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Total synthesis of phospholipomannan of the *Candida albicans*

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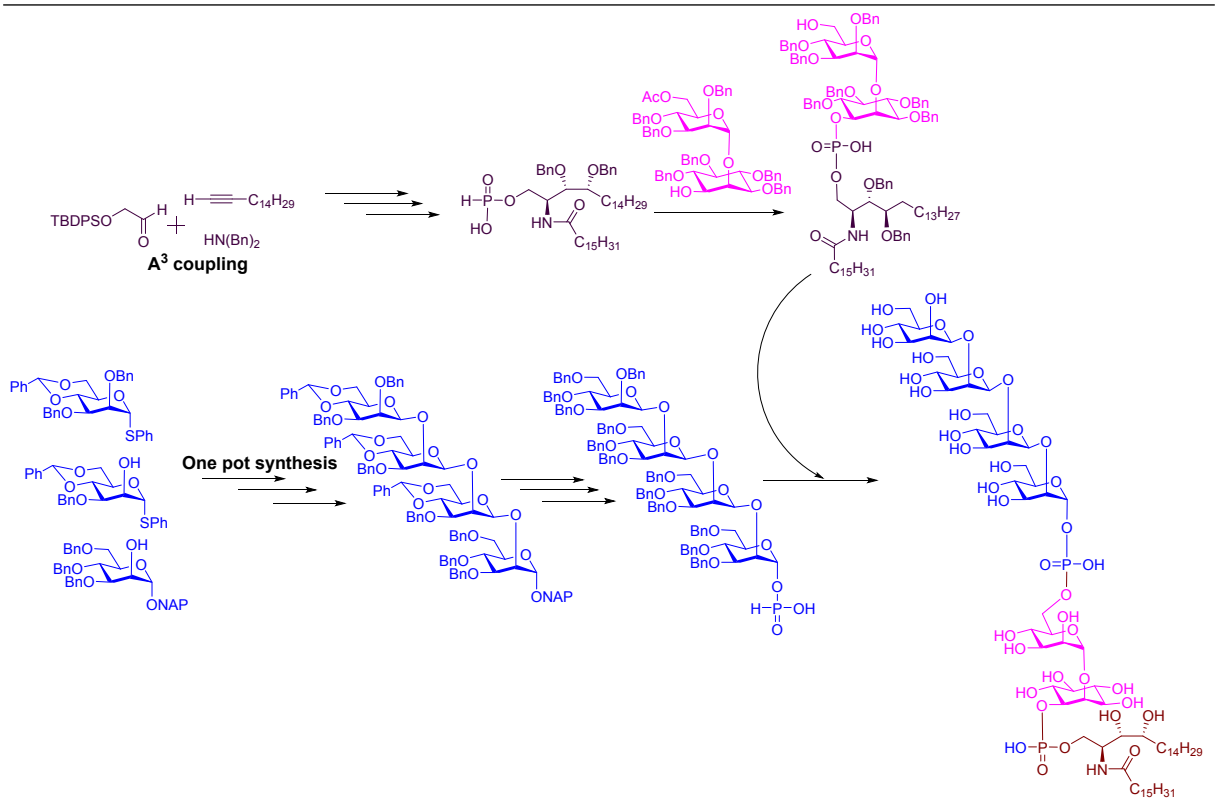


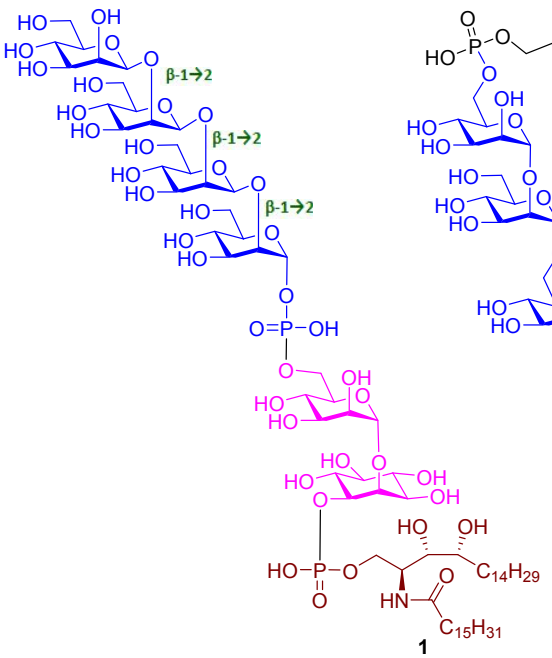
Abstract

First total synthesis of cell surface phospholipomannan anchor [*β*-Man*p*-(1→2)-*β*-Man*p*]$_n$-(1→2)-*β*-Man*p*-(1→2)-*α*-Man*p*-1→*P*-(*O*→6)-*α*-Man*p*-(1→2)-Inositol-1-*P*-(*O*→1)-phytoceramide of *Candida albicans* is reported. The target PLM anchor poses synthetic challenges such as unusual kinetically controlled (1→2)-*β*-oligomannan domain, anomeric phosphodiester, and unique phytoceramide lipid tail linked to the glycan through a phosphate group. The synthesis of PLM anchor was accomplished using a convergent block synthetic approach using three main appropriately protected building blocks; (1→2)-*β*-tetramann repeats, pseudodisaccharide, phytoceramide-1-*H*-phosphonate. The most challenging (1→2)-*β*-tetramann domain was synthesized in one-pot by using pre-activation method. The phytoceramide-1-*H*-phosphonate was synthesized through an enantioselective A^3 three-component coupling reaction. Finally, the phytoceramide-1-*H*-phosphonate moiety was coupled with pseudodisaccharide followed by deacetylation to produce the acceptor, which on subsequent coupling with tetramannosyl-*H*-phosphonate provided the fully protected PLM anchor. Final deprotection was successfully achieved by Pearlman's hydrogenation.

Introduction:

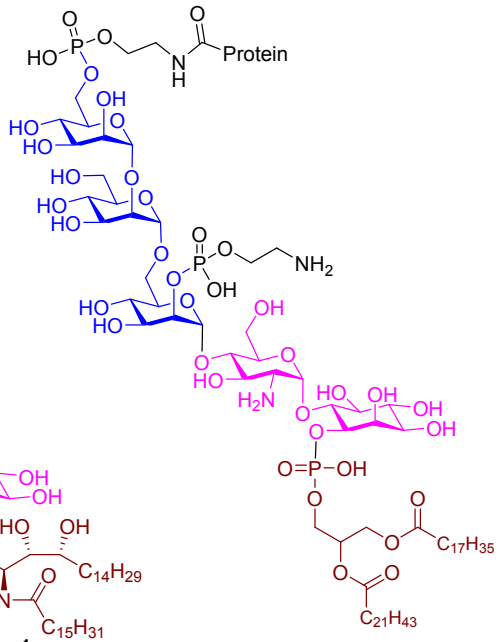
Candida species are harmless commensal colonisers of the gastrointestinal and genitourinary tract and to a lesser extent of the human skin. Under normal circumstances, it lives in 80% of the human population, but overgrowth of *Candida* species results in infectious diseases, particularly in the immunocompromised individuals and there are around 60,000-70,000 such cases per year in the US alone.[1,2] Incidences of infection have risen with the increased prevalence of immuno suppressive therapies and the use of broad-spectrum antibiotics. Since *C. albicans* has rarely been isolated from the environment, it is considered to be obligatorily associated with mammalian hosts. To fully understand its pathogenicity, a major key is to explore and decipher the regulatory networks that support the transition from the commensal to pathogenic state.[3,4] The cell wall of *C. albicans*, as in other eukaryotic pathogens, plays an vital role in pathogenesis by (a) protecting the pathogen from the host immune system (b) initiating adherence to the host cells and (c) releasing immunosuppressive antigens and virulence factors to facilitate the infection. One of the most important cell surface molecule responsible for infectivity and pathology of *C. albicans* has been identified as a complex glycosphingolipid called phospholipomannan (PLM 1, Figure 1).[5,6] The PLM is comprised of mannose-inositol-phosphoceramide lipid anchor (embedded in the cell wall) on which an unusual oligomeric (1→2)-*β*-mannan is linked through an anomeric phosphodiester linkage (Figure 1).[7] Interestingly the PLM anchor is quite distinct from the more widely occurring GPI anchors in human biology in term of the following: (a) (1→2)-*β*-mannan in place of (1→2)-*α*-mannan motif of GPI anchors; (b) (1→2)-*α*-mannose linked to myo-D-inositol in place of (1→6)-*α*-glucosamine-inositol motif and (c) the presence of an unusual

phytoceramide in place of the glycerolipid. More importantly, the PLM anchor is highly immunogenic due to its (1→2)-*β*-mannan structural motif, which is absent in human host. It has been shown that the deletion of GDP-mannose: inositol-phospho-ceramide mannose transferase (MIT1) in *C. albicans* led to a decrease in virulence during both the acute and chronic phases of systemic disease in mice.[8] Moreover short and truncated glycan analogues of PLMs are also known to activate macrophages, indicating the critical role of PLM anchor in the pathogenic process.[9] The enzyme involved in PLM anchor biosynthesis has not been purified yet,[10] which require synthetic substrates and precursors. Also due to their absence in human biology, PLM anchor presents a unique opportunity to design glycoconjugate vaccine or utilizing its biosynthetic machinery as novel drug targets. In order to address these questions (vaccine and drug design), one of the key hurdle is the access of synthetic PLM and its intermediates as their isolation from C. albicans culture is difficult (limited quantities and heterogeneity). The chemical synthesis can provide access to both native and novel PLM structures, indispensable for biological studies.



1

Phospholipomannan (PLM) anchor of *C. albicans*



Glycosylphosphatidylinositol (GPI) anchor of H.Sapiens

Fig 1: Phospholipomannan of *C. Albicans* and GPI anchor of *H. Sapiens*

Early attempts on a synthesis of PLM were made by Bundle et al who reported synthesis of (1→2)-*β*-mannan domain of PLM and (1→2)-*β*-mannan glycoconjugates and studied them in preclinical settings as vaccine candidates.[11a, 11b] Our group recently designed a new strategy to construct (1 → 2)-*β*-Mannan domain using intra-molecular aglycon delivery (IAD).[11c] However, the total synthesis of full-length PLM anchor has eluded success. We now report the first synthesis of full-length PLM anchor of *C. albicans*, built on our previous experience, [11c, 12] in making GPI anchors and Lipophosphoglycans (LPGs).

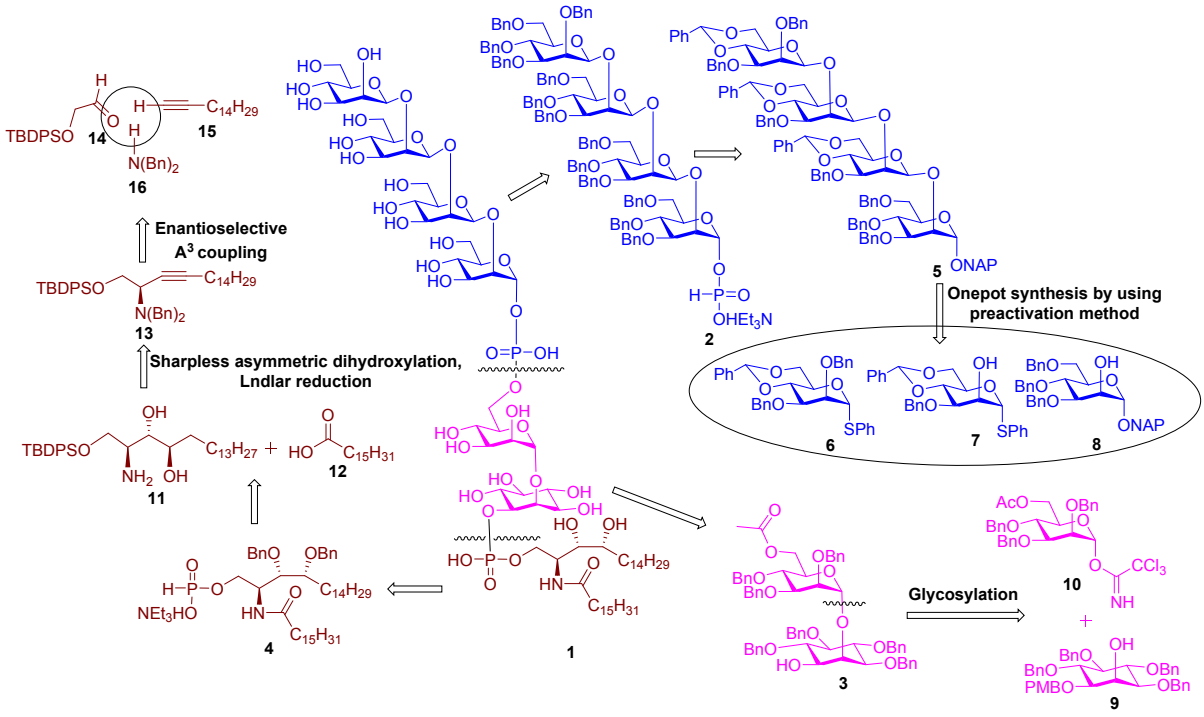
Results and Discussion:

The target PLM anchor presents key synthetic challenges such as unusual kinetically controlled (1→2)-*β*-oligomannan, pseudodisaccharide, anomeric phosphodiester and phytoceramide linked to saccharide through a phosphate. The successful synthesis of a molecule of such complexity required new chemistry, a high degree of planning such as the order of attachment of fragments, choice of glycosylation methods, protection groups, and deprotection. The Scheme 1 depicts our retrosynthetic approach towards the synthesis of **1**.

A convergent assembly of subunits was planned for the target PLM (**1**) from (1 → 2)-*β*-Mannan domain **2**, pseudodisaccharide **3**, and phytoceramide-1-*H*-phosphonate **4**. The most challenging (1 → 2)-*β*-Mannan **2** was synthesized from teramannopyranoside **5**, which in turn was synthesized from intermediates **6**, **7**, and **8** *via* new diastereoselective glycosylation reaction in one-pot. While pseudodisaccharide fragment **3** was synthesized from suitably protected inositol acceptor **9** and the mannopyranoside donor **10** *via* the Schmidt trichloroacetimidate method, both the fragments **9** and **10** could be synthesized from readily available myo-inositol and mannose. On the other hand, the key phytoceramide-1-*H*-

phosphonate fragment **4** could be synthesized from two main building blocks sphingoid base **11** and palmitic acid **12**, where the sphingoid base **11** can be synthesized from alkyne **13** *via* dihydroxylation of the alkene, and *Z*-selective olefination.

