

Three Terpenoids and a Tocopherol-Related Compound from *Ricinus communis*

by **Qin-Gang Tan**^{a)}^{b)}, **Xiang-Hai Cai**^{a)}, **Zhi-Zhi Du**^{a)}, and **Xiao-Dong Luo**^{*a)}

^{a)} State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences, 132 Lanhei Road, Kunming 650204, P. R. China
(phone: +86-871-5223177; fax: +86-871-5150227; e-mail: xdluo@mail.kib.ac.cn)

^{b)} Guilin Medical College, Guilin 541004, P. R. China

Four new compounds named (3*E*,7*Z*,11*E*)-19-hydroxycasba-3,7,11-trien-5-one (**1**), 6*α*-hydroxy-10*β*-methoxy-7*α*,8*α*-epoxy-5-oxocasbane-20,10-olide (**2**), 15*α*-hydroxylup-20(29)-en-3-one (**3**), and (2*R*,4*aR*,8*aR*)-3,4,4*a*,8*a*-tetrahydro-4*a*-hydroxy-2,6,7,8*a*-tetramethyl-2-(4,8,12-trimethyltridecyl)-2*H*-chromene-5,8-dione (**4**) were isolated from the MeOH extracts of the aerial parts of *Ricinus communis* L. by chromatographic methods. Their structures were elucidated by extensive spectroscopic experiments.

Introduction. – *Ricinus communis* L. (Euphorbiaceae), a herb or herbaceous shrub, is widely distributed in tropical regions and cultivated from tropical to extra tropical regions in the world [1]. This plant, which is called ‘mahongliang’ by the local *Dai* people in Yunnan province, P. R. China, is mainly used for the treatment of icteric hepatitis, arthritis, and constipation [2]. Recent researches have revealed the antifertility [3] and the inhibitory activity to HIV-1 reverse transcriptase [4] of the constituents from this plant. Previous chemical investigation on *Ricinus communis* L. led to the isolation of sterols [3], alkaloids [5][6], diterpenoids [7][8], coumarin, and flavonoids [5][9]. In order to find out the chemical basis of the favorable therapeutic effects, we have chemically investigated the aerial parts of *Ricinus communis* L., which led to the isolation of four new compounds named (3*E*,7*Z*,11*E*)-19-hydroxycasba-3,7,11-trien-5-one (**1**)¹⁾, 6*α*-hydroxy-10*β*-methoxy-7*α*,8*α*-epoxy-5-oxocasbane-20,10-olide (**2**)¹⁾, 15*α*-hydroxylup-20(29)-en-3-one (**3**)¹⁾, and (2*R*,4*aR*,8*aR*)-3,4,4*a*,8*a*-tetrahydro-4*a*-hydroxy-2,6,7,8*a*-tetramethyl-2-(4,8,12-trimethyltridecyl)-2*H*-chromene-5,8-dione (**4**) (*Fig. 1*). In this article, we report the isolation and structure elucidation of these new compounds.

Results and Discussion. – Compound **1** possesses a molecular formula of C₂₀H₃₀O₂, as evidenced by the HR-ESI-MS (*m/z* 325.2147, calc. 325.2143 for C₂₀H₃₀NaO₂⁺, [*M* + Na]⁺), indicating six degrees of unsaturation. The IR spectrum showed absorption for OH (3426 cm⁻¹) and conjugated CO groups (1652 cm⁻¹), respectively. The presence of a conjugated CO group was supported by the UV absorption at 270 nm (log ε = 4.74) [10]. The ¹H-NMR spectrum of **1** (*Table 1*) displayed signals of three trisubstituted C=C bonds and four Me groups, two of them attached to sp²-C-atoms (δ(H) 1.85 (*s*,

¹⁾ Arbitrary numbering. For systematic names, see *Exper. Part*.

