A new synthesis of cytotoxic (+)-7-epi-Goniofufurone

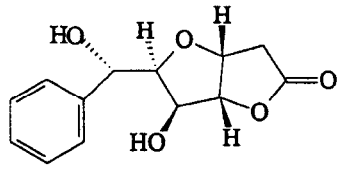
YANG, Min[b](杨敏) LI, Hong-Ming[a](李红明) ZHAO, Gang[a](赵刚)
YU, Qing-Sen[b](俞庆森) DING, Yu*,[a](丁渝)
[a] *Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, Shanghai 200032, China*
[b] *Department of Chemistry, Zhejiang University, Hangzhou, Zhejiang 310027, China*

Cytotoxic styryl lactone, (+)-7-epi-Goniofufurone (1), has been prepared with a new route from 3-*O*-benzyl-1,2-*O*-isopropylidene-5-*C*-phenyl-β-*L*-ido-pentofuranose (6), a derivative of (+)-glucose. Treatment of 14 with HCl solution cleaved TBDMS and isopropylidene and simultaneously caused ring closure to afford 1 while treatment of 14 with $Sc(OTf)_3$ only removed TBDMS to give 15.

Keywords Furans, styryl lactone, cytotoxicity

Introduction

Recently, a group of the bioactive styryl lactones has been isolated from the ethanol extract of the stem bark of *Gonithalamus giganteus* Hook. F. & Thomas (Annonaceae) in Thailand.[1-3] It was shown that they are marginally cytotoxic against human tumor cell, especially significant cytotoxic against 3PS murine lymphocytic leukemia cell.[1] These styryl lactones can be classified into two kinds according to their structure features besides monocyclic lactones. One kind possesses fused bicyclic unit with a six-membered lactone moiety and the other with a five-membered lactone. (+)-7-Epi-Goniofufurone (**1**) is one of the latter class (Fig. 1).



1

Fig. 1 Structure of (+)-7-epi-Goniofufurone (**1**).

Because of their magical structure and unique antitumor activities, many organic chemists have been interested in developing methodology for syntheses of these styryl lactones. Over the past few years, several syntheses of styryl lactones have been reported.[4-8] Herein we would report a new method for the synthesis of **1** from 3-*O*-benzyl-1,2-*O*-isopropylidene-5-*C*-phenyl-β-*L*-ido-pentofuranose (**6**), which was readily prepared[9,10] from (+)-glucose by acetonation, protection of 3-OH with benzyl, selective deacetonation, glycol oxidation cleavage and Grignard reaction.

