A New Dimeric Carbazole Alkaloid from *Glycosmis stenocarpa* Roots

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A new dimeric pyranocarbazole alkaloid, bisisomahanine (1), was isolated from the roots of *Glycosmis stenocarpa* (DRAKE) TAN., along with two known monomeric carbazole alkaloids, murrayafoline-A (2) and murrayanine (3). The planar structure of bisisomahanine was determined to be 9,9″-dihydroxy-3,3″,8,8″-tetramethyl-3,3″-bis-(4-methyl-3-pentenyl)-3,3″,11,11″-tetrahydro-10,10″-(bipyrano[3,2-*a*]carbazole) from the combination of spectroscopic and chemical evidence. Bisisomahanine is the first dimeric prenylated pyranocarbazole alkaloid with a 1,1′ type of linkage; the NMR and CD spectroscopic data indicated it to be a mixture of diastereomers having a dominant configuration at the axis of chirality. ^{1}H- and ^{13}C-NMR assignments of murrayafoline-A were made on the basis of 2D-experiments.

Key words *Glycosmis stenocarpa*; bisisomahanine; murrayafoline-A; bis-pyranocarbazole; dimer; chirality

The genus *Glycosmis*, family Rutaceae, is a rich source of alkaloids, including those of the quinolone, quinazoline, furoquinoline, acridone, sulphur-containing amides and carbazole types.[1,2] Carbazole alkaloids were isolated from the seeds[3] and the roots[4,5] of *G. pentaphylla*, from the bark of *G. mauritiana*[6] and *G. rupestris*,[7] and from the roots of *G. arborea*.[8] Carbazole alkaloids have also been found in other Rutaceous genera, *e.g.*, *Micromelum*, *Murraya*, and *Clausena*. From two genera, *Murraya* and *Clausena*, nearly four fifths of the natural carbazole alkaloids have been isolated.[9,10] In a continuing search for bioactive natural products from Vietnamese plants, a number of plants, including species *Glycosmis stenocarpa* (DRAKE) TAN., have been screened for cytotoxic, antifungal, and antibacterial activities.[11,12] *G. stenocarpa*, local name "com ruou trai hep," is a small shrub, 0.75—1 m high. It is an endemic plant, found in some provinces in north Vietnam.[13] This paper reports the isolation and structural elucidation of a new dimeric pyranocarbazole alkaloid, named bisisomahanine (**1**), and two known monomeric carbazole alkaloids, *viz.* murrayafoline-A (**2**)[14] and murrayanine (**3**),[15] from the roots of *G. stenocarpa*.

Results and Discussion

Bisisomahanine (**1**) was obtained as a pale ivory powder, mp 130—140°C, $[\alpha]_D^{20}$ −13.1°. The UV spectrum showed the typical absorbances at 209, 224, and 245 nm, closely similar to those of **2** and **3**, and indicative of the carbazole skeleton in **1**. Furthermore, it exhibited absorbances at 298 (sharp, strong) and 335 nm (broad, weak), typical of an angular pyranocarbazole unit as described for isomahanine (**4**).[16]

The ^{13}C-NMR and DEPT spectra of **1** showed the presence of six olefinic and aromatic methine carbon signals at δ 109—129, eleven non-protonated carbon signals, and four methyl and two methylene (at δ 40.8, 22.7) carbon signals. Of the eleven non-protonated carbon signals, there were two signals at δ 150.3 and 151.1 assignable to non-protonated aromatic carbons attached to oxygen.

Signals in the ^{1}H-NMR spectrum [δ 1.71 (H-1′), 2.10 (H-2′), 5.06 (H-3′), 1.53 (H-4′b), and 1.63 (H-4′a)] (Table 1) and the peak at *m*/*z* 83 in the EI-MS spectrum were assignable to the isohexenyl side chain.[16,17] The assignments of carbons at positions C-1′ and C-2′ of alkaloid **1** are different than those reported for isomahanine (**4**),[16] and were confirmed by data from HMQC and HMBC experiments (Table 1). The HMQC spectrum of **1** showed the direct ^{1}H–^{13}C correlations between the multiplet methylene proton signals at δ 1.71 and 2.10 to the methylene carbon signal at δ 40.8 and 22.7, respectively. The methylene proton signals at δ 2.10 (H-2′) had ^{1}H–^{13}C long range correlations to the carbon signals at δ 131.7 (C-4′), 124.1 (C-3′), and 40.8 (C-1′), whereas the methylene proton signal at δ 1.71 (H-1′) had HMBC correlations to the carbon signals at δ 128.8 (C-2), 78.3 (C-3), 124.1 (C-3′), and 22.7 (C-2′). The ^{1}H–^{1}H COSY and NOESY spectra of **1** also confirmed the above assignment of the isohexenyl side chain (Fig. 1).

