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SHORT REPORTS

A MONOTERPENE FROM *UMBELLULARIA CALIFORNICA*

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Key Word Index—*Umbellularia californica*; Lauraceae; California laurel; monoterpene; 10-hydroxy-umbellulone; (1*R-cis*)-4-hydroxymethyl-1-methylethyl-bicyclo[3.1.0]hex-3-en-2-one.

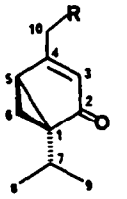
Abstract—A new monoterpene was isolated from leaves and stems of *Umbellularia californica*. The structure was determined to be (1*R-cis*)-4-hydroxymethyl-1-methylethyl-bicyclo[3.1.0]hex-3-en-2-one, based on spectroscopic evidence.

INTRODUCTION

Umbellularia californica (Hook. & Arn). Nutt., commonly known as California bay, is indigenous to California. The leaves of this plant have been used by Costanoan Indians to repel fleas and to treat headache and poison oak dermatitis [1]. The ability of volatile components present in the leaves to repel deer from damaging the crops and to attract insects has also been investigated [2]. A thorough investigation of the leaf oil reveals the presence of monoterpenes, sesquiterpenes and aromatic compounds [3]. In the studies of the constituents of the CH_2Cl_2-soluble fraction, we isolated a new monoterpene **1**.

Examination of the IR spectrum of compound **1** found that this compound contained bands assignable to hydroxyl (3404 cm^{-1}) and α,β-unsaturated carbonyl (1689, 1609 cm^{-1}) groups. The UV spectrum of **1** showed absorption at 220 (log ε 4.22) and 263 nm (log ε 3.95) consistent with α,β-unsaturated carbonyl containing compounds. Analysis of the HR-MS, which gave the molecular formula $C_{10}H_{14}O_2$, and NMR spectral data suggested **1** was a monoterpene. Determination of its structure and confirmation of its structural assignment were achieved by performing derivatization and a series of NMR experiments including COSY, HETCOR and COLOC.

The ^{13}C NMR spectral data of **1** showed that this compound possessed 10 carbons including three quaternary (δ207.9, 181.4, 40.1), three methine (δ121.4, 26.2, 25.3), two methylene (δ61.7, 38.5), and two methyl (δ19.9, 19.2) carbons. The carbon resonances at δ207.9, 121.4 and 61.7 revealed the presence of carbonyl, olefinic and primary OH functionalities in the molecule. A group



	R
1	OH
2	OAc
3	H
4	Br

of resonances at δ19.2, 19.9, 26.2 in the ^{13}C NMR spectrum and δ0.87, 0.94, 2.05 in the ^1H NMR spectrum further indicated the presence of an isopropyl group. To meet the requirement of four degrees of unsaturation, two rings must be included in the molecule. The structure of **1** thus was deduced to be a bicyclic monoterpene bearing a hydroxyl and an α,β-unsaturated carbonyl groups. Acetylation of **1** afforded a monoacetate (**2**) which showed a significant downfield shift of H-10 ($\Delta\delta = 0.35$) and C-10 ($\Delta\delta = 0.3$) and an upfield shift of C-4 ($\Delta\delta = -7.8$), confirming the location of the hydroxyl group at C-10. Compound **1** was thus deduced to be an oxygenated derivative of umbellulone (**3**). Similar to **3**, this compound also possessed two chiral centres, C-1 and C-5, in the molecule. Since the absolute configuration at C-1 and the dependent asymmetric centre at C-5 of (−)umbellulone has been established [4], it was decided to perform chemical transformation from **3** to **1** and compare the optical activity of the derivatized alcohol with that of naturally occurring **1**. Compound **3**, which was isolated from the pentane-soluble extract of *U. californica*, exhib-

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ited comparable $[\alpha]_D(-24.3°, CHCl_3; c\,0.33)$ to that of (−)umbellulone (−39.4°; pure liquid) [5] indicating the same identity of these two compounds. Portions of **3** were then converted to 10-bromoumbellulone (**4**). The resulting bromide was further hydrolysed to give **1** which showed an $[\alpha]_D(-25.1°)$ comparable to that of **1** isolated from *U. californica* (−18.5°). The configuration of **1** at C-1 and C-5 was thus confirmed to be identical to that of (−)umbellulone and its structure was determined to be 10-hydroxyumbellulone which had the systemic name (1*R*-*cis*)-4-hydroxymethyl-1-methylethyl-bicyclo[3.1.0] hex-3-en-2-one. To confirm **1** was not an artifact of umbellulone, portions of the plant material were extracted with CH_2Cl_2. The resultant CH_2Cl_2 extract was compared directly with **1** by TLC. The presence of **1** in the original plant extract indicated that **1** was a naturally occurring compound.

