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INTRAMOLECULAR TRANSESTERIFIED TAXANES FROM *TAXUS YUNNANENSIS*

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Key Word Index—*Taxus yunnanensis*; Taxaceae; yew; root; diterpenoid; taxanes; transesterification.

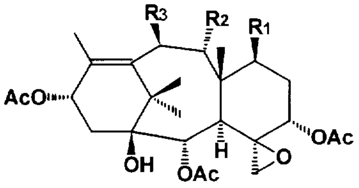
Abstract—Investigation of the roots of *Taxus yunnanensis* led to the isolation of two groups of interconvertible taxanes, made up by two and three compounds, respectively. Three of the compounds are new and were identified as 1 β-hydroxy-10-deacetyl-baccatin I, 10-deacetyl-baccatin VI and 9-deacetyl-baccatin VI. Copyright © 1997 Elsevier Science Ltd

INTRODUCTION

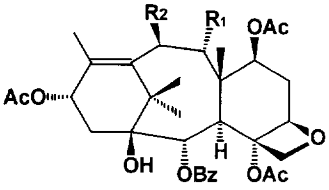
Taxus yunnanensis Cheng et Fu is mainly distributed in the Yunnan Province of China. It has been reported to be rich in taxoids [1–3]. Our research on this plant showed that its roots also contained taxane diterpenoids including taxol [4]. Further investigation of the roots of *T. yunnanensis* led to the isolation of two groups of interconverting taxoids. Group A is made up of compounds **1**–**3**, and group B of compounds **4** and **5**. Compounds within each group are isomerized by intramolecular acyl migration. In group A, isomerization is fast, whereas the process is much slower in group B. In order to identify the structures of these five taxanes, 1D and 2D NMR spectroscopy were used. 2D NMR techniques (especially COLOC) have been successfully employed to assign ^{1}H and ^{13}C NMR chemical shifts of each compound in both group A and group B.

RESULTS AND DISCUSSION

The two groups of compounds were isolated from an ethereal extract of dry *T. yunnanensis* root (40 kg). Attempts to isolate the three constituents of group A by preparative HPLC failed, owing to fast isomerization via acyl migration. From group B, the pure compound (**4**) could be obtained, which had bench life long enough to allow its spectroscopic characterization.



1 R1=OH, R2=R3=OAc
2 R1=R3=OAc, R2=OH
3 R1=R2=OAc, R3=OH
6 R1=R2=R3=OAc



4 R1=OAc, R2=OH
5 R1=OH, R2=OAc
7 R1=R2=OAc

Compounds **1**–**3** had very similar NMR and mass spectra, which showed a close relationship to 1 β-hydroxybaccatin I (**6**) [5]. The molecule ion at m/z 610 $[M]^+$ in the EI-mass spectrum, together with ^{13}C NMR and DEPT spectra, showed these three compounds were monodeacetylated derivatives of **6**.

Comparison of the 1D NMR spectral data of these compounds and **6** allowed us to assign only a few NMR signals. 2D NMR measurements were used to solve this problem. Our strategy to distinguish the ^{1}H

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and ^{13}C signals of the compounds in group A was as follows: (*a*) The ^1H–^1H COSY spectra were used for determining the connectivities between protons; (*b*) The ^1H–^{13}C HETCOR spectra were used for determining the directly bonded ^1H and ^{13}C signals; (*c*) The long range ^1H–^{13}C correlation spectra (COLOC) were used for revealing the connectivities between protons and carbons separated by two or three bonds. The observed correlations of ^1H–^1H COSY and COLOC are shown in Tables 1 and 2, and the NMR assignments are compiled in Tables 3–5.

Based on differences in the chemical shift of H-7, H-9 and H-10, the three compounds in group A were identified as 1 β-hydroxy-7-deacetyl-baccatin I (**1**), 1 β-hydroxy-9-deacetyl-baccatin I (**2**) and 1 β-hydroxy-10-deacetyl-baccatin I (**3**), respectively. Compound **3** is new.

