

**FOUR LIGNANS FROM ROOT OF *PSEUDERANTHEMUM CARRUTHERSII*  
(SEEM.) GUILL. VAR. *ATROPURPUREUM* (BULL.) FOSB.**

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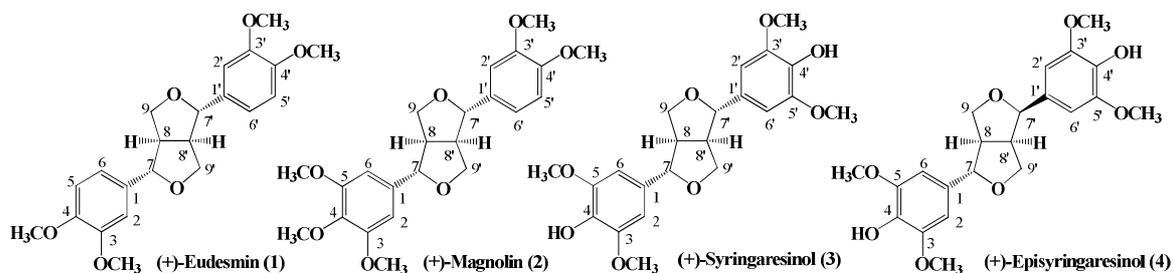
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(Manuscript Received on January 24<sup>th</sup> 2011, Manuscript Revised October 25<sup>th</sup> 2011)

**ABSTRACT:** Four lignans were isolated from the dried root of *Pseuderanthemum carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb. (Acanthaceae), including (+)-eudesmin (1), (+)-magnolin (2), (+)-syringaresinol (3) and (+)-episyngaresinol (4). Their chemical structures were elucidated by spectroscopic methods as well as comparing with data in the literature. These substances were isolated for the first time from this genus.

**Key words:** *Pseuderanthemum*, lignan, eudesmin, magnolin, syringaresinol, episyngaresinol.



## INTRODUCTION

*P. carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb. (Figure 1) has been used in traditional medicine to heal the

wound.<sup>[1]</sup> It has not yet much been chemically studied. In this paper, the isolation of four lignans from the root of this plant and the structure elucidation of these compounds were reported.



**Figure 1.** *Pseuderanthemum carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb.

## EXPERIMENTAL

### General experimental procedures

The NMR spectra were measured on a Bruker Avance spectrometer, at 500 MHz for  $^1\text{H}$ -NMR and 125 MHz for  $^{13}\text{C}$ -NMR. The HR-ESI-MS were recorded on a HR-ESI-MS MicroOTOF-Q mass spectrometer. The above spectra were performed in the Center of Analysis, University of Science, National University – HCM City. Optical rotations of all samples were measured on a KRUSS digital polarimeter.

### Plant material

The root of *P. carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb., (Figure 1) collected in June 2008 in Thu Duc District, Ho Chi Minh City, was identified by Dr. Hoang Viet, Department of Biology, University of Science, National University – HCM City. A voucher specimen (US-A008) was deposited in the herbarium of the Department of Organic

Chemistry, University of Science, National University – HCM City.

### Extraction and isolation

The dried root of *P. carruthersii* *atropurpureum* (5 kg) was exhaustively extracted with ethanol by maceration at room temperature and the ethanolic filtrate was concentrated in vacuo to yield a residue of 400 g. This crude residue was suspended in water and partitioned against chloroform and then ethyl acetate to afford chloroform residue (C, 120 g) and ethyl acetate residue (EA, 20 g), respectively. The chloroform residue (C, 120 g) was applied on a silica gel chromatographic column eluted with petroleum ether - ethyl acetate to give 10 fractions. Fraction 5 (795 mg) was purified by silica gel column chromatography eluted with chloroform - ethyl acetate (9:1) to afford compound **1** (45.0 mg). Fraction 7 (4.18 g) was applied on a silica gel chromatographic column eluted with petroleum ether - acetone (6:4) to afford compound **2**

(12.0 mg). Fraction 8 (1.14 g) was applied on a silica gel chromatographic column eluted with chloroform - ethyl acetate (8:2) to afford compound **3** (3.5 mg) and compound **4** (2.5 mg).

