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Scalemic caged xanthones isolated from the stem bark extract of Garcinia propinqua

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Abstract

Seven new caged xanthones, doitunggarcinones E–K (1–7), all as scalemic mixtures and 10 known compounds (8–17), were isolated from the stem bark extract of *Garcinia propinqua*. The structures were elucidated on the basis of spectroscopic methods. The separation of the enantiomers of 1–6 was achieved by semipreparative chiral HPLC. The absolute configuration of compound (+)-1 was determined by single-crystal X-ray crystallographic analysis using Cu Kα radiation. The absolute configurations of the other related compounds were determined from comparisons of their ECD spectra with that of compound (+)-1. Compounds (−)-6 and 7 showed cytotoxicity against a colon cancer cell line with IC_{50} values of 14.23 and 23.95 μM, respectively.

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Scalemic Caged Xanthones Isolated from the Stem Bark Extract of *Garcinia propinqua*

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ABSTRACT: Seven new caged xanthones, doitunggarcinones E-K (**1-7**), all as scalemic mixtures and 10 known compounds (**8**–**17**), were isolated from the stem bark extract of *Garcinia propinqua*. The structures were elucidated on the basis of spectroscopic methods. The separation of the enantiomers of **1**-**6** was achieved by semi-preparative chiral HPLC. The absolute configuration of compound (+)-**1** was determined by single-crystal X-ray crystallographic analysis using Cu Kα radiation. The absolute configurations of the other related compounds were determined from comparisons of their ECD spectra with that of compound (+)-**1**. Compounds (–)-**6** and **7** showed cytotoxicity against a colon cancer cell line with IC_{50} values of 14.23 μM and 23.95 μM, respectively.

The *Garcinia* genus belongs to the Clusiaceae family, which is found mainly in tropical and subtropical countries. This genus is well known as a rich source of xanthones,[1-10] caged xanthones,[11-21] flavonoids,[22] terpenoids,[23] biphenyls,[24-25] and benzophenones.[26-30] Many of these compounds have a wide range of biological and pharmacological activities, including antimicrobial,[29,31] antidepressant,[29] anti-HIV,[29,32] antibacterial,[2,3,9,10,18,22] and cytotoxic activities.[6,8,12-17,27,29] In a previous paper we reported the isolation of xanthones, caged xanthones, and rearranged benzophenones from the twig and root extracts of *Garcinia propinqua* collected from Doi Tung, Chiang Rai Province, Thailand.[2,33] Herein, the isolation and identification of seven new caged xanthones, doitunggarcinones E-K (**1**–**7**), as scalemic mixtures, together with 10 known compounds (**8**–**17**) from the stem bark extract of *G. propinqua* are reported. The isolated compounds were also assayed for their cytotoxicities against a colon cancer cell line.

RESULTS AND DISCUSSION

A MeOH extract of the stem bark of *G. propinqua* was dissolved in H_2O and partitioned with CH_2Cl_2 and EtOAc. A combination of the CH_2Cl_2 and EtOAc extracts was separated by chromatographic techniques resulting in the isolation of seven new caged xanthones (**1**–**7**) together with 10 known compounds, xerophenone A (**8**),[34] doitunggarcinones A (**9**)[2,35] and B (**10**),[2,35] sampsonione B (**11**),[36] 7*β*-H-11-benzoyl-5*α*-hydroxy-6,6,10,10-tetramethyl-1-(3-methyl-2-butenyl)tetracyclo[7.3.1.$1^{3,11}$0^{3,7}]tetradecane-2,12,14-trione (**12**),[37] hypersampsone M (**13**),[38] assiguxanthone A (**14**),[39] cudraxanthone Q (**15**),[40] 10-*O*-methylmacluraxanthone (**16**),[41] and 5-*O*-methylxanthone V_1 (**17**).[12]

Compound **1** was obtained as a white solid (m.p. 183-185 °C) which showed a protonated molecular ion at *m/z* 527.2643 $[M+H]^+$ (calcd for 527.2645) in the ESITOFMS corresponding to a molecular formula of $C_{30}H_{38}O_8$. The UV spectrum showed absorption bands at λ_{max} 219, 232, 239, 295, and 342 nm while the IR spectrum indicated the presence of

a hydroxy group at 3415 cm^{-1} and conjugated carbonyl group at 1639 cm^{-1}. The presence of carbonyl group was confirmed by the ^{13}C NMR resonance at δ_C 196.1 (C-9). Some of the NMR chemical shifts of compound **1** (Tables 1, 2, S1 and Figures S1-S7, Supporting Information) were similar to those of the 8,8a-dihydro caged xanthone, 1-*O*-methyl-8-methoxy-8,8a-dihydrobractatin, isolated from the leaves of *G. bracteata*.[15] The core structure of **1** was deduced from the following NMR spectroscopic data which show resonances for an H-bonded hydroxy proton [δ_H 12.39 (1H, s, OH-1)], an isolated aromatic proton [δ_H 6.08 (1H, s, H-2)/δ_C 93.4], three methine protons [δ_H 4.00 (1H, dd, J = 4.4, 2.6 Hz, H-8)/δ_C 79.3, δ_H 3.01 (1H, d, J = 4.4 Hz, H-8a)/δ_C 48.6 and δ_H 2.41 (1H, m, H-7)/δ_C 31.6], a caged unit, –$OC(Me)_2CHCH_2C$–, [δ_H 2.26 (1H, dd, J = 15.2, 5.2 Hz, H-21a)/δ_C 25.1, δ_H 2.22 (1H, d, J = 10.2 Hz, H-22)/δ_C 43.2, δ_H 1.41 (1H, dd, J = 15.2, 10.2 Hz, H-21b)/δ_C 25.1, δ_H 1.33 (3H, s, H_3-24)/δ_C 30.2, and δ_H 1.26 (3H, s, H_3-25)/δ_C 27.2], two methoxy groups [δ_H 3.79/δ_C 55.4 and δ_H 3.53/δ_C 71.1], a $–CH_2CH(O)C(O)(CH_3)_2$ moiety [δ_H 4.21 (1H, d, J = 4.7 Hz, H-17)/δ_C 81.5, 2.33 (1H, dd, J = 13.4, 4.7 Hz, H-16a), 2.09 (1H, d, J = 13.4 Hz, H-16b)/δ_C 33.7, 1.56 (3H, s, H-19)/δ_C 21.6 and 1.33 (3H, s, H-20)/δ_C 28.9], and a 1,1-dimethylallyl group [δ_H 6.12 (1H, dd, J = 17.4, 10.8 Hz, H-12)/δ_C 150.3, δ_H 4.80 (1H, dd, J = 17.4, 1.2 Hz, H-13a), δ_H 4.79 (1H, dd, J = 10.8, 1.2 Hz, H-13b)/δ_C 107.6, δ_H 1.54 (3H, s, H_3-15)/δ_C 30.6, and δ_H 1.51 (3H, s, H_3-14)/δ_C 28.2]. Several differences were also found between the NMR spectra of **1** and those of 1-*O*-methyl-8-methoxy-8,8a-dihydrobractatin. Compound **1** displayed resonances for an H-bonded hydroxy group at C-1 and a methoxy group at C-3 while the latter compound had methoxy and hydroxy groups at C-1 and C-3, respectively. While 1-*O*-methyl-8-methoxy-8,8a-dihydrobractatin has a common prenyl group, $–CH_2CH=C(CH_3)_2$, at C-5 and a carbonyl functionality at C-6, the prenyl group in **1** has presumably been oxidized to a 1,2-diol and subsequently formed an intramolecular ketal group at C-6. These structural features were evident from HMBC experiments (Figure 2 and Table S1, Supporting Information)

which showed cross-peaks of H-17 (δ_H 4.21) and H-16b (δ_H 2.09) with C-5 (δ_C 89.5) and C-6 (δ_C 115.3); δ_H 12.39 (OH-1) with C-1 (δ_C 162.5), C-2 (δ_C 93.4), and C-9a (δ_C 102.1); and OMe-3 (δ_H 3.79) with C-3 (δ_C 168.0). All assignments of the ^{1}H and ^{13}C spectroscopic data of **1** are summarized in Tables 1 and 2.

