 spectrometer and ^{13}C-NMR spectra were recorded with a Varian FT-80A spectrometer with tetramethylsilane as an internal standard. Mass spectra were measured with a Hitachi double-focusing mass spectrometer. The specific rotations were measured with a JASCO DIP-SL unit. Gas liquid chromatography (GLC) was carried out on a Hitachi 073 gas chromatograph with FID. For silica gel column chromatography, Kieselgel

60 (Merck) was used. Thin-layer chromatography (TLC) was carried out on Merck plates precoated with Kieselgel 60 F_{254}. Preparative layer chromatography (PLC) was carried out on plates (20×20 cm, 0.75 mm thick) coated with Kieselgel PF_{254} (Merck).

Piperonylic Acid Methyl Ester (5)——Piperonylic acid (1 g, Kokusan Chemical Works Ltd., Tokyo) was methylated with diazomethane in ether to give a methyl ester (**5**) as colorless needles (from ether–hexane) (714 mg), mp 52.5—53°C. ^{1}H-NMR (δ in $CDCl_3$): 3.93 (3H, s, $COOCH_3$), 6.00 (2H, s, $-OCH_2O-$), 6.85 (1H, d, J=8.5 Hz), 7.43 (1H, d, J=2 Hz), 7.60 (1H, dd, J=8.5/2 Hz) (3×arom.-H). *Anal.* Calcd for $C_9H_8O_8$: C, 60.00; H, 4.48. Found: C, 59.57; H, 4.51.

4-Nitro-1,2-methylenedioxybenzene (6)——Methylene iodide (1.87 g) and K_2CO_3 (1.5 g) were added to a solution of 4-nitrocatechol (**13**, 775 mg) in dry dimethylsulfoxide (8 ml), and then the reaction mixture was stirred at 55°C for 6 h. After addition of H_2O (30 ml), the reaction mixture was extracted with ether (30 ml×3) and the combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated. The residue was purified by PLC [benzene–ether (4: 1)] to give **6** (471 mg, yield 53.2%) as yellow prisms (from EtOH), mp 146.5—147.5°C. IR ν_{max}^{KBr} cm^{-1}: 1625, 1603 (aromatic), 1504, 1496, 1339 (NO_2), 918 ($-OCH_2O-$). ^{1}H-NMR (δ in CD_3COCD_3): 6.23 (2H, s, $-OCH_2O-$), 6.98 (1H, d, J=9 Hz), 7.60 (1H, d, J=2.5 Hz), 7.87 (1H, dd, J=9/2.5 Hz) (3×arom.-H). *Anal.* Calcd for $C_7H_5NO_5$: C, 50.31; H, 3.02; N, 8.36. Found: C, 50.65; H, 3.15; N, 8.37.

3,4-Methylenedioxytoluene (7)——$LiAlH_4$ (250 mg) was added to a solution of piperonylic acid methyl ester (**5**, 500 mg) in dry ether (10 ml). The reaction mixture was stirred at room temperature for 2 h. After addition of wet ether, the mixture was filtered and concentrated to dryness. The residue (350 mg) was dissolved in MeOH (7 ml) and shaken with H_2 in the presence of 5% Pd-C (50 mg) as a catalyst at room temperature for 2 h. The catalyst was filtered off and the filtrate was concentrated to dryness. The residue was purified by PLC [hexane–acetone (4: 1)] to give **7** (105 mg) as a colorless oil. ^{1}H-NMR (δ in $CDCl_3$): 2.25 (3H, s, arom.-CH_3), 5.88 (2H, s, $-OCH_2O-$), 6.65 (3H, s, 3×arom.-H).

2,3-Methylenedioxyanisole (8)——Methylene iodide (2.68 g) and K_2CO_3 (1.5 g) was added to a solution of pyrogallol (1.26 g) in dry dimethylsulfoxide (10 ml). The reaction mixture was stirred at 60°C for 5 h, then diluted with H_2O (50 ml) and extracted with ether (40 ml×2). The combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (3: 2)] to give 2,3-methylenedioxyphenol (285 mg, yield 21%) as colorless needles (from ether–hexane), mp 65—65.5°C. IR ν_{max}^{KBr} cm^{-1}: 3290 (OH), 1640, 1628, 1615 (aromatic), 922 ($-OCH_2O-$). ^{1}H-NMR (δ in $CDCl_3$): 5.33 (1H, s, OH), 5.90 (2H, s, $-OCH_2O-$), 6.33—6.83 (3H, m, 3×arom.-H), *Anal.* Calcd for $C_7H_6O_3$: C, 60.87; H, 4.38. Found: C, 60.59; H, 4.31.