\* (+)-*Eudesmin* (**1**), IUPAC name: (7 $\alpha$ ,7' $\alpha$ ,8 $\alpha$ ,8' $\alpha$ )-3,4,3',4'-tetramethoxy-7,9':7',9-diepoxy lignane; colorless oil; HR-ESI-MS  $m/z$  409.1666 [M+Na]<sup>+</sup> (Calcd. for [M+Na]<sup>+</sup> 409.1627); [ $\alpha$ ]<sub>D</sub><sup>20</sup> +350 (c 1 mg/ml, CHCl<sub>3</sub>); <sup>1</sup>H and <sup>13</sup>C NMR (CDCl<sub>3</sub>) shown in Table 1 and Table 2, respectively.

\* (+)-*Magnolin* (**2**), IUPAC name: (7 $\alpha$ ,7' $\alpha$ ,8 $\alpha$ ,8' $\alpha$ )-3,4,5,3',4'-pentamethoxy-7,9':7',9-diepoxy lignane; colorless oil; HR-ESI-MS  $m/z$  439.1762 [M+Na]<sup>+</sup> (Calcd. for [M+Na]<sup>+</sup> 439.1733); [ $\alpha$ ]<sub>D</sub><sup>20</sup> +12 (c 8 mg/ml, CHCl<sub>3</sub>); <sup>1</sup>H and <sup>13</sup>C NMR (CDCl<sub>3</sub>) shown in Table 1 and Table 2, respectively.

\* (+)-*Syringaresinol* (**3**), IUPAC name: (7 $\alpha$ ,7' $\alpha$ ,8 $\alpha$ ,8' $\alpha$ )-3,5,3',5'-tetramethoxy-7,9':7',9-diepoxy lignane-4,4'-diol; colorless oil; HR-ESI-MS  $m/z$  419.1655 [M+H]<sup>+</sup> (Calcd. for [M+H]<sup>+</sup> 419.1706); [ $\alpha$ ]<sub>D</sub><sup>20</sup> +538 (c 1 mg/ml, CHCl<sub>3</sub>); <sup>1</sup>H and <sup>13</sup>C NMR (CDCl<sub>3</sub>) shown in Table 1 and Table 2, respectively.

\* (+)-*Episyringaresinol* (**4**), IUPAC name: (7 $\alpha$ ,7' $\beta$ ,8 $\alpha$ ,8' $\alpha$ )-3,5,3',5'-tetramethoxy-7,9':7',9-diepoxy lignane-4,4'-diol; colorless oil; HR-ESI-MS  $m/z$  419.1697 [M+H]<sup>+</sup> (calcd for [M+H]<sup>+</sup> 419.1706); [ $\alpha$ ]<sub>D</sub><sup>20</sup> +298 (c 1 mg/ml, CHCl<sub>3</sub>); <sup>1</sup>H and <sup>13</sup>C NMR (CDCl<sub>3</sub>) shown in Table 1 and Table 2, respectively.

## RESULTS AND DISCUSSION

The dried root of *P. carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb. was extracted and isolated by silica gel column chromatography to afford four compounds, **1**–**4**.

