Three New Diterpenoids from *Euphorbia sororia* L.

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Three new diterpenoids with jatrophane-type skeleton, sororianolides A–C (**1**–**3**, resp.), were isolated from *Euphorbia sororia*. The identification and structure elucidation of these compounds were based on 1D- and 2D-NMR-spectral data analysis. It was the first time to isolate diterpenoids in this species.

Introduction. – *Euphorbia sororia* A. SCHRENK (Euphorbiaceae) is an annual herb, mainly distributed in northwest China and in some Central Asian regions. As a traditional medicine, the seeds of *E. sororia* are used for the treatment of abdominal pain, abdominal distention, skin disease, and paralysis. Also, the seeds can be used to improve intelligence and appetite [1]. Previous investigations of *E. sororia* about its chemical constituents focused on the AcOEt and BuOH fractions. Some sphingolipids, flavones, and coumarins have been isolated from the aerial parts of this species [2–5]. In this study, we isolated three new diterpenoids from the whole plant. It was the first time to find diterpenoids in this species. The NMR data of sororianolides A–C (**1**–**3**, resp.) showed that they are all jatrophane-type diterpenoids. They are quite rare due to their substituents at C(1).

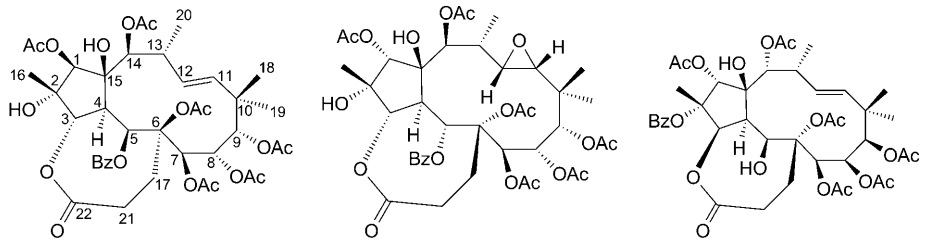
Results and Discussion. – Compound **1**, a white powder, was assigned a molecular formula of $C_{41}H_{52}O_{18}$, as established by the HR-ESI-MS ($[M+Na]^+$) at *m/z* 855.3054 and NMR data. The IR spectrum displayed absorption bands at 3450 and 1745 cm^{-1}, indicating the presence of OH and ester functionalities. Six acetates and one benzoate were easily deduced from the typical signals in the ^1H- and ^{13}C-NMR spectra (*Table*). The structural elements recognized among the remaining 22 signals were four Me groups (one secondary and three tertiary by ^1H-NMR), one lactone C=O group, and two sp^2 C-atoms belonging to a *trans*-disubstituted C=C bond. From the above data, it was deduced that the carbon skeleton of compound **1** was the same as that of the two known compounds isoterracinolides A and B from *E. terracina* [6]. However, compound **1** contains no propionate group, but two more AcO groups and O-bearing sp^3 C-atoms instead. In the HMBC spectrum (*Fig.*), the correlation of the signal for the Bz C=O group (δ(C) 164.2) and the signal for H–C(5)[1]) (δ(H) 6.47) demonstrated that the BzO group is located at C(5). In addition, the correlations between the signals

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

Table. *[1]H-* (400 MHz) *and [13]C-NMR (100 MHz) Data of Compounds* **1**–**3**[a])

