Carbohydrate Research 388 (2014) 130–137

Contents lists available at ScienceDirect

Carbohydrate Research

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

Toward synthesis of carbasugars (+)-gabosine C, (+)-COTC, (+)-pericosine B, and (+)-pericosine C

D. Chanti Babu *, Ch. Bhujanga Rao, K. Venkatesham, J. Jon Paul Selvam, Y. Venkateswarlu †

Division of Natural Product Chemistry, Indian Institute of Chemical Technology, Hyderabad 500 007, India

ARTICLE INFO

Article history:
Received 24 June 2013
Received in revised form 3 August 2013
Accepted 9 August 2013
Available online 20 August 2013

Keywords:
Carbasugars
Streptomyces
Periconia byssoides
Morita–Baylis–Hillman (MBH) reaction
Luche reduction D-(−)-isoascorbic acid and D-ribose

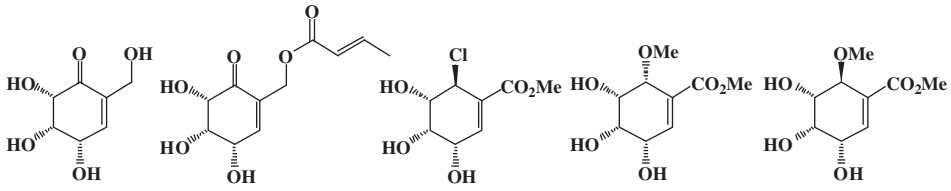
ABSTRACT

Asymmetric total synthesis of (+)-gabosine C, (+)-pericosine B, and (+)-pericosine C has been reported from readily available D-(−)-isoascorbic acid and D-ribose involving *Grubbs* ring closing metathesis, *Morita–Baylis–Hillman* (MBH) reaction, and *Luche* reduction.

1. Introduction

Carbasugars demonstrate glyoxylase inhibitory, antitumor, antibacterial, antifungal, antimalarial, and antiviral activities.[1] Among them gabosines and pericosines exhibit a pivotal role, which are cyclohexene carbasugars. An account of isolation of gabosines and pericosines, their synthetic studies and biological activities has been found in the literature.[2–4] In 1974 (−)-gabosine C, was isolated from culture broth of *Streptomyces filipensis*,[2a] that has been identical to a known antibiotic KD16-U1. Later its crotonic ester was isolated from the culture broth of *Streptomyces griseosporeus*, known as (−)-COTC and shown to be a potent glyoxylase I inhibitor.[2b,c] Pericosines (A–E) were isolated from a micro organism *Perconia byssoides* (OUPS-N133) separated from the gastrointestinal tract of the sea hare *Aplyasia kurodai*.[4a,h] (+)-Pericosine A (**3**), (+)-pericosine B (**4**), and (+)-pericosine C (**5**) demonstrated remarkable activity (ED_{50} = 0.1, 4 and 10.5 μg/mL, respectively) against P388 lymphocytic human cancer (leukemia) cells.[4a,h,i]

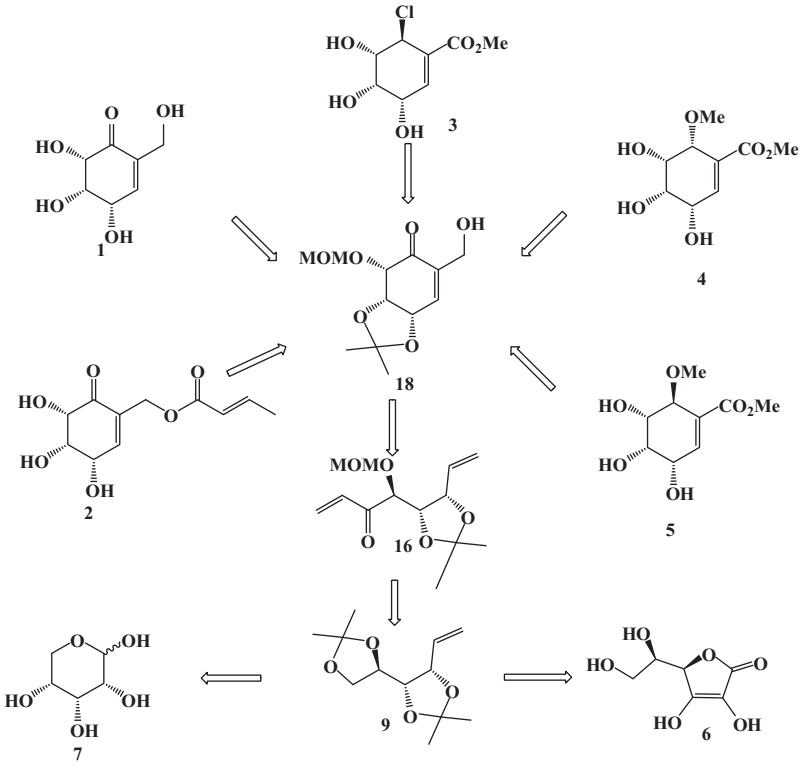
Common structural building of (+)-gabosine C (**1**), (+)-COTC (**2**), (+)-pericosine A (**3**), (+)-pericosine B (**4**), and (+)-pericosine C (**5**), and their biological activity inspired us in their synthesis. For the past several years we have been engaged in the synthesis of biologically active compounds by using natural and commercially available sources.[5,6]



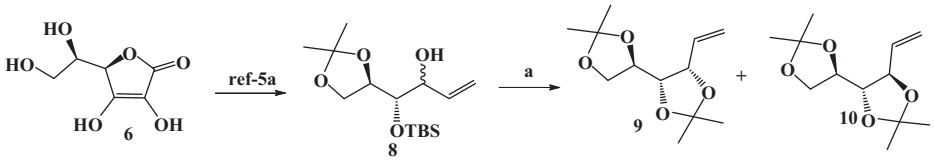
* Corresponding author. Tel.: +91 40 27193167; fax: +91 40 27160512.
E-mail address: chantibabuiict@gmail.com (D.C. Babu).

† Condolences: We expressing our deepest grief and sorrow for sudden death of Dr. Y. Vekateswarlu on 17th July, 2013. He is an excellent teacher and human being; he supported and encourages us at stages of our research career.

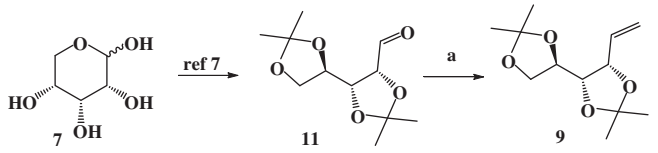
http://dx.doi.org/10.1016/j.carres.2013.08.008
0008-6215/



Scheme 1. The retro synthetic analysis of the (+)-gabosine C (**1**), (+)-COTC (**2**), (+)-pericosine A (**3**), (+)-pericosine B (**4**), and (+)-pericosine C (**5**).



Scheme 2. Reagents and conditions: (a) (i) TBAF, THF, rt, 8 h, (ii) 2,2 DMP, TsOH, DCM, 12 h, two steps 85%.



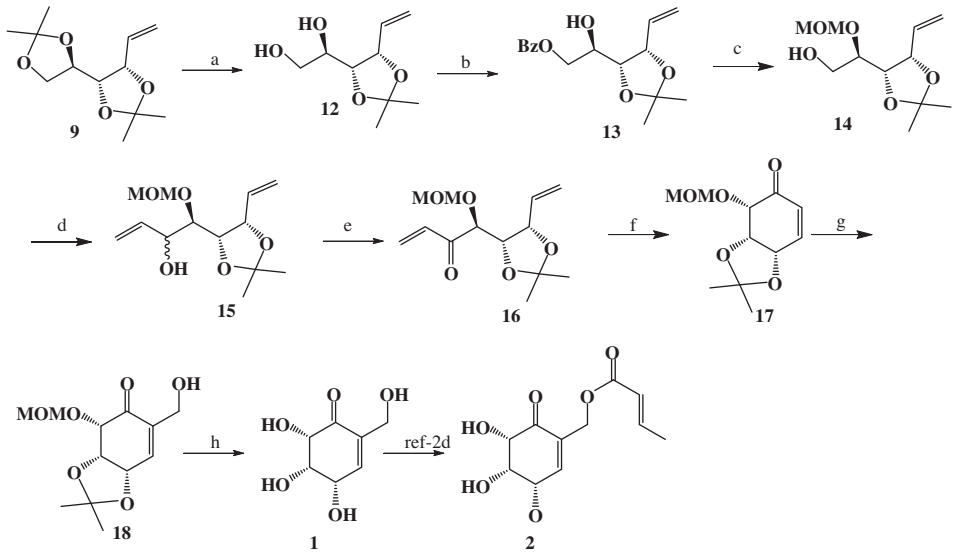
Scheme 3. Reagents and conditions: (a) ^{t}BuOK, $PPh_3PCH_3^+Br^-$, THF, −10°, 4 h, 75%.