Compound **1** was isolated as colorless oil. The <sup>1</sup>H spectrum of compound **1** (shown in Table 1) showed an ABX system [ $\delta$ <sub>H</sub> 6.91 (1H, *d*, 2.0, H–2), 6.88 (1H, *dd*, 8.0, 2.0, H–6) and 6.84 (1H, *d*, 8.0, H–5)] for a 1,3,4-trisubstituted benzene ring, two singlet signals at  $\delta$ <sub>H</sub> 3.91 (3H, *s*) and 3.88 (3H, *s*) for two methoxyl groups. Additionally, the <sup>1</sup>H spectrum exhibited the presence of four typical aliphatic proton signals for a tetrahydrofuranoid lignan at  $\delta$ <sub>H</sub> 4.76 (1H, *d*, 4.5, H–7), 4.26 (1H, *dd*, 9.0, 7.0, H–9<sub>eq</sub>), 3.89 (1H, *m*, H–9<sub>ax</sub>) and 3.12 (1H, *m*, H–8). The <sup>13</sup>C NMR spectrum (Table 2) was simple with signals including of four aromatic carbon signals in the downfield, an oxygenated methine at  $\delta$ <sub>C</sub> 85.9 for C–7, an oxygenated methylene at  $\delta$ <sub>C</sub> 71.9 for C–9, a methine at  $\delta$ <sub>C</sub> 54.3 for C–8 and methoxyl groups at  $\delta$ <sub>C</sub> 56.1. The <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra showed the presence of 13 protons and 11 carbons but HR-ESI-MS showed the pseudomolecular ion peak at  $m/z$  409.1666 [M+Na]<sup>+</sup> supported the molecular formula to be C<sub>22</sub>H<sub>26</sub>O<sub>6</sub> (M=386.1729). The NMR spectra exhibited only a half of the molecule, so the chemical structure of **1** should be a symmetrical lignan. The 8,8' linked tetrahydrofuran moiety between two propyl groups was certified by the connectivity in <sup>1</sup>H–<sup>1</sup>H COSY spectrum with the

correlations of H-8 with H-7/H-9/H-8' and of H-8' with H-7'/H-9'/H-8. The positions of four methoxyl groups were determined by the HMBC spectrum with the correlations of these methoxyl signals with C-3, C-4, C-3' and C-4'. The connections of C-1 with C-7 and of C-1' with C-7' in two phenylpropanoid units were determined by the correlations of H-7 with C-2/C-6 and of H-7' with C-2'/C-6' in the HMBC spectrum. The observation of the stereochemistry of the natural tetrahydrofuranoid lignans showed that H-8 and H-8' is usually a *cis* configuration<sup>[2]</sup>. According to Kotaro Takahashi<sup>[3]</sup>, the stereochemistry of C-7 and C-7' was assigned by the analysis of the coupling constants between H-7/H-8 and H-7'/H-8'; if  $J_{7,8} < 5.5$  Hz, H-7 and H-8 are in a *trans* configuration, otherwise, if  $J_{7,8} > 6.0$  Hz, they are in a *cis* configuration. In this case of (**1**), the *trans* configuration between H-7 and H-8 was determined by their small coupling constants ( $J_{7,8}=4.5\text{Hz}$ ). With the specific rotation of  $[\alpha]_{\text{D}}^{20} +350$  (*c* 1mg/ml, CHCl<sub>3</sub>), the structure of **1** was elucidated as (+)-eudesmin, which was further confirmed by the comparison with the literature data.<sup>[4]</sup>

Compound **2** was isolated as colorless oil. The NMR spectra of **2** were similar to the ones of **1** with the addition of a methoxyl group

connecting to the aromatic ring. The <sup>1</sup>H spectrum of compound **2** (shown in Table 1) showed the presence of a singlet signal at  $\delta_{\text{H}}$  6.57 (2H, *s*, H-2 and H-6) for a 1,3,4,5-tetrasubstituted benzene ring; an ABX system [ $\delta_{\text{H}}$  6.91 (1H, *d*, 1.5, H-2'), 6.88 (1H, *dd*, 8.0, 1.5, H-6') and 6.84 (1H, *d*, 8.0, H-5')] for a 1,3,4-trisubstituted benzene ring, three singlet signals at  $\delta_{\text{H}}$  3.91 (3H, *s*), 3.87 (9H, *s*) and 3.84 (3H, *s*) for five methoxyl groups. The positions of the five methoxyl groups were determined by the correlations of these methoxyl protons with C-3, C-4, C-5, C-3' and C-4' in HMBC spectrum. Based on the good comparison of the 1D and 2D NMR data of **2** with the published data<sup>[5]</sup>, the HR-ESI-MS with  $m/z$  439.1762  $[\text{M}+\text{Na}]^+$  ( $\text{M}=416.1835$ , suitable with the molecular formula of C<sub>23</sub>H<sub>28</sub>O<sub>7</sub>), and the specific rotation value of  $[\alpha]_{\text{D}}^{20} +12$  (*c* 8mg/ml, CHCl<sub>3</sub>), the compound **2** was identified as (+)-magnolin.