Compound **4** was homogenous when first isolated, the comparison with the ^1H NMR spectrum of baccatin VI (**7**) [6] (Table 4) showed that **4** was a mono deacetyl baccatin VI. In the course of the NMR analysis, it was discovered that **4** changed to **5**, in the solid state. The structures of **4** and **5** were established using the same strategy employed for **1**–**3**. Location of the benzoate ester group was determined by COLOC measurements (long-range correlation between the benzoate carbonyl and H-2), and by NOESY experiments, which allowed assignments of the signals of H-9 and H-10.

Thus, compounds **4** and **5** were identified as 10-deacetyl-baccatin VI and 9-deacetyl-baccatin VI, respectively.

The isomerization of taxanes within both groups takes place via intramolecular transesterification. Acyl migrations of an ester group at C-7 and C-9 or C-9 and C-10 are well documented in taxane [7, 8]. It is interesting to note that in the compounds oxygenated at C-7, C-9 and C-10, isomerization was only reported for the diester, whereas monoesters (e.g. 9-dihydrobaccatin III) are apparently stable [9, 10].

EXPERIMENTAL

Optical rotations were measured on a Jasco Dip-369 Digital polarimeter. IR spectra were recorded with a Perkin-Elmer 577 spectrometer. ^1H NMR spectra of pure **4** were obtained in $CDCl_3$ and pyridine-d_5, respectively, on a JEOL JNM GSX-400 spectrometer. All other NMR measurements of group A and B were carried out on a Bruker AM-400 Fourier transform spectrometer operating at 400.134 and 100.614 MHz for ^1H and ^{13}C. The samples were made up in $CDCl_3$ for group A and in pyridine-d_5 for group B. All chemical shifts were expressed in ppm with reference to the solvent signals: 7.24 ppm/77.0 ppm for $CDCl_3$ and 8.71 ppm/149.9 ppm corresponding to the most downfield signals of pyridine-d_5. EI-MS were recorded on a VG Auto Spec 3000 spectrometer at 70 eV.

The ethereal extract from *T. yunnanensis* (40 kg) was chromatographed on a silica gel column (2 kg), eluting with $CHCl_3$-Me_2CO [11]. The material (1 g), eluted with $CHCl_3$–Me_2CO (4:1), was subjected to prep. HPLC (10C18 Cosmosil Packed Column, 20 × 250 mm) eluting with MeOH–H_2O (75:25) to give the compounds of group A (106 mg) and group B (12 mg).

Group A (**1**, **2** *and* **3**). $C_{30}H_{42}O_{13}$, amorphous solid, $[\alpha]_D^{25.4} + 367°$ ($c = 0.5$, $CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3 500, 2 990, 2 930, 1 730, 1 630, 1 435, 1 370, 1 235, 1 135, 1 045, 1 020, 990, 963, 885, 752, 713, 603, and 538. EI-MS *m/z* (rel. int.) 610 $[M]^+$ (7), 593 $[M-OH]^+$ (6), 568 $[M-CH_2{=}C{=}O]^+$ (13), 550 $[M-CH_3COOH]^+$ (12), 533 $[M-CH_3COOH-OH]^-$ (2), 508 $[M-CH_2{=}C{=}O-CH_3COOH]^+$ (1), 491 $[M-CH_3COOH-CH_3COO]^+$ (37), 473 $[M-CH_3COOH \times 2-OH]^+$ (3), 448 $[M-CH_3COOH \times 2-CH_2{=}C{=}O]^+$ (9), 430 $[M-CH_3COOH \times 3]^+$ (16), 388 $[M-CH_3COOH \times 3-CH_2{=}C{=}O]^+$ (8), 371 $[M-CH_3COOH \times 3-CH_3COO]^+$ (9), 370 $[M-CH_3COOH \times 4]^+$ (7), 310 $[M-CH_3COOH \times 5]^+$ (9), 293 $[M-CH_3COOH \times 5-OH]^+$ (8), 281 (11), 195 (77), 149 (74), 133 (74), 123 (92), 110 (82), 95 (84), 91 (60), 69 (58), 60 $[CH_3COOH]^+$ (48), 55 (100), and 43 $[CH_3CO]^+$ (61). ^1H and ^{13}C NMR data: see Tables 3 and 5.

