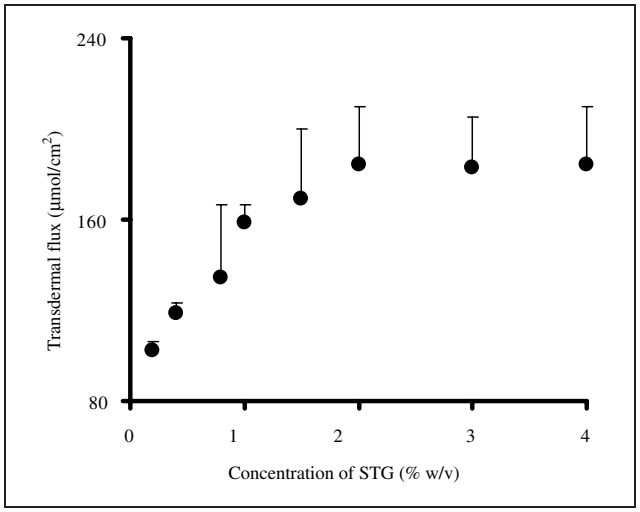

Fig. 2: Concentration dependent transdermal penetration enhancement activity of OTG

ketotifen were carried out across tape stripped (no stratum corneum) skin. This is apparently the maximum flux that can be achieved across the skin if the penetration enhancer was to absolutely compromise the barrier property of the skin. The flux at 2% concentration of OTG and flux across the tape stripped (no stratum corneum) skin were not different significantly ($\sim$184 μmol/cm^2, $P = 0.0.64$). This indicates that the surfactant compromises the barrier property of the skin almost completely. This also indicates that the surfactant could disrupt the lipid layers as well as permeabilizing the coenocytes layers. Our interpretations are somewhat in agreement with Inoue et al. who studied the mechanism of transdermal transport of ketotifen at different pH conditions (2000). They conclude that both lipid as well as proteinacoues phases of stratum corneum contribute to the poor permeability of ketotifen. This study demonstrates that OTG could be a choice as penetration enhancer for hydrophilic molecules like ketotifen. The nonionic nature as well as its ability to interact with both lipid and protein domains of the stratum corneum is most likely the reason for its potent transdermal penetration enhancer properties. Incorporation of OTG in a transdermal therapeutic system of $\sim$10 cm^2 area is anticipated to deliver the therapeutically necessary quantities of ketotifen.

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New prenylated flavones from *Pongamia pinnata*

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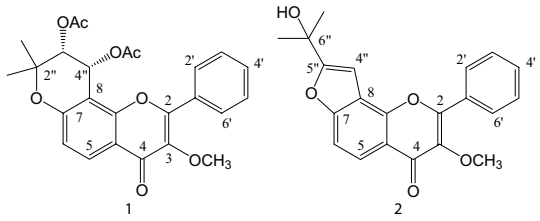
From the stem bark of *Pongamia pinnata*, two new prenylated flavones (**1**, **2**) were isolated, along with seven known compounds (**3**–**9**). Compounds **3** and **4** are isolated for the first time from this plant. The structures of the new compounds were elucidated on the basis of spectroscopic data.

Pongamia pinnata (Linn) Pierre (Leguminosae, Papilionaceac; synonym, *Pongamia glabra* Vent) is a medium sized glabrous tree, growing in the littoral regions of South Eastern Asia and Australia. All parts of the plant have been used as crude drug for the treatment of tumors, piles, skin diseases, wounds, ulcers (Tanaka et al. 1992). Extracts of the plant possess significant anti-diarrhoeal, antifungal, anti-plasmodial, anti-ulcerogenic, anti-inflammatory, and analgesic activities (Dahanukar et al. 2000; Shoba et al. 2001; Simonsen et al. 2001; Srinivasan et al. 2001; Misra et al. 1977). Previous phytochemical investigation of this plant indicated the presence of abounding prenylated flavonoids such as furanoflavones, franoflavonols, chromenoflavones, furanochalcones, and pyranochalcones (Carache-Blanco et al. 2003; Yadav et al. 2004). In this paper, we reported on isolation and identification of some compounds in the stem bark of this plant.