Compound **3** was isolated as colorless oil. The NMR spectra of **3** were similar to the ones of **1** with the difference of substituted groups connecting to the aromatic rings. The <sup>1</sup>H spectrum of compound **3** (shown in Table 1) showed the presence of a singlet signal at  $\delta_{\text{H}}$  6.58 (4H, *s*) for two 1,3,4,5-tetrasubstituted benzene rings, a singlet signal at  $\delta_{\text{H}}$  5.49 (2H, *s*) for two hydroxyl groups and a singlet

**Table 1.** <sup>1</sup>H NMR (*J* in Hz) spectral data of 1-4 (CDCl<sub>3</sub>)

No	Compound			
	1	2	3	4
1	-	-	-	-

2	6.91 ( <i>d</i> , 2.0)	6.57 ( <i>s</i> )	6.58 ( <i>s</i> )	6.59 ( <i>s</i> )
5	6.84 ( <i>d</i> , 8.0)	-	-	-
6	6.88 ( <i>dd</i> , 8.0, 2.0)	6.57 ( <i>s</i> )	6.58 ( <i>s</i> )	6.59 ( <i>s</i> )
7	4.76 ( <i>d</i> , 4.5)	4.74 ( <i>d</i> , 4.0)	4.73 ( <i>d</i> , 4.5)	4.86 ( <i>d</i> , 5.5)
8	3.12 ( <i>m</i> )	3.10 ( <i>m</i> )	3.09 ( <i>m</i> )	3.34 ( <i>m</i> )
9 <sub>eq</sub>	4.26 ( <i>dd</i> , 9.0, 7.0)	4.28 ( <i>dd</i> , 9.0, 7.0)	4.28 ( <i>dd</i> , 9.5, 7.0)	3.86 ( <i>m</i> )
9 <sub>ax</sub>	3.89 ( <i>m</i> )	3.92 ( <i>dd</i> , 9.0, 3.5)	3.90 ( <i>m</i> )	3.34 ( <i>m</i> )
1'	-	-	-	-
2'	6.91 ( <i>d</i> , 2.0)	6.91 ( <i>d</i> , 1.5)	6.58 ( <i>s</i> )	6.60 ( <i>s</i> )
5'	6.84 ( <i>d</i> , 8.0)	6.84 ( <i>d</i> , 8.0)	-	-
6'	6.88 ( <i>dd</i> , 8.0, 2.0)	6.88 ( <i>dd</i> , 8.0, 1.5)	6.58 ( <i>s</i> )	6.60 ( <i>s</i> )
7'	4.76 ( <i>d</i> , 4.5)	4.77 ( <i>d</i> , 4.0)	4.73 ( <i>d</i> , 4.5)	4.42 ( <i>d</i> , 7.0)
8'	3.12 ( <i>m</i> )	3.10 ( <i>m</i> )	3.09 ( <i>m</i> )	2.91 ( <i>m</i> )
9' <sub>eq</sub>	4.26 ( <i>dd</i> , 9.0, 7.0)	4.28 ( <i>dd</i> , 9.0, 7.0)	4.28 ( <i>dd</i> , 9.5, 7.0)	4.14 ( <i>dd</i> , 9.0, 9.0)
9' <sub>ax</sub>	3.89 ( <i>m</i> )	3.92 ( <i>dd</i> , 9.0, 3.5)	3.90 ( <i>m</i> )	3.86 ( <i>m</i> )
<b>-OCH<sub>3</sub></b>				
3	3.91 ( <i>s</i> )	3.87 ( <i>s</i> )	3.90 ( <i>s</i> )	3.91 ( <i>s</i> )
4	3.88 ( <i>s</i> )	3.84 ( <i>s</i> )	-	-
5	-	3.87 ( <i>s</i> )	3.90 ( <i>s</i> )	3.91 ( <i>s</i> )
3'	3.91 ( <i>s</i> )	3.87 ( <i>s</i> )	3.90 ( <i>s</i> )	3.91 ( <i>s</i> )
4'	3.88 ( <i>s</i> )	3.91 ( <i>s</i> )	-	-
5'	-	-	3.90 ( <i>s</i> )	3.91 ( <i>s</i> )
<b>-OH</b>				
4	-	-	5.49 ( <i>s</i> )	5.49 ( <i>s</i> )
4'	-	-	5.49 ( <i>s</i> )	5.47 ( <i>s</i> )

