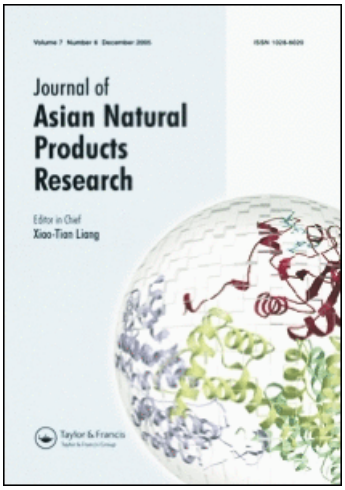

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Novel rearrangement products of the degradated derivative of maoecrystal A, an *ent*-kaurane-type diterpene

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Novel rearrangement products of the degradated derivative of maoecrystal A, an *ent*-kaurane-type diterpene

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Two novel rearrangement products of the degradated derivative of maoecrystal A (**1**), an *ent*-kaurane-type diterpene via a Wagner–Meerwein process, have been reported.

Keywords: Diterpene; *ent*-kaurane-type diterpene; Maoecrystal A; Rearrangement

1. Introduction

The rigorous and successful work of both Fijia and Sun groups on the chemical reactions and the phytochemistry of *Isodon* species has been reported [1,2]. In the previous paper [3], we reported the exhaustive degradation of the ring D of maoecrystal A (**1**), an *ent*-kaurane-type diterpene from *Isodon eriocalyx* (Labiatae) [2]. With the view to a further investigation of chemical reactivity of the diterpenes and in the frame of our researches dealing with the cleavage of 3,20-epoxy ring of compound **2** [3], a degradated derivative of **1**, we have interestingly found a novel rearrangement from **2** to compounds **3** or **4** in 50% or 47% yield, respectively, through pyrolysing **2** under 20 mmHg for 10 min or by heating **2** in DMSO at 130°C for 10 min. This paper is focused on the isolation and structure elucidation of the new compounds **3** and **4**.

2. Results and discussion

Compound **2** was obtained by sulfonation of **1** [3] with MsCl as amorphous powder from $CHCl_3$–acetone in 63% yield (scheme 1). Its molecular formula $C_{23}H_{36}SO_8$ was established by HRFAB-MS. The structure of **2** could be determined easily on the basis of the characteristic signal at δ_H 4.99 (1H, dd, $J = 10.6$, 1.6 Hz) for H-1α in the NMR spectra.

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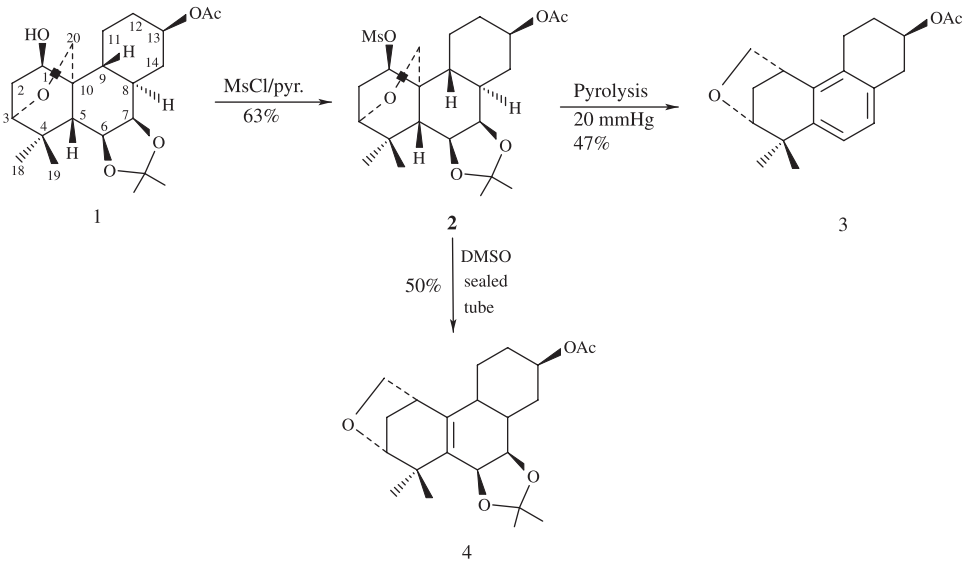

Scheme 1. The rearrangement from the degradated derivative of maoecrystal A (**1**).