Results and discussion

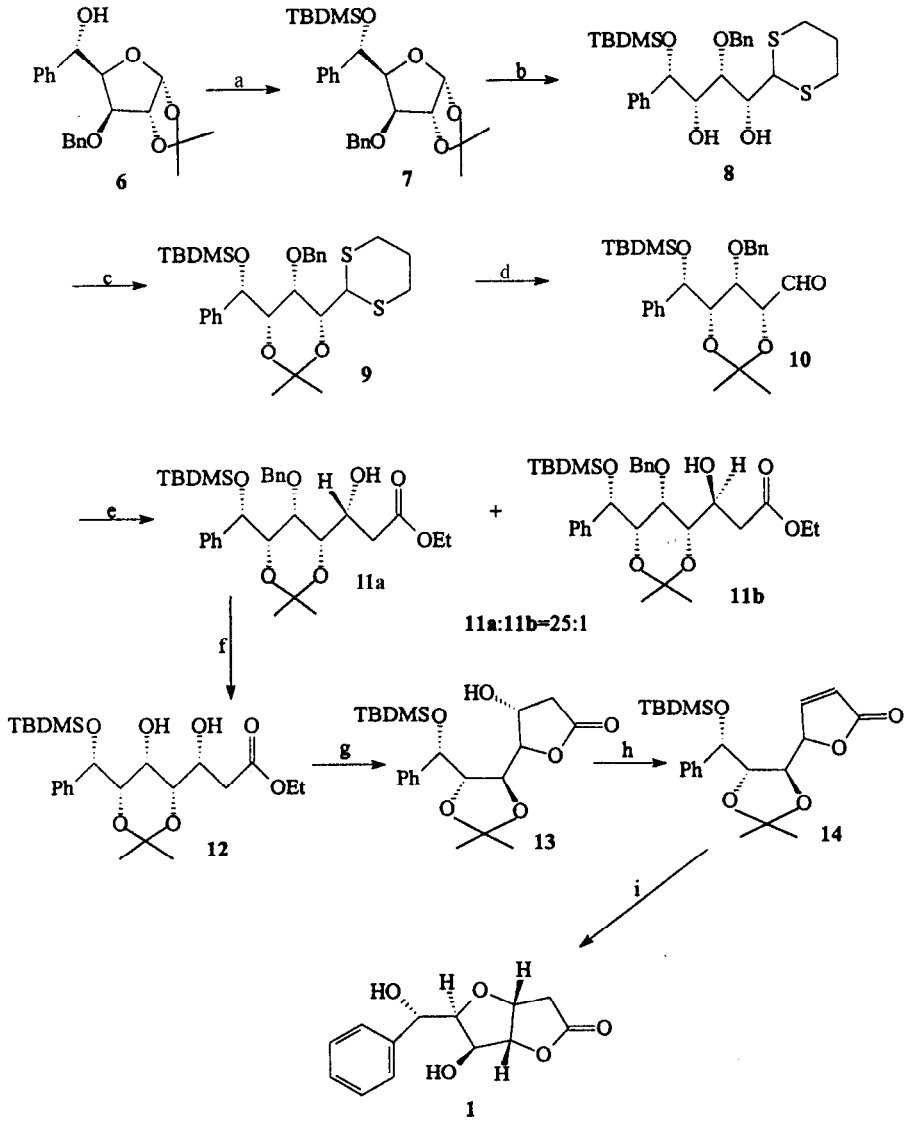
Compound **6** that possesses the chiral centers and carbon skeleton required for target molecule **1** was chosen as the starting material. The key point was how to form the γ-lactone and five-membered ether ring from **6**. The synthetic route is shown in Scheme 1.

Treatment of **6** with *t*-butyldimethylsilyl chloride in the presence of imidazole at r.t. afforded a protected alcohol **7** in 84% yield. Compound **7** was reacted with 1,3-propanedithiol and $TiCl_4$[11] at −20℃ to give a dithioacetal compound **8** in 58% yield. Isopropylidenation of **8** with 2,2-dimethoxypropane and PTSA (cat.) in CH_2Cl_2 afforded **9** in 94% yield. In order to cleave the *S*,*S*-acetal moiety of **9**, several conditions were tested. Among them HgO and $HgCl_2$ in acetone and water, NBS in acetone, $Ce(NH_4)_2(NO_3)_6$ in acetone, $PhI(OCOCF_3)_2$ in methanol have been tried, but none of them gave satisfactory results. Fortunately, while CH_3I and $CaCO_3$ in CH_3CN and water (1:1)[12] were used, the aldehyde **10** was obtained successfully. We rationalized that in the

Received July 7, 1999; accepted August 18, 1999.

structure of **9** (Fig. 2) the axial *O*-benzyl group and the neighbouring equatorial *S*,*S*-acetal of 1,3-dioxane ring are at the same side so that the bulky reagent, such as $PhI(OCOCF)_2$, could not attack *S*,*S*-acetal due to the hindrance from benzyl group. However, the reaction of smaller CH_3I with **9** underwent smoothly, not only because the volume of methyl group is smaller, but also because iodide ion is a stronger leaving group.

Scheme 1



Reagents and conditions: (a) *t*-$BuMe_2SiCl$, imidazole, DMF, r.t., 14 h, 84%; (b) $CH_2(CH_2SH)_2$, $TiCl_4$, CH_2Cl_2, −20℃, 1 h, 58%; (c) $(CH_3)_2C(OCH_3)_2$, PTS(cat), r.t. 1 h, 94%; (d) CH_3I, $CaCO_3$, CH_3CN-H_2O (1:1), 50℃, 7 h; (e) LDA, AcOEt, THF, −78℃, 1.5 h, 83% (two steps); (f) Pd/C (10%, cat.), H_2, r.t., 4 days, 85%; (g) PTSA (cat.), CH_2Cl_2, r.t., 5 h, 79%; (h) MsCl, Pyridine, r.t., 7 h, 73%; (i) 2 mol/L HCl-CH_3OH-CH_2Cl_2, 50℃, 5 h, 79%.