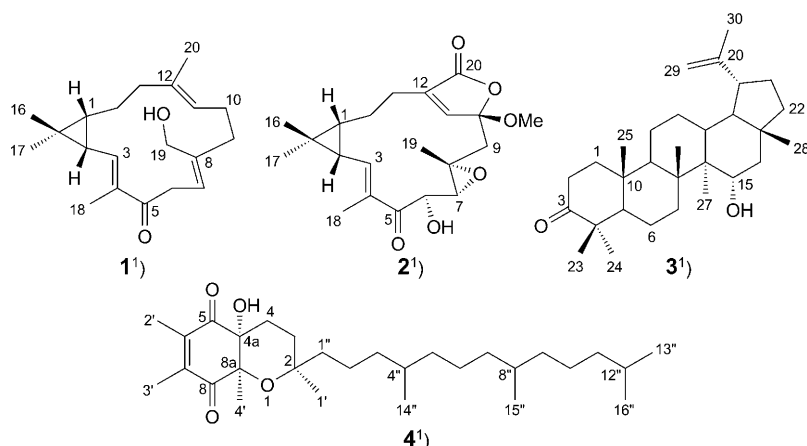


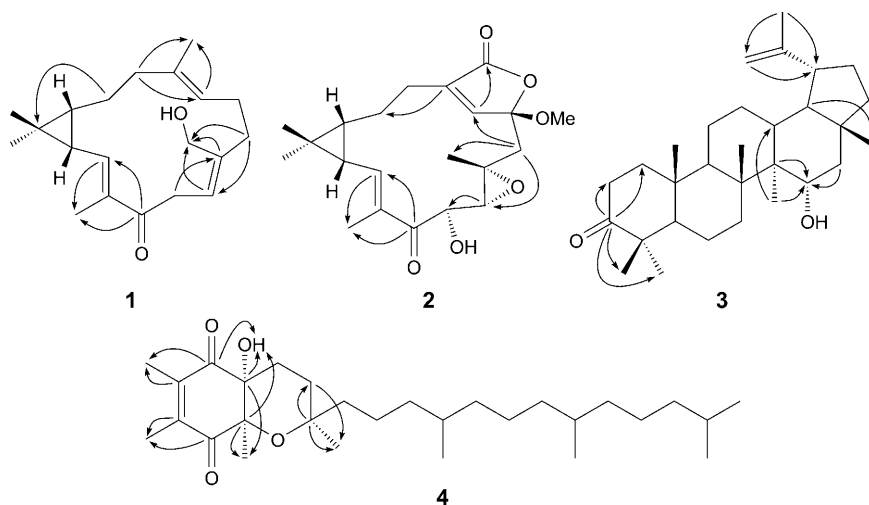
Fig. 1. Structures of the new compounds **1–4** from *Ricinus communis* L.

Me(18¹)) and $\delta(\text{H})$ 1.56 (*s*, Me(20))). With these functionalities, the two remaining degrees of unsaturation were ascribed to two ring systems. The chemical shifts at $\delta(\text{C})$ 35.2, 27.6, 25.3, 15.8, and 28.8 in the ¹³C-NMR spectrum (*Table 1*) together with gem-dimethyl at $\delta(\text{H})$ 1.08 (*s*), 1.15 (*s*) in the ¹H-NMR spectrum indicated the presence of a cyclopropyl ring. These signals were typical for a casbane-type diterpenoid containing a 14-membered macrocyclic ring. By comparison the spectra data of **1** with those of (2*E*,6*E*,12*E*)-4-hydroxycasba-2,6,12-trien-5-one [11] and those of casbane diterpenoid [12], the differences consisted in that one of the Me groups in the latter two compounds was a CH₂ group in **1**. Considering that $\delta(\text{H})$ 4.04 (*d*, *J* = 11.9) and 4.16 (*d*, *J* = 11.9) showed correlations with $\delta(\text{C})$ 128.6 (*d*, C(7)), 139.3 (*s*, C(8)), and 35.4 (*t*, C(9)) in the HMBC spectrum (*Fig. 2*) of **1**, the OH substitution was at C(19). The β -orientation of H–C(1) and H–C(2) was assigned on the basis of the close similarity of the coupling constant data with those of agrostistachin [13], of which the relative configurations were established by X-ray crystallographic analysis. This deduction was supported by the correlations of $\delta(\text{H})$ 1.08 (*s*, Me(16)) with $\delta(\text{H})$ 1.16–1.18 (*m*, H–C(1)) and 1.49 (*t*, *J* = 9.0, H–C(2)) in the ROESY spectrum (*Fig. 3*) of **1**. Thus, compound **1** was identified as (3*E*,7*Z*,11*E*)-19-hydroxycasba-3,7,11-trien-5-one¹.

