

[Chem. Pharm. Bull.]
33(2) 557-564 (1985)

**Studies on the Constituents of Medicinal and Related Plants in Sri Lanka. II.¹⁾
Isolation and Structures of New γ -Pyrone and Related Compounds
from *Hypericum mysorense* HEYNE**

TOHRU KIKUCHI,* SHIGETOSHI KADOTA, SATOKO MATSUDA,
KEN TANAKA, and TSUNEO NAMBA

Research Institute for Wakan-Yaku (Oriental Medicines), Toyama Medical
and Pharmaceutical University, 2630 Sugitani,
Toyama 930-01, Japan

(Received June 11, 1984)

Neutral constituents of *Hypericum mysorense* HEYNE, collected in Sri Lanka, were examined. Hyperenone-A, mysorenone-A, and compound-C (methyl phenacyl 1,1-dimethylprop-2-enylmalonate) were isolated and their structures were determined on the basis of chemical and spectroscopic evidence. Four known xanthenes were also isolated and identified.

Keywords—*Hypericum mysorense*; Guttiferae; hyperenone-A; γ -pyrone; mysorenone-A; methyl phenacyl 1,1-dimethylprop-2-enylmalonate; xanthone; catalytic hydrogenation

Some plants of *Hypericum* genus (Guttiferae) are used as folk medicines in Sri Lanka and India.²⁾ For instance, *Hypericum perforatum* LINN. was used as an antiseptic or an antihelmintic³⁾ and *H. japonicum* THUNB. as an antidysenteric.²⁾ Chemical investigations of some *Hypericum* species have been done by several groups of workers, and flavonoids, xanthenes, bis-anthraquinones, and other constituents were reported.⁴⁾ In 1979, a chemotaxonomic study on *Hypericum mysorense* HEYNE was carried out by Gunatilaka *et al.*,⁵⁾ who reported the isolation and identification of 2,3-dimethoxyxanthone (II) from the timber of this plant. Recently we also examined the constituents of this plant and isolated four known xanthenes and three new compounds, named hyperenone-A, mysorenone-A, and compound-C. The present paper describes the structure elucidation of these new compounds.

Methanolic extract of dried leaves and twigs of *H. mysorense*, collected in Sri Lanka, was digested successively with ether and ethyl acetate. The ether-soluble portion was roughly separated by silica gel column chromatography and the fractions were further separated by preparative thin layer chromatography to give 2-methoxyxanthone (I),⁶⁾ 2,3-dimethoxyxanthone (II),⁵⁾ 1,7-dihydroxyxanthone (III),⁷⁾ 2-hydroxyxanthone (IV),⁶⁾ mysorenone-A (XI), compound-C (XV), and hyperenone-A (V). Of these, the four xanthenes were identified by comparisons of their melting points (mp) and ultraviolet (UV), infrared (IR), and proton nuclear magnetic resonance (¹H-NMR) spectral data with those reported in the literature.⁵⁻⁷⁾

Hyperenone-A (V), mp 81–82 °C, showed the molecular ion peak at m/z 270 in the mass spectrum (MS), and the microanalytical data were consistent with the molecular formula C₁₇H₁₈O₃, which was confirmed by the high-resolution MS. The UV spectrum of V showed maximum absorptions at 236 nm (log ϵ 4.12) and 276 nm (log ϵ 4.07), indicating the presence of a conjugated aromatic chromophore, and the IR spectrum gave a strong absorption corresponding to a conjugated carbonyl grouping. The ¹H-NMR spectrum exhibited signals due to two *tert*-methyl, a methoxyl, a vinyl, and a mono-substituted phenyl (5H, δ 7.5–7.8) groups and the MS of V showed significant fragment peaks at m/z 105 (C₆H₅CO⁺) and 77 (C₆H₅⁺), suggesting that an oxygenic group is located at the benzylic position.

