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(54) Protein and peptide-free synthetic vaccines against streptococcus pneumoniae type 3

(57) The present invention provides a protein- and peptide-free conjugate comprising a synthetic carbohydrate and a carrier molecule, wherein the synthetic carbohydrate is a *Streptococcus pneumoniae* type 3 capsular polysaccharide related carbohydrate and the carrier molecule is a glycosphingolipid. Said conjugate and pharmaceutical composition thereof are useful for immunization against diseases associated with *Streptococcus pneumoniae*, and more specifically against diseases associated with *Streptococcus pneumoniae* type 3.

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Description

Field of the invention

[0001] The present invention provides a protein- and peptide-free conjugate comprising a synthetic carbohydrate and a carrier molecule, wherein the synthetic carbohydrate is a *Streptococcus pneumoniae* type 3 capsular polysaccharide related carbohydrate and the carrier molecule is a glycosphingolipid. Said conjugate and pharmaceutical composition thereof are useful for prevention and/or treatment of diseases associated with *Streptococcus pneumoniae,* and more specifically of diseases associated with *Streptococcus pneumoniae* type 3.

Background of the invention

[0002] Vaccination is a powerful tool for improving human health. By contributing to the education of the immune system, vaccination has pioneered the fight against infectious diseases caused by pathogens such as bacteria.

[0003] *Streptococcus pneumoniae* is a Gram-positive bacterium and one of the main pathogens causing invasive diseases. >90 serotypes of *Streptococcus pneumoniae* have been identified based on difference in their core capsular polysaccharides (CPS) structures consisting of polymer of repeating oligosaccharides units, which are the virulent factor of the bacteria. *Streptococcus pneumoniae* type 3 (SP3) is part of the current pneumococcal vaccines consisting of isolated CPS (PPV-23 valent and PCV-13 valent). The commercially available 23-valent pneumococcal polysaccharide vaccine (PPV) contains purified capsular polysaccharide (CPS) antigens of 23 serotypes. However, this vaccine is not effective in the case of infants and young children. PPV-13 contains immunogenic conjugates comprising the purified polysaccharides of 13 different S. *pneumoniae* serotypes covalently linked to a protein, such as CRM_{197}.

[0004] The currently marketed vaccines are effective in North America and Europe for individuals of a particular age. The manufacturing process for these vaccines is complex and results in a higher price. Therefore, the vaccine is unaffordable in most developing countries.

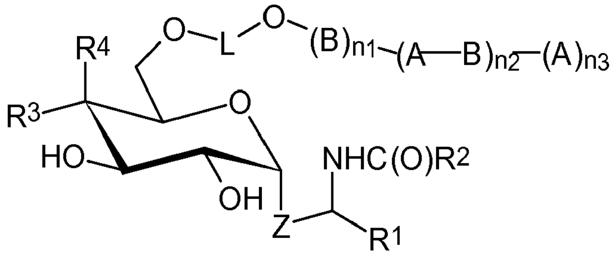
[0005] The glycolipid α-galactosylceramide, also known as KRN7000, is a synthetic derivative of a glycolipid found in marine sponges, and identified as an immune activator that lowered the tumor burden of mice. This glycolipid is known to be presented by antigen-presenting cells (APCs) by loading it unto the protein CD1d. After being loaded with the glycolipid, CD1d will interact with an invariant T-cell receptor (TCR) of invariant natural killer T cells (iNKT cells), resulting in the activation of the iNKT cells, expansion of their population, and secretion of a plethora of cytokines. Also, αGalCer or analogs are being investigated in many contexts as vaccine adjuvants (US 7771726 B2, WO 2006027685 A2). However, all published work on the adjuvant effects of αGalCer and analogs have focused on their use as a physical mixture adjuvant. To the best of our knowledge, no work has focused on covalently linking αGalCer and an antigen. Such a novel approach has several potential advantages. A covalent system would focus the immune response against the desired antigen by perfectly localizing the antigen and the adjuvant in space. Such a system, if designed properly, could promote the slow release of the αGalCer after intracellular antigen processing, possibly allowing the use of higher αGalCer doses without side-effects. Finally, such a system could eliminate the need for protein-carbohydrate conjugate vaccines, and replace them with glycosphingolipid-carbohydrate conjugates. As the protein and peptide parts of vaccines are known to be temperature-sensitive, the vaccines thereof require maintenance under refrigeration.

[0006] It is the objective of the present invention to provide peptide-free and protein-free fully synthetic conjugates comprising a *Streptococcus pneumoniae* type 3 capsular polysaccharide related carbohydrate and pharmaceutical compositions thereof useful for prevention and/or treatment of diseases associated with *Streptococcus pneumoniae,* and more specifically of diseases associated with *Streptococcus pneumoniae* type 3. Moreover, said conjugates and compositions thereof should be heat-resistant or heat-stable.

[0007] The objective of the present invention is solved by the teaching of the independent claims. Further advantageous features, aspects and details of the invention are evident from the dependent claims, the description, the figures, and the examples of the present application.

Description of the invention

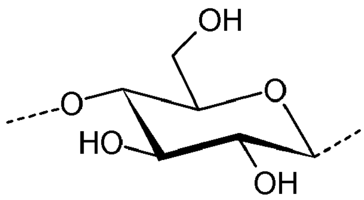
[0008] The present invention provides fully synthetic conjugates of general formula I



I

wherein

A is



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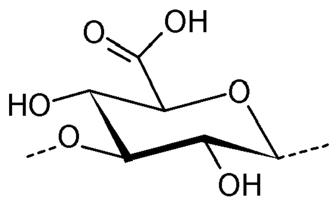
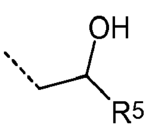
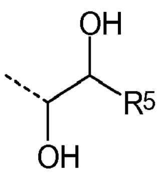
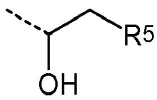
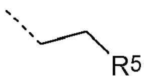
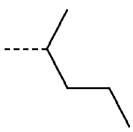
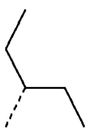
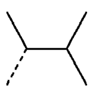
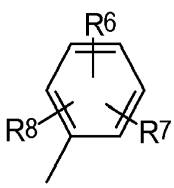


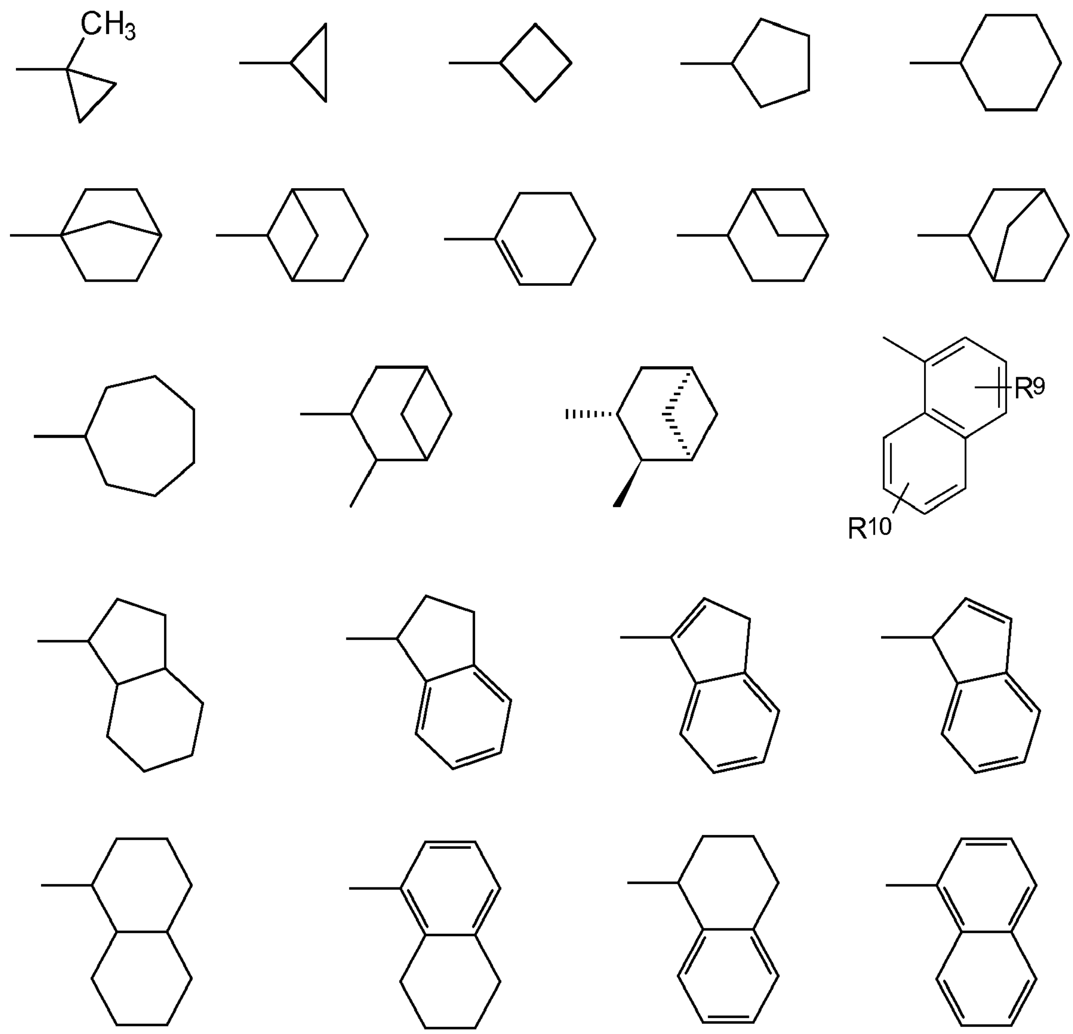
R^1 is selected from

   or 

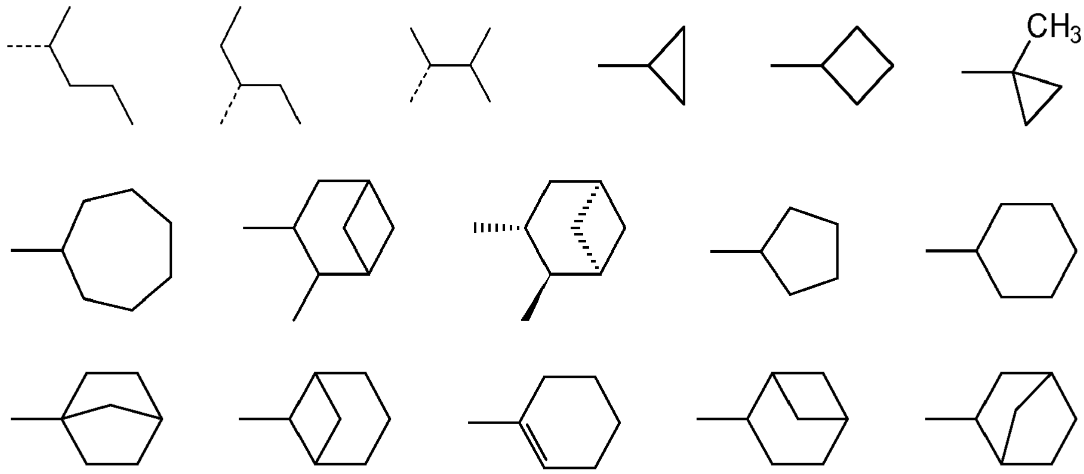
R^2 is $-(X^1)_{p1}-(X^2)_{p2}-(X^3)_{p3}-X^4$;
R^3 and R^4 are selected from -H and -OH and cannot be simultaneously the same;
R^5 is $-(Y^1)_{m1}-(Y^2)_{m2}-(Y^3)_{m3}-Y^4$;
Z represents $-O-CH_2-$, $-O-CH_2-CH_2-$, $-CH_2-CH_2-CH_2-$, or $-CH_2-CH=CH-$;

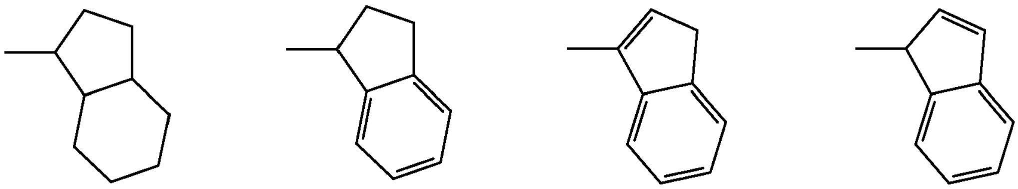
X^4 represents: -H, -iPr, -tBu, or -sBu,

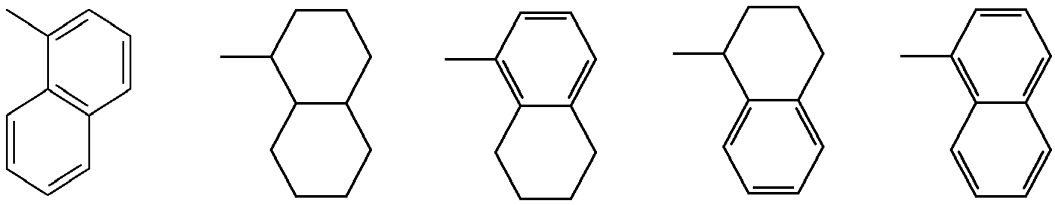
   



Y^4 is selected from: -H, -iPr, -tBu, -Ph, sBu,

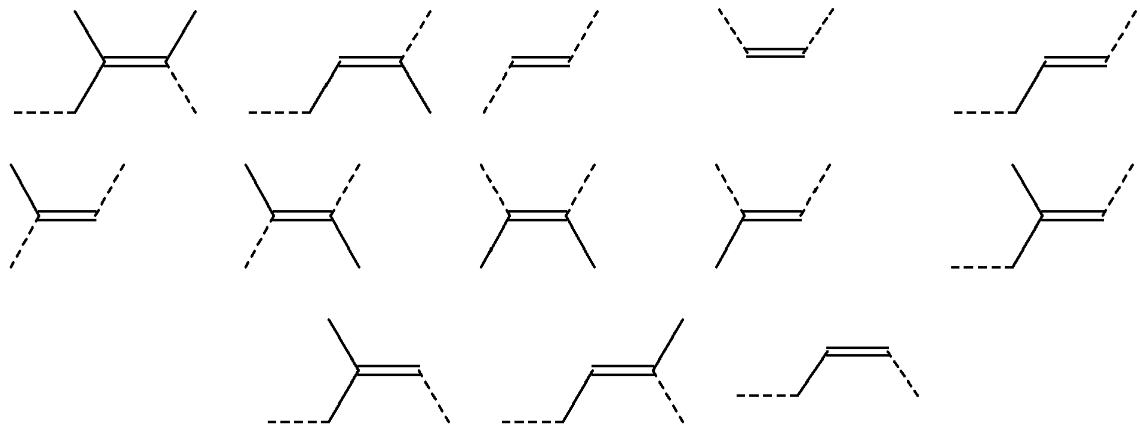






X^1, X^2, X^3, Y^1, Y^2, Y^3 are independently of each other selected from:

$-CH_2-$, $-CH(OH)-$, $-CH(CH_3)-$, $-CH(C_2H_5)-$, $-CH(C_3H_7)-$, $-CH(C_4H_9)-$,

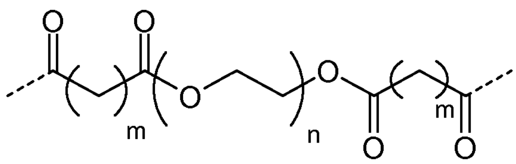


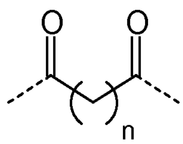
n2 is an integer from 1 to 20;
n1, n3 represent independently of each other an integer selected from 0 and 1;

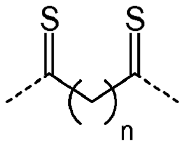
L represents $-L^1-NH-L^2-NH-L^3-$;

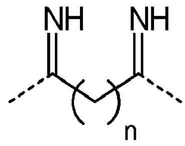
L^1 represents $-L^{1'}-L^{1''}-L^{1'''}-$ or $-L^{1'}-L^{1'''}-$ or $-L^{1'}-$; and
L^3 represents $-L^{3'}-L^{3''}-L^{3'''}-$ or $-L^{3'}-L^{3'''}-$ or $-L^{3'}-$; and
$L^{1'}$, $L^{1''}$, $L^{1'''}$, $L^{3'}$, $L^{3''}$, $L^{3'''}$ are independently of each other selected from: $-CH_2-$, $-C_2H_4-$, $-C_3H_6-$, $-C_4H_8-$, $-C_5H_{10}-$, $-C_6H_{12}-$, $-C_7H_{14}-$, $-C_8H_{16}-$, $-C_9H_{18}-$, $-C_{10}H_{20}-$, $-CR^9R^{10}-$, $-CR^{11}R^{12}-$, $-CR^{13}R^{14}-$, $-CR^{15}R^{16}-$, $-CR^{17}R^{18}-$, $-CR^{19}R^{20}-$, $-(CH_2-CH_2-O)_o-$; -*o*-C_6H_4-, -*m*-C_6H_4-, -*p*-C_6H_4-, $-CH_2-S-CH_2-$, $-CH_2-O-CH_2-$, -S-, -O-;

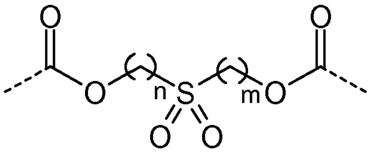
L^2 is selected from: -C(O)-, -E-, -C(O)-NH-NH-C(O)-

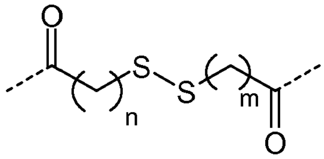


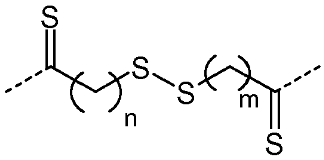


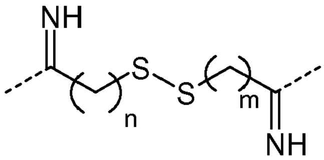


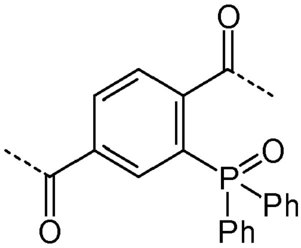


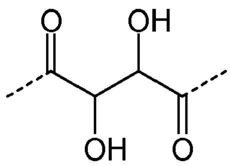


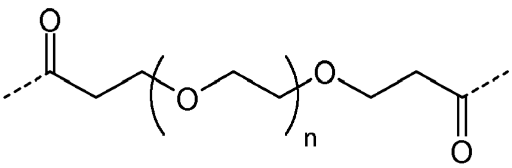


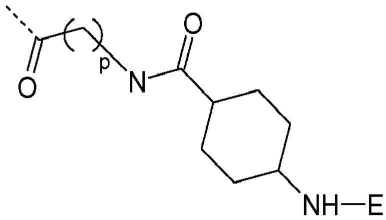


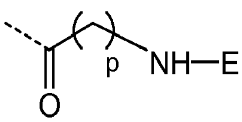


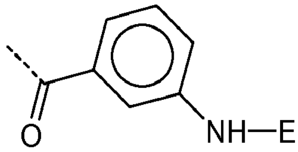


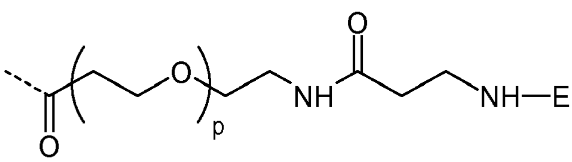


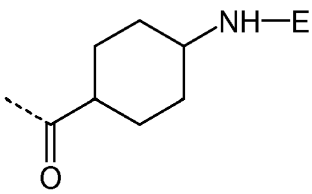


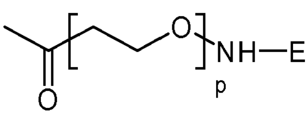


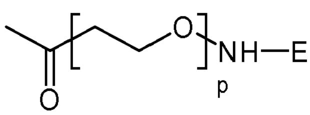




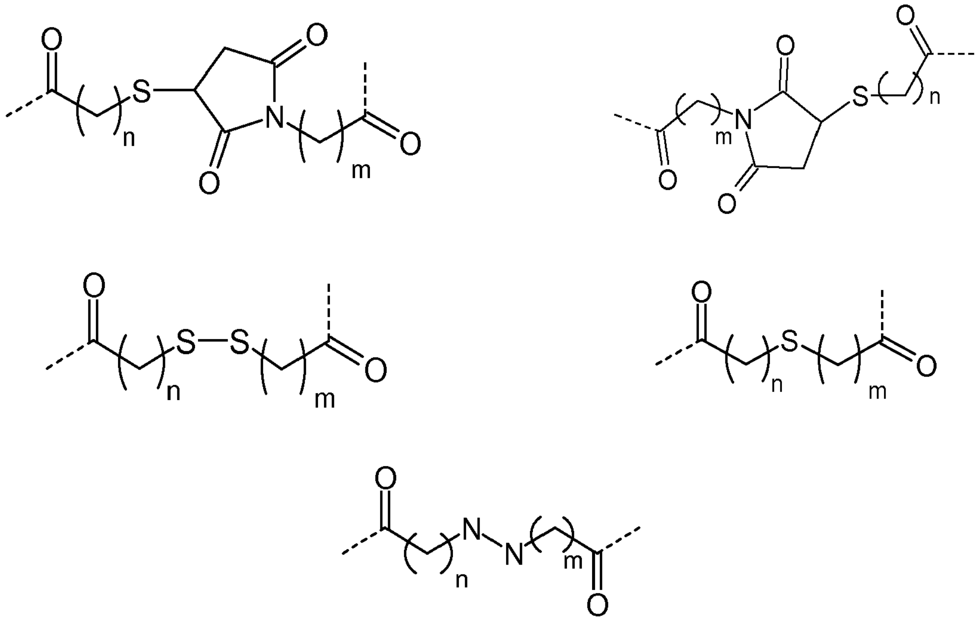








E is selected from



R^6, R^7 and R^8 are independently of each other selected from: -H, $-CH_3$, $-C_2H_5$, $-C_3H_7$, $-C_4H_9$, $-C_5H_{11}$, -Ph, -F, -Cl, -Br, -I;

R^9 to R^{20} represent independently of each other -H, $-OCH_3$, $-OC_2H_5$, $-OC_3H_7$, cyclo-C_3H_5, cyclo-C_4H_7, cyclo-C_5H_9, cyclo-C_6H_{11}, cyclo-C_7H_{13}, cyclo-C_8H_{15}, -Ph, $-CH_2$-Ph, $-CPh_3$, $-CH_3$, $-C_2H_5$, $-C_3H_7$, $-CH(CH_3)_2$, $-C_4H_9$, $-CH_2-CH(CH_3)_2$, $-CH(CH_3)-C_2H_5$, $-C(CH_3)_3$, $-C_5H_{11}$, $-CH(CH_3)-C_3H_7$, $-CH_2-CH(CH_3)-C_2H_5$, $-CH(CH_3)-CH(CH_3)_2$, $-C(CH_3)_2-C_2H_5$, $-CH_2-C(CH_3)_3$, $-CH(C_2H_5)_2$, $-C_2H_4-CH(CH_3)_2$, $-C_6H_{13}$, $-C_3H_6-CH(CH_3)_2$, $-C_2H_4-CH(CH_3)-C_2H_5$, $-CH(CH_3)-C_4H_9$, $-CH_2-CH(CH_3)-C_3H_7$, $-CH(CH_3)-CH_2-CH(CH_3)_2$, $-CH(CH_3)-CH(CH_3)-C_2H_5$, $-CH_2-CH(CH_3)-CH(CH_3)_2$, $-CH_2-C(CH_3)_2-C_2H_5$, $-C(CH_3)_2-C_3H_7$, $-C(CH_3)_2-CH(CH_3)_2$, $-C_2H_4-C(CH_3)_3$, $-CH(CH_3)-C(CH_3)_3$, $-C_7H_{15}$, $-C_8H_{17}$, $-C_6H_4-OCH_3$, $-CH_2-CH_2-OCH_3$, $-CH_2-OCH_3$, $-CH_2-C_6H_4-OCH_3$;

m, n, o, p, p1, p2, p3, m1, m2 and m3 represent independently of each other an integer from 0 to 30;

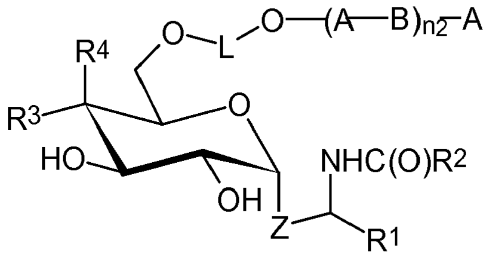
and enantiomers, stereoisomeric forms, mixtures of enantiomers, anomers, deoxy-forms, diastereomers, mixtures of diastereomers, prodrugs, tautomers, hydrates, solvates and racemates of the above mentioned compounds and pharmaceutically acceptable salts thereof.

[0009] The compounds of the present invention bear basic and/or acidic substituents and they may form salts with organic or inorganic acids or bases. Examples of suitable acids for such acid addition salt formation are hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, acetic acid, citric acid, oxalic acid, malonic acid, salicylic acid, p-aminosalicylic acid, malic acid, fumaric acid, succinic acid, ascorbic acid, maleic acid, sulfonic acid, phosphonic acid, perchloric acid, nitric acid, formic acid, propionic acid, gluconic acid, lactic acid, tartaric acid, hydroxymaleic acid, pyruvic acid, phenylacetic acid, benzoic acid, p-aminobenzoic acid, p-hydroxybenzoic acid, methanesulfonic acid, ethanesulfonic acid, nitrous acid, hydroxyethanesulfonic acid, ethylenesulfonic acid, p-toluenesulfonic acid, naphthylsulfonic acid, sulfanilic acid, camphorsulfonic acid, china acid, mandelic acid, o-methylmandelic acid, hydrogen-benzenesulfonic acid, picric acid, adipic acid, d-o-tolyltartaric acid, tartronic acid, (o, m, p)-toluic acid, naphthylamine sulfonic acid, and other mineral or carboxylic acids well known to those skilled in the art. The salts are prepared by contacting the free base form with a sufficient amount of the desired acid to produce a salt in the conventional manner.

[0010] Examples for suitable inorganic or organic bases are, for example, NaOH, KOH, NH_4OH, tetraalkylammonium hydroxide, lysine or arginine and the like. Salts may be prepared in a conventional manner using methods well known in the art, for example by treatment of a solution of the conjugate of general formula I with a solution of an acid, selected out of the group mentioned above.

[0011] Further, it is also possible that the compounds of the present invention bear simultaneously basic and acid groups. Further, it may also occur that these basic and acid groups appear to be in close vicinity to one another enabling an intramolecular proton transfer from the acidic group the basic group. Therefore, in a preferred embodiment of the present invention the conjugate of general formula I may be zwitterionic, bearing at least e.g. one -O- and one $-NH_3^+$ group.

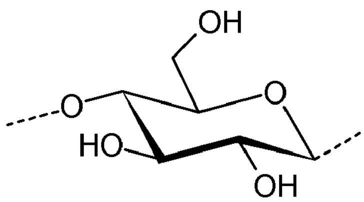
[0012] A preferred embodiment according to the current invention is directed to conjugates of general formula **I**, wherein n1 is 0 and n3 is 1. Thus, conjugates of general formula **IV**



IV

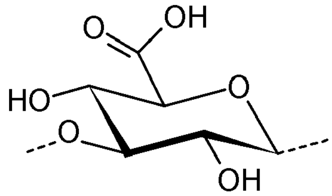
wherein

A is



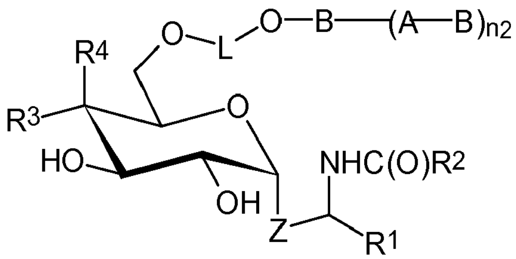
and

B is

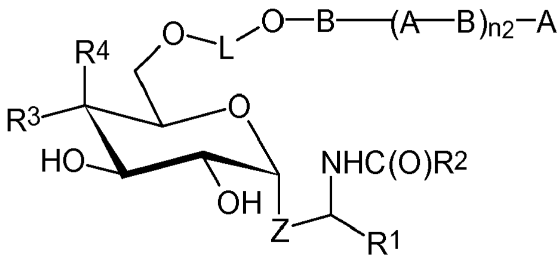


are especially preferred.

[0013] Another embodiment of the present invention refers to conjugates of general formula **I**, wherein n1 is 1 and n3 is 0 or 1. Hence, conjugates of general formula **V** and **VI** are also preferred.

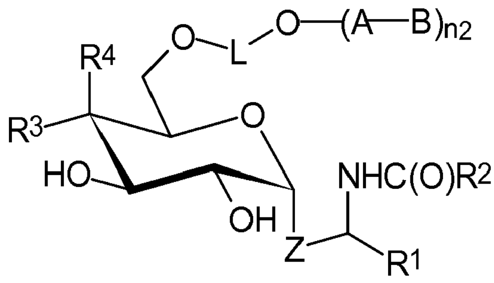


V



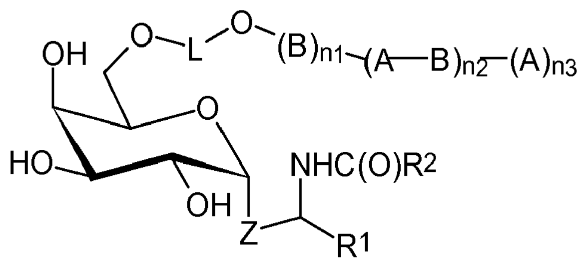
VI

[0014] Even more preferred conjugates of the present invention are conjugates of general formula **I**, wherein n1 and n3 are 0. Therefore, a particularly preferred embodiment of the invention is directed to conjugates of general formula **VII**.