In the downfield region of the ^{1}H-NMR spectrum, two broad singlets at δ 7.51 and 5.14 were assigned to an NH and a phenolic hydroxyl group, respectively; this was supported by the IR bands at 3470 and 3362 cm^{-1}, and the fact that no carbons were attached to these proton signals, as shown by the HMQC spectrum. There were two isolated pairs of *ortho*-coupled protons: the first pair at δ 6.73 (H-5) and 7.71 (H-6), and the second at δ 6.43 (H-1) and 5.54 (H-2). The COSY spectrum confirmed the two separate spin systems. The NMR spectral data of the latter pair were similar to those in some *Murraya* alkaloids such as isomahanine (**4**) and mahanine (**5**),[16] murrayamine C (**7**),[18] and pyrayafoline-D (**6**) (assigned the same structure as **4** by Ito *et al.*),[17] indicating the presence of a pyran ring double bond in the pyranocarbazole-type skeleton of **1**.

The position of fusion between the pyrano and carbazole rings was determined from analysis of the NOESY and HMBC spectral data of **1**. The correlation in the NOESY spectrum between the amino proton at δ 7.51 (11-NH) and the doublet signals at δ 6.43 (H-1) indicated a [3,2-*a*] type-connection in the pyranocarbazole skeleton of **1** rather than a [2,3-*c*] fusion, reported for 7-methoxyglycoumarin,[7] a [3,2-*d*] type, as in the case of glycoborinine,[8] or a [3,2-*e*] type, reported for pyrayafoline-B.[17] The [3,2-*a*] type of **1** was further confirmed by the ^{13}C–^{1}H long range correlations in the HMBC spectrum between the aromatic non-protonated carbon signal at δ 136.1 (C-11a) and H-1, H-6 and the NH proton.

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Table 1. NMR Spectral Data[a] of Alkaloid **1** and Derivative **8** ($CDCl_3$)

Position	**1**				**8**	
	^{1}H (δ)	^{13}C (δ)	COSY	HMBC	^{1}H (δ)	^{13}C (δ)
1	6.43 d (10)	117.4 d	H-2	C-4a, C-11a, C-2, C-11b, C-3, 3-CH_3	6.47 d (10)[c]	117.4 d[c]
2	5.54 d (10)	128.8 d	H-1	C-4a, C-3, C-1′, C-11b, 3-CH_3	5.25 d (10)[c]	128.5 d[c]
3		78.3 s				78.5 s
4a		151.1 s				151.9 s
5	6.73 d (8.4)	109.9 d	H-6	C-4a, C-6a, C-11b	6.72 d (8.4)	109.8 d
6	7.71 d (8.4)	119.5 d	H-5	C-4a, C-11a, C-6b, C-11b	7.75 d (8.4)	120.2 d
6a		117.8 s[b]				116.9 s
6b		117.8 s[b]				122.1 s[b]
7	7.84 br s	122.3 d	H_3-8	C-9, C-10a, C-6a, C-10, 8-CH_3	7.87 s	121.1 d
8		117.9 s[b]				122.3 s[b]
9		150.3 s				145.1 s
10		99.1 s				109.3 s
10a		137.9 s				137.9 s
11a		136.1 s				137.0 s
11b		105.0 s				105.0 s
1′	1.71 m	40.8 t[c]	H_2-2′	C-2, C-3′, C-3, C-2′	1.70 m	41.0 t[c]
2′	2.10 m	22.7 t[c]	H-3′, H_2-1′	C-4′, C-3′, C-1′	2.01 m	22.6 t[c]
3′	5.06 t (6.0)	124.1 d[c]	H_2-2′, H_3-4′a, H_3-4′b	C-1′, C-2′, C-4′a, C-4′b	5.03 t (7.2)[c]	124.1 d[c]
4′		131.7 s[c]				131.7 s[c]
4′a	1.63 s[c]	25.6 q[c]	H-3′	C-4′, C-3′, C-4′b, C-2′	1.61 s[c]	26.1 q[c]
4′b	1.53 s	17.6 q	H-3′	C-4′, C-3′, C-4′a, C-2′	1.51 s[c]	17.6 q[c]
3-CH_3	1.39 br s	25.8 q		C-2, C-3, C-1′	1.42 s[c]	25.7 q[c]
8-CH_3	2.49 s	16.7 q	H-7	C-9, C-10a, C-7, C-6b, C-10, C-8	2.38 s	17.0 q
9-OH	5.14 s			C-9, C-8, C-10		
11-NH	7.51 br s			C-10a, C-11a, C-6a, C-6b	7.80 br s	
9-OAc					1.87 s	20.0 q
						166.4 s