Reaction of **10** with a solution of LDA/EtOAc in THF at −78℃ provided the diastereoisomeric alcohols **11a** and **11b** which were separated easily by flash chromatography in a ratio of 25 to 1 in 83% yield (two steps from **9** to **11**). Due to the presence of 3-*O*-benzyl, 5-*C*-phenyl and 5-*O*-TBS the acetate enolate attacked the

carbonyl group of **10** with high diastereoselectivity from less hindrance. The catalytic hydrogenation of **11a** on Pd/C gave a dihydroxyl product **12** in 85% yield. The lactonization reaction of **12** with PTSA (cat.) in CH_2Cl_2 gave **13** in 79% yield. The structure of **13** was proved by IR, ^1H NMR and NOESY spectra. The configuration of **11(a,b)** and **12** was determined in a similar way. α, β-Unsaturated lactone **14** was formed when **13** was treated with methylsulfonyl chloride in dry pyridine in 73% yield. According to the literature,[5] if TBDMS and isopropylidene groups could be cleaved at the same time then the five-membered ether ring will be constructed by intramolecular Michael addition reaction. In order to cleave TBDMS, several commonly used methods (TBAF

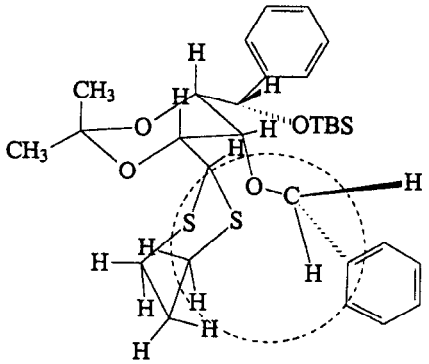
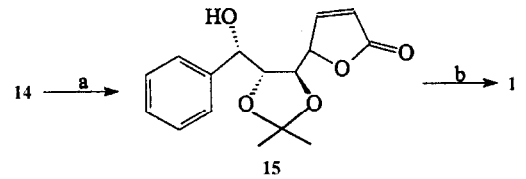


Fig. 2 Proposed model showing higher hindrance from benzyl group in compound **9**.

in THF, KF in THF, HOAc and H_2O, PTSA (cat.) in CH_2Cl_2) were tried but the products were complicated. While **14** was treated with $Sc(OTf)_3$[13] in CH_3CN and water at room temperature (Scheme 2), a crystal product was obtained in 44% yield. X-ray structure analysis proved that it is

Scheme 2



Conditions and reagents: (a) $Sc(OTf)_3$, H_2O, CH_3CN, r.t., 38 h, 44%; (b) 1 mol/L HCl-CH_3OH-CH_2Cl_2, 50℃, 5 h, 75%.

a (TBAF in TBDMS-cleaved compound **15** (Fig. 3). Then we tried to cleave TBDMS and isopropylidene simultaneously with 2 mol/L HCl aqueous in methanol and CH_2Cl_2 at 50℃, and the target molecule **1** was obtained with good yield (75%). The HCl not only cleaved two protecting groups, but also induced the formation of five-membered ether ring. The structure and relative configuration of **1** were confirmed by X-ray structure analysis.

Experimental

Melting points were measured with a ZED-II type apparatus and were uncorrected. IR spectra were measured in $CHCl_3$ or in KBr on a Shimadzu IR-440 infrared spectrophotometer. Mass spectra were taken using HP5989A mass spectrometer. ^1H NMR spectra were recorded on a Brucker AMX-300 (300 MHz) spectrometer in $CDCl_3$ unless otherwise stated, and chemical shifts were reported in δ (TMS as internal standard). Elemental analyses were performed on a Foss-Heraeus Vario EL instrument. Optical rotations were taken with a Perkin-Elmer 241MC Polarimeter at the sodium D line. CH_2Cl_2 was freshly distilled from calcium hydride and THF from sodium benzophenone prior to use. Other solvents were purified before use according to the standard procedures. The commercially available reagents were used as received without further purification.

