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Further Structural Studies of 1-Indanone Derivatives obtained from *Onychium japonicum*

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The structures of pteroside M and pterosin M isolated from the fronds of *Onychium japonicum* were reexamined by the NMR chemical shift reagent method. Furthermore, the stereostructure of pteroside M was established as 4-hydroxy-6-2′-hydroxyethyl-2(*R*),5,7-trimethyl-1-indanone-2′-D-glucopyranoside on the basis of the circular dichroism Cotton effect associated with the n-π^* transition of the conjugated ketones.

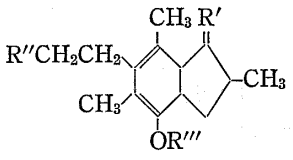
Keywords——pteroside M; pterosin M; absolute configuration; Cotton effect; shift reagent

Many 1-indanone derivatives have recently been isolated from ferns.[2] In the previous paper[3] the structures of new phenolic 1-indanone derivatives, named pteroside M and pterosin M, isolated from the fronds of *Onychium japonicum*, were reported. Although these two compounds have a chiral center at the 2-position, the absolute configuration has not been investigated. In this note we describe the results of further structural elucidation of these compounds by means of the nuclear magnetic resonance (NMR) chemical shift reagent method[4] and analysis of the circular dichroism Cotton effect.

Pteroside M (**1**).[3] $C_{20}H_{28}O_8$, mp 192°, $(\alpha)_D^{15}$ −27° (Me_2CO+H_2O)[5] and pterosin M (**2**)[3] $C_{14}H_{18}O_3$, mp 187°, $(\alpha)_D^{15}$ +7.9° (EtOH) were isolated from an ethyl acetate extract of the fronds of *Onychium japonicum*. As reported in the previous paper, the structures of these two phenolic compounds were unequivocally established by degradation reaction, as well as ^{13}C-NMR and ^1H-NMR spectra.

Hydrolysis of **1** with β-glucosidase or acid gave one mole each of glucose and aglycone, pterosin M (**2**).[3] When **2** was treated with an excess of acetic anhydride in pyridine, the diacetate (**3**) mp 77—79°, *m/e* 318, was formed. The NMR spectrum of **3** in $CDCl_3$ showed signals at δ 1.26 (3H, d, J=8 Hz, $>CHCH_3$), 2.05 (3H, s, $-COCH_3$), 2.40 (3H, s, $-CH_3$), 2.43 (3H, s, $-COCH_3$), 2.70 (3H, s, $-CH_3$), 3.08 and 4.10 (each t, J=8 Hz, $-CH_2CH_2-$). The methyl group at δ 2.43 appeared at the usual benzylic position, whereas the methyl group at δ 2.70 appeared at low field compared with that of toluene. This showed that the latter methyl group is located near the carbonyl group of the neighboring fivemembered ring. In confirmation of this, Clemmensen reduction of **2** on a water bath for 3 hr furnished a reduction product (**4**), mp 154—154.5°, in 93% yield. In compound **4** this methyl signal had moved upfield (δ 2.18), confirming that the methyl group is close to the carbonyl group. Treatment of **4** with thionyl chloride in pyridine gave (**5**), mp 108°, *m/e* 238 in 90% yield. Compounds **5** was converted to the corresponding O-acetyl derivative (**6**), mp 94—95°, *m/e* 315. For reexamination

1) Location: *a) Miyama-cho, Funabashi-shi, Chiba 274, Japan; b) Kaga, Itabashi-ku, Tokyo 173, Japan; c) Tamagawa Gakuen, Machida-shi, Tokyo 194, Japan.*
2) K. Yoshihira, M. Fukuoka, M. Kuroyanagi, S. Natori, M. Umeda, T. Morohoshi, M. Enomoto and M. Saito, *Chem. Pharm. Bull.*, **26**, 2346 (1978).
3) M. Hasegawa, Y. Akabori and S. Akabori, *Phytochem.*, **13**, 509 (1974).
4) J.W. Ronaldson, *Chem. and Ind.*, 764 (1972); A.M. McConnel and R.E. Robertson, *J. Chem. Phys.*, **29**, 1316 (1958).
5) The value of rotation given in the previous report (+129°) was in error.