$(CH_3)_2SO_4$ (0.5 ml) and K_2CO_3 (1 g) were added to a solution of 2,3-methylenedioxyphenol (225 mg) in dry acetone (8 ml). The reaction mixture was stirred at 50°C for 5 h, then diluted with H_2O (30 ml) and extracted with ether (20 ml×3). The combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (7: 3)] to give **8** (180 mg) as colorless needles (from hexane), mp 41.5—42°C. ^{1}H-NMR (δ in $CDCl_3$): 3.88 (3H, s, OCH_3), 5.92 (2H, s, $-OCH_2O-$), 6.38—6.90 (3H, m, 3×arom.-H).

Treatment of 5 with $Pb(OAc)_4$ in dry Benzene, followed by Hydrolysis with 80% AcOH, giving 17——A solution of **5** (180 mg) and $Pb(OAc)_4$ (531 mg) in dry benzene (8 ml) was stirred at 60°C for 20 h, then diluted with ether (50 ml). The reaction mixture was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (4: 1), *Rf* 0.57] to give **10** (44 mg) as a pale brown oil and unchanged **5** (114 mg). **10**: ^{1}H-NMR (δ in $CDCl_3$): 2.13 (3H, s, $COCH_3$), 3.90 (3H, s, $COOCH_3$), 7.00 (1H, d, J=8.5 Hz, $H_{(c)}$), 7.62 (1H, d, J=2 Hz, $H_{(a)}$), 7.77 (1H, dd, J=8.5/2 Hz, $H_{(b)}$), 7.75 (1H, s, $H_{(d)}$). A solution of **10** (44 mg) in 80% AcOH (2 ml) was stirred at room temperature for 1 h. The mixture was concentrated to dryness under reduced pressure and the residue was purified by PLC [hexane–acetone (4: 1)] to give **12** (32 mg) as colorless needles (from ether–benzene), mp 138.5—139.5°C. IR ν_{max}^{KBr} cm^{-1}: 3450, 3250 (OH), 1690 (C=O), 1609 (aromatic). ^{1}H-NMR (δ in CD_3COCD_3): 3.83 (3H, s, OCH_3), 6.92 (1H, d, J=8.5 Hz), 7.45 (1H, dd, J=8.5/2.5 Hz), 7.52 (1H, d, J=2.5 Hz), (3×arom.-H), 8.37 (2H, s, 2×OH). *Anal.* Calcd for $C_8H_8O_4$: C, 57.14; H, 4.80. Found: C, 57.09; H, 4.79. This compound was identified as protocatechuic acid methyl ester by direct comparison with an authentic sample (IR, ^{1}H-NMR and mixed mp).

Treatment of 6 with $Pb(OAc)_4$ in Dry Benzene, followed by Hydrolysis with 80% AcOH, giving 13——Solutions of **6** (177 mg) and $Pb(OAc)_4$ (531 mg) in dry benzene (8 ml) were stirred for 7 h at 60°C, 70°C and 80°C, independently. Each reaction mixture was diluted with ether (60 ml), and then washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–$CHCl_3$ (1: 1)] to give **11** and unchanged **6** in the yields shown in Table I. **11**: ^{1}H-NMR (δ in $CDCl_3$): 2.15 (3H, s, $COCH_3$), 7.03 (1H, d, J=9 Hz, $H_{(c)}$), 7.80 (1H, s, $H_{(d)}$), 7.83 (1H, d, J=2 Hz, $H_{(a)}$), 8.02 (1H, dd, J=9/2 Hz, $H_{(b)}$). A solution of **11** (20 mg) in 80% AcOH (2 ml) was stirred at room temperature for 2 h. The mixture was concentrated to dryness under reduced pressure and the residue was purified by PLC [hexane–acetone (1: 1)] to give **13** (9 mg) as yellow needles (from benzene), mp 177—178°C. IR ν_{max}^{KBr} cm^{-1}: 3360, 3270 (OH), 1520, 1327 (NO_2). *Anal.* Calcd for $C_6H_5NO_4$: C, 46.46; H, 3.25; N, 9.03. Found: C, 46.21; H, 3.28; N, 8.71. This compound was identified as 4-nitrocatechol by direct comparison with an authentic sample (IR and mixed mp).

