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α-Glucosidase Inhibitory Anthranols, Kenganthranols A−C, from the Stem Bark of *Harungana madagascariensis*

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One new prenylated 1,4-anthraquinone and three new prenylated anthranols, named kengaquinone (**1**) and kenganthranols A (**2**), B (**3**), and C (**4**), were isolated from a hexane extract of the stem bark of *Harungana madagascariensis*. Six known compounds including anthraquinones, anthrones, and xanthones were also isolated and identified. The structures of the new compounds were determined by analysis of spectroscopic data and comparison with data of previously known analogues. Some isolated compounds (**3**−**5**, **7**−**11**) were evaluated for their α-glucosidase inhibition activity. Compounds **3**, **4**, **8**, and **11** showed significant activity, whereas compounds **7**, **9**, and **10** were inactive in this test.

Harungana madagascariensis Lam. (Hypericaceae) is a native of tropical Africa. It is a small- to medium-sized shrub (up to 1.65 m high) with fine stellate hairs and ovate lateral leaves.[1] Extracts from different parts of this plant have been investigated, and in vitro as well as in vivo pharmacological models allowed proof of their effectiveness in the treatment of a variety of ailments including jaundice, diarrhea, dysentery, typhoid fever, and constipation.[2−4] The stem bark was also evaluated for antiamoebic and spasmolytic activities.[2] We recently reported on the isolation of two prenylated anthronoids, named harunmadagascarins A and B, with antioxidant properties from the stem bark of this species.[5] Interest in other constituents of this plant has led to the isolation of a further new prenylated 1,4-anthraquinone named kengaquinone (**1**) and three new prenylated anthranols named kenganthranols A (**2**), B (**3**), and C (**4**), according to the district "Keng", where the plant was collected. Madagascin (**6**),[6,7] physcion (**8**),[6,7] vismiaquinone (**7**),[7,8] vismiaquinone B (**9**),[9] harunganin (**5**),[6] harunganol B (**11**),[10] and 1,7-dihydroxyxanthone (**10**)[10] were also isolated. To the best of our knowledge, this is the first report of anthranols in this genus, and only one compound from this class of metabolites has thus far been isolated from the family Hypericaceae.[11] However, several anthranols were synthesized by Dimmel and Shepard.[12] The present paper describes the isolation and characterization of the new compounds and the results of an α-glucosidase inhibition study of some of the isolated compounds.

α-Glucosidase (EC 3.2.1.20) is a small intestinal membrane-bound enzyme that catalyzes the final step in the digestive process of carbohydrates. Its inhibitors retard the uptake of dietary carbohydrates and thus suppress postprandial hyperglycemia.[13] Glucosidases are also involved in several important biological processes such as the synthesis of glycoproteins and the lysosomal catabolism of glycoconjugates. They are potentially useful as antiviral, antimetastatic, and immunomodulatory agents. They are also potentially active against HIV-1 infection.[14]

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Results and Discussion

The hexane extract of the stem bark of *H. madagascariensis*, showing strong α-glucosidase inhibitory activity, was submitted to repeated column chromatography and preparative TLC (PTLC) to afford 1,4-anthraquinone (**1**), anthranols (**2**−**4**), and known compounds (**5**−**11**), as described in the Experimental Section. Kengaquinone (**1**), obtained as a dark violet pigment, was assigned the molecular formula $C_{25}H_{26}O_5$ from the HREIMS $[M]^+$ at *m/z* 406.1739 (calcd 406.1780). The UV−vis spectrum showed bands at 237, 258, 371, and 433 nm, suggesting a quinonoid chromophore. Compound **1** was suspected to be a 1,4-anthraquinone from the bathochromic shift of its long-wavelength absorption maximum.[15] The infrared spectrum of **1** showed characteristic absorption bands at 1720 and 1606 cm^{-1}, indicating the presence of two carbonyl groups, one of which was chelated. The ^{13}C NMR chemical shifts at δ 187.7 and 179.5 were in agreement with this suggestion. The ^{1}H NMR spectrum (Table 1) showed the presence of one aromatic methyl group at δ 2.41 and two hydroxyl groups at δ 16.62 and 10.04, which is characteristic of a torosachrysone-type skeleton.[16]

