J. Indian Chem. Soc.,
Vol. 85, October 2008, pp. 1060-1063

Barleriaquinone-I from the heartwood of *Tectona grandis* Linn.

Pahup Singh[a]*, Deepa Pandey[a], Jaya Mathur[a] and Lalit Pal Singh[b]

[a]Centre of Advanced Studies, Department of Chemistry, University of Rajasthan, Jaipur-302 004, Rajasthan, India

E-mail : pahupsingh@yahoo.co.uk

[b]Department of Chemistry, R. B. S. College, Agra-282 002, Uttar Pradesh, India

Manuscript received 3 June 2008, revised 3 July 2008, accepted 8 July 2008

Abstract : Barleriaquinone-I, a cytotoxic anthraquinone, has been isolated from the heartwood of *Tectona grandis* Linn., along with previously reported lapachol, tecomaquinone-I, deoxylapachol, tectoquinone, stigmasterol and dehydro-α-lapachone. This is the first report on the isolation of barleriaquinone-I from this plant as well as from the family Verbenaceae. A detailed spectral data of the compound together with its HMBC correlations are reported.

Keywords : *Tectona grandis* Linn., Verbenaceae, naphthoquinones, naphthoquinone dimers, anthraquinonas, barleriaquinone-I.

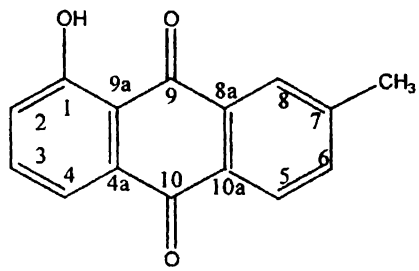
Introduction

Tectona grandis Linn. belongs to the family Verbenaceae and is commonly known as Teak or Sagwan. It is a huge ornamental tree which is native to south and south east Asia. In addition to providing one of the most durable timbers which has remarkable termite resistance, the plant is also of medicinal importance. Flowers and seeds of this plant are diuretic. Bark is useful in scabies and as an astringent for bronchitis[1]. The wood oil is used for the treatment of eczema and ringworm while wood ash is applied to swollen eyelids[1]. Leaves of this plant exhibit wound healing activity[2]. Previous work on *T. grandis* led to the isolation of a number of naphthoquinone and anthraquinone derivatives[3-6].

In pursuing our interest in the allelopathic property of this plant, we examined its heartwood. The phytochemical examination led to the isolation of barleriaquinone-I (**1**), in addition to lapachol, tecomaquinone-I, deoxylapachol, tectoquinone, stigmasterol and dehydro-α-lapachone. Barleriaquinone-I was previously reported from *Barleria buxifolia*[7]. It is a cytotoxic agent having pharmacological activity against human breast adinocarcinoma[8].

Results and discussion

The heartwood shavings of *T. grandis* were extracted with petroleum ether. The extract was chromatographed over neutral alumina and barleriaquinone-I (m.p. 170-171 °C) was isolated as orange-yellow crystals from the benzene-ethyl acetate (3 : 1) fraction of the column. The structure of barleriaquinone-I was established on the basis of UV, IR, MS, ^{1}H, ^{13}C NMR, HMQC and HMBC correlations. The UV spectrum showed absorption bands at 216, 258, 282, 330 and 386 nm, indicating the presence of quinonoid chromophoric group. The IR absorption bands at 1660 and 1630 cm^{-1} revealed presence of non-chelated carbonyl and chelated carbonyl group respectively. In the ^{1}H NMR spectrum, a signal at δ 12.60 corresponded to intramolecularly hydrogen bonded hydroxyl group. The methyl signal appeared at δ 2.53 as singlet and showed NOE correlation with signals at δ 7.59 (1H, brd, *J* 7.5 Hz, H-6) and δ 8.08 (1H, brs, H-8), indicating the *meta* relationship of the two aromatic protons. The quinonoid structure was ascertained by the appearance of signals at δ 188.9 and δ 182.2 for conjugated carbonyls in its ^{13}C spectrum. The connectivity of the



(1)

