# New Furans from *Cirsium chlorolepis*

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**Abstract**

From the roots of *Cirsium chlorolepis* (Compositae) two known compounds, 5-hydroxymethyl-2-furancarboxaldehyde, and 5-methoxymethyl-2-furancarboxaldehyde, and two new compounds, cirsiumaldehyde (**2**), and cirsiumoside (**3**), were isolated. Their structures have been elucidated by means of UV, IR, $^1$H-NMR, $^{13}$C-NMR spectroscopy, and chemical reactions.

**Key words**

*Cirsium chlorolepis*, furans, cirsiumaldehyde, cirsiumoside, structure elucidation.

## Introduction

The roots of *Cirsium chlorolepis* (Compositae) are used in southwest China folk medicine against various diseases, especially for fracture and haematuria. As part of our phytochemical investigation of this plant, we have isolated four furan compounds, two of them being new, and all of them are found for the first time in nature. Their structures have been determined by spectroscopic and chemical methods.

## Materials and Methods

### *General experimental procedures*

Melting points were measured with a PHMK 79/2288 micro-melting point apparatus and are uncorrected. The NMR spectra were measured with a Bruker AM-400 spectrometer in $CDCl_3$ or $CD_3OD$ solutions with TMS as internal standard. Elemental analyses were carried out with an automatic analyser. IR spectra were determined on a Perkin-Elmer-577 spectrophotometer. UV analyses were achieved with a UV-210A. MS measurements were made on a Finnigan-5410 mass spectrometer.

### *Plant material*

The roots were collected in July 1987 from plants in Fuming. A voucher specimen is deposited in the herbarium of Kunming Institute of Botany No. 87-1190 which was determined by Prof. Wu, Zhen-yi.

### *Isolation*

The dried roots (5 kg) was extracted with hot methanol. After solvent evaporation, the concentrate was successively extracted with petroleum, chloroform, and methanol. One part of the residue (100 g) obtained after removal of the methanol was hydrolyzed with 5% HCl. The hydrolysate was chromatographed on silica gel column and eluted with acetone-petroleum (2 : 8) to yield compound **1** (15 mg), compound **2** (30 mg), and compound **4** (20 mg). Another part of the residue (100 g) was directly chromatographed on silica gel column and eluted with chloroform-methanol (9 : 1) to afford 50 mg of compound **3**.

### *Compound 1*

Yellow needles, m.p. 35–36 °C, positive to Fehling's solution. Anal. Calcd. for $C_6H_6O_3$: C, 57.14; H, 4.76. Found: C, 56.92; H, 4.79; IR: $\nu_{max}^{KBr}$ cm$^{-1}$: 3700, 3200, 1670, 1580, 1520; UV: $\lambda_{max}^{EtOH}$ nm: 202, 227, 282: EI-MS: $M^+$ peak: 126 (10%).

### *Compound 1a*

10 mg of compound **1** was dissolved in 10 ml isopropanol with 50 mg of aluminium isopropoxide and refluxed for 2 h, during which acetone was used as the coolant for venting most of the acetone produced in the reaction. The reaction mixture was evaporated under vacuum to dryness to yield a powder. This powder was chromatographed on silica gel column, eluted with chloroform-methanol (9 : 1) to give 5 mg of compound **1a**. Compound **1a** is an oily liquid; $^1$H-NMR ($CD_3OD$, ppm): 6.20 (2H, s, H-3,4), 4.85 (2H, br. s, 2 × $CH_2OH$), 3.70 (4H, s, 2 × $CH_2OH$); $^{13}$C-NMR ($CD_3OD$, ppm): 155.4 (C-2,5), 124.8 (C-3,4), 65.3 (2 × $CH_2OH$).

### *Compound 2*

Pale yellow needles, m.p. 115 °C; positive to Fehling's solution; Anal. Calcd. for $C_{12}H_{10}O_5$: C, 62.60; H, 4.45; Found: C, 62.30; H, 4.35; IR: $\nu_{max}^{KBr}$ cm$^{-1}$: 1670, 1580, 1520, 1195, 1050, 1040, 1030; UV: $\lambda_{max}^{EtOH}$ nm: 202, 226, 282; EI-MS: $M^+$ peak: 234 (2%).

