6a,12a-Dehydro-β-toxicarol and Derricarpin, Two New Isoflavonoids, from the Roots of *Derris oblonga* BENTH

Yun-Lian LIN[a] and Yueh-Hsiung KUO*,[b]

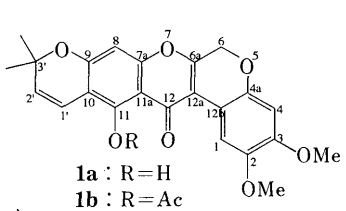
National Research Institute of Chinese Medicine,[a] Taipei Hsien, Taiwan, ROC and Department of Chemistry, National Taiwan University,[b] Taipei, Taiwan, ROC. Received November 10, 1992

A new dehydrorotenoid, 6a,12a-dehydro-β-toxicarol, and a new pterocarpan, derricarpin, together with a known compound, 6a,12a-dehydro-α-toxicarol, have been isolated from the roots of *Derris oblonga*. Their structures were determined on the basis of spectral and chemical evidence.

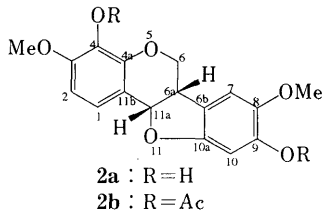
Keywords *Derris oblonga*; 6a,12a-dehydro-β-toxicarol; derricarpin; dehydrorotenone; pterocarpan; root

There are only three species of *Derris* (*D.*) indigenous to Taiwan: *D. laxiflora*, *D. oblonga*, and *D. trifoliata*. The chemical constituents of the first[1] and the last[2] have been investigated. From other species of *Derris*, many interesting components have been isolated, including flavones, flavonols, chalcones, dihydrochalcones, isoflavones, rotenones, stilbenes, coumarins, aurones, pterocarpans, coumestans, triterpenes, and glycosides.[3]

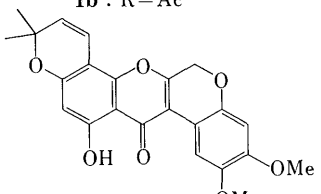
We have now investigated the ethanol extract from the roots of *D. oblonga*, and have isolated two new compounds named 6a,12a-dehydro-β-toxicarol (**1a**) and derricarpin (**2a**), together with a known compound, 6a,12a-dehydro-α-toxicarol (**3**).[4]