protons to the carbon atoms was established by a HMQC experiment and long range couplings were detected by a HMBC experiment. The HMBC spectrum gives information on two- ($^2J_{C-H}$), three- ($^3J_{C-H}$), and four- ($^4J_{C-H}$) bond proton-carbon couplings, the strongest being the 3 bond coupling. In barleriaquinone-I, the most downfield proton at δ_H 12.60 (proton of the -OH group) showed two strong 3-bond and one fairly strong 2-bond correlations with carbon resonances at δ_C 124.1, 133.6 and 162.5 attributed to C-2, C-9a and C-1 respectively. The proton at δ_H 7.28 (H-2) exhibited two 3-bond correlations with carbon resonances at δ_C 119.4 and 133.6 assigned to C-4 and C-9a respectively. The H-3 proton at δ_H 7.66 displayed two 3-bond correlations with carbon signals at δ_C 162.5 and 116.2 which corresponded to C-1 and C-4a respectively. The proton at δ_H 7.81 (H-4) showed two 3-bond correlations with carbon resonances at δ_C 124.1 and 133.6 attributed to C-2 and C-9a respectively. The H-5 proton at δ_H 8.17 exhibited three 3-bond correlations with carbon signals at δ_C 145.4, 133.1 and 182.2 assigned to C-7, C-8a and C-10 respectively. The proton at δ_H 7.59 (H-6) showed three 3-bond correlations with carbon resonances at δ_C 127.1, 131.4 and 21.9 which corresponded to C-8, C-10a and methyl carbon at C-7 respectively. The H-8 proton at δ_H 8.08 displayed three 3-bond correlations with carbon signals at δ_C 188.9, 131.4 and 21.9 ascribable to C-9, C-10a and methyl carbon at C-7 respectively. The protons of the methyl group at δ_H 2.53 exhibited two 3-bond correlations and one 2-bond correlations with carbon resonances at δ_C 135.5, 127.1 an 145.4 assigned to C-6, C-8 and C-7 respectively. These correlations observed in the HMBC spectrum are shown in the structural diagram (Fig. 1). The mass spectrum of

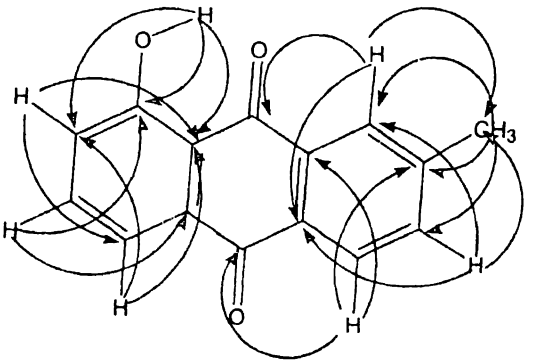


Fig. 1. HMBC correlations of barleriaquinone-I.

Table 1. ^1H, ^{13}C NMR and HMBC data for barleriaquinone-I in $CDCl_3$

Protons	δ_H	Carbon atoms	δ_C	HMBC	
				$^2J_{C-H}$ (2-bond coupling)	$^3J_{C-H}$ (2-bond coupling)
-OH (at C-1)	12.60(s)	C-1	162.5	C-1	C-2, C-9a
H-C(2)	7.28 (dd, *J* 8.4, 1.5 Hz)	C-2	124 1	-	C-4, C-9a
H-C(3)	7.66 (dd, *J* 8.4, 7.6 Hz)	C-3	136.6	-	C-1, C-4a
H-C(4)	7.81 (dd, *J* 7.6, 1.5 Hz)	C-4	119.4	-	C-2, C-9a
		C-4a	116.2	-	-
H-C(5)	8.17 (d, *J* 7.5 Hz)	C-5	127.6	-	C-7, C-8a, C-10
H-C(6)	7.59 (brd, *J* 7.5 Hz)	C-6	135.5		C-8, C-10a, methyl carbon at C-7
		C-7	145.4	-	-
H (Me at C-7)	2.53 (s)	-	-	C-7	C-6, C-8
H-C(8)	8.08 (brs)	C-8	127.1	-	C-9, C-10a, methyl carbon at C-7
		C-8a	133.1	-	-
		C-9	188.9	-	-
		C-9a	133.6	-	-
		C-10	182.2	-	-
		C-10a	131.4	-	-
		Me at C-7	21.9		

barleriaquinone-I displayed the molecular ion peak at *m/z* 238 suggesting the molecular formula to be $C_{15}H_{10}O_3$. Earlier the structure of barleriaquinone-I has been determined on the basis of ^1H and ^{13}C spectra. This is the first report on the isolation of barleriaquinone-I from the heartwood of *T. grandis* together with its detailed ^1H, ^{13}C, 2D spectral data, HMQC and HMBC correlations.

Barleriaquinone-I (**1**) gave colour reactions with alcoholic ferric chloride, alkaline dithionite and methanolic magnesium acetate. It also formed acetate with acetic anhydride and pyridine. Zinc dust distillation of this compound furnished 2-methyl-anthracene, confirming its structure as 1-hydroxy-7-methyl-anthraquinone.

The characterization of lapachol, tecomaquinone-I, deoxylapachol, tectoquinone, stigmasterol and dehydro-α-lapachone was done on the basis of ^1H NMR, mixed m.p.s and co-TLC with authentic samples.

Experimental

General : Melting points were determined in soft glass capillaries in an electrothermal melting point apparatus and are uncorrected. Column chromatography : Neutral active alumina (Merck) deactivated with 10% aqueous acetic acid. Prep. TLC : Merck silica gel $60F_{254}$ precoated glass plates. UV spectra : Hitachi U-200 spectrophotometer, λ_{max} in nm. IR spectra : FTIR Nicolet Magna 550 and Shimadzu 8400 S spectrophotometers, ν in cm^{-1}. ^1H and ^{13}C NMR spectra : JEOL AL 300 MHz and Brukar Avance DRX 500 FT NMR spectrometer, δ in ppm and *J* in Hz. MS : JEOL JMS-SX 102A and JEOL D-300 spectrometers.