Scheme 1: Retrosynthetic analysis of Phospholipomannan (PLM) anchor 1.

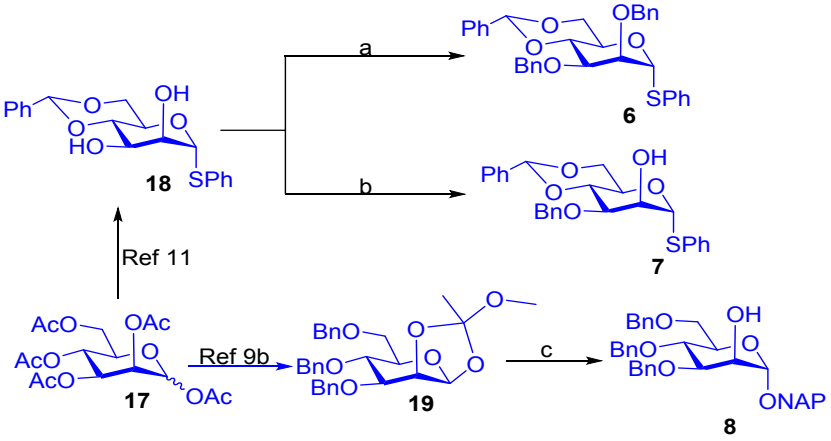


In turn, the alkyne fragment **13** could be synthesized from TBDPS protected aldehyde **14**, C-16 alkyne **15**, and dibenzylamine **16** using an enantioselective A^3 coupling.

The synthesis of the target molecule was started with suitably protected key intermediate tetramannoside in an effective manner. Synthesis of tetramannoside was achieved by using suitably protected mannose subunits **6-8** (Scheme 2). Thio mannopyranoside donor **6** was obtained mannopyranoside derivative **17**.[13] Thio mannopyranosyl acceptor **7** was achieved from the diol **18** via a stannylene acetal derived regioselective 3-*O*-benzylation in 80% yield.[14e] The other mannopyranosyl acceptor **8** was derived from orthoester **19** (which in turn

was obtained from **17** following known method),[9b] through the two-step sequence, and cleavage of orthoester to hemiacetal, 2-naphthyl (NAP) protection of anomeric hydroxy and deacetylation.

Scheme 2: Synthesis of suitably protected mannopyranosyl subunits **6-8**.

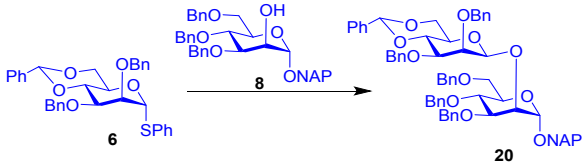


Reagents and Conditions: (a) BnBr, NaH, DMF, 95%; (b) i) Bu_2SnO, MeOH, 4 h, reflux ii) BnBr, TBAB, toluene, DMF, 120 °C, 80%; (c) i) pTSA, DCE, H_2O, ii) NAPBr, NaH, DMF, -20 °C, followed by MeOH, 60 °C, 70%.

In literature, there are several reports for (1→2)-*β*-mannosylation by using different glycosyl donors (anomeric thio, sulfoxide, pentenoate, carboxy-benzyl, dehydrative glycosylations and inversion of gluco to manno).[14] Moreover one-pot glycosylation method by using preactivation were developed for the synthesis of oligosaccharides,[15] however no such attempts were made in the synthesis of (1→2)-*β*-mannosides. In this direction, we made various attempts but resulted in poor overall yield. In the present study to establish the effective conditions for diastereoselective (1→2)-*β*-mannosylation, thioglycosyl donor **6** was selected as a glycosyl donor and fragment **8** was chosen as an acceptor (Table 1). The glycosylation of glycosyl acceptor **8** with glycosyl donor **6** in presence of NIS/TfOH proceeded moderately with 35% yield, providing 7.6/2.4 (52% de) mixture of the *β* and *α*

disaccharides (Table 1, entry 1). The glycosylation of the above substrates in presence of NIS/TMSOTf proceeded in 20% yield, with *β* and *α* selectivity in 7.7/2.3 (54% de) ratio (Table 1, entry 2). In another attempts glycosylation was performed with Ph_2SO/Tf_2O/-78 °C-rt, PhSeBr/AgOTf/-78 °C-rt, and PhSeBr/ Tf_2O/-78 °C-rt proceeded in low yields (Table 1, entry 3-5).

Table 1. Optimization conditions for (1→2)-*β*-mannosylation.



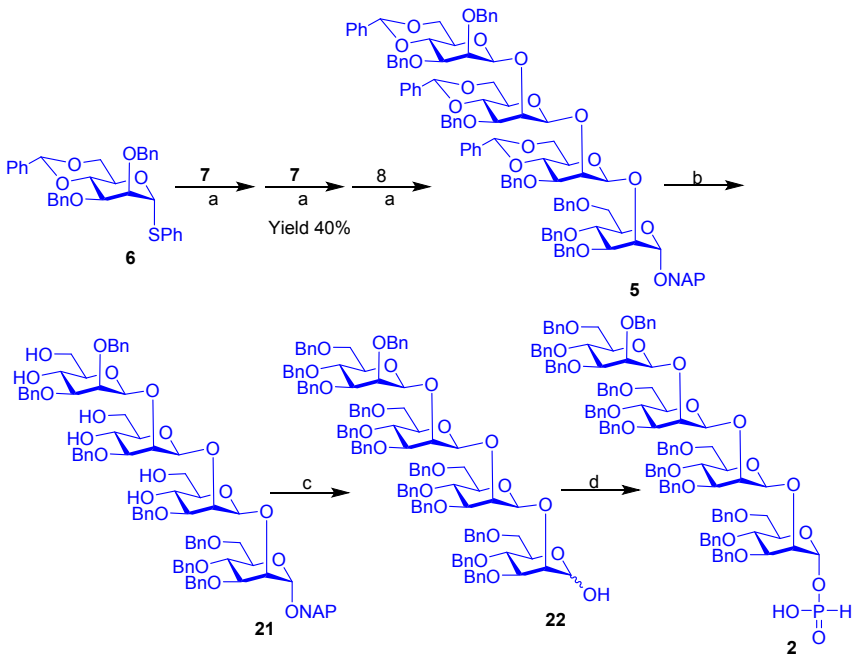
Entries	Conditions	Yield (20)	*β/α	Diastereoselective%
1	NIS, TfOH, -78 °C	35%	7.6/2.4	52
2	NIS, TMSOTf, -45 °C	20%	7.7/2.3	54
3	Ph_2SO, Tf_2O, -78 °C-rt	-	-	-
4	PhSeBr, AgOTf, -78 °C-rt	15%	7.8/2.2	56
5	PhSeBr, Tf_2O, -78 °C-rt	10%	8.05/1.95	61
6	BSP, TTBP, Tf_2O, -78 °C-rt	90%	8.9/1.1	78
7	PhSCl, AgOTf, -78 °C-rt	92%	9.4/0.6	88
* Ratio was calculated by HPLC (SI, page no.8-13)				

The glycosylation was performed with BSP/TTBP/Tf_2O/-78 °C proceeded in the good yield of 90%, providing 8.9/1.1 (78% de) mixture of the *β* and *α* disaccharides (Table 1, entry 6). Then the glycosylation was performed with PhSOTf//-78 °C - 0 °C (generated in-situ from PhSCl/AgOTf)[16] proceeded in excellent yield of 92%, providing 9.4/0.6 (88% de) mixture of the *β* and *α* disaccharides (Table 1, entry 7), this condition was found to be best for (1→2)-*β*-mannosylation. The stereochemistry at anomeric centers of **20** was confirmed by 1J C-H coupling constants 168.01*Hz*, 153.93 *Hz* for (1→2)-*β* and 170.03*Hz*, 172.17 *Hz* for (1→2)-*α*-dimannoside (Supporting Information (SI), page no. 6). With the optimized conditions for (1→2)-*β*-mannosylation in hand, the synthesis of tetramannoside **5** (Scheme 3) was achieved in one-pot by using optimized preactivation conditions PhSOTf (generated in situ by using

PhSCl and AgOTf) at -78 ^{o}C by using donor **6** and acceptor **7**. After 1h, the reaction was brought to -20 ^{o}C, and the continued till the consumption of **7** as confirmed by TLC, then the reaction mixture was cooled to -78 ^{o}C, and added AgOTf, PhSCl, and acceptor **7**, with the similar manner as followed in first addition and monitor for the consumption of acceptor **7** on TLC. Subsequently, the reaction temperature was again lowered to -78 ^{o}C, which was followed by sequential addition of AgOTf, PhSCl, and acceptor **8**. Glycosyl donors were employed a slight excess for the first two glycosylations to ensure complete consumption of the acceptor. On warming up the reaction causes the decomposition of the excess activated glycosyl donor and doesn't affect the following reactions. The desired tetramannoside **5** was isolated from one pot reaction mixture by running the Sephadex LH-20 column followed by flash column chromatography in 40% overall yield.

More importantly, the same acceptor **7** was used for the formation of first and second glycosidic linkages without affecting the anomeric reactivity adjustment. The orientation of glycosidic bonds in tetramannoside **5** was confirmed by converting it into **21** with *p*TSA in methanol in 90% yield, and confirmed by $^{1}J_{CH}$ coupling constants 161.9, 155.0, 162.9 for three (1→2)-*β* linkages and one 168.01 for (1→2)-*α* linkage (SI, page no. 16). Synthesis of key tetramannosyl-*H*-phosphonate **2** was achieved from **21** *via* three steps, including benzylation, and oxidative deprotection of anomeric 2-naphthyl group with DDQ in methanol/DCM in 65%, and *H*-phosphonate preparation using PCl_3, imidazole in 75% yield.

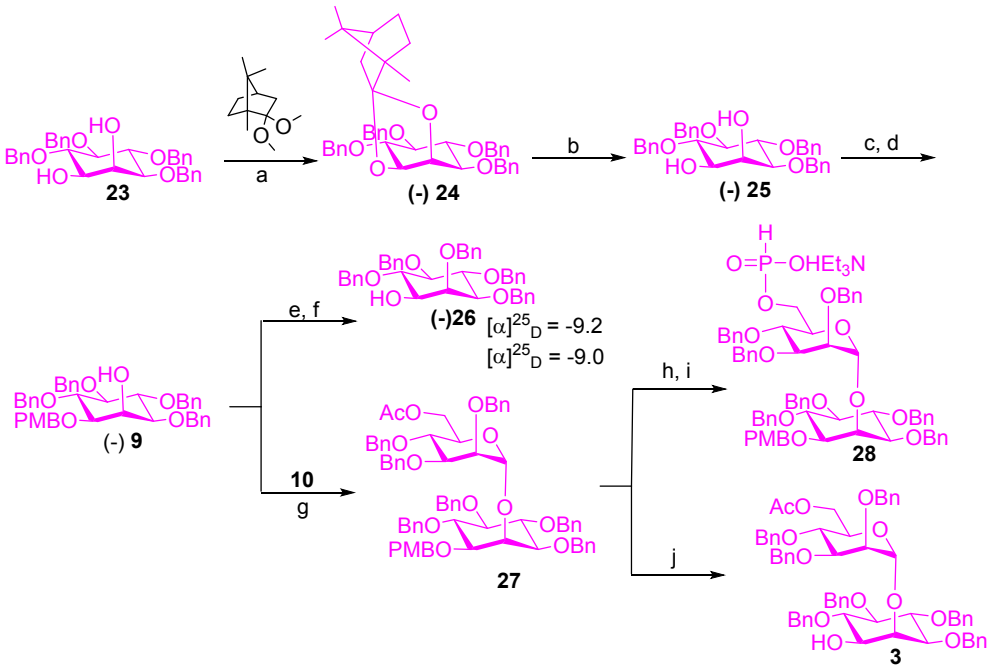
Scheme 3: Synthesis of tetramannosyl fragment **2**.



Reagents and Conditions: (a) PhSCl, AgOTf, TTBP, -78 ^{o}C-rt; (b) pTSA, MeOH, 12 h, 95%; (c) i) BnBr, NaH, DMF, 10 h; ii) DDQ, DCM/MeOH, 4 h, 65%; (d) PCl_3, Imidazole, Et_3N, DCM, -10 ^{o}C, 75%.

En route to obtain optically pure inositol base key intermediates, we began from myo-inositol (Scheme 4), racemate (±) **23,** which was synthesized from myo-inositol using a reported procedure.[17] The resolution of diol (±) **23** was commenced *via* the formation of a camphanylidene ketal diastereomers, which were easily separated through column chromatography. However (-)-**24** was used for further synthesis and stereochemistry of (-)-**24** was confirmed as a D-isomer by converting into known compound (-)-**26**.[12d] The intermediate (-)-**24** was converted into inositol acceptor **9** in two-steps, by cleavage of camphanylidene ketal to (-)-**25** in 90% yield, and stannylene acetal derived regioselective 1-O-4-methoxy benzylation to (-)-**9** in 80% yield.

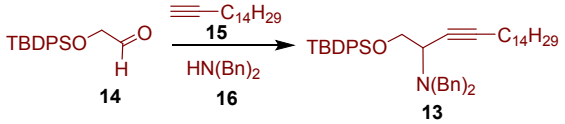
Scheme 4: Synthesis of pseudodisaccharide fragments **3**, **28**.



Reagents and Conditions: (a) DCM, pTSA, reflux, 96% (48:48); (b) pTSA, MeOH, reflux, 90%; (c) Bu_2SnO, MeOH: (d) PMBCl, TBAB, Toluene, 80 °C, 80%; (e) BnBr, NaH, DMF, 94%; (f) 15% TFA in DCM, 90%; (g) TMSOTF, DCM 4° MS, -20 °C, to rt, 84%; (h) NaOMe, MeOH, 0 °C, 91%; (i) PCl_3, Imidazole, Et_3N, DCM, -10 °C, 75%; (j) 10% TFA in DCM, 88%.