The EtOH extract of *Pongmia pinnata* stem bark was submitted to successive chromatography, affording two new prenylated flavones, 3-methoxy-(3″,4″-dihydro-3″,4″-diacetoxy)-2″,2″-dimethylpyrano-(5″,6″:8,7)-flavone (**1**) and 3-methoxy-5″-(2-hydroxypropan-2-yl)-furano-(2″,3″:7,8)-flavone (**2**). The C-5 side attachment of compound **2** is a new prenylation pattern encountered in flavones. In addition, seven known compounds, caryophyllene oxide (**3**) (de Oliveira Chaves et al. 2002), 8-hydroxy-6-methoxy-3-pentyl-1 *H*-isochromen-1-one (**4**) (Kijjoa et al. 1991), stigmasterol (**5**) (Kjima et al. 1990), pongapin (**6**) (Aneja et al. 1958), demethoxykanugin (**7**), kanugin (**8**) (Sibrahmanyam et al. 1977), and 3,3′,4′,7-tetramethoxyflavone (**9**) (Ferreira et al. 1974), were obtained and identified by means of spectroscopic analysis and comparison with published data. Compounds **3** and **4** are isolated for the first time from this plant.

Compound **1,** a yellow plate, showed a molecular ion $[M]^+$ at m/z 452.14719 in the HREIMS, corresponding to the molecular formula $C_{25}H_{24}O_8$ (calcd. 452.14712). Together with HMQC spectra, the 1D NMR (^{13}C, ^1H and DEPT, Table) spectra of compound **1** displayed reso-

nances for one conjugated ketone (δ_C 174.3, C-4), a pair of *ortho*-coupling aromatic protons (δ_H 8.18, 1 H, d, J = 9.0 Hz, H-5; δ_H 6.93, 1 H, d, J = 9.0 Hz, H-6), a monosubstituted aromatic ring (δ_H 7.98, 2 H, m, H-2′, 5′; δ_H 7.49, 3 H, m, H-3′, 4′, 5′), two oxygenated methines (δ_H 5.32, 1 H, d, J = 4.8 Hz, H-3″; δ c 70.9, C-3″; δ_H 6.66, 1 H, d, J = 4.8 Hz, H-4″; δ_c 61.2, C-4″), two acetoxy groups (δ_H 2.10, 3 H, s, δ_C 169.8, δ_C 20.6, OAc-3″; δ_H 1.88, 3 H, s, δ_C 170.3, δ C 20.5, OAc-4″), two methyls (δ_H 1.46, 3 H, s, δ_C 25.7, Me_1-2″; δ_H 1.48, 3 H, s, δ_C 21.8, Me_2-2″), a methoxy group (δ_H 3.89, 3H, s), and an oxygenated quaternary carbon (δ_C 77.3, C-2″). With great similarity to those of 5-methoxy-(3″,4″-dihydro-3″,4″-diacetoxy)-2″,2″-dimethylpyrano-(5″,6″:8,7)-flavone (Carache-Blanco et al. 2003, 2004), these 1D NMR data suggested that compound **1** was a flavone with a acetylated dihydropyrano unit attach to ring A. In HMBC spectra, the correlation between H-5(δ_H 8.18, 1 H, d, J = 9.0 Hz) and C-4 (δ_C 174.3) indicated that the ring A was unsubstituted at the C-5 and C-6 position. The observed HMBC correlations from H-3″ (δ_H 5.32, 1 H, d, J = 4.8 Hz) to C-8 (δ_C 106.4), from H-4″ (δ_H 6.66, 1 H, d, J = 4.8 Hz) to C-8 (δ_C 106.4), C-7 (δ_C 156.0), and C-9 (δ_C 155.0) suggested that the dihydropyran ring attached to A ring at C-7 (oxygenated) and C-8 postion. The locations of the two acetoxy groups at C-3″ and C-4″ were established by HMBC correlations from protons of Me_1-2″, Me_2-2″ to C-3″, from H-3″ to the carbonyl of OAc-3″, and from H-4″ to the carbonyl of OAc-4″. The location of the methoxyl group (δ_H 3.89) at C-3 was revealed by the HMBC correlation from the protons of the methoxy group to C-3 (δ_C 141.7). The absolute configuration of **1** was not determined because of the sample. Thus, compound **1** was characterized as 3-methoxy-(3″,4″-dihydro-3″,4″-diacetoxy)-2″,2″-dimethylpyrano-(5″,6″:8,7)-flavone.