signal at  $\delta_{\text{H}}$  3.90 (12H, *s*) for four methoxyl groups. The positions of four methoxyl groups were determined by the correlations of these methoxyl signals with C-3, C-5, C-3' and C-5' in the HMBC spectrum. On the basis of the comparison of 1D and 2D NMR data with the published literature [6], the HR-ESI-MS with  $m/z$  419.1655  $[\text{M}+\text{H}]^+$  ( $\text{M}=418.1628$ , suitable with the molecular formula of  $\text{C}_{22}\text{H}_{26}\text{O}_8$ ), and the optical rotation value of  $[\alpha]_{\text{D}}^{20} +538$  ( $c$  1mg/ml,  $\text{CHCl}_3$ ), the compound **3** was identified as (+)-syringaresinol, or known as (+)-lirioresinol B.

Compound **4** was isolated as colorless oil. The  $^1\text{H}$  NMR spectrum of **4** (Table 1) showed the presence of two singlet signals at  $\delta_{\text{H}}$  6.60 (2H, *s*) and 6.59 (2H, *s*) for two 1,3,4,5-tetrasubstituted benzene rings, two singlet signals at  $\delta_{\text{H}}$  5.49 (1H, *s*) and 5.47 (1H, *s*) for two hydroxyl groups, a singlet signal at  $\delta_{\text{H}}$  3.91 (12H, *s*) for four methoxyl groups. The  $^1\text{H}$  spectrum also exhibited the presence of eight typical aliphatic proton signals for a tetrahydrofuranoid lignan at  $\delta_{\text{H}}$  4.86 (1H, *d*, 4.5, H-7), 4.42 (1H, *d*, 7.0, H-7'), 4.14 (1H, *dd*, 9.0, 9.0, H-9'<sub>eq</sub>), 3.86 (2H, *m*, H-9'<sub>ax</sub> and H-9<sub>eq</sub>), 3.34 (1H, *m*, H-9<sub>ax</sub>), 3.34 (1H, *m*, H-8) and 2.91 (1H, *m*, H-8'). The typical

tetrahydrofuranoid moiety was also confirmed by the  $^{13}\text{C}$  and DEPT spectra (Table 2) with two oxygenated methines at  $\delta_{\text{C}}$  87.9 and 82.2 for C-7' and C-7, two oxygenated methylenes at  $\delta_{\text{C}}$  71.0 and 69.7 for C-9' and C-9 and two methines at  $\delta_{\text{C}}$  54.6 and 50.1 for C-8' and C-8, respectively. The 8,8' linked tetrahydrofuran skeleton between two propyl groups was certified by connectivity in  $^1\text{H}$ - $^1\text{H}$  COSY

spectrum, with the correlations between H-8 with H-7/H-9/H-8' and H-8' with H-7'/H-9'/H-8. The positions of four methoxyl groups were determined by correlation peaks with C-3, C-5, C-3' and C-5', the connections of C-1 with C-7 and C-1' with C-7' in two phenylpropanoid units were determined by the correlations of H-7 with C-2/C-6 and of H-7' with C-2'/C-6' in the HMBC spectrum.

