Tetrahedron: *Asymmetry* 19 (2008) 1568–1571

Contents lists available at ScienceDirect

Tetrahedron: *Asymmetry*

journal homepage: www.elsevier.com/locate/tetasy

Highly selective approach for the total synthesis of (+)-heliconol A

Debendra K. Mohapatra *, Bhaskar Chatterjee, Mukund K. Gurjar

Organic Chemistry Division, National Chemical Laboratory, Pune 411 008, India

ARTICLE INFO

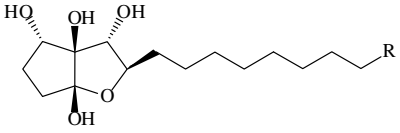
Article history:
Received 24 April 2008
Accepted 29 May 2008
Available online 14 July 2008

ABSTRACT

The total synthesis of heliconol A, a representative of a new class of polyketide-derived hemiketals containing a reduced furanocyclopentane unit, has been achieved via the stereoselective reduction of a ketone, the face selective dihydroxylation, a Sonogashira coupling reaction, and a *cis*-selective reduction as the key steps.

1. Introduction

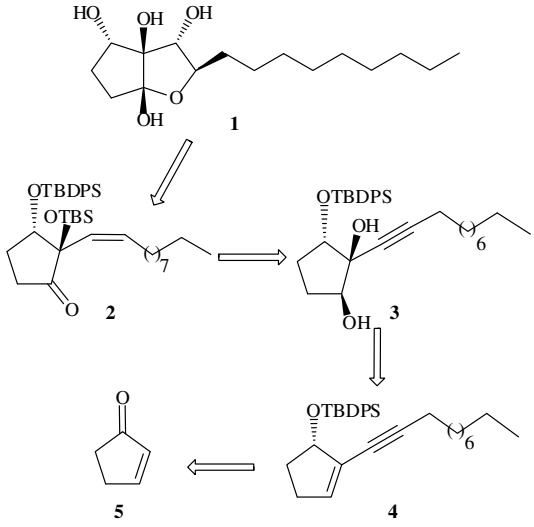
In 2006, Gloer et al. reported the isolation, structure elucidation, and biological activity of three new compounds, heliconol A–C **1**–**3** (Fig. 1), all containing a reduced furanocyclopentane unit from the fresh water aquatic fungus Helicodendron giganteum Glen-Bott (Helotiaceae) collected from a sample of submerged wood in Alaska.[1] Heliconols A–C **1**–**3** were tested against *Candida albicans* (ATCC 14053), *Staphylococcus aureus* (ATCC 29213), *Bacillus subtilis* (ATCC 6051), *Escherichia coli* (ATCC 25922),[2] *Aspergillus flarus* (NRRL 6541), and *Fusarium verticillioides* (NRRL 25457). Heliconol A **1** was found to inhibit the growth of *F. verticilloides* and exhibit profound activity against *C. albicans*, *S. aureus*, and *B. subtilis*.[3] The relative and absolute stereochemistry of heliconol A **1** was *prima facie* established by NOESY and single-crystal X-ray crystallographic analysis of its dibromobenzoate derivative.



Heliconol A -C
1. R = Me
2. R = CH_2OH
3. R = CO_2H

Figure 1. Heliconol A–C.

A total synthesis of enantiomeric (−)-heliconol A was recently reported by She et al.[4] Our retrosynthetic analysis reveals that the furan ring could be obtained by highly selective dihydroxylation (Scheme 1). The *cis*-double bond should be accessible by alkyne reduction. The alkyne functionality could be introduced utilizing a Sonogashira coupling reaction and a hydroxyl group



Scheme 1. Retrosynthetic analysis of (+)-heliconol A.

via a stereoselective reduction using the Corey–Bakshi–Shibata reagent.