### *Compound 3*

White powder, negative to Fehling's solution; m.p. 154 °C; $[\alpha]_D^{18}$: −24.56° (*c* 0.57, methanol); Anal Calcd. for $C_{13}H_{20}O_9$: C, 48.50; H, 6.25; Found: C, 49.01; H, 6.27; IR: $\nu_{max}^{KBr}$ cm$^{-1}$: 3400, 1195, 1160, 1080; $^1$H-NMR ($CD_3OD$, ppm): 6.92 (1H, m, H-3), 6.88 (1H, m, H-4), 6.66 (1H, s, $OCHOCH_3$), 5.82 (1H, d, $J$ = 6.8 Hz, glu. anomeric H), 4.61 (2H, d, $J$ = 0.9 Hz, $CH_2OH$), 3.95 (1H, br. s, $CH_2OH$), 3.78 (3H, s, $OCHOCH_3$); $^{13}$C-NMR ($CD_3OD$, ppm): 153.1 (C-2), 134.0 (C-5), 131.1 (C-3), 129.5 (C-4), 105.3 (glu. C-1), 104.9 ($OCHOCH_3$), 78.60 (glu. C-5), 78.3 (glu. C-3), 76.0 (glu. C-2), 71.6 (glu. C-4), 62.8 ($CH_2OH$), 62.6 (glu. C-6), 56.6 ($OCHOCH_3$).

### *Hydrolysis of compound 3*

Refluxed with 5 % $H_2SO_4$-water for 12 h and detected on TLC and PC, $R_f$ value the same as glucose. The hydrolysis product was chromatographed on silica gel and eluted with acetone-petroleum (2 : 8) to give yellow needles. The IR comparison of the needles with compound **1** indicated they were identical.

### *Compound 4*

Yellow oily liquid, positive to Fehling's solution.

### *Compound 4a*

Formed by adding 2,4-dinitrophenylhydrazine/AcOH/water to a methanol solution of compound **4**. Anal. Calcd. for $C_{13}H_{12}N_4O_6$: C, 48.75; H, 3.75; N, 17.50; Found: C, 48.61; H, 3.73; N, 17.25; $^1$H-NMR ($CDCl_3$, ppm): 9.50 (1H, s, N-NH), 9.12 (1H, d, $J$ = 2.7 Hz, ben. H-3), 8.34 (1H, dd, $J_1$ = 2.7 Hz, $J_2$ = 10 Hz, ben. H-5), 8.05 (1H, d, $J$ = 10 Hz, ben. H-6), 7.94 (1H, s, H-C=N-), 6.80 (1H, d, $J$ = 3.4 Hz, furan H-3), 6.47 (1H, d, $J$ = 3.4 Hz, furan H-4), 4.47 (2H, s, -$CH_2OCH_3$), 3.42 (3H, s, -$CH_2OCH_3$); $^{13}$C-NMR ($CDCl_3$, ppm): 155.2 (furan C-2), 136.8 (ben. C-3), 136.8 (furan C-5), 130.0 (ben. C-5), 123.4 (furan C-3), 123.3 (ben. C-1), 117.0 (HC=N-NH), 115.2 (ben. C-6), 111.5 (furan C-4), 66.5 (-$CH_2OCH_3$), 58.4 (-$CH_2OCH_3$).

## Results and Discussion

The molecular formula of compound **1**, $C_6H_6O_3$, was determined by MS and elemental analysis. The IR spectrum revealed the presence of a carbonyl group (1670 $cm^{-1}$) and an aromatic ring (1580 and 1520 $cm^{-1}$). The $^{13}$C-NMR spectrum in $CDCl_3$ showed signals for four aromatic ring carbons (161.6, 152.2, 124.1, and 110.2 ppm), thus indicative of a 5-membered heterocycle. Elemental analysis of this compound showed no N and S, so the 5-membered aromatic heterocycle is a furan ring. The $^1$H-NMR spectrum in $CDCl_3$ showed signals for two furan protons (7.30 ppm, 1H, d, $J$ = 3.2 Hz; 6.55 ppm, 1H, d, $J$ = 3.2 Hz) which indicated that the furan ring is 2,5-disubstituted (1). The signal at 9.49 ppm (not exchanged by $D_2O$) indicated that one of the two substituents is an aldehyde group.