The partial structure of compound **1** was deduced as an 8,9-dihydroxy-6-methyl-1,4-anthraquinone. The ^{1}H NMR spectrum of kengaquinone (**1**) also showed one proton signal exchangeable with D_2O at δ 7.59 and a set of signals that were assigned to two γ,γ-dimethylallyl groups [two triplets at δ 5.21, 4.95 (J = 7.2, 6.1, each olefinic protons), two doublets at δ 3.63, 3.30 (J = 6.1 and 7.2, each methylene protons), and four singlets at δ 1.66, 1.68, 1.78, 1.88 (each olefinic methyl)]. This was corroborated by the ^{13}C NMR spectrum, which presented the signals of two methylenes (δ 27.5 and 22.1), two methines (δ 119.5 and 122.3), and four methyls (25.7, 25.6, 18.1, and 17.9). In the heteronuclear multiple-bond connectivity (HMBC) experiment, the methylene proton at δ 3.30 showed long-range correlation to a carbonyl group (δ 187.7) and C-3 (δ 154.9), whereas the methylene proton at δ 3.63 showed ^{3}J correlations to C-6 (δ 142.7) and C-10a (δ 132.4). This suggested attachment of the prenyl moieties at the C-2 (δ 123.7) and C-5 (δ 131.8) positions. The ^{2}J and ^{3}J connectivities of the hydroxyl group at δ 7.59 and the methylene group at δ 3.30 with C-2 (δ 123.7) confirmed the position of the prenyl group at C-2. The carbons at C-7 and C-10 were assigned through HMQC and HMBC experiments. The H-7 proton (δ 6.94) showed ^{3}J correlations with an aromatic methyl at δ 20.8, C-5 (δ 131.8), and C-8a (δ 114.1), and the downfield proton signal at δ 8.27 (H-10) exhibited correlations with C-5, C-8a, and C═O (δ 179.5). This finding clearly cor-

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Chart 1

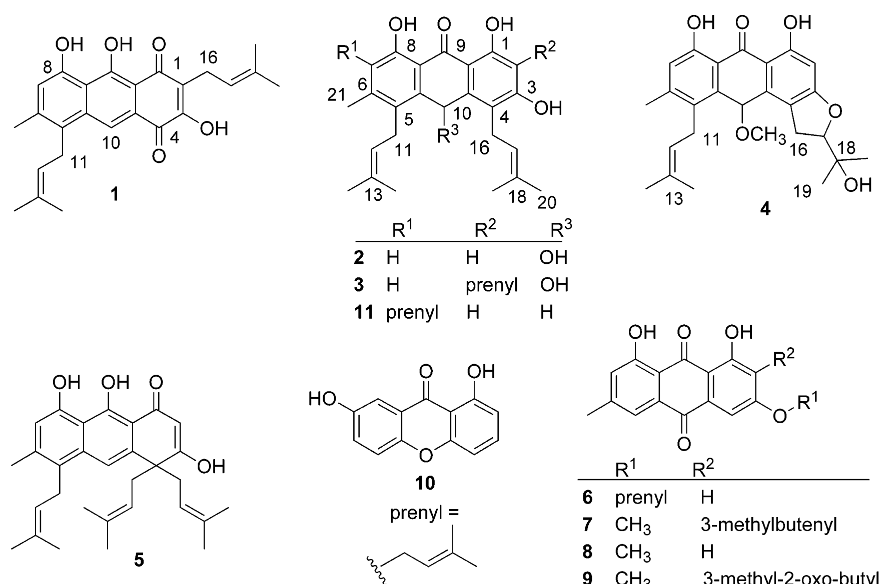

Table 1. ^{1}H NMR Spectral Data of Kengaquinone (**1**) (500 MHz) and Kenganthranols A (**2**) (500 MHz), B (**3**) (400 MHz), and C (**4**) (400 MHz) (δ ppm, $CDCl_3$)

