

HYDROLYZABLE TANNINS HAVING A DEPSIDONE-FORMING VALONEOYL GROUP

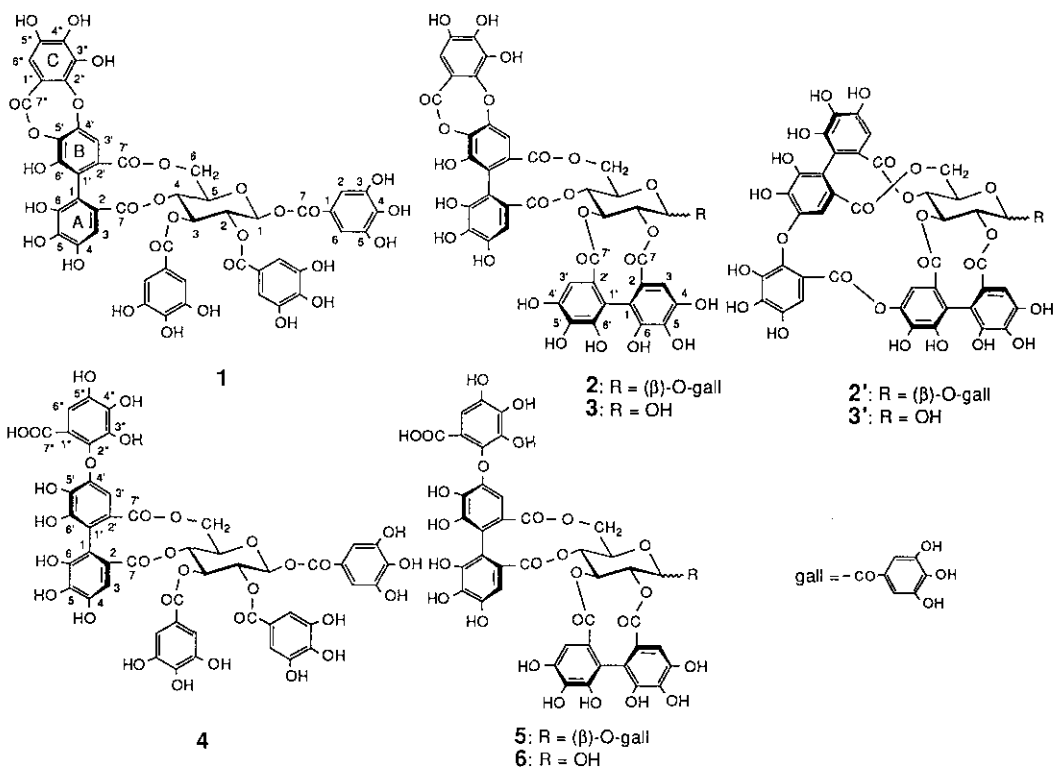
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Abstract — Prostratin C (**1**) isolated from *Euphorbia prostrata*, and praecoxins C (**2**) and D (**3**) isolated from *Stachyurus praecox*, were found to be hydrolyzable tannins having a depsidone-forming valoneoyl group as a constituent unit. The orientation of the valoneoyl group in praecoxins C and D as in the structures **2** and **3** was unequivocally proved by the ¹H-¹³C long-range shift correlation spectrum of rugosin C (**5**) which was chemically correlated with praecoxin C.

Valoneoyl group is one of the constituent units of hydrolyzable tannins,¹ most frequently found in oligomeric hydrolyzable tannins.² We have isolated a new tannin, named prostratin C (**1**), from *Euphorbia prostrata* Ait. (Euphorbiaceae), and found that it has a depsidone-forming valoneoyl group. We have also found that praecoxins C (**2**) and D (**3**), previously isolated from *Stachyurus praecox* Sieb. et Zucc. (Stachyuraceae),³ have this partial structure.