a) Coupling constants (*J*) in Hz are in parentheses. *b*) Exchangeable within the column. *c*) Doubling of signals.

The ^{1}H–^{1}H COSY spectrum of **1** showed cross peaks between the aryl methyl protons at δ 2.49 to the lowest downfield aromatic singlet proton at δ 7.84, which in turn had NOESY interactions with both the methyl group and the proton at δ 7.71 (H-6). The aryl methyl group also showed a NOESY correlation to the hydroxyl group at δ 5.13. These data confirmed the assignment of the signal at δ 7.84 to H-7, characteristic of carbazoles,[14] and the location of the aryl methyl group at C-8 and the hydroxyl group at C-9, biogenetically the same as in many *Murraya* pyranocarbazole alkaloids.[16,19]

Thus most of the 1D- and 2D-NMR spectral data of **1** were similar to those of isomahanine (**4**), with the exception of an additional nonprotonated aromatic carbon signal at δ 99.1 and a lack of the methine aromatic proton and carbon signals due to H-10 (C-10) in the ^{1}H- and ^{13}C-NMR spectra. The HR-EI-MS spectrum of **1** showed a molecular ion at *m/z* 692.3633, corresponding to the molecular formula $C_{46}H_{48}N_2O_4$. In view of the simplicity of the NMR spectra, a symmetric dimeric structure for **1** with the linkage position between two carbazole monomers through C-10/10″ was suggested.

Spectral data of the acetylated derivative **8** of alkaloid **1** also confirmed the linkage position between C-10/10″. *O*-Acetylation of the hydroxyl group at C-9 caused a deshielding of the *ortho* carbon atoms (*ca.* 4 ppm for C-8 and 10 ppm for C-10), a shielding of the *meta* carbon (*ca.* 1 ppm for C-7) and a deshielding of the *para* carbon atoms (*ca.* 4 ppm for C-6b) in **8** in comparison to those of **1** (see Table 1). That the chemical shift of C-10 (δ 109.3) in **8** moved to lower field by *ca.* 10 ppm might be due to the further steric effects in the dimeric structure.

The EI-MS spectrum of **1** showed the molecular ion at *m/z* 692, and a weak peak at *m/z* 677 indicative of loss of a methyl group. The base peak at *m/z* 609 $[M-C_6H_{11}]^+$ was due to the loss of a methylpentenyl group by a cleavage between C-1′ and C-3. There was also another significant peak at *m/z* 263 which could be a doubly charged ion due to loss of two methylpentenyl groups $[M-(2\times C_6H_{11})]^{++}$.

Bisisomahanine had a weak optical rotation $[\alpha]_D^{20}$ −13.1° but showed a strong Circular Dichroism spectrum, with a positive Cotton effect at 209 nm, $\Delta\varepsilon$ +17.2, and negative Cotton effects at 230 nm, $\Delta\varepsilon$ −10.3 and 248 nm, $\Delta\varepsilon$ −16.1. In the absence of other reports on the CD of the known naturally-occurring biscarbazole alkaloids, it is difficult to draw definite conclusions from the curve concerning the absolute stereochemistry of the alkaloid, except to say that the magnitudes of the Cotton effects probably indicate the presence of one predominant atropo-enantiomer.