The molecular formula of compound **2** was determined to be C₂₁H₂₈O₆ based on the HR-ESI-MS (*m/z* 399.1788, calc. 399.1783 for C₂₁H₂₈NaO₆⁺) and the DEPT data, suggesting eight degrees of unsaturation. The IR spectrum showed absorption for OH (3432 cm⁻¹) and conjugated CO groups (1649 cm⁻¹), respectively. The ¹H-NMR spectrum data of **2**¹) (*Table 1*) revealed the presence of five Me groups including one MeO group, two olefinic H-atoms, and two H-atoms attached to an O-bearing C-atom. The ¹³C-NMR and DEPT spectra data (*Table 1*) showed signals of two trisubstituted C=C bonds and two CO groups. The presence of a trisubstituted epoxide was deduced from the signals at $\delta(\text{H})$ 2.70 (*d*, *J* = 6.1) and $\delta(\text{C})$ 63.5 (*d*) and 58.4 (*s*) [14]. Considering the disappearance of a C=C bond in the DEPT spectrum of **2** compared with that of **1**, the epoxidation occurred at C(7) and C(8). The ¹H- and ¹³C-NMR spectra of **2** were similar to those of hookerianolide A [15], except for the presence of

Table 1. $^1\text{H-NMR}$ (400 MHz) and $^{13}\text{C-NMR}$ (100 MHz) Data of **1** and **2** in CDCl_3 , δ in ppm, J in Hz.

	1 ¹⁾		2 ¹⁾	
	$\delta(\text{H})$	$\delta(\text{C})$	$\delta(\text{H})$	$\delta(\text{C})$
H–C(1)	1.16–1.18 (<i>m</i>)	35.2 (<i>d</i>)	1.20–1.25 (<i>m</i>)	33.4 (<i>d</i>)
H–C(2)	1.49 (<i>t</i> , $J=9.0$)	27.6 (<i>d</i>)	1.48 (<i>d</i> , $J=8.4$)	26.7 (<i>d</i>)
H–C(3)	6.37 (<i>d</i> , $J=10.0$)	143.2 (<i>d</i>)	6.56 (<i>d</i> , $J=7.7$)	143.6 (<i>d</i>)
C(4)		136.6 (<i>s</i>)		136.8 (<i>s</i>)
C(5)		199.6 (<i>s</i>)		199.4 (<i>s</i>)
$\text{CH}_2(6)$ or H–C(6)	2.12–2.15, 1.96–2.00 (<i>2m</i>)	39.4 (<i>t</i>)	4.48 (<i>t</i> , $J=6.6$)	72.4 (<i>d</i>)
H–C(7)	5.08 (<i>t</i> , $J=8.0$)	128.6 (<i>d</i>)	2.70 (<i>t</i> , $J=6.1$)	63.5 (<i>d</i>)
C(8)		139.3 (<i>s</i>)		58.4 (<i>s</i>)
$\text{CH}_2(9)$	2.41–2.44, 1.78–1.81 (<i>2m</i>)	35.4 (<i>t</i>)	2.78 (<i>d</i> , $J=15.0$), 1.85 (<i>d</i> , $J=15.0$)	45.7 (<i>t</i>)
$\text{CH}_2(10)$ or C(10)	2.20–2.23, 2.06–2.09 (<i>2m</i>)	23.7 (<i>t</i>)		106.8 (<i>s</i>)
H–C(11)	5.02 (<i>t</i> , $J=8.0$)	119.7 (<i>d</i>)	6.50 (<i>s</i>)	143.0 (<i>d</i>)
C(12)		136.9 (<i>s</i>)		139.6 (<i>s</i>)
$\text{CH}_2(13)$	2.98–3.03, 3.49–3.53 (<i>2m</i>)	39.3 (<i>t</i>)	2.62–2.67, 2.14–2.19 (<i>2m</i>)	24.6 (<i>t</i>)
$\text{CH}_2(14)$	0.84–0.91, 2.10–2.15 (<i>2m</i>)	26.6 (<i>t</i>)	2.12–2.16, 0.97–1.02 (<i>2m</i>)	22.5 (<i>t</i>)
C(15)		25.3 (<i>s</i>)		24.2 (<i>s</i>)
Me(16)	1.08 (<i>s</i>)	15.8 (<i>q</i>)	1.16 (<i>s</i>)	15.7 (<i>q</i>)
Me(17)	1.15 (<i>s</i>)	28.8 (<i>q</i>)	1.19 (<i>s</i>)	28.2 (<i>q</i>)
Me(18)	1.85 (<i>s</i>)	11.6 (<i>q</i>)	1.95 (<i>s</i>)	13.0 (<i>q</i>)
$\text{CH}_2(19)$ or Me(19)	4.04 (<i>d</i> , $J=11.9$), 4.16 (<i>d</i> , $J=11.9$)	59.7 (<i>t</i>)	1.45 (<i>s</i>)	19.5 (<i>q</i>)
Me(20) or C(20)	1.56 (<i>s</i>)	15.9 (<i>q</i>)		170.0 (<i>s</i>)
MeO			3.14 (<i>s</i>)	50.4 (<i>q</i>)