H	1	2	3	4
1-OH		12.59 (1H, s)	13.00 (1H, s)	12.77 (1H, s)
2		6.41 (1H, s)		6.39 (1H, s)
3-OH	7.59 (1H, s)	5.85 (1H, s)	6.35 (1H, s)	
7	6.94 (1H, s)	6.83 (1H, s)	6.81 (1H, s)	6.83 (1H, s)
8-OH	10.04 (1H, s)	12.33 (1H, s)	12.37 (1H, s)	12.46 (1H, s)
9-OH	16.62 (1H, s)			
10	8.27 (1H, s)	5.94 (1H, d, $J = 6.2$)	5.93 (1H, d, $J = 5.4$)	5.76 (1H, s)
10-OH (OMe)		2.10 (1H, d, $J = 6.2$)	2.10 (1H, d, $J = 5.4$)	2.74 (3H, s)
11	3.63 (2H, d, $J = 6.1$)	3.41−3.70 (2H, m)	3.49−3.70 (2H, m)	3.36 (2H, m)
12	4.95 (1H, t, $J = 6.1$)	5.18 (1H, br s)	5.23 (1H, br t)	4.93 (1H, br t)
14 (*Z*)	1.88 (3H, s)	1.82 (3H, s)	1.81 (3H, s)	1.80 (3H, s)
15 (*E*)	1.66 (3H, s)	1.69 (3H, s)	1.69 (3H, s)	1.69 (3H, s)
16a	3.30 (2H, d, $J = 7.2$)	3.41−3.70 (2H, m)	3.49−3.70 (2H, m)	3.08 (1H, dd, $J = 7.6, 15.7$)
16b				3.75 (1H, dd, $J = 9.0, 15.7$)
17	5.21 (1H, t, $J = 7.2$)	5.01 (1H, br s)	5.00 (1H, br t)	4.77 (1H, dd, $J = 7.6, 9.0$)
19 (*Z*)	1.78 (3H, s)	1.85 (3H, s)	1.82 (3H, s)	1.22 (3H, s)[a]
20 (*E*)	1.68 (3H, s)	1.74 (3H, s)	1.72 (3H, s)	1.36 (3H, s)[a]
CH_3-6	2.41 (3H, s)	2.34 (3H, s)	2.32 (3H, s)	2.32 (3H, s)
22			3.44 (2H, d, $J = 6.9$)	
23			5.24 (1H, t, $J = 6.9$)	
25 (*Z*)			1.84 (3H, s)	
26 (*E*)			1.75 (3H, s)	

[a] Signals with the same sign may be interchanged.

roborated the position of the other prenyl group at C-5. From the foregoing spectroscopic data, kengaquinone (**1**) was determined as 3,8,9-trihydroxy-6-methyl-2,5-bis(3,3-dimethylallyl)-1,4-anthraquinone. The proposed structure was further supported by the ^{13}C NMR data (Table 2). Assignments were made using DEPT, HMQC, and HMBC spectra and by comparison of the measured values with those reported for 3,8,9-trihydroxy-6-methyl-1,4-anthraquinone and 6,8,9-trihydroxy-3-methyl-1,4-anthraquinone, synthesized in 1976.[17]

The optically active kenganthranol A (**2**) ($[\alpha]^{25}_{D}$ −23) was isolated as yellow crystals, and its molecular formula was established as $C_{25}H_{28}O_5$ by HREIMS. The compound reacted positively with $FeCl_3$ (dark green color in MeOH). The IR spectrum exhibited strong absorptions due to phenolic hydroxyls (3475 cm^{-1}) and hydrogen-bonded carbonyl groups (1605 cm^{-1}). The UV absorption maxima at 278 and 390 nm suggested that compound **2** was an anthrone derivative.[6,10] The ^{1}H NMR spectrum of **2** (Table 1) showed two chelated hydroxyl groups at δ 12.59 and 12.33, located at positions 1 and 8. The ^{1}H NMR spectrum of **2** exhibited aromatic proton signals at δ 6.83 and 6.41 (s, 1H), a singlet signal at δ 2.34 due to an aromatic methyl group, and a series of signals assignable to two 3,3-dimethylallyl groups [δ 5.18, 5.01 (1H, br s-like t, each olefinic protons); 3.70−3.41 (4H, m, methylene protons); 1.85, 1.82, 1.74, and 1.69 (3H, s, each olefinic methyls)]. The aromatic methyl was tentatively located at position 6 according to biogenetic considerations.[18,19] In the HMBC correlations, shown in Figure 1, the proton signal at δ 2.34 (aromatic methyl) showed correlations with C-5 (δ 131.0) and C-7 (δ 118.8) and one of the vinyl proton signals at δ 5.18 showed a correlation with C-5. Thus, one of the 3,3-dimethylallyl groups was located at position 5. Furthermore, the aromatic protons at δ 6.83 caused a cross-peak with C-5, whereas the other proton signal at δ 6.41 displayed a cross-peak with two oxygenated aromatic carbons at δ 162.9 and 163.6, indicating that the remaining 3,3-dimethylallyl group was located at position C-4. In the ^{13}C NMR spectrum, we observed the signal of only one carbonyl group at δ 193.2, and further investigation of the ^{1}H NMR spectra showed the presence of one proton signal exchangeable with D_2O at δ 2.10 (1H, d, $J = 6.2$) and a proton signal at δ 5.94 (1H, d, $J = 6.2$). In the HMBC spectrum, the signal at δ 5.94 displayed cross-peaks with the carbon signals at δ 131.0 (C-5), 112.2 (C-8a), 121.1 (C-4), and 107.3 (C-9a), and in the