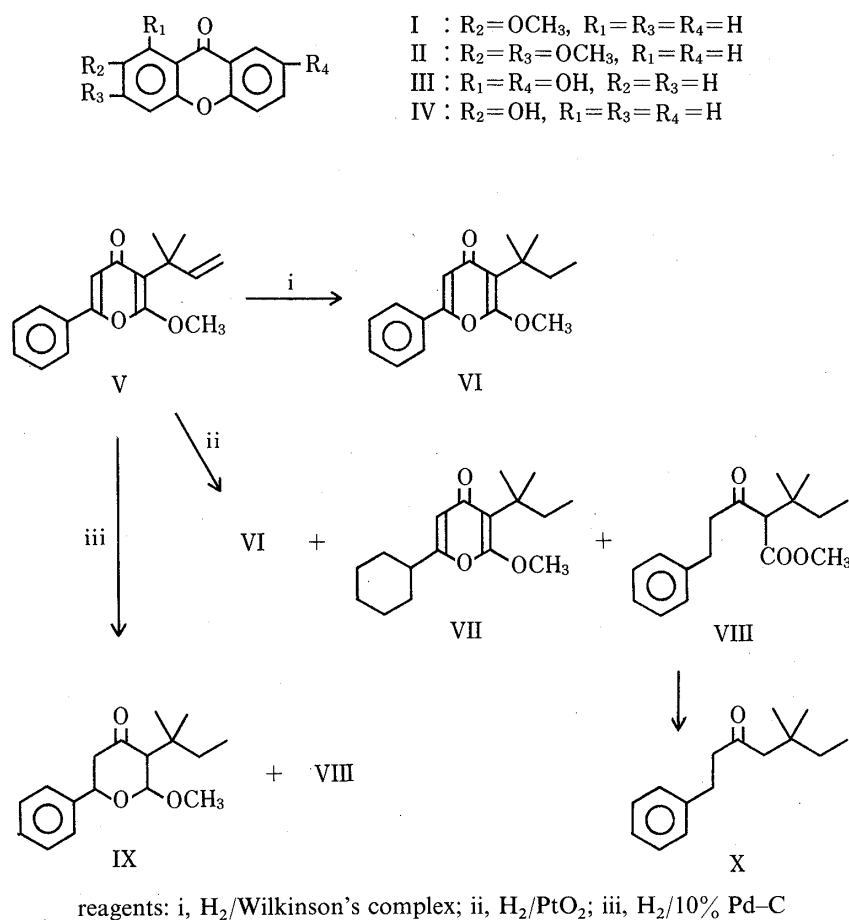


Chart 1

Catalytic reduction of V on Wilkinson's complex afforded only a dihydro compound (VI), mp 125–127 °C, MS m/z 272 (M^+ , C₁₇H₂₀O₃). The ¹H-NMR spectrum of this product (VI) showed characteristic signals at δ 0.76 (3H, t) and 1.84 (2H, q) due to a newly formed ethyl group instead of the vinyl group, while the UV spectrum gave a pattern practically identical with that of the parent compound (V), indicating that the vinyl group is not conjugated with other chromophores.

Similarly, hydrogenation of V on Adams catalyst afforded mainly the same dihydro compound (VI) as above, but in this case two other products were obtained in small amounts. One was an octahydro compound (VII), MS m/z 278 (M^+ , C₁₇H₂₆O₃), which was produced by hydrogenation at the vinyl and phenyl groups in V, as judged from the UV and ¹H-NMR spectral data, and the other was a hexahydro compound (VIII), oil, MS m/z 276 (M^+ , C₁₇H₂₄O₃). On the other hand, catalytic hydrogenation of V using 10% palladium-carbon (Pd-C) afforded the above mentioned VIII and another hexahydro product (IX), MS m/z 276 (M^+ , C₁₇H₂₄O₃).

Compound VIII exhibited IR absorptions at 1715 cm⁻¹ (CO) and 1740 cm⁻¹ (ester), and in the ¹H-NMR spectrum it showed partly overlapped multiplets at δ 2.75–3.00 due to two newly formed methylene groups and a one-proton singlet at δ 3.43 along with the signals arising from the ethyl, *tert*-methyl, methoxyl, and phenyl protons.

Treatment of VIII with potassium hydroxide in aqueous methanol, followed by refluxing in acidic medium, gave rise to an oily decarboxylated compound (X), MS m/z 218 (M^+ , C₁₅H₂₂O), in the ¹H-NMR spectrum of which the methoxyl signal and the one-proton singlet had disappeared and, instead, a multiplet due to two protons newly appeared at δ 2.10. Thus,

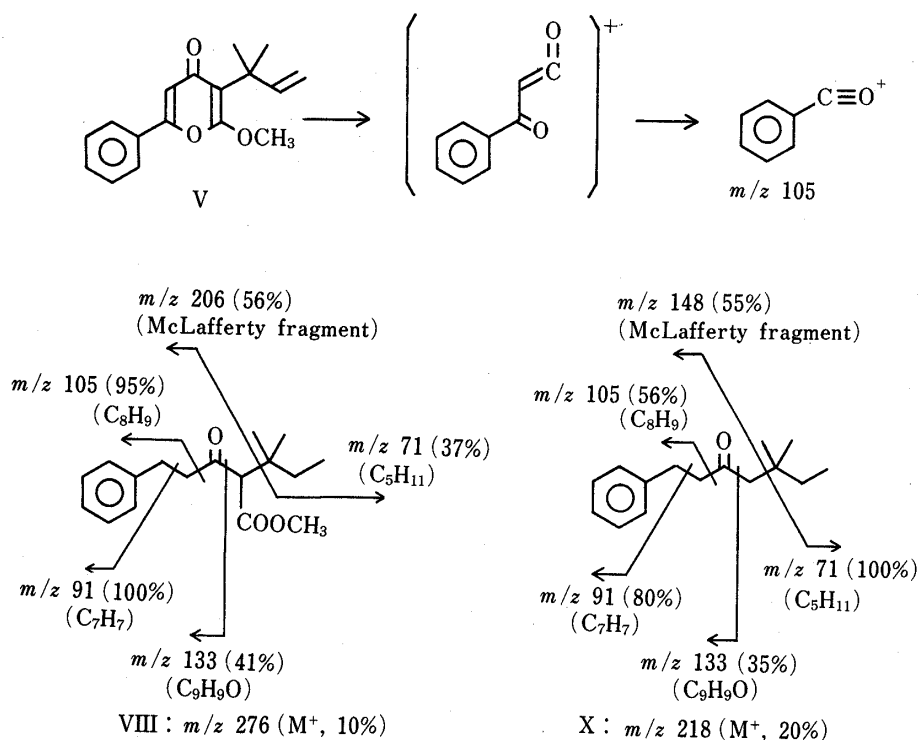


Fig. 1

compound VIII should be a β -keto ester.

From these findings, coupled with the fact that the mass spectra of VIII and X could be interpreted as shown in Fig. 1, this hexahydro compound was deduced to have the structure VIII.

The other hexahydro product (IX) exhibited a carbonyl absorption at 1715 cm^{-1} in the IR spectrum. In the $^1\text{H-NMR}$ spectrum, it showed three characteristic double doublets at $\delta 2.54$ ($J=3$, 17 Hz), 3.01 ($J=13$, 17 Hz), and 5.18 ($J=3$, 13 Hz) and a pair of doublets at $\delta 2.74$ and 5.16 ($J=3$ Hz), which could be reasonably ascribed to the partial structure $-\text{O}-\text{CH}-\text{CH}_2-\text{CO}-\text{CH}-\text{CH}(\text{OCH}_3)-\text{O}-$, besides the signals due to the ethyl, two *tert*-methyl, methoxyl, and phenyl groups. The mutual coupling relations among these signals were fully analyzed by detailed decoupling experiments.

