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STRUCTURE OF CLAUDIMERIN-A, A NOVEL DIMERIC COUMARIN FROM *CITRUS HASSAKU*

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The chemical structure of claudimerin-A (**1**), a novel dimeric coumarin from roots of *Citrus hassaku* (Rutaceae), have been elucidated by spectrometric studies and a single crystal X-ray analysis. The structure of **1** consisted of two clausarin (**2**) units linked symmetrically with the forming of the pyranopyran ring.

KEYWORDS coumarin; *Citrus hassaku*; claudimerin-A; crystal structure; dimer; Rutaceae

In our continuing studies on the constituents of *Citrus* plants,1) many kinds of novel coumarins have been isolated and their structures characterized. We here describe the structure of a novel dimeric coumarin named claudimerin-A (**1**) obtained from *C. hassaku* Hort. ex Y. Tanaka (Rutaceae).2)

Claudimerin-A (**1**) was isolated as colorless cubes (21.3 mg), mp 318 - 320°C, $[\alpha]_D \pm 0°$ ($CHCl_3$), from the acetone extract of dried roots (3.2 kg) of the plant.3) The molecular formula $C_{48}H_{54}O_8$ [M^+ 758.3821. Calcd. 758.3819] was confirmed by a high-resolution MS. The presence of a 5,7-dioxygenated coumarin nucleus in the molecule was suggested by the UV [λ_{max} (EtOH): 212, 244 (sh.), 266, 292, and 328 nm] and IR [ν_{max} ($CHCl_3$): 1715, 1620, and 1600 cm^{-1}] spectra.4) The number of the ^1H signals as well as the ^{13}C signals5) in ^1H- and ^{13}C-NMR spectra, respectively, was half of that expected from the molecular formula, suggesting that **1** had a completely symmetrical structure. Analyses of the ^1H- and ^{13}C-NMR spectra using a ^1H-^{13}C correlated spectroscopy (COSY) technique indicated the presence of a lone H-4 [δ_H 7.67 (s)] on the α,β-unsaturated lactone ring (δ_C 159.67, 128.70, 132.27), two geminal methyls [δ_H 1.50, 1.70 (each 3H, s)] attached to an oxygenated carbon (C-9, δ_C 77.76), and two 1,1-dimethylallyl groups [δ_H 1.54 (3H, s), 1.59 (3H, s), 6.14 (1H, dd, J = 10.7, 17.8 Hz), 4.74 (1H, dd, J = 1.2, 17.8 Hz), 4.78 (1H, dd, J = 1.2, 10.7 Hz); δ_H 1.39 (3H, s), 1.40 (3H, s), 6.09 (1H, dd, J = 10.3, 17.8 Hz), 5.02 (1H, dd, J = 1.2, 10.3 Hz), 5.03 (1H, dd, J = 1.2, 17.8 Hz)] in half of the molecule. In the ^1H detected heteronuclear multiple bond connectivity (HMBC) spectrum (J = 8 Hz) of **1**, one of the methyl protons [δ_H 1.40 or 1.39] showed a three-bond correlation to the carbon at δ_C 128.70 (C-3) as well as the sp^2-carbon at δ_C 145.70 (C-2"), suggesting the location of one of the dimethylallyl moieties at α-position (C-3) on the α, β- unsaturated lactone ring. Remaining signals at δ_H 3.55 (dd, J = 1.5 and 0.7 Hz) and 4.34 (dd, J = 1.5 and 0.7 Hz) attached to the carbons at δ_C 25.96 (C-11) and 73.25 (C-10), respectively, were assigned to *cis*-oriented protons6) on linked carbons between two coumarin moieties.

These spectral data suggested that **1** contained 10, 11-dihydrogenated clausarin (**2**)[3,7] units in the molecule. The complete structure and the relative stereochemistry of **1** were obtained from a single-crystal X-ray analysis.[8] A perspective view of one enantiomer of **1** is provided in Fig. 1.

Claudimerin (**1**) has a novel structural feature composed with two clausarin (**2**) units linked symmetrically with the forming of the pyranopyran ring system.