**Table 2.**  $^{13}\text{C}$  NMR spectral data of 1-4 ( $\text{CDCl}_3$ )

No	Compound			
	1	2	3	4
1	133.7	136.8	132.1	129.4
2	109.4	102.9	102.7	102.3
3	148.8	153.4	147.2	147.1
4	149.4	137.6	134.3	133.7
5	111.2	153.4	147.2	147.1
6	118.4	102.9	102.7	102.3
7	85.9	86.0	86.1	82.2
8	54.3	54.4	54.3	50.1
9	71.9	71.9	71.8	69.7
1'	133.7	133.5	132.1	132.2
2'	109.4	109.3	102.7	102.8
3'	148.8	148.7	147.2	147.0
4'	149.4	149.2	134.3	134.4
5'	111.2	111.2	147.2	147.0
6'	118.4	118.2	102.7	102.8
7'	85.9	85.7	86.1	87.9
8'	54.3	54.1	54.3	54.6
9'	71.9	71.7	71.8	71.0
-OCH <sub>3</sub>				
3	56.1	56.2	56.4	56.3
4	56.1	60.8	-	-
5	-	56.2	56.4	56.3
3'	56.1	55.9	56.4	56.3
4'	56.1	55.9	-	-
5'	-	-	56.4	56.3

The *trans* configuration between H-7 and H-8 was determined by its small coupling

constant ( $J_{7,8}=5.5\text{Hz}$ ) and the *cis* configuration between H-7' and H-8' were determined by its

larger coupling constant ( $J_{7,8}=7.0$  Hz) [3]. The HR-ESI-MS showed  $m/z$  419.1697  $[M+H]^+$  ( $M=418.1628$  suitable with the molecular formula of  $C_{22}H_{26}O_8$ ). The optical rotation value of **4** is  $[\alpha]_D^{20} +298$  ( $c$  1mg/ml,  $CHCl_3$ ). Based on these evidences and the comparison with the published data [6], the compound **4** was identified as (+)-episyringaresinol, known as (+)-lirioresinol A.

## CONCLUSION

From the root of *Pseuderanthemum carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb. collected in June 2008 in Thu Duc District, Ho Chi Minh City, four lignans were isolated and elucidated as (+)-eudesmin (**1**), (+)-magnolol (**2**), (+)-syningaresinol (**3**) and (+)-episyningaresinol (**4**). These substances were isolated for the first time from this genus.

## BỐN LIGNAN CÔ LẬP TỪ RỄ CÂY XUÂN HOA ĐỎ, *PSEUDERANTHEMUM CARRUTHERSII* (SEEM.) GUILL. VAR. *ATROPURPUREUM* (BULL.) FOSB.

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**TÓM TẮT:** Từ bột khô rễ cây Xuân hoa đỏ, *Pseuderanthemum carruthersii* (Seem.) Guill. var. *atropurpureum* (Bull.) Fosb., họ Ô rô (*Acanthaceae*), đã cô lập được bốn lignan, đó là: (+)-eudesmin (**1**), (+)-magnolol (**2**), (+)-syningaresinol (**3**) và (+)-episyningaresinol (**4**). Cấu trúc của các hợp chất này được xác định bằng các phương pháp phổ nghiệm và so sánh với tài liệu tham khảo. Các hợp chất này được cô lập lần đầu tiên trong chi *Pseuderanthemum*.

**Từ khóa:** *Pseuderanthemum*, lignan, eudesmin, magnolol, syningaresinol, episyningaresinol.

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