Fig. 2. Key HMBCs for compounds **1–4**

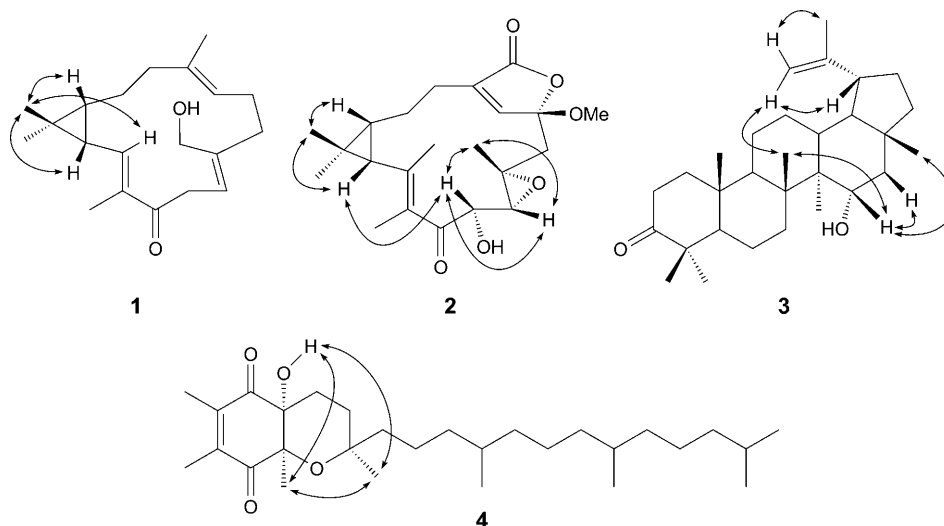


Fig. 3. Key ROESY correlations for compounds 1–4

the ketone and the MeO groups, and the absence of an O-bearing CH group and the downfielded chemical shifts of the two olefinic C-atoms (C(3) and C(4)) in **2**. All these data suggested that the OH group in hookerianolide A at C(5) was replaced by an oxo group in **2**. From the correlations of $\delta(\text{H})$ 6.50 (*s*, H–C(11)), 3.14 (*s*, MeO), 2.78 and 1.85 (*dd*, $J = 15.0$, CH₂(9)) with $\delta(\text{C})$ 106.8 (*s*) in the HMBC spectrum (Fig. 2) of **2**, we assigned the MeO group to be placed at C(10). The β -orientations of H–C(6), H–C(7), and Me(19) were deduced from the ROESY spectrum (Fig. 3), in which the signal of $\delta(\text{H})$ 1.48 (*d*, $J = 8.4$, H–C(2)) was correlated with $\delta(\text{H})$ 1.20–1.25 (*m*, H–C(1)) and 4.48 (*t*, $J = 6.6$, H–C(6)), the signal of $\delta(\text{H})$ 4.48 (*t*, $J = 6.6$, H–C(6)) with $\delta(\text{H})$ 2.70 (*t*, $J = 6.1$, H–C(7)) and 1.45 (*s*, Me(19)). Therefore, compound **2** was identified as 6 α -hydroxy-10 β -methoxy-7 α ,8 α -epoxy-5-oxocasbane-20,10-olide.

Compound **3** has the molecular formula of C₃₀H₄₈O₂ as evidenced by the HR-ESI-MS (m/z 463.3545, calc. 463.3552 for C₃₀H₄₈NaO₂⁺), indicating seven degrees of unsaturation. The IR spectrum showed absorptions for OH (3434 cm⁻¹) and CO groups (1697 cm⁻¹), respectively. Analysis based on the combination of ¹H-, ¹³C-NMR and DEPT data (Table 2) revealed the presence of seven Me groups, a terminal C=C bond ($\delta(\text{H})$ 4.58, 4.67 and $\delta(\text{C})$ 109.7, 150.2), and an O-bearing CH group ($\delta(\text{H})$ 4.15 (*dd*, $J = 4.9, 11.0$) and $\delta(\text{C})$ 69.6). The characteristic chemical shifts of the terminal C=C bond and five rings revealed that **3** was a lupane-type triterpenoid. The spectra data of **3** were similar to those of lup-20(29)-en-3 β ,15 α -diol [16], except that one of the OH groups was replaced by a ketone group. The downfielded shifts of C(2)¹) and C(4) in **3** indicated the location of the oxo group at the usual C(3) position. The only OH group was located at C(15), which was deduced from the correlations of $\delta(\text{H})$ 4.15 (*dd*, $J = 4.9, 11.0$) with $\delta(\text{C})$ 47.9 (*s*, C(14)), 46.5 (*t*, C(16)), and 7.8 (*q*, C(27)) in the HMBC spectrum of **3** (Fig. 2). The α -orientation of the OH group was deduced from the observation of the correlations of $\delta(\text{H})$ 4.15 (*dd*, $J = 4.9, 11.0$, H–C(15)) with $\delta(\text{H})$ 0.83