2. Results and discussion

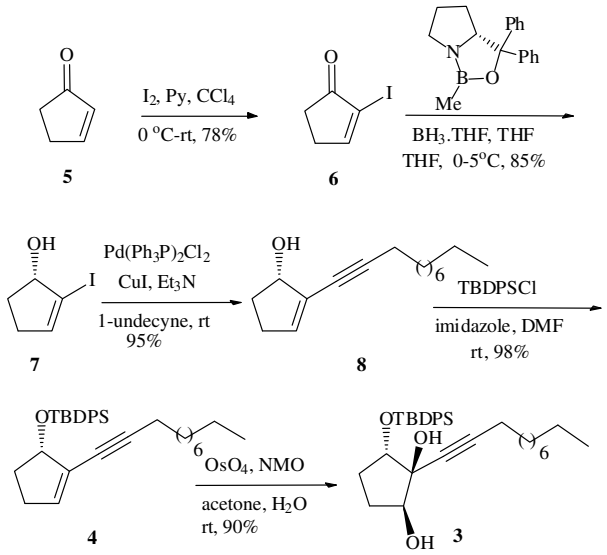
The synthesis began with the commercially available cyclopentenone **5**, which was converted to its 2-iodo-2-cyclopentenone **6** derivative following a literature method.[5] Compound **6** was reduced, from the desired enantioface (here, β), with BH_3·THF and a catalytic amount of (*R*)-2-methyl-CBS-oxazaborolidine[6] leading to the allylic alcohol **7** on a 4 g scale in 85% yield (92% ee) (Scheme 2). Further enhancement of the enantiomeric purity >96% (HPLC analysis) was achieved by recrystallization.

The spectroscopic and analytical data {$[\alpha]_D^{25} = -25.5$ (*c* 1.0, $CHCl_3$); lit.[7] $[\alpha]_D^{25} = -28.3$ (*c* 1.0, $CHCl_3$)} were in good agreement

* Corresponding author. Tel.: +91 20 25902586; fax: +91 20 25902629.
E-mail address: dk.mohapatra@ncl.res.in (D.K. Mohapatra).

0957-4166/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetasy.2008.05.031

with those reported in the literature, which confirmed the absolute stereochemistry of alcohol **7**.[7] The acetylenic side chain was then introduced by $(Ph_3P)_2PdCl_2$–CuI-catalyzed[8] coupling of the (1*S*)-2-iodocyclopenten-1-ol **7** with 1-undecyne (Scheme 2). Protection of the hydroxyl group as its *tert*-butyldiphenylsilyl [9] ether **4** provided sufficient steric bulk on the α-face such that osmylation of **4** proceeded entirely from the opposite side. The resulting diol **3** was selectively oxidized under Swern conditions[10] to a ketone; protection of the tertiary hydroxyl group as its *tert*-butyl-dimethylsilyl ether using TBSOTf and 2,6-lutidine in CH_2Cl_2 at 0 °C provided a bulky group on the β-cyclopentane face: enough conformational freedom was thereby allowed to secure the desired stereocenter during second osmylation.



Scheme 2. Synthesis of intermediate **3**.

Our next task was to reduce the alkyne functionality in a *cis*-selective manner. Toward this end, Lindlar-catalyzed[11] partial hydrogenation of **9** afforded the *Z*-olefin in only 10% yield (by ^1H NMR analysis). Extensive optimization was conducted to effect conversion to *Z*-olefin **2** by treatment with Pd/C in ethyl acetate under a hydrogen atmosphere in 95% yield (Scheme 3). With the intermediate **2** in hand, the stage was set for the synthesis of heliconol A **1**. Osmylation of **2** proceeded entirely from the α-face of the double bond, as expected, leading to **10** as the only product with the requisite stereocenters in 84% yield. Finally, treatment of compound **10** with TBAF in THF at room temperature furnished the target natural product (+)-heliconol A **1** in 96% yield. The spectroscopic and analytical data (^1H and ^{13}C NMR) of synthetic heliconol A {$[\alpha]_D^{25} = +19.6$ (*c* 0.9, acetone)} were identical to those of natural heliconol A {lit.[1] $[\alpha]_D^{25} = +21.0$ (*c* 1.6, acetone)}.

