文章编号:1001-6880(2014)11-1780-05

马槟榔果实的化学成分研究

廖金华[1],胡旭佳[1*],苑春茂[2],何红平[2],邸迎彤[2*]

[1]昆明理工大学生命科学与技术学院,昆明 650500;[2]中国科学院昆明植物研究所植物化学与西部植物资源国家重点实验室,昆明 650201

摘　要:采用硅胶柱色谱和 Sephadex LH-20 等分离方法,对马槟榔 *Capparis masaikai* 果实的化学成分进行分离纯化,依据理化性质及波谱数据分析进行结构鉴定,从中分离鉴定了 10 个单体化合物,分别为:杜仲树脂酚(**1**)、*erythro*-guaiacylglycerol-β-*O*-4′-sinapyl ether(**2**)、hedyotol C(**3**)、hedyotisol A(**4**)、hedyotisol B(**5**)、ozoroalide(**6**)、5α,6α-epoxy-3β-hydroxyergosta-22-ene-7-one(**7**)、松柏醛(**8**)、3-羟基-5-(对羟基苯基)戊酸(**9**)、β-hydroxypropiovanillone(**10**)。分离得到的化合物结构类型包括木脂素、大环内酯、甾醇及酚类。化合物 **1** ~ **10** 为首次从该植物中分离,其中 **1** ~ **7** 为首次从该属植物中分离得到。

关键词:马槟榔;山柑属;化学成分;木脂素

中图分类号:R284.2　　**文献标识码**:A

Chemical Constituents from the Fruits of *Capparis masaikai*

LIAO Jin-hua[1], HU Xu-jia[1*], YUAN Chun-mao[2], HE Hong-ping[2], DI Ying-tong[2*]

[1]*Faculty of Life Science and Technology, Kunming University of Science and Technology, Kunming 650500, China*; [2]*State Key Laboratory of Phytochemistry and Plant Resources in West China, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming 650201, China*

Abstract: Ten compounds were isolated and purified by silica gel column chromatography and Sephadex LH-20 from the fruits of *Capparis masaikai*. Their structures were identified as medioresinol (**1**), *erythro*-guaiacylglycerol-β-*O*-4′-sinapyl ether (**2**), hedyotol C (**3**), hedyotisol A (**4**), hedyotisol B (**5**), ozoroalide (**6**), 5α,6α-epoxy-3β-hydroxyergosta-22-ene-7-one (**7**), coniferyl aldehyde (**8**), 3-hydroxy-5-(*p*-hydroxyphenyl) pentanoic acid (**9**) and β-hydroxypropiovanillone (**10**) by physicochemical properties and spectral data. The structural types of isolated compounds include lignans, macrocyclic lactone, sterols and phenols. Compounds **1-10** were isolated from this plant for the first time, among of them, compounds **1-7** were firstly reported from the genus *Capparis*.

Key words: *Capparis masaikai*; *Capparis*; chemical constituents; lignans

Introduction

The genus *Capparis* comprises about 250 species in the world, which are distributed principally in tropical and subtropical regions[1]. About 30 species of the genus are distributed in China, including Guangdong, Guangxi, Guizhou and Yunnan provinces[2]. The fruits of *Capparis masaikai* are used as a traditional folk Chinese medicine and its seeds are commonly chewed for their sweet taste, due to the presence of sweet proteins[3]. In order to investigate the chemical constituents of this plant, ten compounds were isolated from 90% ethanol extract of *C. masaikai* and identified as medioresinol (**1**), *erythro*-guaiacylglycerol-β-*O*-4′-sinapyl ether (**2**), hedyotol C (**3**), hedyotisol A (**4**), hedyotisol B (**5**), ozoroalide (**6**), 5α, 6α-epoxy-3β-hydroxyergosta-22-ene-7-one (**7**), coniferyl aldehyde (**8**), 3-hydroxy-5-(*p*-hydroxyphenyl) pentanoic acid (**9**) and β-hydroxypropiovanillone (**10**). Compounds **1-10** were isolated from this plant material for the first time and compounds **1-7** were reported from genus

Received: February 26, 2014　Accepted: May 13, 2014

Foundation Item: National Natural Science Foundation of China (No. 31260399); Yunnan Innovation Grant (No. 2009CI072, No. 2011C1078); the Starting Research Project of Importing Talented Teachers in Kunming University of Science and Technology (KKSY201226109); Analysis and Testing Foundation of Kunming University of Science and Technology (No. 20130432)

* Corresponding author Tel: 86-013708876792; E-mail: huxjia@gmail.com

Capparis for the first time.

