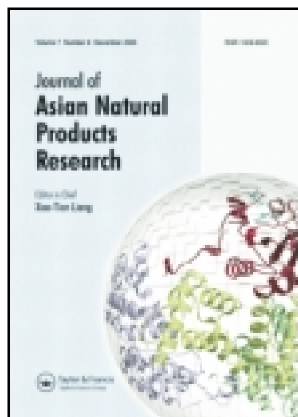
This article was downloaded by: [Malmo Hogskola]
On: 18 December 2011, At: 23:02
Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Journal of Asian Natural Products Research
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ganp20

Phenol esters and other constituents from the stem barks of Stereospermum acuminatissimum

Sylvain Valère Tanemossu Sob [a] [b] , Hippolyte Kamdem Wabo [a] , Chun-Ping Tang [b] , Pierre Tane [a] , Bonaventure Tchaleu Ngadjui [c] & Yang Ye [b]

[a] Department of Chemistry, University of Dschang, P.O. Box 67, Dschang, Cameroon

[b] State Key Laboratory of Drug Research & Natural Products Chemistry Department, Shanghai Institute of Materia Medica, Chinese Academy of Sciences, Shanghai, 201203, China

[c] Department of Organic Chemistry, University of Yaounde I, P.O. Box 812, Yaounde, Cameroon

Available online: 19 Oct 2011

To cite this article: Sylvain Valère Tanemossu Sob, Hippolyte Kamdem Wabo, Chun-Ping Tang, Pierre Tane, Bonaventure Tchaleu Ngadjui & Yang Ye (2011): Phenol esters and other constituents from the stem barks of Stereospermum acuminatissimum , Journal of Asian Natural Products Research, 13:12, 1128-1134

To link to this article: http://dx.doi.org/10.1080/10286020.2011.619182

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.tandfonline.com/page/terms-and-conditions

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings,

demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

Journal of Asian Natural Products Research
Vol. 13, No. 12, December 2011, 1128–1134

Taylor & Francis
Taylor & Francis Group

Phenol esters and other constituents from the stem barks of *Stereospermum acuminatissimum*

Sylvain Valère Tanemossu Sob[ab]*, Hippolyte Kamdem Wabo[a], Chun-Ping Tang[b], Pierre Tane[a], Bonaventure Tchaleu Ngadjui[c] and Yang Ye[b]*

[a]*Department of Chemistry, University of Dschang, P.O. Box 67, Dschang, Cameroon;* [b]*State Key Laboratory of Drug Research & Natural Products Chemistry Department, Shanghai Institute of Materia Medica, Chinese Academy of Sciences, Shanghai 201203, China;* [c]*Department of Organic Chemistry, University of Yaounde I, P.O. Box 812, Yaounde, Cameroon*

(*Received 10 June 2011; final version received 28 August 2011*)

A new ester, 2-(4′-hydroxyphenyl)ethyl dotriacontanoate (**1**), and a new inseparable mixture of octacosan-1,28-dioldiferulate and triacontan-1,30-dioldiferulate (**2**) were isolated from the stem barks of *Stereospermum acuminatissimum*, along with 24 known compounds including 4 triterpenoids, 11 anthraquinones, 2 lignans, 3 phenylpropanoids, 2 4-hydroxyphenethyl esters, 1 methoxyphenol, and 1 iridoid. The structures of the new metabolites were determined with the help of spectroscopic data including extensive 2D NMR spectroscopy. The known compounds were identified by comparison of their physical and spectroscopic data with those reported in the literature. The compounds were tested against *Candida albicans* ATCC 24433, *C. albicans* ATCC 90028, *Candida glabrata* ATCC 90030, *Candida krusei* ATCC 6258, and *Candida parapsilosis* ATCC 22019. Some of them were moderately active.