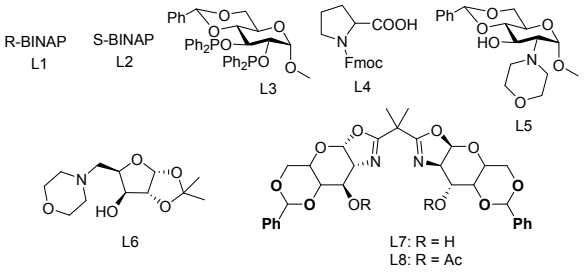
The intermediate (-)-**9** was coupled with mannopyranosyl imidate donor **10** (which was synthesized from *α*-methylmannopyranoside by using reported method[18]) using TMSOTf as activator under anhydrous conditions at -20 °C to get **27** with α-stereochemistry in 84% yield, which was confirmed through 2D-HSQC-NMR by observing anomeric peak as broad singlet at 5.40 ppm in ^{1}H-spectrum and 98.22 ppm in ^{13}C-spectrum. The deacetylation of **27** was achieved by using sodium methoxide in 91% yield, followed by *H*-phosphonate preparation with PCl_3, imidazole provided **28** in 75% yield. On the other hand pseudodisaccharide acceptor **3** was synthesized from **27** by PMB deprotection with 10% TFA/DCM in 88% yield (Scheme 3).

Table 2. Optimization conditions for A^3 coupling.



Entry	Conditions	yield	%ee

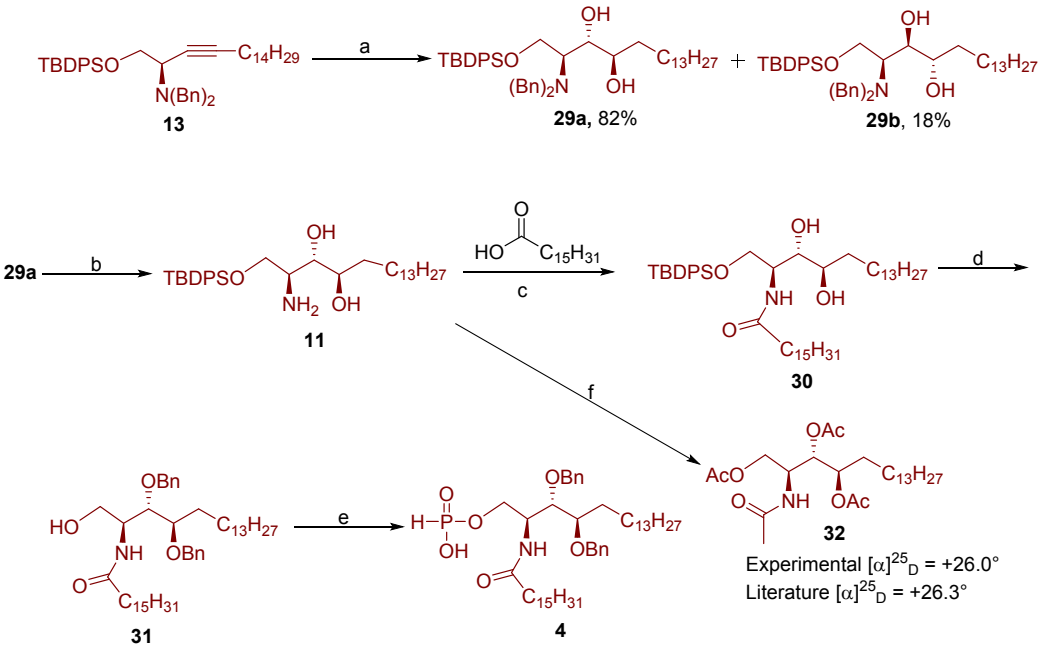
1	CuI, toluene, rt	20%	-
2	CuI, toluene, 50 ^{o}C	45%	-
3	$Cu(OTf)_2$, toluene, rt	50%	-
4	$Zn(OTf)_2$, toluene, rt	30%	-
5	$Zn(OTf)_2$, toluene, 70 ^{o}C	65%	-
6	CuBr, toluene, 40 ^{o}C	92%	-
7	L1, CuBr, toluene, rt	88%	
8	L2, CuBr, toluene, rt	88%	-
9	L3, CuBr, toluene, rt	90%	-
10	L4, CuBr, toluene, rt	89%	-
11	L5, CuBr, toluene, rt	78%	27.2*
12	L6, CuBr, toluene, rt	85%	39.2*
13	L7, CuBr, toluene, rt	90%	67.6*
14	L8, CuBr, toluene, rt	90%	92.8*
* ee% was calculated by HPLC (SI, page no.32-36)			



The synthesis was commenced with the preparation of the phytoceramide-1-*H*-phosphonate **4.** Phytoceramides are widely distributed in plants, yeasts, fungi, and even in mammalian tissues and responsible for number of physiological processes including cell recognition, adhesion, signal transduction, apoptosis, and control of immune response.[19] Considering their importance, several methods were reported regarding synthesis in the literature from the carbohydrates or amino acid derived chiral starting materials, and few are based on asymmetric synthesis.[20] However, in the present study, A^3 coupling strategy was employed considering its ease of operation and high enantio-selectivity outcome, for the synthesis of key intermediate **13** of phytoceramide.[21] To achieve this, several conditions were tried (Table 2), to seek effective A^3 coupling by using suitable stating partners such as glycoaldehyde **14**, 1-hexadecyne **15** and dibenzylamine **16.** Different catalysts such as CuI, $Cu(OTf)_2$, $Zn(OTf)_2$ were employed (Table 2, entry1-5) where all the tried conditions are given low conversion

(20-65%). In the next attempt, CuBr when tried efficiently catalyzed the reaction with 92% yield of the desired alkyne **13** (Table 2, entry 6). Next, to achieve the enantioselectivity several asymmetric ligands was investigated in conjunction with a CuBr salt.in the initial attempts, Phosphine ligands including (R)-BINAP,[22a] (S)-BINAP,[22a] FMOC-Proline,[22b] sugar phosphines,[22c] sugar amino alcohol when tried,[22d, 22e] were not found promising results (Table 2, entry 7-12). Interestingly, when Ac glucoBox was tried the desired alkyne **13,** was obtained in 90% yield with 92.8% ee (Table 2, entry 13).[23] The stereochemistry of **13** was confirmed by converting it into **32**.

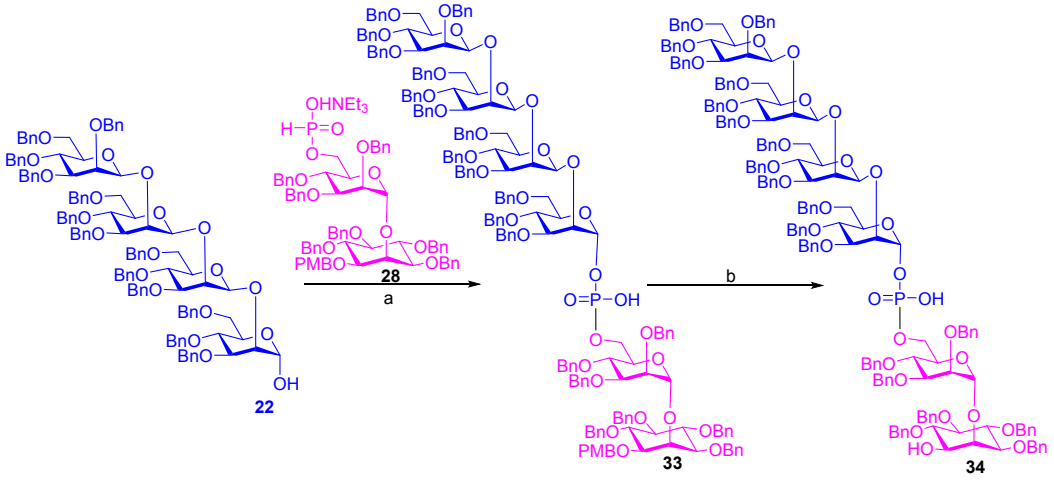
Scheme 5: Synthesis of phytoceramide-1-*H*-phosphonate **4**.



Reagents and Conditions: (a) i) Lindlar Catalyst, EtOAc/ Pyridine, H_2; ii) AD mix-β 1:1 t-BuOH : H_2O, $K_2OsO_4.2H_2O$, $MeSO_2NH_2$, 80%; (b) Pd/C, H_2, 8 h, 95%; (c) i) EDC, HOBT, DMAP, DCM, 12 h; (d) i) BnBr, NaH, DMF, 10 h, 65% for 3 steps; ii) TBAF, THF, 8 h, 70%; (e) PCl_3, Imidazole, Et_3N, DCM, 5 h, 74%; f) i) TBAF, THF; ii) Ac_2O, pyridine.

The alkyne **13** was treated with a lindlars catalyst to get (*Z*)-alkene (Scheme 5). The (*Z*)-alkene was subjected to the sharpless assymetric dihydroxylation to afford a diastereomeric mixture of the diol **29a** and **29b**, which were easily separated through column chromatography. The stereochemistry of diol **29a** was confirmed as D-ribo configuration by converting into a known sphingoid base **32**,[24] through the intermediate **11**. The intermediate **11** was converted into phytoceramide precursor **31** in a three steps sequence i.e., amidation, benzylation of diol, TBDPS deprotection with TBAF in an overall yield of 65%. The intermediate **31** was converted into the key fragment *H*-phosphonate **4** using PCl_3, and imidazole in 74% yield.

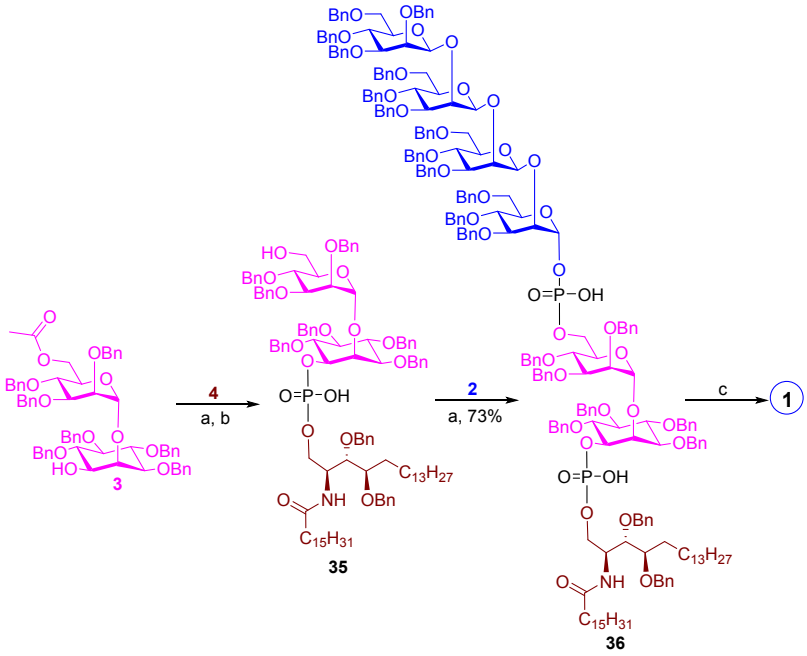
Scheme 6: Synthesis of saccharide acceptor **34**.



Reagents and Conditions: (a) Pivaloyl chloride, Py, I_2, Py/H_2O (19:1); (b) TFA, DCM, 60%.

To achieve the synthesis of PLM, tetramannoside acceptor **22** was coupled with *H*-phosphonate donor of pseudo disaccharide **28** by using pivaloyl chloride as activator and pyridine as a base, the unstable P(III) oxidation state was converted into P(V) **33** by using Iodine/pyridine/water system in a crude yield of 70% yield. The crude reaction mixture was subjected to the PMB group deprotection by using TFA/DCM **34** in 60% crude yield, but the reaction mixture was found to be an inseparable mixture of products (Scheme 6). Later we changed the strategy (Scheme 7), the pseudodisaccharide acceptor **3** was coupled to *H*-phosphonate donor of phytosphingosine **4** by using pivaloyl chloride as activator and pyridine as a base, the unstable P(III) oxidation state was converted into P(V) by using Iodine/pyridine/water system. The crude material was deacetylated by using NaOMe/MeOH to give **35** in 60% overall yield. The fully protected PLM **36** was achieved in 73% yield by coupling acceptor **35** with *H*-phosphonate donor **2** using the same condition were used earlier. The crude α, β mixture of fully protected PLM was subjected to flash column chromatography with Et_3N-deactivated silica gel, which gave pure α-isomer of **36** as a white waxy material, Rf 0.4($CHCl_3$/MeOH/Et_3N = 7:3:0.1). To establish the synthesis of target PLM **1,** the benzylated compound **36** was debenzylated using Perlman's catalyst in THF/MeOH/H_2O and monitored on MS which confirm its formation.

Scheme 7: Synthesis of Phospholipomannan anchor **1**.



Reagents and Conditions: (a) Pivaloyl chloride, Py, I_2, Py/H_2O (19:1); (b) NaOMe/MeOH, 60%; (c) 30% $Pd(OH)_2$, THF, MeOH, H_2O, Formic acid (catalytic).

Conclusion:

In summary, the first total synthesis of PLM anchor of *C. albicans* was achieved *via* convergent block approach. Developed an enantioselective A^3 coupling approach and its application for the synthesis of phytoceramide, and established the first iterative one pot protocol for the synthesis of (1→2)-*β*-tetramannoside.

Experimental section:

General:

Solvents were distilled in the standard way, and commercial reagents were used without any purification. All reactions were performed in flame-dried glass apparatus under inert atmosphere unless mentioned. Anhydrous solvents like CH_2Cl_2, Et_2O, THF, CH_3OH, CH_3CN, DMF, pyridine, and Et_3N were dried in standard way. NMR spectra (^1H, ^{13}C, 2D ^1H-^1H-COSY and ^1H-^{13}C HMBC, HMQC, and NOESY) were recorded on a 400 and 500 MHz spectrometer, and Me_4Si used as an internal standard. NMR chemical shifts (δ) in ppm and coupling constants *J* in Hz. High-resolution mass spectral data were obtained from Q-ToF Mass Spectrometer coupled LC system. The following conditions were used: capillary voltage 3500 V, capillary temperature 350 ^oC, auxiliary gas flow rate 7.0 L/min, spray voltage 4.5 kV, mass range 100-1000 amu (maximum resolution 30000). Optical rotations were measured on a Perkin Elmer polarimeter. Analytical TLC was performed on 60 F254 plates, and visualized in UV, staining solutions ceric-sulfate was used. Column chromatography was carried out with silica (60-120, 230-400 mesh). Analytical and semi-preparative HPLC purifications were carried out on normal and reversed-phase columns connected to a binary pump and monitored using a photodiode array detector.