Thus, the structure of the above product should be IX, and accordingly the structure of hyperenone-A should be represented by the formula V. Formation of the fragment ion at m/z 105 in the MS of V can be explained reasonably on the basis of retro-Diels-Alder fragmentation (Fig. 1).⁸⁾

Mysorenone-A (XI), oil, showed the M^+ peak at m/z 288 in the MS and its molecular formula was determined to be $\text{C}_{17}\text{H}_{20}\text{O}_4$ by the high-resolution MS. The IR spectrum of XI revealed absorptions at 3100 (OH), 1740 (ester), and 1605 cm^{-1} (conjugated CO) and the UV spectrum showed a strong absorption at 321 nm ($\log \epsilon$ 4.04). The $^1\text{H-NMR}$ spectrum of XI was characterized by the appearance of three singlets at $\delta 3.38$ (methine proton flanked by two carbonyl groups), 6.42 (olefinic proton), and 16.17 (hydroxyl proton) in addition to diagnostic signals due to a phenyl, a vinyl, a methoxyl, and two *tert*-methyl groups. The MS showed significant fragment peaks at m/z 105 ($\text{C}_6\text{H}_5\text{CO}^+$), 147 ($\text{C}_6\text{H}_5\text{COCH}_2\text{CO}^+$), and 220 ($\text{M}^+ - \text{C}_5\text{H}_8$, McLafferty fragment) (Fig. 2), suggesting the presence of an oxygenic function at the benzylic position and a *tert*-pentenyl group in XI.

Catalytic hydrogenation of mysorenone-A (XI) on Adams catalyst yielded a dihydro compound (XII), MS m/z 290 (M^+), and an octahydro compound (XIII), MS m/z 296 (M^+),

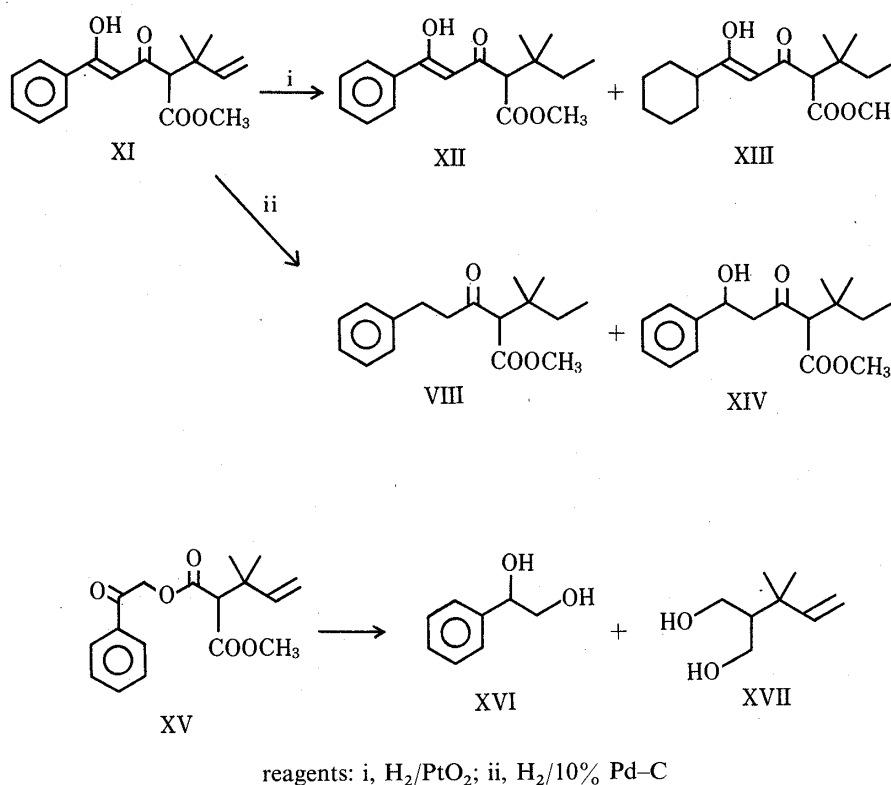


Chart 2

as in the case of hyperenone-A (V). The UV spectrum of XII was practically the same as that of the parent compound (XI) and the $^1\text{H-NMR}$ spectrum exhibited new signals assignable to an ethyl group instead of the vinyl group, whereas the $^1\text{H-NMR}$ spectrum of XIII showed signals ascribable to an ethyl and a cyclohexyl group instead of the vinyl and the phenyl group. It is now evident that the vinyl group is not conjugated with other unsaturated groups.

On the other hand, hydrogenation of XI on Pd-C gave a tetrahydro compound (XIV) and a deoxo compound (VIII), which was proved to be identical with VIII obtained by hydrogenation of hyperenone-A (V). The MS of the former product (XIV) failed to give the molecular ion peak, but it showed the dehydrated ion peak at m/z 274 along with other significant peaks at m/z 204 ($\text{M}^+ - \text{H}_2\text{O} - \text{C}_5\text{H}_{10}$, McLafferty fragment), 131 ($\text{C}_6\text{H}_5\text{CH}=\text{CHCO}^+$, base peak), and 103 ($\text{C}_6\text{H}_5\text{CH}=\text{CH}^+$), and the $^1\text{H-NMR}$ spectrum showed signals at δ 5.19 (1H, dt, $J=3, 6$ Hz), 3.22 (1H, d, $J=3$ Hz), and 2.93 (2H, d, $J=6$ Hz), corresponding to the partial structure $-\text{CH}(\text{OH})-\text{CH}_2-\text{CO}-$. Compound VIII is presumably produced by hydrogenolysis of XIV.

Based on the above results, the structure of mysorenone-A should be represented by the formula XI.

It is particularly interesting that the catalytic hydrogenation of both V and XI with Adams catalyst proceeded preferentially at the phenyl group rather than the γ -pyrone or enolic double bond in sharp contrast to the result observed with Pd-C.