2. Results and discussion

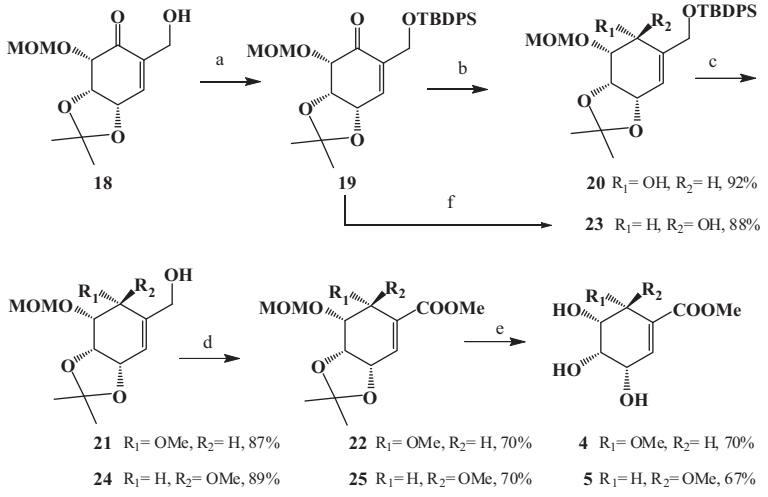
We envisaged (Scheme 1) that a common intermediate **18**, that would give (+)-gabosine C (**1**), (+)-COTC (**2**), (+)-pericosine A (**3**), (+)-pericosine B (**4**), and (+)-pericosine C (**5**) which in turn could be obtained from *Grubbs* cross metathesis reaction of allyl ketone **16** followed by employing and *Morita–Baylis–Hillman* reactions as key steps. Ketone **16** can be derived from diacetonide **9** using sequential reactions, which could be furnished from either D-(−)-isoascorbic acid **6** or D-ribose **7**.

Accordingly, alcohol **8** was obtained from D-isoascorbic acid[5a] (Scheme 2). The TBS protecting group in **8** was removed using TBAF to give diol, which was protected with 2, 2 DMP in DCM to give separable diastereomers compound **9** and compound **10**. In a different route compound **9** was prepared from compound **11** which in turn prepared from D-ribose (Scheme 3).[7] Accordingly, aldehyde **11** was converted into compound **9** using *Wittig* reaction with methyltriphenylphosphonium bromide salt in the presence of ^{t}BuOK.

Hydrolysis of primary acetonide in compound **9** in PPTS/methanol at 0 °C yielded diol **12** (Scheme 4) in 70% yield. The primary alcohol in compound **12** was selectively protected with benzoyl chloride in the presence of pyridine to afford benzoyl ester **13** in 92% yield. Further, the secondary alcohol was masked as MOM ether using MOM-Cl and DIPEA (*Hunig's* base), followed by deprotection of benzoyl group in compound **13** with K_2CO_3 leading to the desired primary alcohol **14**. Now, alcohol **14** was oxidized to corresponding aldehyde using *Swern* oxidation, which on treatment with vinyl magnesium bromide afforded a diastereomeric mixture of alcohol **15**, which was oxidized to enone **16** by treating with IBX in DMSO. Compound **16** was subjected to ring closing metathesis reaction (RCM) using *Hoyeda Grubbs* catalyst to afford cyclohexenone **17** in 60% yield for 8 h. The *Morita–Baylis–Hillman* reaction for α-hydroxymethylation on cyclohexenone **17** was attempted with aqueous formaldehyde (37%) in the presence of imidazole and 1 M $NaHCO_3$ in THF to obtain a mixture of products.[8] However, when compound **17** was reacted with aqueous formaldehyde (37%) in the presence of DMAP at −10 °C furnished intermediate **18** in 38% yield for 3 days.[9] The protecting groups MOM and acetonide in compound **18** were removed using trifluoroacetic acid in methanol to afford (+)-gabosine C (1), [mp 113–115 °C and optical



Scheme 4. Reagents and conditions: (a) PPTs, methanol, 0 °C, 6 h, 70%; (b) pyridine, benzoyl chloride, DCM, 7 h, 92%; (c) (i) DIPEA, MOM-Cl, DCM, 12 h, (ii) K_2CO_3, methanol, 0 °C, 3 h, two steps 83%; (d) (i) $(COCl)_2$, DMSO, triethyl amine, −78 °C, 1 h, (ii) vinyl Magnesium bromide, THF, 3 h, 0 °C, two steps 84%; (e) IBX, DMSO, 3 h, 0 °C, 91%; (f) Hoyeda Grubbs catalyst (5 mol %), DCM, reflux, 8 h, 60%; (g) aqueous formaldehyde (37–40%), DMAP, −10 °C, 3 days, 38%; (h) TFA, methanol 0 °C, 4 h, 70%.



Scheme 5. Reagents and conditions: (a) TBDPS-Cl, imidazole, DCM, 0 °C, 18 h, 89%; (b) $NaBH_4$, MeOH, 0 °C, 1 h, 92%; (c) (i) NaH, MeI, THF, rt, 6 h, (ii) HF–water, THF, 0 °C, 8 h; (d) (i) TEMPO, $PhI(OAc)_2$, MeCN:water (2:1), 3 h; (ii) MeI, K_2CO_3, Me_2CO, rt, 3 h; (e) TFA, methanol, rt, 3 h; (f) $CeCl_3{\cdot}7H_2O$, $NaBH_4$, MeOH, −78 °C, 1 h, 88%.

rotation $[\alpha]_D^{25}$ +175 (*c* 0.6, H_2O)]. The spectroscopic data for (+)-gabosine C (1) were in agreement with those previously reported in the literature for the natural antipode, but as expected its specific rotation was opposite in sign.[2r] Thus, the synthesis of (+) gabosine C (1) from compound **9** was accomplished in 6.52% in overall yield. (+)-COTC (**2**) can be synthesized from (+)-gabosine C (**1**) following previously reported procedure in the literature.[2d]

To accomplish the synthesis of (+)-pericosine B (**4**), the hydroxy function of intermediate **18** was masked as TBDPS ether **19** (Scheme 5). Reduction of the keto functional group in compound **19** with $NaBH_4$ at 0 °C gave a single diastereomeric alcohol **20** (C_5, C_6 anti configuration) in 92% yield. The resulting alcohol in **20** was methylated using NaH/MeI at 0 °C to furnish methylated compound, which on treatment with aqueous HF in THF gave alcohol **21**. The primary alcohol in compound **21** was then oxidized to the corresponding acid using TEMPO/$PhI(OAc)_2$ and the acid was esterified with MeI/K_2CO_3 in acetone to yield methoxy ester **22**. The MOM and acetonide group in **22** were removed by reacting with trifluoroacetic acid to give (+)-pericosine B (**4**). {Mp 84–86 °C $[\alpha]_D^{20}$ +34.6 (*c* 0.3, EtOH)}. The spectroscopic data for (+)-pericosine B (**4**) were in good agreement with the literature.[4n] Thus the synthesis of (+)-pericosine B (**4**) from compound **9** was accomplished in 2.28% overall yield.