Group B (**4** *and* **5**). $C_{35}H_{44}O_{13}$ amorphous solid, $[\alpha]_D^{23.6}$ $-20.2°$ ($c = 0.5$; pyridine. IR ν_{max}^{KBr} cm^{-1}: 3 470, 2 920, 1 722, 1 370, 1 315, 1 265, 1 235, 1 109, 1 040, 1 025, 980, 965, 944, and 718. EI-MS *m/z* (rel int.): 672 $[M]^+$ (10), 655 $[M-OH]^+$ (68), 637 $[M-H_2O-OH]^+$ (5), 612 $[M-CH_3COOH]^+$ (45), 594 $[M-CH_3COOH-H_2O]^+$ (23), 552 $[M-CH_3COOH \times 2]^+$ (15), 534 $[M-CH_3COOH \times 2-H_2O]^+$ (8), 510 $[M-CH_3COOH \times 2-CH_2{=}C{=}O]^+$ (3), 490 $[M-C_6H_5COOH-CH_3COOH]^+$ (14), 475 $[M-CH_3COOH \times 2-C_6H_5]^+$ (28), 430 $[M-C_6H_5COOH-CH_3COOH \times 2]^+$ (23), 412 $[M-C_6H_5COOH-CH_3COOH \times 2-H_2O]^+$ (13), 370 $[M-C_6H_5COOH-CH_3COOH \times 3]^+$ (15), 352 $[M-C_6H_5COOH-CH_3COOH \times 3-H_2O]^+$ (7), 327 $[M-C_6H_5COOH-CH_3COOH \times 3-CH_3CO]^+$ (10), 311 $[M-C_6H_5COOH-CH_3COOH \times 3-CH_3COO]^+$ (13), 195 (33), 149 (60), 122 $[C_6H_5COOH]^+$ (70), 105 $[C_6H_5CO]^+$ (88), 77 $[C_6H_5]^+$ (60), and 43 $[CH_3CO]^+$ (100). ^1H and ^{13}C NMR data, see Tables 4 and 5.

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Table 1. 2D ^1H–^1H COSY data for compounds **1–5** and NOESY data for compound **4**

	COSY					NOESY
H	1*	2*	3*	4†	5†	4†
2	H-3	H-3	H-3	H-3	H-3	H-17, 19
3	H-2, 19	H-2, 19	H-2, 19	H-2	H-2	H-7, 18
5	H-6	H-6	H-6	H-6 α	H-6 α	H-20
6 α	H-5, 6 β, 7	H-5, 6 β, 7	H-5, 6 β, 7	H-6 β, 7	H-6 β, 7	H-6 β
6 β	H-5, 6 α, 7	H-5, 6 α, 7	H-5, 6 α, 7	H-6 α, 7	H-6 α, 7	H-6 α
7	H-6	H-6	H-6	H-6	H-6	H-3, 18
9	H-10	H-10, 9-OH	H-10	H-10	H-10, 9-OH	H-17
10	H-9	H-9	H-9	H-9, 10-OH	H-9	H-18
13	H-14, 18	H-14, 18	H-14, 18	H-14, 18	H-14	H-16
14 α	H-13, 14 β	H-13, 14 β	H-13, 14 β	H-13	H-13	
14 β	H-13, 14 α	H-13, 14 α	H-13, 14 α	H-13	H-13	
16	H-17	H-17	H-17	H-17	H-17	H-13, 17
17	H-16	H-16	H-16	H-16	H-16	H-2, 9, 16, 9-OAc, *m*-Ph
18	H-13	H-13	H-13	H-13		H-10, 4-OAc, 7-OAc
19	H-3	H-3	H-3			H-7-OAc
20a	H-20b	H-20b	H-20b			H-5, 19, *o*-Ph
20b	H-20a	H-20a	H-20a			H-5, 19, *o*-Ph
o-Ph				H-*m*-Ph	H-*m*-Ph	H-20, *m*-Ph
m-Ph				H-*o*-Ph	H-*p*-Ph	H-17, *o*-Ph
p-Ph				H-*m*-Ph	H-*m*-Ph	
OH-9		H-9			H-9	
OH-10				H-10		H-9-OAc

* The data were measured in $CDCl_3$.

† The data were measured in pyridine-d_5.