Compound **2**, a yellow plate, exhibited a molecular ion $[M]^+$ peak at m/z 350.11546 in the HREIMS, indicating a molecular formula of $C_{21}H_{18}O_5$ (calcd. 350.11542). NMR spectra data (see Table) suggested that compound **2** was also a 3-methoxy flavone unsubstituted at C-5, C-6 position and ring B, as described for compound **1**. Apart from the results discussed for compound **1**, the 1D and 2D NMR spectra showed the presence of an oxygenated quaternary carbon (δ_C 68.1, C-6″), a hydroxyl (δ_H 5.59, 1 H, s, OH-6″), a double bond with a olefinic proton (δ_H 7.20, 1 H, d, J = 0.8 Hz, H-4″; δ_C 98.2, C-4″; δ_C 166.7, C-5″), and two identical tertiary methyls (δ_H 1.58, 6 H, s, δ_C 29.3, $Me_{1,2}$-6″). The observed HMBC correlations from the proton of hydroxyl (OH-6″) to C-5″, C-6″, $Me_{1,2}$-6″, from the protons of both methyls ($Me_{1,2}$-6″) to C-5″, 6″,

Table: ^{1}H, ^{13}C, and selected HMBC NMR data for compounds 1[a] and 2[b]

position	**1**			**2**		
	δ_H (J = Hz)	δ_C	HMBC	δ_H (J = Hz)	δ_C	HMBC
2		155.0			154.6	
3		141.7			141.5	
4		174.3			174.3	
5	8.18 (d, 9.0)	128.0	4, 7, 9	7.96 (d, 8.7)	120.8	4, 6, 7, 9
6	6.93 (d, 9.0)	116.0	7, 8, 10	7.70 (dd, 8.7, 0.8)	110.4	7, 8, 10
7		156.0			157.4	
8		106.4			118.0	
9		155.0			149.5	
10		118.5			119.5	
1′		130.7			130.9	
2′	7.98 (m)	128.4		8.16 (m)	128.6	
3′	7.49 (m)	128.5		7.61 (m)	129.2	
4′	7.49 (m)	130.7		7.61 (m)	131.2	
5′	7.49 (m)	128.5		7.61 (m)	129.2	
6′	7.98 (m)	128.4		8.16 (m)	128.6	
2″		77.3				
3″	5.32 (d, 4.8)	70.9	$Me_{1,2}$-2″,2″, 4″,8,OAc-3″			
4″	6.66 (d, 4.8)	61.2	2″, 7, 8, 9, OAc-4″	7.20 (d, 0.8)	98.2	5″, 7, 8, 9
5″					166.7	
6″					68.1	
Me_1-2″	1.46 (s)	25.7	2″, 3″			
Me_2-2″	1.48 (s)	21.8	2″, 3″			
$Me_{1,2}$-6″				1.58 (s)	29.3	5″, 6″
OCH_3-3	3.89 (s)	60.2	3	3.81 (s)	60.2	3
OAc-3″	2.10 (s)	169.8				
		20.6				
OAc-4″	1.88 (s)	170.3				
		20.5				
OH-6″				5.59 (s)		5″, 6″, $Me_{1,2}$-6″

[a] spectra recorded in $CDCl_3$, [b] recorded in DMSO-D_6 (500 MHz for ^{1}H, 125 MHz for ^{13}C); TMS was used as internal standard

from the olefinic proton (H-4″) to C-5″ suggested the presence of a 3-hydroxy-3-methylbut-1-enyl structure in compound **2**. Moreover, in the HMBC spectra of compound **2**, the olefinic proton correlated to C-7, C-8, C-9. The chemical shift of C-7 and C-9 in the ^{13}C NMR spectra showed that C-7 and C-9 were oxygenated aromatic carbons. This evidence disclosed that the prenyl unit located at C-8 of ring A, from C-5″ connected to C-7 through an oxygen ether group, formed a conjugated furano ring. This was confirmed by analysis of HREIMS data and unsaturation degrees of compound **2**. On the basis of the above spectroscopic studies, compound **2** was identified as 3-methoxy-5″-(2-hydroxypropan-2-yl)-furano-(2″,3″:7,8)-flavone.

