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COUMARINS FROM *EDGEWORTHIA CHRYSANTHA**

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Key Word Index—*Edgeworthia chrysantha*; Thymelaeaceae; coumarin; edgeworin; edgeworoside A.

Abstract—Two new coumarins, edgeworin and edgeworoside A, were isolated from the root and stem of *Edgeworthia chrysantha* (*E. papyrifera*) and their structures determined as 3-(7-coumarinyloxy)-7-hydroxycoumarin and 3-(7-coumarinyloxy)-8-(7-hydroxycoumarin-8-yl)-7-α-L-rhamnopyranosyloxycoumarin.

INTRODUCTION

Edgeworthia chrysantha Lindl. (*E. papyrifera* S. et Z., Thymelaeaceae) is distributed in eastern Asia. It is used to make paper in Japan while the flowers and the roots are used as the crude drugs 'meng hua' and 'meng hua gen' in China [1]. In the course of our studies of the phenolic components of thymelaeaceous plants, we investigated the constituents of the roots and the stems of *E. chrysantha* and isolated two new coumarins, edgeworin (**1**) and edgeworoside A (**2**), together with four known coumarins, limettin, umbelliferone, daphnoretin and daphnorin. This paper deals with the structure elucidation of **1** and **2**.

RESULTS AND DISCUSSION

The methanol extract of the roots and stems of *E. chrysantha* was divided into a soluble part and an insoluble part under reflux with *n*-hexane. The insoluble part was fractionated into limettin, umbelliferone, daphnoretin, daphnorin, edgeworin (**1**) and edgeworoside A (**2**) by silica gel column chromatography.

Compounds **1** and **2** fluoresced blue under UV light (365 nm) and had UV spectral characteristics of 7-oxycoumarins. The IR absorptions of **1** and **2** indicated the presence of α,β-unsaturated lactones.

Compound **1**, $C_{18}H_{10}O_6$, M^+ m/z 322, mp 284–296° (decomp.), gave a monoacetate (**3**) on acetylation. The ^{1}H NMR spectrum of **1** (Table 1) indicated the presence of a 7-coumarinyloxy group, similar to that of daphnoretin [2, 3] [δ6.38 (1H, *d*, $J = 9.6$ Hz, H-3), 8.04 (1H, *d*, $J = 9.6$ Hz, H-4), 7.71 (1H, *d*, $J = 8.5$ Hz, H-5), 7.13 (1H, *dd*, $J = 8.5$, 2.2 Hz, H-6) and 7.19 (1H, *d*, $J = 2.2$, H-8)] and a 7-hydroxycoumarin-3-yl group [δ7.94 (1H, *s*, H-4), 7.53 (1H, *d*, $J = 8.6$ Hz, H-5), 6.85 (1H, *dd*, $J = 8.6$, 2.3 Hz, H-6), 6.80 (1H, *d*, $J = 2.3$ Hz, H-8) and 10.54 (1H, *br s*, OH)]. The signals in the ^{13}C NMR spectrum (Table 2) were also assignable to these groups. Ozonolysis of **3** led the formation of 2.4-dihydroxybenzaldehyde and 4-acetoxy-2-hydroxybenzaldehyde. From the results described above, compound **1** was confirmed to be 3-(7-coumarinyloxy)-7-hydroxycoumarin. The HRMS of **1** showed the expected fragmentation ions $C_{17}H_{10}O_5$ (m/z 294.0543), $C_9H_5O_3$ (161.0246), $C_8H_5O_3$ (149.0237) and $C_8H_5O_2$ (133.0306) for structure **1**.