Materials and Methods

General

NMR spectra were recorded on a Bruker AM-400, DRX-500, and Avance III 600 spectrometers with TMS as an internal standard. A Bruker HCT/E squire was used to measure ESI-MS spectra. Column chromatography was performed on silica gel (100-200, 200-300 and 300-400 mesh, Qingdao Marine Chemical Inc.), Sephadex LH-20 (40-70 μm, Amersham Pharmacia Biotech AB, Uppsala, Sweden), MCI gel CHP 20P (75-150 μm, Mitsubishi Chemical Corporation, Tokyo), and Chromatorex RP-C_{18} gel (20-45 μm, Merck, Darmstadt, Germany). TLC spots were visualized under UV light and by dipping into 5% H_2SO_4 in EtOH followed by heating.

Plants materials

The fruits of *C. masaikai* were collected in Wenshan region of Yunnan Province, China, in September 2012, and identified by Prof. Hua Peng (Kunming Institute of Botany, Chinese Academy of Sciences). A voucher specimen (*km*ust 20120910) was deposited at Faculty of Life Science and Technology, Kunming University of Science and Technology.

Extraction and isolation

The air-dried and powdered fruits of *C. masaikai* (5.0 kg) were extracted by refluxing with 90% EtOH for three times. In a vacuum, the EtOH solvent was concentrated to give a crude residue (225.0 g), which was then suspended in water. The water layer was partitioned with EtOAc. The EtOAc portion (80.0 g) was submitted to column chromatography (CC) over silica gel (100-200 mesh) using PE (petroleum ether)/acetone (100∶1→6∶4) and chloroform/MeOH (9∶1→0∶1) to give seven fractions (Fr. A – Fr. G). Fr. C (9.87 g) was subjected to chromatography on a RP-C_{18} (MeOH/H_2O from 6∶4→10∶0) to give ten fractions (Fr. C1 – Fr. C10). Fr. C3 (0.35 g) was purified by Sephadex LH-20 (chloroform/MeOH) and was then chromatographed over repetitive silica gel eluted by gradient PE/acetone (50∶1→1∶1) to yield compounds **6** (8.0 mg), **7** (14.0 mg), and **8** (2.0 mg). Fr. C7 (0.85 g) was first subjected to an MCI gel column eluted with a gradient MeOH/H_2O (8∶2→10∶0) to obtain three subfractions (C7A-C7C). Compounds **9** (20.0 mg) and **10** (15.0 mg) were obtained from Fr. C7B (0.25 g) by CC over silica gel and Sephadex LH-20 (acetone). Fr. E (10.15 g) was repeatedly chromatographed over a RP-C_{18} (MeOH/H_2O from 3∶7→10∶0), Sephadex LH-20 (MeOH), and silica gel columns to yield compounds **1** (66.0 mg), **2** (2.8 mg), **3** (4.0 mg), **4** (17.0 mg) and **5** (10.0 mg).

Structural identification

Compound 1 Yellow oil, $C_{21}H_{24}O_7$, ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 6.89 (1H, d, *J* = 1.8 Hz, H-2), 6.87 (1H, d, *J* = 7.8 Hz, H-5), 6.82 (1H, dd, *J* = 7.8, 1.8 Hz, H-6), 6.58 (2H, s, H-2′, 6′), 5.79 (1H, brs, OH-4), 5.65 (1H, brs, OH-4′), 4.74 (1H, d, *J* = 4.0 Hz, H-7′), 4.72 (1H, d, *J* = 4.0 Hz, H-7) 4.23-4.29 (2H, m, H-9a, 9′a), 3.90 (9H, s, OCH_3-3, 3′, 5′), 3.89 (2H, m, H-9b, 9′b), 3.09 (2H, m, H-8, 8′); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 147.1 (C-3, 5), 146.7 (C-3′), 145.2 (C-4′), 134.2 (C-4), 132.8 (C-1′), 132.0 (C-1), 118.9 (C-6′), 114.3 (C-5′), 108.6 (C-2′), 102.6 (C-2, 6), 86.1 (C-7), 85.8 (C-7′), 71.8 (C-9), 71.6 (C-9′), 56.3 (OCH_3-3′, 5′), 55.9 (OCH_3-3), 54.3 (C-8), 54.0 (C-8′). It was identified as medioresinol by comparison of the physical and spectral data with the reported data[4,5].