Experimental

1. General procedures

Optical rotation were measured with a Jasco 1020 polarimeter. NMR spectra were obtained on a Bruker AVANCE 500 spectrometer (500 MHz for ^1H NMR, 125 MHz for ^{13}C NMR). EIMS and HREIMS spectra were recorded on a Finnigan MAT TSQ 700 mass spectrometer. UV spectra were obtained in a Beckman DU-640 UV spectrophotometer. A Waters Novapack HR C18 column (19 × 300 mm) was used for semipreparative HPLC, along with Waters 600E Multisolvent Delivery System and a Waters 996 Photodiode Array Detector.

2. Plant material

The material investigated were stem bark of *Pongamia pinnata* collected in October 2002 from Hainan Province, southern China. The material was identified by Prof. Si Zhang, Guangdong Key Laboratory of Marine Materia Medica, South China Sea Institute of Oceanology, Chinese Academy of Sciences. A voucher specimen is deposited at the herbarium of the South China Sea Institute of Oceanology (No. GKLMMM005).

3. Extraction and isolation

The dry powdered stem bark (6 kg) of *Pongamia pinnata* was extracted with 95% EtOH at 80 °C three times. After evaporation of the solvents under reduced pressure, the residue (300 g) was then extracted successively into four extracts: petroleum (80 g), ethyl acetate (60 g), *n*-butanol (60 g), and aqueous (80 g). The petroleum extract was fractionated into 63 fractions by open CC over silica gel with gradient mixtures of petroleum-$CHCl_3$ (6 : 1) to $CHCl_3$-acetone (0 : 1) for elution. These fractions were pooled into 17 fractions (P1-P17) according to their similarity on TLC. The silica gel CC of fraction P8 using petroleum-EtOAc (3 : 1) afforded 7 fractions (P8a-P8g). Fraction P8c were purified by CC of Pharmacia-Sephadex LH-20 with MeOH−H_2O (95 : 5) and separated by reverse phase semi-preparative HPLC (ODS column, using MeOH−H_2O (71 : 29) 8 ml/min. flow rate, UV: 254 nm) to afford compound **1** (t_R = 27 min, 3.5 mg). Fraction P8e was purified by Pharmacia-Sephadex LH-20 using MeOH−H_2O (90 : 10) and separated by reverse phase semi-preparative HPLC using MeOH-H_2O (66 : 34) to give compounds **2** (8.3 mg, t_R = 36 min). The CC of fraction P4 using petroleum-EtOAc (35 : 1) afforded **3** and **4**. Fraction P12 yielded **5** after recrystallization. The ethyl acetate extract was subjected to the CC of silica gel, eluted with a gradient of $CHCl_3$−MeOH system (99 : 1 to 0 : 100) to afford 6 fractions (E1–E6). The fraction E3 (3.3 g) was further separated on the CC of silica gel with petroleum-ethyl acetate system (5 : 1 to 1 : 1) to afford 20 fractions (E3a–E3t). Then the fractions E3d, E3f, E3k, and E3s recrystallized to give compounds **6** (34.3 mg), **7** (22.5 mg), **8** (15.3 mg), and **9** (35.8 mg), respectively.

3.1. 3-methoxy-(3″,4″-dihydro-3″,4″-diacetoxy)-2″,2″-dimethylpyrano-(5″,6″:8,7)-flavone (**1**)

$[\alpha]_D^{25}$ −14.5° (c 0.1, $CHCl_3$); UV(MeOH) λ_{max} nm: 252, 314, HREIMS m/z: 452.14719 (calcd. for $C_{25}H_{24}O_8$ 452.14712), EIMS m/z (rel. int., %): 452[M]$^+$ (87), 451 (100), 349 (17), 335 (14), 319 (9), 295 (19), 279 (5), 165 (10), 163 (8); ^1H and ^{13}C NMR spectra data: see Table.

3.2. 3-methoxy-5″-(2-hydroxypropan-2-yl)-furano-(2″,3″:7,8)-flavone (**2**)

UV(MeOH) λ_{max} nm: 263, 306; HREIMS m/z: 350.11546 (calcd. for $C_{21}H_{18}O_5$ 350.11542); EIMS m/z (rel. int., %): 350[M]$^+$ (62.6), 349 (100), 335 (10.6), 331.1 (17.5), 305 (7.8), 263 (6.1), 221 (7.3), 203 (30.7), 167 (17.8), 105 (18.0); ^1H and ^{13}C NMR spectra data: see Table.

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