In 2014, Boonak and co-workers reported that three natural caged xanthones from the roots of *Cratoxylum formosum* ssp. *pruniflorum* were scalemic mixtures with enantiomeric ratios ranging from 1.1:1 to 1.9:1.[42] Thus, compound **1** was further analyzed by chiral HPLC which showed peaks for two enantiomers at t_R 8 and 15 min in an approximate ratio of 1:2 (Figure S55, Supporting Information). These two enantiomers were separated by semi-preparative chiral HPLC to afford **(+)-1** (t_R 8 min), $[\alpha]_D^{24}$ +56.3 (*c* 0.096, $CHCl_3$), and (–)-**1** (t_R 15 min), $[\alpha]_D^{24}$ –42.8 (*c* 0.1, $CHCl_3$). These enantiomers had identical ^{1}H NMR spectra. Enantiomer (+)-**1** crystallized from MeOH/CH_2Cl_2 (4:1, v/v) to give a single crystal that was subjected to X-ray diffraction analysis using Cu Kα radiation to determine its absolute configuration. Compound (+)-**1** formed colorless plate orthorhombic crystals, with a = 9.2535(2) Å, b = 11.5385(3) Å, c = 24.9217(7) Å, α = 90°, β = 90°, γ = 90°, v = 2660.93(12) Å, and chiral group $P2_12_12_1$, z = 4. From the X-ray data analysis (CCDC 1539179), the absolute configuration of (+)-**1** was established as (*5S, 6R, 7R, 8R, 8aS, 10aR, 17R*, *22S*) with a Flack x-parameter of 0.01(6) (Figure 3).

Thus, the absolute configuration of (–)-**1** was assigned as (*5R, 6S, 7S, 8S, 8aR, 10aS, 17S*, *22R*). The ECD spectrum of compound (+)-**1** showed a negative Cotton effect around 233 nm and a positive Cotton effect around 304 nm while the ECD spectrum of compound (–)-**1** displayed Cotton effects of the opposite signs (Figure 4). Thus, compounds **(+)-1** and **(–)-1** were assigned the names, (+)-doitunggarcinone E and (−)-doitunggarcinone E, respectively.

Compound **2**, doitunggarcinone F, was obtained as a white solid with m.p. 202-205 °C. Its molecular formula, $C_{30}H_{38}O_7$, was deduced from ESITOFMS analysis which showed

an $[M+Na]^+$ ion at *m/z* 533.2507 (calcd for 533.2515). The UV, IR, and NMR spectroscopic data (Tables 1, 2, S2 and Figures S9-S15, Supporting Information) of **2** were also similar to those of 1-*O*-methyl-8-methoxy-8,8a-dihydrobractatin[15] and **1**. The only difference between the former compound and **2** was the positions of the hydroxy and methoxy groups at C-1 and C-3. Compound **2** had these groups at C-1 and C-3, respectively, the same as found in compound **1**. The C-6 carbonyl carbon (δ_C 209.2) and the C-5 prenyl group [δ_H 5.29 (1H, t, *J* = 7.8 Hz, H-17)/δ_C 118.0, δ_H 2.88 (1H, m, H-16), δ_H 2.75 (1H, dd, *J* = 14.0, 9.5 Hz, H-16)/δ_C 28.0, δ_H 1.67 (3H, s, H_3-20)/δ_C 26.1 and δ_H 1.63 (3H, s, H_3-19)/δ_C 18.1] in compound **2** were clearly evident. Detailed assignments of the ^1H and ^{13}C spectroscopic data of **2** are summarized in Tables 1 and 2.

Compound **2** was further analyzed and separated by chiral HPLC to yield (+)-**2** [t_R 14 min, $[\alpha]_D^{24}$ +78.5 (*c* 0.1, $CHCl_3$)] and (−)-**2** [t_R 20 min, $[\alpha]_D^{24}$–92.4 (*c* 0.1, $CHCl_3$)] in an approximate ratio of 1:2 (Figure S55, Supporting Information). The absolute configurations of (+)-**2** and (−)-**2** were established by comparing their ECD spectra (Figure 4) with those of compounds (+)-**1** and (−)-**1**. The similarity of the ECD spectra of compounds (+)-**2** and (+)-**1** and those of (−)-**2** and (−)-**1** indicating the absolute configuration of (*5S, 7R, 8R, 8aS, 10aR, 22R*) for (+)-**2** and (*5R, 7S, 8S, 8aR, 10aR, 22S*) for (−)-**2**. Compounds (+)-**2** and (−)-**2** were give the names (+)-doitunggarcinone F and (−)-doitunggarcinone F, respectively.

Compound **3** was isolated as a white solid with m.p. 172-174 ^oC. Its molecular formula, $C_{30}H_{38}O_8$, was deduced from ESITOFMS analysis which showed an $[M+Na]^+$ ion at *m/z* 549.2460 (calcd for 549.2464). The UV, IR and NMR spectroscopic data of compound **3** (Tables 1, 2, S3 and Figures 17-23, Supporting Information) were similar to those of **2** indicating a caged xanthone core structure. The major differences observed in the ^1H and ^{13}C NMR spectroscopic data (Tables 1 and 2) of **2** and **3** were that compound **3** displayed resonances for an (*E*)-3-hydroxy-3-methyl-1-butenyl moiety [δ_H 6.18 (1H, d, *J* = 16.0 Hz, H-

17)/δ_C 144.6, δ_H 5.75 (1H, d, J = 16.0 Hz, H-16)/δ_C 117.7, δ_H 1.36 (3H, s, H_3-20)/δ_C 29.9 and δ_H 1.35 (3H, s, H_3-19)/δ_C 29.5] instead of resonances for a prenyl group evident in the ^{1}H NMR spectroscopic data of **2**. This structure was confirmed by the following HMBC cross-peaks: H-16 (δ_H 5.75) with C-5 (δ_C 88.1), C-6 (δ_C 208.6), C-17 (δ_C 144.6) and C-18 (δ_C 71.1); H-17 (δ_H 6.18) with C-5 (δ_C 88.1), C-16 (δ_C 117.7), and C-17 (δ_C 144.6); and Me-19 (δ_H 1.35)/Me-20 (δ_H 1.36) with C-18 (δ_C 71.1) and C-17 (δ_C 144.6) (Figure 2 and Table S3, Supporting Information). Compound **3** was resolved by chiral HPLC yielding (+)-**3** [t_R 17 min, $[\alpha]_D^{24}$ +39.3 (*c* 0.1, $CHCl_3$)] and (−)-**3** [t_R 30 min, $[\alpha]_D^{24}$–48.5 (*c* 0.1, $CHCl_3$)] in a ratio of 1.2:2. The absolute configurations of compounds (+)-**3** (*5S, 7R, 8R, 8aS, 10aR, 22R*) and (−)-**3** (*5R, 7S, 8S, 8aR, 10aR, 22S*) were established by comparison of their ECD spectra (Figure 4) with those of (+)-**2** and (−)-**2**, respectively. Compounds (+)-**3** and (−)-**3** were named, (+)-doitunggarcinone G and (−)-doitunggarcinone G, respectively.