Table 2. $^1\text{H-NMR}$ (400 MHz) and $^{13}\text{C-NMR}$ (100 MHz) Data of **3** and **4** in CDCl_3 , δ in ppm, J in Hz.

3 ¹⁾			4 ¹⁾		
	$\delta(\text{H})$	$\delta(\text{C})$		$\delta(\text{H})$	$\delta(\text{C})$
$\text{CH}_2(1)$	1.37–1.41, 1.22–1.25 (2m)	39.8 (t)	C(2)		87.0 (s)
$\text{CH}_2(2)$	2.41–2.44 (m)	34.1 (t)	$\text{CH}_2(3)$	1.87–1.92, 1.59–1.64 (2m)	36.4 (t)
C(3)		218.2 (s)	$\text{CH}_2(4)$	2.02–2.06, 1.68–1.73 (2m)	32.0 (t)
C(4)		47.1 (s)	C(5)		201.7 (s)
H–C(5)	1.28–1.31 (m)	54.5 (d)	C(6)		141.9 (s)
$\text{CH}_2(6)$	1.51–1.53 (m)	19.8 (t)	C(7)		146.9 (s)
$\text{CH}_2(7)$	1.86–1.89, 1.33–1.37 (2m)	36.9 (t)	C(8)		198.8 (s)
C(8)		42.2 (s)	C(4a)		93.3 (s)
H–C(9)	1.40–1.43 (m)	50.2 (d)	C(8a)		81.2 (s)
C(10)		37.0 (s)	Me(1')	1.36 (s)	24.2 (q)
$\text{CH}_2(11)$	1.48–1.51, 1.27–1.32 (2m)	21.5 (t)	Me(2')	2.09 (s)	13.4 (q)
$\text{CH}_2(12)$	1.63–1.67 (m)	25.1 (t)	Me(3')	2.10 (s)	13.0 (q)
H–C(13)	1.61–1.65 (m)	37.7 (d)	Me(4')	1.39 (s)	25.8 (q)
C(14)		47.9 (s)	$\text{CH}_2(1'')$	1.55–1.63, 1.67–1.72 (2m)	41.4 (t)
H–C(15)	4.15 (dd, $J=11.0, 4.9$)	69.6 (d)	$\text{CH}_2(2'')$	1.40–1.43, 1.23–1.28 (2m)	22.3 (t)
$\text{CH}_2(16)$	1.75–1.80, 1.28–1.34 (2m)	46.5 (t)	$\text{CH}_2(3'')$	1.05–1.24 (m)	37.3 (t)
C(17)		42.9 (s)	H–C(4'')	1.35–1.40 (m)	32.7 (d)
H–C(18)	1.38–1.44 (m)	47.9 (d)	$\text{CH}_2(5'')$	1.05–1.24 (m)	37.4 (t)
H–C(19)	2.37–2.43 (m)	47.3 (d)	$\text{CH}_2(6'')$	1.20–1.35 (m)	24.4 (t)
C(20)		150.2 (s)	$\text{CH}_2(7'')$	1.05–1.24 (m)	37.5 (t)
$\text{CH}_2(21)$	1.93–1.97, 1.31–1.36 (2m)	30.0 (t)	H–C(8'')	1.35–1.39 (m)	32.8 (d)
$\text{CH}_2(22)$	1.43–1.47, 1.17–1.23 (2m)	39.6 (t)	$\text{CH}_2(9'')$	1.05–1.24 (m)	37.5 (t)
Me(23)	1.05 (s)	26.5 (q)	$\text{CH}_2(10'')$	1.20–1.35 (m)	24.8 (t)
Me(24)	1.01 (s)	20.9 (q)	$\text{CH}_2(11'')$	1.10–1.15 (m)	39.3 (t)
Me(25)	0.93 (s)	16.0 (q)	H–C(12'')	1.48–1.54 (m)	27.9 (d)
Me(26)	1.15 (s)	16.2 (q)	Me(13'')	0.85–0.87 ^a)	22.6 (q)
Me(27)	0.96 (s)	7.8 (q)	Me(14'')	0.87–0.90 ^a)	19.7 (q)
Me(28)	0.83 (s)	19.0 (q)	Me(15'')	0.87–0.90 ^a)	19.8 (q)
$\text{CH}_2(29)$	4.67 (s), 4.58 (s)	109.7(t)	Me(16'')	0.85–0.87 ^a)	22.7 (q)
Me(30)	1.67 (s)	19.3 (q)	OH	3.86 (s)	