Compound **3** was afforded as amorphous powder ($CHCl_3$–acetone), Mp 130–131°C, $[\alpha]_D^{20}$ + 40.5 (0.4, $CHCl_3$). The formula $C_{19}H_{24}O_3$ was confirmed by its HRFAB-MS and 2D NMR data (table 1). The NMR data showed the presence of a tetrasubstituted aromatic moiety (δ_H 7.09, 6.93, each 1H, d, J = 8.4 Hz; δ_C 141.2 s, 139.2 s, 130.8 s, 130.4 s, 127.8 d, 125.3 d) and the absence of an dioxymethylene group as compared with **2**, implying that **3** was derived from an aromatisation process of **2**. Further analysis of proton spectrum, including the COSY data (table 1, figure 1), indicated that H_2-14 (δ 2.87, 3.05), H_3-18 (δ 1.20), and H_2-20 (δ 3.72) correlated to C-8 (δ 130.8), C-5 (δ 141.2), and C-10 (δ 139.2), respectively. The above observations revealed that **3** contained an aromatised B ring which was resulted from a Wagner–Meerwein rearrangement of **2**. Based on $^1H/^1H$-coupling constant ($J_{H\text{-}1,H\text{-}2\alpha}$ = 3.6 Hz) and mechanistically considering an α-face attack of C-20 on C-1 in **2**, the absolute stereochemistry structure of **3** was assigned.

The molecular formula $C_{22}H_{32}O_5$ of compound **4** was obtained by EI-MS $[M]^+ m/z$ = 376.2 and HREI-MS $[M]^+ m/z$ = 376.2174. The ^{13}C NMR spectrum of **4** displayed a tetrasubstituted double bond (δ 140.5 s, 133.2 s) as compared with **2**. Especially, due to the fact that there were HMBC correlations of H-6 (δ 4.65) with C-10 (δ 140.5 s) and H-7 (δ 4.10) with C-5 (δ 133.2 s) (figure 2) the double bond was located at C-5/C-10. Thus, the structure of **4** was firmly established by IR, ^1H NMR, ^{13}C NMR (^1H–^1H COSY, HMBC) (figure 2), and MS spectra.

Apparently, compounds **3** and **4** are chemical products from **2** via a Wagner–Meerwein rearrangement followed by an aromatisation or a dehydration.

3. Experimental

3.1 General experimental procedures

Melting points were determined on a Kofler block and are uncorrected; Optical rotations were measured in a 1.0 dm cell with a PE-341 polarimeter at 20 ± 1°C; IR spectra were

Table 1. ^{1}H NMR and ^{13}C NMR data of compounds **3** and **4** (^{1}H: 400 MHz, ^{13}C: 100 MHz; $CDCl_3$).