Compound 2 White powder, $C_{21}H_{26}O_8$, ESI-MS *m/z*: 429 $[M+Na]^+$, ^{1}H NMR (CD_3OD, 600 MHz) δ: 6.98 (1H, d, *J* = 1.8 Hz, H-2), 6.78 (1H, dd, *J* = 7.8, 1.8 Hz, H-6), 6.75 (1H, d, *J* = 7.8 Hz, H-5), 6.74 (2H, s, H-2′, 6′), 6.55 (1H, d, *J* = 16.2 Hz, H-7′), 6.32 (1H, dd, *J* = 16.2, 6.0 Hz, H-8′), 4.92 (1H, d, *J* = 4.8 Hz, H-7), 4.22 (2H, dd, *J* = 5.4, 1.2 Hz, H-9′a, 9′b), 4.21 (1H, m, H-8), 3.88 (1H, dd, *J* = 12.0, 5.4 Hz, H-9a), 3.82 (9H, s, OCH_3-3, 3′, 5′), 3.55 (1H, dd, *J* = 12.0, 3.0 Hz, H-9b); ^{13}C NMR (CD_3OD, 150 MHz) δ: 154.7 (C-3′, 5′), 148.8 (C-4), 147.0 (C-3), 136.5 (C-4′), 134.9 (C-1′), 133.9 (C-1), 131.5 (C-7′), 130.0 (C-8′), 120.7

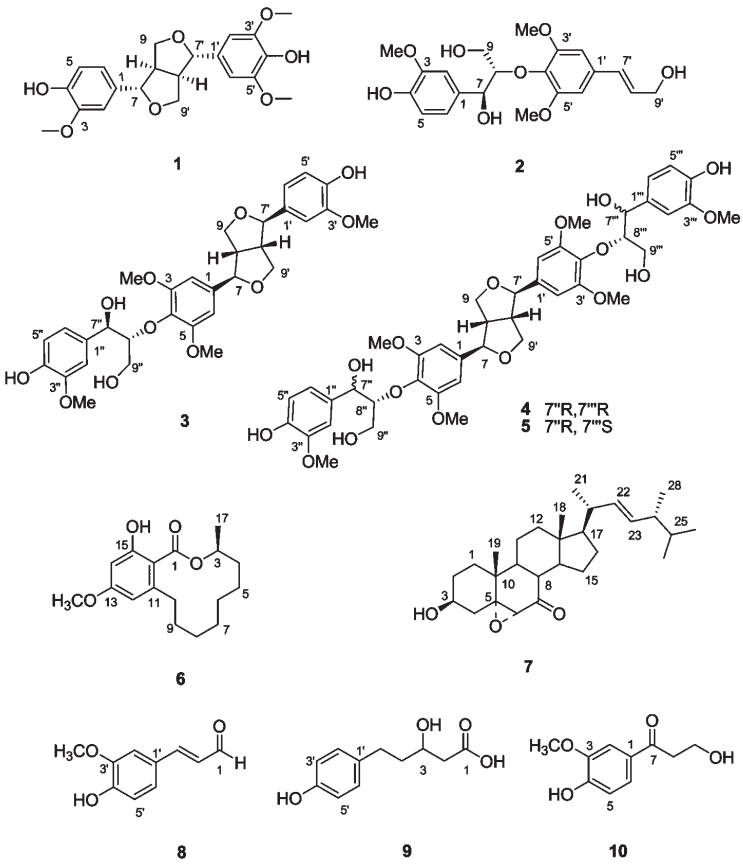

Fig. 1 Chemical structures of compounds 1-10

(C-6), 115.8 (C-5), 111.4 (C-2), 105.0 (C-2′, 6′), 87.7 (C-8), 74.1 (C-7), 63.8 (C-9′), 61.6 (C-9), 56.7 (OCH_3-3,3′), 56.4 (OCH_3-5′). It was identified as *erythro*-guaiacylglycerol-*β*-*O*-4′-sinapyl ether by comparison of the physical and spectral data with the reported data[6].