Compound **2**, $C_{33}H_{24}O_{13}$, M^+ m/z 628, mp 208–209° gave a tetraacetate (**4**) on acetylation and gave L-rhamnose and an aglycone (**5**), $C_{27}H_{14}O_9$, mp 210.5–211.5° on acid hydrolysis. The ^{1}H NMR spectrum of **5** (Table 3) indicated the presence of a 7-coumarinyloxy group, similar to that of **1**, [δ6.37 (1H, *d*, $J = 9.6$ Hz, H-3), 8.04 (1H, *d*, $J = 9.6$ Hz, H-4), 7.70 (1H, *d*, $J = 8.6$ Hz, H-5), 7.11 (1H, *dd*, $J = 8.6$, 2.4 Hz, H-6) and 7.17 (1H, *d*, $J = 2.4$ Hz, H-8)], a 7-oxycoumarin-8-yl group [δ6.22 (1H, *d*, $J = 9.5$ Hz, H-3), 8.02 (1H, *d*, $J = 9.5$ Hz, H-4), 7.62 (1H, *d*, $J = 8.6$ Hz, H-5) and 6.99 (1H, *d*, $J = 8.6$ Hz, H-6)], a 3,7-dioxycoumarin-8-yl group [δ8.03 (1H, *s*, H-4), 7.62 (1H, *d*, $J = 8.6$ Hz, H-5) and 7.05 (1H, *d*, $J = 8.6$ Hz, H-6)] and two hydroxyl groups [δ10.49 (2H, *br s*, OH)]. The signals in the ^{13}C NMR spectrum of **5** (Table 4) were also assignable to these groups. Ozonolysis of **4** led to the formation of 2,4-dihydroxybenzaldehyde and an aldehyde (**6**, colourless viscid oil, $C_{28}H_{28}O_{14}$, M^+ 588). The ^{1}H NMR spectrum of **6** (Table 5) indicated the presence of two 2,6-dioxy-3-formylphenyl groups [δ7.72 (1H, *d*, $J = 8.6$ Hz, H-4), 7.02 (1H, *d*, $J = 8.6$ Hz, H-5) and 9.93 (1H, *s*, CHO)] and [7.62 (1H, *d*, $J = 8.7$ Hz, H-4), 6.91 (1H, *d*, $J = 8.7$ Hz, H-5) and 9.84 (1H, *s*, CHO)], a triacetyl rhamnosyl group [δ5.57 (1H, *d*, $J = 1.5$ Hz, H-1), 5.12 (1H, *dd*, $J = 3.6$, 1.5 Hz, H-2), 4.98 (1H, *dd*, $J = 8.8$, 3.6 Hz, H-3), 5.06 (1H, *t*, $J = 8.8$ Hz, H-4), 4.06 (1H, *dd*, $J = 8.8$, 6.3 Hz, H-5), 1.18 (3H, *d*, $J = 6.3$ Hz, H-6), 2.10 (3H, *s*, OAc), 2.03 (3H, *s*, OAc) and 1.91 (3H, *s*, OAc)], an acetyl group [δ2.16 (3H, *s*)] and two hydroxyl groups [δ11.82 (1H, *s*) and 11.55 (1H, *s*)]. The ^{13}C NMR spectrum of **6** (Table 5) also supported the presence of these groups. From these spectra, the structure of **6** was established to be 6-acetoxy-3,3′-diformyl-2,2′-dihydroxy-6′-triacetylrhamnosylbiphenyl. Based on the above results, compound **2** was deduced to be 3-(7-coumarinyloxy)-8-(7-hydroxycoumarin-8-yl)-7-hydroxycoumarin rhamnoside. In the ^{13}C NMR of **4**, the acetylation shift δ6.77 observed for the signal due to C-4a, indicated that the hydroxyl group of C-7 was acetylated. Accordingly, the linkage position of rham-