3. Conclusion

In conclusion, we have achieved the total synthesis of (+)-heliconol A starting from commercially available cyclopentenone and employing stereoselective reduction of a ketone, face selective dihydroxylation, Sonogashira coupling reaction, and a *cis*-selective reduction as the key reactions in part of a 10 steps linear sequence proceeding in 26% overall yield. Following the same strategy one can achieve the total synthesis of (−)-heliconol A as a single isomer.

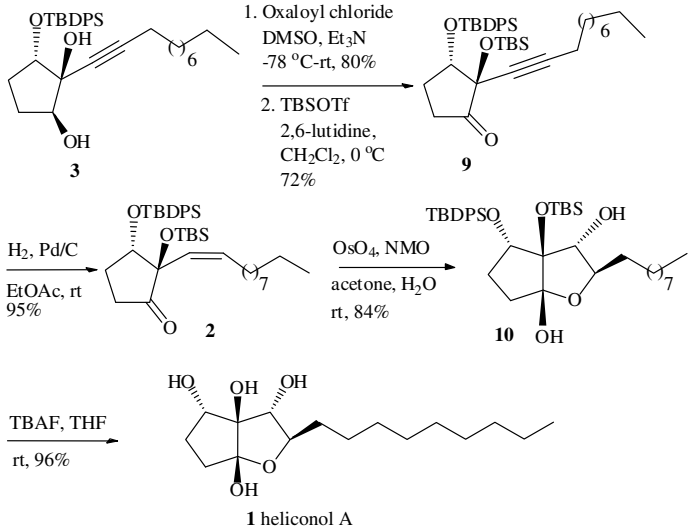
4. Experimental

4.1. General

All chemicals used in this study were purchased from Aldrich, Fluka, or Lancaster and used as received. All the moisture-sensitive reactions were performed under an inert atmosphere of either N_2 or Ar using dry solvents. Elemental analyses were recorded on Elmentar-Vario-EL (Heraeus Company Ltd Germany). The NMR spectra were obtained on a Bruker 200, 400, or 500 Fourier transform spectrometer. Optical rotations were measured with a JASCO DIP 370 digital polarimeter. All reactions are monitored by Thin Layer Chromatography (TLC) carried out on 0.25 mm E-Merck silica gel plates (60F-254) with UV, I_2 or anisaldehyde in ethanol as development reagents.

4.1.1. (*S*)-2-Iodocyclopent-2-enol 7

To a solution of (*R*)-2-methyl-CBS-oxazaborolidine (0.61 g, 2.19 mmol) in THF (15 mL) at 0 °C were added sequentially solutions of **6** (4.55 g, 21.9 mmol) in THF (20 mL) and BH_3·THF (13.13 mL, 13.13 mmol, 1.0 M in THF) dropwise. The reaction mixture was then stirred at 5 °C for 30 min, then quenched by the addition of aqueous buffer (pH 7, 10 mL), followed by 30% H_2O_2



Scheme 3. Synthesis of (+)-heliconol A.

(5 mL). After stirring for 30 min, ethyl acetate (30 mL) was added. The layers were separated; the organic layer was washed successively with 1M HCl (10 mL), H_2O (10 mL), saturated $NaHCO_3$ solution (10 mL), and brine (10 mL); then finally dried over Na_2SO_4, concentrated in vacuo to leave a residue, which on silica gel column chromatography (EtOAc/light petroleum, 1:19) yielded **7** (3.9 g, 85%) as a white solid. Recrystallization from ether–pentane afforded **7** as colorless crystals, mp 61.2–61.6 °C; the enantiomeric purity was determined to be 96% [HPLC, Column: Kromacil 5-CelluCoat (250 × 4.6 mm, 5 μ); Eluent: IPA: PE 01:99; Flow Rate: 0.5 mL/min]. $[\alpha]_D^{25} = -25.5$ (*c* 1.0, $CHCl_3$); IR ($CHCl_3$): 3583, 2851, 1604, 1215, 756 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 1.89 (m, 1H), 2.26–2.38 (m, 2H), 2.50 (m, 1H), 4.70 (m, 1H), 6.28 (t, *J* = 2.41 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$): δ 31.4, 32.8, 82.2, 100.4, 142.5; ESI-MS *m/z* 227.2 $(M+Na)^+$. Anal. Calcd for C_5H_7IO: C, 28.60; H, 3.36. Found: C, 28.48; H, 3.20.