Table 2. ^{13}C NMR Spectral Data of Kengaquinone (**1**) ($CDCl_3$, 125 MHz) and Kenganthranols A (**2**) ($CDCl_3$, 125 MHz), B (**3**) (CD_3OD, 100 MHz), and C (**4**) ($CDCl_3$, 100 MHz) (δ ppm)

C	1	2	3	4
1	187.7	163.6	163.5	165.5
2	123.7	102.1	114.2	98.0
3	154.9	162.9	162.3	167.0
4	179.5	121.1	119.0	119.8
4a	132.5	141.8	141.3	136.3
5	131.8	131.0	130.9	131.9
6	142.7	147.2	148.6	148.0
7	119.3	118.8	119.8	120.0
8	156.9	159.9	161.7	160.7
8a	114.1	112.2	108.5	114.6
9	167.0	193.2	193.2	191.1
9a	105.1	107.3	107.5	110.1
10	121.6	60.7	61.7	68.2
OCH_3				50.0
10a	132.4	139.2	140.8	135.5
11	27.5	26.7	27.9	27.4
12	122.3	122.5	124.3	122.4
13	134.6	132.2	134.5	132.0
14 (*Z*)	18.1	17.5	18.0	18.1
15 (*E*)	25.7	26.7	25.9	26.1
16	22.1	23.4	25.1	28.0
17	119.5	122.9	124.4	91.6
18	134.1	131.8	133.0	71.7
19 (*Z*)	17.9	17.3	18.0	24.9[a]
20 (*E*)	25.6	25.2	25.9	25.7[a]
CH_3-6	20.8	20.4	21.0	20.8
22			22.6	
23			123.0	
24			135.9	
25 (*Z*)			18.1	
26 (*E*)			25.9	

[a] Signals with the same sign may be interchanged.

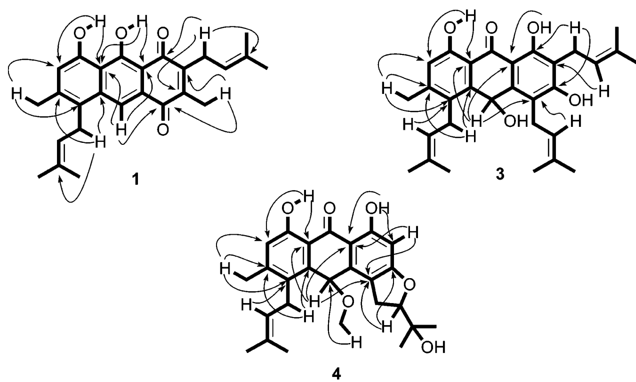

Figure 1. Important HMBC correlations of compounds **1**, **3**, and **4**.