^a) Overlapped.

(s, Me(28)) and 1.15 (s, Me(26)) in the ROESY spectrum (Fig. 3). Therefore, **3** was deduced as 15 α -hydroxylup-20(29)-en-3-one.

Compound **4** was deduced as $\text{C}_{29}\text{H}_{50}\text{O}_4$ by HR-ESI-MS analysis (m/z 485.3606, calc. 485.3606 for $\text{C}_{29}\text{H}_{50}\text{NaO}_4^+$). The DEPT spectrum data of **4** (Table 2) showed the signals of eight Me and eleven CH_2 groups, indicating the existence of a long aliphatic chain. Comprising the ^1H - and ^{13}C -NMR data with those of VE-FPL (= 7 α -acetyl-3,4,4a,7-tetrahydro-4a-hydroxy-2,6,7-trimethyl-2-(4,8,12-trimethyltridecyl)cyclopenta[*b*]pyran-5(2*H*)-one) [17], together with the degrees of unsaturation, **4** was found to be a tocopherol-related compound. The ^{13}C -NMR and DEPT spectra data of **4** (Table 2) showed the presence of two conjugated CO groups and one tetrasubstituted C=C bond, which was supported by the strong absorption at 1679 cm^{-1} and 253 nm in the IR and UV spectra of **4**, respectively. The close chemical shifts of the two CO groups ($\delta(\text{C})$

201.7, 198.8) and of the two olefinic C-atoms ($\delta(\text{C})$ 146.9, 141.9) in **4** differentiated from those of in VE-FPL ($\delta(\text{C})$ 205.0, 207.1 and 139.3, 163.1), indicating the left ring to be a six-membered in **4** instead of the five-membered in VE-FPL. This deduction was confirmed by the correlations of $\delta(\text{H})$ 2.09 (s, Me(2')¹) with $\delta(\text{C})$ 201.7 (s, C(5)) and 141.9 (s, C(6)), of $\delta(\text{H})$ 2.10 (s, Me(3')) with $\delta(\text{C})$ 146.9 (s, C(7)) and 198.8 (s, C(8)) in the HMBC spectrum (Fig. 2) of **4**. Furthermore, the correlations of $\delta(\text{H})$ (3.86, s, OH) with $\delta(\text{C})$ 201.7 (s, C(5)), 93.3 (s, C(4a)), and 81.2 (s, C(8a)), of $\delta(\text{H})$ 1.39 (s, Me(4')) with $\delta(\text{C})$ 93.3 (s) and 81.2 (s), of $\delta(\text{H})$ 1.36 (s, Me(1')) with $\delta(\text{C})$ 87.0 (s, C(2)) and 36.4 (t, C(3)) were also observed. The relative configurations of the OH and the Me(4') groups were assigned as α , based on the observation of the correlations of $\delta(\text{H})$ 3.86 (s, OH) with $\delta(\text{H})$ 1.36 (s, Me(1')) and 1.39 (s, Me(4')) in the ROESY spectrum (Fig. 3). Thus, compound **4** was identified as (2*R*,4*aR*,8*aR*)-3,4,4*a*,8*a*-tetrahydro-4*a*-hydroxy-2,6,7,8*a*-tetramethyl-2-(4,8,12-trimethyltridecyl)-2*H*-chromene-5,8-dione.