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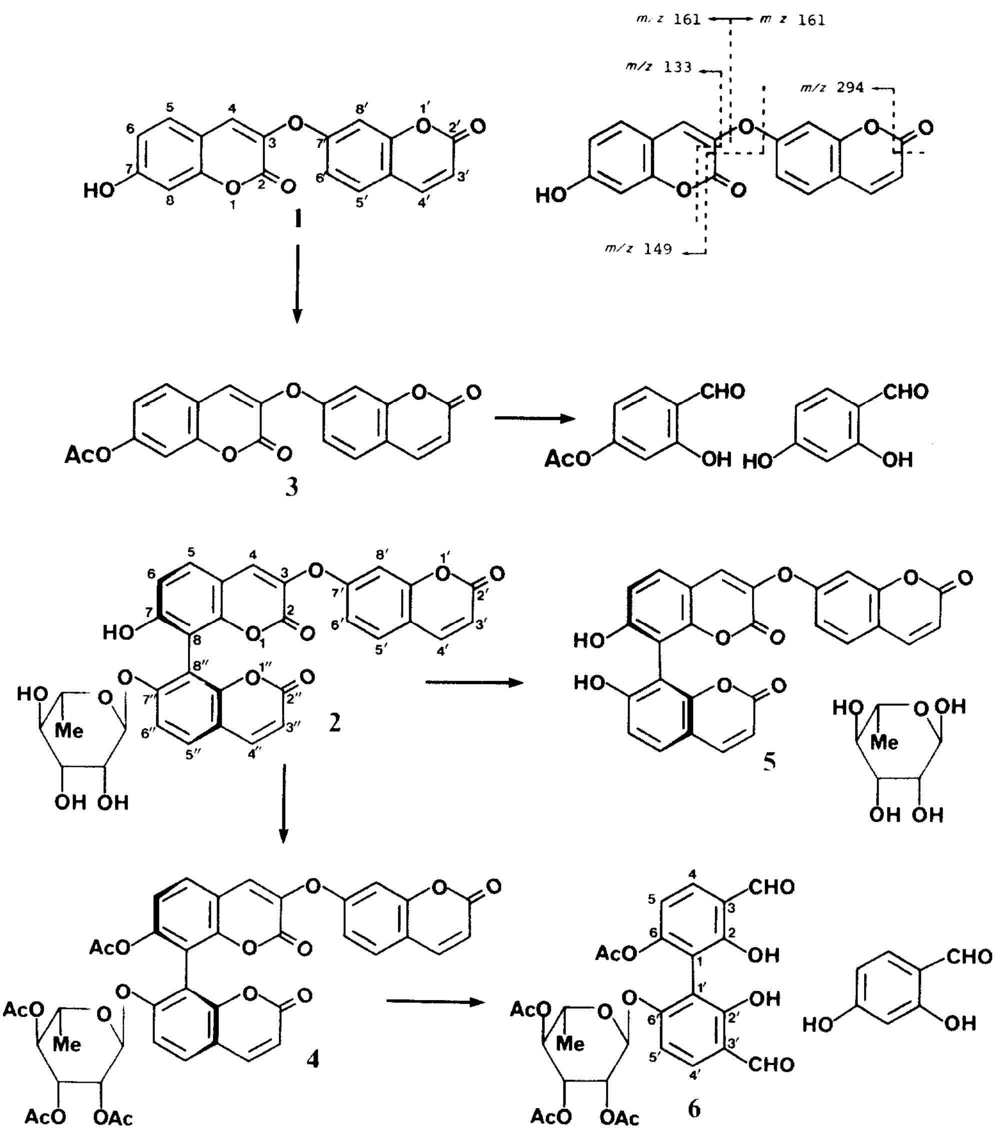
* Part VI in series 'Chemical studies on the constituents of the Thymelaeaceous Plants'. For part V see Baba, K., Takeuchi, K. and Kozawa, M. (1987) *Yakugaku Zasshi* **107**, 863.



nose was concluded to be C-7″. The configuration at C-1 of the L-rhamnosyl group was determined to be α from the chemical shift of H-1 (δ5.50) and the coupling constant [J_{C-H} (172.55 Hz)] [4]. The CD spectrum of **5** showed a splitting Cotton effect (first Cotton: positive, second Cotton: negative) resulting from the exiton interaction at 329 nm, thus the axial chirality of 8-8″ was concluded to be *S*.

Table 1. ^{1}H NMR data for compounds **1** and **3** in DMSO-d_6 (values in parenthesis are coupling constants in Hz)

H	1	3
4	7.64 *s*	7.96 *s*
5	7.53 *d* (8.6)	7.73 *d* (8.5)
6	6.85 *dd* (8.6, 2.3)	7.19 *dd* (8.5, 2.2)
8	6.80 *d* (2.3)	7.36 *d* (2.2)
3′	6.38 *d* (9.6)	6.39 *d* (9.6)
4′	8.04 *d* (9.6)	8.05 *d* (9.6)
5′	7.71 *d* (8.5)	7.73 *d* (8.5)
6′	7.13 *dd* (8.5, 2.2)	7.19 *dd* (8.5, 2.2)
8′	7.19 *d* (2.2)	7.31 *d* (2.2)
OH	10.54 *br s*	
OCOMe		2.31 *s*

Assignments were confirmed by spin decoupling experiments.