Compound **4**, a white solid with m.p. 162-163 ^oC, showed an $[M+Na]^+$ ion at *m/z* 567.2571 (calcd for 567.2570) in ESITOFMS corresponding to a molecular formula of $C_{30}H_{40}O_9$. The UV, IR, and NMR spectroscopic data of **4** (Tables 1, 2, S4 and Figures 25-31, Supporting Information) were similar to those of compound **2** except that the $\Delta^{17(18)}$ double bond in **2** changed to a 3-methylbutan-2,3-diol moiety in **4** [δ_H 4.11 (1H, dd, J = 9.1, 7.1 Hz, H-17)/δ_C 82.4, δ_H 2.80 (1H, dd, J = 15.0, 9.1 Hz, H-16a), δ_H 1.99 (1H, dd, J = 15.0, 7.1 Hz, H-16b)/δ_C 28.9, δ_H 1.33 (3H, s, H-19)/δ_C 28.5 and δ_H 1.12 (3H, s, H-20)/δ_C 24.2]. This structure was further supported by the following HMBC cross-peaks: H-16a (δ_H 2.80) with C-5 (δ_C 92.6), C-10a (δ_C 88.6), C-17 (δ_C 82.4), and C-18 (δ_C 70.1); and Me-19 (δ_H 1.33)/Me-20 (δ_H 1.12) with C-17 (δ_C 82.4) and C-18 (δ_C 70.1) (Figure 2 and Table S4, Supporting Information). The NOESY spectrum showed cross peaks between H-8a/H-16 and between H-8/H-21/H-22 which supported the caged bridge-head orientation. Resolution of compound **4** by chiral HPLC gave (+)-**4** [t_R 9 min, $[\alpha]_D^{24}$ +90.7 (*c* 0.1, $CHCl_3$)] and (−)-**4** [t_R 11 min, $[\alpha]_D^{24}$–

75.6 (*c* 0.1, $CHCl_3$)] in a ratio of 2:1.6 (Figure S55, Supporting Information). The absolute configuration of compound (+)-**4** was identified as (*5S, 7R, 8R, 8aS, 10aR, 22R*) since its ECD spectrum (Figure 4) was similar to those of compounds (+)-**1**, (+)-**2**, and (+)-**3** while the configuration of compound (−)-**4** was identified as (*5R, 7S, 8S, 8aR, 10aR, 22S*) from its ECD spectrum (Figure 4) which displayed Cotton effects of the opposite sign to those of (+)-**4** and similar to those of compounds (−)-**1**, (−)-**2**, and (−)-**3**. Because of an insufficient quantity of (+)-**4** or (−)-**4**, the absolute configurations of these compounds at C-17 could not be determined. Compounds (+)-**4** and (−)-**4** were assigned the names, (+)-doitunggarcinone H and (−)-doitunggarcinone H, respectively.

Compound **5** was isolated as a white solid with m.p. 158-162 ^{o}C. Its molecular formula, $C_{30}H_{38}O_8$, was established from ESITOFMS analysis which showed an $[M+Na]^+$ ion at *m/z* 549.2466 (calcd for 549.2464). Its UV, IR, and NMR spectroscopic data (Tables 1, 2, S5 and Figures 33-39, Supporting Information) were similar to those of **4** except compound **5** had formally been dehydrated at C-18/C-19 to generate a 2-hydroxy-3-methylbut-3-enyl unit [δ_H 5.08 (1H, s, H-19a), δ_H 4.88 (1H, s, H-19b)/δ_C 112.1, δ_H 4.53 (1H, t, *J* = 8.1 Hz, H-17)/δ_C 79.3, δ_H 2.76 (1H, dd, *J* = 13.9, 6.2 Hz, H-16a), δ_H 2.10 (1H, m, H-16b)/δ_C 32.5, and δ_H 1.80 (3H, s, H-20)/δ_C 17.4] instead of the 3-methylbutan-2,3-diol group in **4**. Full assignments of the NMR spectroscopic data of **5** are summarized in Tables 1 and 2. Resolution of **5** by chiral HPLC afforded (+)-**5** [t_R 6 min, $[\alpha]_D^{24}$ +55.1 (*c* 0.1, $CHCl_3$)] and (−)-**5** (t_R 8 min, $[\alpha]_D^{24}$–65.2 (*c* 0.1, $CHCl_3$)] in a ratio of ca 2:1.6 (Figure S55, Supporting Information). The absolute configuration of (*5S, 7R, 8R, 8aS, 10aR, 22R*) for **(+)-5** and (*5R, 7S, 8S, 8aR, 10aS, 22S*) for (−)-**5** were established via the comparison of their ECD spectra (Figure 4) with those of (+)-**1**−(+)-**4** and (−)-**1**−(−)-**4**. Similar to **4**, the absolute configuration of compounds (+)-**5** or (−)-**5** at C-17 could not be determined due to the insufficient quantities of these samples.

Compounds (+)-**5** and (–)-**5** were assigned the trivial names (+)-doitunggarcinone I and (–)-doitunggarcinone I, respectively.

Compound **6** was isolated as a white solid with m.p. 175-178 °C. The ESITOFMS displayed an $[M+Na]^+$ ion at *m/z* 535.2313 (calcd for 535.2308) indicating the molecular formula of $C_{29}H_{36}O_8$. The UV, IR, and NMR spectroscopic data (Tables 1, 2, S6 and Figures 41-47, Supporting Information) were similar to those of **3**. The main structural differences involved the substituents at C-3 and C-4 of the aromatic moiety. Compound **6** displayed resonances for a 2,3,3-trimethyldihydrofuran unit [δ_H 4.37 (1H, m, H-12)/δ_C 90.9, δ_H 1.41 (3H, s, H_3-14)/δ_C 25.7, δ_H 1.37 (3H, d, J = 7.2 Hz, H_3-13)/δ_C 14.3, and δ_H 1.25 (3H, s, H_3-15)/δ_C 21.8].

Compound **6** was resolved by chiral HPLC to afford compounds (+)-**6** [t_R 30 min, $[\alpha]_D^{24}$ +82.3 (*c* 0.1, $CHCl_3$)] and (–)-**6** [t_R 34 min, $[\alpha]_D^{24}$–64.6 (*c* 0.1, $CHCl_3$)] in a ratio of 1.2:2 (Figure S55, Supporting Information). The (*5S, 7R, 8R, 8aS, 10aR, 22R*) absolute configuration of (+)-**6** and (*5R, 7S, 8S, 8aR, 10aR, 22S*) of (–)-**6** were established by comparison of their ECD spectra with those of (+)-**1**–(+)-**5** and (–)-**1**–(–)-**5**, respectively (Figure 4). Compounds (+)-**6** and (–)-**6** were named as (+)-doitunggarcinone J and (–)-doitunggarcinone J, respectively. The C-12 hydrogen in these compounds was too remote from the caged xanthone protons to permit definition of the absolute configuration at C-12 using NOESY data.

Compound **7** was also obtained as a white solid (m.p. 188-191 ^oC), with the molecular formula of $C_{28}H_{32}O_6$ determined from an $[M+Na]^+$ ion at *m/z* 487.2092 (calcd for 487.2097) in ESITOFMS. The UV, IR, as well as NMR spectroscopic data (Tables 1, 2, S7 and Figures 49-53, Supporting Information) of **7** were similar to those of cochinchinoxanthone isolated from *Cratoxylum cochinchinense* stems.[43] However, compound **7** showed additional resonances for a prenyloxy group [δ_H 4.57 (2H, m, H-11)/δ_C 65.2, δ_H 5.47 (1H, m, H-12)/δ_C

118.5, δ_H 1.83 (3H, s, H_3-14)/δ_C 25.4 and δ_H 1.78 (3H, s, H_3-15)/δ_C 17.9] located at C-3 instead of the hydroxy group in cochinchinoxanthone. The HMBC cross-peaks of H-2 (δ_H 6.11), H-4 (δ_H 6.08) and H-11 (δ_H 4.57) with C-3 (δ_C 167.6) supported the above structural feature (Figure 2 and Table S7, Supporting Information). Full details of the NMR spectroscopic data are summarized in Tables 1 and 2. Compound **7** was shown to be a 1:2 mixture of enantiomers by analytical chiral HPLC analysis but was not resolved because of the paucity of material. Compound **7** was named doitunggarcinone K.