Superficially, the ^{1}H-NMR spectrum of bisisomahanine showed one set of proton signals, but on close examination slight doubling of the signal for the C-4′a protons could be discerned. Corresponding doubling could be seen also in the ^{13}C-NMR spectrum, especially of signals arising from the alkyl substituents on the chromene rings, and more clearly in the ^{1}H- and ^{13}C-NMR spectra of the diacetate derivative **8** (Table 1). The ^{1}H-NMR spectrum of **8** showed clearly two sets of signals in a ratio of *ca.* 2 : 1, except for protons H-5, H-6, H-7, and 8-CH_3. The corresponding ^{13}C-NMR spectrum of **8** showed doubling of signals from C-2, C-1′, C-2′, C-3′, C-4′, C-4′a, C-4′b and 3-CH_3. Thus this evidence suggests that compound **1** is a mixture of two diastereomers, in a ratio

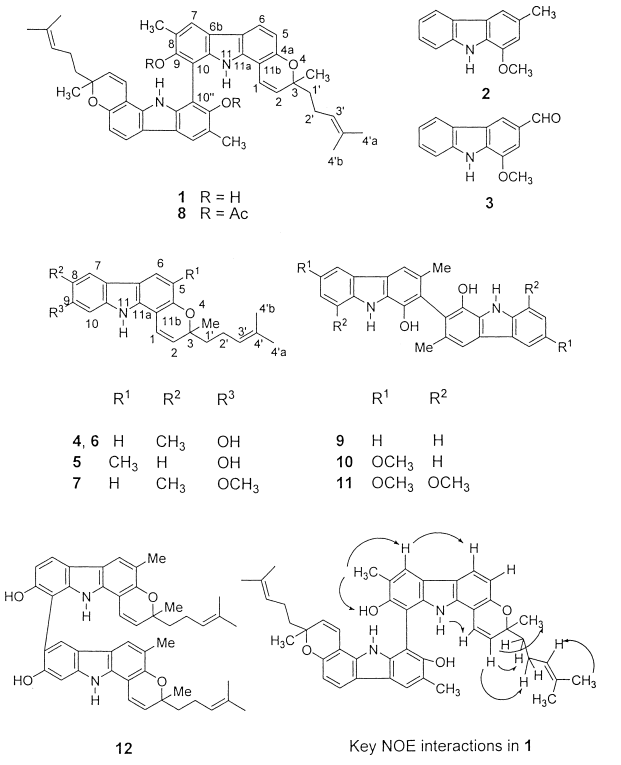

Fig. 1. Carbazole Alkaloids

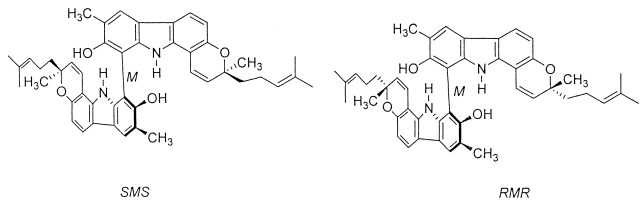

Fig. 2. A Pair of Possible Diastereomers of **1**

of *ca.* 2 : 1. If the formation of the biaryl linkage is stereoselective (to form an *M* or a *P* biaryl)[20] from a racemic isomahanine precursor, the product could give rise to a mixture of three diastereomers (*e.g.* for an *M* biaryl, *RMR*, *RMS*≡*SMR*, and *SMS*) theoretically in the ratio of 1 : 2 : 1, and in principle, though not necessarily, having different nmr spectra (Fig. 2). The observed NMR spectra are suggestive of this situation, but it is not clear from which isomers the different signals arise. If the chirality of the chromene ring induces some bias in the coupling reaction, an unequal mixture of diastereomers could result. Another possibility is that the formation of the biaryl linkage is not completely stereoselective, giving perhaps a major atropo-enantiomer but also an amount of the other axial enantiomer, which could also give rise, with selectivity, to diastereomers. Furthermore there is the possibility of the involvement of chiral isomahanine precursors. Much further work is needed to clarify this complex situation. For the present it can be stated only that bisisomahanine, for which the planar structure **1** has been established, exists as a mixture of stereoisomers having a dominant configuration at the axis of chirality.[20]