	1[1])		**2**[1])			**3**[1])	
	δ(H)	δ(C)	δ(H)	δ(C)		δ(H)	δ(C)
1	5.48 (*s*)	78.9	5.67 (*s*)	76.3		5.75 (*s*)	77.2
2		90.6		90.1			90.9
3	4.40 (*d*, *J* = 3.6)	79.3	5.48 (*d*, *J* = 5.6)	82.8		4.61–4.64 (*m*)	78.7
4	2.72–2.75 (*m*)	41.5	2.93 (*dd*, *J* = 5.6, 1.6)	43.9		2.85–2.87 (*m*)	42.8
5	6.47 (*d*, *J* = 2)	71.7	6.69 (br. *s*)	77.2		6.08–6.10 (*m*)	83.5
6		93.0		80.9			84.3
7	5.65 (*s*)	71.3	5.43 (*s*)	68.2		5.41 (*s*)	69.1
8	5.63 (*d*, *J* = 2.4)	70.1	5.81 (*d*, *J* = 7.2)	68.9		4.81 (*d*, *J* = 5.2)	78.4
9	4.96 (*d*, *J* = 2)	80.6	5.07 (*d*, *J* = 7.2)	75.7		5.81 (*d*, *J* = 5.2)	69.0
10		41.4		39.6			40.4
11	5.74 (*d*, *J* = 16.4)	135.1	3.13 (*d*, *J* = 1.6)	62.8		5.68 (*d*, *J* = 16.4)	136.1
12	5.88 (*dd*, *J* = 16, 9.2)	132.9	3.19 (*dd*, *J* = 8.4, 1.6)	56.6		5.76 (*dd*, *J* = 16.4, 9.2)	133.2
13	2.70–2.72 (*m*)	38.6	1.70–1.72 (*m*)	36.2		2.94–2.96 (*m*)	38.2
14	4.98 (*s*)	78.1	5.15 (*s*)	80.6		5.15 (*s*)	80.8
15		86.1		84.4			86.4
16	1.59 (*s*)	16.0	1.59 (*s*)	17.8		1.50 (*s*)	17.2
17	2.06–2.09 (*m*), 3.22 (*m*)	25.4	1.82–1.86 (*m*), 1.81 (*m*)	31.9		2.56 (*d*, *J* = 5.6), 2.58 *d*, *J* = 5.6)	26.2
18	0.93 (*s*)	26.7	1.04 (*s*)	25.2		0.97 (*s*)	27.1
19	1.31 (*s*)	23.2	0.74 (*s*)	15.9		0.97 (*s*)	22.4
20	1.10 (*d*, *J* = 7.2)	23.1	1.16 (*d*, *J* = 7.2)	19.6		1.09 (*d*, *J* = 7.2)	22.1
21	2.33–2.36 (*m*), 2.50 (*m*)	28.9	2.31–2.34 (*m*), 3.08 (*m*)	27.4		3.10–3.12 (*m*), 2.35 (*m*)	23.4
22		176.7		173.0			171.0
*Ac*O–C(1)		170.7		169.5			170.1
	2.11 (*s*)	21.0	2.11 (*s*)	20.4		2.47 (*s*)	20.8
*Ac*O–C(6)		170.7		171.0			168.2
	2.15 (*s*)	20.7	2.14 (*s*)	22.1		2.61 (*s*)	22.1
*Ac*O–C(7)		171.4		171.0			170.9
	2.23 (*s*)	21.0	2.13 (*s*)	21.7		2.44 (*s*)	20.7
*Ac*O–C(8)		170.1		170.6			169.9
	2.02 (*s*)	21.2	2.19 (*s*)	20.8		2.07 (*s*)	21.3
*Ac*O–C(9)		170.7		170.4			169.7
*Ac*O–C(9)	2.20 (*s*)	22.6	2.20 (*s*)	21.2		1.39 (*s*)	20.8
*Ac*O–C(14)		172.4		172.3			170.9
	2.27 (*s*)	21.1	2.44 (*s*)	20.7		2.22 (*s*)	20.6
*Bz*O–C(5)		164.2		168.5	*Bz*O–C(2)		163.7
1′		131.4		130.5	1′		129.7
2′,6′	8.00 (*dd*, *J* = 8, 2)	130.2	8.12 (*dd*, *J* = 8.8, 1.6)	130.5	2′,6′	7.96 (*dd*, *J* = 8.4, 1.6)	129.9
3′,5′	7.46 (*t*, *J* = 8.8)	129.5	7.46 (*t*, *J* = 8.8)	128.6	3′,5′	7.45 (*t*, *J* = 8.8)	128.5
4′	7.63 (*tt*, *J* = 8, 2)	133.8	7.57 (*tt*, *J* = 7.6, 1.6)	133.9	4′	7.63 (*tt*, *J* = 7.6, 1.6)	133.7
HO–C(2)	2.52 (*s*)		2.41 (*s*)		HO–C(5)	2.52 (*s*)	
HO–C(15)	3.75 (*s*)		3.78 (*s*)			4.13 (*s*)	

[a]) Data of compound **1** determined in (D_6)acetone, **2** in $CDCl_3$, and **3** in CD_3OD (δ in ppm, *J* in Hz).