The isolation of compounds **1**-**7** as scalemic mixtures may suggest that they have been synthesized via a series of non-enzymatic and enzymatic processes. Compounds **1-7** are presumably produced biosynthetically from **14** as shown in Scheme 1. The caged core structure could be obtained from xanthone **14** via *O*-prenylation at C-5 and C-6 (intermediate **14.1**), followed by a Claisen rearrangement (intermediate **14.2**) and then an intramolecular Diels-Alder reaction (intermediate **14.3**).[44] A further Claisen rearrangement of intermediate **14.3** could produce compound **7** whereas *O*-methylation at C-3 would produce intermediate **14.4**. Compounds **1**-**6** could then be obtained from intermediate **14.4** by a series of oxidation/dehydration processes. Using (+)-**2** as an example, a diastereoselective 1,2-dihydroxylation reaction of the $\Delta^{17(18)}$ double bond of (+)-**2** would produce (+)-**4** which upon intramolecular ketalization with the C-6 carbonyl group would give (+)-**1**. If this were the case then (+)-**4** should have a (17*R*) configuration, the same as (+)-**1** (from X-ray analysis). Compounds (+)-**3** and (+)-**5** could also arise from dehydration reactions of (+)-**4** and (+)-**5**, while (+)-**5** could arise directly from (+)-**2** via an allylic oxidation reaction with concomitant transposition of the double bond. Cyclization of the HO-3 onto the C-4 olefinic moiety, with concomitant or prior loss of the methyl group from the MeO-3, would give the dihydrofuran moiety of (+)-**6**.

All compounds were evaluated for their cytotoxicities against a colon cancer cell line. Only compounds (–)-**6** and **7** showed cytotoxicities with IC_{50} values of 14.23 and 23.95 μM, respectively (doxorubicin as positive control had an IC_{50} value of 9.74 μM). It is interesting to note that only the levorotatory enantiomer of (–)-**6** had cytotoxicity while its enantiomer was inactive.

Prenylated caged xanthones have been isolated and identified from many species of the *Garcinia* (Clusiaceae).[11-21,32,43,45-53] A few of these compounds have also been found in another genus of Clusiaceae, *Cratoxylum cochinchinesis*[54,55] and *C. formosum* ssp. *pruniflorum*.[42] Caged xanthones containing a $\Delta^{8(8a)}$ double bond, a carbonyl group at C-6, and the caged bridge-head at C-5/C-7/C-10a are commonly found in natural products.[11,13-19,21,32,42, 43, 45-55] while the differences of caged bridge-head (C-6/C-7/C-10a) and carbonyl group (C-5) are called neocaged xanthones which are rare compounds.[12,15,20,21,32,42] In addition, 8,8a dihydro caged xanthones like compounds **1**-**6**, are rarely found in Nature.[11,14-16,49-53] In this study, we have isolated six new scalemic dihydrocaged xanthones, doitunggarcinones E-J, from the stem bark extracts of *G. propinqua* that resolved by chiral HPLC. Additionally a new caged xanthone, doitunggarcinone K, was also isolated as a scalemic mixture. All compounds were evaluated for their cytotoxicities against a colon cancer cell line but only (–)-doitunggarcinone J and doitunggarcinone K, exhibited moderate cytotoxicities.

EXPERIMENTAL SECTION

General Experimental Procedures. Melting points were measured on a Buchi melting point B-540 visual thermometer. The optical rotations were measured with a Bellingham & Stanley APD440 polarimeter. The UV spectra were recorded with a Perkin-Elmer UV-Vis or Varian Cary 5000 UV-Vis-NIR spectrophotometers. Infrared (IR) spectra were recorded on a Perkin Elmer FTS FT-IR or Perkin Elmer Frontier Optica FT-IR

spectrophotometers. ECD spectra were recorded on a JASCO J-815 spectrometer. The 1D and 2D NMR spectra were recorded on a 400 MHz Bruker FT-NMR Ultra Shield and 600 MHz Bruker AV-600 spectrometers in $CDCl_3$ (δ_H 7.24 and δ_C 77.0) and/or acetone-d_6 (δ_H 2.05 and δ_C (CO) 206.2 and (CH_3) 30.6), with TMS as the internal standard. Chemical shifts are reported in parts per million (δ), and coupling constants (J) are expressed in hertz. ESI-QIT-MS spectra were measured on a Bruker-Hewlett-Packard 1100 Esquire-LC system mass spectrometer. HPLC was performed on a Waters 515 HPLC pump system liquid chromatography using the following columns: RP C_{18} CSC-Inertsil 150A/ODS-2 column (25 × 0.94 cm) and a CHIRALCEL OD-H column (4.6 × 250 mm). Quick column chromatography (QCC) and column chromatography (CC) were carried out on silica gel 60 H (5-40 μm, SiliCycle® Inc.) and silica gel 100 (63-200 μm, SiliCycle® Inc.), respectively. Sephadex LH-20 was also used for CC. Precoated plates of silica gel 60 F_{254} were used for analytical purposes.

Plant Material. The stem bark of *G. propinqua* was collected from Doi Tung, Chiang Rai Province, Thailand in September 2011, The plant was identified by Mr. Matin Van de Bult (Doi Tung Development Project, Chiang Rai, Thailand), and the specimen (MFU-NPR0090) was deposited at the Natural Products Research Laboratory, School of Science, Mae Fah Luang University.

Extraction and Isolation. Chopped and air-dried stem bark of *G. propinqua* (6.0 kg) was extracted with MeOH (2 × 10 L) at room temperature. The extract was evaporated under reduced pressure to give a brown gum (150 g) which was dissolved in H_2O and successively partitioned with CH_2Cl_2 and EtOAc. The CH_2Cl_2 and EtOAc extracts were combined (113 g) and subjected to QCC on silica gel using a gradient of hexanes and EtOAc (100% hexanes to 100% EtOAc) to afford compound **8** (36 mg) and 10 fractions (J1-J10). Fraction J2 (200 mg) was purified by CC (1:9 EtOAc/hexanes) to give compound **11** (3.2 mg). Fraction J3 (250

mg) was separated by CC 9 (1:9 acetone/hexanes) to obtain six subfractions (3J1-3J6). Subfraction 3J1 (50 mg) was further separated by CC (3:7 CH_2Cl_2/hexanes) to afford two subfractions (3J1A and 3J1B). Subfraction 3J1B (25 mg) was further isolated by HPLC using RP C_{18} CSC-Inertsil 150A/ODS-2 column, flow rate 2 mL/min, 4:1 MeOH/H_2O (acidified with 0.05% TFA) to give compound **2** (15 mg, t_R = 20 min). Subfraction 3J2 (20 mg) was purified by RP C_{18} HPLC (flow rate 2 mL/min, 4:1 MeCN-H_2O (acidified with 0.05% TFA) yielding compound **7** (2.2 mg, t_R = 25 min). Subfraction 3J6 (150 mg) was further purified by CC (1:9 acetone/hexanes) to give six subfractions (3J6-A-3J6F). Subfraction 3J6-E (110 mg) was further separated by Sephadex LH-20 (8:2 MeOH/CH_2Cl_2) to afford four subfractions (3J6-E1-3J6-E4). Subfraction 3J6-E2 (80 mg) was washed with hexanes and further purified by RP C_{18} HPLC (flow rate 2 mL/min, 4:1 MeCN-H_2O (acidified with 0.05% TFA) to afford compound **1** (13 mg, t_R = 31 min). The hexanes washing from subfraction 3J6-E2 (60 mg) was purified RP C_{18} HPLC (flow rate 2 mL/min, 4:1 MeCN/H_2O (acidified with 0.05% TFA) to give compounds **3** (14.0 mg, t_R 14 min), **4** (7.2 mg, t_R 17 min), **5** (10.3 mg, t_R 21 min), and **6** (10.5 mg, t_R 12 min). Fraction J4 (85 mg) was further separated by CC (1:9 acetone/hexanes) to yield compounds **9** (11.5 mg) and **10** (3.6 mg). Purification of fraction J5 (15 mg) by PLC (3:7 CH_2Cl_2/hexanes) gave compounds **15** (2.9 mg), **16** (3.0 mg), and **17** (4.5 mg). Fraction J6 (120 mg) was further separated by CC (1:4 acetone/hexanes) to yield compounds **12** (90.7 mg) and **13** (11.5 mg). Compound **14** (5.9 mg) was obtained from subfraction J8 (200 mg) by CC (1:19 EtOAc/hexanes).

*Doitunggarcinone E (**1**).* White solid, m.p. 183-185 ^{o}C; UV (MeOH) λ_{max} (log ε) 219 (4.04), 232 (3.89), 239 (3.72), 295 (3.91) and 342 (3.24) nm; IR (neat) ν_{max} 3415 and 1639 cm^{-1}; ^{1}H NMR ($CDCl_3$, 600 MHz) δand ^{13}C NMR data, see Tables 1 and 2; ESITOFMS *m/z* 527.2643 $[M+H]^+$ (calcd for $C_{30}H_{38}O_8$, 527.2645).