To synthesize (+)-pericosine C (**5**), initially we examined for the reduction of **19** with a series of reducing agents like CBS (*Corey–Bakshi–Shibata*) catalyst, selectrides, and other borohydrides. However, all these experiments resulted in poor diastereoselectivity. Fortunately, *Luche* reduction[10] yielded with a single diastereomeric alcohol **23** (Scheme 5). We extended the strategy from alcohol **23** to (+)-pericosine C (**5**), by adopting the similar reaction protocol used for the construction (+)-pericosine B (**4**) from alcohol **20**. (+)-Pericosine C (**5**) was obtained as a liquid {$[\alpha]_D^{20}$ +72.5 (*c* 0.3, EtOH)}. Spectroscopic data of (+)-pericosine C (**5**) were found to be identical with those of the literature.[4n] Thus the synthesis of (+)-pericosine C (**5**) was accomplished in 2.13% yield from compound **9**. Pericosine A (**3**) could be derived from alcohol **20** by

employing S_N2 chlorination,[11] following the previous sequential reactions like TBDPS deprotection, esterification, and deprotection of acetonide and MOM.

3. Experimental section

3.1. General methods

Commercial reagents were used without further purification, all solvents were purified by standard techniques and Infrared spectra were recorded on PerkinElmer 683 spectrometer. Optical rotations were obtained on Jasco Dip 360 digital polarimeter. NMR spectra were recorded in $CDCl_3$ solvent on Brucker 300 and Varian 500 NMR spectrometers. Chemical shifts (d) are quoted in parts per million and are referenced to tetramethylsilane (TMS) as an internal standard. Coupling constants (*J*) are quoted in Hertz. Column chromatographic separations were carried out on silica gel (60–120 mesh) and flash chromatographic separations were carried out using 230–400 mesh, silica gel. HRMS was recorded on Agilent Technologies 6510 Q-TOF LC/MS.

3.2. Experimental procedures and spectral data

3.2.1. (4*S*,4′*R*,5*S*)-2,2,2′,2′-Tetramethyl-5-vinyl-4,4′-bi(1,3-dioxolane) 9

To a cooled (0 °C) solution of compound **8** (9.8 g, 32.45 mmol) in THF (60 mL) was added tetrabutylammonium fluoride (35.70 mL of 1 M soln in THF, 35.70 mmol) and stirred for 8 h at room temperature. After completion of the reaction as monitored by TLC, saturated $NaHCO_3$ was added and extracted into EtOAc (3 × 15 mL). The combined organic layer was washed with saturated $NaHCO_3$, brine, dried (Na_2SO_4), concentrated, and the crude residue was dissolved in dry dichloromethane (35 mL), was added $Me_2C(OMe)_2$ (4.76 mL, 38.94 mmol) and added catalytic amount of *p*-TsOH at room temperature and stirred for 12 h. After completion of the reaction, the reaction was quenched with saturated $NaHCO_3$ (10 mL), extracted into dichloromethane (3 × 10 mL), and concentrated under reduced pressure to give crude product which was purified over silica gel column chromatography (hexane/ethyl acetate 19:1) to obtain separable compound **9** (74%) and compound **10** 26% total yield (6.28 g, 85%).

Procedure (II) To a cooled (−10°) soln of $PPh_3PCH_3^+Br^-$ (17 g, 47.81 mmol) in THF (150 mL) was added ^{t}BuOK (4.87 g, 43.46 mmol) portion wise and allowed to stir for 2 h at rt. To this mixture, a soln of aldehyde **11** (5 g, 21.73 mmol) in dry THF (20 mL) was added slowly over 10 min and stirred at the same temperature (−10°) for 2 h. After completion of the reaction as monitored by TLC, the mixture was quenched with the addition of saturated NH_4Cl soln (40 mL) and extracted into EtOAc (3 × 30 mL). The combined extract was washed with brine, dried (Na_2SO_4), concentrated, and the crude residue was purified by CC (EtOAc/*n*-hexane, 1:19) to afford compound **9** (3.72 g, 75%) as colorless liquid. $[\alpha]_D^{25}$ +4.8 (*c* 0.3, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.94–5.81 (m, 1H), 5.37 (d, *J* = 18.1 Hz, 1H), 5.23 (d, *J* = 10.5 Hz, 1H), 4.64 (t, *J* = 6.0 Hz, 1H), 4.12–3.99 (m, 3H), 3.90–3.84 (m, 1H), 1.41 (m, 3H), 1.36 (m, 3H), 1.32 (m, 3H), 1.28 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 133.3, 117.6, 109.3, 108.7, 78.7, 78.3, 73.9, 67.2, 27.6, 26.7, 25.4, 25.9. HRMS: Calcd for $C_{12}H_{20}O_4Na$ ([M+Na]$^+$) is 251.1262. Found: 251.1256.

3.2.2. (4*S*,4′*R*,5*R*)-2,2,2′,2′-Tetramethyl-5-vinyl-4,4′-bi(1,3-dioxolane) 10

$[\alpha]_D^{25}$ −6.5 (*c* 3.2, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.97–5.81 (m, 1H), 5.37 (d, *J* = 17.3 Hz, 1H), 5.18 (d, *J* = 10.5 Hz, 1H), 4.32 (t, *J* = 6.7 Hz, 1H), 4.12–3.99 (m, 2H), 3.95–3.92 (m, 1H), 3.61 (t, *J* = 7.5 1H), 1.53 (s, 3H) 1.43 (s, 3H), 1.38 (s, 3H), 1.34 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): 135.8, 117.0, 109.5, 109.3, 81.0, 80.3, 76.6, 66.9, 26.8 (2C), 26.6, 25.1. HRMS: Calcd for $C_{12}H_{20}O_4Na$ ([M+Na]$^+$) 251.1262. Found: 251.1258.

3.2.3. (*R*)-1-((4*R*,5*S*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl) ethane-1,2-diol (12)

To a solution of compound **9** (3 g, 13.15 mmol) in MeOH (20 mL) was added PPTS and the reaction mixture was allowed to stir for 6 h at room temperature. After completion of the reaction as monitored by TLC, the reaction mixture was quenched with saturated $NaHCO_3$ (10 mL), methanol was evaporated and extracted into ethyl acetate (3 × 15 mL), dried over anhydrous Na_2SO_4, and the solvent was evaporated to give crude product, which was purified over silica gel column chromatography (50% ethyl acetate in hexane) to afford compound **12** (1.73 g, 70%) as a white solid. $[\alpha]_D^{25}$ +4.5 (*c* 0.4, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.93–5.82 (m, 1H), 5.40 (d, *J* = 17.8 Hz, 1H), 5.22 (d, *J* = 9.8 Hz, 1H), 4.48–4.30 (m, 1H), 3.84–3.51 (b m, 4 H), 1.36 (s, 6 H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 133.7, 118.6, 106.4, 78.4, 78.1, 69.7, 64.3, 27.7, 25.2. HRMS: $C_9H_{16}O_4Na$ ([M+Na]$^+$) 211.0952. Found: 211.0948.

3.2.4. (*R*)-2-((4*R*,5*S*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl)-2-hydroxyethyl benzoate(13)

To a cooled (0 °C) solution of diol **12** (5 g, 26.59 mmol) in DCM (50 mL) was added pyridine (2.35 mL, 29.24 mmol) followed by benzoyl chloride (3.07 mL, 26.59 mmol) and the reaction mixture stirred at the room temperature for 7 h. After completion of the reaction, the reaction was diluted with water (20 mL) and extracted into DCM (3 × 20 mL). The combined organic layer was washed with dilute HCl, water, and brine, dried (Na_2SO_4), and concentrated. The residue was purified by column chromatography to afford compound **13** (7.76 g, 92%) as a viscous liquid. $[\alpha]_D^{20}$ −4.8 (*c* 0.6, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.05–8.01 (m, 2H), 7.58–7.52 (m, 1H), 7.45–7.40 (m, 2H), 5.95–5.84 (m, 1H), 5.43 (dt, *J* = 1.3, 17.3 Hz, 1H), 5.23 (dt, *J* = 1.3, 10.3 Hz, 1H), 4.52–4.50 (m, 1H), 4.38–4.32 (m, 1H), 4.12–4.07 (m, 1H), 3.82–3.78 (m, 1H), 2.73–2.65 (br s, 1H), 1.43 (s, 3H), 1.42 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 166.6, 136.0, 133.1, 129.7, 128.3, 118.0, 109.0, 80.5, 79.1, 70.8, 66.0, 26.0 (2C). HRMS: Calcd for $C_{16}H_{20}O_5Na$ ([M+Na]$^+$) is 315.1212. Found: 315.1206.