Compound 3 White powder, $C_{31}H_{36}O_{11}$, ESI-MS *m/z*: 607 $[M+Na]^+$, ^{1}H NMR (CD_3OD, 400 MHz) *δ*: 6.95 (2H, brs, H-2′,2″), 6.82 (1H, d, *J* = 8.0 Hz, H-5′), 6.81 (1H, d, *J* = 8.0 Hz, H-5″), 6.77 (1H, d, *J* = 8.0 Hz, H-6′), 6.73 (1H, d, *J* = 8.0 Hz, H-6″), 6.67 (2H, brs, H-2,6), 4.75 (1H, d, *J* = 2.3 Hz, H-7″), 4.70 (2H, d, *J* = 3.8 Hz, H-7,7′), 4.27 (1H, m, H-9a), 4.25 (1H, m, H-9′a), 4.11 (1H, m, H-8″), 3.91 (2H, m, H-9b, 9′b), 3.82 (6H, s, OCH_3-3,5), 3.81 (6H, s, OCH_3-3′,3″), 3.87 (2H, m, H-9″a), 3.40 (2H, m, H-9″b), 3.13 (2H, m, H-8,8′); ^{13}C NMR (CD_3OD, 100 MHz) *δ*: 154.9 (C-3,5), 149.5 (C-3″), 149.0 (C-3′), 147.7 (C-4′), 147.3 (C-4″), 139.3 (C-1), 136.5 (C-4), 134.2 (C-1′), 134.1 (C-1″), 121.1 (C-6′), 120.5 (C-6″), 116.5 (C-5′), 116.0 (C-5″), 111.7 (C-2′), 111.4 (C-2″), 104.6 (C-2,6), 87.9 (C-8″), 87.7 (C-7), 87.6 (C-7′), 74.4 (C-7″), 73.3 (C-9), 73.1 (C-9′), 62.1 (C-9″), 57.1 (OCH_3-3,5), 56.8 (OCH_3-3′), 56.7 (OCH_3-3″), 56.2 (C-8′), 55.9 (C-8). It was identified as hedyotol C by comparison of the physical and spectral data with the reported data[7-8].

Compound 4 White powder, $C_{42}H_{50}O_{16}$, ESI-MS *m/z*: 833 $[M+Na]^+$, ^{1}H NMR ($CDCl_3$, 400 MHz) *δ*: 6.95 (2H, brs, H-2″,2‴), 6.87 (2H, dd, *J* = 8.1, 1.6 Hz, H-6″,6‴), 6.72 (2H, d, *J* = 8.1 Hz, H-5″, 5‴), 6.63 (4H, brs, H-2,6,2′,6′), 4.99 (2H, m, H-7″,7‴), 4.78 (2H, d, *J* = 3.0 Hz, H-7,7′), 4.27 (2H, m, H-9a,9′a), 4.11 (2H, m, H-8″,8‴), 3.91 (2H, m, H-9b,9′b), 3.88 (6H, s, OCH_3-3′,5′), 3.87 (6H, s, OCH_3-3,5), 3.81 (6H, s, OCH_3-3″,3‴), 3.81 (2H, m, H-9″a,9‴a), 3.40 (2H, m, H-9″b,9‴b), 3.13 (2H, m, H-8,8′); ^{13}C NMR ($CDCl_3$, 100 MHz) *δ*: 153.4 (C-3,5,3′,5′), 146.6 (C-3″,3‴),

144.8 (C-4″,4‴), 137.5 (C-1,1′), 134.2 (C-4,4′), 131.2 (C-1″,1‴), 118.7 (C-6″,6‴), 114.2 (C-5″,5‴), 108.3 (C-2″,2‴), 102.8 (C-2,6,2′,6′), 87.0 (C-8″,8‴), 85.8 (C-7,7′), 72.4 (C-7″,7‴), 72.0 (C-9,9′), 60.5 (C-9″,9‴), 56.1 (OCH_3-3,5,3′,5′), 54.4 (OCH_3-3″,3‴), 54.4 (C-8,8′). It was identified as hedyotisol A[b]y comparison of the physical and spectral data with the reported data[8-10].

