[Chem. Pharm. Bull. 33(11)4912—4915(1985)]

Studies on the Constituents of the Roots of *Cassia torosa*. I.[1] The Structures of Two New Naphthalenic Lactones

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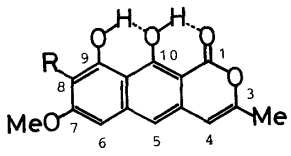
(Received March 22, 1985)

Two new naphtho-α-pyrones, 8-methyltoralactone (**1**) and 8-methyltoralactone 10-methylether (**2**), were isolated from the roots of *Cassia torosa* CAV. along with chrysophanol, chrysophanol-10,10′-bianthrone, physcion, physcion-9-anthrone, emodin and phytosterols (a mixture of stigmasterol, campesterol, and sitosterol). The structures of the two new compounds **1** and **2** were established as 9,10-dihydroxy-7-methoxy-3,8-dimethyl-1*H*-naphtho[2,3-*c*]pyran-1-one and 9-hydroxy-7,10-dimethoxy-3,8-dimethyl-1*H*-naphtho[2,3-*c*]pyran-1-one, respectively, on the basis of spectral and chemical evidence.

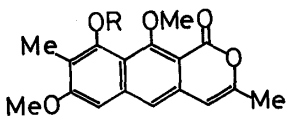
Keywords——*Cassia torosa*; Leguminosae; naphthalenic lactone; anthraquinone; anthrone; 8-methyltoralactone; 8-methyltoralactone 10-methylether

In previous papers,[2–5] we reported the isolation of several anthraquinones and a hydroanthracene, torosachrysone, from the ripe seeds, and physcion-9-anthrone, physcion-10,10′-bianthrone, phytosterols, four hydroanthracenes (anhydrophlegmacin B_2, torosanin, and phlegmacins A_2 and B_2), and torosachrysone 8-β-D-gentiobioside from the unripe seeds of *Cassia torosa* CAV. Recently, we isolated some characteristic hydroanthracenes, germichrysone, germitorosone, methylgermitorosone, and anhydrophlegmacin-9,10-quinones A_2 and B_2, from the seedlings of this plant.[6–8] In this paper, we wish to report the isolation and structural determination of two naphtho-α-pyrone derivatives, 8-methyltoralactone (**1**) and 8-methyltoralactone 10-methylether (**2**), which have been obtained, along with chrysophanol, physcion-9-anthrone, physcion, chrysophanol-10,10′-bianthrone, emodin, and phytosterols, from the roots of this plant. These compounds were obtained from the benzene extract of the fresh roots as described in Experimental.

Five anthracene derivatives were identified as chrysophanol,[6] physcion-9-anthrone,[4] physcion,[6] chrysophanol-10,10′-bianthrone,[9] and emodin[6] by direct comparison with authentic samples. Phytosterols, obtained in the form of colorless needles, mp 150—165 °C, were identified as a mixture of stigmasterol, campesterol, and sitosterol by gas liquid chromatography (GLC).



1: R=Me
3: R=H



2: R=H
4: R=Ac

Chart 1

8-Methyltoralactone (**1**) and 8-methyltoralactone 10-methylether (**2**) showed the characteristic ultraviolet (UV) spectra of naphtho-α-pyrone homologues such as toralactone (**3**).[10]

8-Methyltoralactone 10-methylether (**2**) was obtained as yellow needles; mp 265—267 °C. The high-resolution mass (MS) spectrum gave the molecular formula $C_{17}H_{16}O_5$ as the base peak, and major fragment ions were observed at *m/z* 285 ($M^+ - Me$) and 282 ($M^+ - H_2O$). The characteristic absorptions at 1725, 1630, and 1560 cm^{-1} in the infrared (IR) spectrum suggested the presence of an α-pyrone. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum of **2** showed the presence of two methyl groups, two aromatic methoxyl groups, three aromatic or olefinic protons, and a chelated phenolic hydroxyl group (Table I). The assignments of functional groups were performed on the basis of nuclear Overhauser effect (NOE) and spin-decoupling experiments. In the NOE experiments irradiations of the methoxyl protons at δ 3.95 and two aromatic protons at δ 6.65 and 7.29 increased the area of the signals at δ 6.65 (C_6-H, 23%), δ 7.29 (C_5-H, 17%), and δ 6.19 (C_4-H, 16%), respectively. The irradiation of a methyl (C_3-Me) signal at δ 2.26 changed the quartet at δ 6.19 to a sharp singlet, whereas the irradiation of the other methyl signal at δ 2.24 caused no change. Acetylation with acetic anhydride and pyridine afforded a monoacetate (**4**); mp 280—282.5 °C, $C_{19}H_{18}O_6$. A comparison of the ^{1}H-NMR spectra of **2** and **4** showed that a signal at δ 6.93 (C_6-H) in **4** was shifted downfield by 0.28 ppm relative to that of **2**. On partial demethylation with aluminum chloride in ether, **2** was converted to a monodemethyl compound; mp 299—301 °C, $C_{16}H_{14}O_5$. The ^{1}H-NMR data indicate that the compound has one more chelated hydroxyl group (δ 13.57) and one less methoxyl group (δ 4.15) than **2**. The results indicated that the additional methyl group (δ 2.24) of **2** is located at the C_8-position. Based on these findings, the structure of **2** was established as 9-hydroxy-7,10-dimethoxy-3,8-dimethyl-1*H*-naphtho[2,3-*c*]pyran-1-one.