4.1.2. (*S*)-2-(Undec-1-ynyl)cyclopent-2-enol 8

To a solution of **7** (0.9 g, 4.3 mmol) in Et_3N (15 mL), were simultaneously added $Pd(Ph_3P)_2Cl_2$ (0.3 g, 0.43 mmol) and CuI (0.163 g, 0.86 mmol) at room temperature, and the reaction mixture was degassed with argon. 1-Undecyne (0.98 g, 6.43 mmol) in Et_3N (10 mL) was then added dropwise, and the reaction mixture was again degassed under a stream of argon. After stirring for 1 h, the reaction mixture was filtered; the filtrate was concentrated and residue was purified by silica gel column chromatography (EtOAc/light petroleum, 1:19) to give **8** as a colorless liquid (0.93 g, 95%). $[\alpha]_D^{25} = -23.0$ (*c* 1.4, $CHCl_3$); IR ($CHCl_3$): 3492, 2223, 1669, 1557, 1214, 1051, 861 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 0.88 (t, *J* = 6.5 Hz, 3H), 1.27 (m, 10H), 1.52–1.59 (m, 3H), 1.68–1.86 (m, 2H), 2.25–2.39 (m, 4H), 2.51 (m, 1H), 4.74 (m, 1H), 6.08 (t, *J* = 2.5 Hz, 1H); ^{13}C NMR (50 MHz, $CDCl_3$): δ 14.0, 19.5, 22.6, 28.7, 28.9, 29.1, 29.2, 29.4, 30.5, 31.8, 32.6, 75.7, 78.9, 93.2, 128.7, 137.8; ESI-MS *m/z* 257.28 $(M+Na)^+$. Anal. Calcd for $C_{16}H_{26}O$: C, 81.99; H, 11.18. Found: C, 81.83; H, 10.96.

4.1.3. (*S*)-*tert*-Butyldiphenyl(2-(undec-1-ynyl)cyclopent-2-enyloxy)silane 4

Imidazole (0.44 g, 6.4 mmol) was added to a solution of **8** (0.75 g, 3.2 mmol) in DMF (10 mL) at room temperature. The reaction flask was cooled to 0 °C and then TBDPSCl (1.3 mL, 4.8 mmol) was added dropwise. The reaction mixture was stirred overnight at room temperature. After completion of the reaction, (monitored by TLC), it was quenched with water (30 mL) and extracted with ether (2 × 20 mL). The combined organic layers were dried over Na_2SO_4 and concentrated to give a residue, which was purified on silica gel column chromatography eluting with EtOAc/light petroleum (1:19) to provide **4** as a colorless liquid (1.49 g, 98%). $[\alpha]_D^{25} = -45.6$ (*c* 1.9, $CHCl_3$); IR ($CHCl_3$): 2856, 2211, 1716, 1464, 1217, 757 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 0.88 (t, *J* = 6.4 Hz, 3H), 1.09 (s, 9H), 1.26 (m, 11H), 1.40–1.49 (m, 3H), 1.68 (m, 1H), 1.86 (m, 1H), 2.08–2.41 (m, 4H), 4.81 (t, *J* = 6.3 Hz, 1H), 6.03 (t, *J* = 2.6 Hz, 1H), 7.31–7.40 (m, 6H), 7.68–7.80 (m, 4H); ^{13}C NMR (50 MHz, $CDCl_3$): δ 14.2, 19.3, 19.6, 22.7, 27.0, 28.8, 29.1, 29.3, 29.4, 29.5, 30.3, 31.9, 33.9, 76.9, 80.0, 93.0, 127.3, 127.5, 129.1, 129.4, 129.5, 134.1, 134.7, 136.0, 136.2, 137.6; ESI-MS *m/z* 495.17 $(M+Na)^+$. Anal. Calcd for $C_{32}H_{44}OSi$: C, 81.29; H, 9.38. Found: C, 81.25; H, 9.32.