Treatment of 7 with $Pb(OAc)_4$ in Dry Benzene, giving 14——A solution of **7** (105 mg) and $Pb(OAc)_4$ (410 mg) in dry benzene (6 ml) was stirred at 60°C for 7 h and then diluted with ether (45 ml). The total mixture was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (3: 2)]. The zone with *Rf* 0.70 was extracted with $CHCl_3$–MeOH (4: 1). The extract was kept for 2 days at room temperature and concentrated to give **14** (35 mg) as a pale yellow oil. **14**: ^{1}H-NMR (δ in $CDCl_3$): 2.18 (3H, s, arom.-CH_3), 5.33 (2H, s, D_2O exchangeable, 2×OH), 6.35—6.82 (3H, m, 3×arom.-H). Unchanged **7** (14 mg) was also recovered in the above PLC. Compound **14** (35 mg) was methylated with $(CH_3)_2SO_4$ (0.2 ml) and K_2CO_3 (200 mg) in dry acetone (2 ml) to give the dimethyl ether (26 mg). ^{13}C-NMR (δ in $CDCl_3$): 21.0 (CH_3), 55.8, 56.0 (2×OCH_3), 111.4, 112.6, 120.8, 130.5, 147.0 and 148.9 (6×arom.-C).

Treatment of 8 with $Pb(OAc)_4$ in Dry Benzene, giving 15——A solution of **8** (152 mg) and $Pb(OAc)_4$ (531 mg) in dry benzene (8 ml) was stirred at 60°C for 7 h and then diluted with ether (45 ml). The total mixture was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (7: 3)]. The zone with *Rf* 0.67 was extracted with $CHCl_3$–MeOH (4: 1). The extract was kept for 2 days at room temperature and concentrated to give **15** (35 mg) as a pale yellow oil. **15**: ^{1}H-NMR (δ in $CDCl_3$): 3.86 (3H, s, OCH_3), 5.60 (2H, s, D_2O exchangeable, 2×OH), 6.35—6.90 (3H, m, 3×arom.-H). Unchanged **8** (91 mg) was also recovered in the above PLC. Compound **15** (35 mg) was methylated with $(CH_3)_2SO_4$ (0.2 ml) and K_2CO_3 (200 mg) in dry acetone (2 ml) to give the dimethyl ether (26 mg) as colorless needles (from hexane), mp 45°C. ^{1}H-NMR (δ in $CDCl_3$): 3.83 (9H, s, 3×OCH_3), 6.47—7.10 (3H, m, 3×arom.-H). *Anal.* Calcd for $C_9H_{12}O_3$: C, 64.27; H, 7.19. Found: C, 64.44; H, 7.26. This compound was identified as trimethoxybenzene by direct comparison with an authentic sample (IR and mixed mp).

Treatment of Gomisin A (9) with $Pb(OAc)_4$ in Dry Benzene, giving 16——A solution of **9** (150 mg) and $Pb(OAc)_4$ (300 mg) in dry benzene (5 ml) was stirred at 50°C for 7 h then diluted with ether (45 ml). The total mixture was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (3: 2)]. The zone with *Rf* 0.32 was extracted with $CHCl_3$–MeOH (4: 1). The extract was kept for 2 days at room temperature and concentrated to give **16** (28 mg) as a white amorphous powder. **16**: $[\alpha]_D^{23}$ +110° (*c*=1.05, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3390 (OH), 1592 (aromatic). MS, *m/z*(%): 404 (M^+, 73), 386 (M^+-H_2O, 100). Unchanged **9** (49 mg) was also recovered in the above PLC.