Table 2. 2D COLOC data (8 Hz) for compounds **1–5**

	Correlated proton				
C	1*	2*	3*	4†	5†
1	H-2, 3, 14, 16, 17	H-2, 3, 14, 16, 17	H-2, 3, 14, 16, 17	H-16, 17	H-16
2					
3	H-2, 3, 5, 19	H-2, 3, 5, 19	H-2, 3, 5, 19	H-19, 20	H-19
4	H-3, 5, 6	H-3, 5, 6	H-3, 5, 6, 20a	H-3, 20	H-3
5	H-5	H-5, 6 β	H-5, 6 β	H-6 β, 20	
6	7-OH	H-6 β	H-6 β		
7	H-5				
8	H-2, 3, 6, 19	H-2, 3, 6 β, 19	H-2, 3, 6 β, 19	H-3, 19	H-19
9	H-9, 19			H-3	
10	H-10	H-10			
11	H-16, 17, 18	H-16, 17, 18	H-16, 17, 18	H-16, 17, 18	H-16, 17, 18
12	H-18	H-18	H-18	H-18	H-18
13	H-14 α, 18	H-14 α, 18	H-14 α, 18	H-18	
14	H-2	H-2	H-2	H-13	
15	H-2, 14, 16, 17	H-2, 14, 16, 17	H-2, 14, 16, 17	H-10, 16, 17	H-16, 17
16	H-17	H-17	H-17	H-16, 17	H-17
17	H-16	H-16	H-16	H-16	H-16
18					
19	H-3	H-3, 7	H-3, 7	H-3	
20	H-20b	H-20	H-20b	H-20	
Ph-C=O				H-2	
q-Ph					
o-Ph				*p*-Ph	
m-Ph				*p*-Ph	
p-Ph					

* The data were measured in $CDCl_3$.

† The data were measured in pyridine-d_5.

Table 3. ^{1}H NMR data of compounds **1–3** and **6** in CDCl$_3$

H	**1**	**2**	**3**	**6**
2 β	5.37 *d* (3.0)	5.27 *d* (3.8)	5.40 *d* (3.6)	5.49 *d* (3.2)
3 α	3.00 *d* (3.5)	3.03 *d* (3.8)	3.12 *d* (3.6)	3.18 *d* (3.2)
5 β	4.13 *brd* (3.2)	4.14 *brd* (3.1)	4.11 *brd* (3.1)	4.22 *t* (2.8)
6 α	1.88 *m*	2.04 (overlap)	2.09 *m*	2.17 *m*
6 β	1.88 *m*	1.78 *m*	1.64 *m*	1.75 *m*
7 α	4.19 *dd* (11.2, 4.9)	5.32 *dd* (11.5, 4.2)	5.35 *dd* (11.5, 4.0)	5.50 *dd* (11.6, 4.4)
9 β	6.07 *d* (11.2)	4.31 *dd* (10.6, 8.8)	5.84 *d* (10.6)	6.04 *d* (11.0)
10 α	6.12 *d* (11.2)	5.99 *d* (10.6)	5.10 *d* (10.6)	6.22 *d* (11.0)
13 β	5.97 *m*	6.05 *m*	6.05 *m*	6.09 *t* (8.4)
14 α	1.80 *dd* (14.8, 6.6)	1.80 *dd* (14.8, 6.6)	1.80 *dd* (14.8, 6.6)	1.88 *dd* (15.0, 6.8)
14 β	2.44 *dd* (14.8, 9.8)	2.44 *dd* (14.8, 9.8)	2.44 *dd* (14.8, 9.8)	2.54 *dd* (15.0, 9.6)
Me-16	1.58 *s*	1.48 *s*	1.60 *s*	1.24 *s*
Me-17	1.17 *s*	1.18 *s*	1.24 *s*	1.65 *s*
Me-18	2.06 *s*	2.034 *s*	1.99 *d* (0.8)	2.23 *s*
Me-19	1.11 *s*	1.37 *s*	1.15 *s*	1.25 *s*
20a	3.45 *d* (5.6)	3.42 *d* (5.2)	3.48 *d* (5.6)	3.55 *d* (5.6)
20b	2.26 *d* (5.6)	2.20 *d* (5.2)	2.23 *d* (5.6)	2.31 *d* (5.6)
OAc-Me	2.12 *s*	2.15 *s*	2.13 *s*	2.22 *s*
	2.05 *s*	2.05 *s*	2.04 *s*	2.12 *s*
	2.03 *s*	2.03 *s*	2.04 *s*	2.09 *s*
	2.02 *s*	1.97 *s*	2.03 *s*	2.06 *s*
	1.97 *s*	1.97 *s*	1.96 *s*	2.05 *s*
				2.00 *s*
OH-7	5.66 *brs*			
OH-9		2.78 *d* (8.8)		
OH-10			2.36 *brs*	