EXPERIMENTAL

General procedures. Mps: uncorr; EIMS: 70 eV; ^{1}H and ^{13}C NMR: 300 and 75.4 MHz, respectively, with TMS as an int. standard. C: Merck silica gel 60 F_{254} (70–230 mesh); TLC and prep. TLC: Merck silica gel 60 F_{254} plates (0.25 mm) and Merck silica gel 60 F_{254} plates (concentrating zone, 2 mm) were employed. Spots and bands were detected by UV irradiation (253.6 and 365 nm).

Extraction and isolation. Air-dried roots and stems of *Edgeworthia chrysantha* Lindl. (4 kg), which was cultivated and collected in the botanical garden of this university in March 1987, were chopped into small pieces and extracted with MeOH (10 1 × 5) under reflux. The combined MeOH extracts were concd to 2 1 *in vacuo*. After removal of a ppt. by filtration, the

Table 2. ^{13}C NMR data for compounds **1** and **2** in DMSO-d_6

C	1	3
2	157.31	156.77
3	135.59	138.89
4	131.45	129.19
4a	115.15	117.22
5	129.79	129.26
6	113.84	119.25
7	160.99	152.30
8	102.39	110.26
8a	153.85	152.41
2′	160.40	160.34
3′	114.11	114.38
4′	144.41	144.40
4a′	114.60	114.95
5′	130.19	130.20
6′	113.61	114.16
7′	160.14	159.58
8′	104.10	104.78
8a′	155.39	155.39
OCOMe		169.33
		20.68

Assignments were confirmed by ^{1}H–^{13}C long range coupling and ^{1}H–^{13}C COSY experiments.

filtrate was concd *in vacuo*. The residue was treated with *n*-hexane and the insoluble part concd *in vacuo* to give a residue (742 g), which was subjected to CC on silica gel eluted successively with $CHCl_3$–MeOH solvent mixture of increasing polarity. On concn, the 2% MeOH eluates gave limettin (0.35 g), umbelliferone (0.12 g) and daphnoretin (2.49 g), the 4% MeOH eluates gave edgeworin (**1**) (0.15 g) on rechromatography on silica gel with $CHCl_3$–MeOH, and the 10–20% MeOH eluates gave edgeworoside A (**2**) (0.67 g) and daphnorin (0.51 g).

Edgeworin (**1**). Colourless crystalline powder, mp 284–296° (dec.), blue fluorescence under UV. UV λ_{max}^{MeOH} nm (log ε): 335 (4.15); 230 (sh. 3.15); 208 (4.31); IR ν_{max}^{Nujol} cm^{-1}: 3400–3150; 1720; 1700; 1605; HRMS *m/z*: 322.0478 (M^+, calcd. for $C_{18}H_{10}O_6$: 322.0476); 294.0543 ($C_{17}H_{10}O_5$: 294.0527); 161.0246 ($C_9H_5O_3$: 161.0239); 149.0237 ($C_8H_5O_3$: 149.0238); 133.0306 ($C_8H_5O_2$: 133.0289). ^{1}H and ^{13}C NMR see Tables 1 and 2.

Acetylation of **1**. A soln of **1** (0.1 g) in a mixture of Ac_2O (5 ml) and pyridine (5 ml) was allowed to stand at room temp. overnight. The reaction mixture was treated in the usual way, and the product was recrystallized from *n*-hexane–EtOAc to give the monoacetate **3** (0.11 g) as a colourless crystalline powder, mp 236–238°. ^{1}H and ^{13}C NMR see Tables 1 and 2.

Ozonolysis of **3**. **3** (0.1 g) was ozonized in $CHCl_3$ (50 ml) under cooling ($-10°$) and the solvent was evapd off *in vacuo*. H_2O (30 ml) was added to the residue and mixture was stirred, allowed to stand overnight and extracted with EtOAc. The EtOAc soln was dried and concd *in vacuo*. The residue was subjected to prep. TLC with $CHCl_3$–MeOH (100:1) to afford 2.4-dihydroxybenzaldehyde (0.025 g) and 4-acetoxy-2-hydroxybenzaldehyde

Table 3. ^{1}H NMR data for compounds **2**, **4** and **5** in DMSO-d_6 (values in parenthesis are coupling constants in Hz)