There is now a sizeable number of dimeric carbazole alkaloids which can be considered as arising from phenolic coupling of monomeric alkaloids to produce biaryls with linkages adjacent to the phenolic substituents.[9] Thus, bis-2-hydroxy-3-methylcarbazole,[16] isolated from *Murraya koenigii*, has a 1,1′ type of linkage. The synthetic compounds[21] **9** and **10** and clausenamine-A[22] **11** have 2,2′ type of linkages. Here we suggest using the term "type of linkage" for distinguishing the linkage position of both the simple carbazole and pyranocarbazole dimers, considering only the parent carbazole ring systems themselves for numbering purposes. Examples of C_{36} ($C_{18}+C_{18}$) dimers arising from dimethyl-pyranocarbazole monomers are bis-7-hydroxygirinimbine A[23] and 8,8″-biskoenigine[19] with 8,8′ type of linkages, bis-7-hydroxygirinimbine B[23] with an 8,6′ type of linkage and kwangsine[24] which is a 5,5′ dimer of koenine; bismurrayafoline-B[25] is a prenylated carbazole dimer with a 2,2′ type of linkage. Mahanine (**5**), with a methyl, methylpentenyl substituted chromene ring is a homologue of the putative 7-hydroxygirinimbine which, because of two free *ortho* positions to the phenolic group, can give rise to the two abovementioned C_{36} dimers, A and B. Likewise two mahanine C_{46} ($C_{23}+C_{23}$) dimers can be anticipated, but to date only bismahanine (**12**)[18] with an 8,6′ type of linkage has been reported. Isomahanine (**4**), having only one free ortho position, gives rise to bisisomahanine (**1**) having a 1,1′ type of linkage through C10/C10″. Other known C_{46} dimers arising from geranylated carbazole monomers are bismurrayafoline-C and -D[26] with 2,2′ type of linkages, and bismurrayafoline E [27] also with a 1,1′ type of linkage.

Compound (**2**), the main component of the methanol extract of *G. stenocarpa* root, was determined to be murrayafoline-A from 1D- and 2D-NMR experiments and by comparison with reported data.[14] However the ^{13}C-NMR data ($CDCl_3$) of **2** were previously not assigned.[14] New ^{1}H- and ^{13}C-NMR data of **2** are now reported, together with assignments made on the basis of COSY, NOESY, HMBC, and HMQC evidence.[28] Murrayanine **3** was isolated from the hexane fraction of the methanolic root extract and its structure determined by the reported spectroscopic data.[15,31] The trivial name murrayanine has recently been reused for a new carbazole alkaloid from *Murraya koenigii*.[19]

Experimental

General Experimental Procedures ^{1}H- and ^{13}C-NMR, COSY, NOESY, HMQC, HMBC spectra were measured on a Bruker AVANCE 500 spectrometer. Chemical shifts are shown in δ (ppm) with TMS as an internal reference. UV spectra were recorded on an UV/VIS Cintra 40 double-beam spectrometer (GBC 2855), and IR spectra on an IMPACTS 410 (NICOLET, U.S.A.). EI-MS spectra were obtained by a 5989B MS (Hewlett Packard) spectrometer. HR-MS spectrum was obtained by a KRATOS MS25 RFA spectrometer. The optical rotation was measured in $CHCl_3$ with a POLARIMETER-D spectropolarimeter and the CD spectrum was measured on a Jasco J-710 spectropolarimeter in acetonitrile solvent. All solvents were distilled before use.

Plant Material Roots of *G. stenocarpa* were collected at Hoang Hoa Tham commune, Chi Linh district, Hai Duong Province, Vietnam, in January 2001, and identified by the botanist, Dr. Ngo Van Trai. A voucher specimen (TC036) is deposited at the Institute of Materia Medica (Ministry of Health, Hanoi, Vietnam).

Extraction and Isolation Dried powdered roots (1.1 kg) of *G. stenocarpa* were extracted with MeOH (3×3 l), filtered and evaporated *in vacuo*. The suspension of the methanol residue in MeOH/H_2O (1 : 1) was successively extracted with *n*-hexane, chloroform, and butanol to give hexane (30 g), chloroform (17 g), and butanol extracts. The hexane extract (30 g) was chromatographed on silica gel (250 g, Merck silica 80—120 mesh) using a gradient of hexane and EtOAc as eluent to give 19 fractions. Fraction 4 was further rechromatographed on flash silica gel (hexane/EtOAc 10/1 as eluent) to yield murrayafoline-A (**2**) (3.3 g, 3%). Fractions 10 to 14 were

combined and also rechromatographed on silica gel (using hexane/EtOAc 6/1 as eluent) to give **1** (33 mg, 0.03%). Fraction 16 contained crystals, which were recrystalized from a mixture of hexane/EtOAc (80/20), giving murrayanine (**3**) (165 mg, 0.15%).