1: R′=O, R″=O-Glucose, R‴=H
2: R′=O, R″=OH, R‴=H
3: R′=O, R″=OCOCH$_3$, R‴=COCH$_3$
4: R′=H$_2$, R″=OH, R‴=H
5: R′=H$_2$, R″=Cl, R‴=H
6: R′=H$_2$, R″=Cl, R‴=Ac

of the structure of pterosin M in terms of the NMR spectrum, the europium shift reagent technique was applied to **6**. The NMR spectrum of **6** and the effect of the addition of Eu (dpm)$_3$ are shown in Fig. 1. The acetyl proton, methyl protons and methylene protons (adjacent to halogen) of **6** can be readily assigned, and the resonance arising from the remaining protons appeared as a broad envelope at δ 2.20—3.20. Upon addition of 30 mg (0.88×10^{-4} mol) of Eu(dpm)$_3$ to the solution, a drastic change occurred in the spectrum of **6**. Significant changes were a shift of the 4-position OAc (δ 2.10 to 6.87), C-5 methyl (δ 2.25 to 4.70), C-7 methyl (δ 2.25 to 2.62) and C-3 methylene protons (δ 2.20—3.20 to 5.43 and 6.06). From the results in Fig. 1, it is clear that the C-5 methyl and C-3 methylene protons are very close to the oxygen atom of the O-acetyl group. The results are consistent with the structure of pterosin M deduced from the ^{13}C-NMR, ^{1}H-NMR spectra and by chemical degradation as reported in the previous paper. Therefore the structures of **1**—**6** have been established as shown below.

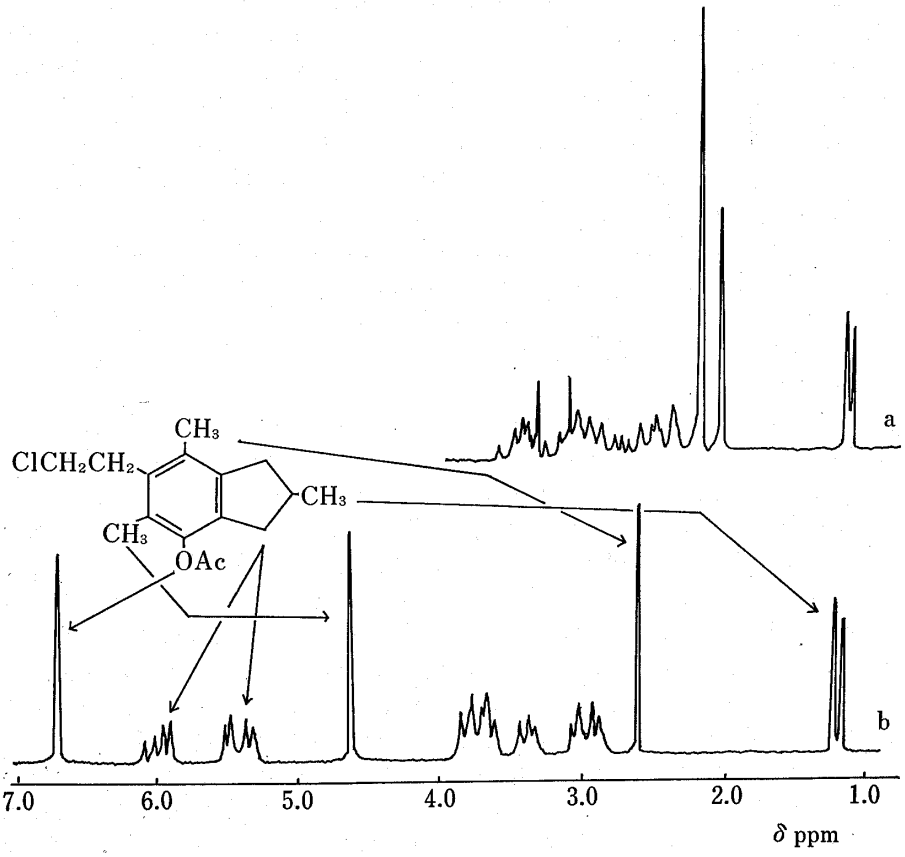


Fig. 1. The NMR Spectra of **6** (20 mg) before (a) and after (b) the Addition of 30 mg of Eu(dpm)$_3$

The compounds of this type bear only one chiral center at C-2, which carries a methyl group. In a polar solvent such as methanol the compounds having (2*R*) configuration[6] ex-

6) M. Kuroyanagi, M. Fukuoka, K. Yoshihira and S. Natori, *Chem. Pharm. Bull.*, **27**, 731 (1979).
7) M. J. Brinne, G. Quannes and J. Jaques, *Bull. Soc. Chem. Fr.*, 613 (1967).

hibited positive Cotton effects associated with an n-π^* transition in the vicinity of 320 nm and bisignated CD curves in chloroform. The cirular dichroism curve of pterosin M in methanol showed a positive Cotton effect due to n-π^* transition $(O)_{329}$ +2720. Therefore, the aboslute configuration at C-2 of pterosin was concluded to be R. Furthermore, the contribution[7] of the glucose component to the rotation of **1** (M_D of 1—M_D of 2=—125.4°) suggests that the glucose belongs to the D series. Based on these results, pteroside M is concluded to be 4-hydroxy-6-2'-hydroxyethyl-2(*R*),5,7-trimethyl-1-indanone-2'-D-glucopyranoside.