COSY correlation we observed the ^3J correlation between the signal at δ 5.94 and 2.10. Thus, the hydroxyl group was assigned to be at C-10. The signal at δ 60.7 (C-10) in the ^{13}C NMR spectrum was in accordance with these findings. On the basis of the above evidence, the structure of kenganthranol A (**2**) was assigned to be 1,3,8-trihydroxy-6-methyl-4,5-bis(3,3-dimethylallyl)anthranol. The proposed structure was supported by comparison of the NMR data with those reported for harunganol A.[10]

Compound **3** ($[\alpha]^{25}_D$ +12.5), isolated as a yellow powder, showed a yellow fluorescence under UV light (254 nm) and gave a green color (in MeOH) with $FeCl_3$ solution. The molecular formula was determined as $C_{30}H_{36}O_5$ from HREIMS ($[M]^+$ at *m*/*z* 476.2541) in conjunction with the NMR spectra. The IR spectrum of compound **3** indicated the presence of two hydroxyl groups (3446 and 3440 cm^{-1}) and a chelated carbonyl (1602 cm^{-1}). The UV−vis absorption bands at λ_{max} 279 and 389 nm were in agreement with an anthronoid skeleton.[6,10] Comparison of the ^{1}H NMR spectrum of **3** with that of **2** showed that the singlet at δ 6.41 assigned to H-2 of kenganthranol A (**2**) was missing. The spectrum of **3**, however, did show a spin system that could be assigned to one additional 3,3-dimethylallyl group [δ 5.24 (1H, t, J = 6.9, olefinic protons), 3.44 (2H, d, J = 6.9, methylene protons), 1.84 and 1.75 (3H, s, both olefinic methyls)]. This was supported by the ^{13}C NMR spectrum, displaying signals of one olefinic carbon (δ 123.0), one methylene group (δ 22.6), and two methyl groups (δ 25.9 and 18.1). The additional prenyl group can be at either C-2 or C-7. However, the location of this group was readily established from HMBC studies (Figure 1), where the methylene proton signal at δ 3.44 showed correlations with the two oxygenated aromatic carbon signals at δ 162.3 (C-3) and 163.5 (C-1), demonstrating that this group should be at position 2. Accordingly, kenganthranol B (**3**) was characterized as (+)-1,3,8,10-tetrahydroxy-6-methyl-2,4,5-tris(3,3-dimethylallyl)anthrone. The ^{13}C NMR signals (Table 2) of **3** were fully assigned using DEPT, HMQC, and HMBC spectra and by comparison with the published values for harongin anthrone.[5,6]

Compound **4** was obtained as yellow crystals. It was also optically active ($[\alpha]^{25}_D$ +6.25) and showed the molecular ion at *m*/*z* 438.2010 in the HREIMS spectrum in agreement with the formula $C_{26}H_{30}O_6$. The observed molecular ion in the EIMS differed by 30 mass units from compound **2**. The IR spectrum showed characteristic absorption bands at 3731 and 3624 cm^{-1} due to hydroxyl groups, and the UV spectrum (bands at 280 and 389 nm) was closely related to those of compounds **2** and **3**, suggesting that **4** was also an anthranol derivative. The ^{1}H NMR spectrum of this compound exhibited the presence of one prenyl group [δ 4.93 (1H, br t, olefinic proton); 3.36 (2H, m, methylene proton); 1.80 and 1.69 (each 3H, s, both olefinic methyls)] and a 1-hydroxy-1-methylethyldihydrofuran ring [δ 4.77 (1H, dd, J = 7.6, 9.0, oxymethine proton); 3.75 (1H, dd, J = 9.0, 15.7, methylene proton); 3.08 (1H, dd, J = 7.6, 15.7, methylene proton); 1.36 and 1.22 (each 3H, s, gem-dimethyl protons)]. The presence of the hydroxy methylethyldihydrofuran ring was supported by the ^{13}C NMR, which displayed the following signals: δ 91.6 (oxymethine carbon), 71.7 (oxygenated sp^3 carbon), 28.9 (methylene carbon), 24.9 and 25.7 (gem-dimethyl carbon). The prenyl group was deduced to be attached at C-5 on the basis of ^2J and ^3J interactions between the methylene protons (δ 3.36) and C-5 (δ 131.9), C-6 (δ 148.0), and C-10a (δ 135.5). A long-range correlation between the methylene protons at δ 3.75 and 3.08 and C-4a and C-3 established the dihydrofuran moiety to be placed at C-3−C-4. The ^{1}H NMR also indicated signals for one aromatic methyl group at δ 2.32 and two sharp singlet signals of aromatic protons at δ 6.83 and 6.39, assignable to H-7 and H-2. Furthermore, the spectrum of **4** showed one methoxyl group at δ 2.74. The unusual upfield shift of this group suggested that it was located at the C-10 position, as demonstrated by Dimmel.[20] This hypothesis was supported by the correlation of the proton signal at δ 2.74 with C-10 (δ 68.2) in the HMBC spectra. Thus, the structure of kenganthranol C (**4**) was determined to be (+)-1,8-dihydroxy-3,4-[2-(1-hydroxy-1-methylethyl)dihydrofurano]-6-methyl-10-methoxy-5-(3,3-dimethylallyl)-anthrone. The proposed structure was supported by HMBC (Figure 1), but the relative configuration of the two chiral centers at C-10 and C-17 has not been established.