Compound-C (XV) was isolated as a colorless oil in small amount and its molecular formula was determined to be $\text{C}_{17}\text{H}_{20}\text{O}_5$ by the MS and high-resolution MS. The $^1\text{H-NMR}$ spectrum of XV closely resembled that of mysorenone-A (XI) except for the appearance of a pair of doublets due to methylene protons at δ 5.35 and 5.50 (each 1H, $J=16$ Hz) and its MS gave peaks at m/z 136 ($\text{C}_8\text{H}_8\text{O}_2^+$) and 168 ($\text{C}_9\text{H}_{12}\text{O}_3^+$), together with peaks at m/z 105, 141, and 236 (Fig. 2), suggesting that it might be an ester-type compound having the formula XV. Furthermore, the IR spectrum showed carbonyl absorptions at 1760 and 1740 cm^{-1} in

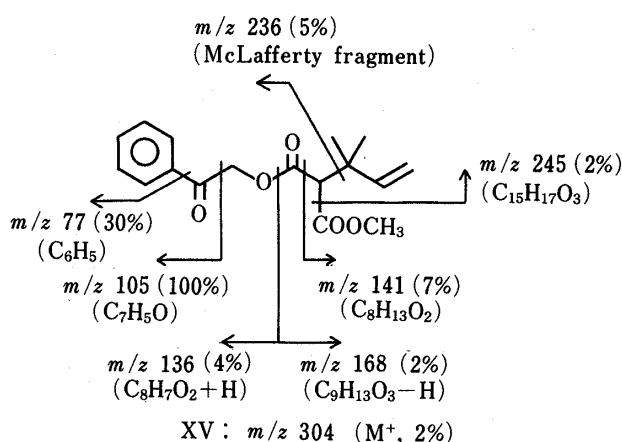
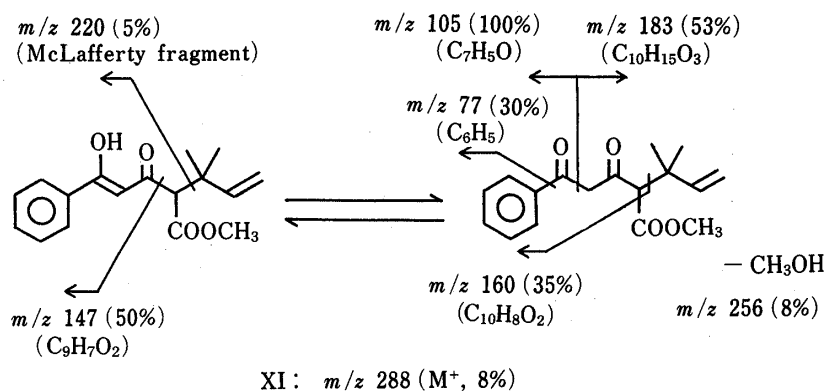


Fig. 2

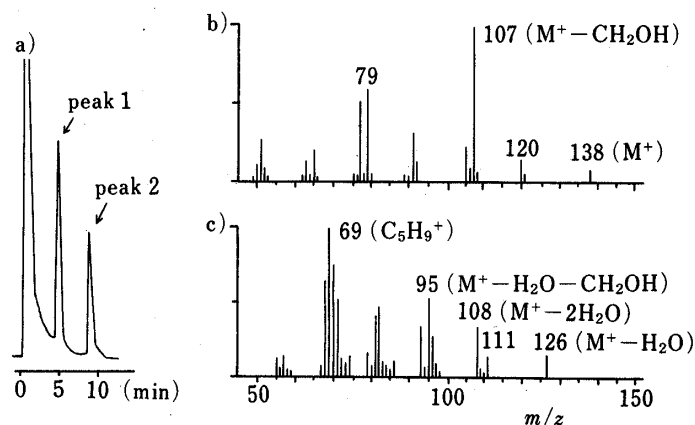


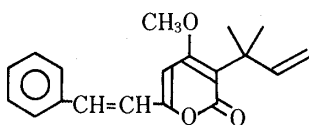
Fig. 3. Gas Chromatogram and GC-MS of the Reduction Product of Compound-C (XV)

a) Gas chromatogram. b) Mass spectrum of peak 2. c) Mass spectrum of peak 1.

accordance with the presumed malonate ester structure.⁹⁾

As expected, lithium aluminum hydride reduction of XV afforded a mixture of diols (XVI and XVII), which gave two peaks on gas chromatography (GC) (Fig. 3). The GC-MS of the later peak (Fig. 3) showed the molecular ion peak at m/z 138 ($C_8H_{10}O_2$), and this product was found to be identical with authentic α,β -dihydroxyethylbenzene (XVI).¹⁰⁾ The MS corresponding to the earlier GC peak showed a peak at m/z 126 assignable to the ($M^+ - H_2O$) ion, although the molecular ion peak was not observed. The other fragment ion peaks given in Fig.

3, c) could be rationalized in terms of the presumed formula XVII. Thus, compound-C is concluded to be methyl phenacyl 1,1-dimethylprop-2-enylmalonate (XV).