Experimental

Acetylation of 2——Compound **2** (4.7 mg) was treated with Ac_2O (250 mg) in pyridine (1 ml) at room temprature overnight to afford a corresponding diacetate (**3**) (5.5 mg, 90% yield), mp 77—79° (from hexane). MS *m/e*: 318 (M^+). IR ν_{max}^{KBr} cm^{-1}: 2975, 2940, 1750, 1700, 1604. NMR (in $CDCl_3$) δ: 1.26 (3H, d, J=8 Hz), 2.05 (3H, s), 2.43 (3H, s), 2.40 (3H, s), 2.70 (3H, s), 3.08 (2H, t, J=8 Hz), 4.17 (2H, t, J=8 Hz) and 2.2—3.4 (3H, m,). *Anal.* Calcd for $C_{18}H_{24}O_4$: C, 71.02; H, 7.95 Found: C, 71.00; H, 8.05.

The Clemmensen Reduction of 2——Zinc amalgam (obtained from 0.8 g of Zn and 0.9 g of $HgCl_2$) was added to a solution of conc HCl (30 ml), H_2O (1.5 ml) and toluene (2 ml). Compound **2** (2.7 mg) was dissolved in this, and the mixture was refluxed for 10 hr. The reaction mixture was extracted with ether and the ethereal layer was washed with water, dried, and concentrated. The residue was recrystallized from ethanol to afford **4** (2.36 mg, 93%), mp 154—155.5°. MS *m/e*: 220 (M^+), IR ν_{max}^{KBr} cm^{-1}: 3430, 3240, 2930, 1603, 1590, 1460, 1380. NMR (in $CDCl_3$) δ: 0.5 (1H, s), 1.17 (3H, d, J=7 Hz), 2.18 (3H, s), 2.22 (3H, s), 2.25—3.20 (5H, m), 3.05 (2H, t, J=8 Hz), 3.22 (2H, t, J=8 Hz). *Anal.* Calcd for $C_{14}H_{20}O_2$: C, 76.32; H, 9.15. Found: C, 76.01; H, 9.49.

Chlorination of 4——A solution of **4** (4.4 mg) in a mixture of $SOCl_2$ (4 ml) and pyridine (2 ml) was refluxed for 3 hr. The reaction mixture was diluted with ice-water and extracted with ether. The ethereal solution was washed with water, dried, and concentrated. The residue was recrystallized from hexane to afford crystals (4.4 mg, 87%), mp 108.9°. MS *m/e*: 254 (M^+), IR ν_{max}^{KBr} cm^{-1}: 3400, 2960, 1603, 1590, 1460. NMR (in $CDCl_3$) δ: 0.9 (1H, s), 1.17 (3H, d, J=7 Hz), 2.18 (3H, s), 2.22 (3H, s), 2.30—3.15 (5H, m), 3.01—3.20 (2H, m), 3.43—3.62 (2H, m). *Anal.* Calcd for $C_{14}H_{19}ClO$: C, 70.12; H, 7.98; Cl, 14.87. Found: C, 70.30; H, 8.14; Cl, 14.87.

Acetylation of 5——Compound **5** (2.9 mg) was treated with Ac_2O (300 mg) in pyridine (1 ml) at room temperature overnight to afford the corresponding acetate (**5**), in 95% yield, mp 94—95° (from hexane). MS *m/e*: 280 (M^+). IR ν_{max}^{KBr} cm^{-1}: 2930, 1750, 1603, 1590, 1460, 1380. NMR (in $CDCl_3$) δ: 1.17 (3H, d, J=7 Hz), 2.10 (3H, s), 2.25 (6H, s), 2.20—3.20 (5H, m), 2.96—3.16 (2H, m), 3.37—3.57 (2H, m). *Anal.* Calcd for $C_{16}H_{21}ClO_2$: C, 68.57; H, 7.50; Cl, 12.68. Found: C, 68.55; H, 7.90; Cl, 13.45.

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