(1S,2R,3S,4R,5S)-3-O-Benzyl-1,2-O-isopropylidene-5-C-phenyl-5-O-t-butyldimethylsilyl-β-L-ido-pentofuranose (**7**)

To a stirred solution of **6** (2 g, 5.62 mmol) and imidazole (573.9 mg, 8.43 mmol) in dry DMF (50 mL) at r.t. was added *t*-butyldimethylsilyl chloride (1.27 g, 8.43 mmol) and stirred at room temperature for 14 h. The solution was diluted with Et_2O (50 mL) and washed with water and brine. The organic layer was dried (Na_2SO_4) and filtered. Removal of the solvent and flash chromatograph of the resultant residue (EtOAc-petroleum ether, 1:6) afforded **7** (2.22 g, 84%) as a white solid. mp 78—79℃. $[\alpha]_D^{20}$ −12.3(*c* 1.18, EtOAc). δ_H: −0.09(s, 3H), 0.10(s, 3H), 0.82(s, 9H), 1.29(s, 3H), 1.50(s, 3H), 3.34(d, J = 3.0 Hz, 1H), 4.14(AB, J = 11.5 Hz, 1H), 4.26(dd, J = 8.0, 3.0 Hz, 1H), 4.40(AB, J = 11.5 Hz, 1H), 4.50(d, J = 3.7 Hz, 1H), 4.97(d, J = 8.0 Hz, 1H), 6.01(d, J = 3.7 Hz, 1H), 7.26—7.40 (m, 10H). *m/z*(%): 471(M^+H, 0.50), 221(Ph-

CHOTBS$^+$, 65.10), 90($PhCH_2^+$, 100). Anal. $C_{27}H_{38}O_5Si$. Calcd: C, 68.94; H, 8.09. Found: C, 68.98; H, 8.32.

(2*R*, 3*S*, 4*R*, 5*S*)-3-*O*-*Benzyl*-2, 4-*dihydroxyl*-5-*C*-*phenyl*-5-*O*-*t*-*butyldimethylsilyl pentanal* 1, 3-*propanedithiol acetal* (**8**)

To a stirred solution of **7** (2 g, 4.25 mmol) and 1, 3-propanedithiol (0.69 g, 6.38 mmol) in dry CH_2Cl_2 (40 mL) was added dropwise $TiCl_4$ (0.72 g, 4.68 mmol) at −20℃. After stirred for 1 h at −20℃, saturated aqueous $NaHCO_3$ (10 mL) was added. The mixture was filtered through a bed of Celite and washed with 5% NaOH (20 mL). The organic layer was dried (Na_2SO_4) and filtered. Concentration of the filtrate and flash chromatograph of the resultant residue (EtOAc-petroleum ether, 1:3) afforded **8** (1.28 g, 58%) as a colorless oil. $[\alpha]_D^{20}$ +8.43(*c* 1.08, EtOAc). δ_H: −0.20(s, 3H), 0.08(s, 3H), 0.90(s, 9H), 1.96 (m, 2H), 2.62—2.87(m, 4H), 3.80(s, 1H), 4.00—4.07(m, 3H), 4.37(AB, *J* = 11.1 Hz, 1H), 4.55(AB, *J* = 11.1 Hz, 1H), 4.88(d, *J* = 5.8 Hz, 1H), 7.17—7.33(m, 10H). *m*/*z*(%): 521(M^+H, 1.10), 251($C_{13}H_{15}OS_2^+$, 27.48), 221(PhCHOTBS$^+$, 43.79), 119($C_4H_7S_2^+$, 73.18), 91($PhCH_2^+$, 100). Anal. $C_{27}H_{40}O_4S_2Si$. Calcd: C, 62.31; H, 7.69. Found: C, 62.56; H, 8.01.