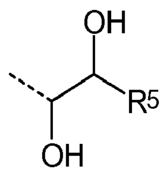
VII

[0015] The conjugates according to the current invention comprise a *Streptococcus pneumoniae* type 3 capsular polysaccharide related carbohydrate conjugated or connected to a glycosphingolipid. Preferably, the glycosphingolipid of the present invention contains as sugar moiety an α-galactoside. Therefore, a further embodiment of the present invention refers to conjugates of general formula **VIII:**

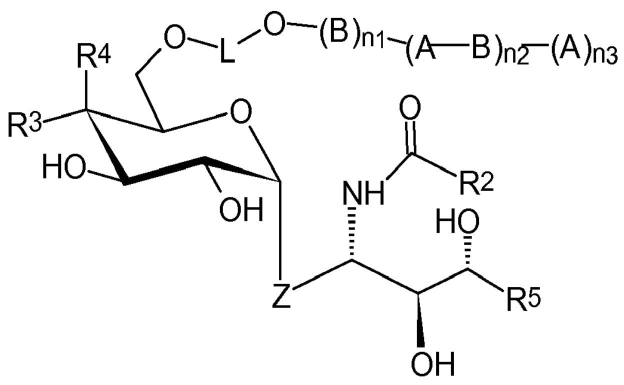


VIII

[0016] Conjugates of general formula **IV**, **V**, **VI** and **VII**, wherein R^3 is -H and R^4 is -OH are particularly preferred.
[0017] A further embodiment is directed towards conjugates of general formula **I**, **IV**, **V**, **VI** and **VII**, wherein R^3 is -OH and R^4 is -H, in other words, the glycosphingolipid presents an α-glucoside as a sugar moiety.
[0018] Preferably, the Z residue is selected from -O-CH_2- or -O-CH_2-CH_2-; and R^1 residue represents

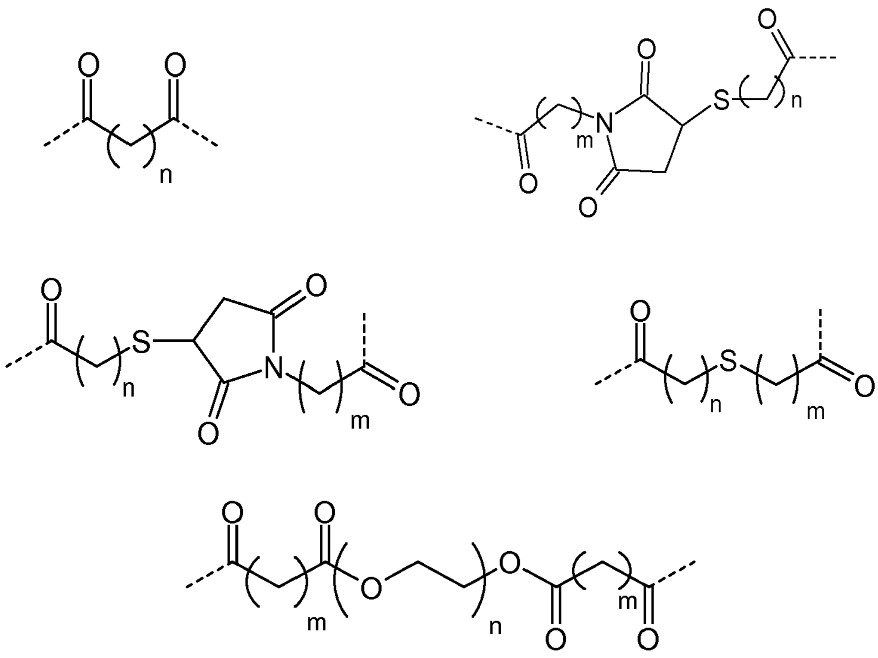


wherein R^5 has the meaning as defined herein.
[0019] In yet another preferred embodiment, the residue Z represents -CH_2-CH_2-CH_2-, or -CH_2-CH=CH-.
[0020] Other particularly preferred conjugates according to the current invention are conjugates of general formula **IX**:



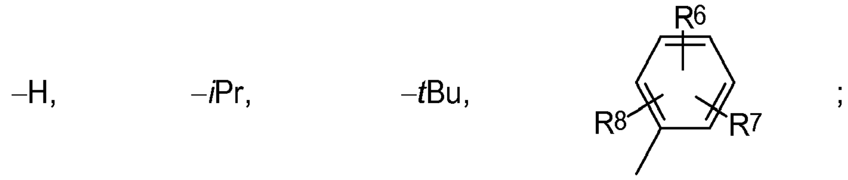
IX

[0021] The carbohydrate related to *Streptococcus pneumoniae* type 3 capsular polysaccharide is connected to the glycosphingolipid via a linker L, of general formula $-L^1$-NH-L^2-NH-L^3-, wherein the L^2 residue is preferably selected from:

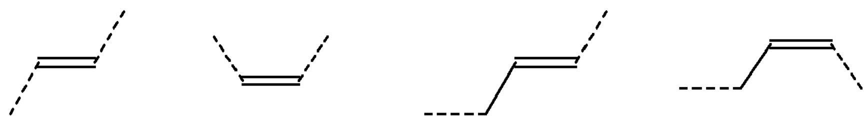


and m and n represent independently of each other an integer from 0 to 30.

[0022] Preferably, the X^4 residue is selected from:



the Y^4 is selected from: -H, -iPr, -tBu, or -Ph; and the X^1, X^2, X^3, Y^1, Y^2, Y^3 residues are independently of each other selected from: $-CH_2-$, -CH(OH)-, $-CH(CH_3)-$, $-CH(C_2H_5)-$, $-CH(C_3H_7)-$, $-CH(C_4H_9)-$,

 ,

wherein the substituents R^6, R^7 and R^8 are independently of each other selected from: -H, $-CH_3$, $-C_2H_5$, $-C_3H_7$, $-C_4H_9$, $-C_5H_{11}$, -Ph, -F, -Cl, -Br, -I.

[0023] More preferably, the substituents R^6, R^7 and R^8 are independently of each other selected from -H, -F, -Cl, -Br, and -I.

[0024] Another aspect of the present invention relates to the use of the inventive conjugates as drugs, i.e. as pharmaceutically active agents applicable in medicine.

Surprisingly, it was found that the novel conjugates of the present invention are also suitable to raise a protective immune response in human and/or animal host and therefore, are suitable for protection against diseases associated with *Streptococcus pneumoniae,* and especially *Streptococcus pneumoniae* type 3. Thus, the inventive conjugates disclosed herein are useful for prevention or treatment of diseases associated with *Streptococcus pneumoniae* type 3. Such diseases include, but are not restricted to pneumonia, meningitis, otitis media, bacteremia and acute exacerbation of chronic bronchitis, sinusitis, arthritis and conjunctivitis. Moreover, it was found that the treatment of an animal with the novel conjugate of the current invention lead to the formation of immunoglobuline IgG-isotypes, which prove the development of memory B-cells in the living organism. The presence of memory B-cells demonstrates immunological memory. Thus, it has been shown that the conjugates of the current invention are capable to induce a long term protection in an animal against *Streptococcus pneumoniae* type 3. The described vaccination is moreover independent on further adjuvants, does not need any protein-carrier and refrigeration of the vaccine.

[0025] Therefore, conjugates according to the present invention are suitable for the use as a pharmaceutically active agent applicable in medicine, especially for use in vaccination against diseases caused or associated with *Streptococcus pneumoniae* type 3.

[0026] Another aspect of the present invention is directed to pharmaceutical compositions comprising at least one conjugate of the present invention as active ingredient, together with at least one pharmaceutically acceptable carrier, excipient and/or diluent. The pharmaceutical compositions of the present invention can be prepared in a conventional solid or liquid carrier or diluent at suitable dosage level in a known way. The preferred preparations are adapted for oral application. These administration forms include, for example, pills, tablets, film tablets, coated tablets, capsules, powders and deposits.

[0027] Furthermore, the present invention also includes pharmaceutical preparations for parenteral application, including dermal, intradermal, intragastral, intracutan, intravasal, intravenous, intramuscular, intraperitoneal, intranasal, intravaginal, intrabuccal, percutan, rectal, subcutaneous, sublingual, topical, or transdermal application, which preparations in addition to typical vehicles and/or diluents contain at least one compound according to the present invention and/or a pharmaceutical acceptable salt thereof as active ingredient.

[0028] The pharmaceutical compositions according to the present invention containing at least one compound according to the present invention, and/or a pharmaceutical acceptable salt thereof as active ingredient will typically be administered together with suitable carrier materials selected with respect to the intended form of administration, i.e. for oral administration in the form of tablets, capsules (either solid filled, semi-solid filled or liquid filled), powders for constitution, extrudates, deposits, gels, elixirs, dispersable granules, syrups, suspensions, and the like, and consistent with conventional pharmaceutical practices. For example, for oral administration in the form of tablets or capsules, the active drug component may be combined with any oral non-toxic pharmaceutically acceptable carrier, preferably with an inert carrier like lactose, starch, sucrose, cellulose, magnesium stearate, dicalcium phosphate, calcium sulfate, talc, mannitol, ethyl alcohol (liquid filled capsules) and the like. Moreover, suitable binders, lubricants, disintegrating agents and coloring agents may also be incorporated into the tablet or capsule. Powders and tablets may contain about 5 to about 95 weight % of the benzothiophene-1,1-dioxide derived compound and/or the respective pharmaceutically active salt as active ingredient.

[0029] Suitable binders include starch, gelatin, natural carbohydrates, corn sweeteners, natural and synthetic gums such as acacia, sodium alginate, carboxymethylcellulose, polyethylene glycol and waxes. Among suitable lubricants, there may be mentioned boric acid, sodium benzoate, sodium acetate, sodium chloride, and the like. Suitable disintegrants include starch, methylcellulose, guar gum, and the like. Sweetening and flavoring agents as well as preservatives may also be included, where appropriate. The disintegrants, diluents, lubricants, binders etc. are discussed in more detail below.

[0030] Moreover, the pharmaceutical compositions of the present invention may be formulated in sustained release form to provide the rate controlled release of any one or more of the components or active ingredients to optimize the therapeutic effect(s), e.g. antihistaminic activity and the like. Suitable dosage forms for sustained release include tablets having layers of varying disintegration rates or controlled release polymeric matrices impregnated with the active components and shaped in tablet form or capsules containing such impregnated or encapsulated porous polymeric matrices.

[0031] Liquid form preparations include solutions, suspensions, and emulsions. As an example, there may be mentioned water or water/propylene glycol solutions for parenteral injections or addition of sweeteners and opacifiers for oral solutions, suspensions, and emulsions. Liquid form preparations may also include solutions for intranasal administration. Aerosol preparations suitable for inhalation may include solutions and solids in powder form, which may be present in combination with a pharmaceutically acceptable carrier such as an inert, compressed gas, e.g. nitrogen. For preparing suppositories, a low melting fat or wax, such as a mixture of fatty acid glycerides like cocoa butter is melted first, and the active ingredient is then dispersed homogeneously therein e.g. by stirring. The molten, homogeneous mixture is then poured into conveniently sized moulds, allowed to cool, and thereby solidified.

[0032] Also included are solid form preparations, which are intended to be converted, shortly before use, to liquid form preparations for either oral or parenteral administration. Such liquid forms include solutions, suspensions, and emulsions.

[0033] The conjugates according to the present invention may also be delivered transdermally. The transdermal compositions may have the form of a cream, a lotion, an aerosol and/or an emulsion and may be included in a transdermal patch of the matrix or reservoir type as is known in the art for this purpose.

[0034] The term capsule as recited herein refers to a specific container or enclosure made e.g. of methyl cellulose, polyvinyl alcohols, or denatured gelatins or starch for holding or containing compositions comprising the active ingredient(s). Capsules with hard shells are typically made of blended of relatively high gel strength gelatins from bones or pork skin. The capsule itself may contain small amounts of dyes, opaquing agents, plasticizers and/or preservatives. Under tablet a compressed or moulded solid dosage form is understood which comprises the active ingredients with suitable diluents. The tablet may be prepared by compression of mixtures or granulations obtained by wet granulation, dry granulation, or by compaction well known to a person of ordinary skill in the art.

[0035] Oral gels refer to the active ingredients dispersed or solubilized in a hydrophilic semi-solid matrix. Powders for constitution refers to powder blends containing the active ingredients and suitable diluents which can be suspended e.g. in water or in juice.

[0036] Suitable diluents are substances that usually make up the major portion of the composition or dosage form. Suitable diluents include carbohydrates such as lactose, sucrose, mannitol, and sorbitol, starches derived from wheat, corn rice, and potato, and celluloses such as microcrystalline cellulose. The amount of diluent in the composition can range from about 5 to about 95 % by weight of the total composition, preferably from about 25 to about 75 weight %, and more preferably from about 30 to about 60 weight %.

[0037] The term disintegrants refers to materials added to the composition to support break apart (disintegrate) and release the pharmaceutically active ingredients of a medicament. Suitable disintegrants include starches, "cold water soluble" modified starches such as sodium carboxymethyl starch, natural and synthetic gums such as locust bean, karaya, guar, tragacanth and agar, cellulose derivatives such as methylcellulose and sodium carboxymethylcellulose, microcrystalline celluloses, and cross-linked microcrystalline celluloses such as sodium croscaramellose, alginates such as alginic acid and sodium alginate, clays such as bentonites, and effervescent mixtures. The amount of disintegrant in the composition may range from about 2 to about 20 weight % of the composition, more preferably from about 5 to about 10 weight %.

[0038] Binders are substances, which bind or "glue" together powder particles and make them cohesive by forming granules, thus serving as the "adhesive" in the formulation. Binders add cohesive strength already available in the diluent or bulking agent. Suitable binders include carbohydrates such as sucrose, starches derived from wheat corn rice and potato, natural gums such as acacia, gelatin and tragacanth, derivatives of seaweed such as alginic acid, sodium alginate and ammonium calcium alginate, cellulose materials such as methylcellulose, sodium carboxymethylcellulose and hydroxypropylmethylcellulose, polyvinylpyrrolidone, and inorganic compounds such as magnesium aluminum silicate. The amount of binder in the composition may range from about 2 to about 20 weight % of the composition, preferably from about 3 to about 10 weight %, and more preferably from about 3 to about 6 weight %.