Chiral HPLC Separation and ECD Spectroscopic Data (+)-**1** and (–)-**1**: Separation of the two enantiomers of **1** (13.0 mg) was performed by semi-preparative HPLC on a chiral column (CHIRALCEL OD-H column, flow rate 2 mL/min, 49:1 *n*-hexane–*i*PrOH). Compound (+)-**1** (t_R = 8 min) [(4.8 mg), $[\alpha]_D^{24}$ +56.3 (*c* 0.1, $CHCl_3$)]; ECD (*c* 9.5×10^{-5} M, MeOH) λ_{max} ($\Delta\varepsilon$); 230 (-1.07×10^2), 233 (-1.05×10^2) and 304 ($+0.6\times10^2$) nm] and (–)-**1** (t_R = 15 mim) [(6.5 mg), $[\alpha]_D^{24}$ –42.8 (*c* 0.1, $CHCl_3$)]; ECD (*c* 9.7×10^{-5} M, MeOH) λ_{max} ($\Delta\varepsilon$); 233 ($+1.04\times10^2$), 238 ($+0.96\times10^2$) and 302 (-0.96×10^2) nm] were obtained.

*Doitunggarcinone F (**2**).* White solid, m.p. 202-205 °C; UV (MeOH) λ_{max} (log ε) 218 (4.11), 232 (3.91), 240 (3.67), 295 (3.98) and 341 (3.26) nm; IR (neat) ν_{max} 3414, 1710, 1636 cm^{-1}; ^1H NMR ($CDCl_3$, 600 MHz) and ^{13}C NMR data, see Tables 1 and 2; ESITOFMS *m/z* 533.2507 $[M+Na]^+$ (calcd for $C_{30}H_{38}O_7$, 533.2515).

Chiral HPLC Separation and ECD Spectroscopic Data (+)-**2** and (–)-**2**: Separation of the two enantiomers of **2** (15.0 mg) was performed by the method described for **1**, to give compound (+)-**2** (t_R = 14 min) [(5.5 mg), $[\alpha]_D^{24}$ +78.5 (*c* 0.1, $CHCl_3$)]; ECD (*c* 7.8×10^{-5} M, MeOH) λ_{max} ($\Delta\varepsilon$); 236 (-1.44×10^2) and 303 ($+1.96\times10^2$) nm] and (–)-**2** (t_R = 20 mim) [(5.2 mg), $[\alpha]_D^{24}$ –92.4 (*c* 0.1, $CHCl_3$)]; ECD (*c* 6.9×10^{-5} M, MeOH) λ_{max} ($\Delta\varepsilon$); 236 ($+1.76\times10^2$) and 303 (-2.37×10^2) nm].

*Doitunggarcinone G (**3**).* White solid, m.p. 172-174°C; UV (MeOH) λ_{max} (log ε) 218 (4.00), 230 (3.84), 240 (3.60), 295 (3.86) and 340 (3.20) nm; IR (neat) ν_{max} 3465, 1741, 1634 cm^{-1}; ^1H NMR ($CDCl_3$, 600 MHz) and ^{13}C NMR data, see Tables 1 and 2; ESITOFMS *m/z* 549.2460 $[M+Na]^+$ (calcd for $C_{30}H_{38}O_8$, 549.2464).

Chiral HPLC Separation and ECD Spectroscopic Data (+)-**3** and (–)-**3**: Separation of the two enantiomers of **3** (14.0 mg) was performed by the method described for **1**, yielding compound (+)-**3** (t_R = 17 min) [(6.2 mg), $[\alpha]_D^{24}$ +39.3 (*c* 0.1, $CHCl_3$)]; ECD (*c* 7.2×10^{-5} M, MeOH) λ_{max} ($\Delta\varepsilon$); 235 (-1.44×10^2), 241 (-1.17×10^2) and 305 ($+1.93\times10^2$) nm] and (–)-**3**

(t_R = 30 mim) [(5.1 mg), $[\alpha]_D^{24}$ −48.5 (*c* 0.1, $CHCl_3$)]; ECD (*c* 7.2×10^{-5} M, MeOH) λ_{max} (Δε); 236 ($+1.07\times10^2$), 240 ($+1.18\times10^2$) and 305 (-1.66×10^2) nm].

*Doitunggarcinone H (**4**).* White solid, m.p. 162-164°C; UV (MeOH) λ_{max} (log ε) 219 (4.04), 232 (3.88), 240 (3.89), 294 (3.92) and 340 (3.25) nm; IR (neat) ν_{max} 3407, 1714, 1636 cm^{-1}; ^1H NMR ($CDCl_3$, 600 MHz) and ^{13}C NMR data, see Tables 1 and 2; ESITOFMS *m/z* 567.2571 $[M+Na]^+$ (calcd for $C_{30}H_{40}O_9$, 567.2570).

Chiral HPLC Separation and ECD Spectroscopic Data (+)-**4** and (–)-**4**: Separation of the two enantiomers of **4** (7.2 mg) was performed by the method described for **1**, yielding compound (+)-**4** (t_R = 9 min) [(3.8 mg), $[\alpha]_D^{24}$ +90.7 (*c* 0.1, $CHCl_3$)]; ECD (*c* 7.7×10^{-5} M, MeOH) λ_{max} (Δε); 232 (-1.24×10^2), 239 (-0.95×10^2) and 301 ($+0.87\times10^2$) nm] and (–)-**4** (t_R = 11 mim) [(3.2 mg), $[\alpha]_D^{24}$ −75.6 (*c* 0.1, $CHCl_3$)]; ECD (*c* 8.3×10^{-5} M, MeOH) λ_{max} (Δε); 232 ($+0.92\times10^2$), 238 ($+0.77\times10^2$) and 301 (-0.79×10^2) nm].

*Doitunggarcinone I (**5**).* White solid, m.p. 158-162°C; UV (MeOH) λ_{max} (log ε) 219 (4.10), 235 (3.88), 240 (3.73), 294 (3.96) and 342 (3.13) nm; IR (neat) ν_{max} 3465, 1737, 1637 cm^{-1}; ^1H NMR ($CDCl_3$, 600 MHz) and ^{13}C NMR data, see Tables 1 and 2; ESITOFMS *m/z* 549.2466 $[M+Na]^+$ (calcd for $C_{30}H_{38}O_8$, 549.2464).

Chiral HPLC Separation and ECD Spectroscopic Data (+)-**5** and (–)-**5**: Separation of the two enantiomers of **5** (10.3 mg) was performed by the method described for **1**, yielding compound (+)-**5** (t_R = 6 min) [(4.5 mg), $[\alpha]_D^{24}$ +55.1 (*c* 0.1, $CHCl_3$)]; ECD (*c* 8.9×10^{-5} M, MeOH) λ_{max} (Δε); 233 (-0.81×10^2), 240 (-1.02×10^2) and 298 ($+0.89\times10^2$) nm] and (–)-**5** (t_R = 8 mim) [(4.0 mg), $[\alpha]_D^{24}$ −65.2 (*c* 0.1, $CHCl_3$)]; ECD (*c* 9.5×10^{-5} M, MeOH) λ_{max} (Δε); 231 ($+0.28\times10^2$), 241 ($+0.61\times10^2$) and 302 (-0.73×10^2) nm].

*Doitunggarcinone J (**6**).* White solid, m.p. 175-178°C; UV (MeOH) λ_{max} (log ε) 216 (4.02), 233 (3.72), 242 (3.57), 296 (3.78) and 335 (3.31) nm; IR (neat) ν_{max} 3479, 1741, 1637

372 cm^{-1}; ^{1}H NMR ($CDCl_3$, 600 MHz) and ^{13}C NMR data, see Tables 1 and 2; ESITOFMS *m/z*

373 535.2313 $[M+Na]^+$ (calcd for $C_{29}H_{36}O_8$, 535.2308).

