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Tanshinlactone, a Novel Seco-abietanoid from *Salvia miltiorrhiza*

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Further study on the constituents of *Salvia miltiorrhiza* BUNGE (Labiatae) afforded a novel seco-abietanoid named tanshinlactone. The structure of tanshinlactone was characterized on the basis of spectral data. The biogeneses of tanshinlactone and a related compound are discussed.

Keywords——*Salvia miltiorrhiza*; Labiatae; tanshinlactone; danshenspiroketallactone; seco-abietanoid

Introduction

In the previous paper,[1)] we reported on the isolation and structures of five new abietanoids from *Salvia miltiorrhiza* BUNGE (Labiatae). Further study on the minor constituents of the same source has resulted in the isolation of a novel seco-abietanoid having a lactone ring instead of an *ortho*-quinone, named tanshinlactone (**1**). This paper describes the structural characterization of this lactone (**1**) based on its spectral data.

Results and Discussion

The mother liquor of tanshinone IIA described in the previous paper[1)] was repeatedly separated by column chromatography on silica gel to afford a novel lactone, tanshinlactone (**1**) in 0.000033% yield from the dried material, in addition to danshenspiroketallactone (**2**) in 0.000025% yield. Danshenspiroketallactone (**2**) was recently isolated from the same source as ours by Kong *et al.* and its structure was elucidated by X-ray analysis.[2)] Tanshinlactone (**1**) was obtained as colorless needles, $C_{17}H_{12}O_3$, mp 185—187 °C. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum of **1** showed signals due to six aromatic protons [δ 8.45 (H-1, d, $J=8.3$ Hz), 7.51 (H-2, dd, $J=7.8$, 8.3 Hz), 7.43 (H-3, d, $J=7.8$ Hz), 7.83 (H-6, d, $J=9.0$ Hz), 7.87 (H-7, d, $J=9.0$ Hz), 7.42 (H-15, q, $J=1.5$ Hz)] and two methyl groups [δ 2.39 (H-17, d, $J=1.5$ Hz), 2.70 (H-18, s)], as seen in the case of tanshinone I (**3**). However, **1** was different from **3** in the following respects. The carbon-13 nuclear magnetic resonance (^{13}C-NMR) spectrum of **3** showed two signals due to an *ortho*-quinone at δ 183.4 (s) and 175.6 (s) (Table I). On the other hand, **1** contained a α-pyrone type lactone [δ 158.4 (s), $\nu_{(C=O)}$ 1726 cm^{-1}] instead of an *ortho*-quinone. On the basis of the data mentioned above, the structure of tanshinlactone can be represented by **1a** or **1b**. Of these two possible structures, the former (**1a**) should be assigned to tanshinlactone, as discussed below. The mass spectrum (MS) of **1** had a fragment ion peak at m/z 184.0467 corresponding to $C_{12}H_8O_2$ (Calcd 184.0523) (**4**). The generation of **4a** from **1a** may be rather easy compared to that of **4b** from **1b**. Next, tanshinlactone (**1a**) may be biogenetically produced from tanshinone I (**3**) in a manner such as that shown in Chart 1. The intermediate β-keto carboxylic acid **5** may be

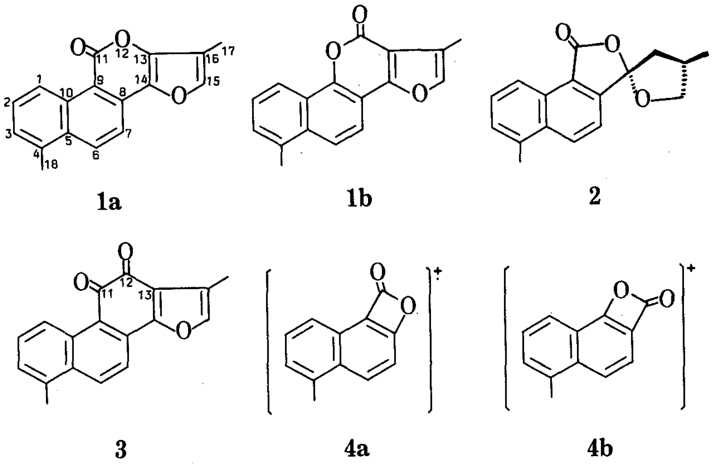

Fig. 1

Table I. ^{13}C-NMR Data for **1** and **3**

Carbon No.	**1**	**3**	Carbon No.	**1**	**3**
1	120.6 (d)	118.7 (d)	10	133.1 (s)	133.6 (s)
2	128.8 (d)	130.6 (d)	11	158.4 (s)	183.4 (s)
3	126.8 (d)	128.4 (d)	12	—	175.6 (s)
4	134.4 (s)	135.2 (s)	13	158.4 (s)	121.7 (s)
5	123.4 (s)	123.2 (s)	14	149.4 (s)	161.1 (s)
6	128.8 (d)	132.9 (d)	15	140.4 (d)	142.0 (d)
7	116.6 (d)	124.8 (d)	16	120.3 (s)	120.5 (s)
8	110.3 (s)	129.6 (s)	17	9.0 (q)	8.8 (q)
9	108.0 (s)	126.9 (s)	18	20.0 (q)	19.8 (q)