3.2.5. (*R*)-2-((4*S*,5*S*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl)-2-(methoxymethoxy) ethanol (14)

To a cooled (0 °C) solution of secondary alcohol **13** (7.5 g, 25.68 mmol) in dry CH_2Cl_2 (50 mL) were added *N*,*N*-diisopropyl ethylamine (6.71 mL, 26.4 mmol), methoxymethyl chloride (2.34 mL, 30.81 mmol), and catalytic amount DMAP and the reaction mass was refluxed for 12 h. After completion of the reaction as monitored by TLC, the reaction was diluted with water (20 mL) and extracted with CH_2Cl_2 (3 × 20 mL). The combined organic layer was washed with brine, dried over anhydrous Na_2SO_4, and the solvent was removed under reduced pressure to afford crude mixture, which was dissolved in MeOH (40 mL) and added K_2CO_3 (6.40 g, 46.42 mmol), and stirred for 3 h at rt. After completion of the reaction as monitored by TLC, the mixture was filtered and the solvent was removed under reduced pressure to afford the crude reaction mass, which was diluted with H_2O (25 mL) and extracted into EtOAc (3 × 15 mL). The combined extract was washed with brine, dried (Na_2SO_4), concentrated, and the residue was purified by column chromatography to afford compound **14** (4.95 g, 83%) as a colorless liquid. $[\alpha]_D^{20}$ +55.7 (*c* 0.7, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.79–5.94 (m, 1H), 5.30–5.37 (m, 1H), 5.19–5.25 (m, 1H), 4.56–4.69 (m, 3H), 4.11 (dd, *J* = 8.3, 6.4 Hz, 1H), 3.80–3.86 (m, 1H), 3.59–3.67 (m, 1H), 3.48–3.54 (td, *J* = 8.4, 6.4,

2.4 Hz, 1H), 3.42 (s, 3H), 1.47 (s, 3H), 1.36 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 133.7, 117.5, 108.7, 97.6, 81.2, 78.6, 76.9, 63.7, 55.9, 27.6, 25.2. HRMS: Calcd for $C_{11}H_{20}O_5Na$ ([M+Na]$^+$) 255.1212. Found: 255.1210.

3.2.6. (*R*)-1-((4*S*,5*S*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl)-1-(methoxymethoxy)but-3-en-2-ol (15)

To a cooled (−78 °C) solution of alcohol **14** (4.9 g, 21.12 mmol) in dry dichloromethane (50 mL) were added dimethylsulfoxide (3 mL, 42.24 mmol) and oxalyl chloride (2.7 mL, 31.68 mmol) and was stirred for 30 min and triethylamine (14.7 mL, 105.6 mmol) was added drop wise to the reaction mixture and the reaction mixture was slowly warmed to room temperature (30 min). After completion of the reaction, the reaction was quenched with a saturated aqueous solution of NH_4Cl (20 mL) and extracted into dichloromethane (3 × 10 mL) and the combined organic layer was washed with brine (30 mL), dried over anhydrous $MgSO_4$, and concentrated in vacuo to obtain crude aldehyde and utilized in the next reaction. To a cooled (0 °C) solution of crude aldehyde in dry THF (60 mL) was added slowly vinyl magnesium bromide (31.6 mL of a 1 M solution in THF, 31.68 mmol) over 20 min. The reaction mixture was stirred at the same temperature for 1 h and then slowly warmed to room temperature over 2 h. After completion of the reaction as monitored by TLC, the reaction was quenched with saturated NH_4Cl (20 mL) and extracted into EtOAc (3 × 15 mL). The combined organic extract was washed with brine, dried over anhydrous Na_2SO_4, concentrated under reduced pressure which was purified over silica gel column to furnish pure compound **15** as a pale yellow liquid (4.57 g, 84%). ^{1}H NMR (300 MHz, $CDCl_3$). δ 6.11–5.89 (br m, 2H), 5.43–5.33 (m, 2H), 5.28–5.24 (m, 2H), 4.68–4.6 (q, *J* = 6.6 Hz, 2H), 4.64–4.60 (m, 1H) 4.46–4.40 (b m, 1H), 4.26 (dd, *J* = 6.2, 1.8 Hz, 1H), 3.37 (br s, 3H), 3.11 (d, *J* = 8.8 Hz, 1H), 1.50 (s, 3H), 1.35 (s, 3H). HRMS Calcd for $C_{13}H_{22}O_5Na$ ([M+Na]$^+$) 281.1368. Found: 281.1362.

3.2.7. (*S*)-1-((4*S*,5*S*)-2,2-Dimethyl-5-vinyl-1,3-dioxolan-4-yl)-1-(methoxymethoxy)but-3-en-2-one (16)

To a cooled (0 °C) solution of IBX (813 mg, 2.9 mmol) in dry DMSO (2 mL) was added alcohol **15** (500 mg, 1.93 mmol) in dry CH_2Cl_2 (10 mL). The resulting reaction mixture was stirred at room temperature for 3 h. After completion of the reaction as monitored by TLC, solid was filtered and washed with diethyl ether. The filtrate was washed with water and brine and dried over anhydrous Na_2SO_4, which was concentrated under reduced pressure. The crude product was subjected to silica gel column chromatography to give ketone **16** as a liquid (450 mg, 91%). $[\alpha]_D^{20}$ +56.8 (*c* 0.2, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.69 (dd, *J* = 10.5, 6.7 Hz, 1H), 6.39 (dd, *J* = 1.1, 17.3 Hz, 1H), 5.99–5.88 (m, 1H), δ 5.80 (dd, *J* = 1.5, 10.5 Hz, 1H), 5.45 (d, *J* = 16.6 Hz, 1H), (d, *J* = 10.5 Hz, 1H), 4.76 (t, *J* = 6.0 Hz, 1H), 4.57 (dd, *J* = 6.0, 15.8 Hz, 1H), 4.37 (dd, *J* = 6.0, 9.0 Hz, 1H), 4.06 (d, *J* = 4.0 Hz, 1H), 3.29 (s, 3H), 1.46 (s, 3H), 1.33 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 197.9, 133.1, 132.71, 128.9, 117.8, 109.4, 97.2, 79.8, 78.4, 77.7, 56.6, 27.4, 25.2. HRMS: Calcd for $C_{13}H_{20}O_5Na$ ([M+Na]$^+$) is 279.1212. Found: 279.1208.

3.2.8. (3*aS*,4*S*,7*aS*)-4-(Methoxymethoxy)-2,2-dimethyl-3a,4-dihydrobenzo[*d*][1,3] dioxol-5(7aH)-one (17)

To a degassed solution of ketone **16** (200 mg, 0.78 mmol) in dry CH_2Cl_2 (50 mL) was added Hoyeda Grubbs catalyst (24 mg, 5 mol %) and refluxed for 8 h. After completion of the reaction as monitored by TLC, the reaction mixture was filtered and the solvent was evaporated to give crude product that was purified by column chromatography to afford compound **17** (106 mg, 60%) as a liquid. $[\alpha]_D^{20}$ +125.8 (*c* 0.4, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.62–6.57 (dt, *J* = 2.6, 10.1 Hz, 1H), 6.05–6.01 (dd, *J* = 1.1, 10.3 Hz, 1H), 4.98 (d, *J* = 6.9 Hz, 1H), 4.90–4.83 (m, 3H), 4.52 (d, *J* = 2.8 Hz, 1H), 3.48 (s, 3H), 1.41 (s, 3H), 1.37 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 194.6, 143.5, 129.7, 110.6, 96.0, 83.9, 78.2, 76.5, 56.1, 27.3, 26.9. HRMS $C_{11}H_{16}O_5$: *m*/*z* 251 [M+Na]$^+$. HRMS: Calcd for $C_{11}H_{16}O_5$ Na ([M+Na]$^+$) is 251.0895. Found: 251.0887.