Keywords: *Stereospermum acuminatissimum*; Bignoniaceae; phenol esters; antifungal activity

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

1. Introduction

Stereospermum acuminatissimum K. Schum. (Bignoniaceae) is a tall tree with pink or pale purple flowers found in the forest of west tropical Africa or planted for ornamental purposes [1]. The leaves and barks are used in Cameroonian traditional medicine for antimalarial and anti-inflammatory purposes. To the best of our knowledge, no phytochemical study is reported on this plant. Previous studies of species of *Stereospermum* genus have led to the isolation of lignans, phenolic and iridoid glycosides [2,3], quinones [4–8], and hydroxyphenylethyl esters [8]. As part of our continuing search of new biologically active substances from Cameroonian medicinal species [9,10], we have carried out the chemical investigation of the title plant and now report on the constituents of the stem barks.

The air-dried and powdered stem barks of *S. acuminatissimum* (3 kg) were macerated with CH_2Cl_2–MeOH (1:1) (3 × 72 h) and the solvent removed under reduced pressure to afford a crude extract. The CH_2Cl_2–MeOH (1:1) extract was subjected to sequential liquid–liquid partition with petroleum ether (PE), $CHCl_3$, EtOAc, and *n*-BuOH. The $CHCl_3$ fraction was separated by chromatography on silica gel and Sephadex LH-20, affording the new compound 2-(4′-hydroxyphenyl)ethyl dot riacontanoate (**1**) and the new mixture

*Corresponding authors. Email: sobsyl@yahoo.fr; yye@mail.shcnc.ac.cn

ISSN 1028-6020 print/ISSN 1477-2213 online
© 2011 Taylor & Francis
http://dx.doi.org/10.1080/10286020.2011.619182
http://www.tandfonline.com

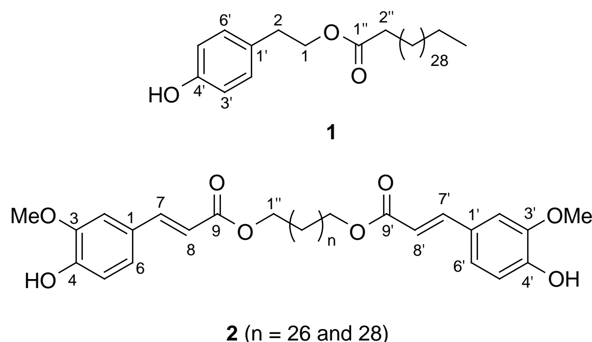


Figure 1. Structures of compounds **1** and **2**.

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

of octacosan-1,28-dioldiferulate and triacontan-1,30-dioldiferulate (**2**) (Figure 1) together with the known compounds ursolic acid (**3**) [11], pomolic acid (**4**) [11], quinovic acid (**5**) [11], oleanolic acid (**6**) [11], (+)-cycloolivil (**7**) [2], paulownin (**8**) [12], methyl *trans*-ferulate (**9**) [13,14], coniferaldehyde (**10**) [15], (*E*)-methyl 3-(4′-hydroxyphenyl)acrylate (**11**) [14], 2-(4′-hydroxyphenyl)ethyl undecanoate (**12**) [8], 2-(4′-hydroxyphenyl)ethyl nonacosanoate (**13**) [8], 2-methoxy-4-[3′-(3″,4″,5″-trimethoxyphenyl)allyloxymethyl]phenol (**14**) [8], pinnatal (**15**) [5], stereochenol B (**16**) [7], sterekunthal B (**17**) [5], sterequinone B (**18**) [4], sterequinone F (**19**) [8], sterequinone H (**20**) [8], sterequinone A (**21**) [4], sterequinone E (**22**) [4], zenkequinone B (**23**) [6], zenkequinone A (**24**) [6], sterequinone C (**25**) [4], and norviburtinal (**26**) [8].