[0039] Lubricants refer to a class of substances which are added to the dosage form to enable the tablet granules etc. after being compressed to release from the mould or die by reducing friction or wear. Suitable lubricants include metallic stearates such as magnesium stearate, calcium stearate, or potassium stearate, stearic acid, high melting point waxes, and other water soluble lubricants such as sodium chloride, sodium benzoate, sodium acetate, sodium oleate, polyethylene glycols and D,L-leucine. Lubricants are usually added at the very last step before compression, since they must be present at the surface of the granules. The amount of lubricant in the composition may range from about 0.2 to about 5 weight % of the composition, preferably from about 0.5 to about 2 weight %, and more preferably from about 0.3 to about 1.5 weight % of the composition.

[0040] Glidents are materials that prevent caking of the components of the pharmaceutical composition and improve the flow characteristics of granulate so that flow is smooth and uniform. Suitable glidents include silicon dioxide and talc. The amount of glident in the composition may range from about 0.1 to about 5 weight % of the final composition, preferably from about 0.5 to about 2 weight %.

[0041] Coloring agents are excipients that provide coloration to the composition or the dosage form. Such excipients can include food grade dyes adsorbed onto a suitable adsorbent such as clay or aluminum oxide. The amount of the coloring agent may vary from about 0.1 to about 5 weight % of the composition, preferably from about 0.1 to about 1 weight %.

[0042] The mentioned pharmaceutical formulations, or more specifically vaccines are characterized in that they comprise a fully defined synthetic conjugate of general formula **I**.

[0043] The conjugates of the invention of the general formula **I** are present in said vaccine formulation in the range of 10 to 1000 μg/g. In a preferred embodiment of the invention the conjugates of general formula **I** are present in said vaccine formulation in the range of 10 to 1000 ng/g. In a more preferred embodiment of the invention the conjugates of general formula **I** are present in said vaccine formulation in the range of 100 to 1000 pg/g.

[0044] The mentioned vaccine formulation displays an extraordinary stability at room temperature due to the modular constitution of the compounds of the present invention, wherein said vaccine formulation may be maintained at a temperature of at least 25 °C for a period of at least 3 months prior to reconstitution. The temperature-stability of the herein described vaccine formulations constitutes a particular advantage of the present invention over the vaccines directed against *Streptococcus pneumoniae* type 3, which were described up to present.

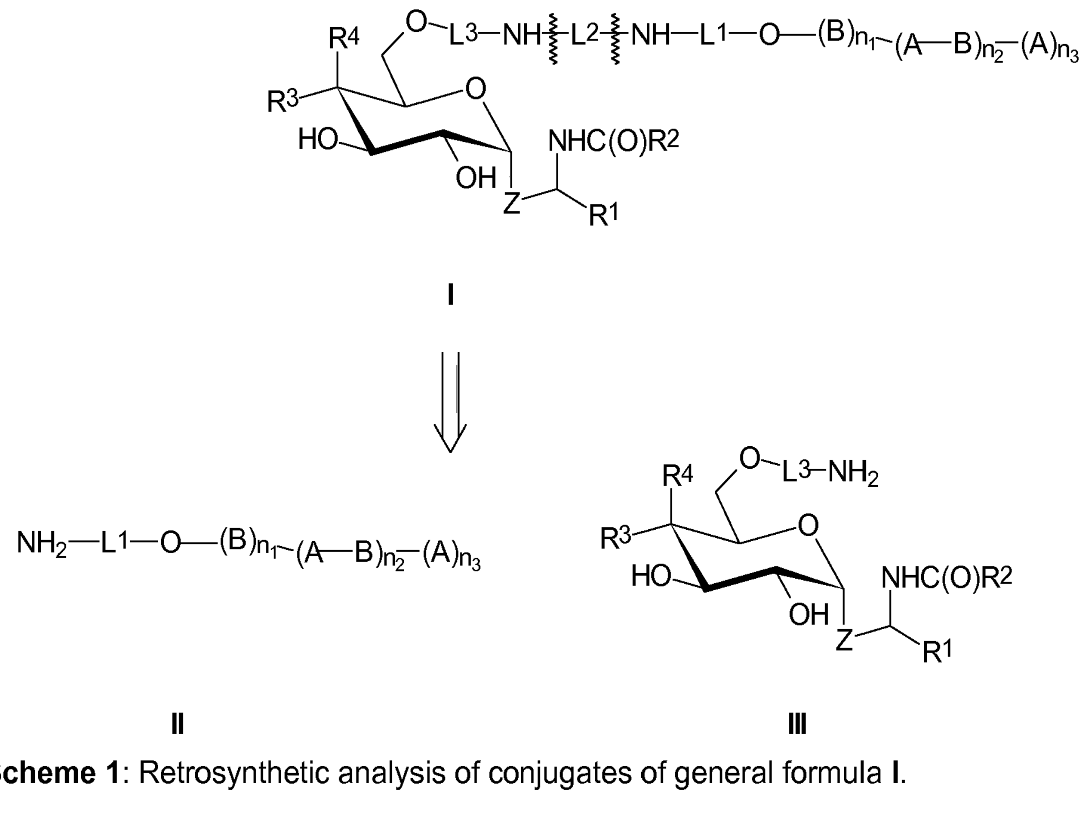
[0045] In a preferred embodiment of the invention the said period is comprises 6 months or at least 12 months.

[0046] When applied *in vivo* the conjugates of the present invention were found of being capable of effectively and continuously immunizing against *Streptococcus pneumoniae* type 3. This is rather advantageous, since thereby the conjugates of the present invention can stimulate the generation of antibodies of high titers and long lasting resistance in *in vivo* conditions, and moreover they exhibit a long-term stability at room temperature. Therefore, the conjugates of the present invention are particular heat stable and thus no refrigeration is required.

[0047] A yet another aspect of the present invention refers to a method of inducing an immune response in a human and/or animal host against *Streptococcus pneumoniae* type 3 comprising administering to the human and/or animal host, the conjugate or pharmaceutical composition of the invention.

Chemical synthesis

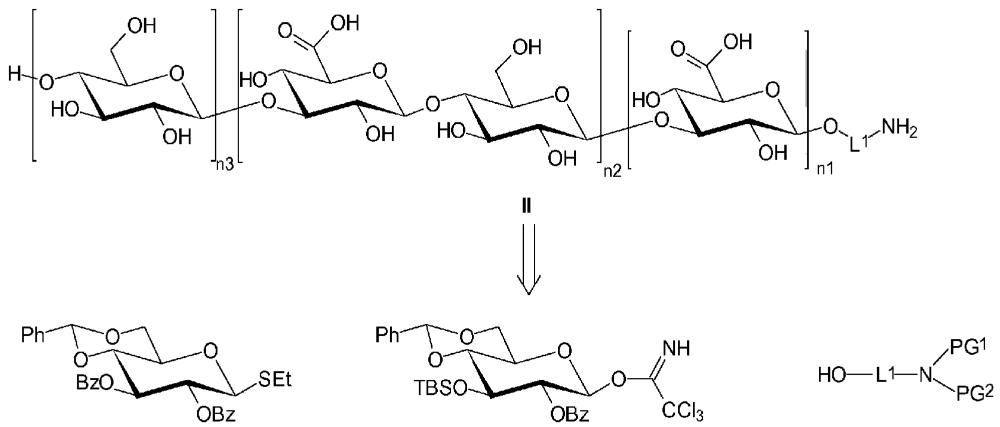
[0048] The conjugates of general formula I can be generated starting from carbohydrate **II**, which presents a linker L^1 having a terminal amino group, and glycosphingolipid **III** presenting at the C-6 position of the glycoside moiety a linker L^3 with a terminal amino group.



Scheme 1: Retrosynthetic analysis of conjugates of general formula **I**.

Synthesis of *Streptococcus pneumoniae* type 3 capsular polysaccharide related carbohydrate.

[0049] The synthetic carbohydrate of general formula **II** , which are related to the capsular polysaccharide of *Streptococcus pneumoniae* type 3, can be accessed via a sequence of protecting group manipulation reactions and glycosylation reactions starting from glucose building blocks **2** and **3** and amino alcohol **4** (see **Scheme 2**).



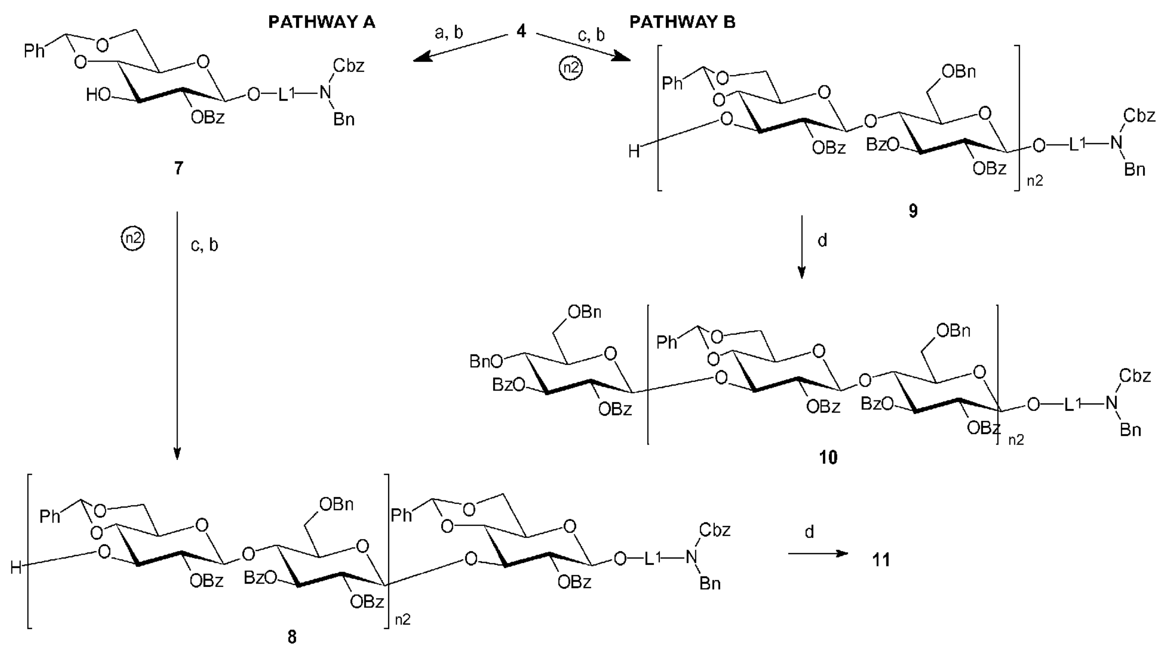
2 **3** **4**

Scheme 2: Retrosynthetic scheme of carbohydrates of general formula **II**: n1 = 0 or 1; n2 = integer from 1 to 20; n3 = 0 or 1.

[0050] The synthetic carbohydrate of general formula **II** used in the present invention are functionalized at the reducing end with a linker L^1 having a terminal amino group, which allows for conjugation to the glycosphingolipid. Thioglycoside **2** has a benzoyl participating protecting at the C-2 position to ensure the formation of the β-glycosidic linkage and a benzylidene acetal at the C-4 and C-6 positions, which can be regioselectively opened to free the C-4 hydroxyl for subsequent glycosylation. Glucose imidate **3** is equipped with a *tert*-butyl(dimethyl)silyl ether at the C-3 position and with a benzoate ester at the C-2 position to favour the formation of the β-glycosidic linkage. The amino group in amino alcohol **4** was masked with benzyl and benzyloxycarbonyl protecting groups, so as not to interfere as a nucleophile during the glycosylation reactions.

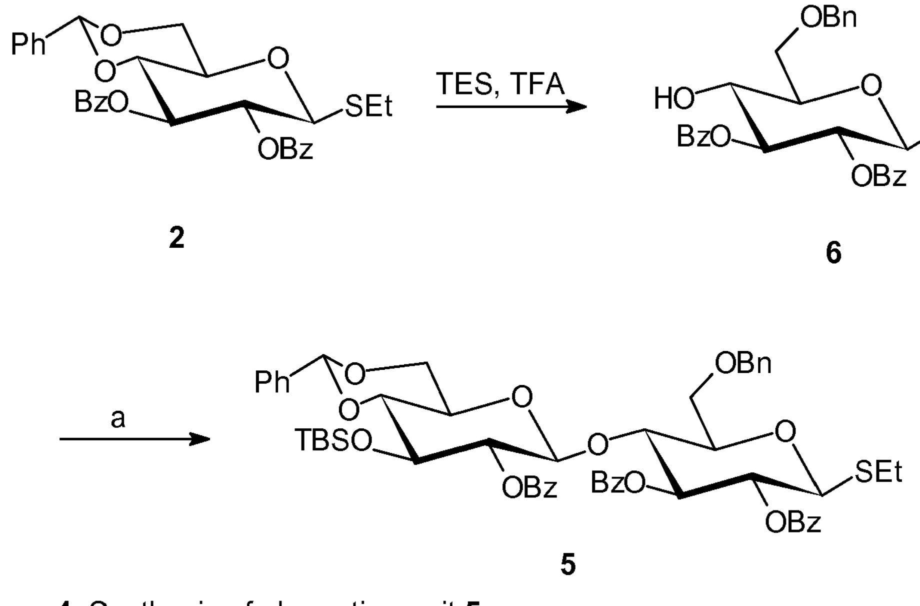
[0051] However, the person skilled in the art could use other suitable protecting groups for amine protection, as long as said protecting groups are compatible with the conditions used during subsequent assembly and deprotection procedures.

[0052] Thus, starting from amino alcohol **4**, fully protected saccharides **8**, **9**, **10**, and **11**, which are precursors of carbohydrates of general formula **II** can be assembled following synthetic pathway A or B (see **Scheme 3**). More precisely, fully protected saccharide **8** that can be converted in few steps to carbohydrates of general formula **II**, with n1 equal to 1 and n2 defined as above, are assembled following synthetic pathway A. Firstly, amino alcohol **4** and glucose imidate **3** are coupled using TMSOTf as activator to provide a monosaccharide intermediate (**step a**), which is further submitted to deprotection reaction by treatment with HF/pyridine to give compound **7** (**step b**) that represents the nucleophile for the following coupling reaction. The coupling reaction (**step a**) could be mediated by other activators known by the person skilled in the art, including $BF_3{\cdot}OEt_2$, PPTS, $LiClO_4$ and $Cu(OTf)_2$. Moreover, the selective cleavage of the tert-butyl(dimethylsilyl)ether during the deprotection reaction (**step b**) could be accomplished using TBAF, HF·pyridine, $(Me_2N)_3S^+\ F_2SiMe_3^-$ and many others reagents. After appending the first monosaccharide to the linker, target molecule **8** can be constructed by simple repetition of the reaction sequence comprising steps c and b. To accelerate the synthetic procedure, disaccharide building block **5** employed as elongation unit during the assembly, was prepared as described in **Scheme 4**.