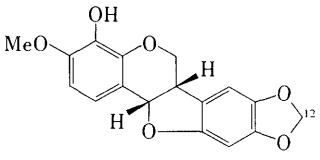
1a : R=H
1b : R=Ac



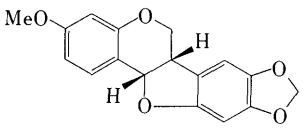
2a : R=H
2b : R=Ac



3



4



5

6a,12a-Dehydro-β-toxicarol (**1a**) was obtained as yellow needles, mp 195—196 °C. The ultraviolet (UV) spectrum shows absorptions at λ_{max}^{MeOH} 238 (4.36), 288 (4.49), and 304 (4.41) nm, that is the characteristic absorptions of 6a,12a-dehydrorotenoid.[5] Elemental analysis gave the molecular formula as $C_{23}H_{20}O_7$, and the mass spectrum (MS) shows fragmentation peaks at 408 (M^+, 64%), 393 (100%), 363 (13%) and 361 (6%). The infrared (IR) spectrum shows absorptions at 3200—2800 (chelated OH), 1650 (chelated CO), 1620, 1590, and 1505 cm^{-1} (aromatic), and the proton nuclear magnetic resonance (^{1}H-NMR) spectrum (Table I) shows signals at δ 3.85 and 3.93 (each 3H, s) due to two phenolic methyl ethers. The doublets at δ 5.60 and 6.71 (each 1H, d, J=10.0 Hz), and one singlet at δ 1.45 (6H) are characteristic of the *cis* double bond and *gem*-dimethyl group of 2,2-dimethylchromene.[6] Signals due to three aromatic protons were discernible at δ 6.27, 6.53 and 8.25 (each 1H, s). The latter signal (δ 8.25) is a characteristic signal for H-1 in dehydrorotenone deshielded by a C-12 carbonyl group.[4,7] Two singlets at δ 4.94 (2H) and 13.20 (1H) were assigned to H-6 and chelated phenolic proton, respectively. By comparison of the ^{1}H-NMR (Table I) and ^{13}C-NMR (Table II) data with those of 6a,12a-dehydro-α-toxicarol (**3**),[4] compound **1a** can be assigned as an isomer of compound **3**. In compound **3**, the 2,2-dimethylchromene group was fused on C-8 and C-9, and therefore the 2,2-dimethylchromene moiety in compound **1a** must be fused on C-9 and C-10. Further evidence for the fusion of 2,2-dimethylchromene on C-9 and C-10 was obtained as follows. Compound **1a** formed a monoacetate **1b** [with Ac_2O–pyridine at 60 °C, overnight; mp 195—196 °C; ν_{max}^{KBr} 1760 cm^{-1}; δ $CDCl_3$ 2.49 (3H, s) and 6.47 (1H, d, J=10.0 Hz, H-1′)]. The result reveals it contains one chelated phenolic hydroxyl group. There was an upfield (0.24 ppm) shift of H-1′ in **1b**[3,8] compared with **1a**, as well as the presence of a 3.1% nuclear Overhauser effect (NOE) between H-1′ and AcO-11 in **1b**.

Derricarpin (**2a**) was obtained as colorless needles, mp 202—204 °C. Elemental analysis gave the molecular formula $C_{17}H_{16}O_6$, and the MS showed peaks at m/z 316 (M^+, 100%), 301 (48%), 283 (20%), 164 (24%), and 149 (19%).

TABLE I. ^{1}H-NMR Data[a] for **1a**, **2a**, **3**, and **4**[b] (300 MHz, $CDCl_3$)

H	1a	3	2a	4
1	8.25 s	8.26 s	7.03 d (8.7)	7.07 d (9.0)
2			6.65 d (8.7)	6.67 d (9.0)
4	6.53 s	6.51 s		
6	4.94 s	4.95 s	3.68 t (10.9)	3.40—4.40 m
			4.34 dd (5.0, 10.9)	
6a			3.54 m	3.40—4.40 m
7			6.79 s	6.75 s
8	6.27 s	6.25 s		
10			6.49 s	6.45 s
11a			5.40 d (7.0)	5.40 d (7.0)
1′	6.71 d (10.0)	6.62 d (10.0)		
2′	5.60 d (10.0)	5.57 d (10.0)		
4′, 5′	1.45 s, 1.45 s	1.46 s, 1.46 s		
OMe	3.85 s, 3.93 s	3.84 s, 3.91 s	3.85 s, 3.95 s	3.92 s
OH	13.20	12.96	5.40 s, 5.60 s	5.49 s

a) Figures in parentheses are coupling constants. *b*) 60 MHz.

TABLE II. ^{13}C-NMR Data (δ-Value) for **1a**, **2a**, **3**, and **5**

C	1a	3	2a	5
1	110.0 d	110.7 d	133.9 d	132.1 d
2	144.3 s	144.1 s	107.8 d	109.8 d
3	149.6 s	149.2 s	153.8 s	157.1 s
4	100.6 d	101.0 d	146.7 s	104.7 s[a]
4a	146.3 s	146.2 s	147.3 s	156.6 s
6	64.8 t	64.7 t	66.9 t	66.4 t
6a	157.1 s[b]	156.8 s[d]	40.3 d	40.2 d
6b			121.1 d	117.9 d
7			105.4 d	103.7 d[a]
7a	159.4 s[b]	159.2 s[d]		
8	94.8 d	100.5 s	143.2 s	154.2 s
9	162.5 s	162.3 s	141.1 s	148.0 s
10	100.6 s	94.6 d	98.1 d	93.8 d
10a			145.2 s	140.9 s
11	155.9 s[b]	150.8 s[d]		
11a	105.8 s	100.6 s	78.0 d	78.5 d
11b			114.0 s	112.6 s
12	176.2 s	179.2 s		
12a	106.1 s[c]	105.9 s		
12b	109.9 s[c]	109.9 s		
1′	115.5 d	114.3 d		
2′	128.2 d	127.7 d		
3′	78.1 s	78.0 s		
4′	28.3 q	28.2 q		
5′	28.3 q	28.2 q		
OMe	55.9 q	55.9 q	56.3 q	
OMe	56.4 q	56.3 q	56.9 q	
OCH_2O				101.3 t