All of these compounds are presumed to be formed via the acetate/malonate pathway for the aromatic skeleton, followed by prenylation. The new compounds (**1**−**4**) may occur by specific oxidations, reductions, and/or cyclization of the corresponding prenylated emodin anthrone, which in turn is derived from **5**, the major constituent of the plant.

Because the hexane extract of the stem bark of *H. madagascariensis* showed strong α-glucosidase enzyme inhibitory activity, the isolated compounds available in sufficient quantity (**3**−**5**, **7**−**11**) were evaluated for their α-glucosidase inhibition activity. The

Table 3. α-Glucosidase Inhibition of Compounds **3**−**5** and **7**−**11** with Deoxynojirimycin and Acarbose as Standards

compound	α-glucosidase inhibition IC_{50} ± SEM (μM)
3	6.3 ± 0.23
4	21.9 ± 1.20
5	6.0 ± 0.093
7	not active[a]
8	192.3 ± 0.00
9	not active[a]
10	not active[a]
11	12 ± 0.29
deoxynojirimycin	425.6 ± 8.14
acarbose	780 ± 0.028

[a] No inhibition at 800 μM concentration.

compounds inhibited α-glucosidase in a dose-dependent fashion, and results are shown in Table 3.

Compound **3** of the anthranol series showed the highest inhibition at 6.3 ± 0.23 μM, which is twice as active as compound **11** (12 ± 0.29 μM) and ca. 2 orders of magnitude higher than established inhibitors such as deoxynojirimycin or acarbose (Table 3). Perhaps the prenyl group at C-2 is more important for activity than that at C-7. The anthrafurane **4** is less active (21.9 ± 1.2 μM) than the anthranols **5** and **11** despite the presence of a prenyl group. Interestingly, the simpler, nonprenylated anthraquinone, the emodine derivative **8**, also showed some inhibitory activity (192.3 ± 0.00 μM). However, compounds **7** and **9**, with bulky 3-methylbutenyl and 3-methyl-2-oxo-butyl groups at C-2, were not active. Most of the compounds, but in particular the anthranols **2**−**4** and anthrone **11**, showed significantly higher activities than deoxynojirimycin (425.6 ± 8.14 μM), which is one of the most potent α-glucosidase enzyme inhibitors, and acarbose (780 ± 0.26 μM), a widely used clinically useful drug. The exceptionally high α-glucosidase enzyme inhibitory activity makes the anthranols **2**−**4** and anthrone **11** interesting leads for drug development.

Experimental Section

General Experimental Procedures. Melting points were determined on a Büchi 535 melting point apparatus and are uncorrected. IR spectra were recorded on a JASCO 302-A spectrophotometer in $CHCl_3$. UV spectra were obtained on a Hitachi UV 3200 spectrophotometer. EIMS (ionization voltage 70 eV) was measured on a Varian MAT 311 A mass spectrometer, and HREIMS were taken on a JEOL HX 110 mass spectrometer. 1D and 2D NMR spectra were run on Bruker AMX 400 and AMX 500 MHz NMR spectrometers. The chemical shifts are given in ppm (δ), relative to TMS as internal standard, and coupling constants are in Hz. Optical rotations were measured on a JASCO DIP-360 digital polarimeter using a 10 cm cell. Column chromatography was carried out on silica gel (70−230 mesh, Merck) and flash silica gel (230−400 mesh, Merck). TLC was performed on Merck precoated silica gel 60 F_{254} aluminum foil, and spots were detected using ceric sulfate spray reagent. A Molecular Devices spectrophotometer was used for measurement of enzyme inhibition.