Experimental procedures:

Synthesis of suitably protected mannose-based building blocks:

Phenyl-4,6-*O*-Benzylidene-thio-*α*-D-mannopyranoside (18): D-(+)-mannose (10.0 g, 55.55 mmol) was suspended in acetic anhydride (40.0 mL, 423.52 mmol). At 0 °C (Ice bath) several drops of perchloric acid (69%, aqueous) were added. The reaction was allowed to stir for 1h at 0 °C (Immersion cooler). After completion of the reaction, diluted with 500 mL of CH_2Cl_2, washed with water and saturated $NaHCO_3$ solution. The combined organic phases were dried over Na_2SO_4 and concentrated in vacuum. The crude pentaacetate was used for the subsequent glycosylation without further purification. Under an argon atmosphere the crude penta acetate (21.65 g, 55.50 mmol) was dissolved in anhydrous CH_2Cl_2 (250 mL) and BF_3Et_2O (11.5 g, 81.02 mmol) was added. At 0 °C thiophenol (8.4 mL, 83.2 mmol) was added dropwise, and the reaction mixture was allowed to stir at rt. After completion of the reaction judged by TLC, the saturated $NaHCO_3$ solution was added until BF_3Et_2O was hydrolysed. The organic phase was washed with saturated $NaHCO_3$ solution followed by water several times. The combined organic phases were dried over Na_2SO_4, concentrated in vacuum. To a solution of above crude thio-mannopyranoside in dry MeOH (250 mL) was added 1M NaOMe (10 mL). The reaction mixture was stirred under an argon atmosphere for 10 h, then neutralized with DOWEX 50 H^+-form, filtered, and the filtrate was concentrated in vacuum. The crude product was subjected to column chromatography (CH_2Cl_2/MeOH, 8:2) to give thio mannopyranoside (13.42 g, 90%) as a solid (R_f 0.65$CHCl_3$/MeOH = 8:2).

To a solution of thio mannopyranoside (10.0 g, 36.76 mmol) in dry DMF (200 mL), *p*-TSA (0.63 g, 3.67 mmol) and benzaldehyde dimethylacetal (5.5 mL, 36.76 mmol) were added at rt. The reaction mixture was stirred for 2 h on the rota at 60 °C under reduced pressure (200 mbar). Then the reaction was concentrated on vacuum, and the residue was diluted with EtOAc (200 mL), the organic phase was washed with saturated $NaHCO_3$ (200 mL), followed

by water (2 x 100 mL), dried over Na_2SO_4, and concentrated in vacuum. The crude product was subjected to column chromatography ($CHCl_3$/MeOH, 8:1) to give desired product **18** in (7.26 g, 55%) as a white solid (R_f0.55$CHCl_3$/MeOH = 9:1).

Phenyl-2,3-*O*-Benzyl-4,6-*O*-benzylidene-thio-*α*-D-mannopyranoside (6): To a solution of **18** (5.0 g, 13.88 mmol) in anhydrous DMF (100 mL), NaH (60% dispersion in mineral oil, 1.99 g, 83.31 mmol) was added under N_2 atmosphere at 0°C (Immersion cooler). After stirring for 30 min, BnBr (3.96 mL, 33.33 mmol) was added dropwise. Then the reaction was allowed to stir overnight at, reaction was quenched with ice, and diluted with EtOAc, and subjected to aqueous workup, organic layer was dried over Na_2SO_4, and concentrated in vacuum. The crude residue was subjected to column chromatography to afford compound **6** (7.12 g, 95%) as a foam (R_f0.65 Hexanes/EtOAc = 9:1).[17]

^{1}H NMR (400 MHz, $CDCl_3$): δ 3.89 (t, *J* = 9.8 Hz, 1H), 3.93 - 3.99(m, 1H), 4.04 (dd, *J* = 3.2, 1.4 Hz, 1H), 4.19 - 4.35 (m, 3H), 4.65 (d, *J* = 12.2 Hz, 1H), 4.72 (s, 2H), 4.82 (d, *J* = 12.2 Hz, 1H), 5.51 (d, *J* = 1.3 Hz, 1H), 5.65 (s, 1H), 7.20 - 7.43 (m, 18H), 7.52 (dd, *J* = 7.6, 1.8 Hz, 2H).

Phenyl-3-*O*-Benzyl-4,6-*O*-benzylidene-thio-*α*-D-mannopyranoside (7): A mixture of **18** (5.0 g, 13.88 mmol) and dibutyltin oxide (3.45 g, 13.88 mmol) in anhydrous methanol (100 mL) was refluxed for 4 h, then the reaction mixture was concentrated in vacuum, the residue was dissolved in anhydrous toluene/DMF (1:1, 100 mL) and freshly activated 4Å MS were added. The reaction mixture was cooled to 0 ºC (Immersion cooler), after which TBAB (13.42 g, 41.65 mmol) and BnBr (1.98 mL, 2.84 mmol) were added to the solution. The reaction was stirred at 120 °C for 12h, then filtered through Celite and washed with EtOAc. The organic layer was washed with water, dried over Na_2SO_4, and concentrated in vacuum,

the crude residue was subjected to column chromatography to give desired compound **7** (4.99 g, 80%) as a foam (R_f 0.65Hexanes/EtOAc = 7:3).[12e] **^{1}H NMR (400 MHz, $CDCl_3$):** δ 2.84 (bs, 1H), 3.78 (t, *J* = 10.2 Hz, 1H), 3.89 (dd, *J* = 9.5, 3.3 Hz, 1H), 4.12 (dt, *J* = 12.3, 7.2 Hz, 2H), 4.214.30 (m, 2H), 4.67 (d, *J* = 11.8 Hz, 1H), 4.82 (d, *J* = 11.8 Hz, 1H), 5.55 (s, 1H), 5.52 (s, 1H), 7.18-7.45 (m, 15H).

2-Naphthyl-3,4,6-tri-*O*-Benzyl-*α*-D-mannopyranoside (8): The compound 17 was converted into 19 by using reported literature.[18] To a solution of compound **19** (2.0 g, 3.95 mmol) in DCE/ H_2O, added catalytic amount *p*-TSA. The reaction was vigorously stirred at rt over 3 h, after which the reaction mixture quenched with triethylamine and evaporated, the crude residue was dissolved in EtOAc and washed with water, and concentrated in vacuum. The crude residue was again dissolved in DMF 30 mL, and cooled to 0 ^oC (Immersion cooler), NaH (60%, 0.2 g, and 8.33 mmol) was slowly added under N_2 atmosphere, after stirring for 30 min, 2-bromomethylnapthalene (0.988 g, 4.47 mmol) was added. The reaction was stirred overnight at rt, then quenched with methanol and heated to 60 ^oC. The reaction mixture was poured in water and extracted with 2 x 200 mL EtOAc, after which the combined organic layer was washed with brine, dried over Na_2SO_4, and concentrated in vaccum. The crude residue was subjected to column chromatography to give compound **8** (1.63 g, 70%) as a colour less syrup (R_f 0.45Hexanes/EtOAc = 7:3).**^{1}H NMR (400 MHz, $CDCl_3$):** δ 2.52 (s, 1H), 3.72 (d, *J* = 10.5 Hz, 1H), 3.75 - 3.81 (m, 1H), 3.89 (d, *J* = 5.8 Hz, 2H),3.96 (dd, *J* = 9.1, 3.2 Hz, 1H),4.09 (d, *J* = 1.6 Hz, 1H),4.54 (dd, *J* = 17.5, 11.5 Hz, 2H),4.62 - 4.71 (m, 4H),4.85 (dd, *J* = 17.3, 11.4 Hz, 2H),4.85 (dd, *J* = 17.3, 11.4 Hz, 2H), 5.04 (d, *J* = 1.1 Hz, 1H), 7.15 - 7.19(m, 2H),7.26 - 7.37 (m, 13H), 7.46 (ddd, *J* = 18.7, 9.2, 5.2 Hz, 3H), 7.75 (s, 1H), 7.82 (dd, *J* = 8.9, 4.4 Hz, 3H).

2-Naphthyl-(2,3-di-*O*-benzyl-4,6-*O*-benzylidene-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*α*-D-mannopyranoside (20):

PhSCl/AgOTf method: A solution of donor **6** (100 mg, 0.18 mmol) and freshly activated 4Å molecular sieves (1.0 g) in CH_2Cl_2 was stirred at room temperature for 30 min, and cooled to -78 ^oC (Immersion cooler), which was followed by addition of AgOTf (142.5 mg, 0.55 mmol) dissolved in CH_3CN (0.5 mL) without touching the wall of reaction vessel. After 5 min orange coloured solution of benzene sulfinyl chloride (PhSCl) (29.42 mg, 0.18 mmol) was added to the solution through a micro syringe. This addition needs to be performed quickly in order to PhSCl from freezing inside the syringe tip or on the flask wall. The yellow colour of the solution quickly dissipated within a few seconds, which indicates the complete consumption of PhSCl. After the donor was completely consumed, according to TLC (about 10-15 min at -78^{o}C), a solution of acceptor **8** (98.3 mg, 0.16 mmol) and TTBP (41 mg, 0.18 mmol) In $CH_2Cl_2$was slowly added dropwise by using a syringe. The reaction mixture was warmed to -20^{o}C in 2h, the reaction was quenched with Et_3N, diluted with CH_2Cl_2, filtered, and concentrated in vacuum. The residue was dissolved in CH_3CN and insoluble material was filtered off, concentrated in vacuum. The crude residue was purified by silica gel column chromatography with EtOAc and hexane (1:9) as the eluent to give **20** (174 mg, *β/α*: 9.4/0.6, 99% yield, ratio was determined by HPLC, SI page no. 13) as a foamy solid. **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 3.24-3.30 (m, 1H), 3.53 (dd, *J* = 4.0, 8.0 Hz, 1H), 3.67-3.75 (m, 2H), 3.79-3.88 (m, 2H), 3.95 (t, *J* = 12.0 Hz, 1H), 4.0-4.03 (m, 2H), 4.18-4.23 (m, 2H), 4.30-4.33 (m, 2H), 4.47 (d, *J* = 12.0 Hz, 1H), 4.54 (d, *J* = 12.0 Hz, 1H), 4.59-4.69 (m, 5H), 4.78 (d, *J* = 12.0 Hz, 1H), 4.83-4.92 (m, 3H), 5.06-5.11 (m, 2H), 5.59 (s, 1H), 7.08-7.10 (m, 2H), 7.20-7.54 (m, 31H), 7.76 (s, 1H), 7.82-7.86 (m, 3H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 138.7, 138.3, 138.1, 137.6, 134.4, 133.2, 133.0, 128.8, 128.7, 128.3, 128.3,

128.1, 128.1, 127.9, 127.8, 127.7, 127.6, 127.5, 127.4, 127.4, 127.0, 126.3, 126.1, 126.0, 125.9, 101.4, 100.4, 96.6, 78.3, 78.2, 77.2, 76.2, 75.1, 75.0, 74.3, 73.3, 73.0, 71.8, 71.7, 70.8, 69.4, 68.9, 68.5, 67.6., $[\alpha]_D^{20}$ = -29.7 (*c* = 1.0, $CHCl_3$); HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{65}H_{64}O_{11}$ 1020.4449; found 1020.4445.

2-Naphthyl-(2,3-di-*O*-benzyl-4,6-*O*-benzylidene-*β*-D-mannopyranosyl)(1→2)-(3-*O*-benzyl-4,6-*O*-benzylidene-*β*-D-mannopyranosyl)(1→2)-(3-*O*-benzyl-4,6-*O*-benzylidene-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*α*-D-mannopyranoside (5): A solution of donor **6** (200 mg, 0.37 mmol) and freshly activated 4Å molecular sieves (2.0 g) in CH_2Cl_2 was stirred at room temperature for 30 min, and cooled to -78 °C (Immersion cooler), which was followed by addition of AgOTf (285 mg, 1.11 mmol) dissolved in CH_3CN (1.0 mL) without touching the wall of reaction vessel. After 5 min, orange coloured solution of PhSCl (58.49 mg, 0.37 mmol) was added to the solution through a micro syringe. This addition needs to be performed quickly in order to prevent freezing of PhSCl inside the syringe tip or on the flask wall. The yellow colour of the solution quickly dissipated within a few seconds, which indicates the complete consumption of PhSCl. After the donor was completely consumed, according to TLC (about 10-15 min at -78 °C), a solution of acceptor **7** (151 mg, 0.336 mmol) and TTBP (82 mg, 0.336 mmol) in CH_2Cl_2 was slowly added dropwise by using a syringe. The reaction mixture was warmed to -20 °C in 2h, and then the mixture was cooled to -78 °C, this was followed by another glycosylation by the same protocol using sequential addition of AgOTf (256 mg, 1.0 mmol) in CH_3CN (2.0 mL), PhSCl (52.6 mg, 0.33 mmol), acceptor **7** (137 mg, 0.306 mmol) and TTBP (75.9 mg, 0.306 mmol) in anhydrous CH_2Cl_2 (2.0 mL). Thereafter, another glycosylation was achieved following the same protocol using AgOTf (267 mg, 0.925 mmol) in CH_3CN (1.0 mL), PhSCl (48.3 mg, 0.306 mmol), acceptor **8** (164 mg, 0.278 mmol) and

TTBP (69.18 mg, 0.278 mmol) in anhydrous CH_2Cl_2 (5.0 mL). Finally, the reaction was quenched with Et_3N, diluted with CH_2Cl_2, filtered, and concentrated in vacuum. The residue was dissolved in CH_3CN and insoluble material was filtered off, concentrated in vacuum. The crude residue was subjected to Sephadex LH-20 column, followed by flash column chromatography with EtOAc and toluene (0.3:9.7) as the eluent to give **5** (251 mg, 40% overall yield) as a foamy solid (R_f 0.7 Hexanes/EtOAc = 7:3). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 3.31-3.37 (m, 1H), 3.39-3.44 (m, 1H), 3.53-3.65 (m, 6H), 3.73-3.87 (m, 6H), 3.91-4.01 (m, 5H), 4.21-4.27 (m, 2H), 4.29-4.34 (m, 3H), 4.36-4.41 (m, 3H), 4.45-4.56 (m, 9H), 4.60 (d, *J* = 4.0.0 Hz, 1H), 4.65-4.68 (m, 3H), 4.71-4.81 (m, 5H), 4.87 (d, *J* = 12.0 Hz, 1H), 5.02 (d, *J* = 12.0 Hz, 1H), 5.09 (d, *J* = 12.0 Hz, 1H), 5.38 (s, 1H), 5.43 (s, 1H), 5.53 (s, 1H), 5.62 (s, 1H), 6.91 (d, *J* = 8.0 Hz, 2H), 7.07-7.52 (m, 60H), 7.75 (bs, 1H), 7.81-7.85 (m, 3H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 139.6, 138.6, 138.5, 138.3, 137.9, 137.8, 137.7, 137.5, 137.3, 136.9, 133.9, 133.1, 133.0, 129.0, 128.7, 128.4, 128.4, 128.4, 128.3, 128.2, 128.2, 128.1, 128.0, 128.0, 128.04, 128.0, 127.9, 127.9, 127.69, 127.6, 127.5, 127.2, 127.2, 127.1, 127.04, 127.0, 126.9, 126.4, 12.3, 126.2, 126.1, 126.1, 125.9, 103.5, 102.0, 101.6, 101.3, 101.2, 99.2, 95.7, 79.3, 78.6, 78.4, 78.1, 77.2, 76.5, 76.1, 76.0, 75.5, 74.8, 74.3, 73.8, 72.4, 72.1, 71.5, 71.1, 70.8, 70.5, 69.6, 68.8, 68.8, 68.7, 67.8, 67.7, 67.7. HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{105}H_{104}NaO_{21}$ 1729.6968; found 1729.6976.