75 MHz in $CDCl_3$. Assignments established by off-resonance and DEPT methods. *a*—*d*) Assignments may be interchanged.

The UV and IR spectra suggested that it is a phenolic substance devoid of a carbonyl functional group. The ^{1}H-NMR spectrum (Table I) revealed the presence of the characteristic signals of pterocarpan[9] at δ 3.54 (1H, m, H-6a), 5.40 (1H, d, J=7.0 Hz, H-11a), 3.68 (1H, t, J=10.9 Hz, H_{ax}-6), and 4.34 (1H, dd, J=10.9, 5.0, H_{ex}-6). Signals due to four aromatic protons were discernible at δ 6.65 and 7.03 (each 1H, d, J=8.7 Hz, H-2, H-1), and 6.49 and 6.79 (each 1H, s, H-10, H-7). Derricarpin (**2a**) also contains two phenolic methyl ethers [δ 3.85 and 3.95 (each 3H, s)] and two phenolic hydroxyl groups [δ 5.40 and 5.60 (each 1H, s), disappeared on D_2O addition]. The ^{1}H-NMR spectrum of **2a** is similar to that of 4-hydroxy-3-methoxy-8,9-methylenedioxypterocarpan (**4**)[10] (Table I). Acetylation of **2a** with acetic anhydride in pyridine at room temperature overnight gave the diacetate **2b** [mp 190—191 °C; ν_{max}^{KBr} 1760 cm^{-1}; δ $CDCl_3$ 2.28 and 2.33 (each 3H, s)]. The results reveal that it contains two phenolic hydroxyl groups. Based on the above evidence, derricarpin is a 3,4,8,9-tetra-oxygenated pterocarpan. Finally, two methoxy groups were assigned to the C-3 and C-8 positions, based on an NOE experiment; in which clear NOE's were observed between H-7 and the methoxy group (δ 3.85) (20.4% enhancement), as well as between H-2 and the methoxy group (δ 3.89) (22.3%, enhancement). The proposed structure was also supported by the ^{13}C-NMR signals [Table II, compare with the data of maackiain (**5**)[11]].

Experimental

Melting points were determined on a Yanagimoto micromelting point apparatus and are uncorrected. IR spectra were recorded on a Perkin-Elmer 781 spectrophotometer. ^{1}H- and ^{13}C-NMR spectra were run on a Brucker AM 300 at 300 MHz in $CDCl_3$ solution with tetramethylsilane (TMS) as an internal standard. Chemical shifts are given in δ-values and coupling constants (J) are given in hertz (Hz). EIMS and UV spectr a were taken on a JEOL JMS-100 spectrometer and Hitachi U-3200 spectrophotometer, respectively.

Extraction and Isolation The roots of *Derris oblonga* were crushed into small pieces and dried at 50 °C to give 6.1 kg of raw material, which was extracted with 95% ethanol (80 l) three times (8 h each time) at 60 °C. The combined extracts were evaporated *in vacuo* to give a residue (293 g), which was subsequently subjected to partition with ether and H_2O (each 1 l). The upper layer provided a black viscous mass (270 g), which was subjected to column chromatography on silica gel with hexane–$CHCl_3$, $CHCl_3$, and $CHCl_3$–MeOH gradient solvent systems. The $CHCl_3$ and 5% MeOH/$CHCl_3$ eluates gave 6a,12a-dehydro-α-toxicarol (**3**) (253 mg), and 6a,12a-dehydro-β-toxicarol (**1a**) (12 mg) and derricarpin (**2a**) (18 mg), respectively.