1[1]) **2** **3**

Figure. *Compounds* **1**–**3** *isolated from* E. sororia

of H–C(1) (δ(H) 5.84), H–C(7) (δ(H) 5.65), H–C(8) (δ(H) 5.63), H–C(9) (δ(H) 4.96), H–C(14) (δ(H) 4.98), and the signals for the Ac C=O groups (δ(C) 170.7, 171.4, 170.1, 170.7, 172.4) revealed that five AcO groups are attached at C(1), C(7), C(8), C(9), and C(14), respectively. Two free OH groups were located at C(2) and C(15) on the basis of HMBCs (HO–C(15) with the neighbor C-atoms) and NOESY spectrum (HO–C(2) with H–C(1) and H–C(3)). The seventh AcO group was located at C(6), which was the last O-bearing sp^3 C-atom.

The relative configuration of compound **1** was established by a NOESY experiment, in which correlations of the signal of H–C(4) with those of H–C(1), Me(20), H–C(5), and H–C(7), of the signal of Me(20) with those of H–C(14) and AcO–C(9), of the signal of Me(19) with those of H–C(14) and H–C(12), and the signal of AcO–C(9) with the one of AcO–C(14) were observed clearly. Meanwhile, the correlations of the signal of HO–C(15) with the one of Me(16), the signal of H–C(8) with the one of H–C(9), and the correlations among the signals of Me(18), H–C(11), H–C(13), H–C(3), and CH_2(17) could also easily be found. This suggested that the six AcO groups at C(1), C(6), C(7), C(8), C(9), and C(14) possess β-, β-, β-, α-, α-, and β-orientations, respectively, the BzO group at C(5) has β-orientation, and the two free OH groups at C(2) and C(15) are in α- and β-orientation, respectively. Therefore, the structure of sororianolide A (**1**) was determined as *rel*-(1*S*,2*S*,3*R*,3a*R*,4*S*,5*R*,6*E*,9*S*,10*S*,11*R*,13*S*,13a*R*)-3,4,9,10,11,12-hexakis(acetyloxy)-2,3,3a,4,5,8,9,10,11,12,13,13a-dodecahydro-2,3a-dihydroxy-2,5,8,8-tetramethyl-16-oxo-1*H*-1,12-(epoxypropano)-cyclopenta[12]annulen-13-yl benzoate.

Compound **2**, a white powder, showed a *pseudo*-molecular-ion peak ($[M+Na]^+$) at *m*/*z* 871.2991 in the HR-ESI-MS, corresponding to the molecular formula $C_{41}H_{52}O_{19}$. The NMR spectral features of compound **2** (*Table*) were very close to those of compound **1**. The only difference was that compound **2** has no C=C bond, but two more O-bearing sp^3 C-atoms. The chemical shifts of H–C(11)[1]) (δ(H) 3.13), H–C(12) (δ(H) 3.19), C(11) (δ(C) 62.8), and C(12) (δ(C) 56.6) indicated that an epoxy group must be at the positions of C(11) and C(12). Moreover, the cross-peaks in the NOESY spectrum indicated that the corresponding substituents in **2** were in part different from those in compound **1**. The correlations among Me(19), H–C(14), HO–C(2), Me(20), H–C(4), H–C(7), and H–C(12) were observed clearly. These H-atoms possess α-orientation. The correlations among HO–C(15), Me(16), CH_2(17), Me(18), CH_2(21), H–C(3), H–C(13), H–C(1), H–C(11), and H–C(5) suggested these H-atoms

possess β-orientation. Therefore, the structure of sororianolide B (**2**) was determined as *rel*-(1a*R*,3*S*,4*S*,5*R*,7*R*,7a*R*,8*S*,9*S*,10*S*,10a*R*,11*S*,12*R*,12a*S*)-3,4,5,6,10,11-hexakis(acetyloxy)-tetradecahydro-9,10a-dihydroxy-2,2,9,12-tetramethyl-14-oxo-1a*H*-8,6-(epoxypropano)cyclopenta[5,6]cyclododeca[1,2-*b*]oxiren-7-yl benzoate.