Plant material : The heartwood of *Tectona grandis* was collected from Taj Garden, Agra, India. Identification was done with the help of Department of Botany, University of Rajasthan, Jaipur, India and a voucher specimen was deposited at RUBL Herbarium, Jaipur (RUBL 20112).

Extraction and isolation : The air dried heartwood shavings of *Tectona grandis* (5 kg) were extracted with petroleum ether (60–80 °C) on a water bath for 3 × 12 h. The crude extract obtained after removal of solvent was separated into acidic and neutral fractions by extracting the same with 2 *N* Na_2CO_3 solution. The acidic fraction (aqueous layer) yielded lapachol as bright-yellow needles, 110 g, m.p. 139–140 °C. The neutral fraction (ethereal layer) was concentrated *in vacuo* and the resulting semi solid mass (15 g) was chromatographed over neutral alumina. Five fractions were obtained from the column. Fraction 1 (petroleum ether-benzene, 3 : 1) afforded tecomaquinone-I as blue green crystals, 500 mg, m.p. 198–199 °C. Fraction 2 (petroleum ether-benzene, 1 : 1) yielded deoxylapachol as pale yellow needles, 140 mg, m.p. 61–62 °C, tectoquinone as yellow-orange crystals, 240 mg, 175–176 °C and stigmasterol as colourless shining needles, 300 mg, m.p. 166–167 °C. Dehyro-α-lapachone was isolated from fraction 3 (petroleum ether-benzene, 1 : 3) as orange needles, 220 mg, m.p. 143–144 °C. Fraction 4 (benzene) and fraction 5 (benzene-ethyl acetate, 3 : 1) revealed the presence of a yellow compound on TLC. After repeated preparative TLC in petroleum ether-benzene (1 : 1), it was purified and isolated as orange-yellow crystals, 45 mg, m.p. 170–171 °C. From its detailed spectral study it was identified as barleriaquinone-I.

Barleriaquinone-I :

Orange-yellow crystals, 45 mg, m.p. 170–171 °C, R_f : 0.55 (petroleum ether-benzene, 1 : 1). UV λ_{max} (EtOH) : 216, 258, 282, 330, 386 nm; IR ν_{max} (KBr) : 1660 (non-chelated carbonyl), 1630 (chelated carbonyl), 1580 cm^{-1}. MS (*m/z*) : 238.1423 $[M^+]$ ($C_{15}H_{10}O_3$), 223 $[M-15]^+$, 210 $[M-28]^+$, 182 $[M-56]^+$.

Barleriaquinone-I acetate : A mixture of barleriaquinone-I (25 mg), acetic anhydride (1 ml) and pyridine (0.5 ml) were refluxed over water bath for 2–3 h. The reaction mixture was cooled and then poured into ice cold water. The acetate separated out in the form of a precipitate. It was filtered, dried and crystallized from ethyl acetate as yellow needles (18 mg), m.p. 154–155 °C. UV λ_{max} (EtOH) : 214, 232, 280, 340 nm; ^1H NMR [300 MHz, $CDCl_3$, δ (ppm)] : 2.44 (6H, s, $-OCOCH_3$, $-CH_3$), 7.28 (1H, dd, *J* 8.4, 1.5 Hz, H-2), 7.66 (1H, dd, *J* 8.4, 7.6 Hz, H-3), 7.81 (1H, dd, *J* 7.6, 1.5 Hz, H-4), 8.17 (1H, d, *J* 7.5 Hz, H-5), 7.59 (1H, brd, *J* 7.5 Hz, H-6), 8.08 (1H, brs, H-8).

Acknowledgement

Authors thank Y. Fujimoto, Tokyo, Japan, for recording 2D NMR, HMBC spectra and Head, Department of Chemistry, University of Rajasthan for providing laboratory facilities. Authors are also thankful to CSIR, New Delhi for Emeritus Scientistship to Pahup Singh and Research Associateship to Deepa Pandey.

References

1. R. N. Chopra, S. L. Nayar and I. C. Chopra, "The Glossary of Indian Medicinal Plant", CSIR, New Delhi, 1956, p. 240.

2. M. Majumdar, N. Nayeem, J. V. Kamath and M. Asad, *Pak. J. Pharma. Sci.*, 2007, **20**, 120.

3. P. Singh, S. Jain and S. Bhargava, *Phytochemistry*, 1989, **28**, 1258.

4. K. C. Joshi, P. Singh and R. T. Pardasani, *Planta Medica*, 1977, **32**, 71.

5. S. Bhargava, S. Jain, A. Suri and P. Singh, *J. Indian Chem. Soc.*, 1991, **68**, 631.

6. P. K. Gupta and P. Singh, *J. Asian Nat. Prod. Res.*, 2004, **6**, 237.

7. S. Gopalakrishnan, S. Neelakantan, P. V. Raman, T. Okuyama and S. Shibata, *Chem. Pharm. Bull.*, 1984, **32**, 4137.

8. J. J. Inbaraj, M. C. Krishna, R. Gandhidasan and R. Murugesan, *Biochimica et Biophysica Acta*, 1999, **1472**, 462.