8-Methyltoralactone (**1**) was obtained as yellow needles; mp 299—302 °C, $C_{16}H_{14}O_5$. By direct comparison, compound **1** was shown to be identical with the above monodemethyl compound which was obtained by partial demethylation of **2**. Therefore, the structure of **1**

TABLE I. ^{1}H-NMR Data for Compounds **1**, **2**, **3**, and **4**[a]

	1	2		3	4
C_3-Me	2.26 d (J=1.0 Hz)	2.26 d (J=1.0 Hz)		2.26 d (J=1.0 Hz)	2.24 d (J=1.0 Hz)
C_4-H	6.20 q (J=1.0 Hz)	6.19 q (J=1.0 Hz)	16%	6.23 q (J=1.0 Hz)	6.18 q (J=1.0 Hz)
C_5-H	6.96 s	7.29 s	17%	6.97 s	7.33 s
C_6-H	6.61 s	6.65 s	23%	6.61 d (J=2.4 Hz)	6.93 s
C_7-OMe	3.93 s	3.95 s		3.90 s	3.97 s
C_8-H				6.53 s (J=2.4 Hz)	
C_8-Me	2.21 s	2.24 s			2.20 s
C_9-OH	9.58 d (J=0.98 Hz)	10.19 s		9.41 d-like	
C_9-OAc					2.45 s
C_{10}-OH	13.57 d (J=0.98 Hz)			13.54 d (J=0.98 Hz)	
C_{10}-OMe		4.15 s			4.00 s

a) Measured in $CDCl_3$ at 100 MHz, with TMS as the internal standard. The following abbreviations are used: s, singlet; d, doublet; q, quartet. Arrows and figures in % indicate enhancement in the NOE experiment.

was shown to be 9,10-dihydroxy-7-methoxy-3,8-dimethyl-1*H*-naphtho[2,3-*c*]pyran-1-one.

In the ^{1}H-NMR of **1**, two chelated C_9 and C_{10}-OH signals (δ 9.58 and 13.57) appeared as doublets (each $J=0.98$ Hz). The irradiation of the chelated hydroxyl signal at δ 9.58 changed the doublet at δ 13.57 to a singlet, whereas irradiations of the aromatic protons (C_5 and C_6-H) at δ 6.96 and 6.61 caused no change. From the results of the above decoupling experiments, the couplings between the two chelated hydroxyl groups may be attributed to a "through-space" mechanism.[11]

Biogenetically, the two naphtho-α-pyrone derivatives may be derived from heptaketide. It is an interesting that these compounds are found only in the growing root, and not in the seeds and seedlings of this plant.

Experimental

All the melting points were taken on a Yanagimoto micromelting-point apparatus and are uncorrected. The UV spectra were obtained on a Hitachi 200-10 spectrophotometer, and the IR spectra were recorded on a JASCO IR A-2 spectrophotometer. The NMR spectra were taken on a JEOL FX-100 instrument; the chemical shifts are given in ppm relative to internal tetramethylsilane (TMS). The MS were obtained on a Hitachi RMU-7M spectrometer. Column chromatography was performed on silicic aicd (SiO_2) (Mallinckrodt).

Extraction and Isolation——The fresh roots (3.5 kg) of *Cassia torosa* CAV. collected at the Drug Plant Garden of the College of Science and Technology, Nihon University, were extracted with C_6H_6 (2 × 7 l) at room temperature. The extract was concentrated *in vacuo* to give a brown mass (7.4 g). The mass was chromatographed on a SiO_2 column and eluted in succession with C_6H_6 and C_6H_6–AcOEt. Fractions 1 and 2 were eluted with C_6H_6, fractions 3 and 4 with C_6H_6–AcOEt (9 : 1), and fraction 5 with C_6H_6–AcOEt (4 : 1). Fraction 1 was rechromatographed with hexane–AcOEt (19 : 1) to give chrysophanol (20 mg), physcion-9-anthrone (8 mg), and physcion (5 mg). Fraction 2 was rechromatographed with C_6H_6 to afford physcion-9-anthrone (11 mg), physcion (45 mg), and chrysophanol-10,10′-bianthrone (18 mg). Fraction 3 gave emodin (30 mg) and phytosterols (26 mg) on column chromatography with C_6H_6–AcOEt (9 : 1).