EXPERIMENTAL

The stems of *Umbellularia californica* (2.3 kg) were extracted with MeOH (15 l × 3) at room temp. After removal of MeOH under red. pres., the residue was partitioned between H_2O and pentane, CH_2Cl_2, and *n*-BuOH successively. The CH_2Cl_2-soluble fraction (8.4 g) was chromatographed on a column of silica gel and subjected to gradient elution with pentane–Et_2O–EtOAc and EtOAc–MeOH. Rechromatography of compound **1** containing column fr. over silica gel (elution with $CHCl_3$) afforded **1** (395 mg). Similar isolation procedure was performed on the leaves (0.4 kg) to give **1** (80 mg) as an oil $[\alpha]_D$ −18.5° ($CHCl_3$; c 0.27); IR ν_{max} cm^{-1}: 3404, 2962, 2917, 1689, 1609, 1367, 1285, 1127, 1046; UV λ_{max} (MeOH) nm (log ε): 220 (4.22), 263 (3.95); ^{1}H NMR (300 MHz, $CDCl_3$): δ5.46 (1H, *bs*, H-3), 4.40 (2H, AB*q*, *J* = 16.7 Hz, CH_2-10), 2.09 (1H, *dd*, *J* = 6.8, 3.2 Hz, H-5), 2.05 (1H, *qq*, *J* = 6.9, 6.9 Hz, H-7), 1.32 (1H, *dd*, *J* = 6.8, 3.9 Hz, H-6a), 1.20 (1H, *dd*, *J* = 3.3, 3.3 Hz, H-6b), 0.94 (3H, *d*, *J* = 6.9 Hz, Me-9), 0.87 (3H, *d*, *J* = 6.9 Hz, Me-8); ^{13}C NMR (75 MHz, $CDCl_3$): δ207.9 (*s*, C-2), 181.4 (*s*, C-4), 121.4 (*d*, C-3), 61.7 (*t*, C-10), 40.1 (*s*, C-1), 38.5 (*t*, C-6), 26.2 (*d*, C-7), 25.3 (*d*, C-5), 19.9 (*q*, C-9), 19.2 (*q*, C-8); HREI-MS *m/z* (rel. int.): 166.0994 (calcd for $C_{10}H_{14}O_2$ *m/z* 166.0994); EI-MS *m/z*: 166 $[M]^+$ (10), 151 (5), 135 (14), 124 (100), 121 (14), 107 (53), 105 (51), 95 (74), 77 (33), 67 (27), 55 (24). The pentane-soluble fr. was chromatographed over a silica gel column to give an oil which exhibited identical spectral data to that of umbellulone (**3**) [6].

Acetylation of compound **1**. Portions of **1** (100 mg) were acetylated by Ac_2O–pyridine to give an oil, **2** (93 mg), which exhibited the following spectral data: ^{1}H NMR (300 MHz, $CDCl_3$): δ5.31 (1H, *d*, *J* = 1.3 Hz, H-3), 4.75 (2H, AB*q*, *J* = 16.7, 1.7 Hz, CH_2-10), 2.03 (1H, *dd*, *J* = 6.8, 3.2 Hz, H-5), 1.95 (3H, *s*, MeCO), 1.94 (1H, *qq*, *J* = 6.9, 6.9 Hz, H-7), 1.24 (1H, *dd*, *J* = 6.8, 3.8 Hz, H-6a), 1.11 (1H, *dd*, *J* = 3.5, 3.5 Hz, H-6b), 0.86 (3H, *d*, *J* = 6.9 Hz, Me-9), 0.80 (3H, *d*, *J* = 7.0 Hz, Me-8); ^{13}C NMR (75 MHz, $CDCl_3$): δ 205.9 (*s*, C-2), 173.6 (*s*, C-4), 169.7 (*s*, MeCO), 122.7 (*d*, C-3), 62.0 (*t*, C-10), 39.7 (*s*, C-1), 37.6 (*t*, C-6), 26.3 (*d*, C-7), 25.3 (*d*, C-5), 20.2 (*q*, MeCO), 19.6 (*q*, C-9), 19.0 (*q*, C-8); CI-MS *m/z* (rel. int.): 209 $[M+H]^+$ (16), 167 (26), 166 (64), 149 (100), 124 (32), 121 (24), 107 (27), 105 (20).

Preparation of 10-*hydroxyumbellulone* (**1**) *from umbellulone* (**3**). Portions of **3** (150 mg) were brominated by N-bromosuccinimide (214 mg)/CCl_4, 2,2′-azobis(2-methylpropionitrile) for 3 hr under reflux to give **4** (51 mg) as needles (mp 101–102° (hexane)) which exhibited the following ^{1}H NMR data: δ5.57 (1H, *bs*, H-3), 4.18 (2H, *bs*, CH_2-10), 2.27 (1H, *dd*, *J* = 6.7, 3.2 Hz, H-5), 2.13 (1H, *qq*, *J* = 6.9, 6.9 Hz, H-7), 1.44 (1H, *dd*, *J* = 6.8, 3.9 Hz, H-6a), 1.32 (1H, *dd*, *J* = 3.3, 3.3 Hz, H-6b), 1.03 (3H, *d*, *J* = 6.9 Hz, Me-9), 0.96 (3H, *d*, *J* = 6.9 Hz, Me-8). Portions of **4** (23 mg) were hydrolysed by $AgNO_3$ in 50% aq. Me_2CO for 3 hr (oil bath 70–80°) to give **1** (9.8 mg) which exhibited identical ^{1}H NMR data to that of **1** isolated from this plant. The $[\alpha]_D$ obtained for this hydrolysed product was −25.1° ($CHCl_3$; *c* 0.20).

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