XVIII

Chart 3

It is worth noting here that mundulea lactone (XVIII), which is closely related to hyperenone-A, was reported to be a constituent of *Mundulea suberosa* BENTH. (Leguminosae).¹¹⁾

Experimental

Melting points were determined on a Kofler-type apparatus and are uncorrected. UV spectra were taken in EtOH solutions and IR spectra in CHCl_3 solutions unless otherwise noted. $^1\text{H-NMR}$ spectra were measured on a Varian XL-200 spectrometer in CDCl_3 solutions using tetramethylsilane as an internal standard. MS and high-resolution MS were obtained with a JEOL JMS-D 300 spectrometer (ionization voltage, 70 eV; accelerating voltage, 30 eV) using a direct inlet system or a GC injection system (2% OV-17 2 m $\times$ 2 mm i.d. glass column at column temperature 120–200 °C, carrier gas He) and the relative intensities (%) of peaks are given in parentheses. GC was done on a Shimadzu GC-6AM instrument with a 2% OV-17 column (2 m $\times$ 3 mm i.d. glass tube; injection temperature, 220 °C; column temperature, 200 °C; carrier gas, N_2). Column chromatography was carried out using Mallinckrodt silica gel and the eluates were concentrated *in vacuo*. For thin layer chromatography (TLC), Merck Kieselgel 60 F₂₅₄ was used and spots were detected under UV light or by coloration with $\text{Ce}(\text{SO}_4)_2\text{-H}_2\text{SO}_4$ reagent. For preparative TLC, Merck Kieselgel PF₂₅₄ or F₂₅₄ (0.5 mm) was employed and plates were examined under UV light. Extraction of substances from silica gel was done with $\text{MeOH-CH}_2\text{Cl}_2$ mixture (5:95 or 1:9) and extracts were concentrated *in vacuo*.

Extraction, Isolation and Properties of Xanthenes and New Compounds from *H. mysorens*—Air-dried leaves and twigs (120 g), collected at Horton Plains, Sri Lanka in the flowering season (January, 1982), were extracted with refluxing MeOH (500 ml $\times$ 3) for 3 h and the combined extract was concentrated *in vacuo*. The residue (20 g) was digested successively with ether and ethyl acetate to give the ether-soluble fraction (1.9 g) and the ethyl acetate-soluble fraction (2 g).

The ether-soluble fraction was chromatographed on silica gel (60 g) and eluted successively with CH_2Cl_2 (F-1 and F-2), 2% $\text{MeOH-CH}_2\text{Cl}_2$ (F-3), and 3% $\text{MeOH-CH}_2\text{Cl}_2$ (F-4).

F-2 (0.4 g) was then separated by preparative TLC with CHCl_3 , and the less polar fraction was recrystallized from ether–hexane to give 2-methoxyxanthone (I) (3 mg), colorless needles, mp 133–134 °C. The more polar fraction (mixture) was further separated by preparative TLC with benzene as the eluent, giving mysorenone-A (XI) (35 mg), slightly colored oil, from the upper zone and compound-C (XV) (4 mg), colorless oil, from the lower zone.

F-3 (0.17 g) was further separated by preparative TLC with MeOH-CHCl_3 (2:98) as the eluent to give 2,3-dimethoxyxanthone (II) (7 mg), colorless needles from isopropyl ether–hexane, mp 163–166 °C.

F-4 (0.38 g) was also separated by preparative TLC with MeOH-CHCl_3 (2:98). The least polar fraction gave hyperenone-A (V) (120 mg) after recrystallization from isopropyl ether–hexane and the next most polar fraction gave 1,7-dihydroxyxanthone (III) (5 mg), yellow needles from CHCl_3 , mp 239–242 °C. The most polar fraction gave 2-hydroxyxanthone (IV) (4 mg), yellowish needles from CHCl_3 , mp 240–242 °C.

Hyperenone-A (V): Colorless prisms, mp 81–82 °C. UV λ_{max} nm (log ϵ): 236 (4.12), 276 (4.07); IR ν_{max} cm^{-1} : 1650, 1605, 1560 (γ -pyrone). $^1\text{H-NMR}$ δ : 1.51 (3H $\times$ 2, s, *tert*- CH_3), 4.10 (3H, s, OCH_3), 4.92, 4.98 (each 1H, dd, $J = 2, 11$ Hz, and $J = 2, 17$ Hz, respectively; $=\text{CH}_2$), 6.23 (1H, dd, $J = 12, 17$ Hz, $=\text{CH}$), 6.65 (1H, s, $=\text{CH}$), 7.52 (3H, m, aromatic protons), 7.74 (2H, m, aromatic protons). MS m/z (rel. int. %): 270 (M^+ , 25), 255 ($\text{M}^+ - \text{CH}_3$, 100), 241 (30), 239 ($\text{M}^+ - \text{OCH}_3$, 22), 227 (25), 105 (98), 77 (76). High-resolution MS: Found 270.1226, Calcd for $\text{C}_{17}\text{H}_{18}\text{O}_3$ (M^+) 270.1255; Found 255.1008, Calcd for $\text{C}_{16}\text{H}_{15}\text{O}_3$ 255.1020; Found 241.0878, Calcd for $\text{C}_{15}\text{H}_{13}\text{O}_3$ 241.0864; Found 239.1001, Calcd for $\text{C}_{16}\text{H}_{15}\text{O}_2$ 239.1071; Found 227.0799, Calcd for $\text{C}_{14}\text{H}_{11}\text{O}_3$ 227.0708; Found 105.0375, Calcd for $\text{C}_7\text{H}_5\text{O}$ 105.0340; Found 77.0401, Calcd for C_6H_5 77.0391. Anal. Calcd for $\text{C}_{17}\text{H}_{18}\text{O}_3$: C, 75.53; H, 6.85. Found: C, 75.49; H, 6.85.

Mysorenone-A (XI): Slightly colored oil, UV λ_{max} nm (log ϵ): 220 (3.63), 250 (3.57), 321 (4.04); IR ν_{max} cm^{-1} : 3100, 1740, 1605, 1580. $^1\text{H-NMR}$ δ : 1.23, 1.24 (each 3H, s, *tert*- CH_3), 3.38 (1H, s, CO-CH-CO), 3.71 (3H, s, OCH_3),

5.05 (2H, m, =CH₂), 6.09 (1H, dd, $J=12, 17$ Hz, =CH), 6.42 (1H, s, HO-C=CH), 7.50 (3H, m, aromatic protons), 7.91 (2H, m, aromatic protons), and 16.17 (1H, s, HO-C=CH; disappeared on addition of D₂O). MS: see Fig. 2. High-resolution MS: Found 288.1363, Calcd for C₁₇H₂₀O₄ 288.1361; Found 256.1131, Calcd for C₁₆H₁₆O₃ 256.1099; Found 183.1009, Calcd for C₁₀H₁₅O₃ 183.1021; Found 160.0529, Calcd for C₁₀H₈O₂ 160.0524; Found 147.0398, Calcd for C₉H₇O₂ 147.0446; Found 105.0348, Calcd for C₇H₅O 105.0340; Found 77.0366, Calcd for C₆H₅ 77.0391.