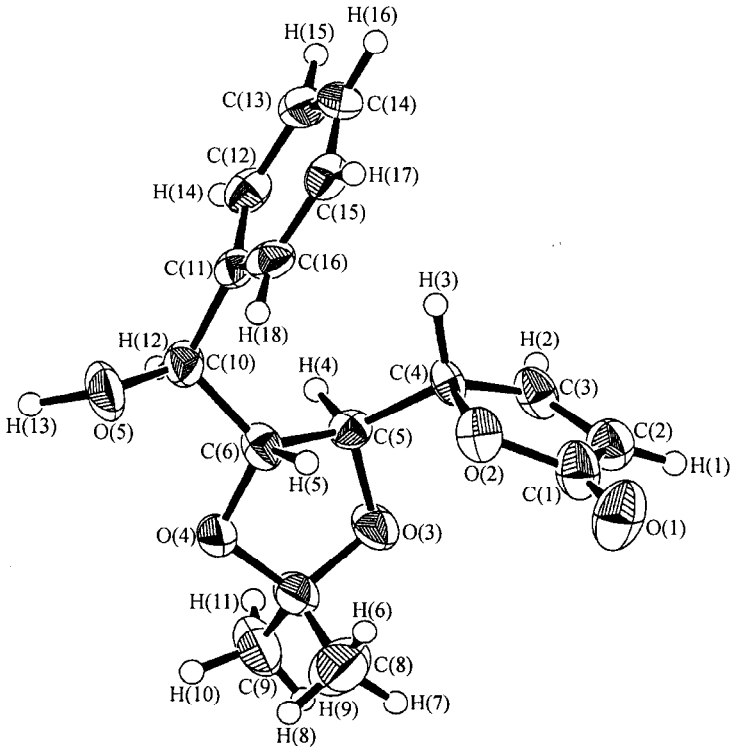


Fig. 3 Structure of **15** by X-ray diffraction analysis.

(2*R*, 3*S*, 4*R*, 5*S*)-3-*O*-*Benzyl*-2, 4-*O*-*isopropylidene*-5-*C*-*phenyl*-5-*O*-*t*-*butyldimethylsilyl pentanal* 1,3-*propanedithiol acetal* (**9**)

To a stirred solution of **8** (1.20 g, 2.31 mmol) in dry CH_2Cl_2 (20 mL) at room temperature was added acetone dimethyl ketal (0.43 mL, 3.46 mmol) and PTSA (cat.). The solution was stirred at room temperature for a further 1 h and quenched with a saturated $NaHCO_3$ solution (5 mL). The organic layer was washed with water and brine then dried (Na_2SO_4). Removal of solvent gave a white solid which was purified by flash chromatography (EtOAc-petroleum ether, 1:5) to gave **9** (1.22 g, 94%) as a white solid. mp 107—109℃. $[\alpha]_D^{20}$ −34.29(*c* 1.05, EtOAc). δ_H: −0.21(s, 3H), 0.07(s, 3H), 0.89(s, 9H), 1.50(s, 3H), 1.60(s, 3H), 2.00—2.05(m, 2H), 2.57—2.61

(m, 4H), 3.15(s, 1H), 3.82(dd, J = 10.3, 1.0 Hz, 1H), 3.92(dd, J = 8.3, 1.2 Hz, 1H), 4.12 (d, J = 10.3 Hz, 1H), 4.47(AB, J = 12.5 Hz, 1H), 4.75(AB, J = 12.5 Hz, 1H), 4.84(d, J = 8.3 Hz, 1H), 7.26—7.38(m, 10H). m/z(%): 251 ($C_{13}H_{15}OS_2^+$, 19.59), 221(PhCHOTBS$^+$, 22.75), 119($C_4H_7S_2^+$, 17.07), 91($PhCH_2^+$, 100). Anal. $C_{30}H_{44}O_4S_2Si$. Calcd: C, 64.29; H, 7.86; Found: C, 64.46; H, 8.04.

(2R, 3S, 4R, 5S)-3-O-Benzyl-2, 4-O-isopropylidene-5-C-phenyl-5-O-t-butyldimethylsilyl pentanal (**10**)

To a stirred solution of **9** (1.2 g, 2.14 mmol) in CH_3CN (20 mL) and water (20 mL) was added CH_3I (1.6 mL, 25.68 mmol) and $CaCO_3$(5.10 g, 51.36 mmol). The mixture was stirred at 50℃ for 7 h and filtered through Celite. The aqueous layer was extracted with Et_2O (3 × 15 mL). The combined organic layer extracts were dried (Na_2SO_4) and filtered. Removal of solvent gave crude aldehyde **10** as yellow oil which was used in the following step without further purification.