2. Results and discussion

Compound **1** was obtained as a white powder. It reacted positively to the $FeCl_3$ reagent suggesting the presence of a phenolic hydroxyl group. The molecular formula $C_{40}H_{72}O_5$ was deduced from the EI-MS at *m/z* 601 $[M+H]^+$. This molecular formula was confirmed by the HR-EI-MS at *m/z* 600.5447 $[M]^+$. The IR spectrum showed strong absorption bands due to hydroxyl ($3301\,cm^{-1}$) and ester carbonyl ($1728\,cm^{-1}$) groups, and also of an aromatic ring ($1519\,cm^{-1}$). The ^1H NMR spectrum exhibited two doublets of *ortho*-coupled aromatic protons at δ_H 7.08 (2H, $J = 8.4$ Hz, H-2′) and 6.76 (2H, $J = 8.4$ Hz, H-3′), suggesting the presence of a 1,4-disubstituted aromatic ring. This spectrum also showed two triplets of two protons each at δ_H 4.23 ($J = 7.1$ Hz, H-1) and 2.85 ($J = 7.1$ Hz, H-2) of an oxymethylene and a benzylic methylene, respectively. These data suggested the presence of a 4-hydroxyphenylethyl group, which was substantiated by a fragment at *m/z* 121 in its EI-MS [8]. The ^1H NMR spectrum further displayed a three-proton triplet at δ_H 0.89 ($J = 6.8$ Hz), which was characteristic of a terminal methyl group of an aliphatic chain [5]. The triplet at δ_H 2.27 (2H, $J = 7.6$ Hz, H-2″) was assignable to a methylene adjacent to a carbonyl group. A broad singlet at δ_H 1.25 integrating for 56 protons accounted for the presence of an aliphatic chain comprising 28 methylenes. The ^{13}C NMR spectrum showed signals of one ester carbonyl (δ_C 173.9), one oxygenated aromatic carbon (δ_C 154.2), two aromatic methines (δ_C 130.0 and 115.3), one oxymethylene (δ_C 64.9), and one aliphatic methyl group (δ_C 14.1). In the HMBC spectrum (Figure 2), pertinent correlations were observed between H-3″and C-1″, between H-2″ and C-1″, as well as between H-1 and C-1″, H-2 and C-2′. Further correlations were observed

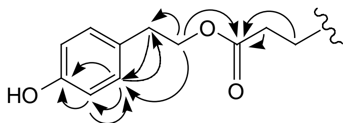


Figure 2. Selected HMBC correlations for compound **1**.

between H-2′ and C-2, C-3′ and C-4′, and between H-3′ and C-4′ and C-2′. Compound **1** was thus characterized as 2-(4′-hydroxyphenyl)ethyl dotriacontanoate. Two phenylethyl esters were previously isolated from *Stereospermum personatum* [8].

Compound **2** was obtained as a white powder. It was isolated as an inseparable mixture of phenylalkanoids of *trans*-ferulic acid and long-chain alcohols as shown in the ^{1}H and ^{13}C NMR spectra. The IR spectrum showed absorption bands typical of hydroxyl (3432 cm^{-1}), conjugated ester carbonyl groups (1704 and 1668 cm^{-1}), and aromatic ring (1592 cm^{-1}). The ^{1}H NMR spectrum exhibited one singlet of methoxyl groups at δ_H 3.92. This spectrum also showed two doublets at δ_H 6.29 ($J = 15.6$ Hz, H-8/H-8′) and 7.60 ($J = 15.6$ Hz, H-7/H-7′), typical of deshielded *trans* olefinic protons of an α,β-unsaturated carbonyl group [16] and signals of an ABX system of aromatic protons at δ_H 6.91 (d, $J = 8.1$ Hz, H-5/H-5′), 7.03 (br s, H-2/H-2′), and 7.07 (br d, $J = 8.4$ Hz, H-6/H-6′). The ^{13}C NMR spectrum showed signals of substituted aromatic carbons at δ_C 127.0 (C-1/C-1′), 146.7 (C-3/C-3′), and 147.8 (C-4/C-4′). These data suggested the presence of a *trans*-ferulate system. The broad singlet at δ_H 1.28 and the multiplet at δ_H 1.66 in the ^{1}H NMR spectrum and signals at δ_C 29.3 and 29.7 in the ^{13}C NMR spectrum were indicative of long-chain aliphatic alcohol moieties [17]. The number of carbons of the long-chain alcohol was determined by the HR-ESI-MS, which exhibited molecular formulas $C_{48}H_{74}O_8$ and $C_{50}H_{78}O_8$. Compound **2** was thus assigned as a mixture of octacosan-1,28-dioldiferulate and triacontan-1,30-dioldiferulate. The relative ratio in the ESI-MS of $C_{50}H_{78}O_8$ and $C_{48}H_{74}O_8$ was 1.26; the relative amount of these two compounds was obtained as 48:38.