2-Naphthyl-(2,3-di-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*α*-D-mannopyranoside (21): To a solution of **5** (200 mg, 0.11 mmol) in CH_2Cl_2/MeOH (1:1, 20 mL), *p*TSA (200 mg, 1.16 mmol) was added, allowed to stir for 12 h, after completion of reaction was confirmed by TLC analysis, then the reaction was stopped by adding Et_3N and concentrated in vacuum. The crude residue was worked up with EtOAc/H_2O, organic layer

was concentrated in vaccum. The crude residue was subjected to column chromatography MeOH: $CHCl_3$ (1:9) as a eluent to afford **21** (148.2 mg, 95% yield) as a foamy solid $[\alpha]_D^{20}$ = -29.7 (*c* = 1.0, MeOH). **^{1}H NMR (400 MHz, C_5D_5N):** 3.78-3.86 (m, 2H), 3.91 (t, *J* = 9.1 Hz, 2H), 4.06 (dd, *J* = 10.6, 4.3 Hz, 1H), 4.09-4.15 (m, 2H), 4.20-4.51 (m, 12H), 4.55-4.67 (m, 8H), 4.76 (dd, *J* = 12.1, 5.8 Hz, 3H), 4.80-5.18 (m, 75H, Including H_2O peak), 5.25 (d, *J* = 8.5 Hz, 3H), 5.33 (d, *J* = 10.8 Hz, 2H),, 5.47 (s, 1H), 5.50 (s, 1H), 5.67 (s, 1H), 5.77 (s, 1H), 6.02 (s, 1H), 7.02-7.07 (m, 3H), 7.09-7.15 (m, 4H), 7.17 (bs, 9H), 7.27 (dd, *J* = 11.0, 4.1 Hz, 3H), 7.32 (d, *J* = 9.5 Hz, 5H), 7.37 (dd, *J* = 6.9, 4.1 Hz, 3H), 7.43-7.48 (m, 2H), 7.49-7.52 (m, 2H), 7.55 (d, *J* = 7.9 Hz, 6H), 7.60 (d, *J* = 7.4 Hz, 2H), 7.69 (t, *J* = 8.2 Hz, 3H), 7.88 (dd, *J* = 16.7, 8.6 Hz, 4H). **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 150.9, 150.7, 150.5, 142.0, 140.9, 140.6, 140.5, 140.34, 140.3, 139.9, 136.6, 136.4, 136.2, 136.0, 134.7, 134.4, 129.7, 129.6, 129.5, 129.4, 129.2, 129.17, 129.1, 129.0, 128.9, 128.8, 128.7, 128.4, 128.2, 128.1, 128.0, 127.7, 127.5, 127.3, 124.6, 124.4, 124.2, 104.8, 102.6, 100.7, 98.2, 84.4, 83.6, 82.4, 80.0, 79.9, 79.7, 78.9, 77.3, 76.6, 76.5, 75.9, 74.5, 73.4, 73.2, 73.1, 72.1, 71.5, 71.4, 71.1, 70.6, 70.4, 68.6, 68.3, 68.1, 64.6, 64.1, 63.5. HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{84}H_{92}NaO_{21}$ 1459.6029; found 1459.6042.

2,3,4,6-Tetra-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*α*-D-mannopyranoside (22): The solution of **21** (200 mg, 0.139 mmol) in anhydrous DMF stirred under nitrogen at 0 °C (Immersion cooler), and sodium hydride (60% dispersion in mineral oil, 100 mg, 4.166 mmol) was slowly added. After stirring for 30 min, benzyl bromide (0.120 mL, 0.99 mmol) was added dropwise. The reaction was stirred overnight at room temperature, then quenched with ice, diluted with EtOAc, and poured into water. The aqueous layer was extracted 2x with EtOAc, after which the combined organic layer was

washed with brine, dried over Na_2SO_4, and concentrated in vaccum. R_f0.55 (EtOAc/Hexane = 2:8). HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C126H_{128}NaO_{21}$ 1999.8846; found 1999.8858. The crude residue was dissolved in dichloromethane (10 ml) and methanol (3.0 ml). DDQ (163 mg, 0.718 mmol) was added in three equal portions at half-hour intervals. Stirring continued for 2 h, the solvent was removed by evaporation, the residue taken up in chloroform and washed with sat.$NaHCO_3$. After which the combined organic layer was washed with brine, dried over Na_2SO_4, and concentrated in vaccum. Chromatography on silica in dichloromethane– methanol 10:1 gave **22 (**155 mg, 65%) as a foamy solid, (R_f 0.2Hexanes/EtOAc = 7:3). $[\alpha]_D^{20}$ = +16.57 (*c* = 0.33, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 2.74 (bs, 1H), 2.96 (dd, *J* = 20.0, 5.0 Hz, 1H), 3.25 (dd, *J* = 20.0, 5.0 Hz, 1H), 3.44 (dd, *J* = 20.0, 5.0 Hz, 1H), 3.48-3.63 (m, 8H), 3.65-3.71 (m, 6H), 3.75-3.82 (m, 2H), 3.88-3.94 (m, 4H), 4.02-4.05 (m, 3H), 4.19-4.22 (m, 2H), 4.26-4.31 (m, 4H), 4.34-4.45 (m, 10H), 4.48-4.56 (m, 4H), 4.60-4.64 (m, 3H), 4.73-4.83 (m, 5H), 4.93 (d, *J* = 20.0, 5.0 Hz, 1H), 5.0 (dd, *J* = 20.0, 5.0 Hz, 1H), 5.12-5.14 (m, 3H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 139.8, 139.7, 138.8, 138.8, 138.7, 138.7, 138.6, 138.5, 138.5, 138.3, 138.3, 138.27, 138.2, 138.0, 137.8, 137.83, 128.6, 128.67, 128.3, 128.35, 128.30, 128.2, 128.25, 128.22, 128.21, 128.1, 128.16, 128.09, 128.00, 127.9, 127.87, 127.8, 127.7, 127.73, 127.7, 127.5, 127.4, 127.3, 127.28, 127.2, 127.1, 127.0, 126.9, 126.93, 101.6, 98.8, 98.5, 98.4, 98.2, 93.8, 93.6, 83.2, 83.1, 79.8, 79.7, 77.99, 77.9, 77.2, 75.8, 75.6, 75.3, 75.2, 75.2, 75.0, 74.9, 74.7, 74.6, 74.6, 74.49, 74.4, 74.3, 74.2, 74.2, 73.56, 73.5, 73.4, 73.3, 73.2, 73.1, 72.6, 71.9, 71.4, 71.3, 71.2, 70.6, 70.5, 70.5, 70.4, 70.3, 70.3, 69.7, 69.7, 69.3, 69.1, 69.1, 68.8**;** HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{115}H_{120}NaO_{21}$ 1859.8220; found 1859.8238.

Triethylammonium-*O*-Hydrogen-Phosphonato-2,3,4,6-Tetra-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*α*-D-mannopyranoside (2):

To a stirred solution of imidazole (111 mg, 1.6 mmol) in anhydrous DCM (1.0 ml) at -10° C were added PCl_3 (30 ul, 0.326 mmol) and Et_3N (106 ul, 0.756 mmol). The mixture was stirred for 20 min, after which alcohol **22** (200 mg, 0.108 mmol) in anhydrous DCM (2.0 ml) was added dropwise over a period of 15 min. The mixture was stirred at -10 °C for 3 h, and quenched by addition of water/pyridine (1/4, 20.0 ml). The aqueous layer was extensively washed with $CHCl_3$ and the combined organic layers were further washed with triethylammonium borate (TEAB) buffer and dried over Na_2SO_4. Evaporation in vacuum gave the crude residue, which was subjected to flash column chromatography with Et_3N-deactivated silica gel to afford H-phosphonate **28** as a white waxy material in 75% (163 mg) (R_f0.55 $CHCl_3$/MeOH/Et_3N = 7:3:0.1). $[\alpha]_D^{20}$ = +16.57 (*c* = 0.33, $CHCl_3$). **^{1}H NMR (400 MHz, $CDCl_3$): δ** 7.41 – 6.81 (m, 65H), 6.76 (d, *J* = 664.2 Hz, 1H), 5.61 (s, 1H), 5.33 (s, 1H), 4.89 (dd, *J* = 28.3, 10.6 Hz, 3H), 4.74 – 4.53 (m, 8H), 4.52 – 4.18 (m, 13H), 4.10 (d, *J* = 11.5 Hz, 5H), 3.83 (s, 4H), 3.74 (s, 2H), 3.63 (s, 2H), 3.56 – 3.33 (m, 8H), 3.19 (d, *J* = 49.5 Hz, 9H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 138.8, 138.7, 138.57, 138.5, 138.4, 138.3, 138.2, 128.4, 128.3, 128.3, 128.2, 128.2, 128.2, 128.1, 128.1, 128.0, 127.9, 127.8, 127.8, 127.7, 127.7, 127.6, 127.6, 127.5, 127.5, 127.4, 127.4, 127.3, 127.3, 100.9, 99.4, 94.2, 79.9, 79.8, 79.1, 78.9, 75.2, 75.0, 75.0, 75.0, 74.9, 74.8, 74.7, 74.5, 73.3, 73.2, 73.1, 73.0, 72.7, 72.5, 72.4, 72.3, 72.1, 72.0, 71.9, 71.8, 69.4, 69.2, 69.1, 68.8, 45.6, 8.5. **^{31}P NMR ($CDCl_3$, 161.98 MHz):** δ 1.99. HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{121}H_{136}NO_{23}P$ 2001.9241; found 2001.9265.

Synthesis of pseudo-disaccharide:-

3,4,5,6-tetra-*O*-benzyl-*myo*-inositol (23): Synthesis is started from myoinositol, which was converted into 1,2-cyclohexylidene-myoinositol by using known protocol. To a solution of 1,2-cyclohexylidene-myoinositol (10.0 g, 38.44 mmol) in anhydrous DMF (100 mL) at 0 ^{o}C (Immersion cooler) was slowly added sodium hydride (60%, 7.38 g, 307.54 mmol). After stirring for 30 min, BnBr (21.91mL, 184.56 mmol) was added. The reaction was allowed to stir overnight at rt, then quenched with ice, diluted with EtOAc, and poured into water. The aqueous layer was extracted 2x with EtOAc, after which the combined organic layer was washed with brine, dried over Na_2SO_4, and concentrated in vaccum. (HRMS (EI): m/z [M + H]$^+$ calculated for $C_{40}H_{45}O_6$621.3216, observed: 621.3171.) The residue was dissolved in CH_2Cl_2/MeOH (2:1, 200mL), added acetyl chloride (2.0 mL) dropwise. After 3 h, the reaction was stopped by adding Et_3N and concentrated in vacuum. The crude material was purified by silica gel column chromatography to give ± **23** (18.69 g, 90%) as a white solid (R_f0.18Hexanes/EtOAc = 7:3). **^{1}H NMR ($CDCl_3$, 500 MHz):** δ 2.43 (d, *J* = 4.5 Hz, 1H), 2.51 (s, 1H), 3.45-3.50 (m, 3H), 3.84 (t, *J* = 10.0 Hz, 1H) 3.97 (t, *J* = 10.0 Hz, 1H), 4.20 (bs, 1H), 4.69-4.75 (m, 3H), 4.83 (d, *J* = 5.0 Hz, 1H), 4.85 (d, *J* = 5.0 Hz, 1H), 4.90-4.96 (m, 3H), 7.28-7.37 (m, 20H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 138.6, 138.4, 137.7, 128.57, 128.5, 128.4, 128.3, 128.2, 127.9, 127.88, 127.8, 127.82, 127.6, 83.2, 81.6, 81.3, 79.9, 75.9, 75.7, 75.6, 72.7, 71.7, 69.1., HRMS (ESI-TOF) m/z: [M + H]$^+$ calcd for $C_{34}H_{37}O_6$ 541.2590; found 541.2563.