Prostratin C (**1**), [α]_D +79° (MeOH), and also rugosins A (**4**), B, and D,⁴⁻⁶ prostratin A,⁶ and other tannins of known structures,⁶ have been isolated from the leaf extract of *E. prostrata*. The ¹H nmr spectrum (500 MHz, CD₃COCD₃-D₂O) of **1** exhibited three 2H-singlets (δ 7.12, 6.99, and 6.95) of galloyl groups, and three 1H-singlets (δ 7.20, 6.93, and 6.49) attributable to a valoneoyl group. The sugar signals in the ¹³C (Table 1) and ¹H nmr spectra, which are almost superimposable on those of co-existing rugosin A (**4**), show that prostratin C (**1**) is a hydrolyzable tannin closely related to **4**. The spectral differences between **1** and **4** were observed in the chemical shifts of the valoneoyl protons (**4**, δ 7.14, 6.51, and 6.32), and a remarkable upfield shift of one (δ 163.0) of the six ester carbonyl carbon resonances in **1**. These data, together with the [M-H]⁻ peak at *m/z* 1087 (18 mass units lower than that of **4**) in the negative *fab*-ms spectrum, indicated that prostratin C has a monolactonized valoneoyl group in its molecule. The hot-water treatment of **1** gave **4** in a high yield to indicate the structure **1** for prostratin C.⁷ The presence of a depsidone-



forming valoneoyl group in **1** was also exhibited in the ^{13}C nmr spectrum by the upfield shift of C-5' and the downfield shifts of the other carbon signals of ring B, relative to the corresponding signals of **4** (Table 1).

The ring B carbon signals of the depsidone-forming valoneoyl group were also exhibited by praecoxin C, requiring re-investigation of its depside linkage.

The previous assignment of the location of depside linkage in praecoxin C was based on the ^{13}C nmr (22.6 MHz) spectral comparison with rugosin C (**5**),⁴ which is produced by the cleavage of the depside linkage in praecoxin C under a mild condition.³ However, the spectrometry with a higher magnetic field (125.7 MHz for ^{13}C nmr), with the aid of the long-range ^1H - ^{13}C shift-correlation (COLOC) spectroscopy, now established the assignments of the ^{13}C signals of **5**, shown in Table 2, in which almost all the signals of the hexahydroxydiphenyl (HHDP) group were discriminated from those of the HHDP moiety in the valoneoyl group. The COLOC spectrum also revealed following two sets of connectivity: $\delta_{\text{H}} 6.53$ (valoneoyl H-3) — $\delta_{\text{C}} 168.0$ (valoneoyl C-7) — $\delta_{\text{H}} 5.06$ (glucose H-4); $\delta_{\text{H}} 6.23$ (valoneoyl H-3') — $\delta_{\text{C}} 167.9$ (valoneoyl C-7') — $\delta_{\text{H}} 3.76$ (glucose H-6).⁸ These correlations indicate that the orientation of valoneoyl group in **5** is the same as that in **4**.^{5,9}

In the ^{13}C signals of praecoxin C (**2**), which were assigned as in Table 2, the chemical shifts of the HHDP signals were practically the same as those of **5**. On the other hand, the chemical shifts of ^{13}C signals of the valoneoyl group were closely similar to those of the depsidone-forming valoneoyl group in **1**. The changes in the chemical shifts of H-

Table 1. ^{13}C Chemical shifts of **1** and **4** (125.7 MHz)

	1 ^{a)}	4 ^{a)}
glucose		
C-1	93.7	93.6
C-2	71.7	71.7
C-3	72.9	73.1
C-4	70.8	70.7
C-5	72.8	73.0
C-6	63.9	63.0
galloyl		
C-1	119.9	119.8
	120.5	120.5
	120.5	120.6
C-2, C-6	110.1	110.1
	110.2	110.2
	110.3	110.3
C-3, C-5	145.8	145.8
	145.9	145.9
	146.1	146.1
C-4	139.2	139.1
	139.2	139.3
	139.8	139.8
C-7	164.9	164.9
	165.3	165.5
	166.1	166.2
valoneoyl		
C-1	114.2	115.9
C-2	125.1	125.5 ^{b)}
C-3	107.5	107.7
C-4	145.8	145.2
C-5	136.6	136.7
C-6	145.2	144.7
C-7	167.6	167.6
C-1'	122.1	117.8
C-2'	132.8	126.1 ^{b)}
C-3'	111.2	106.1
C-4'	151.7	146.8
C-5'	135.7	137.4
C-6'	148.6	144.7
C-7'	167.0	167.8
C-1''	111.7	115.3
C-2''	141.3	137.5
C-3''	137.1	140.4
C-4''	143.4	139.8
C-5''	143.8	143.3
C-6''	109.9	110.1
C-7''	163.0	166.3

 a) In $\text{CD}_3\text{COCD}_3\text{-D}_2\text{O}$.

b) These values are interchangeable.