4.1.4. (1*S*,2*S*,5*S*)-5-(*tert*-Butyldiphenylsilyloxy)-1-(undec-1-ynyl)-cyclopentane-1,2-diol 3

OsO_4 (0.4 mL, 0.008 mmol, 0.02 M in toluene) was added to a solution of **4** (1.2 g, 2.54 mmol) and NMO (1.2 mL, 5.0 mmol, 50% aqueous solution) in acetone/water (4:1, 20 mL) at room temperature. The mixture was stirred overnight and then quenched with a saturated solution of sodium sulfite (10 mL). The layers were separated, and the aqueous layer was extracted with ethyl acetate (3 × 20 mL). The combined organic layers were dried over Na_2SO_4, and concentrated under reduced pressure to leave a residue, which on silica gel column purification (EtOAc/light petroleum, 1:6) furnished **3** as a colorless liquid (1.15 g, 90%). $[\alpha]_D^{25} = -9.2$ (*c* 1.5, $CHCl_3$); IR ($CHCl_3$): 3484, 2401, 1600, 1427, 1215, 929, 758 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 0.89 (t, *J* = 6.8 Hz, 3H), 1.10 (s, 9H), 1.28 (m, 9H), 1.37–1.40 (m, 2H), 1.47–1.54 (m, 4H), 1.82–1.91 (m, 2H), 2.08 (m, 1H), 2.23 (t, *J* = 7.2 Hz, 2H), 4.23 (dd, *J* = 4.9, 7.0 Hz, 2H), 7.36–7.43 (m, 6H), 7.68 (dd, *J* = 1.3, 7.9 Hz, 2H), 7.77 (dd, *J* = 1.4, 7.9 Hz, 2H); ^{13}C NMR (50 MHz, $CDCl_3$): δ 14.2, 19.0, 19.3, 22.7, 26.9, 27.0, 27.8, 28.7, 29.0, 29.2, 29.3, 29.5, 31.9, 77.6, 78.5, 79.3, 79.8, 87.5, 127.6, 129.6, 133.8, 134.3, 135.8, 136.0; ESI-MS *m/z* 529.587 $(M+Na)^+$. Anal. Calcd for $C_{32}H_{46}O_3Si$: C, 75.84; H, 9.15. Found: C, 75.71; H, 9.26.

4.1.5. (2*R*,3*S*)-3-(*tert*-Butyldiphenylsilyloxy)-2-hydroxy-2-(undec-1-ynyl)cyclopentanone

To a solution of oxalyl chloride (0.96 mL, 1.9 mmol, 2 M in CH_2Cl_2) in dry CH_2Cl_2 (10 mL) at −78 °C was added a solution of dry DMSO (0.3 mL, 3.85 mmol) in CH_2Cl_2 (2 mL). After stirring for 30 min at that temperature, diol **3** (0.65 g, 1.3 mmol) in CH_2Cl_2 (5 mL) was added dropwise. Stirring was continued for 24 h after which Et_3N (0.8 mL, 5.8 mmol) was added slowly and stirred for 30 min before warming it to room temperature. The reaction mixture was then diluted with water (10 mL) and the aqueous layer was extracted with CH_2Cl_2 (3 × 30 mL). The combined organic layers were dried over Na_2SO_4 and concentrated. Purification by silica gel column chromatography (EtOAc/light petroleum, 1:9) afforded the keto-derivative (0.52 g, 80%) as a colorless oil. $[\alpha]_D^{25} = -2.0$ (*c* 1.3, $CHCl_3$); IR ($CHCl_3$): 3458, 2409, 1758, 1471, 757 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 0.87 (t, *J* = 6.5 Hz, 3H), 1.10 (s, 9H), 1.25 (m, 10H), 1.47–1.58 (m, 2H), 1.83–2.11 (m, 5H), 2.27 (t, *J* = 7.03 Hz, 2H), 2.55 (m, 1H), 4.10 (dd, *J* = 6.9, 8.73 Hz, 1H), 7.33–7.44 (m, 6H), 7.69–7.79 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 14.1, 19.0, 19.4, 22.6, 26.5, 26.8, 28.5, 28.7, 29.1, 29.3, 29.5, 31.9, 32.6, 74.2, 78.1, 78.3, 91.5, 127.6, 129.8, 133.1, 134.0, 135.8, 136.0, 210.3; ESI-MS *m/z* 527.98 $(M+Na)^+$. Anal. Calcd for $C_{32}H_{44}O_3Si$: C, 76.14; H, 8.79. Found: C, 75.98; H, 8.84.