Ethyl (3R, 4S, 5R, 6R, 7S)-5-O-benzyl-3-hydroxyl-4, 6-O-isopropylidene-7-C-phenyl-7-O-t-butyldimethylsilyl heptylate (**11a**) *and its diastereoisomer* (**11b**)

To a stirred solution of i-Pr_2NH (0.36 mL, 2.57 mmol) in dry THF (4 mL) was added n-BuLi (1.6 mol/L, 1.6 mL, 2.57 mmol) at 0℃. The solution was stirred at room temperature for 0.5 h and then ethyl acetate (0.32 mL, 3.21 mmol) was added at −78℃. The reaction mixture was stirred for a further 1 h, then a solution of **10** in THF (5 mL) was added dropwise at −78℃, which was stirred at the same temperature for 1.5 h and quenched with a saturated NH_4Cl solution (5 mL). After the temperature of the mixture raised to room temperature, it was extracted with Et_2O (3 × 15 mL). The combined organic extracts were washed with water (30 mL) and brine, dried (Na_2SO_4) and filtered. Concentration of the filtrate and flash chromatograph of the resultant residue (EtOAc-petroleum ether, 1:10) gave the major product **11a** (961.5 mg, 80%) and the minor product **11b** (38.5 mg, 3.2%), both are colorless oil. **11a**: $[\alpha]_D^{20}$ −32.5(c 1.13, EtOAc). δ_H: −0.06(s, 3H), 0.06(s, 3H), 0.80(s, 9H), 1.26(m, 3H), 1.45(s, 3H), 1.49(s, 3H), 2.37(dd, J = 16.9, 8.4 Hz, 1H), 2.80(dd, J = 16.9, 2.8 Hz, 1H), 3.13(s, 1H), 3.56(dd, J = 9.2, 0.8 Hz, 1H), 3.92 (dd, J = 8.4, 1.2 Hz, 1H), 4.06—4.21(m, 3H), 4.31(d, J = 12.4 Hz, 1H), 4.78(d, J = 12.4 Hz, 1H), 4.88(d, J = 8.4 Hz, 1H), 7.27—7.38(m, 10H). m/z(%): 557(M^+ − 1), 243($C_{11}H_{15}O_6^+$, 34.21), 221(PhCHOTBS$^+$, 33.10), 129($C_6H_9O_3^+$, 7.48), 91($PhCH_2^+$, 100). Anal. $C_{31}H_{46}O_7Si$. Calcd: C, 66.67; H, 8.24; Found: C, 66.75; H, 8.49. **11b**: $[\alpha]_D^{20}$ −19.3(c 1.04, EtOAc).

Ethyl (3R, 4S, 5R, 6R, 7S)-2, 5-dihydroxyl-4, 6-O-isopropylidene-7-C-phenyl-7-O-t-butyldimethylsilyl heptylate (**12**)

A stirred solution of **11a** (900 mg, 1.61 mmol) in EtOAc (20 mL) was hydrogenated on Pd/C (10%, 9 mg) at room temperature under atmospheric pressure for four days and filtered through Celite. Concentration of the filtrate and flash chromatograph of the resultant residue (EtOAc-petroleum ether, 1:4) afforded **12** (640 mg, 85%) as colorless oil. $[\alpha]_D^{20}$ + 3.2(c 1.00, EtOAc). δ_H: 0.16(s, 3H), 0.28(s, 3H), 1.11(s, 9H), 1.40(s, 3H), 1.51(s, 3H), 1.61(s, 3H), 2.62(dd, J = 16.4, 8.7 Hz, 1H), 2.67(dd, J = 16.4, 1.4 Hz, 1H), 2.95(d, J = 7.4 Hz, 1H), 3.73(m, 1H), 3.88(m, 1H), 4.11—4.24(m, 3H), 4.85(d, J = 5.3 Hz, 1H), 7.20—7.34(m, 5H). m/z(%): 119($C_4H_7S_2^+$, 45.15), 73($CH_3CH_2OCO^+$, 87.56), 43($(CH_3)_2CH^+$, 44.64). Anal. $C_{24}H_{40}O_7Si$. Calcd: C, 61.54; H, 8.55. Found: C, 61.34; H, 8.82.

(3R, 4S, 5R, 6R, 7S)-5, 6-O-Isopropylidene-7-C-phenyl-7-O-t-butyldimethylsilyl-L-ido-heptanono-3-hydroxyl-γ-lactone (**13**)