No.	***3***		***4***	
	δ_H Mult (J=Hz)	*δ_C*	*δ_H Mult (J=Hz)*	*δ_C*
1	3.49 t (3.6)	36.0 d	2.76 t (3.6)	37.0 d
2	2.06 m (hidden)	32.2 t	1.91 d (10.8) (β) 1.76 m (α)	32.1 t
3	3.98 m (hidden)	83.6 d	3.87 t (hidden)	84.7 d
4	–	41.5 s	–	42.3 s
5	–	141.2 s	–	133.2 s
6	7.09 ABq (8.4)	125.3 d	4.65 dd (6.4, 1.2)	72.8 d
7	6.93 ABq (8.4)	127.8 d	4.10 dd (6.4, 2.4)	76.4 d
8	–	130.8 s	1.35 m	41.5 s
9	–	130.4 s	2.17 m	35.4 d
10	–	139.2 s	–	140.5 s
11	2.67 2.97	23.5 t	2.11 m (hidden) (β) 1.14 m (hidden) (α)	27.0 t
12	2.01 m	27.6 t	1.58 m (hidden) (β) 1.40 m (hidden) (α)	31.5 t
13	5.18 m	69.0 d	4.17 m	72.7 d
14	2.87 dd (16.8, 6.0) 3.05 dd (16.8, 4.4)	34.7 t	1.97 m 1.64 m	34.6 t
18	1.20 s	29.1 q	1.08 s	27.4 q
19	1.30 s	27.2 q	1.09 s	24.4 q
20	3.72 d (7.2)	74.8 t	3.77 d (hidden) (β) 3.56 d (6.8) (α)	75.1 t
OAc	2.05 s	170.5 s 21.1 q	2.01 s	170.6 s 21.3 q
O*C*O	–	–	–	107.8 s
$C(CH_3)_2$	–	–	1.33 s, 1.32 s	26.7 q, 26.2 q

recorded on a Nicolet 200 SXV spectrometer; MS spectra were obtained with a Auto-Spec-3000 instrument; ^{1}H NMR and ^{13}C NMR spectra were acquired on a Bruker AC-E 200 or a Varian INOVA-400/54 spectrometer, with TMS as internal standard; Silica gel GF_{254} and H (10–40 mm, Qingdao Sea Chemical Factory, China) were used for TLC and CC.

3.1.1 Compound 2. To a solution of compound **1** [3] (120 mg, 0.30 mmol) and DMAP as catalyst in pyridine (10 ml), MsCl (0.5 mg, 0.50 mmol) was added and the solution was heated at 50°C for 3 h. Evaporation in vacuum to dryness afforded a residue which was further

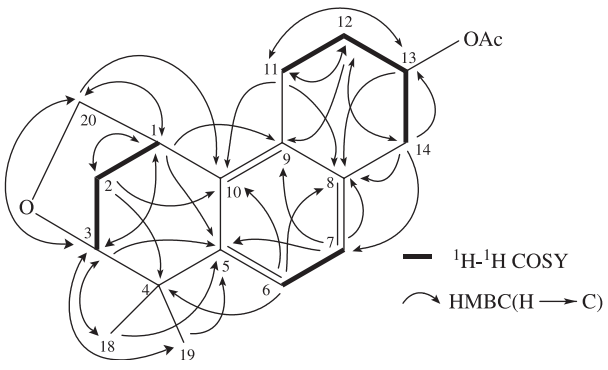

Figure 1. Selected HMBC and COSY correlations for **3**.

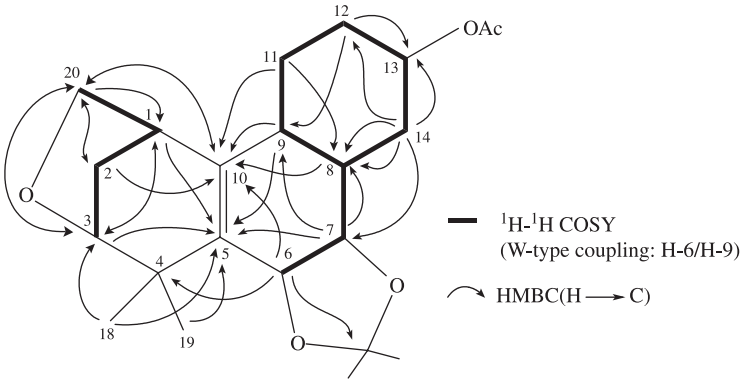

Figure 2. Key HMBC and COSY correlations for **4**.

diluted with saturated $NaHCO_3$, the solution was extracted with $CHCl_3$ (10 ml × 3). Drying (Na_2SO_4), removal of solvent, and column chromatography (silica gel H, 5 g; $CHCl_3$/acetone = 30:1) afforded the pure product **2** as amorphous powder, 90 mg (63%).