Compound-C (XV): Colorless oil, UV $\lambda_{\max}$ nm (log ϵ): 243 (3.99) 282 (3.15); IR $\nu_{\max}$ cm⁻¹: 1760, 1740, 1710. ¹H-NMR δ : 1.35, 1.36 (each 3H, s, *tert*-CH₃), 3.62 (1H, s, CO-CH-CO), 3.78 (3H, s, OCH₃), 5.13 (2H, m, =CH₂), 5.35, 5.50 (each 1H, d, $J=16$ Hz, CO-CH₂-O), 6.16 (1H, dd, $J=11, 17$ Hz, =CH), 7.62 (3H, m, aromatic protons), and 7.98 (2H, m, aromatic protons). MS: see Fig. 2. High-resolution MS: Found 304.1282, Calcd for C₁₇H₂₀O₅ 304.1311; Found 245.1174, Calcd for C₁₅H₁₇O₃ 245.1177; Found 236.0665, Calcd for C₁₂H₁₂O₅ 236.0684; Found 168.0817, Calcd for C₉H₁₂O₃ 168.0786; Found 141.0896, Calcd for C₈H₁₃O₂ 141.0915; Found 136.0548, Calcd for C₈H₈O₂ 136.0524; Found 105.0339, Calcd for C₇H₅O 105.0340; Found 77.0385, Calcd for C₆H₅ 77.0391.

Catalytic Hydrogenation of Hyperenone-A (V)—1) With Wilkinson Complex: Hyperenone-A (V) (5 mg) was hydrogenated in benzene (1 ml) with tris(phenyl)phosphine-rhodium chloride (1 mg) for 12 h. The reaction mixture was purified by preparative TLC with MeOH-CHCl₃ (2:98) and then recrystallized from ether-hexane to give dihydrohyperenone-A (VI) (4.5 mg), plates, mp 125–127 °C, UV $\lambda_{\max}$ nm (log ϵ): 236 (4.05) 276 (4.01); IR $\nu_{\max}$ cm⁻¹: 1650, 1603, 1560. ¹H-NMR δ : 0.76 (3H, t, $J=7$ Hz, CH₃CH₂-), 1.38 (3H $\times$ 2, s, *tert*-CH₃), 1.84 (2H, q, $J=7$ Hz, CH₃CH₂-), 4.08 (3H, s, OCH₃), 6.59 (1H, s, =CH), 7.50 (3H, m, aromatic protons), 7.74 (2H, m, aromatic protons). MS m/z (rel. int. %): 272 (M⁺, 40), 257 (M⁺ - CH₃, 100), 243 (M⁺ - C₂H₅, 40), 241 (M⁺ - OCH₃, 20), 229 (80), 216 (98), 201 (30), 141 (70), 105 (30), 77 (20). High-resolution MS: Found 272.1423, Calcd for C₁₇H₂₀O₃ 272.1412; Found 257.1196, Calcd for C₁₆H₁₇O₃ 257.1178; Found 243.0974, Calcd for C₁₅H₁₅O₃ 243.1021; Found 241.1192, Calcd for C₁₆H₁₇O₂ 241.1123; Found 229.0839, Calcd for C₁₄H₁₃O₃ 229.0865; Found 216.0778, Calcd for C₁₃H₁₂O₃ 216.0786; Found 201.0579, Calcd for C₁₂H₉O₃ 201.0552; Found 141.0554, Calcd for C₇H₉O₃ 141.0552; Found 105.0339, Calcd for C₇H₅O 105.0340; Found 77.0377, Calcd for C₆H₅ 77.0391.

2) With Adams Catalyst: V (5 mg) was hydrogenated in MeOH (0.5 ml) with PtO₂ (1 mg) for 36 h. After removal of the catalyst by filtration, the reaction mixture was concentrated *in vacuo* and the residue was separated by preparative TLC using acetone-CHCl₃ (1:99). The most polar band afforded dihydrohyperenone-A (1.9 mg), mp 125–127 °C, identical with the above mentioned VI. The next most polar band gave an octahydro compound (VII) (0.5 mg), oil, UV $\lambda_{\max}$ nm (log ϵ): 215 (3.62) and 260 (3.51). ¹H-NMR δ : 0.71 (3H, t, $J=7$ Hz, CH₃CH₂-), 1.30 (3H $\times$ 2, s, *tert*-CH₃), 1.79 (2H, q, $J=7$ Hz, CH₃CH₂-), 2.37 (1H, m), 3.91 (3H, s, OCH₃), and 5.91 (1H, s, =CH). MS m/z (rel. int. %): 278 (M⁺, 22), 263 (M⁺ - CH₃, 95), 249 (M⁺ - C₂H₅, 75), 235 (100), and 222 (65).