Compound 5 White powder, $C_{42}H_{50}O_{16}$, ESI-MS *m/z*: 833 $[M+Na]^+$, ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 6.95 (2H, brs, H-2″,2‴), 6.87 (2H, d, J = 8.1 Hz, H-6″,6‴), 6.72 (2H, d, J = 8.1 Hz, H-5″,5‴), 6.62 (4H, brs, H-2,6,2′,6′), 5.00 (2H, m, H-7″,7‴), 4.77 (2H, d, J = 3.0 Hz, H-7,7′), 4.33 (2H, m, H-9a,9′a), 4.11 (2H, m, H-8″,8‴), 3.96 (1H, m, H-9b), 3.94 (1H, m, H-9b′), 3.91 (6H, s, OCH_3-3′,5′), 3.88 (6H, s, OCH_3-3,5), 3.82 (3H, s, OCH_3-3″), 3.81 (3H, s, OCH_3-3‴), 3.81 (1H, m, H-9″a), 3.54 (1H, m, H-9‴a), 3.47 (1H, m, H-9″b), 3.33 (1H, m, H-9‴b), 3.10 (2H, m, H-8,8′); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 153.4 (C-3,5), 153.1 (C-3′,5′), 146.6 (C-3‴), 146.5 (C-3″), 145.4 (C-4‴), 144.8 (C-4″), 137.6 (C-1′), 137.5 (C-1), 134.6 (C-4), 134.4 (C-4′), 131.3 (C-1″,1‴), 120.3 (C-6‴), 118.7 (C-6″), 114.2 (C-5″,5‴), 109.8 (C-2‴), 108.3 (C-2″), 102.7 (C-2,6), 106.6 (C-2′,6′), 89.0 (C-8‴), 87.0 (C-8″), 85.8 (C-7′), 85.7 (C-7), 74.0 (C-7‴), 72.3 (C-7″), 72.0 (C-9,9′), 60.5 (C-9″,9‴), 56.1 (OCH_3-3,5,3′,5′), 54.4 (OCH_3-3″,3‴), 54.4 (C-8,8′). It was identified as hedyotisol B by comparison of the physical and spectral data with the reported data[8,9].

Compound 6 White needles, $C_{17}H_{24}O_4$, ESI-MS *m/z*: 315 $[M+Na]^+$, ^{1}H NMR (CD_3OD, 400 MHz) δ: 6.28 (1H, d, J = 2.0 Hz, H-12), 6.23 (1H, d, J = 2.0 Hz, H-14), 5.16 (1H, m, H-3), 3.75 (3H, s, OCH_3), 2.65 (1H, ddd, J = 13.4, 7.8, 7.8 Hz, H-10a), 2.49 (1H, ddd, J = 13.4, 7.8, 7.8 Hz, H-10b); ^{13}C NMR (CD_3OD, 100 MHz) δ: 170.1 (C-1), 160.7 (C-13), 159.4 (C-15), 143.8 (C-11), 117.6 (C-16), 109.2 (C-12), 97.8 (C-14), 73.4 (C-3), 56.2 (OCH_3), 33.6 (C-4), 31.3 (C-10), 31.1 (C-9), 27.7 (C-8), 26.3 (C-7), 25.6 (C-6), 22.3 (C-5), 19.9 (C-17). It was identified as ozoroalide by comparison of the physical and spectral data with the reported data[11].

Compound 7 White needles, $C_{28}H_{44}O_3$, ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 5.19 (1H, m, H-23), 5.13 (1H, m, H-22), 3.90 (1H, m, H-3), 3.05 (1H, s, H-6), 1.02 (3H, s, H-19), 0.98 (3H, d, J = 6.6 Hz, H-21), 0.89 (3H, d, J = 6.8 Hz, H-28), 0.82 (3H, d, J = 6.6 Hz, H-27), 0.80 (3H, d, J = 6.6 Hz, H-26), 0.67 (3H, s, H-18); ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 207.7 (C-7), 135.4 (C-22), 132.0 (C-23), 68.7 (C-3), 68.1 (C-5), 63.0 (C-6), 55.1 (C-17), 52.0 (C-14), 46.7 (C-8), 43.9 (C-13), 43.3 (C-9), 42.8 (C-24), 40.1 (C-20), 39.5 (C-12), 38.7 (C-4), 35.0 (C-10), 33.0 (C-25), 32.8 (C-1), 30.8 (C-2), 28.4 (C-16), 24.8 (C-11), 21.1 (C-15), 21.0 (C-21), 19.9 (C-27), 19.6 (C-26), 17.6 (C-28), 15.5 (C-19), 12.3 (C-18). It was identified as 5α,6α-epoxy-3β-hydroxyergosta-22-ene-7-one by comparison of the physical and spectral data with the reported data[12].