Table 4. ^{1}H NMR data of compounds **4**, **5** and **7**

H	**4***	**4**†	**5**†	**7***
2 β	5.86 *d* (5.6)	6.59 *d* (6.0)	6.32 *d* (5.8)	5.86 *d* (5.6)
3 α	3.17 *d* (5.6)	3.68 *d* (6.0)	3.58 *d* (5.8)	3.18 *d* (5.6)
5 α	4.94 *d* (8.8)	5.20 *d* (8.4)	5.25 *d* (8.4)	4.96 *d* (8.8)
6 α	2.46 *ddd* (15.2, 8.6, 6.4)	2.70 *ddd* (15.2, 8.4, 6.4)	2.77 *m*	2.50 *ddd* (14.8, 8.8, 7.2)
6 β	1.89 *m*	2.14 *m*	2.19 *m*	1.86 *dd* (11.8, 10.4)
7 α	5.48 *brt* (9.2)	6.00 *t* (8.8)	6.09 *t* (8.8)	5.54 *t* (8.4)
9 β	5.93 *d* (11.0)	6.65 *d* (11.0)	4.92 *dd* (10.7, 6.6)	6.00 *d* (11.2)
10 α	5.15 *d* (11.0)	5.65 *dd* (11.0, 4.4)	6.69 *d* (10.7)	6.21 *d* (11.2)
13 β	6.20 *brt* (8.8)	6.61 (overlap)	6.54 *m*	2.17 (overlap)
H$_2$-14	2.20 *m*	2.79 *m*	2.78 *m*	2.17 *brt* (8.8)
Me-16	1.30 *s*	1.59 *s*	1.42 *s*	1.78 *s*
Me-17	1.60 *s*	1.47 *s*	1.91 *s*	1.23 *s*
Me-18	1.92 *d* (1.6)	2.23 *s*	2.47 *s*	2.03 *s*
Me-19	1.81 *s*	2.01 *s*	2.32 *s*	1.60 *s*
20a	4.32 *ABd* (8.4)	4.49 *s*	4.54 *s*	4.32 *ABd* (8.4)
20b	4.13 *ABd* (8.4)	4.49 *s*	4.54 *s*	4.12 *ABd* (8.4)
H$_2$-*o*-Ph	8.10 *dd* (7.3, 1.5)	8.35 *dd* (7.2, 1.2)	8.34 (overlap)	8.09 *d* (8.4)
H$_2$-*m*-Ph	7.47 *t* (7.6)	7.45 *t* (7.2)	7.46 (overlap)	7.48 *t* (7.6)
H-*p*-Ph	7.60 *t* (7.3)	7.52 *t* (7.2)	7.52 (overlap)	7.61 *t* (7.2)
OAc-Me	2.30 *s*	2.28 *s*	2.26 *s*	2.29 *s*
	2.20 *s*	2.18 *s*	2.18 *s*	2.20 *s*
	2.17 *s*	2.15 *s*	2.16 *s*	2.11 *s*
	2.14 *s*	2.06 *s*	2.06 *s*	2.11 *s*
				2.00 *s*
OH-1	1.74 *s*	6.22 *s*		1.83 *s*
OH-9			6.33 *d* (6.6)	
OH-10		7.20 *d* (4.4)		

* The ^{1}H NMR data were measured in CDCl$_3$.

† The ^{1}H NMR data were measured in pyridine-d_5.