6a,12a-Dehydro-β-toxicarol (1a) mp 194—196 °C. IR ν_{max}^{KBr} cm^{-1}: 3200—2800, 1650, 1620, 1590, 1505, 1285, 1195, 1150, 1050, 875, 820, 760. ^{1}H-NMR: Table I. ^{13}C-NMR: Table II. *Anal.* Calcd for $C_{23}H_{20}O_7$: C, 67.64; H, 4.94. Found: C, 67.58; H, 4.99.

Derricarpin (2a) mp 202—204 °C. $[\alpha]_D^{20}$ −144.1° (c=0.5, $CHCl_3$). UV λ_{max}^{MeOH} nm (log ε): 300 (3.90). IR ν_{max}^{KBr} cm^{-1}: 3480, 1620, 1490, 1210, 1145, 1095, 1010, 880, 855, 775. ^{1}H-NMR: Table I. ^{13}C-NMR: Table II. *Anal.* Calcd for $C_{17}H_{16}O_6$: C, 64.55; H, 5.10. Found: C, 64.67; H, 5.08.

6a,12a-Dehydro-α-toxicarol (3)[4] mp 261—263 °C. UV λ_{max}^{MeOH} nm (log ε): 278 (4.81), 314 (4.39), 331 (4.41). IR ν_{max}^{KBr} cm^{-1}: 3400, 1650, 1570, 1510, 1255, 1040, 870, 820, 775. MS m/z (%): 408 (86), 393 (100), 365 (14), 361 (11). ^{1}H-NMR: Table I. ^{13}C-NMR: Table II.

Acetylation of 1a and 2a with Acetic Anhydride in Pyridine Compound **1a** (5 mg) or **2a** (7 mg) was allowed to react with Ac_2O (1.0 ml) in pyridine (1.0 ml) at 60 °C or room temperature overnight, respectively. Usual work-up gave the monoacetate **1b** (5 mg) [mp 195—196 °C. IR ν_{max}^{KBr} cm^{-1}: 1760, 1635, 1605, 1500, 1190, 1145, 1040, 830, 790. ^{1}H-NMR ($CDCl_3$) δ: 1.47 (6H, s), 2.49, 3.84, 3.92 (each 3H, s), 4.91 (2H, s), 5.75, 6.47 (each 1H, d, J=10.0 Hz), 6.51, 6.67, 8.32 (each 1H, s)] or the diacetate **2b** (6 mg) [mp 190—191 °C. IR ν_{max}^{KBr} cm^{-1}: 1760, 1620, 1485, 1190, 1100, 1010, 890, 865, 780. ^{1}H-NMR ($CDCl_3$) δ: 2.28, 2.33, 3.78, 3.83 (each 3H, s), 3.56 (1H, m, H-6a), 3.67 (1H, t, J=10.9 Hz, H_{ax}-6), 4.29 (1H, dd, J=10.9, 4.9 Hz, H_{eq}-6), 5.50 (1H, d, J=7.0 Hz, H-11a), 6.56, 6.88 (each 1H, s, H-10, H-7), 6.69, 7.35 (each 1H, d, J=8.7 Hz, H-2, H-1)], respectively.

Acknowledgement This research was supported by the National Science Council of R.O.C.