Methylation of 16, giving Schizandrin (17)——$(CH_3)_2SO_4$ (0.1 ml) and K_2CO_3 (200 mg) were added to a solution of **16** (22 mg) in dry acetone (2 ml). The reaction mixture was stirred at 50°C for 3 h and then diluted with H_2O (10 ml) and extracted with ether (15 ml×3). The combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (7: 3), *Rf* 0.30] to give **17** (20 mg) as colorless prisms (from ether–hexane), mp 130—131.5°C, $[\alpha]_D^{24}$ +81.5° (*c*=0.650, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3495 (OH), 1593 (aromatic). *Anal.* Calcd for $C_{24}H_{32}O_7$: C, 66.65; H, 7.46. Found: C, 66.56; H, 7.42. This compound was identified as schizandrin (**17**) by direct comparison with an authentic sample (IR, $[\alpha]_D$ and mixed mp).

Isolation of Angeloylgomisin Q (1)——In the previous paper,[16a] it was reported that the pet. ethereal and methanolic extracts of the fruits of *Schizandra chinensis* Baill. (4.671 kg) afforded twelve fractions (fr. 1—12) on silica gel column chromatography with hexane, acetone–benzene and acetone solvent systems. Fr. 7, 8 and 9 were combined and rechromatographed on silica gel using a benzene–ether solvent system to give nine fractions [fr. (7—9)-a—i] as described in the previous paper.[17] Fr. (7—9)-f, after separation of schizandrin (**17**)[16a] was subjected to silica gel column chromatography (SiO_2, 425 g, 5.5×39 cm) using hexane–AcOEt solvent system and the fractions eluted with hexane–AcOEt (7: 3) were concentrated. Repeated column chromatography [i) SiO_2 400 g/hexane–AcOEt; ii) SiO_2 120 g/benzene–AcOEt] and PLC [i) benzene-AcOEt (7: 3), *Rf* 0.52; ii) hexane–AcOEt (3: 2), *Rf* 0.69] of the residue (19.19 g) gave **1** (220 mg, yield 0.0047%).

Angeloylgomisin Q (1)——Pure angeloylgomisin Q was obtained as colorless prisms (from ether–hexane), mp 82.5—83.5°C, $[\alpha]_D^{23}$ −26.4° (*c*=1.10, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3500 (OH), 1642 (C=C), 1596, 1581 (aromatic). UV λ_{max}^{EtOH} nm (log ε): 220 (4.74), 250—251 (sh 4.17), 285—286 (sh 3.45). MS, *m/z*(%): 530 (M^+, 17), 430 [$M^+-CH_3CH=C(CH_3)COOH$, 14], 359 (45), 83 [$CH_3CH=\overset{+}{C}(CH_3)CO$, 100], 55 ($CH_3CH=C-CH_3$, 69). *Anal.* Calcd for $C_{29}H_{34}O_{10}$: C, 65.64; H, 7.22. Found: C, 65.65; H, 7.30. ^{1}H-NMR spectral data are given in Table II.

Hydrolysis of 1——A solution of **1** (81 mg) in 3% KOH–EtOH (2 ml) was kept at 75°C for 7 h, then diluted with H_2O (20 ml) and extracted with ether (15 ml×3). The combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to give a residue, which was purified by PLC [hexane–acetone (3: 2)] to give a diol (**18**), colorless needles (from ether–hexane), mp 191—193°C, $[\alpha]_D^{22}$ −106° (*c*=1.24, $CHCl_3$) (37 mg). IR ν_{max}^{KBr} cm^{-1}: 3410, 3370 (OH), 1595, 1575 (aromatic). UV λ_{max}^{EtOH} nm (log ε): 218 (4.58), 251 (4.08), 277 (sh 3.44), 287 (sh 3.32). ^{13}C-NMR (δ in $CDCl_3$): 19.0 [$C_{(8)}$–$\underline{C}H_3$], 28.6 [$C_{(7)}$–$\underline{C}H_3$], 36.5 [$C_{(9)}$], 41.7 [$C_{(8)}$], 56.0, 56.0, 60.6, 60.7, 60.9, 61.0 (6×OCH_3), 73.8 [$C_{(7)}$], 86.1 [$C_{(6)}$], 107.6 [$C_{(11)}$], 110.2 [$C_{(4)}$], 120.6, 121.2 [$C_{(15)}$ and $C_{(16)}$], 133.3 [$C_{(5)}$], 136.6 [$C_{(10)}$], 140.6, 141.6 [$C_{(2)}$ and $C_{(13)}$], 151.3 [$C_{(14)}$], 152.0 [$C_{(1)}$ and $C_{(3)}$], 154.2 [$C_{(12)}$].[16b] *Anal.* Calcd for $C_{24}H_{32}O_8$: C, 64.27; H, 7.19. Found: C, 64.32; H, 7.25.