A solution of **12** (625 mg, 1.34 mmol) and PTSA (31.3 mg, cat.) in dry CH_2Cl_2 (10 mL) was stirred at room temperature for 3 h and quenched with a saturated $NaHCO_3$ solution (5 mL). The organic layer was washed with water (2 × 10 mL) and brine, dried (Na_2SO_4) and filtered. Concentration of the filtrate under reduced pressure and flash chromatograph of the resultant residue (EtOAc-petroleum ether, 1:4) afforded **13** (446.7 mg, 79%) as white solid. mp 131—133℃. $[\alpha]_D^{20}$ + 54.3 (c 1.00, EtOAc). ν_{max}: 3515(OH), 1768(γ-lactone)

cm^{-1}. δ_H: -0.03(s, 3H), 0.08(s, 3H), 0.90(s, 9H), 1.10(s, 3H), 1.32(s, 3H), 2.28(dd, J = 18.0, 1.5 Hz, 1H), 2.86(dd, J = 8.4, 5.5 Hz, 1H), 4.39 (d, J = 6.2 Hz, 1H), 4.92(d, J = 5.5 Hz, 1H), 7.26—7.35(m, 5H). *m/z*(%): 422(M^+, 1,75), 291(M^+ - OTBS, 36.75), 221(PhCHOTBS$^+$, 100). Anal. $C_{22}H_{34}O_6Si$. Calcd: C, 62.52; H, 8.06. Found: C, 62.27; H, 8.28.

(4*S*, 5*R*, 6*R*, 7*S*)-5, 6-*O*-*Isopropylidene*-7-*C*-*phenyl*-7-*O*-*t*-*butyldimethylsilyl*-*L*-*ido*-*hept*-2-*enono*-γ-*lactone* (**14**)

To a stirred solution of **13** (410 mg, 0.97 mmol) in dry pyridine (25 mL) at room temperature was added dropwise MsCl (0.9 mL 11.64 mmol). The solution was stirred at room temperature for 7 h before addition of water (20 mL). The mixture was extracted with ethyl acetate (3 × 15 mL) and the organic layer was washed further with 5% HCl (20 mL), water and brine. The solution was dried (Na_2SO_4) and filtered. Evaporation of the solvent gave a residue which was purified by flash chromatography (EtOAc-petroleum ether, 1:7) to afford **14** (286 mg, 73%) as white solid. mp 153—154℃. $[\alpha]_D^{14}$ +6.1(*c* 0.45, EtOAc). ν_{max}: 1752(α,β-unsaturated γ-lactone) cm^{-1}. δ_H: -0.02(s, 3H), 0.10(s, 3H), 0.89(s, 9H), 1.15(s, 3H), 1.32(s, 3H), 3.85(dd, J = 8.1, 2.0 Hz, 1H), 4.45(dd, J = 8.1, 5.6 Hz, 1H), 4.52(t, J = 2.0 Hz, 1H), 4.93 (d, J = 5.6 Hz, 1H), 6.08(dd, J = 5.8, 2.0 Hz, 1H), 7.26(dd, J = 5.8, 1.5 Hz, 1H), 7.28—7.38 (m, 5H). *m/z*(%): 221(PhCHOTBS$^+$, 100), 183 (M^+-221, 11.58), 139($C_6H_3O_4^+$, 29.95). Anal. $C_{22}H_{32}O_5Si$. Calcd: C, 65.35; H, 7.92. Found: C, 65.61; H, 7.86.

(4*S*,5*R*,6*R*,7*S*)-5,6-*O*-*Isopropylidene*-7-*C*-*phenyl*-*L*-*ido*-*hept*-2-*enono*-γ-*lactone* (**15**)

To a stirred solution of **14** (31.6 mg, 0.08 mmol) in CH_3CN (1.5 mL) was added $Sc(OTf)_3$ (0.58 mg, 1.84% of **14**) and water (7.04 μL, 0.39 mmol). The solution was stirred at room temperature for 38 h and filtered through Celite. The filtrate was concentrated under reduced pressure and the resultant residue was purified by flash chromatography (EtOAC-petroleum ether, 1:1) to give **15** as a white solid (10.2 mg, 44%). Recrystallization from CH_2Cl_2 and petroleum ether (1:3) gave colorless needles. mp 144—146℃. $[\alpha]_D^{19}$ -65.8(*c* 0.2, MeOH). ν_{max}: 3513, 1754(α,β-unsaturated-γ-lactone) cm^{-1}. δ_H: 1.36(s, 3H), 1.40(s, 3H), 2.92 (br, 1H), 3.96(dd, J = 8.0, 1.8 Hz, 1H), 4.02 (dd, J = 3.4, 1.8 Hz, 1H), 4.45(dd, J = 8.0, 6.8 Hz, 1H), 4.70(d, J = 6.8 Hz, 1H), 6.03(dd, J = 5.5, 3.4 Hz, 1H), 7.15(dd, J = 5.5, 1.5 Hz, 1H), 7.33—7.42(m, 5H). *m/z*(%): 290(M^+, 10.65), 272(M^+ - H_2O, 95.02), 214(M^+ + H - Ph, 91.67), 182(M^+ - 107 - H, 83.94), 107(PhCHOH$^+$, 100). Anal. $C_{16}H_{18}O_5$. Calcd: C, 66.21; H, 6.21. Found: C, 66.55; H, 6.15.