Scheme 3: Assembly of the carbohydrates related to the capsular polysaccharide of SP-3: **a. 3**, TMSOTf; **b.** HF, pyridine; **c. 5**, NIS, TfOH; **d. 10**, NIS/TfOH.

[0053] First thioglucoside **2** was subjected to regioselective reductive opening by treatment with TES in presence of TFA to give alcohol **6,** which was further coupled to imidate **3** in presence of TMSOTf to provide elongating unit **5**.

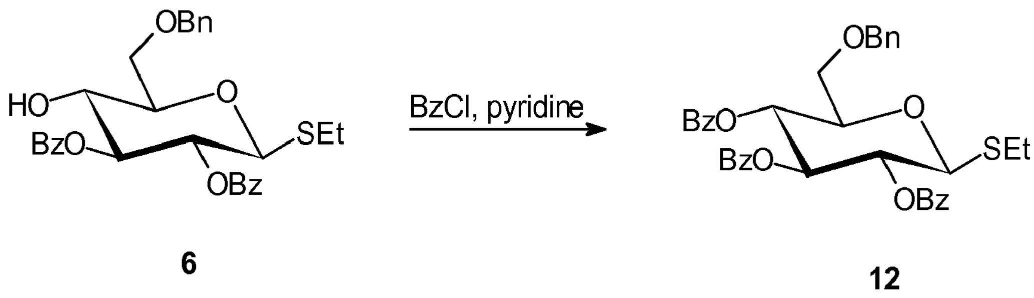


Scheme 4: Synthesis of elongating unit **5**.

[0054] With disaccharide **5** in hand, the reactions sequence comprising steps c and b was repeated till the desired length of the fully protected carbohydrate **8** (n2 times) was achieved. Each reactions sequence consists of a coupling reaction, followed by a deprotection reaction, thus introducing a [→3-β-D-Glc*p*-(1→4)-β-D-Glc*p*-(1→] repeating unit at the non reducing end of the growing saccharide leading after n2 repetitions to fully protected saccharide **8**. The coupling reaction (**step c**) involves treatment of the growing saccharide with elongating unit **5** in presence of NIS/TfOH. Other activating systems, including IDPC, NBS-$LiClO_4$, Ph_2SO/Tf_2O, BSP-Tf_2O can be used as alternative to NIS/TfOH for mediating the glycosidic coupling.

[0055] In a similar way, fully protected saccharide **9**, which is the precursor of synthetic carbohydrates of general formula **II** with n1 and n3 equal to 0 and n2 as previously defined was prepared starting from amino alcohol **4** by simple repetition of the reactions sequence comprising step c and b. Thus, after n2 repetitions of the glycosidic coupling (**step c**), followed by the deprotection reaction (**step b**), fully protected carbohydrate **9** was obtained.

[0056] The precursors of carbohydrates of general formula II with n3 equal to 1 were obtained starting from fully protected carbohydrates 8 and 9. In this scope, building block **12** was prepared according to **Scheme 5**, to provide the sugar moiety at the non-reducing end of carbohydrates **10** and **11**.

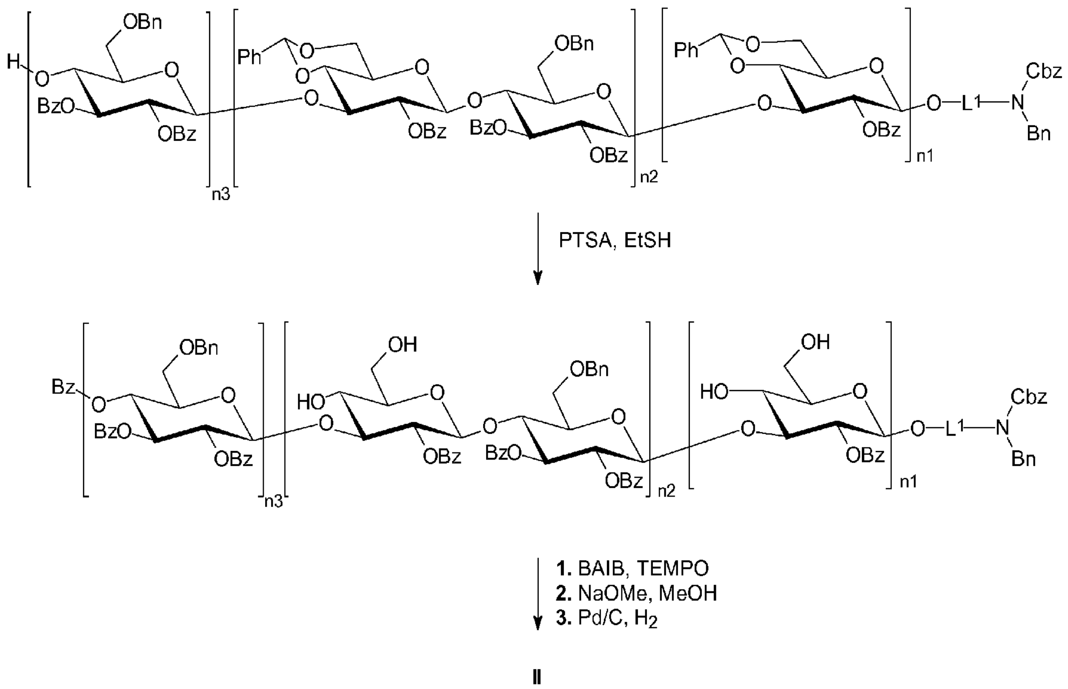


Scheme 5: Synthesis of glucose building block **12**.

[0057] Finally, fully protected carbohydrates **8** and **9** were treated with thioglucoside **12** in presence of NIS/TfOH to provide fully protected carbohydrates **11** and **10**.

[0058] Prior to the oxidation reaction, which is necessary for installing the carboxylic groups on the carbohydrates related to the SP3 capsular polysaccharide, the free hydroxyl groups on the glucose moiety at the non-reducing end of saccharides **10** and **11** were protected as a benzoate ester by treatment with benzoyl chloride in presence of pyridine.

[0059] To complete the synthesis, the fully protected saccharides accessed as described above were converted to the carbohydrates of general formula **II** (see **Scheme 6**). Firstly, the benzylidene acetals were cleaved by treatment with p-TSA and ethanethiol to free the primary hydroxyls prior to oxidation to the corresponding carboxylic acids. Then, the oxidation reaction using BAIB and TEMPO as oxidative agents was performed. The benzoate esters on the oxidized carbohydrates were further cleaved by applying Zemplèn conditions, and the resulting intermediates were submitted to hydrogenolysis on Pd/C to give synthetic carbohydrates of general formula **II**.

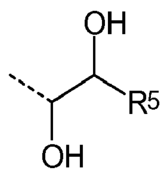


Scheme 6: Synthesis of carbohydrates of general formula **II**: n1 = 0 or 1; n2 = integer from 1 to 20; n3 = 0 or 1.

Synthesis of the glycosphingolipid III

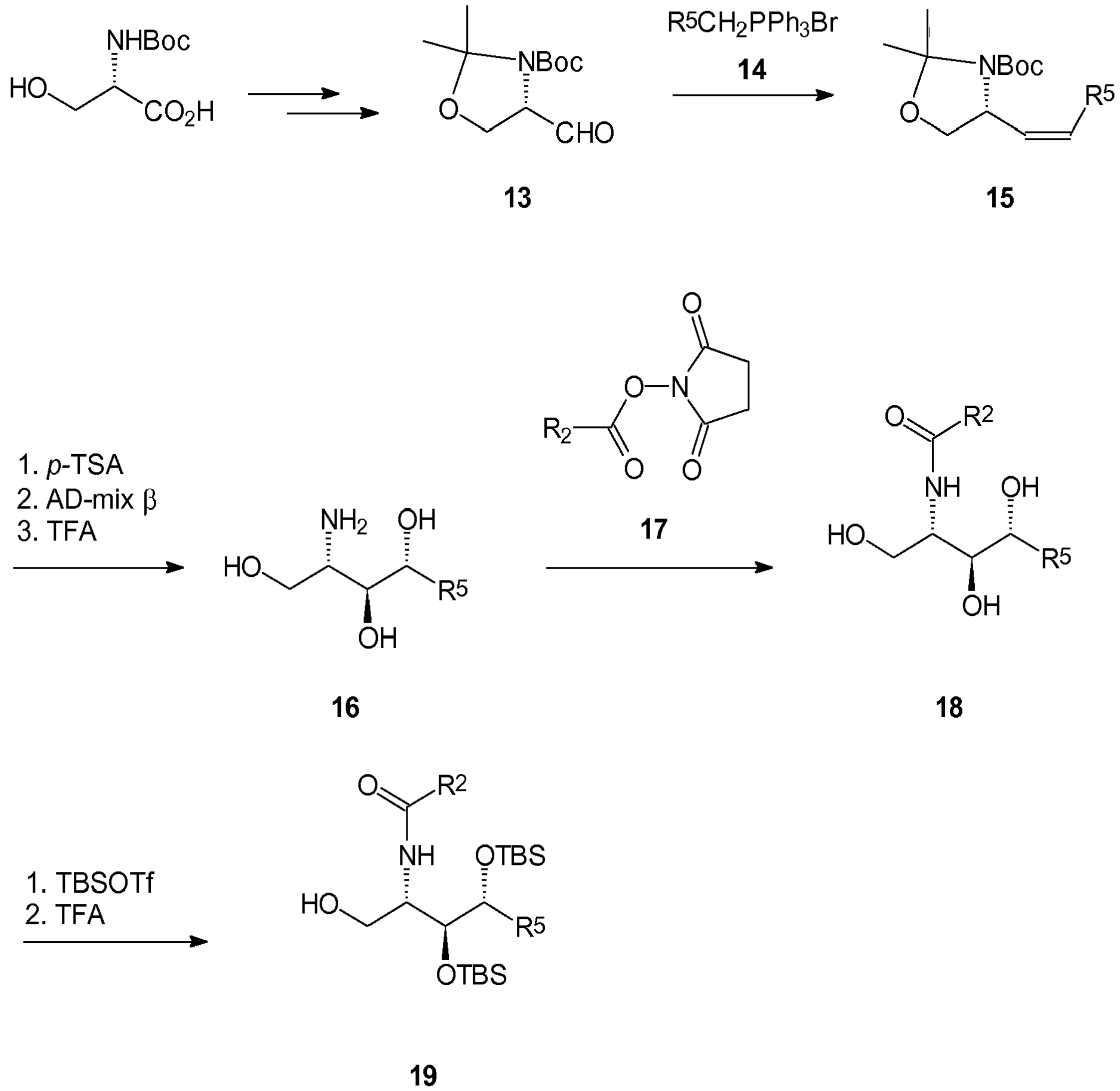
[0060] The glycosphingolipids of general formula **III**, suitable for obtaining conjugates of general formula **I** can be accessed through a variety of synthetic pathways.

[0061] For instance, the glycosphingolipids according to the present invention with Z being $-OCH_2-$ and R^1 being



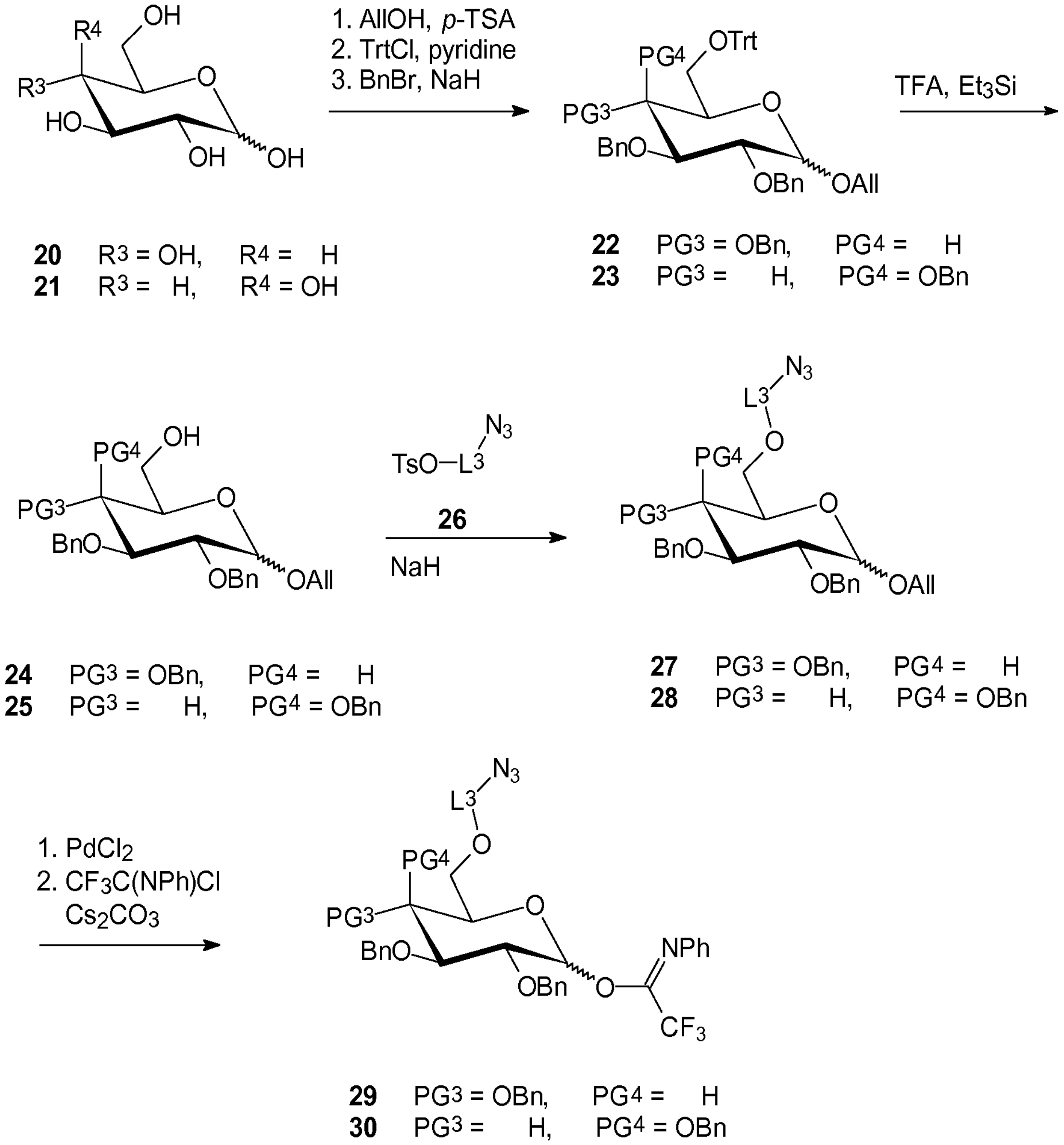
can be synthesized according to the synthetic pathway described below.