4.1.6. (2*R*,3S)-2-(*tert*-Butyldimethylsilyloxy)-3-(*tert*-butyldiphenylsilyloxy)-2-(undec-1-ynyl)cyclopentanone 9

To a solution of the keto-derivative (0.38 g, 0.76 mmol) in CH_2Cl_2 (10 mL) at 0 °C was added 2,6-lutidine (0.2 mL, 1.53 mmol) followed by TBSOTf (0.3 mL, 1.14 mmol). The reaction mixture was stirred for 30 min and then quenched with water (5 mL). The layers were separated and the aqueous layer was extracted with CH_2Cl_2 (3 × 20 mL). The combined layers were dried over Na_2SO_4, concentrated and purified on silica gel column chromatography (EtOAc/light petroleum, 1:19) to yield **9** as a colorless liquid (0.34 g, 72%). $[\alpha]_D^{25} = +6.6$ (*c* 1.5, $CHCl_3$); IR ($CHCl_3$): 2930, 2401, 1760, 1428, 1215 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 0.07 (s, 3H), 0.10 (s, 3H), 0.73 (s, 9H), 0.77 (t, *J* = 5.0 Hz, 3H), 0.96 (s, 9H), 1.15 (m, 10H), 1.34–1.44 (m, 3H), 1.57–1.67 (m, 2H), 1.88–2.32 (m, 5H), 4.04 (t, *J* = 5.5 Hz, 1H), 7.21–7.33 (m, 6H), 7.59–7.65 (m, 4H); ^{13}C NMR (50 MHz, $CDCl_3$): δ −3.1, −2.8, 14.2, 18.2, 19.1, 19.4, 22.7, 25.8, 26.8, 26.9, 28.4, 29.1, 29.2, 29.3, 29.5, 29.7, 31.9, 75.7, 77.3, 78.9, 91.7, 127.6, 127.7, 129.7, 129.8, 133.4, 134.4, 135.9, 136.0, 209.3; ESI-MS *m/z* 636.57 $(M+NH_4)^+$. Anal. Calcd for $C_{38}H_{58}O_3Si_2$: C, 73.73; H, 9.44. Found: C, 73.48; H, 9.32.

4.1.7. (2*R*,3*S*,*Z*)-2-(*tert*-Butyldimethylsilyloxy)-3-(*tert*-butyldiphenylsilyloxy)-2-(undec-1-enyl)cyclopenta-none 2

Compound **9** (0.21 g, 0.34 mmol) was hydrogenated in ethyl acetate (7 mL) with 10% Pd/C (50 mg) at atmospheric pressure. After stirring for 1 h, (completion of reaction was monitored by

TLC), the reaction mixture was filtered over a pad of Celite, concentrated and purified on silica gel column chromatography eluting with EtOAc/light petroleum (1:19) yielding olefin **2** as a colorless liquid (0.2 g, 95%). $[\alpha]_D^{25} = +2.4$ (*c* 0.9, $CHCl_3$); IR ($CHCl_3$): 2925, 1758, 1635, 1451, 1086 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 0.12 (s, 3H), 0.21 (s, 3H), 0.95 (s, 9H), 1.01 (t, *J* = 6.0 Hz, 3H), 1.16 (s, 9H), 1.38 (m, 13H), 1.81–1.96 (m, 2H), 2.08–2.24 (m, 3H), 2.29–2.54 (m, 2H), 4.32 (t, *J* = 5.7 Hz, 1H), 5.74 (dt, *J* = 5.8, 12.0 Hz, 1H), 5.82 (d, *J* = 12.0 Hz, 1H), 7.49–7.56 (m, 6H), 7.75–7.84 (m, 4H); ^{13}C NMR (50 MHz, $CDCl_3$): δ −3.4, −2.6, 14.1, 18.4, 19.3, 22.7, 25.9, 26.8, 26.9, 27.1, 29.2, 29.3, 29.5, 29.5, 29.6, 31.9, 32.9, 79.5, 82.8, 125.1, 127.5, 129.7, 133.1, 135.4, 135.8, 136.0, 136.0, 215.2; ESI-MS *m/z* 643.44 $(M+Na)^+$. Anal. Calcd for $C_{38}H_{60}O_3Si_2$: C, 73.49; H, 9.74. Found: C, 73.26; H, 9.45.