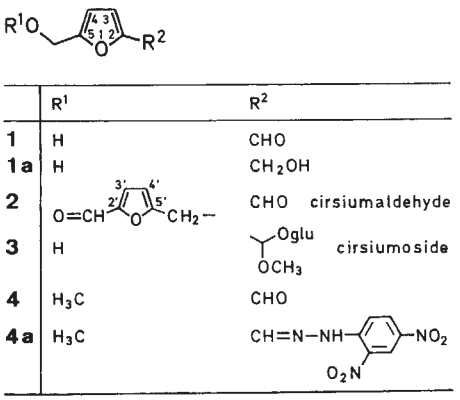


**Fig. 1** Structures of compounds **1**–**4**.

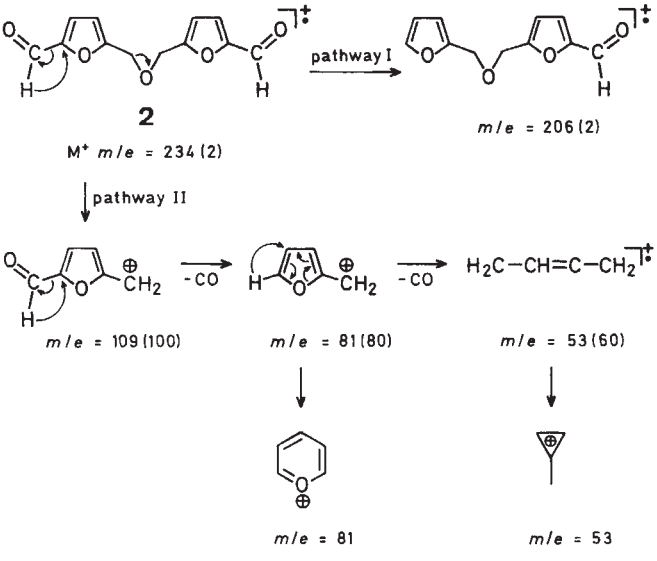


**Fig. 2** Mass spectral fragmentation of compound **2**.

| Compound | 1 | | 2 | 4 |
|---|---|---|---|---|
| $^1$H-NMR (in $CDCl_3$, ppm) | | | | |
| $CH_2OCH_3$ | – | | – | 3.63 (3H, s) |
| $CH_2OCH_3$ | – | | – | 4.49 (2H, s) |
| $CH_2OH$ | 4.65 (2H, s) | | – | – |
| $CH_2OH$ | 4.86 (1H, br. s) | | – | – |
| $CH_2O$- | – | | 4.64 (4H, s) | – |
| H-4 | 6.55 (1H, d, $J$ = 3.2 Hz) | | 6.58 (2H, d, $J$ = 3.6 Hz) | 6.61 (1H, d, $J$ = 3.4 Hz) |
| H-3 | 7.30 (1H, d, $J$ = 3.2 Hz) | | 7.23 (2H, d, $J$ = 3.6 Hz) | 7.34 (1H, d, $J$ = 3.4 Hz) |
| CHO | 9.49 (1H, s) | | 9.63 (2H, s) | 9.61 (1H, s) |
| $^{13}$C-NMR (in $CDCl_3$, ppm) | | | | |
| $CH_2OCH_3$ | – | | – | 58.4 |
| $CH_2OCH_3$ | – | Ref. data (2) | – | 66.5 |
| $CH_2OH$ | 57.1 | 57.0 | – | – |
| $CH_2O$- | – | – | 64.67 | – |
| C-4 | 110.2 | 110.4 | 111.8 | 111.6 |
| C-3 | 124.1 | 124.9 | 121.7 | 122.7 |
| C-2 | 152.2 | 152.1 | 152.9 | 153.0 |
| C-5 | 161.6 | 161.6 | 157.3 | 158.6 |
| CHO | 178.2 | 178.5 | 177.7 | 178.0 |