Table 5. ^{13}C NMR data of compounds **1**–**6** and **7**

C	**1***	**2***	**3***	**4**†	**5**†	**6***	**7***
1	75.9	76.0	76.1	78.3	78.0	76.0	78.8
2	72.4	72.0	72.3	74.5	74.3	72.1	73.2
3	40.4	42.0	41.1	47.5	47.8	41.3	47.2
4	58.2	58.5	58.1	82.0	82.3	58.2	81.4
5	78.0	78.0	77.7	84.1	84.3	77.7	83.8
6	32.3	30.6	31.3	35.3	35.3	31.1	34.5
7	68.9	71.8	68.9	72.6	73.4	68.6	69.6
8	47.2	45.8	46.6	46.5	46.5	46.6	45.7
9	77.9	76.2	77.7	78.4	75.3	75.1	74.9
10	70.4	72.1	68.4	68.2	74.0	70.7	70.3
11	135.7	136.7	139.5	140.2	136.5	135.6	133.5
12	140.5	139.1	136.7	135.3	139.2	140.3	141.2
13	71.0	71.1	71.3	70.8	70.6	71.1	71.7
14	38.4	38.6	38.5	36.9	36.9	38.5	35.0
15	43.3	43.4	43.3	44.0	44.0	43.2	42.7
16	21.7	22.1	21.7	28.9	28.5	28.4	28.2
17	28.4	28.5	28.6	23.8	23.7	21.8	22.2
18	15.4	15.5	15.2	14.9	15.3	15.4	15.0
19	12.5	14.7	13.6	13.5	14.1	13.6	12.7
20	49.8	49.5	49.8	76.7	76.7	49.9	76.3
Ph-C=O				166.3	166.3		166.8
q-Ph				131.1	131.1		129.2
o-Ph				130.4	130.4		130.1
m-Ph				128.9	128.9		128.6
p-Ph				133.4	133.4		133.7
OAc-C=O	170.1	170.4	170.4	170.9	170.9	170.1	170.4
	169.6	170.1	170.4	170.9	170.3	169.8	170.2
	169.3	169.3	170.1	170.3	170.0	169.7	169.9
	169.1	169.3	169.3	169.8	169.7	169.3	169.1
	168.3	169.1	169.1			169.2	168.9
						169.1	
OAc-Me	21.5	21.5	21.5	22.7	22.7	21.6	22.7
	21.3	21.5	21.3	21.7	21.7	21.4	21.4
	21.0	21.3	21.3	21.2	21.2	21.4	21.2
	20.7	20.7	20.7	21.2	21.2	20.9	20.9
	20.4	20.7	20.7			20.9	20.8
						20.6	

* The ^{13}C NMR data were measured in $CDCl_3$.

† The ^{13}C NMR data were measured in pyridine-d_5.

REFERENCES

1. Zhang, Z. P. and Jia, Z. J., *Phytochemistry*, 1990, **29**, 3673.
2. Chen, W. M., Chang, P. L., Wu, B. and Zheng, Q. T., *Chinese Chemistry Letters*, 1991, **2**, 441.
3. Liu, X. K., Wu, D. G. and Wang, Z. Y., *Kexu Tongbao*, 1992, **23**, 2186.
4. Zhang, H. J., Takeda, Y., Minami, Y., Yoshida, K., Unemi, N., Mu, Q., Xiang, W. and Sun, H. D., *Acta Botanica Yunnanica*, 1993, **15**, 424.
5. Barboni, L., Gariboldi, P., Torregiani, E., Appendino, G., Gabetta, B., Zini, G. and Bombardelli, E., *Phytochemistry*, 1993, **33**, 145.
6. Della Casa De Marcano, D. P. and Halsall, T. G., *Journal of the Chemical Society, Chemical Communications*, 1975, 365.
7. Chu, A., Davin, L. B., Zajcek, J., Lewis, N. G. and Croteau, R., *Phytochemistry*, 1993, **34**, 473.
8. Chmurny, G. N., Paukstelis, J. V., Alvarado, A. R., McGuire, M. T., Snader, K. M., Mushchik, G. M. and Hilton, B. D., *Phytochemistry*, 1993, **34**, 477.
9. Kobayashi, J., Inubushi, A., Hosoyama, H., Yoshida, N., Sasaki, T. and Shigermori, H., *Tetrahedron*, 1995, **51**, 5971.
10. Zamir, L. O., Nedea, M. E., Zhou, Z. H., Belair, S., Caron, G., Sauriol, F., Jacqmain, E., Jean, F. I., Garneau, F. X. and Mamer, O., *Canadian Journal of Chemistry*, 1995, **73**, 655.
11. Zhang, H. J., Takeda, Y. and Sun, H. D., *Phytochemistry*, 1995, **39**, 1147.