Compound **3**, a white powder, was assigned a molecular formula of $C_{41}H_{52}O_{18}$, as established by the HR-ESI-MS ($[M+Na]^+$) at *m*/*z* 855.3063 and NMR data. The IR spectrum displayed absorption bands at 3592 and 1744 cm^{-1}, indicating the presence of OH and ester functionalities. Six AcO groups and one benzoate residue were easily deduced from the typical signals in the ^{1}H- and ^{13}C-NMR spectra. The structural elements recognized among the remaining 22 C-atom signals (*Table*) were four Me groups, one lactone C=O group, and one *trans*-disubstituted C=C bond. From the above data, it was deduced that the carbon skeleton of compound **3** was the same as that of two known compounds, terracinolides A and B from *E. terracina* [7–9]. However, compound **3** contains no ketone group but two more AcO groups and O-bearing sp^3 C-atoms instead. In the HMBC spectrum, the correlations between the signals of H–C(1)[1]) (δ(H) 5.75), H–C(7) (δ(H) 5.41), H–C(8) (δ(H) 4.81), H–C(9) (δ(H) 5.81), H–C(14) (δ(H) 5.15) and the Ac C=O groups (δ(C) 170.1, 170.9, 169.9, 169.7, 170.9) revealed that five AcO groups were attached at C(1), C(7), C(8), C(9), and C(14), respectively. The correlations between the signals of AcO–C(6) (δ(C) 168.2) and of CH_2(17) (δ(H) 2.56 and 2.58), suggested that there was an AcO group at C(6). One of the free OH groups was located at C(5) (weak correlations between the signals of HO–C(5) (δ(H) 2.52) and of H–C(4) (δ(H) 2.85–2.87 in the g-COSY spectrum)) and the other free OH group was located at C(15) (HMBCs between the signals of HO–C(15) (δ(H) 4.13) and of the neighbor C-atoms C(1), C(4), C(15)). The HMBC between the signal of C(6) (δ(C) 84.3) and those of CH_2(17) (δ(H) 2.56 and 2.58) and CH_2(21) (δ(H) 2.35), revealed that C(6) is part of the lacton ring. The benzoate was located at C(2), which is a quaternary C-atom, therefore, we could not find correlations between the C=O C-atom of the Bz group and any H-atoms in the HMBC spectrum.

Moreover, the cross-peaks in the NOESY spectrum of the signal of H–C(4) with those of H–C(5), H–C(7), H–C(3), and H–C(12) indicated that these H-atoms possess α-orientation. The correlations between the signals of AcO–C(8) and HO–C(5), of AcO–C(6) and AcO–C(9), the correlation between the signals of H–C(14) and Me(20), and correlations among the signals of H–C(3), AcO–C(14), and CH_2(21) were observed clearly. This suggested that the six AcO groups at C(1), C(6), C(7), C(8), C(9), and C(14) possess α-, α-, β-, β-, β-, and α-orientations respectively, the BzO group at C(2) has α-orientation, the free OH groups at C(5) and C(15) are in β-positions, the Me(20) possesses α-orientation, and the substituent at C(3) shows β-orientation. Therefore, sororianolide C (**3**) was determined as *rel*-(1*R*,2*S*,3*R*,3a*R*,4*R*,5*R*,6*E*,9*R*,10*R*,11*R*,13*S*,13a*S*)-3,4,9,10,11,12-hexakis(acetyloxy)-2,3,3a,4,5,8,9,10,11,12,13,13a-dodecahydro-3a,13-dihydroxy-2,5,8,8-tetramethyl-16-oxo-1*H*-1,12-(epoxypropano)cyclopenta[12]annulen-2-yl benzoate.

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Experimental Part

General. All solvents used were of analytical grade and purchased from *Tianjin Chemical Factory* (Tianjin, P. R. China). *Sephadex LH-20* Gel was purchased from *Pharmacia Fine Chemicals Inc.*, Nanjing, P. R. China. Column chromatography: silica gel (SiO_2; 200–300 mesh, *Qingdao Haiyang Chemical Co., Ltd.*) and *MCI* gel (*CHP20P*, 75–150 μm). Optical rotations: *JASCO J-810* spectropolarimeter. IR Spectra: *Shimadzu FTIR-8400s* spectrophotometer with KBr pellets. ^{1}H-, ^{13}C-, and 2D-NMR spectra: *Varian Inova-400* spectrometers with TMS as internal standard. ESI-MS: *VG Autospec-3000* mass spectrometer. HR-ESI-MS: *Finnigan LC QDECA* mass spectrometer.