Phytosterols——Recrystallized from MeOH, mp 150—165 °C. Stigmasterol, campesterol, and sitosterol (22 : 13 : 5) were detected by GLC (isothermally at 250 °C on 3% SE-30/Chromosorb W, N_2, hydrogen flame ionization detector (FID)).

8-Methyltoralactone (1)——Crude crystals were recrystallized from Me_2CO to give yellow prisms; mp 299—302 °C. UV $\lambda_{max}^{dioxane}$ nm (log ε): 250 sh (4.52), 261 sh (4.67), 271 (4.89), 281 (4.98), 291 sh (4.67), 315 (3.62), 331 (3.62), 352 (3.76), 392 (3.94), 410 sh (3.84). IR ν_{max}^{KBr} cm^{-1}: 3400, 2900, 1670, 1630, 1575, 1500. MS *m/z*: 286 (M^+, 100%), 285 (M^+-H, 6), 271 (M^+-Me, 6), 255 (M^+-OMe, 6). High-resolution MS *m/z*: Calcd for $C_{16}H_{14}O_5$: 286.0840. Found: 286.0833. The ^{1}H-NMR data are shown in Table I.

8-Methyltoralactone 10-Methylether (2)——Crude crystals were recrystallized from C_6H_6 to give yellow needles; mp 265—267 °C. UV $\lambda_{max}^{dioxane}$ nm (log ε): 246 sh (4.26), 262 sh (4.57), 272 (4.78), 284 (4.87), 294 sh (4.56), 317 (3.58), 330 (3.57), 389 (3.56). IR ν_{max}^{KBr} cm^{-1}: 3300, 2950, 1725, 1670, 1630, 1600, 1560. MS *m/z*: 330 (M^+, 100%), 285 (M^+-Me, 13), 282 (M^+-H_2O, 12), 267 (M^+-Me-H_2O, 5), 257 ($M^+-Me-CO$, 8). High-resolution MS *m/z*: Calcd for $C_{17}H_{16}O_5$: 300.0996. Found: 300.0973. The ^{1}H-NMR data are shown in Table I.

Acetate (4) of 1——Compound **1** (3 mg) gave a monoacetate (**9**) upon acetylation with Ac_2O–pyridine; this product was recrystallized from MeOH to give a pale yellow powder (2.4 mg); mp 280—282.5 °C. UV $\lambda_{max}^{dioxane}$ nm (log ε): 254 sh (4.21), 264 sh (4.39), 273 (4.64), 284 (4.72), 308 (3.88), 322 (3.87), 399 (3.49), 377 (3.50), 396 sh (3.31). IR ν_{max}^{KBr} cm^{-1}: 1770, 1730, 1670, 1630. High-resolution MS *m/z*: Calcd for $C_{19}H_{18}O_6$: 342.1101. Found: 342.1070. The ^{1}H-NMR data are shown in Table I.

8-Methyltoralactone (1) from 8-Methyltoralactone 10-Methylether (2)——A solution of **2** (5 mg) in dry Et_2O (5 ml) was refluxed with aluminium chloride (50 mg) for 8 h, and then the mixture was evaporated. The residue was taken up in a mixture of AcOH (0.5 ml) and conc. HCl (0.25 ml), and refluxed for 5 min. H_2O was then added and the whole was extracted with AcOEt. The extract was concentrated *in vacuo*, and the residue was purified by SiO_2 column chromatography with C_6H_6 to give the partially demethylated compound (**1**) (2.5 mg) as yellow needles from Me_2CO; mp 299—301 °C. High-resolution MS *m/z*: Calcd for $C_{16}H_{14}O_5$: 286.0840. Found: 286.0844. This product was identical with 8-methyltoralactone (**1**) by direct comparison (thin layer chromatography (TLC), UV, IR, ^{1}H-NMR, and mmp).

Acknowledgements We wish to thank Miss Y. Kimura of the Department of Pharmacy, Nihon University, for IR spectra, and Mr. M. Aimi and Dr. T. Takido of the Analytical Center, College of Science and Technology, Nihon University, for the MS and ^{1}H-NMR spectra.

References and Notes

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