Compound **2**: Mp 108–109°C; R_f (75% cyclohexane–acetone) 0.55; $[\alpha]_D^{20}$ − 50.7 (*c* 0.6, $CHCl_3$); ν_{max} (KBr) 2940, 2872, 1731 (COO), 1458, 1371, 1250, 1032 cm^{-1}; δ_H (200 MHz, $CDCl_3$) 1.06, 1.21, 1.29, 1.48 (each 3H, s, $CH_3 \times 4$), 1.97 (3H, s, OAc), 3.03 (3H, s, OMs), 3.21 (1H, t, $J = 3.4$ Hz, H-3β), 3.34, 3.63 (each 1H, ABq, $J = 10.0$ Hz, H_2-20), 3.94 (1H, dd, $J = 1.6$, 4.8 Hz, H-7β), 4.25 (1H, dd, $J = 4.8$, 9.6 Hz, H-6α), 4.61 (1H, m, H-13), 4.99 (1H, dd, $J = 10.6$, 1.6 Hz, H-1α); δ_C (50 MHz, $CDCl_3$) 170.5 (C-16), 108.2 (C-21), 76.1 (C-3), 75.8 (C-1), 75.5 (C-6), 75.0 (C-7), 72.3 (C-13), 61.3 (C-20), 40.8 (C-5), 39.9 (C-10), 38.7 (OMs), 35.3 (C-4), 35.0 (C-8), 34.6 (C-9), 32.0 (C-2, C-14), 31.3 (C-12), 29.0 (C-18), 28.8 (C-22), 26.7 (C-23), 24.4 (C-19), 23.5 (C-11), 21.2 (C-17); *m/z* (ESI) 471 (5, M^+–H), 457 (69, M–CH_3); HRFAB-MS *m/z* 473.2285 $[M + H]^+$, (calcd for $C_{23}H_{37}SO_8$, 473.2294).

3.1.2 Compound 3. Compound **2** (67 mg, 0.14 mmol) in 50 ml of a round-bottomed flask was heated in oil bath under reduced pressure (20 mmHg) at 130°C for 10 min. After cooling, the residue was chromatographed over silica gel H (5 g) eluting with $CHCl_3$/acetone (80:0.7) to give compound **3**, 20 mg (47%).

Compound **3**: Mp 130–131°C; R_f (99% $CHCl_3$/Me_2CO) 0.52; $[\alpha]_D^{20}$ + 40.5 (*c* 0.4, $CHCl_3$); ν_{max} (KBr) 2950, 1731 (COO), 1630, 1530, 1456, 1371, 1258, 1100 cm^{-1}; δ_H (400 MHz, $CDCl_3$) and δ_C (100 MHz, $CDCl_3$) see table 1 and figure 1; *m/z* (EI) 300 (1, M^+), 258 (30), 240 (30, M–HOAc); HRFAB-MS *m/z* 301.1184 $[M + H]^+$, (calcd for $C_{19}H_{25}O_3$, 301.1178).

3.1.3 Compound 4. A mixture of compound **2** (67 mg, 0.14 mmol) and DMSO (1.5 ml) in a sealed tube was heated at 130°C for 10 min. Cooling and column chromatography (silica gel H, 10 g; cyclohexane ⟶ cyclohexane–acetone = 4:1) afforded the pure compound **4** as white amorphous powder, 20 mg (50%).

Compound **4**: Mp 84–85°C; R_f (99% $CHCl_3$/Me_2CO) 0.52; $[\alpha]_D^{20}$ − 35.5 (*c* 0.4, $CHCl_3$); ν_{max} (KBr) 2944, 2878, 1728 (COO), 1456, 1370, 1250, 1109 cm^{-1}; δ_H (400 MHz, $CDCl_3$) and δ_C (100 MHz, $CDCl_3$) see table 1 and figure 2; *m/z* (EI) 376 (2, M^+), 375 (5, M–H),

319 (30), 301 (95); HREI-MS *m*/*z* 376.2174 $[M]^+$, (Δ 0.3 mmu from calculated value) (calcd for $C_{22}H_{32}O_5$, 376.2177).

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