H	2	4	5
Aglycone			
4	8.03 *s*	8.12 *s*	8.03 *s*
5	7.64 *d* (8.6)	7.91 *d* (8.5)	7.62 *d* (8.6)
6	7.06 *d* (8.6)	7.42 *d* (8.5)	7.05 *d* (8.6)*
3′	6.37 *d* (9.5)	6.39 *d* (9.5)	6.37 *d* (9.6)
4′	8.01 *d* (9.5)	8.05 *d* (9.5)	8.04 *d* (9.6)
5′	7.69 *d* (8.5)	7.73 *d* (8.4)	7.70 *d* (8.5)
6′	7.06 *dd* (8.5, 2.2)	7.15 *dd* (8.4, 2.8)	7.11 *dd* (8.5, 2.4)
8′	7.18 *d* (2.2)	7.18 *d* (2.8)	7.17 *d* (2.4)
3″	6.34 *d* (9.6)	6.40 *d* (9.5)	6.22 *d* (9.5)
4″	8.10 *d* (9.6)	8.12 *d* (9.5)	8.02 *d* (9.5)
5″	7.80 *d* (8.9)	7.89 *d* (8.7)	7.62 *d* (8.6)
6″	7.33 *d* (8.9)	7.33 *d* (8.7)	6.99 *d* (8.6)*
Rhamnose			
1	5.50 *d* (2.1)	5.78 *d* (1.5)	
2	3.54 *m*	4.92 *dd* (3.3, 1.5)	
3	2.93 *m*	4.63 *dd* (10.0, 3.3)	
4	3.18 *m*	4.84 *t* (10.0)	
5	3.27 *m*	3.85 *dq* (10.0, 6.2)	
6	1.00 *d* (5.9)	1.03 *d* (6.2)	
OCOMe		2.15 *s*	
		1.99 *s*	
		1.95 *s*	
		1.91 *s*	
OH	10.53 *br s*		10.49 (×2) *br s*
	4.98 *d* (4.4)		
	4.83 *d* (4.3)		
	4.58 *d* (5.8)		

Assignments were confirmed by spin decoupling experiments.

*Values may be interchanged.

Table 4. ^{13}CNMR data for compounds **2**, **4** and **5** in DMSO-d_6

C	**2**	**4**	**5**
Aglycone			
2	156.46	156.29	156.77
3	134.96	138.51	134.97
4	131.14	129.41	131.34
4a	110.57	117.34	110.80
5	129.06	129.76	129.10[a]
6	111.44	120.18	113.25[b]
7	158.57	150.62	158.76[c]
8	106.56	113.26	106.92[d]
8a	150.87	150.06	151.23
2′	159.87[a]	159.86[a]	159.86[e]
3′	113.84	113.93	113.83
4′	143.93	144.36	143.93
4a′	114.33	115.06	114.34
5′	129.93	130.38	129.83
6′	112.96	114.24	113.24
7′	159.36	159.31	159.47
8′	104.22	104.50	103.94
8a′	154.83	155.35	154.89
2″	160.06[a]	160.28[a]	160.42[e]
3″	112.96	114.46	111.03
4″	144.61	144.81	144.90
4a″	113.47	114.18	111.30
5″	129.37	130.84	128.82[a]
6″	113.28	110.87	112.75[b]
7″	156.98	155.61	159.35[c]
8″	109.56	108.28	107.08[d]
8a″	152.58	152.54	153.37
Rhamnose			
1	98.35	94.95	
2	69.77	68.25	
3	70.11	67.59	
4	71.26	69.63	
5	69.57	67.06	
6	17.77	17.24	
OCOMe		170.02, 169.89, 169.80, 167.64, 20.82, 20.71, 20.52, 20.52	

Assignments were confirmed by ^{1}H-^{13}C long range coupling and ^{1}H-^{13}C COSY experiments.

[a–e] Values in the same column may be interchanged.