In addition to the above new esters, 24 known compounds (**3**–**26**) were also isolated. Their structures were established by comparison of NMR spectral data with those in the literature.

Candida albicans is the causative fungus of many superficial infections and over 90% of the systemic or deep yeast of infections, particularly in immunocompromised patients. It colonizes the wound site in burn patients, causing mortality in 73% of bone marrow recipients [18,19]; there is evidence of invasive candidal infections in patients with hematological malignances due to intensive myelosuppressive chemotherapy [18]. In addition, a number of non-*albicans Candida* strains are currently emerging [18,20]. This prompted us to evaluate the antifungal activity of some of the isolated compounds against five *Candida* strains, *C. albicans* ATCC 24433, *C. albicans* ATCC 90028, *Candida glabrata* ATCC 90030, *Candida krusei* ATCC 6258, and *Candida parapsilosis* ATCC 22019. Some of them showed only moderate activity (Table 1). Compound **11** was more active against *C. krusei* ATCC 6258 [minimum inhibitory concentration (MIC) = 25 μg/ml] than the reference compound fluconazole (MIC = 50 μg/ml). The most sensitive strains were *C. krusei* ATCC 6258, *C. albicans* ATCC 90028, and *C. glabrata* ATCC 90030.

3. Experimental

3.1 General experimental procedures

IR spectra were recorded on a Nicolet Magna FT-IR 750 spectrophotometer using KBr disks. UV spectra were recorded on a Shimadzu UV-2550 spectrophotometer. ^{1}H and ^{13}C NMR spectra were recorded at 300 and 75 MHz,

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

Table 1. Antifungal activities (MIC in μg/ml) of some compounds isolated from the stem barks of *S. acuminatissimum*.

Yeasts	Test substances																			
	1	**2**	**3**	**4**	**6**	**7**	**9**	**10**	**11**	**13**	**15**	**16**	**19**	**20**	**21**	**22**	**23**	**25**	RA1	RA2
C. albicans ATCC 24433	50	50	50	100	100	50	50	50	150	100	100	50	50	100	50	50	100	50	0.195	0.195
C. albicans ATCC 90028	50	50	50	50	50	50	50	100	50	50	50	100	50	100	50	50	50	50	0.195	0.097
C. glabrata ATCC 90030	100	50	100	50	50	50	100	100	50	100	100	50	100	100	50	100	50	100	0.195	25
C. krusei ATCC 6258	50	50	50	50	50	50	50	50	25	50	50	50	50	50	50	50	50	50	1.562	50
C. parapsilosis ATCC 22019	100	100	100	50	50	50	100	100	100	100	50	100	100	100	50	100	100	100	1.562	3.125

Note: RA1, reference antibiotic 1 (Amphotericin B); RA2, reference antibiotic 2 (Fluconazole).

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

respectively, in $CDCl_3$. The chemical shift (δ) values are given in ppm with TMS as an internal standard, and coupling constants (J) are in Hz. EI-MS and HR-EI-MS were recorded on a Finnigan MAT-95 mass spectrometer. ESI-MS and HR-ESI-MS were recorded on a Micromass LC-MS-MS mass spectrometer. Silica gel was used for flash chromatography and was produced by Qingdao Marine Chemical Industrials (Qingdao, China). Preparative HPLC was carried out on a Varian SD1 instrument with a 320 single wave detector. Chromatographic separation was carried out on two C18 columns (220 × 25 mm, 10 μm, Merck, Darmstadt, Germany; 220 × 50 mm, 10 μm, Merck), using a gradient solvent system of CH_3CN–H_2O containing 0.1% HCO_2Cl, at a flow rate of 15 and 60 ml/min, respectively. Sephadex LH-20 (Pharmacia Biotech AB, Uppsala, Sweden) was also used as a column packing material. TLC was carried out on precoated silica gel GF_{254} plates (Yantai Chemical Industrials, Yantai, China), and the TLC spots were viewed at 254 nm and visualized by 5% sulfuric acid in alcohol containing 10 mg/ml vanillin.