(-)-1,2-*O*--(R)-[camphanyldene]-3,4,5,6-tetra-*O*-benzyl-*myo*-inositol (24): To a Solution of starting material **23** (5.0 g, 9.25 mmol) in dry DCM (100 ml) camphor dimethylacetal (2.01 g, 10.18 mmol) was added followed by *p*TSA (0.318 g, 1.85 mmol). The reaction mixture was refluxed for 2h and TLC was checked, substrate was completely consumed. Reaction mixture was neutralized with Et_3N and evaporated on vaccum then purified by

column chromatography (1, 2, 3, 4, 5, 6 % EtOAc / Hexane) to give (-)- **24** (2.90 g, 48%) as a colourless syrup (R_f 0.5Hexanes/EtOAc = 9:1) and (+)- **24** (2.90 g, 48%) as a colourless syrup (R_f 0.4Hexanes/EtOAc = 9:1) $[\alpha]_D^{20}$ = -7.7 (*c* = 0.66, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz)** (-)- **24 :** δ 0.83 (s, 3H), 0.87 (s, 3H), 1.08 (s, 3H), 1.26 (t, *J* = 8.0 Hz, 2H), 1.35-1.42 (m, 1H), 1.48 (d, *J* = 12.0 Hz, 1H), 1.71-1.76 (m, 2H), 1.92-2.01 (m, 2H), 3.43 (t, *J* = 8.80 Hz, 1H), 3.70-3.78 (m, 2H), 3.83 (t, *J* = 8.40 Hz, 1H), 3.96 (t, *J* = 6.40 Hz, 1H), 4.30 (t, *J* = 4.80 Hz, 1H), 4.68-4.82 (m, 7H), 4.90 (d, *J* = 11.20 Hz, 1H), 7.22-7.39 (m, 20H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 138.8, 138.6, 138.4, 128.39, 128.36, 128.34, 128.3, 128.08, 128.0, 127.8, 127.7, 127.6, 127.59, 127.5, 117.7, 83.2, 82.1, 80.8, 77.4, 76.2, 75.2, 73.9, 73.2, 72.4, 51.5, 48.0, 45.2, 45.0, 29.8, 29.7, 27.0, 20.6, 20.4, 10.2., HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{44}H_{51}O_6$ 675.3686; found 675.3661.

(-)-3,4,5,6-tetra-O-benzyl-*myo*-inositol (25): To a solution of (-)-**24** (3.0 g, 4.45 mmol) in CH_2Cl_2/MeOH (1:1, 100mL) at rt, was added pTSA (0.765 g, 4.45 mmol) and heated to 50 ^oC on oil bath, After 4 h, TLC indicates complete consumption of starting material, then the reaction was quenched with TEA and concentrated in vacuum. The reaction mass was dissolved in EtOAc and washed with water, dried over Na_2SO_4, and concentrated in vaccum. The crude residue was subjected to column chromatography to afford (-)-**25** (2.30 g, 96%) as a white solid. (R_f0.18Hexanes/EtOAc = 7:3). $[\alpha]_D^{20}$ = -11.62 (*c* = 0.86, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 2.43 (d, *J* = 3.3 Hz, 1H), 2.51 (s, 1H), 3.45-3.50 (m, 3H), 3.84 (t, *J* = 9.5 Hz, 1H), 3.97 (t, *J* = 9.5 Hz, 1H), 4.20 (t, *J* = 2.7 Hz, 1H), 4.68-4.76 (m, 3H), 4.84 (dd, *J* = 10.8, 3.9 Hz, 2H),4.93 (dd, *J* = 13.3, 11.0 Hz, 3H), 7.27-7.35 (m, 20H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 100 MHz):** δ 138.6, 138.5, 137.8, 128.55, 128.5, 128.39, 128.3, 127.9, 127.88, 127.84, 127.8, 127.6, 83.2, 81.6, 81.3, 80.0, 75.9, 75.6, 75.5, 72.7, 71.7, 69.2., HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{34}H_{37}O_6$ 541.2590; found 541.2605.

(-)-3,4,5,6-tetra-*O*-benzyl-1-*O*-(4-methoxybenzyl)-*myo*-inositol (9): A mixture of (-)-**25** (2.00 g, 3.70 mmol) and dibutyltin oxide (0.925 g, 3.70 mmol) in anhydrous methanol (60 mL) was refluxed on oil bath for 4 h, until solution becomes clear. After concentration in vacuum, the residue was dissolved in dry Toluene/DMF (1:1, 40 mL) and freshly activated 4Å molecular sieves were added. And cooled to 0 ºC on ice bath, after which tetrabutyl ammonium bromide (2.37 g, 7.41 mmol) and *p*-methoxybenzyl chloride (0.60 mL, 4.4 mmol) were added to the solution. After stirring overnight under a Nitrogen atmosphere at 80º C, reaction mixture filtered through Celite and washed with EtOAc. The organic layer was washed with water, dried over Na_2SO_4, and concentrated in vacuum. Which after silica gel column chromatography gave compound (-)-**9** (2.2 g, 90%)as a white solid (R_f 0.55Hexanes/EtOAc = 7:3).**^{1}H NMR ($CDCl_3$, 400 MHz):**δ 1.91 (bs, 1H), 3.28-.3.32 (m, 2H), 3.37 (t, *J* = 12.09 Hz, 1H),3.73 (s, 3H), 3.91 (dd, *J* = 8.0, 16.0, Hz, 2H), 4.12 (t, *J* = 4.0 Hz, 1H), 4.54-4.56 (m, 2H),4.64 (s, 2H), 4.74-4.84 (m, 6H), 6.78 (d, *J* = 8.0 Hz, 2H), 7.17-7.26 (m, 22H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 159.3, 138.8, 138.76, 138.7, 137.9, 130.0, 129.5, 128.4, 128.3, 128.04, 128.0, 127.9, 127.8, 127.6, 113.8, 83.1, 81.2, 79.8, 79.4, 75.9, 72.7, 72.4, 67.5, 55.3., $[\alpha]_D^{20}$ = -1.3 (*c* = 0.75, $CHCl_3$); HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{42}H_{44}NaO_7$ 683.2985; found 683.2963.

(-)-2,3,4,5,6-penta-*O*-benzyl-*myo*-inositol (26): To a solution of (-)-**9** (100 mg, 0.1515 mmol) in anhydrous DMF (100 mL) stirring under Nitrogen at 0ºC (Immersion cooler) was slowly added sodium hydride (60%, 15 mg 0.59 mmol). After stirring for 5 min, BnBr (22 ul, 0.183 mmol) was added dropwise. The reaction was allowed to stir overnight at rt, then quenched with ice, diluted with EtOAc, and poured into water. The aqueous layer was extracted 2x with EtOAc, after which the combined organic layer was washed with brine, dried over Na_2SO_4, and concentrated in vaccum. The residue was dissolved in CH_2Cl_2 5ml,

added TFA (100 ul in 1 ml DCM) dropwise. After 30 min, the reaction was quenched with Et_3N and concentrated in vacuum. The crude material was purified by silica gel column chromatography gave compound (-)-**26** (85.5mg, 90%) as a white waxy (R_f0.45Hexanes/EtOAc = 7:3). Experimental $[\alpha]_D^{20}$ = -9.2 (*c* = 1.0, $CHCl_3$), literature $[\alpha]_D^{20}$ = -9.0 (*c* = 1.0, $CHCl_3$), **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 2.16 (bs, 1H), 3.37-.3.43 (m, 3H), 3.74 (t, *J* = 9.60 Hz, 1H),3.95-4.01 (m, 2H), 4.59-4.93 (m, 10H), 7.18-7.28 (m, 25H).

2-*O* -[6-*O*-Acetyl-2,3,4,-tri-*O*-benzyl-*α*-D-mannopyranosyl]-3,4,5,6-tetra-*O*-benzyl-1-*O*-(4-methoxybenzyl)-*myo*-inositol (27): The trichloroacetimidate donor **10** (625 mg, 0.984 mmol) and the acceptor **9** (500 mg, 0.757 mmol) were co-evaporated with anhydrous toluene, dried for 2 h on high vacuum and then dissolved in dry CH_2Cl_2 (20 mL) and freshly activated 1 g of 4Å molecular sieves were added. The suspension was then stirred under Nitrogen at room temparature for 30 min. The reaction mixture was cooled at -20 ^{o}C (Immersion cooler) and treated with TMSOTf solution (12 µL, 0.033 mmol) and then warm to room temperature. After stirring for 1 h, the reaction was neutralized with trimethylamine followed by filtration through Celite to remove molecular sieves, concentration in vacuum, The crude material was subjected to column chromatography to afford compound (+)-**27** (773mg, 90%) as a white waxy material (R_f 0.55 Hexanes/EtOAc = 7:3). $[\alpha]_D^{20}$ = +19.79 (*c* = 0.48, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 1.98 (s, 3H), 3.32 (t, *J* = 9.2 Hz, 2H), 3.42 (t, *J* = 9.2 Hz, 1H), 3.68-3.78 (m, 6H), 3.86 (dd, *J* = 2.4, 9.2 Hz, 1H), 3.93-3.99 (m, 2H), 4.13-4.21 (m, 2H), 4.37 (t, *J* = 12.4 Hz, 2H), 4.46-4.63 (m, 7H) 4.72 (d, *J* = 12.0 Hz, 1H), 4.78-4.93 (m, 7H), 5.40 (bs, 1H), 6.75 (d, *J* = 8.42 Hz, 2H) 7.19-7.33 (m, 37H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 100 MHz)** δ 170.8, 159.4, 138.7, 138.6, 138.6, 138.5, 138.48, 138.43, 138.4, 138.2, 137.89, 129.8, 129.6, 128.44, 128.4, 128.38, 128.3, 128.2, 128.1, 128.04, 128.0, 127.9, 127.88, 127.8, 127.7, 127.65, 127.6, 127.5, 127.4, 127.3, 113.8, 98.2, 83.4, 81.3, 81.1, 80.7,

78.9, 78.5, 76.1, 75.7, 75.1, 74.2, 73.1, 72.5, 72.2, 71.9, 71.6, 69.9, 63.4, 55.1, 20.9., HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{71}H_{74}NaO_{13}$ 1157.5027; found 1157.5013.

Triethylammonium-2-*O*-[6-*O*-Hydrogen-Phosphonato-l-2,3,4,-tri-*O*-benzyl-*α*-D-mannopyranosyl]-3,4,5,6-tetra-*O*-benzyl-1-*O*-(4-methoxybenzyl)-*myo*-inositol (28):

To a solution of (+)-**27** (200 mg, 0.183 mmol) in 5 ml of (1:1) mixture of DCM/MeOH, added catalytic amount of NaOMe (22 mg). The mixture was allowed to stir at rt for 3 h, neutralized to pH 6-7 using Amberlyst H^+ resin. The solution was filtered off and the filtrate was concentrated which after silica gel column chromatography gave compound de-acylated intermediate (182 mg, 95%)as a colourless syrup (R_f0.40Hexanes/EtOAc = 7:3). $[\alpha]_D^{20}$ = -1.5 (*c* = 1.3, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 3.29-3.36 (m, 2H), 3.43 (t, *J* = 12.0 Hz, 1H) 3.53-3.62 (td, *J* = 4.0, 12.0, 16.0 Hz, 2H), 3.69-3.81 (m, 6H), 3.87 (dd, *J* = 4.0, 8.0 Hz, 1H) 3.96-4.06 (m, 2H) 4.30 (bs, 1H) 4.44-4.54 (m, 2H) 4.57-4.67 (m, 6H) 4.71 (d, *J* = 12.0 Hz, 1H) 4.77-4.95 (m, 7H) 5.37 (d, *J* = 1.2 Hz, 1H) 6.81 (d, *J* = 8.0 Hz, 2H) 7.19-7.36 (m, 37H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 159.5, 138.8, 138.7, 138.6, 138.4, 138.2, 138.0, 129.9, 129.7, 113.9, 98.6, 83.48, 81.4, 81.1, 80.8, 79.0, 78.8, 76.1, 75.7, 75.6, 75.1, 74.7, 74.6, 73.1, 72.3, 72.1, 72.1, 72.0, 62.1, 55.2., HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{69}H_{74}O_{13}$ 1110.5129; found 1110.5366.

To a solution of imidazole (183 mg, 2.7 mmol) in dry CH_2Cl_2 (1.0 ml) at -10° C (Immersion cooler) were added PCl_3 (47 ul, 0.540 mmol) and Et_3N (192 ul, 1.38 mmol). The mixture was allowed to stir for 20 min, after which de-acylated intermediate (200 mg, 0.180 mmol) in dry CH_2Cl_2 (2.0 ml) was added dropwise over a period of 15 min. The mixture was allowed to stir at -10 °C for 3 h, and quenched by addition of water/pyridine (1/4, 20.0 ml). The aqueous layer was extensively washed with $CHCl_3$ and the combined organic layers were further

washed with triethylammonium borate (TEAB) buffer and dried over Na_2SO_4. Concentrated in vacuum, the crude residue was subjected to flash column chromatography to afford H-phosphonate **28** as a white waxy material (R_f 0.55 $CHCl_3$/MeOH/Et_3N = 7:3:0.1). $[\alpha]_D^{20}$ = +16.57 (*c* = 0.33, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 500 MHz):** δ 1.11 (t, *J* = 5.0 Hz, 9H), 2.77 - 2.80 (m, 6H), 3.25 (dd, *J* = 20.0, 5.0 Hz, 2H), 3.35 (t, *J* = 5.0 Hz, 1H), 3.60-3.72 (m, 6H), 3.80 (d, *J* = 10.0 Hz, 1H), 3.89-3.93 (m, 3H), 4.07 (d, *J* = 10.0 Hz, 1H), 4.32 (bs, 1H), 4.38 (bs, 1H), 4.50-4.62 (m, 5H), 4.67-4.83 (m, 8H), 5.35 (s, 1H, Anomeric H), 6.74 (d, *J* = 5.0 Hz, 1H), 6.82 (d, *J* = 620.0 Hz, 1H), 7.12-7.26 (m, 38H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 158.2, 137.6, 137.6, 137.59, 137.5, 137.4, 137.1, 136.8, 128.5, 127.27, 127.24, 127.2, 127.1, 127.05, 127.0, 126.8, 126.3, 112.7, 96.8, 82.3, 80.2, 79.98, 79.9, 78.0, 77.4, 75.0, 74.55, 74.5, 74.2, 73.9, 73.4, 71.7, 71.2, 71.1, 70.9, 70.2, 70.1, 69.8, 69.6, 61.5, 54.1, 44.1, 7.3., **^{31}P NMR($CDCl_3$, 161.98 MHz):** δ 5.14., HRMS (ESI-TOF) m/z: [M + Na^+ calcd for $C_{75}H_{88}NNaO_{14}P$ 1280.5840; found 1280.5870.