References

1) A. G. R. Nair, T. R. Seetharaman, S. Sankarasubramanian, G. R. Rao, *J. Natural Products*, **49**, 710 (1986).
2) Y. L. Lin, Y. L. Chen, Y. H. Kuo, *Chem. Pharm. Bull.*, **39**, 3132 (1991); *idem, Chem. Express*, **6**, 747 (1991); *idem, Chem. Pharm. Bull.*, **40**, 2295 (1992).
3) R. B. Filho, O. R. Gottlieb, A. P. Mourao, A. I. da Rotha, F. S. Oliveira, *Phytochemistry*, **14**, 1454 (1975); M. C. Do Nascimento, W. B. Mors, *ibid.*, **20**, 147 (1981); H. Y. Hsu, Y. P. Chen, M. Hang, "The Chemical Constituents of Oriental Herbs," 1982, p. 528; H. H. Harper, *J. Chem. Soc.*, **1939**, 1099; Y. L. Chen, C. S. Tsai, *J. Taiwan Pharm. Assoc.*, **7**, 31 (1955); A. Wetter, J. Jadot, *Phytochemistry*, **15**, 747 (1976); Y. Obara, H. Matsubara, K. Munakata, *Agric. Biol. Chem.*, **40**, 1245 (1976); M. Marlier, G. Darsenne, J. Casimir, *Phytochemistry*, **15**, 183 (1976); T. Komada, T. Yamakawa, Y. Minoda, *Agric. Biol. Chem.*, **44**, 2387 (1980); Y. Obara, H. Matsubara, *Meijo Daigaku Gakujutsu Hokoku*, **17**, 40 (1981) [*Chem. Abstr.*, **95**, 200536*c* (1981)]; S. H. Harper, *J. Chem. Soc.*, **1940**, 309; S. H. Harper, W. G. E. Underwood, *ibid.*, **1965**, 4203; M. C. Do Nascimento, R. L. de Vaoconcellos Dias, W. B. Mors, *Phytochemistry*, **15**, 1553 (1976); A. P. John, A. Pelter, *J. Chem. Soc.*, **1966**, 606; S. S. Chibber, R. P. Sharma, *Phytochemistry*, **18**, 1082 (1979); *idem, ibid.*, **19**, 1857 (1980); A. Pelter, P. Stainto, *J. Chem. Soc.* (*C*), **1966**, 701; C. P. Falshaw, R. A. Harmer, W. D. Ollis, R. F. Wheeler, V. B. Lalitha, N. V. Subba Rao, *ibid.*, **1969**, 374; A. P. Johnson, A. Pelter, P. Stainton, *ibid.*, **1966**, 192; M. C. Do Nascimento, W. B. Mors, *Phytochemistry*, **11**, 3023 (1972); M. Garcia, M. H. C. Kano, D. M. Vieira, M. C. Do Nascimento, W. B. Mors, *ibid.*, **25**, 2425 (1986).
4) J. Reisch, M. Gombos, K. Szendrei, I. Novak, *Phytochemistry*, **15**, 234 (1976).

5) P. M. Dewick, "The Flavonoids Advances in Research," J. B. Harbone, T. J. Mabry (ed.), Chapman and Hall, London, 1982, p. 536.
6) J. S. P. Schwarz, A. I. Cohen, W. D. Ollis, E. A. Kaczka, L. M. Jackman, *Tetrahedron*, **20**, 1317 (1964).
7) L. Crombie, J. W. Lown, *J. Chem. Soc.*, **1962**, 775; D. G. Corlson, D. Weisleder, W. H. Tallent, *Tetrahedron*, **29**, 2731 (1973); L. Crombie, P. J. Godin, D. A. Whiting, K. S. Siddalingaiah, *J. Chem. Soc.*, **1961**, 1871.
8) T. M. Smalberger, R. Vleggaar, J. C. Webber, *Tetrahedron*, **30**, 3927 (1974); M. Shabbir, A. Zaman, L. Crombie, B. Tuck, D. A. Whiting, *J. Chem. Soc.* (*C*), **1968**, 1899; A. K. Singhal, R. P. Sharma, G. Thyagrajam, W. Herz, S. V. Govinelan, *Phytochemistry*, **19**, 929 (1980).
9) S. H. Harper, A. D. Kemp, W. G. E. Underwood, R. V. Campbell, *J. Chem. Soc.* (*C*), **1969**, 1109; A. Pelter, P. I. Amerechi, *ibid.*, **1969**, 887; J. C. Breytenbach, G. J. H. Rall, *J. Chem. Soc., Perkin Trans. 1*, **1980**, 1804; K. G. R. Pachler, W. G. E. Underwood, *Tetrahedron*, **23**, 1817 (1967).
10) J. T. Cook, W. D. Ollis, I. O. Sutherland, O. R. Gottlieb, *Phytochemistry*, **17**, 1419 (1978).
11) H. D. Vanetten, P. S. Mathews, E. H. Mercer, *Phytochemistry*, **22**, 2291 (1983); F. Gomez, J. S. Calderon, L. Quijano, M. Dominguez, T. Rios, *ibid.*, **24**, 1126 (1985).