3.2.9. (3*aS*,4*S*,7*aS*)-6-(Hydroxymethyl)-4-(methoxymethoxy)-2,2-dimethyl-3a,4-dihydrobenzo[*d*][1,3]dioxol-5(7aH)-one (18)

To a solution of compound **17** (300 mg, 1.31 mmol), in THF (1 mL), was added 40% aqueous formaldehyde (0.3 mL, 3 mmol), and DMAP (16 mg, 0.13 mmol). The reaction was stirred for 3 days at −10 °C. After completion of the reaction, was acidified with 1 N HCl (0.2 mL) and extracted with ethyl acetate (3 × 5 mL). The combined organic layer was washed with water (5 mL) and brine (5 mL), dried over Na_2SO_4, and concentrated under reduced pressure to give crude residue, which was purified over silica gel column to give compound **18** (128 mg, 38%). $[\alpha]_D^{20}$ +64.6, (*c* 0.3, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.54 (s, 1H), 4.97 (d, *J* = 6.9 Hz, 1H), 4.90–4.87 (m, 1H), 4.86 (d, *J* = 6.9 Hz, 1H), 4.83–4.81 (m, 1H), 4.49 (d, *J* = 3.5 Hz, 1H), 4.49 (d, *J* = 3.5 Hz, 1H), 4.32 (br s, 2H), 3.69–3.66 (br s, 1H), 3.47 (s, 3H), 1.41 (s, 3H), 1.35 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 195.3, 139.2, 136.5, 111.6, 96.5, 77.5, 74.9, 72.5, 60.6, 56.0, 27.8, 26.8. HRMS: Calcd for $C_{12}H_{18}O_6Na$ ([M+Na]$^+$) is 281.1004. Found: 281.1006.

3.2.10. (4*S*,5*S*,6*S*)-4,5,6-Trihydroxy-2-(hydroxymethyl)cyclohex-2-enone ((+) gabosine C) (1)

To a solution of compound **18** (70 mg, 0.27 mmol) in methanol (1 mL), was added TFA (0.5 mL) and the reaction mixture stirred at room temperature for 4 h. After completion of the reaction, the reaction was diluted with saturated $NaHCO_3$ solution; methanol was evaporated and extracted into ethyl acetate (3 × 5 mL). The combined organic solvent was the solvent washed with water (5 mL) and brine (5 mL), dried over Na_2SO_4, and concentrated under reduced pressure to give crude residue, which was purified over silica gel column using MeOH/$CHCl_3$ (1:9) to give (+) gabosine C (**1**) as solid (33 mg) in a 70% yield. $[\alpha]_D^{20}$ +175 (*c* 0.6, H_2O). ^{1}H NMR (300 MHz, CD_3OD): δ 6.70–6.67 (m, 1H), 4.67–4.61 (m, 1H), 4.39–4.35 (dd, *J* = 3.0, 6.0 Hz, 1H), 4.27–4.23 (m, 3H). ^{13}C NMR (75 MHz, CD_3OD): δ 199.3, 145.1, 137.8, 77.7, 76.9, 69.4, 59.3. HRMS: Calcd for $C_7H_{10}O_5Na$ ([M+Na]$^+$) is 197.0426. Found: 197.0418.

3.2.11. (3*aS*,4*S*,7*aS*)-6-((*tert*-Butyldiphenylsilyloxy)methyl)-4-(methoxymethoxy)-2,2-dimethyl-3a,4-dihydrobenzo[*d*][1,3]dioxol-5(7aH)-one (19)

To a cooled (0 °C) solution of **18** (200 mg, 0.78 mmol) in dry dichloromethane (25 mL) was added imidizole (63 mg, 0.94 mmol) followed by TBDPSCl (0.12 mL, 0.78 mmol) and stirred for 18 h at 0 °C temperature. After completion of the reaction, the solvent was removed under reduced pressure and the crude was purified over silica gel column chromatography (hexane/ethyl acetate 7:3) to furnish a pure compound **19** (344 mg, 89%) as a colorless liquid. $[\alpha]_D^{25}$ −37.7, (*c* 0.36, $CHCl_3$). R_f: 0.65 (SiO_2, 30% EtOAc in petroleum ether). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.64–7.61 (m, 4 H), 7.44–7.32 (m, 6 H), 6.76 (s, 1H), 4.94–4.88 (m, 2H), 4.84–4.78 (m, 2H), 4.53–4.48 (m, 1H), 4.41 (d, *J* = 2.8 Hz, 1H), 4.34–4.28 (m, 1H), 3.45 (s, 3H), 1.41 (s, 3H), 1.35 (s, 3H), 1.08 (br s, 9H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 193.9, 137.3, 136.9, 135.4 (4C), 132.9 (2C), 129.8 (2C), 127.7 (4C), 111.4, 96.5, 77.6, 74.9, 72.7, 60.1, 55.0, 27.7, 26.9, 26.8 (3C), 19.2. HRMS: Calcd for $C_{28}H_{36}O_6SiNa$ ([M+Na]$^+$) is 519.2180. Found: 519.2184.

3.2.12. (3*aS*,4*R*,5*R*,7*aS*)-6-((*tert*-Butyldiphenylsilyloxy)methyl)-4-(methoxymethoxy)-2,2-dimethyl-3a,4,5,7a-tetrahydrobenzo[*d*][1,3]dioxol-5-ol (20)

To a cooled (0 °C) solution of ketone **19** (600 mg, 1.21 mmol) in methanol (10 mL) was added $NaBH_4$ (46 mg, 1.21 mL) and the reaction mixture was stirred for 1 h. After completion of the reaction, the reaction was quenched with aq NH_4Cl (10 mL) and concentrated under reduced pressure and extracted into EtOAc (3 × 10 mL). The combined organic extracts were dried over anhydrous $MgSO_4$ and concentrated under reduced pressure to give crude product which was purified using silica gel chromatography (30% ethyl acetate in hexane) to afford allylic alcohol **20** (555 mg, 92% yield) as a colorless oil. R_f = 0.6 (EtOAc/hexane 3:7). $[\alpha]_D^{20}$ −39.7 (*c* 0.38, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.68–7.64 (m, 4 H), 7.42–7.34 (m, 6 H), 5.80 (s, 1H), 4.90 (d, *J* = 6.9 Hz, 1H), 4.79 (d, *J* = 6.9 Hz, 1H), 4.69–4.67 (m, 1H), 4.60 (d, *J* = 4.9 Hz, 1H), 4.38 (d, *J* = 13.9 Hz, 1H), 4.25 (d, *J* = 14.9 Hz, 1H), 4.10 (dd, *J* = 2.9, 9.9 Hz, 1H), 3.76–3.75 (m, 1H), 3.45 (s, 3H), 3.21 (d, *J* = 10.9 Hz, 1H, –*OH*), 1.44 (s, 3H), 1.38 (s, 3H), 1.07 (br s, 9H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 139.9, 135.4 (4C), 133.3 (2C), 129.7 (2C), 127.6 (4C), 120.0, 110.7, 95.1, 76.2, 73.8, 71.9, 64.8, 64.6, 55.7, 28.0, 26.8 (3C), 26.5, 19.2. HRMS: Calcd for $C_{28}H_{38}O_6SiNa$ ($[M+Na]^+$) is 521.2338. Found: 521.2332.

3.2.13. ((3*aS*,6*R*,7*R*,7*aS*)-6-Methoxy-7-(methoxymethoxy)-2,2-dimethyl-3a,6,7,7a-tetrahydrobenzo[*d*][1,3]dioxol-5-yl) methanol (21)

To an ice-cooled, stirred solution of NaH (132 mg, 60% w/v dispersion in mineral oil, 4.20 mmol) in dry THF (5 mL) was added compound **20** (525 mg, 1.05 mmol) in THF (5 mL) and methyl iodide (0.1 mL, 1.58 mmol). The mixture was stirred at room temperature for 6 h, quenched with saturated NH_4Cl solution and extracted into EtOAc (2 × 10 mL). The combined organic layers were washed with water and brine, dried over Na_2SO_4, and concentrated in vacuo. The methoxy ether was used as such for the next reaction without any further characterization. To a cooled (0 °C) solution of methoxy ether in THF (3 mL), was added aqueous HF (1 drop) at room temperature for 8 h. After completion of the reaction, the reaction was quenched with $NaHCO_3$ and extracted into ethyl acetate (3 × 15 mL). The combined organic solvent was the solvent washed with brine, dried over Na_2SO_4, and concentrated under reduced pressure to give crude residue which was purified over silica gel column (petroleum ether/ethyl acetate 1:1) to give alcohol **21** (250 mg, 87%). $[\alpha]_D^{25}$ +60.3 (*c* 0.27, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): 5.92 (s, 1H), 4.86 (d, *J* = 6.9 Hz, 1H), 4.72 (d, *J* = 6.9 Hz, 1H), 4.60–4.57 (m, 1H), 4.33–4.29 (m, 1H), 4.26–4.22 (m, 2H), 4.20–4.16 (m, 1H), 3.96–3.94 (m, 1H), 3.92–3.89 (m, 1H), 3.51 (s, 3H), 3.42 (s, 3H), 1.47 (s, 3H), 1.40 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 139.6, 120.5, 110.4, 96.6, 77.8, 74.2, 71.1, 68.9, 64.2, 57.8, 55.4, 26.6, 25.4. HRMS: Calcd for $C_{13}H_{22}O_6Na$ ($[M+Na]^+$) is 297.1314. Found: 297.1312.