Experimental Part

General. Column chromatography (CC): silica gel (SiO₂; Qingdao Marine Chemical Inc., P. R. China) and RP-18 (20–40 μm , Merck). Optical rotations: Horiba SEPA-300 spectropolarimeter. UV Spectra: Shimadzu 210-A double-beam spectrophotometer; λ_{max} (log ϵ) in nm. IR Spectra: Bruker Tensor 27 spectrometer, KBr pellet and $\tilde{\nu}$ in cm⁻¹. NMR Spectra: Bruker AM-500 spectrometer; δ in ppm with TMS as internal standard, *J* in Hz. HR-ESI-MS: VG Autospec-3000 spectrometer.

Plant Material. The aerial parts of *Ricinus communis* L. were collected in Kunming, Yunnan province, P. R. China, in March, 2007, and identified by Dr. Chun-Xia Zeng, Kunming Institute of Botany. A voucher specimen (NO. KUN20070310) has been deposited with the Herbarium of Kunming Institute of Botany, Chinese Academy of Sciences.

Extraction and Isolation. The air-dried aerial parts (16.0 kg) of *Ricinus communis* L. were crushed and extracted with 95% aq. MeOH (30 l \times 3) at r.t. (48 h \times 3). After evaporation of MeOH, the viscous concentrate was dissolved in H₂O and partitioned with AcOEt (3 l \times 4) to afford AcOEt and H₂O extracts. The AcOEt extract (325 g) was subjected to SiO₂ CC (2.2 kg, 200–300 mesh) and eluted with CHCl₃/Me₂CO (1:0 \rightarrow 1:1) to give eight fractions (Fr. I–VIII). Fr. III (63.0 g) was subjected to CC (SiO₂; 700 g) and eluted with petroleum ether (PE)/acetone (20:1 \rightarrow 8:1) to afford five subfractions (Subfr. III1–III5). Subfr. III3 (6.1 g) was chromatographed on RP-18 CC (MeOH/H₂O, 4:1 \rightarrow 1:0), and then purified by SiO₂ CC (PE/AcOEt 12:1) to afford compound **4** (18.3 mg). Fr. V (103 g) was subjected to SiO₂ (1 kg) CC and eluted with PE/acetone (5:1 \rightarrow 1:1) to afford six subfractions (Subfr. V1–V6). Subfr. V2 (6.28 g) was subjected to RP-18 CC (MeOH/H₂O, 3:1 \rightarrow 1:0), and then purified by SiO₂ CC (Pt/acetone 10:1) to afford compound **3** (34.8 mg). Separation of Subfr. V4 (4.5 g) with RP-18 CC (MeOH/H₂O, 4:1 \rightarrow 1:0) to give compound **1** (102 mg). Subfr. V6 (7.8 g) was first subjected to RP-18 CC (MeOH/H₂O, 4:1 \rightarrow 1:0) and then to SiO₂ CC (PE/AcOEt 8:1) to afford compound **2** (16.4 mg).

(3*E*,7*Z*,11*E*)-19-Hydroxycasba-3,7,11-trien-5-one (=rel-(1*R*,2*E*,10*E*,14*S*)-7-(Hydroxymethyl)-3,11,15-tetramethylbicyclo[12.1.0]pentadeca-2,6,10-trien-4-one; **1**). Colorless oil. $[\alpha]_{\text{D}}^{20} = -16.8$ ($c = 0.72$, CHCl₃). UV (CHCl₃): 270 (4.74), 236 (4.46), 202 (4.29). IR (KBr): 3426, 2926, 1652, 1452, 1274, 1066, 1003. ¹H- and ¹³C-NMR (CHCl₃): Table 1. HR-ESI-MS: 325.2147 ($[M + \text{Na}]^+$, C₂₀H₃₀NaO₂⁺; calc. 325.2143).

6*α*-Hydroxy-10*β*-methoxy-7*α*,8*α*-epoxy-5-oxocasban-20,10-olide (=rel-(1*R*,5*R*,6*R*,8*E*,10*S*,12*R*)-6-Hydroxy-1-methoxy-3,8,11,11-tetramethyl-4,17-dioxatetracyclo[13.2.1.0^{3,5}.0^{10,12}]octadeca-8,15(18)-diene-7,16-dione; **2**). White amorphous powder. $[\alpha]_{\text{D}}^{20} = -38.7$ ($c = 0.29$, CHCl₃). UV (CHCl₃): 270 (4.78), 233 (4.54), 205 (4.45). IR (KBr): 3432, 1742, 1649, 1614, 1150, 960. ¹H- and ¹³C-NMR (CHCl₃): Table 1. HR-ESI-MS: 399.1788 ($[M + \text{Na}]^+$, C₂₁H₂₈NaO₆⁺; calc. 399.1783).