4.1.8. (2*R*,3*R*,3a*R*,4*S*,6a*R*)-3a-(*tert*-Butyldimethylsilyloxy)-4-(*tert*-butyldiphenylsilyloxy)-2-nonyl-hexahydro-2*H*-cyclopenta[*b*]furan-3,6a-diol 10

To a solution of **2** (0.12 g, 0.2 mmol) and NMO (0.1 mL, 0.4 mmol, 50% aqueous solution) in acetone/water (4:1, 5 mL) was added OsO_4 (1 mL, 0.02 mmol, 0.02 M in toluene). The reaction mixture was stirred for 96 h, (completion being monitored by TLC), then quenched with a saturated solution of sodium sulfite (5 mL). Ethyl acetate (10 mL) was added and the layers were separated. The aqueous layer was back extracted with ethyl acetate (3 × 20 mL), the combined organic layers were dried over Na_2SO_4, concentrated in vacuum and the residue was purified by flash silica gel column chromatography (EtOAc/light petroleum, 1:19) to afford **10** as a colorless liquid (0.11 g, 84%). $[\alpha]_D^{25} = +5.0$ (*c* 1.2, $CHCl_3$); IR ($CHCl_3$): 3494, 2929, 1662, 1590, 1428, 1113, 970 cm^{-1}; ^1H NMR (200 MHz, $CDCl_3$): δ 0.08 (s, 3H), 0.13 (s, 3H), 0.83 (s, 9H), 0.87 (t, *J* = 5.9 Hz, 3H), 1.09 (s, 9H), 1.26 (m, 15H), 1.56–1.73 (m, 4H), 1.89 (m, 1H), 3.09 (br s, 1H), 3.88 (dd, *J* = 5.96, 12.8 Hz, 1H), 4.03 (t, *J* = 5.8 Hz, 1H), 4.31 (m, 1H), 4.92 (d, *J* = 5.8 Hz, 1H), 7.33–7.45 (m, 6H), 7.66–7.81 (m, 4H); ^{13}C NMR (50 MHz, $CDCl_3$): δ −3.2, −2.9, 14.1, 17.7, 19.0, 22.7, 25.7, 26.2, 27.0, 29.3, 29.5, 30.2, 31.9, 34.7, 35.1, 84.0, 84.5, 84.7, 85.7, 109.4, 127.8, 127.8, 130.1, 130.2, 131.7, 133.1, 135.9, 135.9; ESI-MS *m/z* 677.15 $(M+Na)^+$. Anal. Calcd for $C_{38}H_{62}O_5Si_2$: C, 69.67; H, 9.54. Found: C, 69.73; H, 9.41.