Bisisomahanine (**1**): 9,9″-Dihydroxy-3,3″,8,8″-tetramethyl-3,3″-bis-(4-methyl-3-pentenyl)-3,3″,11,11″-tetrahydro-10,10″-(bipyrano[3,2-*a*]carbazole), pale ivory powder, violet spot on TLC plate with H_2SO_4/vanillin agent, *Rf*: 0.3 (hexane/EtOAc 7 : 1), $[\alpha]_D^{20}$ −13.1° (*c*=0.25, $CHCl_3$), mp 130—140 °C; CD (CH_3CN): $\Delta\varepsilon_{209}$=+17.2, $\Delta\varepsilon_{248}$=−16.1, $\Delta\varepsilon_{230}$=−10.3. HR-EI-MS *m/z* 692.3633 (Calcd for $C_{46}H_{48}N_2O_4$, 692.3614); EI-MS *m/z*: 692 (M^+), 609 $(M-83)^+$ (100%), 263 $[M-(2\times83)]^{++}$, 207, 167, 149, 129, 111, 105, 97, 83. IR (KBr) cm^{-1}: 3470, 3362, 2923, 2859, 1723, 1621, 1447, 1258, 1188, 1132, 1048, 807, 725, 641, 550. UV λ_{max} ($CDCl_3$) nm (log ε): 209 (4.1), 224 (3.7), 245 (5.0), 298 (4.9), 335 (4.4). ^{1}H-NMR ($CDCl_3$) and ^{13}C-NMR ($CDCl_3$): see Table 1.

Preparation of 8 Acetylation (dry DMAP and Ac_2O, room temp., 10 h) of **1** (9 mg) gave **8** (9.2 mg) after work-up as a yellow solid showing a violet spot on TLC plate with H_2SO_4/vanillin agent, *Rf* : 0.28 (hexane/EtOAc 7 : 1), ^{1}H-NMR ($CDCl_3$) and ^{13}C-NMR ($CDCl_3$): see Table 1.

Murrayafoline-A (**2**): Brown oil, $C_{14}H_{13}NO$, *Rf*: 0.25 (hexane/EtOAc, 10 : 0.5), EI-MS *m/z*: 211 (100%) $(M)^+$, 196 $(M-CH_3)^+$, 167, 139, 115, 101, 77. UV λ_{max} ($CHCl_3$) nm: 209, 222, 243, 291, 327, 340; ^{1}H-NMR ($CDCl_3$) δ: 8.12 (1H, br s, NH), 8.00 (1H, d, *J*=7.4 Hz, H-5), 7.46 (1H, br s, H-4), 7.39 (1H, d, *J*=7.4 Hz, H-8), 7.36 (1H, t, *J*=7.4 Hz, H-7), 7.18 (1H, t, *J*=7.4 Hz, H-6), 6.71 (1H, br s, H-2), 3.97 (3H, s, 1-OCH_3), 2.52 (3H, s, 3-CH_3). ^{13}C-NMR ($CDCl_3$) δ: 145.4 (s, C-1), 139.5 (s, C-8a), 129.5 (s, C-3), 128.0 (s, C-9a), 125.5 (d, C-7), 124.4 (s, C-4a), 123.6 (s, C-4b), 120.4 (d, C-5), 119.2 (d, C-6), 112.5 (d, C-4), 110.9 (d, C-8), 107.7 (d, C-2), 55.5 (q, 1-OCH_3), 21.9 (q, 3-CH_3).

Murrayanine (**3**): Silver white plates (EtOAc), mp 155 °C, $C_{14}H_{11}NO_2$, EI-MS *m/z*: 225 $(M)^+$ (100%), 210 $(M-CH_3)^+$, 182, 154, 127, 126, 99, 75, 63. UV λ_{max} ($CHCl_3$) nm: 210, 222, 241, 250, 274, 287, 327, 340. ^{1}H- and ^{13}C-NMR ($CDCl_3$) data were as reported.[15,31]