The least polar band afforded a hexahydro compound (VIII) (0.4 mg), oil, UV $\lambda_{\max}$ nm (log ϵ): 209 (3.98) and 270 (3.31); IR $\nu_{\max}$ cm⁻¹: 1740 and 1715. ¹H-NMR δ : 0.82 (3H, t, $J=7$ Hz, CH₃CH₂-), 1.01, 1.03 (each 3H, s, *tert*-CH₃), 1.40 (2H, q, $J=7$ Hz, CH₃CH₂-), 2.70–3.00 (4H, m, C₆H₅-CH₂CH₂-CO), 3.46 (1H, s, CO-CH-CO), 3.65 (3H, s, OCH₃), and 7.14–7.26 (5H, m, aromatic protons). MS: see Fig. 1. High-resolution MS: Found 276.1706, Calcd for C₁₇H₂₄O₃ 276.1725; Found 206.0917, Calcd for C₁₂H₁₄O₃ 206.0943; Found 133.0658, Calcd for C₉H₉O 133.0653; Found 105.0695, Calcd for C₈H₉ 105.0704; Found 91.0552, Calcd for C₇H₇ 91.0547; Found 71.0848, Calcd for C₅H₁₁ 71.0860.

3) With Pd-C: In the same manner as above, hydrogenation of V (5 mg) with 10% Pd-C (1 mg) was carried out in MeOH (0.5 ml) for 9 h, and two products were detected by TLC. The reaction mixture was separated by preparative TLC with AcOEt-hexane (1:9) as the eluent and the lower band gave the hexahydro compound (VIII) (0.9 mg), which was identical with the sample (VIII) obtained in 2). The upper band gave another hexahydro compound (IX) (0.4 mg), colorless oil, UV $\lambda_{\max}$ nm (log ϵ): 212 (3.86) 256 (1.96); IR $\nu_{\max}$ cm⁻¹: 1715. ¹H-NMR δ : 0.86 (3H, t, $J=7$ Hz, CH₃CH₂-), 1.05, 1.12 (3H $\times$ 2, s, *tert*-CH₃), 1.55 (2H, m, CH₃CH₂-), 2.54, 3.01 (each 1H, dd, $J=3, 17$ Hz and $J=13, 17$ Hz, respectively, CO-CH₂), 2.74 (1H, d, $J=3$ Hz, CO-CH), 3.57 (3H, s, OCH₃), 5.16 (1H, d, $J=3$ Hz, O-CH-OCH₃), 5.18 (1H, dd, $J=3, 13$ Hz, C₆H₅-CH-O), and 7.35–7.60 (5H, m, aromatic protons). MS m/z (rel. int. %): 276 (M⁺, 1), 245 (M⁺ - OCH₃, 5), 216 (M⁺ - HCO₂CH₃, 45), 175 (M⁺ - OCH₃-C₅H₁₀, 75), 104 (90), 99 (100), 77 (41). High-resolution MS: Found 276.1655, Calcd for C₁₇H₂₄O₃ 276.1725; Found 245.1478, Calcd for C₁₆H₂₁O₂ 245.1541; Found 216.1521, Calcd for C₁₅H₂₀O 216.1514; Found 175.0813, Calcd for C₁₁H₁₁O₂ 175.0759; Found 104.0605, Calcd for C₈H₈ 104.0626; Found 99.0784, Calcd for C₆H₁₁O 99.0810; Found 77.0390, Calcd for C₆H₅ 77.0391.

Hydrolysis and Decarboxylation of the Hexahydro Compound VIII—To a solution of VIII (0.3 mg) in MeOH (0.1 ml) was added 2% NaOH-H₂O (0.1 ml) and the mixture was heated in a water bath for 15 min. The mixture was then made acidic by the addition of 5% HCl (0.1 ml) and heated for 30 min. After evaporation of the solvent, the product was taken up in CH₂Cl₂ and examined by GC-MS. MS: see Fig. 1. High-resolution MS: Found 218.1639, Calcd for C₁₅H₂₂O 218.1670; Found 148.0828, Calcd for C₁₀H₁₂O 148.0888; Found 133.0664, Calcd for C₉H₉O 133.0653; Found 105.0708, Calcd for C₈H₉ 105.0704; Found 91.0534, Calcd for C₇H₇ 91.0547; Found 71.0849, Calcd for C₅H₁₁ 71.0860.

Catalytic Hydrogenation of Mysorenone-A (XI)—1) With Adams Catalyst: Mysorenone-A (XI) (3 mg) was hydrogenated with PtO₂ (1 mg) in MeOH (0.3 ml) for 12 h and the reaction mixture was separated by preparative

TLC using AcOEt–hexane (1 : 9) as the eluent. The more polar fraction gave dihydromysorenone-A (XII) (0.9 mg), oil, UV $\lambda_{\max}$ nm (log ϵ): 217 (3.13), 252 (3.08), 319 (3.59). $^1\text{H-NMR}$ δ : 0.88 (3H, t, $J=7$ Hz, CH_3CH_2), 1.09, 1.10 (each 3H, s, *tert*- CH_3), 1.47 (2H, q, $J=7$ Hz, CH_3CH_2), 3.37 (1H, s, CO–CH–CO), 3.72 (3H, s, OCH_3), 6.47 (1H, s, =CH), 7.50 (3H, m, aromatic protons), 7.93 (2H, m, aromatic protons), and 16.22 (1H, s, enolic OH). MS m/z (rel. int. %): 290 (M^+ , 1), 259 ($\text{M}^+ - \text{OCH}_3$, 2), 220 (McLafferty fragment, 65), 188 (McLafferty fragment – OCH_3 , 30), 160 (75), 147 (100), 143 (8), 105 ($\text{C}_6\text{H}_5\text{CO}^+$, 95), 77 (30). The less polar fraction afforded octahydromysorenone-A (XIII) (0.6 mg), oil, UV $\lambda_{\max}$ nm (log ϵ): 282 (3.40). $^1\text{H-NMR}$ δ : 0.88 (3H, t, $J=7$ Hz, CH_3CH_2), 1.04, 1.06 (each 3H, s, *tert*- CH_3), 1.40 (2H, q, $J=7$ Hz, CH_3CH_2), 2.20 (1H, m), 3.34 (1H, s, CO–CH–CO), 3.70 (3H, s, CO_2CH_3), 5.76 (1H, s, =CH), and 15.70 (1H, s, enolic OH). MS m/z (rel. int. %): 296 (M^+ , 1), 265 ($\text{M}^+ - \text{OCH}_3$, 5), 226 (McLafferty fragment, 60), 194 (60), 153 (95), 143 (100), 111 (97), and 83 (97).