374 *Chiral HPLC Separation and ECD Spectroscopic Data* (+)-**6** and (–)-**6**: Separation of

375 the two enantiomers of **6** (10.5 mg) was performed by the method described for **1**, yielding

376 compound (+)-**6** (t_R = 30 min) [(4.7 mg), $[\alpha]_D^{24}$ +82.3 (*c* 0.1, $CHCl_3$)]; ECD (*c* 8.0×10^{-5} M,

377 MeOH) λ_{max} ($\Delta\varepsilon$); 233 (-0.38×10^2), 243 (-0.50×10^2) and 304 ($+0.82\times10^2$) nm] and (–)-**6**

378 (t_R = 34 mim) [(5.3 mg), $[\alpha]_D^{24}$ –64.6 (*c* 0.1, $CHCl_3$)]; ECD (*c* 7.6×10^{-5} M, MeOH) λ_{max} ($\Delta\varepsilon$);

379 236 ($+0.67\times10^2$), 245 ($+0.66\times10^2$) and 301 (-0.90×10^2) nm].

380 *Doitunggarcinone* K *(7).* White solid, m.p. 188-191 °C; [(2.2 mg), $[\alpha]_D^{24}$ –24.5 (*c*

381 0.02, $CHCl_3$)]; UV (MeOH) λ_{max} (log ε) 214 (4.14), 227 (3.92), 246 (3.47), 322 (3.77) and

382 350 (3.69) nm; IR (neat) ν_{max} 3447, 1737, 1640 cm^{-1}; ^{1}H NMR ($CDCl_3$, 600 MHz) and ^{13}C

383 NMR data, see Tables 1 and 2; ESITOFMS *m/z* 487.2092 $[M+Na]^+$ (calcd for $C_{28}H_{32}O_6$,

384 487.2097).

385 *Chiral HPLC Analysis of* **7**: Compound **7** was analyzed by analytical chiral HPLC

386 using the conditions described for **1**, to give peaks for two enantiomers at the retention times

387 of t_R 9 min and t_R 12 min in an approximate ratio of 1:2. Lack of material precluded their

388 quantitative resolution.

389 **X-ray Crystallographic Analysis of Compound (+)-1**

390 Single-crystal X-ray diffraction data was collected on a Bruker APEX DUO

391 diffractometer with cross-coupled multilayer optics Cu-Kα radiation. Data were corrected for

392 absorption effects using the multi-scan technique (SADABS). The structure was solved by

393 direct methods.

394 **Single-crystal X-ray Data for (+)-1**: Colorless plate crystal of $C_{30}H_{38}O_8$, *M* =

395 526.60, crystal system orthorhombic with *a* = 9.2535(2) Å, *b* = 11.5385(3) Å, *c* = 24.9217(7)

396 Å, α = 90°, β = 90°, γ = 90°, *v* = 2660.93(12) Å, and chiral group $P2_12_12_1$, *z* = 4. The X-ray

diffraction analysis using Cu-K*a* radiation values were 7.75 cm^{-1}, 23279 reflections measured, 6495 independent reflections (R_{int} = 0.029). Final *R* indices: R_1 [$I > 0.00\sigma$ (*I*)] = 0.030 and wR_2 = 0.077. The standard deviation of an observation of unit weight was 1.03. The absolute configurations of (+)-**1** was assigned as (*5S*, *6R, 7R, 8S, 8aS, 10as*, *17R*, *22S*) with a Flack x-parameter of 0.01(6). Crystallographic data for compound (+)-**1** have been deposited with the Cambridge Crystallographic Data Center (CCDC 1539179). These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

Cytotoxic Assay

HCT116 colon cancer cells (1×10^4 cells/well) were cultured in a 96 well plate and allowed to adhere for 24 h at 37 ºC. The cells were treated with compounds (10 µM or µg/mL) in DMEM medium for 24 h. The medium was removed and fresh DMEM containing 0.5 mg/mL of MTT solution was added to each well for 2 h. After that, the medium was discarded by aspirator. The violet formazan crystals in the viable cells were dissolved in 100 µL of DMSO. The absorbance of each well were read at a wavelength of 570 nm using a microplate reader. Doxorubicin was used as a positive control with an IC_{50} value of 9.74 µM.

$$\% \text{ Cell viability is expressed as: } \frac{\text{Absorbance of treated well}}{\text{Absorbance of control well}} \times 100$$

$$\% \text{ Cytotoxicity} = 100 - \% \text{ cell viability}$$

ASSOCIATED CONTENT

Supporting Information.

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.jnat-prod.6b00xxx.

The chiral HPLC chromatograms for compounds (**1**-**7**), ESITOFMS, 1D and 2D NMR spectra for all new compounds (**1**-**7**), and details for the X-ray single crystal structure of (+)-**1**.

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Notes

The authors declare no competing financial interests.

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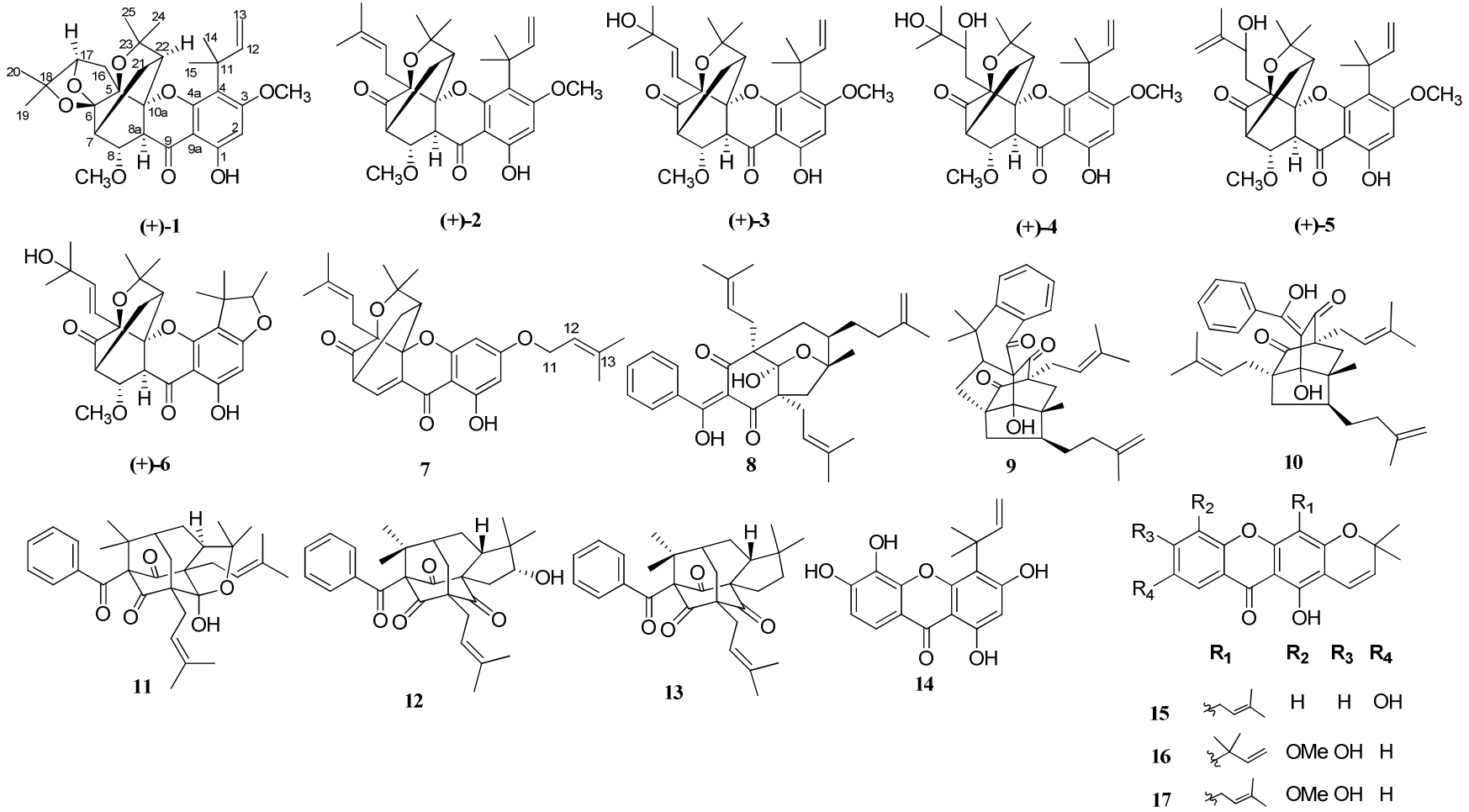


Figure 1. Chemical structures of isolated compounds from *G. propinqua*.