3.2.14. (3*aS*,6*R*,7*R*,7*aS*)-Methyl 6-methoxy-7-(methoxymethoxy)-2,2-dimethyl-3a,6,7,7a-tetrahydrobenzo [*d*][1,3]dioxole-5-carboxylate. (22)

To a cooled (−78 °C) solution of alcohol **21** (180 mg, 0.66 mmol) in CH_3CN (5 mL), H_2O (2.5 mL) and was added TEMPO (21 mg, 0.13 mmol) and BAIB (530 mg, 1.65 mmol) and stirred for 3 h. The reaction mixture was quenched with saturated $Na_2S_2O_3$ solution (5 mL) and extracted into ethyl acetate (2 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated. The crude acid was purified over silica gel column using ethyl acetate and hexane (1:1) to obtain pure acid as a viscous liquid. The acid was used as such for the next reaction without any further characterization. To a cooled solution of acid in dry acetone (10 mL) were added K_2CO_3 (137 mg, 1.32 mmol) and methyl iodide (0.08 mL, 1.32 mmol) and stirred for 3 h. After completion of the reaction, the reaction mixture was filtered through a celite pad and washed with ethyl acetate. The filtrate was concentrated under vacuum and the residue was dissolved in EtOAc (50 mL), washed with brine, and dried over Na_2SO_4. The solvent was removed under reduced pressure, the crude ester was purified over silica gel column eluting using EtOAc/hexane (2:3) to give ester **22** (140 mg, 70%) as a syrup. $[\alpha]_D^{20}$ −40.6 (*c* 0.2, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.78 (dd, *J* = 3.5, 1.5 Hz, 1H), 4.86 (s, 2H), 4.66 (dd, *J* = 6.0, 3.7 Hz, 1H), 4.59–4.53 (m, 1H), 4.37 (d, *J* = 4.5 Hz, 1H), 3.84–3.81 (m, 1H), 3.81 (s, 3H), 3.59 (s, 3H), 3.48 (s, 3H), 1.43 (s, 3H), 1.38 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 166.4, 137.0, 130.1, 111.4, 94.9, 73.1, 72.7, 72.5, 71.6, 61.1, 55.7, 52.1, 27.7, 26.0. HRMS: Calcd for $C_{14}H_{22}O_7Na$ ($[M+Na]^+$) is 325.1263. Found: 325.1258.

3.2.15. (3*S*,4*S*,5*S*, 6*R*)-Methyl 3,4,5-trihydroxy-6-methoxycyclohex-1-enecarboxylate (4)

To a solution of compound **22** (50 mg, 0.17 mmol) in methanol (3 mL), was added TFA (0.5 mL) and stirred at room temperature for 3 h. After completion of the reaction, the reaction was quenched with saturated $NaHCO_3$ solution (5 mL), concentrated under reduced pressure, and extracted into ethyl acetate (3 × 10 mL). The combined organic solvent was washed with brine, dried over Na_2SO_4, and concentrated under reduced pressure to give crude residue which was purified over silica gel column using MeOH/$CHCl_3$ (1:24) to give (+)-pericosine B (**4**) (26 mg, 70% yield). $[\alpha]_D^{20}$ +34.6 (*c* 0.3, EtOH). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.72 (dd, *J* = 3.9, 1.5 Hz, 1H), 4.25 (d, *J* = 3.9 Hz, 1H), 4.15 (m, 1H), 3.92 (m, 1H), 3.85 (m, 1H), 3.76 (s, 3H), 3.59 (s, 3H). ^{13}C NMR (75 MHz, CD_3COCD_3): δ 166.9, 141.9, 130.5, 76.9, 72.5, 69.9, 69.5, 61.4, 52.1. HRMS: Calcd for $C_9H_{14}O_6Na$ ($[M+Na]^+$) is 241.0688. Found: 241.0684.

3.2.16. (3*aS*,4*R*,5*S*,7*aS*)-6-((*tert*-Butyldiphenylsilyloxy) methyl)-4-(methoxymethoxy)-2,2-dimethyl-3a,4,5,7a-tetrahydrobenzo [*d*][1,3]dioxol-5-ol (23)

To a cooled (−78 °C) solution of ketone **19** (620 mg, 1.25 mmol) in methanol were added $CeCl_3{\cdot}7H_2O$ (930 mg, 2.5 mmol) and $NaBH_4$ (48 mg, 1.25 mL) and stirred for 1 h. After completion of the reaction, the reaction was quenched with aq NH_4Cl (10 mL), concentrated under reduced pressure, and extracted into EtOAc (3 × 20 mL). The combined organic extract was dried over anhydrous $MgSO_4$ and concentrated under reduced pressure to give crude product which was purified over silica gel column (30% ethyl acetate in hexane) to afford allylic alcohol **23** (547 mg, 88% yield) as a colorless oil. R_f = 0.6 (EtOAc/hexane 3:7). $[\alpha]_D^{20}$ +5.92 (*c* 0.76, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.64–7.58 (m, 4 H), 7.40–7.30 (m, 6 H), 5.66 (s, 1H), 4.78 (d, *J* = 6.7 Hz, 1H), 4.69 (d, *J* = 6.7 Hz, 1H), 4.48–4.43 (m, 4.29–4.25 (m, 1H), 4.18–4.15 (m, 4.13–4.09 (m, 1H), 3.90 (dd, *J* = 3.7, 9.8 Hz, 1H), 3.51 (d, *J* = 10.5 Hz, 1H), 3.35 (s, 3H), 3.11 (br s, 1H), 1.25 (br s, 6 H), 1.04 (br s, 9 H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 140.1, 135.5 (4C), 132.8 (2C), 129.7 (2C), 127.9 (4C), 120.8, 114.0, 94.6, 72.7, 72.0, 70.3, 65.4, 64.0, 55.6, 29.7, 26.9, 26.8 (3C), 19.2. HRMS: Calcd for $C_{28}H_{38}O_6SiNa$ ($[M+Na]^+$) is 521.2338. Found: 521.2334.

3.2.17. ((3*aS*,6*S*,7*R*,7*aS*)-6-Methoxy-7-(methoxymethoxy)-2,2-dimethyl-3a,6,7,7a-tetrahydrobenzo[*d*][1,3]dioxol-5-yl)methanol (24)

To an ice-cooled, stirred solution of NaH (132 mg, 60% w/v dispersion in mineral oil, 4.20 mmol) in THF (5 mL) was added compound **23** (525 mg, 1.05 mmol) in THF (5 mL) and methyl iodide (0.1 mL, 1.58 mmol) and stirred at room temperature for 6 h. After completion of the reaction, the reaction was quenched with saturated NH_4Cl solution and extracted with EtOAc (2 × 10 mL). The combined organic layer was washed with water and brine, then

dried over Na_2SO_4, and concentrated in vacuo. The crude material was used for next step without further purification. To a cooled (0 °C) solution of methoxy ether (440 mg, 0.86 mmol) in THF (3 mL), was added aqueous HF (1 drop) and stirred at room temperature for 8 h. After completion of the reaction, the reaction was quenched with sodium bicarbonate and extracted into extracted with EtOAc (2 × 10 mL). The combined organic layer was washed with water and brine, then dried over Na_2SO_4, and concentrated in vacuo which was purified by silica gel column using (petroleum ether/ethyl acetate 1:1) to give alcohol **24** (256 mg, 89%). $[\alpha]_D^{25}$ +23.8 (*c* 0.25, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$): δ 5.90 (s, 1H), 4.88 (d, *J* = 6.9 Hz, 1H), 4.73 (d, *J* = 6.9 Hz, 1H), 4.59 (m, 1H), 4.30 (m, 1H), 4.24 (br s, 2H), 4.17 (m, 1H), 3.92 (br s, 1H), 3.51 (s, 3H), 3.42 (s, 3H), 1.48 (s, 3H), 1.39 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 138.9, 124.0, 109.6, 96.7, 78.7, 78.4, 75.1, 73.1, 64.4, 61.0, 55.5, 27.5, 26.3. HRMS: Calcd for $C_{13}H_{22}O_6Na$ ($[M+Na]^+$) is 297.1314. Found: 297.1312.