2-*O*-[6-*O*-Acetyl-2,3,4,-tri-*O*-benzyl-*α*-D-mannopyranosyl]-3,4,5,6-tetra-*O*-benzyl-1-*O*-*myo*-inositol (3): To a stirred solution of tittle compound **27** (200 mg, 0.183 mmol) in dichloromethane at 0 °C (Ice bath) were added 5 ml of 10 % TFA in DCM. The reaction was allowed to stir at rt for 30 min. It was neutralized with trimethylamine and concentrated in vacuum. The crude material was purified by silica gel column chromatography gave compound (-)-**3** (158mg, 89%) as a syrup (R_f0.32Hexanes/EtOAc = 7:3). $[\alpha]_D^{20}$ = -14.0 (*c* = 0.5, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 1.96 (s, 3H), 2.14 (bs, 1H), 3.35 (dd, *J* = 2.4, 8.0 Hz, 1H), 3.39-3.46 (m, 2H), 3.51 (t, 1H), 3.66 (bs,1H), 3.77 (t, 1H), 3.89 (dd, *J* = 2.4, 9.2 Hz, 1H), 3.94-4.03 (m, 2H), 4.14-4.19 (m, 2H), 4.29 (bs, 1H), 4.53-4.82 (m, 10H), 4.91-4.97 (m, 3H), 5.34 (s, 1H, Anomeric H), 7.22-7.39 (m, 35H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 170.9, 138.5, 138.3, 138.3, 138.3, 137.7, 128.7, 128.52, 128.5, 128.46,

128.42, 128.4, 128.3, 128.2, 128.1, 128.04, 128.0, 127.95, 127.9, 127.82, 127.8, 127.7, 127.65, 127.6, 127.5, 127.3, 98.5, 83.5, 81.7, 80.7, 78.9, 78.5, 75.8, 75.7, 75.3, 75.2, 74.4, 74.3, 73.7, 72.2, 72.0, 71.8, 69.9, 63.3, 20.9., HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{63}H_{67}O_{12}$ 1015.4633; found 1015.4595.

Synthesis of Phytoceramide fragment 4:-

2-*O*-(*tert*-butyldiphenylsilyl)-acetaldehyde (14): To a solution of ethylene glycol (1.0 g, 16.11 mmol) in anhydrous DCM was added TBDPSCl (2.0 g, 7.2 mmol) followed by Imidazole (5.48 g, 80.64 mmol) and a catalytic amount of DMAP. The reaction was stirred at rt for 6 h. The reaction mixture was diluted with DCM and transferred into a separatory funnel, washed with H_2O (2 x 100 mL). The organic layer was dried over Na2SO4 and concentrated in vacuo. Purification of the crude material by flash column chromatography on silica gel using hexane/ethyl acetate = 9.5:0.5 as eluent afforded the alcohol (3.38 g, 70%) as colourless syrup (R_f0.4Hexanes/EtOAc = 9:1). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 3.70 (bs, 1H), 3.83 – 3.76 (m, 1H), 7.50 – 7.33 (m, 3H), 7.69 (d, *J* = 6.3 Hz, 2H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 135.5, 133.2, 129.8, 127.8, 64.9, 63.7, 26.8, 19.2.

To a solution of Oxalyl chloride (374 µL, 4.33 mmol) in anhydrous DCM (20.0 mL) at -78 °C (Immersion cooler) under N_2, DMSO (600 µL, 8.33 mmol) was added dropwise. After 15 min a solution of the alcohol (1.0g, 3.33 mmol) in Anhydrous DCM (10.0 mL) was slowly added dropwise. After 30 min, Et_3N (3.2 mL, 23.33 mmol) was added dropwise. The reaction was stirred for 30 min at -78 °C then slowly allowed to warm to rt. The reaction mixture was diluted with DCM and transferred into a separatory funnel containing 1N HCL (50 mL). The layers were separated and the organic layer was washed with 10% BICAP solution followed by H_2O (25 mL).dried over Na2SO4 and concentrated in vacuo. Purification of the crude

material by flash column chromatography on silica gel using hexane/ethyl acetate = 9.5:0.5 as eluent afforded the aldehyde **14** (894 mg, 90%) as light yellow syrup (R_f0.7Hexanes/EtOAc = 9:1). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 1.11 (s, 9H), 4.22 (s, 2H), 7.38-7.48 (m, 6H), 7.65-7.68 (m, 4H), 9.73 (s, 1H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 201.5, 135.5, 132.6, 130.1, 128.0, 70.0, 26.8, 19.3.

(R)-*N,N*-dibenzyl-1-*O*-(tert-butyldiphenylsilyl)-octadec-3-yn-2-amine (13): To a solution of CuBr (96 mg, 0.67 mmol, and 0.1 equiv) in dry toluene 50 mL under N2 atmosphere, 2.0 g powdered 4Å MS was added, and allowed to stir 10 minutes at rt. To this aldehyde (2.0 g, 6.7 mmol), alkyne (2.23 mL, 8.05 mmol) and amine (1.45 g, 7.38 mmol) were added. The reaction mixture was allowed to stir at 40 °C. Upon completion, the reaction was filtered, diluted with EtOAc and quenched by the addition of a saturated ammonium chloride solution (3 mL). The reaction mixture was subjected to aqueous workup. The EtOAc layer was washed with brine (10 mL), dried over Na_2SO_4 and concentrated in vacuum. The crude material was subjected to flash column chromatography using hexane/ethyl acetate = 9:1 as eluent afforded the alkyne **13** (4.31 g, 90% with ee of 92.8%, calculated by HPLC, SI page no. 35) as light yellow syrup (R_f 0.30Hexanes/EtOAc = 9.9:0.1). $[\alpha]_D^{20}$ = + 3.4 (*c* = 1.0, $CHCl_3$); Stereochemistry of the product **13** was confirmed by converting it into **32**

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 – 7.60 (m, 3H), 7.46 – 7.35 (m, 6H), 7.33 – 7.18 (m, 11H), 5.64 (dt, *J* = 10.9, 7.3 Hz, 1H), 5.43 (t, *J* = 10.3 Hz, 1H), 3.91 – 3.82 (m, 3H), 3.66 (dd, *J* = 10.9, 4.6 Hz, 1H), 3.60 (dd, *J* = 10.0, 5.6 Hz, 1H), 3.49 (bs, 1H), 3.46 (bs, 1H), 1.70 (dtd, *J* = 21.5, 14.3, 7.1 Hz, 2H), 1.26 (bs, 24H), 1.05 (s, 9H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 100 MHz):** δ 140.5, 135.7, 135.6, 135.2, 133.68, 133.6, 129.5, 128.67, 128.1, 127.64, 127.6, 126.6, 124.4, 65.3, 56.8, 54.4, 32.0, 29.9, 29.79, 29.78,

29.75, 29.7, 29.6, 29.4, 27.9, 26.8, 22.7, 19.2, 14.2. HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{48}H_{66}NOSi$ 700.4914; found 700.4915.

(2S,3S,4R)-1-*O*-((tert-butyldiphenylsilyl)oxy)-2-(dibenzylamino)octadecane-3,4-diol (29): To a solution of **13** (1.0 g, 1.40 mmol) in 30 mL of ethyl acetate/pyridine (10:1) was added Lindlar's catalyst (150 mg). The reaction mixture was allowed to stir for 10 h under positive atmosphere of H_2 at rt and filtered off through a celite pad. The filtrate was concentrated in vacuum and the residue was subjected to column chromatography using petroleum ether/EtOAc (9:1) as eluent to afforded the alkene (0.902 mg, 90%) as colourless syrup (R_f 0.20Hexanes/EtOAc = 9.9:0.1). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 7.63 – 7.60 (m, 3H), 7.46 – 7.35 (m, 6H), 7.33 – 7.18 (m, 11H), 5.64 (dt, *J* = 10.9, 7.3 Hz, 1H), 5.43 (t, *J* = 10.3 Hz, 1H), 3.91 – 3.82 (m, 3H), 3.66 (dd, *J* = 10.9, 4.6 Hz, 1H), 3.60 (dd, *J* = 10.0, 5.6 Hz, 1H), 3.49 (bs, 1H), 3.46 (bs, 1H), 1.70 (dtd, *J* = 21.5, 14.3, 7.1 Hz, 2H), 1.26 (bs, 24H), 1.05 (s, 9H), 0.88 (t, *J* = 6.8 Hz, 3H). **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 140.5, 135.7, 135.6, 135.2, 133.6, 133.6, 129.5, 128.6, 128.1, 127.6, 127.6, 126.6, 124.4, 65.3, 56.8, 54.4, 32.0, 29.9, 29.79, 29.78, 29.75, 29.7, 29.6, 29.4, 27.9, 26.8, 22.7, 19.2, 14.2.

To a solution of AD mix-β (1.97 g) in 1:1 t-BuOH and H_2O (25 mL) was added a solution of alkene (1.0 g, 1.39 mmol) in 1:1 t-BuOH and H_2O (10 mL) at 0 °C (Immersion cooler). $K_2OsO_4.2H_2O$ (51 mg, 0.139 mmol) and methanesulfonamide (159 mg, 1.60 mmol) were added, and the reaction mixture was allowed to stir at rt for 72 h. The reaction mixture was quenched by adding Na_2SO_3 (3.0 g) and allowed to stir at rt for 20 min, diluted with CH_2Cl_2 (40 mL) and washed with water (30 mL). The separated aqueous layer was extracted with CH_2Cl_2 (30 mL × 2) and dried over anhydrous Na_2SO_4. The combined organic layers were concentrated on a rotary evaporator, and the crude residue was subjected to column chromatography to afford **29a** (942 mg, 90%) as a viscous liquid (R_f 0.35Hexanes/EtOAc =

9:1) and **29b** (942 mg, 90%) as a viscous liquid (R_f0.35Hexanes/EtOAc = 9:1). $[\alpha]_D^{20}$ = -5.46 (*c* = 0.75, $CHCl_3$). **^{1}H NMR ($CDCl_3$, 400 MHz):** δ 0.89 (t, *J* = 8.0 Hz, 3H), 1.09 (s, 9H), 1.16-1.39 (m, 29H), 2.97-3.03 (m, 1H), 3.15 (bs, 1H), 3.58 (d, *J* = 16.0, Hz, 1H), 3.80 (t, *J* = 4.0 Hz, 1H), 3.88-3.93 (m, 1H), 3.98-4.04 (m, 2H), 4.09-4.13 (m, 1H), 7.15 (d, *J* = 8.0 Hz, 2H), 7.22-7.33 (m, 9H), 7.45-7.55 (m, 6H), 7.70-7.72 (m, 3H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 100 MHz):** δ 142.9, 139.9, 135.7, 135.7, 132.5, 132.3, 130.2, 130.1, 128.9, 128.4, 128.1, 128.0, 127.15, 127.1, 74.9, 74.3, 63.8, 59.0, 56.8, 51.4, 32.3, 31.9, 29.8, 29.76, 29.7, 29.4, 26.9, 25.4, 22.7, 19.1, 14.5, 14.1., HRMS (ESI-TOF) m/z: $[M + H]^+$ calcd for $C_{48}H_{70}NO_3Si$ 736.5125; found 736.5128.

(2S,3S,4R)-2-amino-*O*-(tert-butyldiphenylsilyl)-octadecane-3,4-diol (11): To a solution of **29a** (500 mg, 0.667 mmol) in THF/MeOH (1:1) 10 mL was added Pd-OH catalyst (100 mg). The reaction was allowed to stir for 5 h under positive atmosphere of H_2 at rt and filtered through a celite pad. The filtrate was concentrated and the residue was subjected to column chromatography using $CHCl_3$/MeOH (9.5/0.5) as eluent afforded the amine **11** (337 mg, 91%) as colourless syrup (R_f 0.55 ($CHCl_3$/MeOH = 9:1).**^{1}H NMR (400 MHz, DMSO):** δ 7.65 (d, *J* = 6.4 Hz, 4H), 7.52 – 7.39 (m, 6H), 3.65 (t, *J* = 8.0 Hz, 1H), 3.55 (t, *J* = 8.0 Hz 1H), 3.43 (m, 2H), 3.21 (t, *J* = 8.0 Hz, 1H), 1.55 (m, 1H), 1.41 (m, 1H), 1.24 (s, 24H), 1.00 (s, 9H), 0.85 (t, *J* = 6.4 Hz, 3H)., $[\alpha]_D^{20}$ = -3.6 (*c* = 0.5, $CHCl_3$); HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{34}H_{57}NO_3SiNa$ 578.4005; found 578.4007.

***N*-((2S,3S,4R)-1-*O*-((*tert*-butyldiphenylsilyl)oxy)-3,4-dihydroxy-octadecan-2-yl)-palmitamide (30):** DIC (136.0 mg, 1.08 mmol) was added to the stirred solution of amine **5** (0.5 g, 0.9 mmol), acid **6** (254 mg, 0.99 mmol) and DMAP (132.0 mg, 1.08 mmol) in dry CH_2Cl_2 (5.0 mL) under nitrogen atmosphere, and allowed to stir for 6.0 h at rt. Then concentrated in vacuum. The reaction mass was dissolved in EtOAc and washed with 3%

HCl (20 mL), followed by washed with saturated $NaHCO_3$ and water. After which the organic layer was dried over Na_2SO_4, and concentrated in vaccum. The crude residue was subjected to column chromatography to afford **30** (664 mg, 93%) as a viscous liquid (R_f 0.25Hexanes/EtOAc = 9:1).**^{1}H NMR ($CDCl_3$, 400 MHz):** δ 0.90 (t, *J* = 6.8 Hz, 6H), 1.10 (s, 9H), 1.27 (bs, 52H), 1.71-1.77 (m, 1H), 2.12-2.16 (m, 2H), 3.19 (t, *J* = 8.4, Hz, 1H), 3.67 (d, *J* = 8.0 Hz, 1H), 3.99 (dd, *J* = 4.0, 10.4 Hz, 1H), 4.03 (dd, *J* = 3.6, 10.8 Hz, 1H), 4.27-4.31 (m, 1H), 5.99 (d, *J* = 9.2 Hz, 1H), 7.40-7.50 (m, 6H), 7.63-7.67 (m, 4H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 100 MHz):** δ 174.8, 135.5, 135.5, 132.2, 132.0, 130.3, 130.2, 128.1, 128.0, 70.9, 67.1, 49.4, 36.6, 32.8, 31.9, 29.8, 29.7, 29.7, 29.6, 29.5, 29.3, 29.3, 29.1, 26.9, 22.8, 19.1, 14.1., $[\alpha]_D^{20}$ = -15 (*c* = 1.0, $CHCl_3$); HRMS (ESI-TOF) m/z: $[M + Na]^+$ calcd for $C_{50}H_{87}NNaO_4Si$ 816.6302; found 813.6298.