The aqueous solution was acidified with 1 N HCl, washed with H_2O, dried over Na_2SO_4 and concentrated

to give a residue, which was sublimed (70°C, 15 mmHg) to give colorless prisms (2 mg), mp 59.5—62°C. The presence of angelic acid and tiglic acid in this sublimate in a ratio of 1: 50 was demonstrated by GLC.[15] GLC conditions: column, SP-1200(10%)+H_3PO_4(1%) on Chromosorb WAW (80—100 mesh) 3 mm×2 m; carrier gas, N_2, 29 ml/min; angelic acid, t_R(min), 6.8; tiglic acid, t_R(min), 9.1.

Acetyldeangeloylgomisin B (20)——A solution of **19** (101 mg)[16a] in a mixture of dry pyridine (0.8 ml) and acetic anhydride (0.3 ml) was kept at 50°C for 8 h, then diluted with H_2O (20 ml) and extracted with ether (15 ml×3). The ethereal extract was washed with 1 N HCl, then with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [$CHCl_3$–EtOH (19: 1)] to give **20** (86 mg) as colorless prisms (from ether–hexane), mp 201—203°C, $[\alpha]_D^{23}$ −52.0° (c=1.27, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3550, 3470 (OH), 1743, 1730 (C=O), 1620, 1592 (aromatic). *Anal.* Calcd for $C_{25}H_{30}O_9$: C, 63.28; H, 6.37. Found: C, 63.05; H, 6.43.

Treatment of 20 with $Pb(OAc)_4$ in Dry Benzene, giving 21——A solution of **20** (84 mg) and $Pb(OAc)_4$ (126 mg) in dry benzene (4 ml) was stirred at 50°C for 8 h, then diluted with ether (45 ml). The total mixture was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (3: 2)]. The zone with *Rf* 0.35 was extracted with $CHCl_3$–MeOH (4: 1). The extract was kept for 24 h at room temperature and concentrated to give **21** (11.5 mg) as a white amorphous powder. Unchanged **20** (16.5 mg) was also recovered in the above PLC. **21**: $[\alpha]_D^{23}$ −70.6° (c=0.510, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3420 (OH), 1720 (C=O), 1595 (aromatic).

Methylation of 21——$(CH_3)_2SO_4$ (0.2 ml) and K_2CO_3 (200 mg) were added to a solution of **21** (11.5 mg) in dry acetone (2 ml). The reaction mixture was treated in the same manner as described for the methylation of **16** to give **22** (8.5 mg) as a white amorphous powder, $[\alpha]_D^{24}$ −57.9° (c=0.570, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}; 3500 (OH), 1734, 1719 (C=O), 1595, 1580 (aromatic).

Hydrolysis of 22——A solution of **22** (14 mg) in dioxane (0.5 ml) and 0.5 M methanolic potassium hydroxide (0.75 ml) was kept at 40°C for 3 h, then diluted with H_2O (10 ml) and extracted with ether (15 ml×3). The combined ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated to dryness. The residue was purified by PLC [hexane–acetone (3: 2)] to give **18** (11.5 mg) as colorless needles (from ether–hexane), mp 190—192.5°C, $[\alpha]_D^{23}$ −96.5° (c=0.508, $CHCl_3$). *Anal.* Calcd for $C_{24}H_{32}O_8$: C, 64.27; H, 7.19. Found: C, 64.36; H, 7.19. This compound was identified as **18** by direct comparison with an authentic sample (IR, $[\alpha]_D$ and mixed mp).

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References and Notes

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