4.1.9. (+)-Heliconol A 1

To a solution of **10** (0.082 g, 0.13 mmol) in THF (2 mL) at 0 °C, TBAF (0.3 mL, 0.3 mmol, 1 M in THF) was added and the reaction mixture was stirred for 30 min at room temperature. After completion (monitored by TLC), the reaction was quenched with a saturated solution of NH_4Cl (1 mL) and ethyl acetate (2 mL). The layers were separated and the aqueous layer was extracted with ethyl acetate (3 × 10 mL). The combined organic layers were dried over Na_2SO_4, concentrated in vacuo and purified by flash silica gel chromatography eluting with ethyl acetate/light petroleum (7:3) to afford **1** (heliconol A) as a liquid (0.036 g, 96%). $[\alpha]_D^{25} = +19.6$ (*c* 0.9, acetone); IR ($CHCl_3$): 3369, 2925, 2854, 1653, 1464, 1309, 1016 cm^{-1}; ^1H NMR (400 MHz, DMSO): δ 0.84 (t, *J* = 7.0 Hz, 3H), 1.23 (m, 13H), 1.34–1.41 (m, 2H), 1.49–1.59 (m, 3H), 1.77–1.87 (m, 2H), 3.56 (dt, *J* = 4.4, 7.5 Hz, 1H), 3.72 (t, *J* = 7.2 Hz, 1H), 4.04 (m, 1H), 4.59 (s, 1H), 5.51 (d, *J* = 4.0 Hz, 1H), 5.58 (d, *J* = 6.7 Hz, 1H), 5.85 (s, 1H); ^{13}C NMR (100 MHz, DMSO): δ 14.0, 22.2, 25.4, 28.8, 29.0, 29.1, 29.2, 30.6, 31.4, 34.1, 35.1, 80.1, 81.5, 83.3, 84.0, 108.6; ESI-MS *m/z* 325.16 $(M+Na)^+$. Anal. Calcd for $C_{16}H_{30}O_5$: C, 63.55; H, 10.00. Found: C, 63.46; H, 9.86.

Acknowledgments

B.C. thank UGC, New Delhi, for a research grant. We thank Dr. Ganesh Pandey for his support and encouragement. We are grateful to Dr. P. R. Rajmohanan for NMR data.

References

1. Mudur, S. V.; Swenson, D. C.; Gloer, J. B.; Campbell, J.; Shearer, C. A. *Org. Lett.* **2006**, *8*, 3191–3194.
2. (a) Bauer, A. W.; Kirby, W. M.; Sherris, J. C.; Turck, M. *Am. J. Clin. Pathol.* **1996**, *45*, 493–496; (b) Wagenaur, M. M.; Clardy, J. *J. Nat. Prod.* **2001**, *64*, 1006–1009.
3. Wicklow, D. T.; Joshi, B. K.; Gamble, W. R.; Gloer, J. B.; Dowd, P. F. *Appl. Environ. Microbiol.* **1998**, *64*, 4482–4484.
4. Quan, W.; Yu, B.; Zhang, J.; Liang, Q.; She, X.; Pan, X. *Tetrahedron* **2007**, *63*, 9991–9996.
5. Johnson, C. R.; Adams, J. P.; Braun, M. P.; Senanayake, C. B. W.; Wovkulich, P. M.; Uskoković, M. R. *Tetrahedron Lett.* **1992**, *33*, 917–918.
6. (a) Corey, E. J.; Bakshi, R. K.; Shibata, S. *J. Am. Chem. Soc.* **1987**, *109*, 5551–5553; (b) Corey, E. J.; Bakshi, R. K.; Shibata, S.; Chen, C. P.; Singh, V. K. *J. Am. Chem. Soc.* **1987**, *109*, 7925–7926; (c) Deloux, L.; Srebnik, M. *Chem. Rev.* **1993**, *93*, 763–784; (d) Corey, E. J.; Helal, C. J. *Angew. Chem., Int. Ed.* **1998**, *37*, 1986–2012.
7. Johnson, K. R.; Sakaguchi, H. *Synlett* **1992**, 813–816.
8. Sonogashira, K.; Tohda, Y.; Hagihara, N. *Tetrahedron Lett.* **1975**, *16*, 4467–4470.
9. Smith, A. B.; Branca, S. J.; Pilla, N. N.; Guaciaro, M. A. *J. Org. Chem.* **1982**, *47*, 1855–1869.
10. Omura, K.; Swern, D. *Tetrahedron* **1978**, *34*, 1651–1660.
11. Lindlar, H.; Dubuis, R. *Organic Syntheses*; Wiley: New York, 1973. Collect. Vol. V, p 880.