2) With Pd–C: XI (5 mg) was hydrogenated with 10% Pd–C (1 mg) in MeOH (1 ml) for 12 h, and after removal of the catalyst, the mixture was separated by preparative TLC with benzene. The less polar fraction gave a deoxo product (VIII) (1.5 mg), oil, MS m/z : 276 (M^+ , $\text{C}_{17}\text{H}_{24}\text{O}_3$), which was identical with the hexahydro product (VIII) obtained from hyperenone-A in all respects. The more polar fraction gave a tetrahydro compound (XIV) (1.5 mg), oil, IR $\nu_{\max}$ cm^{-1} : 3500, 1740, 1710. $^1\text{H-NMR}$ δ : 0.86 (3H, t, $J=7$ Hz, CH_3CH_2), 1.08 (3H $\times$ 2, s, *tert*- CH_3), 1.44 (2H, q, $J=7$ Hz, CH_3CH_2), 2.93 (2H, d, $J=6$ Hz, CO– CH_2), 3.22 (1H, d, $J=3$ Hz, CH–OH), 3.50 (1H, s, CO–CH–CO), 3.70 (3H, s, CO_2CH_3), 5.19 (1H, dt, $J=3, 6$ Hz, CH–OH), 7.30–7.40 (5H, m, aromatic protons). MS m/z (rel. int. %): 274 ($\text{M}^+ - \text{H}_2\text{O}$, 1), 204 (McLafferty fragment, 25), 144 (20), 131 (100), 103 (25), 77 (15).

Lithium Aluminum Hydride Reduction of Compound-C (XV)—Excess of lithium aluminum hydride was added to a solution of XV (0.5 mg) in dry ether (0.1 ml) and the mixture was stirred for 1 h at room temperature. After decomposition of the excess reagent by addition of a small amount of H_2O , the precipitate was removed by filtration and washed thoroughly with ether. The ether solution was concentrated to give a small amount of oily residue (a mixture of XVI and XVII). This was examined by GC and GC-MS, and peak 2 was identified as α, β -dihydroxyethylbenzene (XVI) by direct comparisons with an authentic sample.¹⁰⁾

Acknowledgement This work was supported in part by a Grant-in-Aid for Overseas Scientific Survey from the Ministry of Education, Science, and Culture, and also grants from the Division of Drug Industry of Toyama Prefecture administration and the Pharmaceutical Industry Division of Toyama City administration, which are gratefully acknowledged.

References and Notes

- 1) T. Kikuchi, S. Matsuda, S. Kadota, Y. Sakai, T. Namba, K. Watanabe, and R. B. Dissanayake, *Chem. Pharm. Bull.*, **32**, 3906 (1984).
- 2) R. N. Chopra, J. C. Chopra, K. L. Handa, and L. D. Kapur, "Chopra's Indigenous Drugs of India," 2nd ed., U. N. Dhur & Sons Private Ltd., Calcutta, 1958, p. 597, 605.
- 3) T. A. Chistik, *Farmakol. Toksikol.* (Moscow), **20**, 76 (1957).
- 4) N. P. Maksyutina and D. G. Kolesnikov, *Med. Prom. SSSR*, **18**, 41 (1964); P. Lebreton and N. P. Bouchez, *Plant. Med. Phyther.*, **1**, 188 (1967); G. H. Stout, V. F. Stout, and M. J. Welsh, *Tetrahedron*, **19**, 667 (1963); E. Ritchie and W. C. Taylor, *Tetrahedron Lett.*, **1964**, 1431; C. Mathis and G. Ourisson, *Phytochemistry*, **2**, 157 (1963); T. Kariyone and N. Kawano, *Yakugaku Zasshi*, **73**, 204 (1953); H. Brockmann, F. Pohl, K. Maier, and M. N. Haschad, *Justus Liebigs Ann. Chem.*, **533**, 1 (1953); H. Brockmann and R. Muhlmann, *Chem. Ber.*, **81**, 467 (1948); H. Brockmann and R. Muhlmann, *ibid.*, **82**, 348 (1949); H. Brockmann, R. Neff, and E. Muhlmann, *ibid.*, **83**, 467 (1950); H. Brockmann, F. Lindenmann, K. H. Ritter, and F. Depke, *ibid.*, **83**, 583 (1950); H. Brockmann and R. Randebruck, *ibid.*, **84**, 533 (1951); C. Matis and G. Ourisson, *Phytochemistry*, **3**, 115 (1964).
- 5) A. A. Gunatilaka, S. Balasubramaniam, and V. Kumar, *Phytochemistry*, **18**, 182 (1979).
- 6) K. Mizutani, K. Miyazaki, K. Ishigaki, and H. Hosoya, *Bull. Chem. Soc. Jpn.*, **47**, 1596 (1974).
- 7) R. A. Finnegan and J. K. Patel, *J. Chem. Soc., Perkin Trans. 1*, **1972**, 1896.
- 8) G. Kerasaint, M. C. Goetschel, and C. Mentzer, *Bull. Soc. Chim. Fr.*, **5**, 1966 (1963).
- 9) R. A. Abramovitch, *Can. J. Chem.*, **36**, 151 (1958).
- 10) α, β -Dihydroxyethylbenzene (XVI), mp 65–66°C, was prepared by the reduction of 2-hydroxyacetophenone (Tokyo Kasei Kogyo Co., Ltd.) with lithium aluminum hydride in the usual manner. See N. A. Milas and S. Sussman, *J. Am. Chem. Soc.*, **59**, 2425 (1937).
- 11) V. R. Lalitha, G. Srimannarayana, and N. V. Subba Rao, *Current Sci.*, **35**, 410 (1966).