[0062] Commercially available L-Boc serine was chosen as starting material and converted in three steps to aldehyde **13** (see **Scheme 7**). The residue R^5 was introduced on the molecule by applying Wittig reaction. Hence, triphenylphosphonium ylide **14**, which was prepared from the corresponding bromide R^5CH_2Br, was reacted with aldehyde **13** in presence of *n*-butyl lithium to provide exclusively Z-alkene **15**. Conveniently, a variety of bromides of general formula R^5CH_2Br are commercially available or can be easily accessed by the person skilled in the art. Cleavage of the isopropylidene moiety with *p*-TSA, followed by Sharpless dihydroxylation and subsequent removal of the tert-butyloxycarbonyl protecting group in presence of trifluoroacetic acid provided triol **16**. At this level, the residue R^1 was entirely introduced on the molecule. In the next step, the residue R^2 was appended by simple amide bond formation. Treatment of the activated ester **17** with amine **16** gave amide **18**, which was converted in two steps to ceramide **19** ready for conjugation to the glucose or galactose sugar moiety.



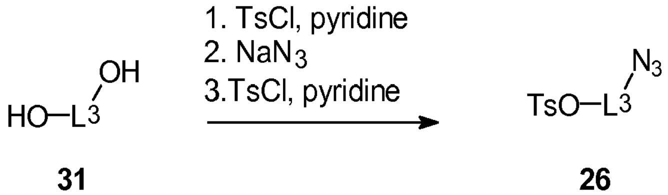
Scheme 7: Synthesis of ceramide **19** ready for conjugation.

[0063] Glucose building block **29** and galactose building block **30** ready for conjugation with the ceramide **19** were synthesized starting from D-glucose **20**, and D-galactose **21**, respectively. Standard protecting group chemistry depicted on **Scheme 8** give arise to the suitably protected glucose **24** and galactose **25** with free alcohol at C6 position. The introduction of the linker L^3 at the C6 position was achieved at this level via Williamson's etherification with azide **26** of general formula $TsO-L^3-N_3$. A variety of azides of general formula $TsO-L^3-N_3$ can be prepared following routes described in the literature and known to the person skilled in the art. **Scheme 9** describes such a synthetic route, which provides azide **26** in 3 steps starting from diol **31** that can be commercially available or accessed via modification of commercially available material.

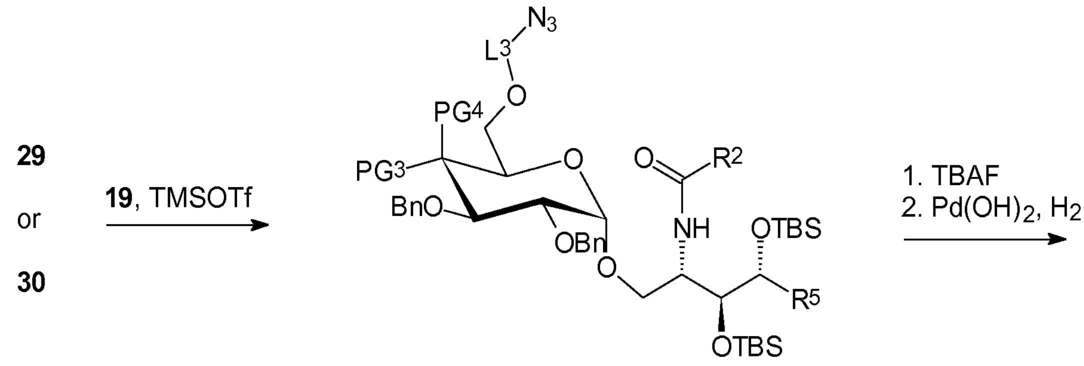


Scheme 8: Synthesis of glycosyl imidates **29** and **30.**

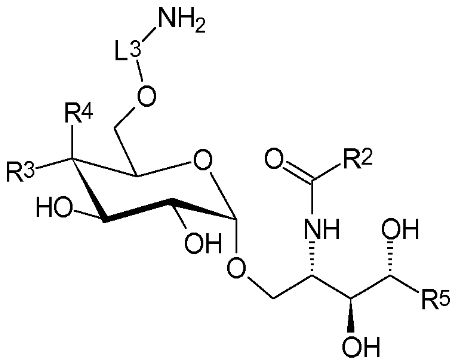
[0064] Building blocks **27** and **29** equipped at C6 with linker L^3 having a terminal azido group were further subjected to isomerization of the anomeric allyl protecting group and hydrolysis to give intermediate lactols, which were converted to the glycosyl imidates **29** and **30** by reaction with 2,2,2-trifluoro-N-phenylacetimidoyl chloride in presence of cesium carbonate.



Scheme 9: Synthesis of azide **26.**



32 PG3 = OBn, PG4 = H
33 PG3 = H, PG4 = OBn



34 R3 = OH, R4 = H
35 R3 = H, R4 = OH

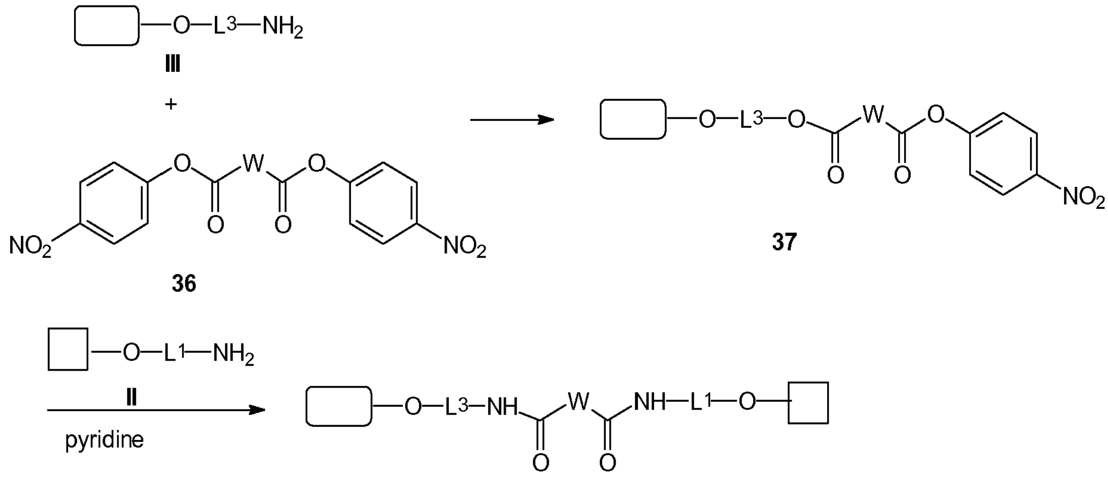
Scheme 10: Synthesis of glycosphingolipids **34** and **35.**

[0065] With both ceramide **19** and glycosyl donors **29** and **30** on hand, the glycosylation in the presence of catalytic amount of TMSOTf to give arise to glycosphingolipids **32** and **33** with complete α-selectivity was performed (see **Scheme 10**). Removal of the silylether protecting groups with TBAF followed by hydrogenolysis with *Pearlman's* catalyst provided target glycosphingolipids **34** and **35**.

Synthesis of conjugates

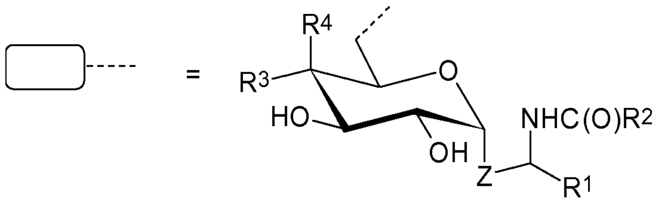
[0066] Once the carbohydrates of general formula **II** and the glycosphingolipid of general formula **III** were synthesized, a variety of methods can be employed for conjugation in order to provide the conjugates of general formula **I**. Schemes **11** and **12** sum up some of these methods; however the methods that can be used for connecting carbohydrate **II** and glycosphingolipid **III**, or for conjugating carbohydrate II to glycosphingolipid **III** are not restricted to the methods disclosed below.

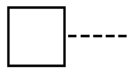
[0067] For example, **scheme 11** describes how carbohydrate **II** can be connected to glycosphingolipid **III** via a symmetric linker L^2 of general formula -C(O)-W-C(O)-. First glycosphingolipid **III**, which is functionalized at C6 of the galactose or glucose sugar moiety with a linker L^3 presenting a terminal amino group is reacted with a activated diester **36** to provide activated monoester **37**. In this case, the ester was activated with a 4-nitrophenyl activating moiety. However, other activating moieties such as 2,4,5-trichlorophenyl, pentachlorophenyl, pentafluorophenyl, succinimido, 4-oxo-3,4-dihydrobenzo-triazin-3-yl, and sulfated moieties thereof can be considered as alternative for 4-nitrophenyl activating moiety. The reaction is performed in slightly alkaline conditions (pH from 7.2 to 9) in a mixture of solvents containing 5-10% water-soluble solvent, such as DMF, pyridine or DMSO. Once activated monoester **37** was obtained, the next step is the coupling with the carbohydrate of general formula **II**, which takes place in presence of pyridine to give target conjugate **38**.

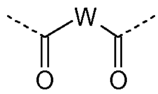


38

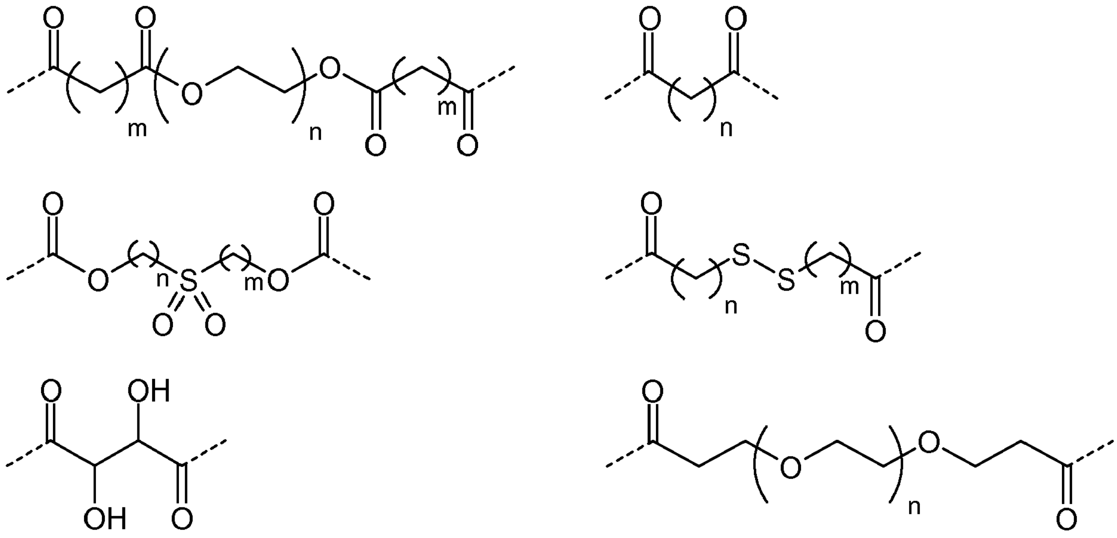
wherein



 = $---(B)_{n_1}-(A-B)_{n_2}-(A)_{n_3}$

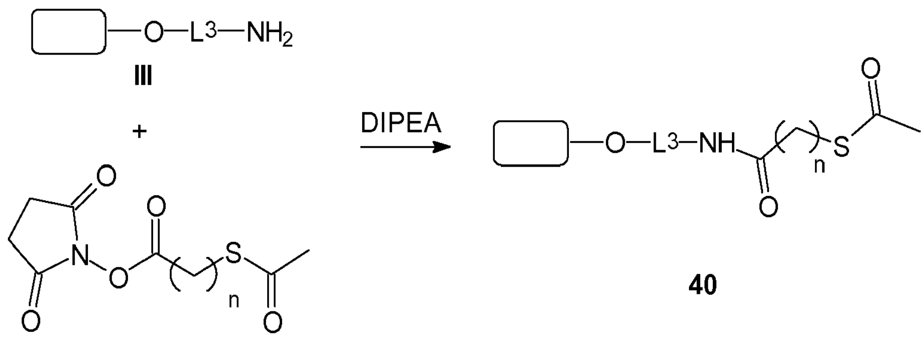
and 

can be selected, but it is not restricted to one of the following fragments



Scheme 11: Synthesis of conjugate **38**.

[0068] In case linker L^2 is asymmetric, a synthetic pathway such as the one presented by **Scheme 12** could be followed. First, glycosphingolipid **III** is reacted with N-succinimide activated ester **39**, to provide in presence of a base amide **40** equipped with a masked thiol group. In a similar manner, carbohydrate II is treated with activated ester **41** leading to amide **42** presenting a terminal maleimide. Cleavage of the acetate group in presence of ammonium hydroxide freed the primary thiol on compound **40** to provide an intermediate, which reacted with the terminal maleimide on compound **42** to give conjugate **43**.



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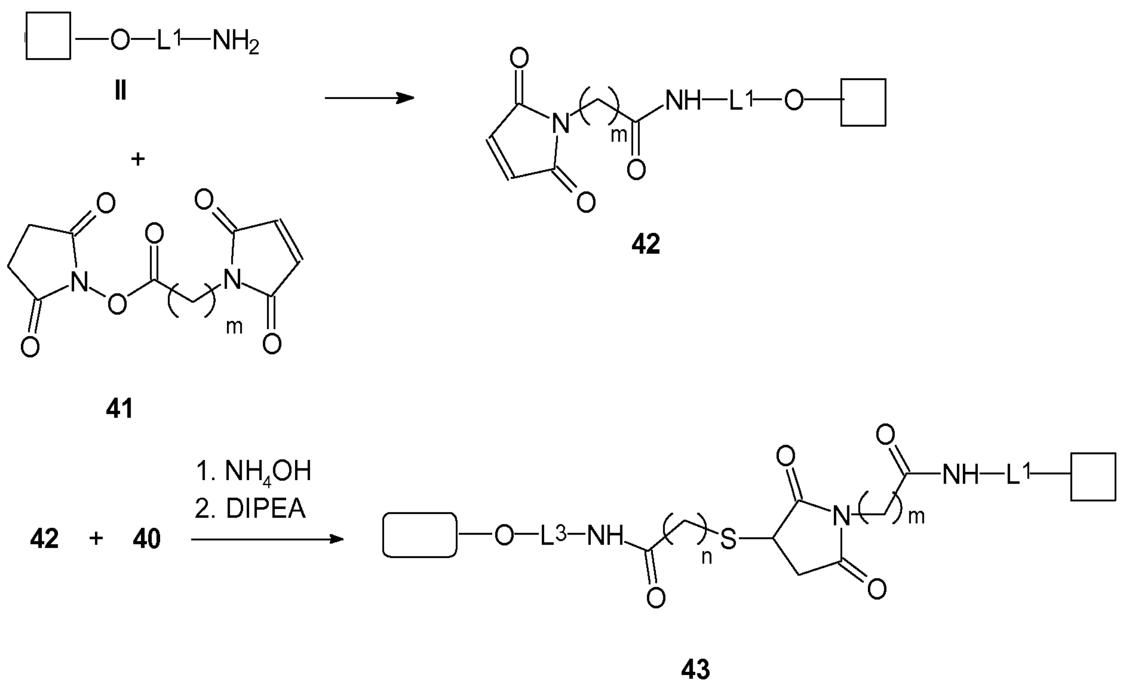
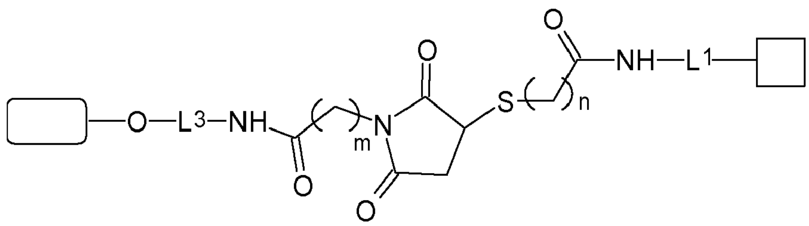


Scheme 12: Synthesis of conjugate **43**.