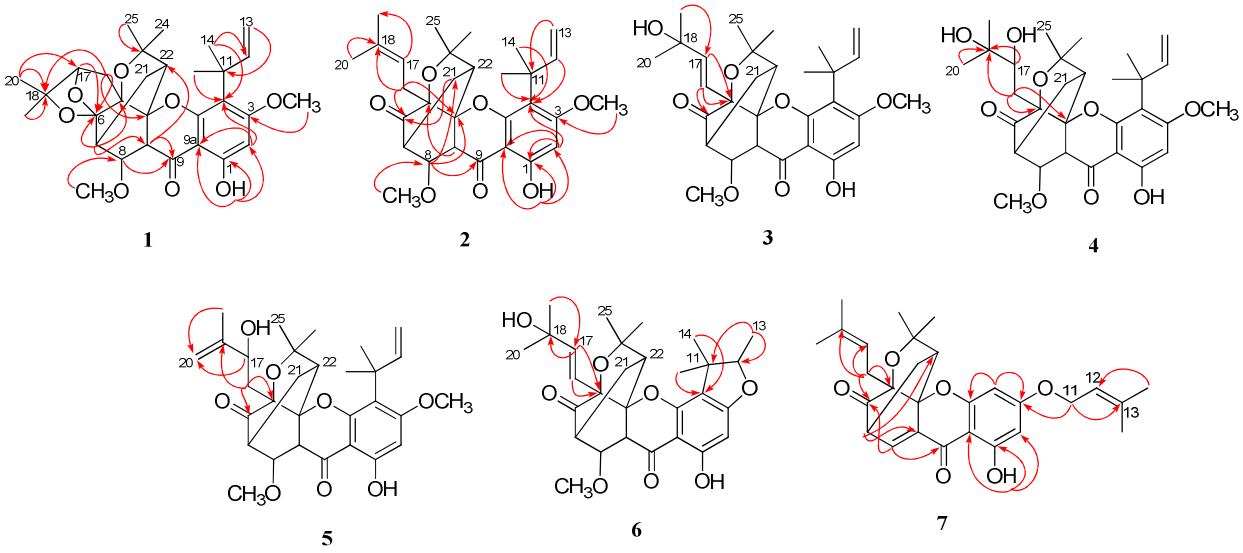


Figure 2. Selected HMBC correlations ($^{1}H \rightarrow ^{13}C$) of compounds **1-7**.

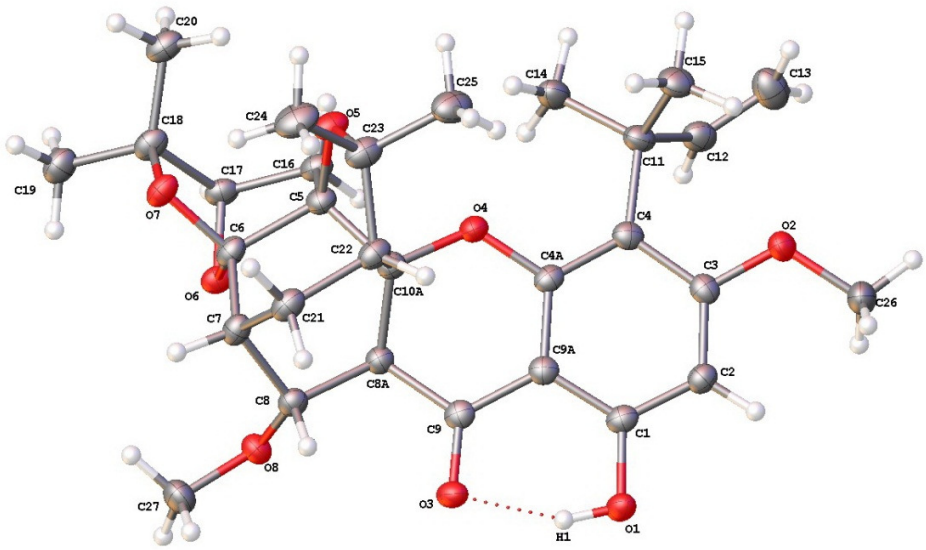


Figure 3. X-ray ORTEP diagram of compound **(+)-1**.

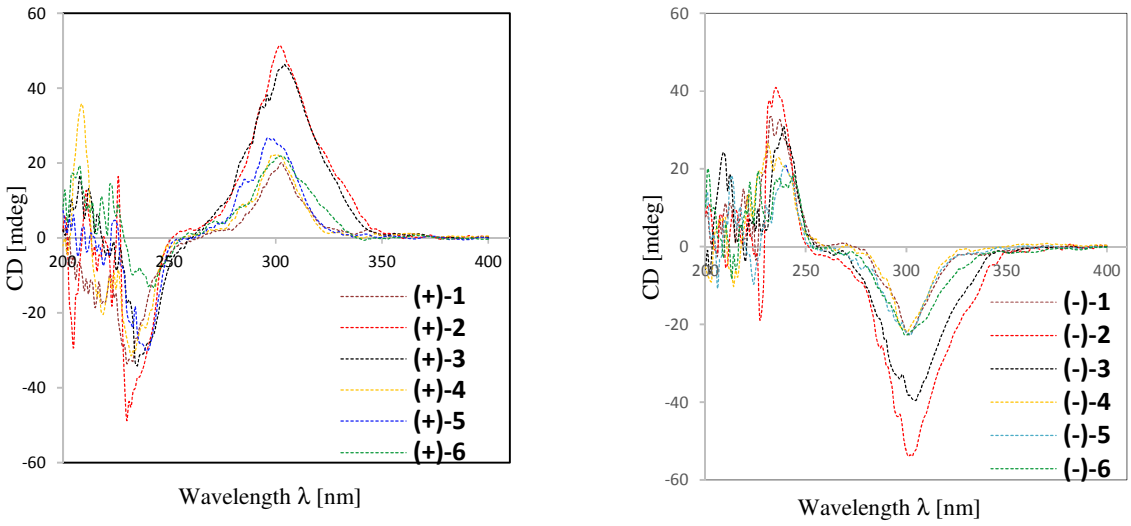
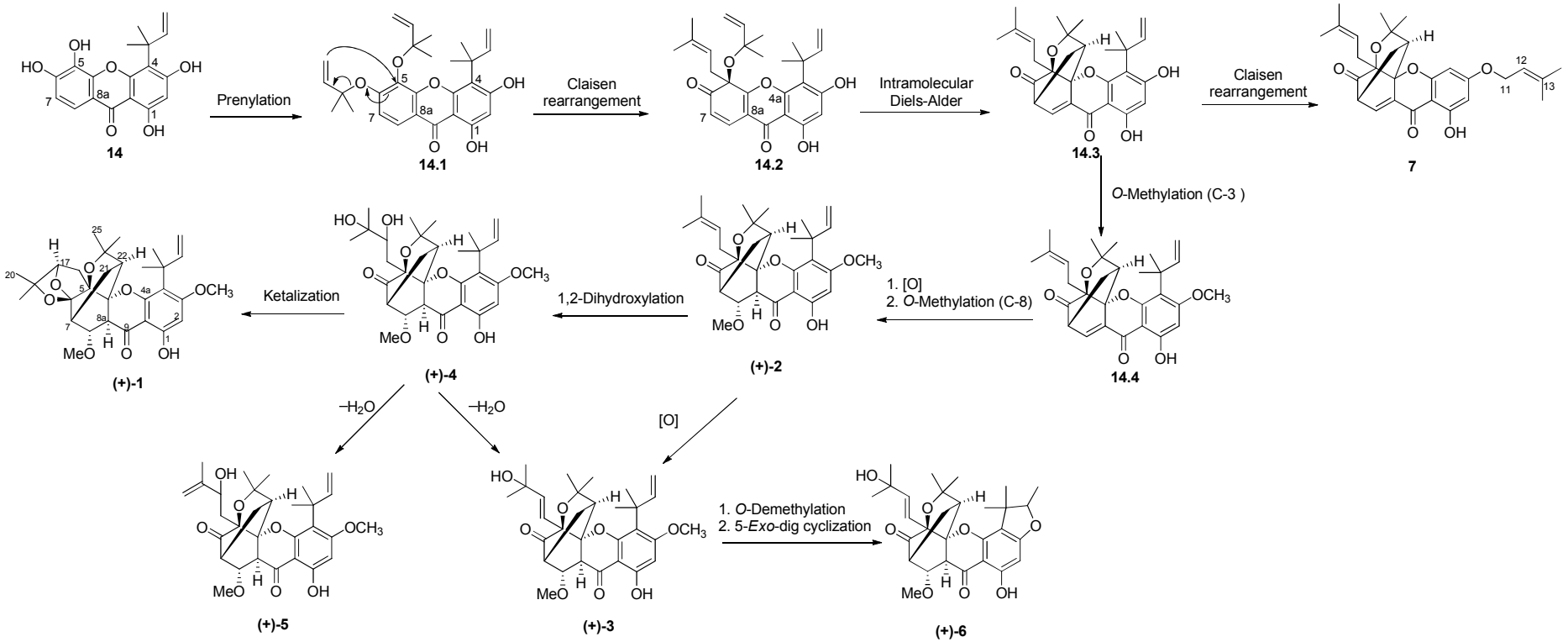