3.2 Plant material

The stem bark of *S. acuminatissimum* was collected in February 2008 at Mount Eloumden, Yaounde, Center Region of Cameroon. The plant was identified by Mr Nana Victor, Botanist, at the Cameroon National Herbarium, Yaoundé, where a voucher specimen (No. 43622/HNC) has been deposited.

3.3 Extraction and isolation

Air-dried and finely powdered stem bark of *S. acuminatissimum* (3 kg) was extracted by percolation at room temperature with a mixture of CH_2Cl_2–MeOH (1:1). The crude extract (220 g) was dissolved in the mixture H_2O–MeOH (70:30) and sequentially partitioned with PE, $CHCl_3$, EtOAc, and *n*-BuOH. Evaporation of the solvent from the PE, $CHCl_3$, EtOAc, and *n*-BuOH solutions yielded 13, 17, 38.50, and 138 g of respective extracts. The $CHCl_3$ extract was subjected to dry flash column chromatography (CC) on silica gel (200–300 mesh, 7 × 80 cm, 340 g) eluting with gradients of CH_2Cl_2–acetone and acetone–MeOH. Twenty-three fractions of 250 ml each were collected, combined on the basis of their TLC profiles, and concentrated to dryness to give six major fractions A–F: A (500 mg, CH_2Cl_2), B (120 mg, CH_2Cl_2), C (420 mg, CH_2Cl_2–acetone 1:0, 95:5), D (1.48 g, CH_2Cl_2–acetone 95:5, 9:1), E (1.30 g, CH_2Cl_2–acetone 9:1, 85:15, 8:2, 7:3, 1:1), and F (1.26 g, CH_2Cl_2–acetone 1:1, 0:1; acetone–MeOH 9:1, 0:1). Fraction A, eluted on a silica gel (200–300 mesh, 3 × 45 cm, 280 g) CC with a step gradient of PE–EtOAc (5 ml/min), afforded compounds **1** (40 mg), **19** (23 mg), **2** (34 mg), **25** (14 mg), and **3** (26 mg). Fraction B was subjected to the same procedure to give compounds **9** (12 mg) and **15** (6.7 mg). Fraction C was further purified by repeated silica gel CC with a gradient of PE–EtOAc, followed by gel permeation through Sephadex LH-20 (60 × 4.5 cm, 120 g; Pharmacia) eluting with $CHCl_3$–MeOH (1:1; 100 ml) to yield compounds **13** (7 mg), **17** (5 mg), **26** (3 mg), and **10** (4.5 mg). Sub-fractions eluted with the mixture of PE–EtOAc (7:3) were further purified by HPLC (flow rate 10 ml/min, wavelength 220 nm) with a gradient of CH_3CN–H_2O, to afford compounds **11** (10 mg), **18** (7.9 mg), **20** (13 mg), and **24** (8.2 mg). Fraction D was repeatedly chromatographed over silica gel with the mixture CH_2Cl_2–acetone in increasing polarity, to give compounds **4** (39 mg), **5** (3 mg), **12** (9 mg), **16** (6 mg), **6** (28 mg), **7** (7.8 mg), **22** (4 mg), **14** (2.8 mg), **21** (11.5 mg), **23** (9.4 mg), and **8** (4 mg).