Plant Material. E. sororia cultivated in Jimsaer, Xinjiang Uighur Autonomous Region, P. R. China, was harvested in 2007, and identified by Dr. *G. M. Shen*, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences. A voucher specimen (XJIPC0736) was deposited with the Xinjiang Technical Institute of Physics and Chemistry, Chinese Academy of Sciences.

Extraction and Isolation. Air-dried and powdered whole plant of *E. sororia* (28 kg) was exhaustively extracted with MeOH at r.t. (50 l × 5, each for 4 d) to give 4 kg of crude extract, which was suspended in H_2O (3 l) and then partitioned with petroleum ether (PE) to give a PE fraction (2 kg). This fraction was roughly separated by SiO_2 CC, using PE and MeOH as eluents to give two fractions (*Frs. A* and *B*). *Fr. B* was chromatographed on *MCI*-gel *CHP 20P* (90% MeOH/H_2O, 100% MeOH). The 90% MeOH fraction (*Fr. C*, 400 g) was subjected to CC over SiO_2 (200–300 mesh) and eluted with PE/acetone (from 1:0 to 0:1) to give subfractions *C1–C6*. *Subfr. C2* (2.4 g) was purified with *RP-18* CC (MeOH/H_2O 8:2) to afford compounds **1** (15 mg) and **2** (2.1 mg). *Subfr. C3* was chromatographed on SiO_2 eluting with hexane/acetone 20:1, followed by further separation over *LH-20* and SiO_2 columns, to give **3** (1.2 mg).

Sororianolide A (= rel-(*1S,2S,3*R,*3a*R,*4S,5*R,*6*E,*9S,10S,11*R,*13S,13a*R)*-3,4,9,10,11,12-Hexakis(acetyloxy)-2,3,3a,4,5,8,9,10,11,12,13,13a-dodecahydro-2,3a-dihydroxy-2,5,8,8-tetramethyl-16-oxo-1*H*-1,12-(epoxypropano)cyclopenta[12]annulen-13-yl Benzoate*; **1**). White powder. $[\alpha]_D^{26} = +42$ ($c = 0.08$, MeOH). IR (KBr): 3450, 2983, 1745, 1730, 1660, 1283, 1133, 1070. ^{1}H- and ^{13}C-NMR: see *Table*. ESI-MS (pos.): 855.4 ($[M+Na]^+$). HR-ESI-MS: 855.3054 ($[M+Na]^+$, $C_{41}H_{52}NaO_{18}^+$; calc. 855.3051).

Sororianolide B (= rel-(*1a*R,*3S,4S,5*R,*7*R,*7a*R,*8S,9S,10S,10a*R,*11S,12*R,*12a*S*)-3,4,5,6,10,11-Hexakis(acetyloxy)-tetradecahydro-9,10a-dihydroxy-2,2,9,12-tetramethyl-14-oxo-1a*H*-8,6-(epoxypropano)cyclopenta[5,6]cyclododeca[1,2-*b*]oxiren-7-yl Benzoate*; **2**). White powder. $[\alpha]_D^{26} = -10$ ($c = 0.06$, MeOH). IR (KBr): 3445, 1745, 1726, 1606, 1452, 1373, 1033. ^{1}H- and ^{13}C-NMR: see *Table*. ESI-MS (pos.): 871.3 ($[M+Na]^+$). HR-ESI-MS: 871.2991 ($[M+Na]^+$, $C_{41}H_{52}NaO_{19}^+$; calc. 871.3000).

Sororianolide C (= rel-(*1*R,*2S,3*R,*3a*R,*4*R,*5*R,*6*E,*9*R,*10*R,*11*R,*13S,13a*S*)-3,4,9,10,11,12-Hexakis(acetyloxy)-2,3,3a,4,5,8,9,10,11,12,13,13a-dodecahydro-3a,13-dihydroxy-2,5,8,8-tetramethyl-16-oxo-1*H*-1,12-(epoxypropano)cyclopenta[12]annulen-2-yl Benzoate*; **3**). White powder. $[\alpha]_D^{26} = +40$ ($c = 0.10$, MeOH). IR (KBr): 3592, 1744, 1728, 1709, 1650, 1601, 1283, 1141, 1070. ^{1}H- and ^{13}C-NMR: see *Table*. ESI-MS (pos.): 855.2 ($[M+Na]^+$). HR-ESI-MS: 855.3063 ($[M+Na]^+$, $C_{41}H_{52}NaO_{18}^+$; calc. 855.3051).

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