Plant Material. The stem bark of *Harungana madagascariensis* was collected in Bandjoun, Western Province of Cameroon, district Keng, by Mr. Nana (National Herbarium of Yaounde, Cameroon), and the plant specimens were compared with the herbarium specimen (HNC 32358).

Extraction and Isolation. The air-dried and ground stem bark of *H. madagascariensis* (4.2 kg) was extracted twice with pure MeOH (48 and 6 h) at room temperature. The resulting extract was concentrated under vaccum to obtain a crude extract (456.5 g), which was reextracted with hexane follow by ethyl acetate. The hexane-soluble part (120 g) was chromatographed over 400 g of silica gel and eluted with hexane−EtOAc with gradient polarity (0−30%). Ninety-eight fractions, each of ca. 500 mL, were collected. The fractions obtained with hexane−ethyl acetate (98:2) elution gave compound **11** (160 mg).

The fraction obtained with hexane−ethyl acetate (96:4) elution was subjected to silica gel chromatography using pure hexane and a mixture of hexane−ethyl acetate with gradient polarity, yielding a total of 125 fractions of ca. 100 mL, which were combined on the basis of TLC analysis to five subfractions (I−V). Fraction III obtained with hexane−ethyl acetate (98:2) gave a yellow crystalline mixture of **6** and **7**. These two compounds could be separated by slightly different solubilities in hexane−ethyl acetate (98:2) into **6** (35 mg) and **7** (27 mg). Fractions IV (250 mg) and V (70 mg) were combined on the basis of TLC and were chromatographed on silica gel using hexane−ethyl acetate with an increasing ratio of ethyl acetate (1−6%) to obtain 18 fractions. Fractions 9−13 were combined and rechromatographed over a silica gel column using hexane−ethyl acetate (98:2) to obtain again compounds **6** and **7** and compounds **2** (15 mg) and **3** (7 mg). Fractions 15−17 were combined and chromatographed on silica gel using hexane−ethyl acetate (97.5:2.5) as solvent to obtain compound **5** (175 mg).

The fraction (20.6 g) obtained with hexane−ethyl acetate (9:1) was rechromatographed on a silica gel column using a mixture of hexane−ethyl acetate with increasing polarity. A total of 62 fractions ca. 50 mL each were collected and combined on the basis of TLC analysis. Fractions 3−6 (15.5 mg), obtained with 4% hexane−ethyl acetate, were repeatedly subjected to silica gel column chromatography using increasing concentrations of ethyl acetate in hexane as eluent to give compounds **1** (5.2 mg) and **2** (8.7 mg). Fractions 8−12 (200 mg), obtained with hexane−ethyl acetate (94:6), were rechromatographed over silica gel column chromatography and eluted with hexane−ethyl acetate (96:4). From this column, compounds **4** (10.2 mg), **8** (33.6 mg), **9** (22.3 mg), and **10** (70.3 mg) were obtained in hexane−ethyl acetate (96:4).

Kengaquinone [(3,8,9-trihydroxy-6-methyl-2,5-bis(3,3-dimethylallyl)-1,4-anthraquinone] (1): dark violet gummy pigment from hexane; UV (MeOH) λ_{max} (log ϵ) 231 (4.58), 237 (4.59), 258 (4.62), 371 (4.78), 433 (4.85) nm; IR ($CHCl_3$) ν 3416, 3380, 3323, 2923, 1720, 1606, 1438, 1378, 1230, 1100, 1031, 753 cm^{-1}; ^1H and ^{13}C NMR data, see Tables 1 and 2; EIMS *m/z* 406 $[M]^+$ (12), 391 (16), 363 (18), 350 (64), 335 (100), 333 (13), 321 (23), 309 (10), 307 (20), 225 (10), 165 (12), 95 (10), 83 (21), 71 (19); HREIMS *m/z* 406.1739 (calcd for $C_{25}H_{26}O_5$, 406.1780).