3.2.18. (3*aS*,6*S*,7*R*,7*aS*)-Methyl 6-methoxy-7-(methoxymethoxy)-2,2-dimethyl-3a,6,7,7a-tetrahydrobenzo [*d*][1,3]dioxole-5-carboxylate (25)

To a cooled (−78 °C) solution of alcohol **24** (180 mg, 0.66 mmol) in CH_3CN (5 mL) and H_2O (2.5 mL) were added TEMPO (21 mg, 0.13 mmol) and BAIB (530 mg, 1.65 mmol) and stirred for 3 h. After completion of the reaction, the reaction was quenched with saturated $Na_2S_2O_3$ solution (5 mL) and extracted into ethyl acetate (2 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated to get crude acid as a viscous liquid. The acid was used as such for the next reaction without any further characterization. To a cooled solution of acid in dry acetone (10 mL) were added K_2CO_3 (137 mg, 1.32 mmol) and methyl iodide (0.08 mL, 1.32 mmol) and stirred for 3 h. The reaction mixture was filtered through a celite pad and washed with ethyl acetate. Then filtrate was concentrated under vacuum and the residue was dissolved in EtOAc (50 mL), washed with brine, and dried over Na_2SO_4. The solvent was removed under reduced pressure, the crude ester was purified over silica gel column eluting with EtOAc/hexane (2:3) to give ester **25** (140 mg, 70%) as a syrup. $[\alpha]_D^{20}$ +44.7 (*c* 0.15, $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ 6.87 (d, *J* = 3.2, 1H), 4.86 (d, *J* = 6.8 Hz, 1H), 4.74 (d, *J* = 6.8 Hz, 1H), 4.69–4.65 (m, 1H), 4.57 (dd, *J* = 3.2, 5.6 Hz, 1H), 4.42 (d, *J* = 6.2 Hz, 1H), 4.08 (dd, *J* = 3.2, 6.2 Hz, 1H), 3.83 (s, 3H), 3.57 (s, 3H), 3.46 (s, 3H), 1.43 (s, 3H), 1.41 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$): δ 166.6, 136.0, 132.2, 110.2, 97.0, 75.0, 74.0 (2C), 71.5, 59.6, 55.6, 52.0, 26.9, 25.7. HRMS: Calcd for $C_{14}H_{22}O_7Na$ ($[M+Na]^+$) is 325.1263, Found: 325.1263.

3.2.19. (3*S*,4*S*,5*S*,6*S*)-Methyl 3,4,5-trihydroxy-6-methoxycyclohex-1-enecarboxylate (5)

To a solution of compound **25** (50 mg, 0.17 mmol) in methanol (3 mL), was added TFA (0.5 mL) and stirred at room temperature for 3 h. After completion of the reaction, the reaction was neutralized with saturated $NaHCO_3$ solution, concentrated under reduced pressure, and extracted into ethyl acetate (3 × 10 mL). The combined organic solvent was washed with brine, dried over Na_2SO_4, and concentrated under reduced pressure to give crude residue which was purified over silica gel column using $MeOH/CHCl_3$ (1:24) to give (+)-pericosine C **5** (24 mg, 67%) as a liquid. $[\alpha]_D^{20}$ +72.5 (*c* 0.3, EtOH). ^1H NMR (300 MHz, $CDCl_3$): δ 6.75 (d, *J* = 3.7 Hz, 1H), 4.43 (d, *J* = 6.0 Hz, 1H OH), 4.25–4.21 (m, 1H), 4.17 (d, *J* = 4.5 Hz, 1H), 3.97–3.92 (m, 2H), 3.85–3.91 (m, 2H), 3.77 (s, 3H), 3.49 (s, 3H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ 166.7, 140.4, 131.5, 79.1, 73.3, 70.1, 67.4, 59.4, 52.0 ppm. HRMS: Calcd for $C_9H_{14}O_6Na$ ($[M+Na]^+$) is 241.0688. Found: 241.0684.

4. Conclusion

In conclusion, we have reported a simple and efficient route for the total synthesis of the bio-active compounds (+)-gabosine C, (+)-pericosine B, and (+)-pericosine C from a common intermediate **18**. This approach might be applicable to other gabosines, pericosines, and biologically important cyclohexene derived carbasugar related molecules.

Acknowledgments

The authors D.C.B., C.B.R., K.V., and J.J.P.S. are thankful to UGC and CSIR, New Delhi for the financial support and thankful to the Director, IICT for her constant encouragement.