[0069] Obviously, the terminal maleimide could be installed on the glycosphingolipid of general formula **III** and the terminal thiol group could be installed on the carbohydrate of general formula **II** to generate conjugate **44**.



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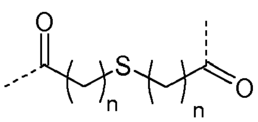
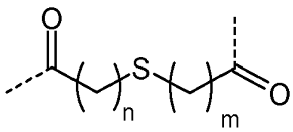
[0070] The terminal thiol generated from intermediate **40** could be also involved in a thiol-ene reaction with the appropriate alkene partner to provide conjugates of general formula **I** having a symmetric linker L^2 such as



or an asymmetric one



[0071] The following examples are included to demonstrate preferred embodiments of the invention. It should be appreciated by those of skill in the art that the techniques disclosed in the examples, which follow represent techniques discovered by the inventor to function well in the practice of the invention, and thus can be considered to constitute preferred modes for its practice. However, those of skill in the art should, in light of the present disclosure, appreciate that many changes can be made in the specific embodiments which are disclosed and still obtain a like or similar result without departing from the spirit and scope of the invention.

[0072] Further modifications and alternative embodiments of various aspects of the invention will be apparent to those skilled in the art in view of this description. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the invention. It is to be understood that the forms of the invention shown and described herein are to be taken as examples of embodiments. Elements and materials may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the invention may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of this description of the invention. Changes may be made in the elements described herein without departing from the spirit and scope of the invention as described in the following claims.

Examples

Chemical synthesis

Abbreviations:

[0073]

NIS:	*N*-iodosuccinimide;
TfOH:	triflic acid;
hr:	hour;
DCM:	dichloromethane;
TLC:	thin layer chromatography;
MW:	microwave
rt:	room temperature;
RM:	reaction mixture;
EtOAc:	ethyl acetate;
MS:	molecular sieves;
TMS:	trimethylsilyl;
Tempo:	2,2,6,6-tetramethyl-1-piperidinyloxy, free radical;
BAIB:	bis(acetoxy)iodobenzene.

General information for chemical synthesis

[0074] Commercial reagents were used without further purification except where noted. Solvents were dried and redistilled prior to use in the usual way. All reactions were performed in oven-dried glassware under an inert atmosphere unless noted otherwise. Analytical thin layer chromatography (TLC) was performed on Kieselgel 60 F254 aluminium plates precoated with a 0.25 mm thickness of silica gel. The TLC plates were visualized with UV light and by staining with Hanessian solution (ceric sulfate and ammonium molybdate in aqueous sulfuric acid) or sulfuric acid-ethanol solution. Column chromatography was performed on Fluka Kieselgel 60 (230-400 mesh). Optical rotations (OR) were measured with a Schmidt & Haensch UniPol L1000 polarimeter at a concentration (c) expressed in g/100 mL. ^{1}H and ^{13}C NMR spectra were measured with a Varian 400-MR or Varian 600 spectrometer with Me_4Si as the internal standard. NMR chemical shifts (δ) were recorded in ppm and coupling constants (J) were reported in Hz. High-resolution mass spectra (HRMS) were recorded with an Agilent 6210 ESI-TOF mass spectrometer at the Freie Universität Berlin, Mass Spectrometry Core Facility.

A. Synthesis of *Streptococcus pneumoniae* type 3 capsular polysaccharide related carbohydrate

Example 1: Synthesis of (2R,4aR,6R,7R,8S,8aR)-6-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxine-7,8-diyl dibenzoate (1*)

[0075] (2R,4aR,6S,7R,8S,8aR)-6-(ethylthio)-2-phenylhexahydropyrano[3,2-d][1,3]dioxine-7,8-diyl dibenzoate (6.0 g, 11.53 mmol) and benzyl benzyl(2-hydroxyethyl)carbamate dried azeotropically using toluene in rotary evaporator (3.93 g, 13.83 mmol) were taken in dry DCM (100 mL) and added 5 g of microwave-dried 4 A MS to it and stirred at rt for 15 min and then cooled to -10 °C. After addition of NIS (3.83 g, 17.29 mmol) and TfOH (0.15 mL, 1.73 mmol), the reaction mixture under stirring was warmed from -10 °C to -5 °C during 1 hr. RM was then quenched with 10% aq. $Na_2S_2O_3$

solution (50 mL) and then extracted with EtOAc (25 ml X 3). Combined organic layer was then washed with brine (10 ml), dried over anhydrous Na_2SO_4, filtered and concentrated in vacuum to get pale yellow oily compound. Crude product was purified on silica gel column chromatography using 20-30% EtOAc in hexanes to provide desired product 1* as pale yellow colored transparent gummy liquid (7.60 g, 89%).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 (dd, J = 8.4, 1.2 Hz, 4H), 7.59 - 6.90 (m, 21 H), 5.91 - 5.71 (m, 1 H), 5.62 - 5.41 (m, 2H), 5.22 - 4.95 (m, 2H), 4.80 (d, J = 7.7 Hz, 0.5H), 4.67 (d, J = 7.7 Hz, 0.5H), 4.56 - 4.22 (m, 3H), 4.10 - 3.52 (m, 5H), 3.50 - 3.33 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.7, 165.4, 156.35, 156.2, 137.9, 136.9, 133.4, 133.2, 129.9, 129.5, 129.3, 129.1, 128.7, 128.5, 128.4, 128.3, 128.1, 127.8, 127.4, 127.2, 126.2, 101.9, 101.6, 78.9, 72.6, 72.1, 69.1, 68.7, 67.4, 67.2, 66.7, 51.7, 46.9, 45.8.

Example 2: Synthesis of (2R,3R,4S,5R,6R)-2-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-6-((benzyloxy)methyl)-5-hydroxy tetrahydro-2H-pyran-3,4-diyl dibenzoate (2*)

[0076] Glucose **1*** (7.50 g, 10.08 mmol) was taken in DCM (75 mL) under argon with activated 3A MS for 10 min before cooling to 0 °C. Triethylsilane (12.88 mL, 81.0 mmol), followed by TFA (4.66 mL, 60.5 mmol) were added dropwise and the RM was stirred at rt for 16 h before quenching with water (100 mL). The RM was extracted with DCM (30 mL X 3), and the combined organic layers were washed thoroughly with water (20 mL X 3), brine (20 mL), dried over anhydrous Na_2SO_4, filtered, evaporated in vacuum to get colorless gummy solid. The crude product was purified by silica column chromatography using 30%-100% EtOAc in hexanes to provide after evaporation in vacuum target compound as colorless oil (6.1 g, 81 %).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 - 7.84 (m, 4H), 7.60 - 6.87 (m, 21 H), 5.55 - 5.36 (m, 2H), 5.22 - 4.90 (m, 2H), 4.77 - 4.53 (m, 3H), 4.51 - 4.30 (m, 2H), 4.06 - 3.93 (m, 2H), 3.87 - 3.53 (m, 4H), 3.46 - 3.20 (m, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.3, 165.5, 138.0, 137.7, 133.6, 130.1, 129.9, 128.6, 128.5, 128.1, 127.9, 127.8, 127.4, 101.3, 101.2, 76.7, 74.7, 73.9, 71.6, 71.5, 71.2, 70.0, 69.0, 67.4, 67.2, 51.7, 46.8,45.8.

Example 3: Synthesis of (2R,3R,4S,5R,6R)-5-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tert-butyldimethylsilyl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-2-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-6-((benzyloxy)methyl)tetrahydro-2H-pyran-3,4-diyl dibenzoate (3*)

[0077] (2R,3R,4S,5R,6R)-2-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-6-((benzyloxy) methyl)-5-hydroxytetrahydro-2H-pyran-3,4-diyl dibenzoate (2.0 g, 2.68 mmol) was taken in DCM (30 mL) with activated 4A acid washed MS and stirred at rt for 30 min before cooling to 0 □C. TMSOTf (0.49 μL, 0.27 mmol) was then added followed by the (2R,4aR,6S,7R,8S,8aR)-8-((tert-butyldimethylsilyl)oxy)-2-phenyl-6-(2,2,2-trichloro-1-iminoethoxy)hexahydropyrano[3,2-d][1,3]dioxin-7-yl benzoate (2.20 g, 3.89 mmol) in DCM (5 mL) over 5 min and the reaction mixture was stirred for 30 min at 0 □C. The RM was quenched with Et_3N (1 mL), filtered and the solvents removed under vacuum. The crude product was purified by flash chromatography using EtOAc in hexanes to get product **3*** (3.2 g, 98%).
^{1}H NMR (400 MHz, $cdcl_3$) δ 8.13 - 6.88 (m, 35H), 5.67 - 5.52 (m, 1 H), 5.46 - 5.31 (m, 1H), 5.20 (s, 1 H), 5.16 - 4.89 (m, 3H), 4.68 (t, *J* = 11.2 Hz, 1 H), 4.55 (d, *J* = 8.1 Hz, 1.5H), 4.47 - 4.24 (m, 3.5H), 4.20 - 3.89 (m, 1.5H), 3.89 - 3.19 (m, 9.5H), 3.13 (td, *J* = 9.7, 4.9 Hz, 1 H), 2.63 (t, *J* = 10.2 Hz, 1 H), 0.63 (s, 9H), -0.12 (s, 3H), -0.19 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.4, 165.36, 164.7, 138.2, 137.1, 133.4, 133.2, 129.94, 129.9, 129.2, 128.7, 128.6, 128.5, 128.4, 128.2, 128.0, 127.8, 127.3, 126.4, 101.7, 101.2, 101.1, 81.2, 75.5, 75.1, 74.6, 73.7, 73.4, 73.0, 68.9, 68.0, 67.3, 66.1, 51.7, 46.9, 25.6, 18.0, -4.1, -4.8.

Example 4: Synthesis of (2R,3R,4S,5R,6R)-5-(((2R,4aR,6S,7R,8S,8aS)-7-(benzoyloxy)-8-hydroxy-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-2-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-6-((benzyloxy)methyl)tetrahydro-2H-pyran-3,4-diyl dibenzoate (4*)

[0078] (2R,3R,4S,5R,6R)-5-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tert-butyl dimethylsilyl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-2-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-6-((benzyloxy)methyl)tetrahydro-2H-pyran-3,4-diyl dibenzoate (1.6 g, 1.317 mmol) was taken in pyridine (10 mL) at 0 °C and treated with HF-pyridine (3.56 mL, 39.5 mmol). The mixture was stirred at rt for 24 h. RM was washed with water and extracted with DCM (20 mL X 3). Combined organic layers were then washed with diluted HCl (50 mL X 2), saturated $NaHCO_3$ solution (50 mL), brine (10 mL), dried over Na_2SO_4, filtered and concentrated in vacuum to get crude product, which after purification using silica column chromatography using 35-40% EtOAc in hexanes yielded target compound as white colored foam (1.3 g, 90%).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 - 6.92 (m, 1 H), 5.65 - 5.51 (m, 1 H), 5.44 - 5.30 (m, 1 H), 5.23 (s, 1 H), 5.11 - 5.04 (m, 3H), 4.77 - 4.49 (m, 3H), 4.49 - 4.24 (m, 4H), 4.25 - 3.91 (m, 2H), 3.91 - 3.59 (m, 4H), 3.57 - 3.00 (m, 7H), 2.68 (t, J = 10.3 Hz,1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.4, 165.3, 156.4, 156.2, 138.2, 136.9, 133.6, 133.2, 130.3, 130.0,

129.9, 129.4, 128.7, 128.7, 128.5, 128.5, 128.4, 128.1, 128.1, 127.8, 127.4, 126.4, 101.8, 101.2, 101.1, 80.6, 75.9, 74.9, 74.7, 73.7, 73.5, 72.6, 72.0, 71.9, 68.9, 67.9, 67.4, 67.2, 66.0, 51.7, 46.9, 45.9.

Example 5: Synthesis of (2S,3R,4S,5R,6R)-2-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-6-(((2R,3R,4S,5R,6R)-4,5-bis(benzoyloxy)-6-(2-(benzyl((benzyloxy) carbonyl)amino)ethoxy)-2-((benzyloxy)methyl)tetrahydro-2H-pyran-3-yl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-8-yl)oxy)-5-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tert-butyldimethylsilyl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-6-((benzyloxy)methyl)tetrahydro-2H-pyran-3,4-diyl dibenzoate (5*)

[0079] Acceptor **4*** (1.0 g, 0.91 mmol), (2S,3R,4S,5R,6R)-5-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tert-butyldimethylsilyl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-6-((benzyloxy)methyl)-2-(ethylthio)tetrahydro-2H-pyran-3,4-diyl dibenzoate (**12***) (1.08 g, 1.091 mmol) and 20 g of dried 4A MS were taken in DCM (30 mL), stirred at rt for 15 min and then cooled to -10 °C. NIS (0.245 g, 1.09 mmol) and TfOH (0.016 mL, 0.18 mmol) were then added and the reaction mixture was for 1 h stirred at -5 °C. (2S,3R,4S,5R,6R)-5-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tert-butyldimethylsilyl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-6-((benzyloxy)methyl)-2-(ethylthio)tetrahydro-2H-pyran-3,4-diyl dibenzoate (0.45 g, 0.454 mmol, 0.5 equiv.) and NIS (0.102 mg, 0.454 mmol, 0.5 equiv.) were added again to the reaction mixture and stirred at -5 °C for 1 h, then warmed to 5 °C. After filtration through a Celite® bed, the RM was quenched with 10% $Na_2S_2O_3$ solution (25 mL) and then extracted with DCM (15 ml X 3). Combined organic layers were then washed with sat. $NaHCO_3$ solution (15 mL), brine (10 ml), dried over anhydrous Na_2SO_4, filtered and concentrated in vacuum to get white colored fluffy solid compound. Crude product was purified by silica column chromatography using 30-35% EtOAc in hexanes to get target **5*** as fluffy white solid (1.0 g, 54%).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.05 - 6.87 (m, 60H), 5.57 - 5.40 (m, 1 H), 5.39 - 5.24 (m, 2H), 5.21 - 4.86 (m, 7H), 4.60 (d, *J* = 7.9 Hz, 1 H), 4.54 - 4.15 (m, 9H), 4.07 - 3.85 (m, 3H), 3.81-3.70 (m, 3H), 3.60 (dd, *J* = 10.6, 4.8 Hz, 1 H), 3.52 (dd, *J* = 10.6, 4.9 Hz, 1 H), 3.47 - 3.14 (m, 9H), 3.13 - 2.96 (m, 3H), 2.64 (t, *J* = 10.4 Hz, 1H), 2.55 (t, *J* = 10.3 Hz, 1 H), 0.58 (s, 9H), -0.18 (s , 3H), -0.26 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.4, 165.1, 164.9, 164.5, 164.0, 156.4, 156.2, 138.4, 138.1, 137.1, 137.0, 133.2, 133.0, 132.6, 130.3, 130.1, 130.0, 129.96, 129.9, 129.8, 129.4, 129.1, 128.6, 128.5, 128.51, 128.4, 128.3, 128.2, 128.15, 128.1, 128.06, 128.0, 127.8, 127.3, 126.4, 126.1, 101.7, 101.5, 101.2, 101.18, 101.0, 100.2, 81.1, 79.5, 77.4, 75.9, 75.6, 75.1, 74.4, 73.7, 73.5, 73.4, 73.2, 72.4, 68.8, 67.9, 67.3, 66.2, 66.0, 51.7, 46.9, 45.9, 21.2, 17.9, -4.1, -4.9.