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References and Notes

1) Hofer O., Greger H., "Sulfur-Containing Amides from *Glycosmis* Species (Rutaceae)," Vol. 80, ed. by Herz W., Falk H., Kirby G. W., Moore R. E., Springer, New York, 2000, pp. 187—223.
2) Cuong N. M., Sung T. V., Taylor W. C., *Phytochemistry*, **52**, 1711—1714 (1999).
3) Mukherjee S., Mukherjee M., Ganguly S. N., *Phytochemistry*, **22**, 1064—1065 (1983).
4) Bhattacharyya P., Chakrabartty P. K., Chowdhury B. K., *Phytochemistry*, **24**, 882—883 (1985).
5) Jash S. S., Biswas G. K., Bhattacharyya S. K., Bhattacharyya P., Chakrabartty P. K., Chowdhury B. K., *Phytochemistry*, **31**, 2503—2505 (1992).
6) Kumar V., Reisch J., Wickramasinghe A., *Aust. J. Chem.*, **42**, 1375—1379 (1989).
7) Rahmani M., Ling C. Y., Sukari M. A., Ismail H. B. M., Meon S., Aimi N., *Planta Med.*, **64**, 780 (1998).
8) Chakravarty A. K., Sarkar T., Masuda K., Shiojima K., *Phytochemistry*, **50**, 1263—1266 (1999).
9) Chakraborty D. P., Roy S., "Carbazole Alkaloids IV," Vol. 85, ed. by Herz W., Falk H., Kirby G. W., Springer, New York, 2003, pp. 125—230.
10) Chakraborty D. P., "Chemistry and Biology of Carbazole Alkaloids," Vol. 44, ed. by Cordell G. A., Academic Press, New York, 1993, pp. 257—364.
11) Cuong N. M., Nam N. H., Kim Y., You Y. J., Bae K., Sung T. V., Ahn B. Z., *Kor. J. Pharmacogn.*, **33**, 64—68 (2002).
12) Cuong N. M., Huong L. M., Hang T. N., Sung T. V., *Tap chi Duoc Lieu*, **5**, 144—148 (2002).
13) Ho P. H., "An Illustrated Flora of Vietnam," Vol. 2, Nha Xuat ban Tre, Hanoi, 1999.
14) Furukawa H., Wu T. S., Ohta T., Kuoh C. S., *Chem. Pharm. Bull.*, **33**, 4132—4138 (1985).
15) Chakraborty D. P., Barman B. K., Bose P. K., *Tetrahedron*, **21**, 681—685 (1965).
16) Reisch J., Goj O., Wickramasinghe A., Herath H. M. T. B., Henkel G., *Phytochemistry*, **31**, 2877—2879 (1992).
17) Ito C., Nakagawa M., Wu T. S., Furukawa H., *Chem. Pharm. Bull.*, **39**, 1668—1671 (1991).
18) Ito C., Thoyama Y., Omura M., Kajiura I., Furukawa H., *Chem. Pharm. Bull.*, **41**, 2096—2100 (1993).
19) Wang Y. S., He H. P., Shen Y. M., Hong X., Hao X. J., *J. Nat. Prod.*, **66**, 416—418 (2003).
20) Bringmann G., Gunther C., Ochse M., Schupp O., Tasler S., "Biaryls in Nature," Vol. 82, ed. by Herz W., Falk H., Kirby G. W., Moore R. E., Tamm C., Springer, New York, 2001, pp. 1—249.
21) Lin G., Zhang A., *Tetrahedron*, **56**, 7163—7171 (2000).
22) Wu T.-S., Huang S.-C., Wu P.-L., *Tetrahedron Lett.*, **37**, 7819—7822 (1996).
23) Wu T.-S., Wang M.-L., Lai J.-S., Ito C., Furukawa H., *Phytochemistry*, **30**, 1052—1054 (1991).
24) Xie F.-Z., Ming D.-S., Chen R.-Y., Yu D.-Q., *Acta Pharmaceutica Sinica*, **35**, 826—828 (2000).
25) Furukawa H., Wu T.-S., Ohta T., *Chem. Pharm. Bull.*, **31**, 4202—4205 (1983).
26) Ito C., Nakagawa M., Wu T.-S., Furukawa H., *Chem. Pharm. Bull.*, **39**, 2525—2528 (1991).
27) Nutan M. T. H., Hassan C. M., Rashid M. A., *Fitoterapia*, **70**, 130—133 (1999).
28) The ^{1}H chemical shifts reported in ref. 14 differ from our values and those reported elsewhere[29] by 0.12 to 0.26 ppm. In a review article[30] the ^{13}C-NMR chemical shifts have been misquoted from ref. 14 (one of the two values δ 110.9 should be 119.1); there are also eight misassignments together with four incorrect multiplicities.
29) Knolker H.-J., Bauermeister M., *Tetrahedron*, **49**, 11221—11236 (1993).
30) Chakraborty D. P., Roy S., "Carbazole Alkaloids III," Vol. 71, ed. by Herz W., Kirby G. W., Steglich W., Tamm Ch., Springer, New York, 1991, pp. 73—152.
31) Li W. S., McChesney J. D., El-Feraly F. S., *Phytochemistry*, **30**, 343—346 (1991).