Compound 8 Yellow needles, $C_{10}H_{10}O_3$, ^{1}H NMR (CD_3OD, 600 MHz) δ: 9.57 (1H, d, J = 7.8 Hz, H-1), 7.59 (1H, d, J = 15.6 Hz, H-3), 7.26 (1H, d, J = 1.8 Hz, H-2′), 7.17 (1H, dd, J = 8.4, 1.8 Hz, H-6′), 6.85 (1H, d, J = 8.4 Hz, H-5′), 6.66 (1H, dd, J = 15.6, 7.8 Hz, H-2), 3.91 (3H, s, OCH_3); ^{13}C NMR (CD_3OD, 150 MHz) δ: 196.4 (CHO-1), 156.5 (C-3), 151.9 (C-4′), 149.6 (C-3′), 127.0 (C-1′), 126.8 (C-2), 125.3 (C-6′), 116.5 (C-5′), 111.9 (C-2′), 56.5 (OCH_3). It was identified as coniferyl aldehyde by comparison of the physical and spectral data with the reported data[13].

Compound 9 Colorless gum, $C_{11}H_{14}O_4$, ^{1}H NMR (CD_3OD, 500 MHz) δ: 6.98 (2H, d, J = 8.4 Hz, H-2′,6′), 6.66 (2H, d, J = 8.4 Hz, H-3′,5′), 4.97 (1H, brs, OH-4′), 3.96 (1H, m, H-3), 2.63 (2H, m, H-5), 2.53 (2H, m, H-2), 1.70 (2H, m, H-4); ^{13}C NMR (CD_3OD, 125 MHz) δ: 175.7 (C-1), 156.4 (C-4′), 134.2 (C-1′), 130.4 (C-2′,6′), 116.2 (C-3′,5′), 68.8 (C-3), 43.3 (C-4), 40.3 (C-2), 32.0 (C-5). It was identified as 3-hydroxy-5-(p-hydroxy-

phenyl) pentanoic acid by comparison of the physical and spectral data with the reported data[14].

Compound 10 Colorless gum, $C_{10}H_{12}O_4$, ^{1}H NMR (CD_3OD, 500 MHz) δ: 7.56 (1H, dd, J = 8.0, 1.4 Hz, H-6), 7.53 (1H, d, J = 1.4 Hz, H-2), 6.84 (1H, d, J = 8.0, H-5), 3.92 (2H, m, H-9), 3.89 (3H, s, OCH_3-3), 3.14 (2H, m, H-9); ^{13}C NMR (CD_3OD, 125 MHz) δ: 199.6 (C-7), 153.3 (C-4), 149.0 (C-3), 130.6 (C-1), 124.7 (C-6), 115.8 (C-2), 111.8 (C-5), 58.9 (C-9), 56.3 (OCH_3-3), 41.6 (C-8). It was identified as β-hydroxypropiovanillone by comparison of the physical and spectral data with the reported data[15,16].

References

1 Tlili N, Elfalleh W, Saadaoui E, *et al*. The caper (*Capparis* L.): ethnopharmacology, phytochemical and pharmacological properties. *Fitoterapia*, 2011, 82: 93-101.

2 Zhang ML, Gordon CT. Flora of China. Beijing: Science Press, 2008. 7, 433-450.

3 Hu Z, Lewis JA, Hanley AB, *et al*. 2-Hydroxyethylglucosinolate from *Capparis masaikai* of Chinese origin. *Phytochemistry*, 1989, 28: 1252-1254.

4 Zan K, Chen XQ, Fu Q, *et al*. Chemical ingredients isolated from the aerial parts of *Artemisia anomala*. *J Chin Pharm Sci*, 2010, 19: 95-99.