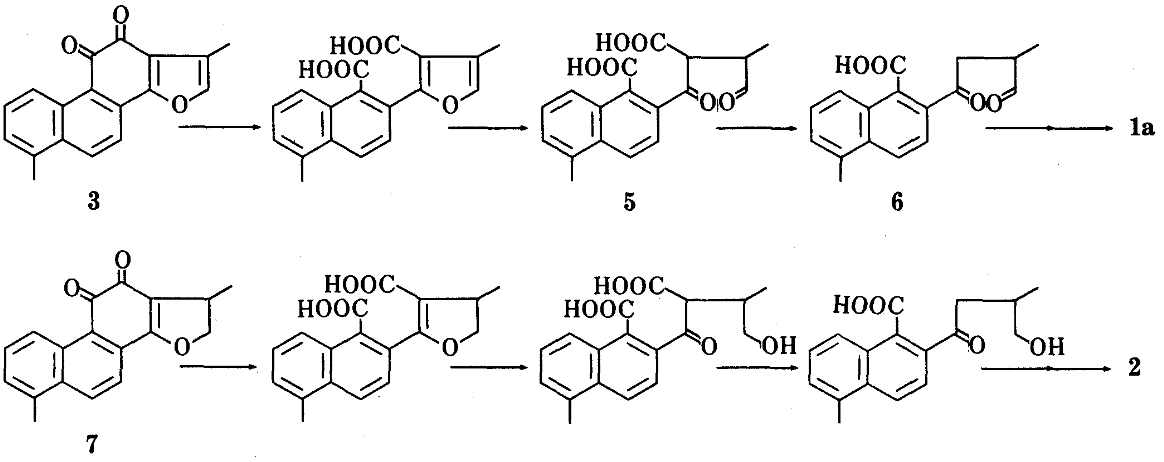

Chart 1. Possible Biogenetic Pathways to Tanshinlactone (**1**) and Danshenspiroketallactone (**2**)

easily decarboxylated to produce the ketone **6**, which is subsequently oxidized and cyclized to produce **1a**. This pathway seems to be reasonable, because danshenspiroketallactone (**2**) may also be produced from dihydrotanshinone I (**7**) by such a biogenetic pathway, as shown in Chart 1.

Experimental

The ^{1}H-NMR (100 MHz) and ^{13}C-NMR spectra were recorded in $CDCl_3$. Chemical shifts are shown in ppm (δ)

with tetramethylsilane as an internal standard. MS were recorded using a direct-inlet system (70 eV). Infrared (IR) spectra were taken in a KBr disk. Ultraviolet (UV) spectra were recorded in MeOH.

Separation——The mother liquor of tanshinone IIA (78 g) described in the previous paper[1] was concentrated. The concentrate (15.6 g) was chromatographed on silica gel (120 g) and eluted successively with cyclohexane and cyclohexane–$CHCl_3$ (9 : 1) to afford tanshinlactone (**1**) (40 mg) and danshinspiroketallactone (**2**) (30 mg) in addition to tanshinone IIA (8.0 g). Recrystallization of tanshinlactone (**1**) from $CHCl_3$–MeOH gave colorless needles.

Tanshinlactone (1)——mp 185—187 °C. Found: M^+ 264.0829; $C_{17}H_{12}O_3$ requires 264.0783. UV λ_{max} nm (log ε): 242 (4.42), 272 (4.38), 282 (4.48), 308 (3.98), 323 (4.15), 340 (4.02), 357 (4.05). IR ν_{max} cm^{-1}: 1726, 1620, 1580. ^1H-NMR δ: 2.39 (3H, d, J=1.5 Hz, 17-H), 2.70 (3H, s, 18-H), 7.42 (1H, q, J=1.5 Hz, 15-H), 7.43 (1H, d, J=7.8 Hz, 3-H), 7.51 (1H, dd, J=7.8, 8.3 Hz, 2-H), 7.83 (1H, d, J=9.0 Hz, 6-H), 7.87 (1H, d, J=9.0 Hz, 7-H), 8.45 (1H, d, J=8.3 Hz, 1-H).

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