Table 5. ^{13}CNMR and ^{1}HNMR data for compound **6** in $CDCl_3$ (values in parenthesis are coupling constants in Hz)

	C	H
1	114.16	
2	161.67*	
3	119.07	
4	136.52	7.72 *d* (8.6)
5	115.44	7.02 *d* (8.6)
6	155.71	
1′	109.36	
2′	161.40*	
3′	116.68	
4′	134.23	7.62 *d* (8.7)
5′	106.10	6.91 *d* (8.7)
6′	159.71	
Rhamnose		
1	94.76	5.57 *d* (2.1)
2	69.42	5.12 *dd* (3.6, 2.1)
3	68.16	4.98 *dd* (8.8, 3.6)
4	70.91	5.06 *t* (8.8)
5	67.71	4.06 *dd* (8.8, 6.3)
6	17.66	1.18 *d* (6.3)
CHO	196.63	9.93 *s*
	195.56	9.84 *s*
OH		11.82 *s*
		11.55 *s*
OAc	20.92 × 2	2.16 *s*
	20.82	2.10 *s*
	20.65	2.03 *s*
		1.91 *s*

Assignments were confirmed by spin decoupling and ^{1}H–^{13}C COSY experiments.

*Values may be interchanged.

(0.03 g) which were identical with authentic samples prepared from umbelliferone and umbelliferone acetate, respectively.

Edgeworoside A(**2**). Colourless crystalline powder, mp 208–209°, blue fluorescence under UV. FABMS *m/z* 628 $[M]^+$; UV λ_{max}^{MeOH} nm (log ε): 325 (4.48); 209 (4.73); IR ν_{max}^{Nujol} cm^{-1}: 3500–3120; 1725; 1700; 1590, CD (MeOH; c 2.88×10^{-5}) $\Delta\varepsilon^{23}$ (nm): 0 (392); +48.93 (344); 0 (323); −17.36 (311); 0 (258); +33.14 (225); 0 (218). ^{1}H and ^{13}CNMR see Tables 3 and 4.

Acetylation of **2**. A soln of **2** (0.27 g) in a mixture of Ac_2O (10 ml) and pyridine (10 ml) was allowed to stand at room temp. overnight. The reaction mixture was treated in the usual way, and the product was purified by silica gel CC with $CHCl_3$–MeOH (50:1) to afford the tetracetate **4** (0.31 g), colourless viscid oil. HRMS *m/z*: 797.1772 ($M^+ + 1$, calcd. for $C_{41}H_{33}O_{17}$: 797.1716). ^{1}H and ^{13}CNMR see Tables 3 and 4.

Hydrolysis of **2**. A soln of **2** (0.2 g) in 5% HCl–MeOH (50 ml) was heated on a boiling water bath for 5 hr and the mixture dild with H_2O (100 ml) and extracted with EtOAc. The EtOAc soln was washed with H_2O, dreid and concd *in vacuo* to give the aglycone **5** (0.12 g), colourless fine needles, mp 210.5–211.5°. UV λ_{max}^{MeOH} nm (log ε): 329 (4.27); 208 (4.50); CD (MeOH; c 3.32 $\times 10^{-5}$) $\Delta\varepsilon^{23}$ (nm): 0 (415); +28.04 (348); 0 (329); −13.00 (316); 0 (243); +20.06 (225); 0 (218). ^{1}H and ^{13}C NMR see Tables 3 and 4. HRMS *m/z*: 482.0622 (M^+, calcd. for $C_{27}H_{14}O_9$: 482.0636). The aq layer was neutralized with $BaCO_3$, then filtered. The filtrate was concd to a syrup, which was subject to TLC examination to detect rhamnose [Merck HPTLC plate $Si_{50000}F_{254}$, *n*-PrOH–H_2O–NH_4OH (80:20:1), R_f 0.62].

Ozonolysis of **4**. **3** (0.28 g) was ozonized in $CHCl_3$ (100 ml) under cooling (−10°) and the solvent evapd off *in vacuo*. H_2O (50 ml) was added to the residue and mixture stirred, allowed to stand overnight and extracted with EtOAc. The EtOAc soln was dried and concd *in vacuo*. The residue was subject to prep. TLC with $CHCl_3$–MeOH (100:1) to afford 2,4-dihydroxybenzaldehyde (0.055 g) and **6** (0.015 g). **6**: colourless viscid oil, UV λ_{max}^{MeOH} nm (log ε): 312 (3.32); 275 (3.81); 225 (3.99); 206.5 (4.15); HRMS *m/z*: 588.1475 (M^+, calcd. for $C_{28}H_{28}O_{14}$: 588.1476); 273.0368 ($C_{14}H_9O_6$: 273.0398). ^{1}H and ^{13}CNMR see Table 5.

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