5 Shu JC, Liu JQ, Peng CY, *et al*. Study on the lignan constituents in seeds of *Nandina domestica* Thunb. *Chin JMAP*, 2013, 30: 115-118.

6 Liao SG, Wu Y, Yue JM. Lignans from *Wikstroemia hainanensis*. *Helv Chim Acta*, 2006, 89: 73-80.

7 Jeong EJ, Cho JH, Sung SH, *et al*. Inhibition of nitric oxide production in lipopolysaccharide-stimulated RAW264.7 macrophage cells by lignans isolated from *Euonymus alatus* leaves and twigs. *Bioorg Med Chem Lett*, 2011, 21: 2283-2286.

8 Xiong L, Zhu CG, Li YR, *et al*. Lignans and neolignans from *Sinocalamus affinis* and their absolute configurations. *J Nat Prod*, 2011, 74: 1188-1200.

9 Han HY, Liu HW, Wang NL, *et al*. Sesquilignans and dilignans from *Campylotropis hirtella* (France.) Schindl. *Nat Prod Res*, 2008, 22: 984-989.

10 Bao SY, Ding Y, Deng ZW, *et al*. Phyncosides A-F, phenolic constituents from the Chinese mangrove plant *Bruguiera sexangula* var. *rhynchopetala*. *Chem Pharm Bull*, 2007, 55: 1175-1180.

11 Abreu PJM, Liu YH. Ozoroalide, a new macrolide from *Ozoroa insignis*. *Fitoterapia*, 2007, 78: 388-389.

12 Lee JS, Ma CM, Park DK, *et al*. Transformation of ergosterol peroxide to cytotoxic substances by rat intestinal bacteria. *Biol Pharm Bull*, 2008, 31: 949-954.

13 Luo JR, Jiang HE, Zhao YX, *et al*. Components of the heartwood of *Populus euphratica* from an ancient tomb. *Chem Nat Compd*, 2008, 44: 6-9.

14 Ayer WA, Singer PP. Phenolic metabolites of the bird's nest fungus Nidyla Niveo-Tomentosa. *Phytochemistry*, 1980, 19: 2717-2721.

15 Jones L, Bartholomew B, Latif Z, *et al*. Constituents of *Cassia laevigata*. *Fitoterapia*, 2000, 71: 580-583.

16 Ren Gang, Luo ZP, Huang HL, *et al*. Study on the chemical constituents of the roots of *Dendropanax chevalieri*. *J Chin Med Mater*, 2012, 35: 62-64.

(上接第 1748 页)

4 Du JY (杜江燕), Wang BX (王炳详), Xu F (徐飞), *et al*. Voltammetric and circular dichroism studies on interaction between 1,4-dihydropyridine derivatives and DNA. *Chem J Chin Univ* (高等学校化学学报), 2005, 26: 663-666.

5 Wu XY (伍小云), Hu AX (胡艾希), Xie YL (谢艳丽). Synthesis and characterization of 4-aryl-1,4-dihydropyridine-3,5-dicarboxylates. *Chin J Org Chem* (有机化学), 2006, 26: 93-98.

6 Cai XH (蔡小华), Zhang GL (张国林). One-pot synthesis of dihydropyridines under solvent-free condition. *Chin J Org Chem* (有机化学), 2006, 26: 93-98.

7 Liu DM (柳冬梅), Du LT (杜丽婷), Sun J (孙晶), *et al*. Efficient synthesis of alkylenedioxy-bridged bisdihydropyridines. *Chin J Org Chem* (有机化学), 2008, 28: 930-933.

8 Tong BH (童碧海), Li FY (李芳耀), Pan YM (潘英明). Study progress of dehydroabietic acid modifications. *Technol Dev Chem Ind* (化工技术与开发), 2004, 33(6): 20-27.

9 Mo QJ (莫启进), Duan WG (段文贵), Ma XL (马献力), *et al*. Syntheses and fungicidal activities of 2-sustituted acylamino-5-dehydroabietyl-1,3,4-thiadiazole derivatives. *Chemistry* (化学通报), 2012, 75: 160-165.

10 Chen Y (陈泳), Lin ZX (林中祥). Bioactivity of resin acids and their derivatives. *Nat Prod Res Dev* (天然产物研究与开发), 2009, 21: 712-718.