 Table 2. ^{13}C Chemical shifts of **2** and **5** (125.7 MHz)

	2 ^{a)}	5 ^{b)}
glucose		
C-1	92.3	91.9
C-2	75.8	75.8
C-3	76.9	77.1
C-4	69.4	69.0
C-5	73.3	73.1
C-6	64.0	63.0
galloyl		
C-1	119.9	119.3
C-2, C-6	110.3	110.1
C-3, C-5	146.2	146.1
C-4	139.9	140.0
C-7	164.9	165.1
hexahydroxydiphenoyl		
C-1	114.9	114.9
C-2	126.0 ^{c)}	125.7 ^{d)}
C-3	107.2	107.1
C-4	145.1	145.0
C-5	136.5	136.4
C-6	144.5	144.3 ^{e)}
C-7	168.4	168.7
C-1'	114.1	114.3
C-2'	126.4 ^{c)}	126.0 ^{d)}
C-3'	107.2	107.1
C-4'	145.0	145.0
C-5'	136.1	136.2
C-6'	144.5	144.4 ^{e)}
C-7'	169.1	169.3
valoneoyl		
C-1	114.6	115.9
C-2	125.0	125.7 ^{d)}
C-3	107.3	107.3
C-4	145.8	145.2
C-5	136.7	136.6
C-6	145.3	145.0
C-7	167.8	168.0
C-1'	122.1	117.6
C-2'	132.8	125.1 ^{d)}
C-3'	111.2	105.4
C-4'	151.7	147.0
C-5'	135.5	137.0
C-6'	148.5	144.6
C-7'	167.0	167.9
C-1''	111.4	115.2
C-2''	141.4	137.1
C-3''	137.1	139.9
C-4''	143.4	139.9
C-5''	143.8	143.1
C-6''	110.0	109.7
C-7''	163.2	167.0

 a) In CD_3COCD_3 .

 b) In $\text{CD}_3\text{COCD}_3\text{-D}_2\text{O}$.

c-e) The values with the same superscript are interchangeable.

3' and H-6" of the valoneoyl group, occurring upon the cleavage of the depside linkage in praecoxin C [δ 7.20 \rightarrow 6.23 (H-3'); δ 6.95 \rightarrow 7.09 (H-6")], are also closely similar to those due to the transformation from **1** to **4** [δ 7.20 \rightarrow 6.32 (H-3'); δ 6.93 \rightarrow 7.14 (H-6")]. These findings clearly indicate that the carboxyl group on ring C of the valoneoyl group is not esterified with a hydroxyl group on the HHDP group as in **2**,³ and that the structure **2**, having a depsidone-forming valoneoyl group, should be formulated for praecoxin C.

The structure of praecoxin D was previously proposed to be **3**,³ based also on its transformation into praecoxin A (**6**)⁴ in a mild condition.³ The changes in the chemical shifts of valoneoyl protons due to this structural transformation [δ 7.17 \rightarrow 6.30 (H-3'), δ 6.97 \rightarrow 7.17 (H-6") (α -anomer); δ 7.19 \rightarrow 6.32 (H-3'), δ 6.97 \rightarrow 7.17 (H-6") (β -anomer)] are analogous to those occurring upon the cleavage of depsidic linkage of praecoxin C. The structure **3**, therefore, is assigned for praecoxin D based on the structural revision of praecoxin C.

The revision of the proposed structure for praecoxin E, another tannin from *S. praecox*,³ will be published elsewhere in detail.

ACKNOWLEDGEMENTS

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REFERENCES AND NOTES

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6. T. Yoshida, O. Namba, T. Okuda, and L. Chen, 109th Annual Meeting of Pharmaceutical Society of Japan, Nagoya, April 1989, Abstract Papers, p. 200.
7. It is uncertain at present whether **1** and **4** are artefacts produced from rugosin D and **1**.
8. The assignments of H-3 and H-3' of the valoneoyl group were based on the correlations, [δ_{H} 6.53 — δ_{C} 145.2 (valoneoyl C-4)] and [δ_{H} 6.23 — δ_{C} 147.0 (valoneoyl C-4')] in the COLOC spectrum, and the assignments of these carbons were based on the downfield shift of the latter carbon attributable to the ether linkage at C-4'.
9. The orientation of valoneoyl group in rugosin F (T. Okuda, T. Hatano, and N. Ogawa, *Chem. Pharm. Bull.*, 1982, **30**, 4234) is also established as the same as that in **4**, since partial hydrolysis of rugosin F gave **5**.

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