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011

*3.3.1 2-(4′-Hydroxyphenyl)ethyl dotriacontanoate (**1**)*

A white powder, UV ($CHCl_3$) λ_{max} (log ε): 282 (3.00), 276 (3.07) nm; IR (KBr) υ_{max}: 3301, 2918, 2848, 1728, 1519, 1473, 1463, 1184, 827, 719 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ_H: 7.08 (2H, d, $J = 8.4$ Hz, H-2′), 6.76 (2H, d, $J = 8.4$ Hz, H-3′), 4.23 (2H, t, $J = 7.1$ Hz, H-1), 2.85 (2H, t, $J = 7.1$ Hz, H-2), 2.27 (2H, t, $J = 7.6$ Hz, H-2″), 1.59 (2H, m, H-3″), 1.25 (56H, brs, H-4″ to H-31″), 0.89 (3H, t, $J = 6.8$ Hz, H-32″); ^{13}C NMR (75 MHz, $CDCl_3$) δ_C: 173.9 (C-1″), 154.2 (C-4′), 130.0 (C-6′ and C-2′), 115.3 (C-5′ and C-3′), 64.9 (C-1), 34.2 (C-2), 31.9 (C-2″), 29.7 and 22.7 (C-3″ and C31″), 14.1 (C-32″); EI-MS (70 eV) *m/z* (rel. int.): 601 $[M + H]^+$(3), 452 (24), 435 (9), 121 (41), 120 (100); HR-EI-MS *m/z* 600.5447 $[M]^+$ (calcd for $C_{40}H_{72}O_3$, 600.5481).

*3.3.2 Octacosan-1,28-dioldiferulate and triacontan-1,30-dioldiferulate (**2**)*

A white powder, UV ($CHCl_3$) λ_{max} (log ε): 257 (4.01) nm; IR (KBr) υ_{max}: 3432, 2917, 2850, 1704, 1668, 1592, 1471, 1274, 1163, 717 cm^{-1}; ^1H NMR (300 MHz, $CDCl_3$) δ_H: 1.28 ($-[CH_2]_n-$, brs), 1.66 (OCH_2CH_2, m), 3.92 (s, OMe groups), 4.18 (t, $J = 6.6$ Hz, OCH_2), 5.84 (s, OH), 6.29 (d, $J = 15.6$ Hz, H-8/H-8′), 6.91 (d, $J = 8.1$ Hz, H-5/H-5′), 7.03 (2H, brs, H-2/H-2′), 7.07 (br d, $J = 8.4$ Hz, H-6/H-6′), 7.60 (d, $J = 15.6$ Hz, H-7/H-7′); ^{13}C NMR (75 MHz, $CDCl_3$) δ_C: 29.3 and 29.7 ($-[CH_2]_n-$), 55.9 (OMe), 64.6 (CH_2O), 109.2 (C-2/C-2′), 114.7 (C-5/C-5′), 115.7 (C-8/C-8′), 123.0 (C-6/C-6′), 127.0 (C-1/C-1′), 144.6 (C-7/C-7′), 146.7 (C-3/C-3′), 147.8 (C-4/C-4′), 167.4 (C-9/C-9′); ESI-MS *m/z* (rel. int.): 806 (48), 805 (94), 791 (24), 778 (38), 777 (100), 749 (18), 629 (8), 601 (1), 452 (4), 194 (24), 177 (75), 137 (19), 121 (22), 120 (44). HR-ESI-MS: *m/z* 778.5350 $[M]^+$ (calcd for $C_{48}H_{74}O_8$, 778.5384) and 806.5663 (calcd for $C_{50}H_{78}O_8$, 806.5697).

3.4 Bioassays

The antifungal assays were carried out as previously described [21]. Sabouraud Dextrose Agar was used for the activation of micro-organisms and Sabouraud Dextrose Broth (Conda, Madrid, Spain) for antifungal assays. Stock solutions of the compounds in DMSO were diluted to give serial twofold dilutions that were added to each medium resulting in concentrations ranging from 1.56 to 200 μg/ml. The final concentration of DMSO in the assay did not exceed 1%. The antimicrobial agents amphotericin B (at the concentrations ranging between 0.0488 and 6.25 μg/ml) and fluconazole (at the concentrations ranging between 0.0488 and 6.25 μg/ml for *C. albicans* ATCC 24433, *C. albicans* ATCC 90028, and *C. parapsilosis* ATCC 22019 and between 0.781 and 100 μg/ml for *C. glabrata* ATCC 90030 and *C. krusei* ATCC 6258) served as positive controls. The plates were incubated for 48 h at 35°C. Tests were carried out in triplicate. The MIC was the lowest of the substances that prevented visible growth of micro-organisms.