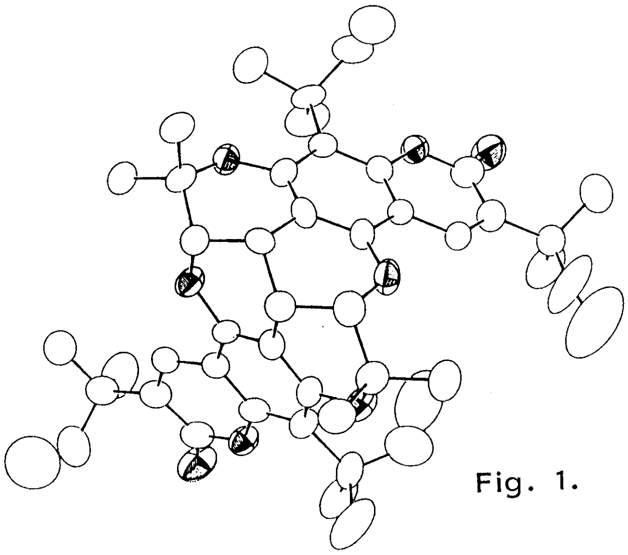
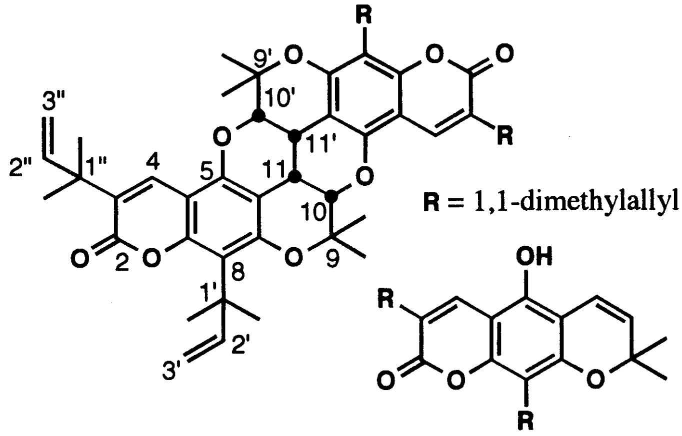


Fig. 1.



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2) The plant material was collected at Innoshima (Hiroshima prefecture, Japan).

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5) ^{13}C-NMR: δ_C 159.67 (C-2), 128.70 (C-3), 132.27 (C-4), 102.78 (C-4a), 148.08 (C-5), 95.83 (C-6), 154.17 (C-7), 113.14 (C-8), 152.82 (C-8a), 77.76 (C-9), 73.25 (C-10), 25.96 (C-11), 41.02 (C-1'), 150.08 (C-2'), 107.69 (C-3' or 3"), 40.06 (C-1"), 145.70 (C-2"), 111.75 (C-3" or 3'), 29.1, 24.6, 29.6, 25.8, 25.9, 26.0 (CH_3).

6) Results of nuclear Overhauser effect (NOE) experiments: irradiation of the signal at δ_H 3.55 (H-11) — 15 and 7 % enhancements of signals at δ_H 4.34 (H-10) and 1.50 (9-CH_3), respectively; irradiation of the signal at δ_H 4.34 (H-10) — 11, 2, and 3 % increments of signals at δ_H 3.55 (H-11), 1.50 (9-CH_3), and 1.70 (9-CH_3), respectively.

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8) Crystal data for **1**. $C_{48}H_{54}O_8$, M = 817.0, monoclinic, a = 15.959 (2), b = 17.863 (2), c = 17.960 (2) Å, β = 116.08 (1), V = 4599 (16) Å^3, Z = 4, space group $P2_1/C$, Dc = 1.180 g/cm^3. Data were collected on an Enraf-Nonius CAD4 diffractometer with graphite monochromated Mo Kα radiation. Intensity data were reduced with the site of the program of SDA. The structure was solved by direct methods (MULTAN 82). The Hydrogen position was idealized and included in subsequent cycles of full-matrix least-squares refinement as fixed and converged at $R = 0.087$.

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