(+)-7-*Epi*-*Goniofufurone* (**1**)

To a stirred solution of **14** (253 mg, 0.63 mmol) in CH_3OH (16 mL) and CH_2Cl_2 (7 mL) was added dropwise 2 mol/L HCl (2.5 mL). The solution was stirred at 50℃ for 5 h, then filtered through Celite. Concentration of the filtrate followed by flash chromatography (EtOAc-petroleum ether, 1:1) afforded **1** (124 mg, 79%) as a white solid which was recrystallized from acetone and petroleum ether (1:3) to give colorless needles. mp 203—204℃ (Lit[1] 190—192℃). $[\alpha]_D^{15}$ +111.8(*c* 0.36, EtOH) {Lit[1] $[\alpha]_D^{20}$ +108(*c* 0.2, EtOH)}. ν_{max}: 3368(OH), 1756(γ-lactone) cm^{-1}. δ_H ($CDCl_3$ + $(CD_3)_2CO$): 2.63(dd, J = 18.6, 2.2 Hz, 1H), 2.82(dd, J = 18.6, 5.0 Hz, 1H), 4.13(dd, J = 5.6, 3.3 Hz, 1H), 4.18(d, J = 3.3 Hz, 1H), 4.93 (d, J = 3.3 Hz, 1H), 5.08(d, J = 5.8 Hz, 1H), 5.14 (t, J = 5.0 Hz, 1H), 7.24—7.45(m, 5H). *m/z* (%): 250(M^+, 0.53), 233(MH^+ - H_2O, 12.33), 126(M^+ - PhCHOH - H_2O, 40.62), 107(PhCHOH$^+$, 82.77). Anal. $C_{13}H_{14}O_5$. Calcd: C, 62.40; H, 5.60. Found: C, 62.30; H, 5.56.

References

1. Fang, X.P.; Anderson, J.E.; Chang, C.J.; Mclaughlin, J.L.; Fanwick, P.E., *J. Nat. Prod.*, **54**, 1034 (1991).
2. Fang, X.P.; Anderson, J.E.; Chang, C.J.; Fanwick, P.E.; Mclaughlin, J.L., *J. Chem. Soc., Perkin Trans. 1*, 1655(1990).
3. Fang, X.P.; Anderson, J.E.; Chang, C.J.; Mclaughlin, J.L., *Tetrahedron*, **49**, 9751(1991).

4. Martin, K.; Ei-ichi, N., *Tetrahedron Lett.*, **37**, 9041 (1996).
5. Shing, T.K.M.; Tsui, H.C.; Zhou, Z.H., *J. Org. Chem.*, **60**, 3121(1995).
6. Mukai, C.; Hirai, S.; Hanaoka, M., *J. Org. Chem.*, **62**, 6619(1997).
7. Chen, W.; Roberts, S.M., *J. Chem. Soc., Perkin Trans. 1*, 103(1998).
8. Tsubuki, M., Kanai, K., Nagase, H., Honda, T., *Tetrahedron*, **55**, 2493(1999).
9. Murphy, P.J., *J. Chem. Soc., Chem. Commun.*, 1096 (1992).
10. Inch, T.D., *Carbohydr. Res.*, **5**, 45(1967).
11. Philip, C.; Bulman, P.; Richard, A.R.; Leo, A.P., *Tetrahedron Lett.*, **24**, 3555(1983).
12. Ley, S.V.; Maw, G.N.; Trudell, M.L., *Tetrahedron Lett.*, **31**, 5521(1990).
13. Oriyama, T.; Kobayashi, Y., Noda, K., *Synlett*, 1047 (1998).

(E9907085 SONG, J.P.; LING, J.)