Acknowledgements

The authors gratefully acknowledge the support from the Academy of Sciences for the Developing World (TWAS) and the Chinese Academy of Sciences (CAS) through a CAS-TWAS fellowship to SVTS at the Shanghai Institute of Materia Medica, Shanghai, China.

References

[1] J. Hutchinson and J. Dalziel, in *Flora of West Tropical Africa*, edited by F.N. Hepper, 2nd ed., (Millbank, London, 1963), Vol. 2, p. 386.

[2] T. Kanchanapoom, P. Noiara, H. Otsuka, and S. Ruchirawat, *Phytochemistry* **67**, 516 (2006).

[3] R.T. Ghogomu, B. Bodo, B. Nyasse, and B.L. Sondengam, *Planta Med.* **45**, 464 (1985).

[4] U.S. Kumar, P. Aparna, R.J. Rao, T.P. Rao, and J.M. Rao, *Phytochemistry* **63**, 925 (2003).

[5] B. Onegi, C. Kraft, I. Köhler, M. Freund, K. Jenett-Siems, K. Siems, G. Beyer, M.F. Melzig, U. Bienzle, and E. Eich, *Phytochemistry* **60**, 39 (2002).
[6] B.N. Lenta, B. Weniger, C. Antheaume, D.T. Noungoue, S. Ngouela, J.C.N. Assob, C. Vonthron-Sénécheau, P.A. Fokou, K.P. Devkota, E. Tsamo, and N. Sewald, *Phytochemistry* **68**, 1595 (2007).
[7] M.R. Haque, K.M. Rahman, M.N. Iskander, C.M. Hasan, and M.A. Rashid, *Phytochemistry* **67**, 2663 (2006).
[8] U.S. Kumar, A.K. Tiwari, S.V. Reddy, P. Aparna, R.J. Rao, A.Z. Ali, and J.M. Rao, *J. Nat. Prod.* **68**, 1615 (2005).
[9] S.V.T. Sob, P. Tane, B.T. Ngadjui, J.D. Connolly, and D. Ma, *Tetrahedron* **63**, 8993 (2007).
[10] S.V.T. Sob, H.K. Wabo, P. Tane, B.T. Ngadjui, and D. Ma, *Tetrahedron* **64**, 7999 (2008).
[11] S.B. Mahato and A.P. Kundu, *Phytochemistry* **37**, 1517 (1994).
[12] A.J.D. Silvestre, D.V. Evtuguin, A.P.M. Sousa, and A.M.S. Silva, *Biochem. Syst. Ecol.* **33**, 1298 (2005).
[13] T.S. Wu, Y.L. Leu, and Y.Y. Chan, *Chem. Pharm. Bull.* **47**, 571 (1999).
[14] P.L. Wu, T.S. Wu, C.X. He, C.H. Su, and K.L. Lee, *Chem. Pharm. Bull.* **53**, 56 (2005).
[15] L.K. Sy and G.D. Brown, *Phytochemistry* **50**, 781 (1999).
[16] H. Jayasuriya, D.L. Zink, R.P. Borris, W. Nanakorn, H.T. Beck, M.J. Balick, M.A. Goetz, L. Gregory, W.L. Shoop, and S.B. Singh, *J. Nat. Prod.* **67**, 228 (2004).
[17] Y.M. Chiang, Y.H. Kuo, S. Oota, and Y. Fukuyama, *J. Nat. Prod.* **66**, 1070 (2003).
[18] R. Fenner, M. Sortino, S.M.K. Rates, R. Dall'Agnol, A. Ferraz, A.P. Bernardi, D. Albring, C. Nör, G.V. Poser, E. Schapoval, and S. Zacchino, *Phytomedicine* **12**, 236 (2005).
[19] J.D. Meyers, *Semin. Oncol.* **17**, 424 (1990).
[20] W.G. Powderly, K.H. Mayer, and J.R. Perfect, *AIDS Res. Hum. Retroviruses* **15**, 1405 (1999).
[21] J.D.D. Tamokou, M.F. Tala, H.K. Wabo, J.R. Kuiate, and P. Tane, *J. Ethnopharmacol.* **124**, 571 (2009).

Downloaded by [Malmo Hogskola] at 23:02 18 December 2011