Kenganthranol A [(−)-1,3,8-trihydroxy-6-methyl-4,5-bis(3,3-dimethylallyl)anthranol] (2): yellow crystals from hexane−ethyl acetate; mp 183−185 °C; $[\alpha]^{25}_D$ −23 (*c* 0.26, CH_3COCH_3); UV (MeOH) λ_{max} (log ϵ) 278 (4.2), 390 (4.4) nm; IR ($CHCl_3$) ν 3729, 3475, 3150, 2969, 2918, 1634, 1605, 1469, 1386, 1264, 1190, 1095, 856, 776 cm^{-1}; ^1H and ^{13}C NMR data, see Tables 1 and 2; EIMS *m/z* 408 $[M]^+$ (4), 390 (29), 375 (9), 352 (34), 336 (70), 319 (62), 309 (48), 296 (32), 293 (19), 280 (100), 268 (12), 253 (9), 236 (7), 219 (4), 211 (5), 202 (5), 189 (6), 179 (5), 165 (10), 149 10), 111 (12), 83 (19), 69 (28); HREIMS *m/z* 408.1889 (calcd for $C_{25}H_{28}O_5$, 408.1936).

Kenganthranol B [(+)-1,3,8,10-tetrahydroxy-6-methyl-2,4,5-tris-(3,3-dimethylallyl)anthrone] (3): yellow crystals from hexane−ethyl acetate; mp 176−181 °C; $[\alpha]^{25}_D$ +12.5 (*c* 0.01, CH_3COCH_3); UV (MeOH) λ_{max} (log ϵ) 279 (3.87), 389 (3.98) nm; IR ($CHCl_3$) ν 3749, 3446, 2964, 2922, 2858, 1602, 1460, 1384, 1271, 1205, 1095, 1035, 948, 777 cm^{-1}; ^1H and ^{13}C NMR data, see Tables 1 and 2; EIMS *m/z* 476 $[M]^+$ (5), 458 (37), 443 (20), 420 (18), 404 (70), 402 (59), 387 (100), 377 (73), 364 (54), 348 (84), 333 (31), 331 (53), 321 (45), 319 (49), 308 (47), 305 (44), 293 (77), 281 (21), 255 (7), 215 (8), 167 (8), 152 (11), 105 (14), 69 (82), 55 (49); HREIMS *m/z* 476.2541 (calcd for $C_{30}H_{36}O_5$, 476.2562).

Kenganthranol C [(+)-1,8-dihydroxy-3,4-[2-(1-hydroxy-1-methylethyl)dihydrofurano]-6-methyl-10-methoxy-5-(3,3-dimethylallyl)-anthrone] (4): yellow crystals from hexane−ethyl acetate; mp 194 °C; $[\alpha]^{25}_D$ +6.25 (*c* 0.16, CH_3COCH_3); UV (MeOH) λ_{max} (log ϵ) 280 (4.00), 316 (3.83), 389 (4.21) nm; IR ($CHCl_3$) ν 3731, 3624, 2976, 2928, 1715, 1638, 1612, 1579, 1471, 1400, 1294, 1241, 1164, 1061, 670 cm^{-1}; ^1H and ^{13}C NMR data, see Tables 1 and 2; EIMS *m/z* 438 $[M]^+$ (4), 406 (100), 391 (9), 382 (30), 373 (13), 367 (25), 352 (67), 349 (26), 331 (15), 319 (23), 309 (15), 305 (20), 293 (31), 289 (10), 265 (10), 251 (6), 235 (6), 202 (6), 165 (7); HREIMS *m/z* 438.2010 (calcd for $C_{26}H_{30}O_6$, 438.2042).

Enzyme Inhibition Assay. The α-glucosidase inhibition assay was performed according to the slightly modified method of Oki et al.[21] α-Glucosidase (E.C.3.2.1.20) from *Saccharomyces* sp. was purchased from Wako Pure Chemical Industries Ltd. (Wako 076-02841). The inhibition was measured spectrophotometrically at pH 6.9 and at 37 °C using 0.5 μM *p*-nitrophenyl α-D-glucopyranoside (PNP-G) as a

substrate and 250 units/mL of enzyme, in 50 mM sodium phosphate buffer containing 100 mM NaCl. 1-Deoxynojirimycin (0.425 mM) and acarbose (0.78 mM) were used as positive controls. The increment in absorption at 400 nm due to the hydrolysis of PNP-G by α-glucosidase was monitored continuously with a spectrophotometer (Molecular Devices).

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