Figure 4. ECD spectra of resolved compounds **1-6** in MeOH.



Scheme 1. Putative biosynthesis pathway to compounds **1**-**7**.

Table 1. ^{1}H NMR Spectroscopic Data (600 MHz) of Compounds **1**– **7** in $CDCl_3$.

Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	-	-	-	-	-	-	-
2	6.08, s	6.11, s	6.11, s	6.10, s	6.12, s	6.07, s	6.11, brs
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	6.08, brs
4a	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	2.41, m	2.81, m	2.90, m	2.20, m	2.46, m	2.95, m	3.52, m
8	4.00, dd (4.4, 2.6)	4.34, m	4.40, d (3.3)	4.13, m	4.13, m	4.46, m	7.44, d (4.9)
8a	3.01, d (4.4)	3.31, m	3.18, m	3.21, d (3.5)	3.03, m	3.16, m	-
9	-	-	-	-	-	-	-
9a	-	-	-	-	-	-	-
10a	-	-	-	-	-	-	-
11	-	-	-	-	-	-	4.57, m
12	6.12, dd (17.4, 10.8)	6.16, dd (17.2, 10.8)	6.09, dd (17.6, 10.9)	6.13, dd (17.5, 10.6)	6.16, dd (17.2, 10.8)	4.37, m	5.47, m
13	4.80, dd (17.4, 1.2)	4.80, d (17.2)	4.80, d (17.6)	4.82, d (17.5)	4.82, d (17.2)	1.37, d (7.2)	
	4.79, dd (10.8, 1.2)	4.78, d (10.8)	4.78, d (10.9)	4.81, d (10.6)	4.81, d (10.8)		
14	1.54, s	1.55, s	1.54, s	1.53, s	1.57, s	1.41, s	1.83, s
15	1.51, s	1.62, s	1.51, s	1.51, s	1.53, s	1.25, s	1.78, s
16	2.33, dd (13.4, 4.7)	2.88, m	5.75, d (16.0)	2.80, dd (15.0, 9.1)	2.76, dd (13.9, 6.2)	5.72, d (15.8)	2.63, m
	2.09, d (13.4)	2.75, dd (14.0, 9.5)		1.99, dd (15.0,7.1)	2.10, m		
17	4.21, d (4.7)	5.29, t (7.8)	6.18, d (16.0)	4.11, dd (7.1, 9.1)	4.53, t (8.1)	6.27, d (15.8)	4.47, m
18	-	-	-	-	-	-	-
19	1.56, s	1.63, s	1.35, s	1.33, s	5.08, s	1.36, s	1.42, s
					4.88, s		
20	1.33, s	1.67, s	1.36, s	1.12, s	1.80, s	1.35, s	1.14, s
21	2.26, dd (15.2, 5.2)	1.96, dd (14.4, 5.4)	1.97, dd (14.6, 5.8)	2.17, dd (15.3, 5.9)	2.18, m	2.02, m	2.35, d (15.5)
	1.41, dd (15.2, 10.2)	1.39, m	1.43, m	1.40, m	1.27, m	1.49, m	1.33, m
22	2.22, d (10.2)	2.48, d (8.5)	2.51, d (8.3)	2.53, dd (4.6, 3.5)	2.22, m	2.62, m	2.44, d (8.8)
23	-	-	-	-	-	-	-
24	1.26, s	1.11, s	1.42, s	1.40, s	1.40, s	1.22, s	1.32, s
25	1.33, s	1.36, s	1.16, s	1.41, s	1.39, s	1.51, s	1.70, s
OH-1	12.39, s	12.36, s	12.24, s	12.19, s	12.31, s	12.00, s	12.47, s
OMe-3	3.79, s	3.79, s	3.79, s	3.81, s	3.81, s		
OMe-8	3.53, s	3.30, s	3.36, s	3.45, s	3.43, s	3.36, s	

Table 2. ^{13}C NMR Spectroscopic Data (150 MHz) of Compounds **1** – **7** in $CDCl_3$.

Position	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	162.5	163.0	162.8	162.5	162.5	164.3	164.9
2	93.4	94.0	93.8	93.7	93.7	92.3	95.7
3	168.0	168.1	168.1	168.0	168.0	169.6	167.6
4	114.0	115.2	115.1	114.2	114.3	114.2	94.7
4a	157.0	157.0	156.9	156.3	156.5	158.0	160.7
5	89.5	86.9	88.1	92.6	92.0	87.7	84.2
6	115.3	209.2	208.6	207.0	207.2	208.4	202.9
7	31.6	44.8	44.3	41.7	34.7	44.1	46.5
8	79.3	74.9	74.2	75.6	75.2	73.4	133.7
8a	48.6	47.4	47.5	47.8	49.0	47.6	135.4
9	196.1	195.0	194.5	194.7	195.0	192.6	179.3
9a	102.1	102.6	102.5	105.0	102.2	102.3	101.1
10a	88.5	88.5	89.3	88.6	87.7	88.6	90.0
11	41.2	41.3	41.3	41.1	41.0	43.4	65.2
12	150.3	150.2	150.0	149.9	150.1	90.9	118.5
13	107.5	107.8	107.7	107.5	107.6	14.3	139.4
14	30.6	30.8	31.1	30.0	30.5	25.7	25.4
15	28.2	28.8	28.7	28.4	28.5	21.8	17.9
16	33.7	28.0	117.7	28.9	32.5	117.3	28.8
17	81.5	118.0	144.6	82.4	79.3	144.8	118.3
18	85.8	133.9	71.1	70.1	144.7	71.2	135.2
19	21.6	18.1	29.5	28.5	112.1	29.7	25.2
20	28.9	26.1	29.9	24.2	17.4	30.0	16.7
21	25.1	20.3	20.0	23.6	24.2	20.0	24.9
22	43.2	44.0	43.2	34.0	41.8	43.9	48.5
23	79.5	81.1	82.1	83.4	83.2	82.0	83.3
24	27.2	27.5	27.3	26.2	26.6	30.927.4	28.8
25	30.2	30.5	30.5	30.5	30.4	27.430.9	29.9
OMe-3	55.4	55.4	55.4	55.4	55.4		-
OMe-8	57.1	55.7	55.8	55.8	56.0	55.9	-

Table of Content

Scalemic Caged Xanthones Isolated from the Stem Bark Extract of *Garcinia propinqua*

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