***N*-((2S,3S,4R)-3,4-di-*O*-(benzyl)-octan-2-yl)-palmitamide (31):** To a solution of **30** (0.5 g, 0.69 mmol) in anhydrous DMF (10 mL) under nitrogen at 0^o C (Immersion cooler) was slowly added NaH (60%, 90 mg, 3.78 mmol). After stirring for 30 min, BnBr (274 ul, 2.26 mmol) was added dropwise. The reaction was allowed to stir for 2 h at 0 ^{o}C, then quenched with methanol, diluted with EtOAc, and poured into water, and extracted with 2x EtOAc, after which the combined organic layer was washed with brine, dried over Na_2SO_4, and concentrated in vaccum. The crude material was subjected to column chromatography to afford **31** (364 mg, 70%) as a colourless syrup (R_f 0.3Hexanes/EtOAc = 9:1). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 0.89 (d, *J* = 7.0 Hz, 6H), 1.28 (s, 48H), 1.60 - 1.66 (m, 4H), 2.18 – 2.22 (m, 2H), 2.34 (t, *J* = 7.5 Hz, 1H), 3.42 (bs, 2H), 3.56 – 3.64 (m, 2H), 4.50 – 4.58 (m, 4H), 4.60 – 4.66 (m, 1H), 5.89 (d, *J* = 9.4 Hz, 1H), 7.27 (dd, *J* = 6.8, 2.4 Hz, 2H), 7.32 – 7.39 (m, 8H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 174.7, 137.8, 137.5, 128.57, 128.55, 128.5, 128.4, 128.1, 128.0, 127.93, 127.9, 127.6, 127.0, 82.0, 74.6, 73.1, 70.5, 69.0,

65.3, 48.8, 36.7, 33.9, 33.0, 31.9, 29.75, 29.74, 29.7, 29.6, 29.5, 29.49, 29.4, 29.3, 29.3, 29.2, 29.1, 25.9, 25.7, 24.7, 22.7, 14.1., $[\alpha]_D^{20}$ = -10 (*c* = 0.1, $CHCl_3$); HRMS (ESI-TOF) m/z: [M + H]$^+$ calcd for $C_{48}H_{82}NO_4$ 736.6244; found 736.6246.

***N*-((2S,3S,4R)-triethylammonium-1-*O*-Hydrogen-Phosphonato-3,4-di-*O*-(benzyl)-octan-2-yl-palmitamide (4):** To a solution of imidazole (300 mg, 4.40 mmol) in dry CH_2Cl_2 (5.0 ml) at -10 ^oC (Immersion cooler) were added PCl_3 (100 ul, 1.09 mmol) and Et_3N (300 ul, 2.07 mmol). The reaction was allowed to stir for 20 min, after which time a solution of alcohol **31** (180 mg, 0.218 mmol) in dry CH_2Cl_2 (5.0 ml) was added dropwise in 15 min. Then reaction was allowed to stir at -10^o C (Immersion cooler) for 3 h, after confirming the complete consumption of alcohol reaction was quenched with water/pyridine (1/4, 20.0 ml). The aqueous layer was extensively washed with $CHCl_3$ and the combined organic layers were further washed with Triethylammonium borate (TEAB) buffer and filtered, dried over Na2SO_4. Evaporation in vacuum gave the crude residue, the crude residue was subjected to flash column chromatography to afford H-phosphonate **4** (159 mg, 74%) as a white waxy. (R_f 0.55$CHCl_3$/MeOH/Et_3N = 9:1:0.1). **^{1}H NMR (400 MHz, $CDCl_3$):** δ 0.87 (t, *J* = 6.4 Hz, 6H), 1.25 (bs, 50H), 1.61 (d, *J* = 8.0 Hz, 3H) 2.02 (bs, 2H), 2.93-2.99 (m, 1H), 3.54 (dd, *J* = 13.0, 7.4 Hz, 1H), 3.76 (d, *J* = 6.6 Hz, 1H), 3.95 – 3.82 (m, 1H), 4.02 (d, *J* = 7.8 Hz, 1H), 4.49 (s, 2H), 4.66 (s, 2H), 6.26 (d, *J* = 8.5 Hz, 1H), 6.91 (d, *J* = 628 Hz, 1H), 7.26-7.32 (m, 10H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 173.5, 138.2, 137.8, 134.4, 128.5, 128.3, 128.3, 128.3, 128.1, 128.0, 127.8, 127.7, 120.1, 79.1, 77.7, 74.1, 72.6, 62.4, 49.9, 49.8, 45.6, 36.8, 31.9, 30.6, 29.9, 29.7, 29.6, 29.5, 29.3, 29.3, 29.2, 25.6, 25.0, 22.6, 14.1, 8.5., **^{31}P NMR ($CDCl_3$, 161.98 MHz)** δ 5.14. HRMS (ESI-TOF) m/z: [M + Na]$^+$ calcd for $C_{55}H_{88}NNaO_6P$ 912.6247; found 912.6249.

2-*O*-[l-2,3,4,-tri-*O*-benzyl-*α*-D-mannopyranosyl])(1→2)-(3,4,5,6-tetra-*O*-benzyl-1-(*N*-((2S,3S,4R)-triethylammonium-1-*O*-Phosphonato-3,4-di-*O*-(benzyl)-octan-2-yl-palmitamide)*O*-*myo*-inositol (35): Freshly prepared H-phosphonate **4** (200 mg, 0.22 mmol) and the acceptor **3** (225mg, 0.225 mmol) were co-evaporated with dry pyridine (3 times), and desiccated for overnight, then dissolved in dry pyridine (2.0 ml). Followed by the addition of pivaloyl chloride (54 µL, 0.44 mmol). Allowed to stir at rt for 1 h, the reaction mixture was treated with an I_2 solution {0.1 g I_2 in pyridine: water, 5: 1 (6.0 mL)} and the mixture was further stirred for 3 h. The reaction mixture was diluted with $CHCl_3$ (6 mL) and washed with 5% $NaHSO_5$ (5 mL), dried over Na_2SO_4, and concentrated in vaccum. The crude residue was dissolved in methanol and treated with chelex 100 sodium form, the reaction mass was stirred for 3 h, and filtered off, concentrated in vaccum. The crude reaction mass was dissolved in dry MeOH, to this solution NaOMe was added ant stirring was continued for 3 h, to the reaction mixture Amberlyst IR120 H^+ form was added and allowed to stir for 15 min, filtered off an concentrated in vaccum. The crude residue was subjected to flash column chromatography to afford **35** (236 mg, 60%) as a white waxy (R_f $0.5CHCl_3$/MeOH/Et_3N = 7:3:0.1).**^{1}H NMR (400 MHz, $CDCl_3$):** δ 0.89 (t, *J* = 6.8 Hz, 6H), 1.29 (d, *J* = 17.7 Hz, 48H), 1.63 (dd, *J* = 14.6, 7.3 Hz, 4H),1.97 (s, 3H),2.25 – 2.14 (m, 2H),2.34 (t, *J* = 7.5 Hz, 1H),3.55 – 3.29 (m, 5H),3.59 (t, *J* = 6.0 Hz, 1H), 3.70 – 3.64 (m, 1H),3.78 (t, *J* = 9.4 Hz, 1H),4.06 – 3.87 (m, 3H),4.17 (dd, *J* = 16.2, 6.4 Hz, 2H), 4.29 (s, 1H), 4.69 – 4.50 (m, 9H),4.69 – 4.50 (m, 9H),4.85 – 4.72 (m, 3H),4.95 (ddd, *J* = 10.8, 6.2, 4.3 Hz, 3H),5.35 (s, 1H), 5.82 (d, *J* = 9.4 Hz, 1H), δ 7.46 – 7.15 (m, 39H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 174.4, 170.8, 138.57, 138.5, 138.45, 138.4, 138.38, 138.35, 137.9, 137.8, 137.6, 128.76, 128.7, 128.51, 128.5, 128.47, 128.44, 128.4, 128.39, 128.36, 128.3, 128.28, 128.2, 128.19, 128.13, 128.1, 128.04, 128.01, 128.0, 127.96, 127.94, 127.92, 127.9, 127.89, 127.87, 127.8,

127.77, 127.7, 127.64, 127.6, 127.59, 127.56, 127.5, 127.3, 98.6, 83.5, 82.0, 81.7, 80.8, 78.9, 78.5, 75.8, 75.7, 75.3, 75.2, 74.6, 74.5, 74.38, 73.8, 73.1, 72.2, 72.0, 71.9, 70.6, 69.9, 69.1, 63.4, 48.8, 36.7, 33.6, 33.1, 31.9, 29.7, 29.5, 29.4, 29.3, 29.2, 29.1, 25.8, 25.7, 24.7, 22.6, 20.8, 14.1.,**^{31}P NMR($CDCl_3$, 161.98 MHz):** δ 0.17.$[\alpha]_D$ = +23.33 (c 0.01, $CHCl_3$); MALDI TOF MS: calcd for $C_{109}H_{143}NNaO_{17}P$ $(M+Na)^+$ 1793.0070, found 1793.0010.

2,3,4,6-Tetra-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*β*-D-mannopyranosyl)(1→2)-(3,4,6-tri-*O*-benzyl-*α*-D-mannopyranosyl)(1→2)-([l-2,3,4,-tri-*O*-benzyl-*α*-D-mannopyranosyl]-(3,4,5,6-tetra-*O*-benzyl-1-(N-((2S,3S,4R)-triethylammonium-1-*O*-Phosphonato-3,4-di-*O*-(benzyl)-octan-2-yl-palmitamide)*O*-*myo*-inositol (36): Freshly prepared H-phosphonate **2** (30 mg, 0014 mmol) and the acceptor **35** (26.5mg, 0.014 mmol) were co-evaporated with dry-pyridine (3 times), and desiccated for overnight, then dissolved in anhydrous pyridine (1.0 ml). Followed by the addition of pivaloyl chloride (3.0 µL, 0.028 mmol). After stirring at rt for 1 h, iodine solution {0.01 g iodine in pyridine: water, 1.25:0.25 (1.5 mL)} and the mixture was further stirred for 3 h. The reaction was diluted with $CHCl_3$ (6 mL) and washed with 5% $NaHSO_4$ solution (5 mL). The organic phase was dried over Na_2SO_4, concentrated in vacuum. The above crude residue was dissolved in methanol and treated with chelex 100 sodium form, stirring was continued for 3 h, and filtered off, concentrated in vacuum. The crude residue was subjected to flash column chromatography to afford **36** (40 mg, 73%) as a white waxy (R_f0.4$CHCl_3$/MeOH/Et_3N = 7:3:0.1).**^{1}H NMR (400 MHz, $CDCl_3$):** δ 0.90 (t, *J* = 6.7 Hz, 6H), 1.27 (s, 52H), 1.62 - 1.70 (m, 4H), 2.15 – 2.26 (m, 2H),), 2.34 (t, *J* = 7.5 Hz, 3H), 3.37 – 4.98 (several m, 83 H), 5.20 (d, *J* = 10.8 Hz, 2H), 5.36 (s, 3H),5.83 (d, *J* = 9.3 Hz, 2H), 7.56 – 6.87 (m, 102H)., **^{13}C {1H} proton-decoupled NMR ($CDCl_3$ 125 MHz):** δ 174.5, 170.9, 138.8, 138.7, 138.6, 138.5, 138.47, 138.42, 138.4, 138.3, 138.1, 137.9, 137.8,

137.74, 137.7, 137.6, 128.7, 128.6, 128.52, 128.5, 128.45, 128.4, 128.39, 128.37, 128.3, 128.2, 128.17, 128.13, 128.1, 128.05, 128.03, 128.0, 127.94, 127.9, 127.8, 127.78, 127.7, 127.6, 127.59, 127.5, 127.47, 127.4, 127.3, 127.2, 126.9, 101.6, 98.6, 98.4, 98.1, 93.6, 83.5, 82.0, 81.7, 80.8, 79.8, 78.9, 78.5, 75.8, 75.7, 75.4, 75.24, 75.2, 74.9, 74.8, 74.6, 74.3, 74.1, 73.7, 73.4, 73.1, 72.2, 72.0, 71.9, 71.3, 70.6, 70.4, 70.2, 69.9, 69.6, 69.1, 69.0, 63.4, 48.8, 36.7, 33.6, 33.1, 31.9, 29.7, 29.6, 29.3, 29.2, 29.1, 25.9, 25.7, 24.7, 22.7, 20.9, 14.1.,**^{31}P NMR ($CDCl_3$, 161.98 MHz):** δ 0.17, -1.59. Mass calculated for $[C_{224}H_{261}NO_{40}P_2]^{2-}$ 3666.79, found 1834.89 $[M]^{2-}$

D-mannopyranosyl (1→2)-*β*-D-mannopyranosyl (1→2)-*β*-D-mannopyranosyl (1→2)-*α*-D-mannopyranosyl)(1→6)-*α*-6-phophonato-D-mannopyranosyl]-(1→2)-*α*- 1-(*N*-((2S,3S,4R)-triethylammonium-1-*O*-Phosphonato-octan-2-yl-palmitamide)*O*-*myo*-inositol (1): The fully protected PLM intermediate **36** (0.01 g, 0.0027mmol) was dissolved in MeOH (0.5 mL): THF (0.5 mL): H_2O (0.5 mL) and formic acid (50 µL), catalyst 20% $Pd(OH)_2$ (0.02 g) was added and degassed with high vacuum suction and stirred at room temperature. The progress of the reaction mixture was monitored on LC-MS and TLC and monitored for the consumption of starting material. After the consumption of starting material, the reaction mixture was filtered and evaporated and got (4 mg) whitish gummy material. 1H NMR (400 MHz, D_2O) δ 4.26 – 3.46 (m, 54H), 2.47 (m, 2H), 2.40 (s, 2H), 2.16 (m, 2H), 1.95 (m, 6H), 1.71 – 1.08 (m, 40H), 0.92 (m, 6H); Mass calcd for $[C_{70}H_{129}NO_{40}P_2]^{2-}$ 1685.76, found 1705.22 $[M+2H+NH4]^+$ and 1732.89 $[M+H+2Na]^+$.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information containing ^{1}H NMR, ^{13}C NMR, ^{31}P NMR, 2D NMR spectra and HPLC chromatogram is available on ACS Publications website with free of cost.

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