**Table 1** $^1$H-NMR and $^{13}$C-NMR data of compounds **1**, **2** and **4**.

The $^{13}$C-NMR spectrum in $CD_3OD$ of the highly symmetrical reduction product (**1a**) of compound **1** only showed three signals at 155.4, 124.9, and 65.3 ppm. This supported the above result and revealed the other substituent on the furan ring of compound **1** to be a hydroxymethyl group. Thus compound **1** was determined as 5-hydroxymethyl-2-furancarboxaldehyde (Fig. 1). The $^{13}$C-NMR spectral comparison of compound **1** with literature data (2) is given in Table 1.

Compound **2** (named as cirsiumaldehyde) is a pale yellow crystalline solid with the molecular formula $C_{12}H_{10}O_6$, as determined by MS ($M^+$: 234) and elemental analysis. Its IR spectrum is very similar to that of compound **1**, and its $^{13}$C-NMR spectrum in $CDCl_3$ only showed six signals at 177.7, 157.3, 152.9, 121.7, 111.8, and 64.7 ppm. Hence, we assume that compound **2** may be the dimer of compound **1**. The MS data of compound **2** showed signals at *m/e*: 234 ($M^+$ peak), 206, 109, 81, 53 (Fig. 2) in support of this assumption and through comparison of the $^1$H-NMR and $^{13}$C-NMR data of compound **1** with those of compound **2** (Table 1), it is easy to find spectral similarities. Two $^{13}$C-NMR signals (57.1 and 64.7 ppm) differing by about 7 ppm are expected for the change from an alcoholic function to an ether. So compound **2** was determined as the dimer of compound **1**, and named cirsiumaldehyde (Fig. 1).

Compound **3** (named cirsiumoside) is a white powder with the molecular formula $C_{13}H_{20}O_9$, as determined by MS ($M^+$: 320) and elemental analysis. Its IR spectrum revealed the presence of an ether linkage (1080 and 1036 $cm^{-1}$) and an aromatic ring (1520 and 1580 $cm^{-1}$). Hydrolysis of compound **3** gave two compounds. One of them was determined as glucose by TLC and PC, and the other was determined as 5-hydroxymethyl-2-furancarboxaldehyde (**1**) by IR analysis. The $^1$H-NMR spectrum of compound **3** in $CD_3OD$ showed signals for two aromatic protons (6.92 and 6.66 ppm) which indicated that the glucose unit should be linked to the 2- or the 5-position of compound **1**. Its $^1$H-NMR and $^{13}$C-NMR spectra in $CD_3OD$ showed methoxyl signals at 3.78 ppm (3H, s) and 56.6 ppm (q), respectively. This methoxyl-group can best be accomodated into a hemiacetal formed from the niginal aldehydic group of the aglycone, a fact compatible with the negative reaction to Fehling's solution. Thus compound **3** was determined as 5-hydroxymethyl-2-methoxyfurylalcohol-*O*-*β*-D-pyranoglucoside, and named as cirsiumoside (Fig. 1).

Compound **4** gave orange red crystals (compound **4a**) after reaction with 2,4-dinitrophenylhydrazine. The molecular formula of compound **4a**, $C_{13}H_{12}N_4O_6$, was determined by elemental analysis (C, 48.61; H, 3.73; N, 17.25). The $^1$H-NMR spectrum of compound **4a** in $CDCl_3$ showed signals at 6.80 ppm (1H, d, $J$ = 3.4 Hz) and 6.47 ppm (1H, d, $J$ = 3.4 Hz) for a 2,5-disubstituted furan (Table 1), and signals at 3.42 ppm (3H, s) and 4.47 ppm (2H, s) for methoxymethyl protons. So compound **4** was determined as 5-methoxymethyl-2-furancarboxaldehyde (Fig. 1).

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