References

1. Arjona, A.; Gómez, A. M.; López, J. C.; Plumet, J. *Chem. Rev.* **2007**, *107*, 1919–2036.
2. (a) Tatsuta, K.; Tsuchiya, T.; Mikami, N.; Umezawa, S.; Umezawa, H.; Naganawa, H. *J. Antibiot.* **1974**, *27*, 579–586; (b) Takeuchi, T.; Chimura, H.; Hamada, M.; Umezawa, H.; Yoshioka, O.; Oguchi, N.; Takahashi, Y.; Matsuda, A. *J. Antibiot.* **1975**, *28*, 737–742; (c) Chimura, H.; Nakamura, H.; Takita, T.; Takeuchi, T.; Umezawa, H.; Kato, K.; Saito, S.; Tomisawa, T.; Iitaka, Y. *J. Antibiot.* **1975**, *28*, 743–748; (d) Umezawa, S.; Tatsuta, K.; Takeuchi, T.; Umezawa, H.; Takita, T. *Chem. Abstr.* **1977**, *87*, 184080b; (e) Sugimoto, Y.; Suzuki, H.; Yamaki, H.; Nishimura, T.; Tanaka, N. *J. Antibiot.* **1982**, *35*, 1222; (f) Douglas, K. T.; Shinkai, S. *Angew. Chem.* **1985**, *97*, 32; (g) Mirza, S.; Molleyres, L.-P.; Vasella, A. *Helv. Chim. Acta* **1985**, *68*, 988–996; (h) Takayama, H.; Hayashi, K.; Koizumi, T. *Tetrahedron Lett.* **1986**, *27*, 5509–5512; (i) Shing, T. K. M.; Tang, Y. *Tetrahedron* **1990**, *46*, 6575–6584; (j) Tony, K. M. S.; Ying, T. *J. Chem. Soc., Chem. Commun.* **1990**, 312; (k) Bach, G.; Braiding-Mack, S.; Grabley, S.; Hammann, P.; Hütter, K.; Thiericke, R.; Uhr, H.; Wink, J.; Zeeck, A. *Ann. Chem.* **1993**, 241; (l) Lygo, B.; Swiatyj, M.; Trabsa, H.; Voyle, M. *Tetrahedron Lett.* **1994**, *35*, 4197–4200; (m) Tatsuta, K.; Yasuda, S.; Araki, N.; Takahashi, M.; Kamiya, Y. *Tetrahedron Lett.* **1998**, *39*, 401–402; (n) Lubineau, A.; Billault, I. *J. Org. Chem.* **1998**, *63*, 5668–5671; (o) Huntley, C. F. M.; Wood, H. B.; Ganem, B. *Tetrahedron Lett.* **2000**, *41*, 2031–2034; (p) Mehta, G.; Lakshminath, S. *Tetrahedron Lett.* **2000**, *41*, 3509–3512; (q) Banwell, M. G.; Bray, A. M.; Wong, D. *J. New J. Chem.* **2001**, *25*, 1351–1354; (r) Takahashi, T.; Yamakoshi, Y.; Okayama, K.; Yamada, J.; Ge, W.-Y.; Koizumi, T. *Heterocycles* **2002**, *56*, 209–220; (s) Shinada, T.; Fuji, T.; Ohtani, Y.; Yoshida, Y.; Ohfune, Y. *Synlett* **2002**, 1341–1343; (t) Ramana, G. V.; Rao, B. V. *Tetrahedron Lett.* **2005**, *46*, 3049–3051; (u) Shing, T. K. M.; Cheng, H. M. *J. Org. Chem.* **2007**, *72*, 6610–6613; (v) Carreño, M. C.; Merino, E.; Ribagorda, M.; Somoza, A.; Urbano, A. *Chem. Eur. J.* **2007**, *13*, 1064–1077.
3. (a) Mac, D. H.; Samineni, R.; Petrignet, J.; Srihari, P.; Chandrasekhar, S.; Yadav, J. S.; Grée, R. *Chem. Commun.* **2009**, 4717–4719; (b) Stathakis, C. I.; Athanatou, M. N.; Gallos, J. K. *Tetrahedron Lett.* **2009**, *50*, 6916–6918; (c) Shing, T. K. M.; So, K. H.; Kwok, W. S. *Org. Lett.* **2009**, *11*, 5070–5073; (d) Shing, T. K. M.; Cheng, H. M. *Org. Biomol. Chem.* **2009**, *7*, 5098–5102; (e) Monrad, R. N.; Fanefjord, M.; Hansen, F. G.; Jensen, N. M. E.; Madsen, R. *Eur. J. Org. Chem.* **2009**, 396–402; (f) Shing, T. K. M.; Cheng, H. M. *Synlett* **2010**, 142–144; (g) Rao, J. P.; Rao, B. V *Tetrahedron: Asymmetry* **2010**, *21*, 930–935; (h) Vikas, K.; Pintu, D.; Partha, G.; Arun, K. S. *Tetrahedron* **2011**, *67*, 4539–4546; (i) Tony, K. M.; Shing, Y.; Chen, Y.; Ng, W.-L. *Tetrahedron* **2011**, *67*, 6001–6005; (j) Mac, D. H.; Samineni, R.; Sattar, A.; Chandrasekhar, S.; Yadav, J. S.; Grée, R. *Tetrahedron* **2011**, *67*, 9305–9310; (k) Krishna, P. R.; Kadiyala, R. R. *Tetrahedron Lett.* **2011**, *53*, 744–747; (l) Prasad, K. R.; Kumar, S. M. *Synlett* **2011**, 160–1604.
4. (a) Numata, A.; Iritani, M.; Yamada, T.; Minoura, K.; Matsumura, E.; Yamori, T.; Tsuruo, T. *Tetrahedron Lett.* **1997**, *38*, 8215–8218; (b) Donohoe, T. J.; Blades, K.; Helliwell, M.; Waring, M. J.; Newcombe, N. J. *Tetrahedron Lett.* **1998**, *39*, 8755–8758; (c) Usami, Y.; Hatsuno, C.; Yamamoto, H.; Tanabe, M.; Numata, A. *Chem. Pharm. Bull.* **2005**, *52*, 1130–1133; (d) Usami, Y.; Ueda, Y. *Chem. Lett.* **2005**, *34*, 1062–1063; (e) Usami, Y.; Horibe, Y.; Takaoka, I.; Ichikawa, H.; Arimoto, M. *Synlett* **2006**, 1598–1600; (f) Usami, Y.; Ueda, Y. *Synthesis* **2007**, 3219–3225; (g) Usami, Y.; Takaoka, I.; Ichikawa, H.; Horibe, Y.; Tomiyama, S.; Ohtsuka, M.; Imanishi, Y.; Arimoto, M. *J. Org. Chem.* **2007**, *72*, 6127–6134; (h) Yamada, T.; Iritani, M.; Ohishi, H.; Tanaka, K.; Doi, M.; Minoura, K.; Numata, A. *Org. Biomol. Chem.* **2007**, *5*, 3979–3986; (i) Usami, Y.; Ichikawa, H.; Arimoto, M. *Int. J. Mol. Sci.* **2008**, *9*, 401–421; (j) Usami, Y.; Mizuki, K.; Ichikawa, H.; Arimoto, M. *Tetrahedron: Asymmetry* **2008**, *19*, 1461–1464; (k) Usami, Y.; Suzuki, K.; Mizuki, K.; Ichikawa, H.; Arimoto, M. *Org. Biomol. Chem.* **2009**, *7*, 315–318; (l) Usami, Y.; Ohsugi, M.; Mizuki, K.; Ichikawa, H.; Arimoto, M. *Org. Lett.* **2009**, *11*, 2699–2701; (m) Fejes, Z.; Mándi, A.; Komáromi, I.; Bényei, A.; Naesens, L.; Fenyvesi, F.; Szilágyi, L.; Herczegh, P. *Tetrahedron* **2009**, *65*, 8171–8175; (n) Boyd, D. R.; Sharma, N. D.; Acaru, C. A.; Malone, J. F.; O'Dowd, C. R.; Allen, C. C. R.; Stevenson, P. J. *Org. Lett.* **2010**, *12*, 2206–2209; (o) Usami, Y.; Mizuki, K. *J. Nat. Prod.* **2011**, *74*, 877–881; (p) Suman, R. Y.; Kadigachalam, P.; Ranjan, K.; Basak, A.; John, P. P.; Vankar, D. Y. *Tetrahedron Lett.* **2012**, *53*, 132–136; (q) Muniraju, Ch.; Rao, J. P.; Rao, B. V. *Tetrahedron: Asymmetry* **2012**, *23*, 86–93.

5. (a) Babu, D. C.; Selavam, J. J. P.; Reddy, D. K.; Shekhar, V.; Venkateswarlu, Y. *Tetrahedron* **2011**, *67*, 3815–3819; (b) Selvam, J. J. P.; Rajesh, K.; Suresh, V.; Babu, D. C.; Venkateswarlu, Y. *Tetrahedron: Asymmetry* **2009**, *20*, 1115–1119; (c) Abushanab, E.; Vemishetti, P.; Leiby, R. W.; Singh, H. K.; Mikkilineni, A. B.; Wu, D. C. J.; Saibaba, R.; Panzica, R. P. *J. Org. Chem.* **1988**, *53*, 2598–2602.
6. (a) Swamy, N. R.; Suryakiran, N.; Naidu, P. P.; Venkateswarlu, Y. *Carbohydr. Res.* **2012**, *352*, 191–196; (b) Ramesh, D.; Shekhar, V.; Chanti Babu, D.; Rajaram, S.; Ramulu, U.; Venkateswarlu, Y. *Tetrahedron Lett.* **2012**, *53*, 1258–1260; (c) Babu, D. C.; Rao, B. Ch.; Ramesh, D.; Swamy, S. R.; Venkateswarlu, Y. *Tetrahedron Lett.* **2012**, *53*, 3633–3636; (d) Reddy, D. K.; Rajesh, K.; Shekhar, V.; Babu, D. C.; Venkateswarlu, Y. *Tetrahedron Lett.* **2010**, *51*, 5440–5442; (e) Prbhakar, P.; Rajaram, S.; Reddy, D. K.; Shekar, V.; Venkateswarlu, Y. *Tetrahedron: Asymmetry* **2010**, *21*, 216–221; (f) Suresh, V.; Selvam, J. J. P.; Rajesh, K.; Sekhar, V.; Babu, D. C.; Venkateswarlu, Y. *Synthesis* **2010**, *11*, 1763–1765.
7. Allevi, P.; Ciuffreda, P.; Tarocco, G.; Anastasia, M. *Tetrahedron: Asymmetry* **1995**, *6*, 2357–2364.
8. Luo, S.; Wang, P. G.; Cheng, J.-P. *J. Org. Chem.* **2004**, *69*, 555–558.
9. Rezgui, F.; Gaid, M. M. E. *Tetrahedron Lett.* **1998**, *39*, 5965–5966.
10. (a) Luche, J. L.; Gemal, A. L. *J. Am. Chem. Soc.* **1979**, *101*, 5848–5849; (b) Gemal, A. L.; Luche, L. *J. Am. Chem. Soc.* **1981**, *103*, 5454–5459.
11. (a) Azad, C. S.; Saxena, A. K. *Tetrahedron* **2013**, *69*, 2608–2612; (b) Appel, R.; Halstenberg, M. In *Organophosphorus Reagents in Organic Synthesis*; Cadogan, J. I. G., Ed.; Academic: London, 1979. Chapter 9.