15*α*-Hydroxylup-20(29)-en-3-one (**3**). White amorphous powder. $[\alpha]_{\text{D}}^{20} = +48.3$ ($c = 0.41$, CHCl₃). IR (KBr): 3434, 2960, 2868, 1697, 1461, 1384. ¹H- and ¹³C-NMR (CHCl₃): Table 2. HR-ESI-MS: 463.3545 ($[M + \text{Na}]^+$, C₃₀H₄₈NaO₂⁺; calc. 463.3552).

rel-(2R,4aR,8aR)-3,4,4a,8a-Tetrahydro-4a-hydroxy-2,6,7,8a-tetramethyl-2-(4,8,12-trimethyltridecyl)-2H-chromene-5,8-dione (**4**). Colorless oil. $[\alpha]_D^{20} = -12.7$ ($c = 0.11$, CHCl_3). UV (CHCl_3): 352 (3.05), 339 (3.08), 253 (4.66), 228 (4.36), 210 (4.24), 201 (4.22). IR (KBr): 3487, 2954, 1679, 1462, 1377. ^1H - and ^{13}C -NMR (CHCl_3): Table 2. HR-ESI-MS: 485.3606 ($[M + \text{Na}]^+$, $\text{C}_{29}\text{H}_{50}\text{NaO}_4$; calc. 485.3601).

The authors are grateful to the *National Natural Science Foundation of China* (C30670214), *National Basic Research Program of China* (973 Program 2009CB522300), and the *Chinese Academy of Sciences* (KSCX2-YW-N-014, *XiBuZhiGuang* Project) for partial financial support.

REFERENCES

- [1] Editorial Committee of Flora of China of Chinese Academy of Sciences, 'Flora of China', Vol. 44, Science Press, Beijing, 1994, p. 88.
- [2] Yunnan Institute of Materia Medica, 'Illustrated Handbook for Medicinal Materials from Nature in Yunnan', Vol. 1, Yunnan Science and Technology Press, Kunming, 2005, p. 468.
- [3] X. Zhang, F. Han, P. Gao, D. Yu, S. Liu, *Nat. Prod. Res.* **2007**, *21*, 982.
- [4] H. X. Wang, T. B. Ng, *Planta Med.* **2001**, *67*, 669.
- [5] S. S. Kang, G. A. Cordell, D. D. Soejarto, H. H. S. Fong, *J. Nat. Prod.* **1985**, *48*, 155.
- [6] A. C. Leite, E. C. Cabral, D. A. P. dos Santos, J. B. Fernandes, P. C. Vieira, M. F. das G. F. da Silva, *Quim. Nova* **2005**, *28*, 983.
- [7] L. Crombie, G. Kneen, G. Pattenden, *J. Chem. Soc., Chem. Commun.* **1976**, 66.
- [8] D. Sitton, C. A. West, *Phytochemistry* **1975**, *14*, 1921.
- [9] S. M. Khafagy, Z. F. Mahmoud, N. A. E. Salam, *Planta Med.* **1979**, *37*, 191.
- [10] Y.-H. Choi, J. M. Pezzuto, A. D. Kinghorn, N. R. Farnsworth, *J. Nat. Prod.* **1988**, *51*, 110.
- [11] H. S. Santos, F. M. R. Mesquita, T. L. G. Lemos, F. J. Q. Monta, R. Braz-Filho, *Quim. Nova* **2008**, *31*, 601.
- [12] V. L. A. Moura, F. J. O. Monte, R. Braz Filho, *J. Nat. Prod.* **1990**, *53*, 1566.
- [13] Y.-H. Choi, J. Kim, J. M. Pezzuto, A. D. Kinghorn, N. R. Farnsworth, H. Letter, H. Wagner, *Tetrahedron Lett.* **1986**, *27*, 5795.
- [14] G. J. Greenland, B. F. Bowden, *Aust. J. Chem.* **1994**, *47*, 2013.
- [15] Y. Bai, Y.-P. Yang, Y. Ye, *Tetrahedron Lett.* **2006**, *47*, 6637.
- [16] R. Tanaka, K. Masuda, S. Matsunaga, *Phytochemistry* **1993**, *32*, 472.
- [17] J. Kitajima, K. Kimizuka, M. Arai, Y. Tanaka, *Chem. Pharm. Bull.* **1998**, *46*, 1647.

Received March 20, 2009