Example 6: Synthesis of (2S,3R,4S,5R,6R)-2-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-6-(((2R,3R,4S,5R,6R)-4,5-bis(benzoyloxy)-6-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-2-((benzyloxy)methyl)tetrahydro-2H-pyran-3-yl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-8-yl)oxy)-5-(((2R,4aR,6S,7R,8S,8aS)-7-(benzoyloxy)-8-hydroxy-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-6-((benzyloxy)methyl)tetrahydro-2H-pyran-3,4-diyl dibenzoate (6*)

[0080] Tetrasaccharide **5*** (1.0 g, 0.493 mmol) was taken in pyridine (10 mL) at 0 °C and added HF-pyridine (1.33 mL, 14.78 mmol) to it and stirred at rt for 36 hrs. The RM was washed with water and extracted with DCM (20 mL X 3). Combined organic layers were then washed with cold diluted HCl (50 mL X 2), saturated $NaHCO_3$ solution (50 mL), brine (10 mL), dried over Na_2SO_4, filtered and concentrated in vacuum to get crude product, which after purification on silica column chromatography using 50% EtOAc in hexanes yielded target compound as a white colored foam (0.71 g, 75%).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 - 6.94 (m, 60H), 5.56 - 5.41 (m, 1 H), 5.37 - 5.23 (m, 2H), 5.22 - 5.14 (m, 2H), 5.13 - 5.02 (m, 2H), 5.02 - 4.91 (m, 3H), 4.60 (dd, *J* = 7.9, 3.5 Hz, 2H), 4.56 - 4.48 (m, 1 H), 4.46 (d, *J* = 7.9 Hz, 1 H), 4.43 - 4.24 (m, 4H), 4.20 (d, *J* = 12.1 Hz, 2H), 4.09 - 3.88 (m, 3H), 3.85 - 3.70 (m, 3H), 3.61 (dd, *J* = 10.6, 4.7 Hz, 1 H), 3.54 - 3.31 (m, 5H), 3.31 - 3.15 (m, 5H), 3.16 - 2.97 (m, 3H), 2.65 (t, *J* = 10.4 Hz, 1 H), 2.56 (t, *J* = 10.4 Hz, 1 H), 2.38 (d, *J* = 3.5 Hz, 1 H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.3, 165.2, 165.0, 164.9, 164.7, 163.9, 138.2, 137.9, 136.8, 136.8, 133.4, 133.0, 132.5, 130.0, 129.9, 129.8, 129.7, 129.6, 129.5, 129.2, 129.0, 128.5, 128.4, 128.35, 128.3, 128.1, 128.0, 127.97, 127.9, 127.8, 127.7, 127.2, 126.2, 126.0, 101.6, 101.3, 101.0, 100.9, 100.8, 100.0, 80.4, 79.3, 78.3, 77.2, 76.6, 76.0, 75.5, 74.8, 74.3, 73.6, 73.2, 72.3, 72.1, 68.7, 67.6, 67.2, 66.1, 65.7, 51.5, 46.7, 45.7.

Example 7: Synthesis of (2S,3R,4S,5R,6R)-2-(((2R,4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-6-(((2R,3R,4S,5R,6R)-4,5-bis(benzoyloxy)-6-(2-(benzyl((benzyloxy) carbonyl)amino)ethoxy)-2-((benzyloxy)methyl)tetrahydro-2H-pyran-3-yl)oxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-8-yl)oxy)-6-((benzyloxy)methyl)-5-(((2R,4aR,6S,7R,8S,8aR)-7,8-bis(benzoyloxy)-2-phenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)tetrahydro-2H-pyran-3,4-diyl dibenzoate (7*)

[0081] Tetrasaccharide **6*** (0.65 g, 0.339 mmol) was taken in pyridine (5 mL), treated with BzCl (0.79 mL, 0.679 mmol) and stirred at rt for 16 hrs. The RM was diluted with water and extracted with DCM (20 mL X 3). Combined organics were washed with cold diluted HCl (10 mL X 2), saturated $NaHCO_3$ (10 mL X 2), water (10 mL), brine (20 mL), dried over Na_2SO_4, filtered, and concentrated in vacuum to get crude product, which was then triturated using cold MeOH (5 mL X 3) to get target **7*** as white solid (0.65 g, 95%).

^1H NMR (400 MHz, $CDCl_3$) δ 8.10 - 6.92 (m, 65H), 5.55 - 5.41 (m, 2H), 5.40 - 5.15 (m, 4H), 5.13 - 4.96 (m, 4H), 4.93 (s, 1 H), 4.67 (d, J = 7.9 Hz, 1 H), 4.61 (d, J = 7.9 Hz, 1 H), 4.55 - 4.47 (m, 1 H), 4.45 (d, J = 7.9 Hz, 1 H), 4.43 - 4.16 (m, 6H), 4.10 - 3.86 (m, 3H), 3.84 - 3.72 (m, 1 H), 3.65 - 3.34 (m, 6H), 3.33 - 3.15 (m, 6H), 3.11 - 3.06 (m, 3H), 2.67-2.59 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.6, 165.4, 165.2, 165.1, 164.8, 164.0, 156.3, 156.2, 138.1, 138.1, 138.0, 137.0, 136.8, 133.4, 133.1, 132.7, 130.2, 129.9, 129.9, 129.8, 129.8, 129.7, 129.5, 129.3, 129.3, 129.2, 129.1, 128.6, 128.6, 128.6, 128.5, 128.4, 128.35, 128.3, 128.2, 128.16, 128.1, 127.8, 127.3, 126.2, 126.1, 125.4, 101.5, 101.3, 101.2, 101.0, 100.1, 79.5, 78.4, 77.4, 76.3, 75.6, 74.3, 73.7, 73.5, 73.4, 73.1, 72.3, 72.3, 72.3, 68.8, 68.0, 67.8, 67.1, 66.24, 66.2, 51.7, 46.9, 45.8.

Example 8: Synthesis of (2S,3R,4S,5R,6R)-2-(((2S,3R,4S,5R,6R)-3-(benzoyloxy)-2-(((2R,3R,4S,5R,6R)-4,5-bis(benzoyloxy)-6-(2-(benzyl((benzyloxy carbonyl)amino)ethoxy)-2-((benzyloxy)methyl)tetrahydro-2H-pyran-3-yl)oxy)-5-hydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-4-yl)oxy)-6-((benzyloxy)methyl) -5-(((2S,3R,4S,5R,6R)-3,4-bis(benzoyloxy)-5-hydroxy-6-(hydroxymethyl) tetrahydro-2H-pyran-2-yl)oxy)tetrahydro-2H-pyran-3,4-diyl dibenzoate (8*)

[0082] Tetrasaccharide **7*** (0.54 g, 0.267 mmol) was taken in DCM (5 mL) at rt, treated with PTSA (10 mg, 0.053 mmol) and EtSH (0.297 mL, 4.01 mmol), and stirred for 4 hrs. The RM was quenched with Et_3N (1 mL), evaporated in vacuum and purified using 60% EtOAc in hexanes to get target **8*** as white colored solid product (0.46 g, 93%).

^1H NMR (400 MHz, $CDCl_3$) δ 8.02 - 7.81 (m, 10H), 7.59 - 6.91 (m, 45H), 5.52 (t, *J* = 9.2 Hz, 1 H), 5.47 - 5.15 (m, 5H), 5.12 - 4.90 (m, 3H), 4.62 (d, *J* = 7.6 Hz, 1 H), 4.61 - 4.57 (m, 1 H), 4.52 (d, *J* = 7.7 Hz, 1 H), 4.47 - 4.36 (m, 3H), 4.34 - 4.18 (m, 4H), 4.13 - 3.99 (m, 2H), 3.95 - 3.73 (m, 2H), 3.69 (td, *J* = 9.1, 4.3 Hz, 1 H), 3.61 - 3.50 (m, 3H), 3.27 (m, 1 H), 3.11 - 2.95 (m, 3H), 2.89 (d, *J* = 4.3 Hz, 1 H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 167.4, 165.36, 165.23, 165.2, 165.2, 164.9, 163.8, 156.3, 156.2, 138.1, 137.3, 133.7, 133.6, 133.3, 133.0, 132.7, 130.1, 130.0, 129.9, 129.8, 129.7, 129.6, 129.51, 129.5, 129.2, 129.0, 128.9, 128.8, 128.7, 128.69, 128.6, 128.5, 128.4, 128.3, 128.13, 128.1, 127.8, 127.3, 127.2, 101.3, 101.1, 100.8, 100.3, 85.1, 77.4, 77.0, 76.0, 75.8, 74.8, 74.7, 74.4, 73.8, 73.6, 73.3, 72.2, 71.7, 71.7, 69.4, 69.3, 68.9, 67.6, 67.1, 62.5, 61.6, 51.7, 46.9, 45.9. MALDI-TOF: calculated for $C_{104}H_{99}NNaO_{30}$ $[M + H]^+$, 1864.61, found 1864.77.

Example 9: Synthesis of (2S,3S,4S,5R,6R)-4,5-bis(benzoyloxy)-6-(((2R,3R,4S,5R,6S)-4,5-bis(benzoyloxy)-6-(((2R,3R,4S,5S,6S)-3-(benzoyloxy)-2-(((2R,3R,4S,5R,6R)-4,5-bis(benzoyloxy)-6-(2-(benzyl((benzyloxy)carbonyl) amino)ethoxy)-2-((benzyloxy)methyl)tetrahydro-2H-pyran-3-yl)oxy)-6-carboxy-5-hydroxytetrahydro-2H-pyran-4-yl)oxy)-2-((benzyloxy)methyl)tetrahydro-2H-pyran-3-yl)oxy)-3-hydroxytetrahydro-2H-pyran-2-carboxylic acid (9*)

[0083] Tetrasaccharide **8*** (0.125 g, 0.068 mmol) was taken in a mixture DCM/water (7 ml, 5:2) and cooled to 0 °C. After addition of tempo (2,1 mg, 0.014 mmol), followed by BAIB (0.109 g, 0.339 mmol), the RM was stirred at 0 °C for 20 min and slowly warmed up to rt and further stirred at rt for 2 h (total 3h). The RM was diluted with DCM (5 mL) and water (5 mL), and the layers were separated. The aqueous layer was extracted with DCM (5 mL X 4). The combined organic layers were dried over Na_2SO_4, filtered, concentrated in vacuum to provide the crude product, which was then purified on silica column using 10-15% acetone in DCM + 1-2% AcOH to yield after evaporation desired product **9*** as a yellowish solid (0.09 g, 71 %).

^1H NMR (400 MHz, CD_3OD) δ 8.00 - 6.52 (m, 55H), 5.61 - 5.29 (m, 3H), 5.27 - 5.05 (m, 3H), 4.99 (d, *J* = 9.8 Hz, 1 H), 4.94 (d, *J* = 8.0 Hz, 1 H), 4.88- 4.83 (m, 2H), 4.76 (d, *J* = 7.9 Hz, 1H), 4.53 (d, *J* = 8.0 Hz, 1.5H), 4.43 (dd, *J* = 12.1, 4.8 Hz, 1 H), 4.37 (d, *J* = 7.8 Hz, 0.5H), 4.33 - 4.02 (m, 7H), 3.87 - 3.39 (m, 11H), 3.26 - 3.03 (m, 4H). ^{13}C NMR (101 MHz, CD_3OD) δ 170.4, 170.35, 167.2, 167.18, 166.9, 166.7, 166.5, 166.4, 165.7, 158.0, 157.7, 139.2, 138.8, 138.6, 134.8, 134.5, 134.4, 134.1, 134.0, 131.4, 130.8, 130.8, 130.7, 130.6, 130.5, 130.3, 130.1, 129.8, 129.7, 129.53, 129.5, 129.4, 129.3, 129.2, 129.1, 128.8, 128.6, 128.2, 102.2, 101.9, 101.8, 101.7, 84.2, 77.6, 76.7, 76.4, 75.4, 74.6, 74.4, 73.7, 73.5, 73.3, 71.5, 71.1, 69.5, 69.4, 68.5, 68.31, 68.3, 52.6, 52.5, 47.10. MALDI-TOF: calculated for $C_{104}H_{95}NO_{32}$ $[M + H]^+$, 1892.57, found 1892.71.

Example 10: Synthesis of (2S,3S,4S,5R,6R)-6-(((2R,3S,4R,5R,6R)-6-(2-(benzyl((benzyloxy)carbonyl)amino)ethoxy)-2-((benzyloxy)methyl)-4,5-dihydroxytetrahydro-2H-pyran-3-yl)oxy)-4-(((2S,3R,4R,5S,6R)-6-((benzyloxy) methyl)-5-(((2R,3R,4S,5S,6S)-6-carboxy-3,4,5-trihydroxytetrahydro-2H-pyran-2-yl)oxy)-3,4-dihydroxytetrahydro-2H-pyran-2-yl)oxy)-3,5-dihydroxytetrahydro-2H-pyran-2-carboxylic acid (10*)

[0084] Tetrasaccharide **9*** (0.09 g, 0.48 mmol) was taken in MeOH (5 mL), treated with 0.5 M solution NaOMe in methanol (4.81 mL, 2.405 mmol) and stirred at rt for 24 hrs. The RM was then neutralized with Amberlite® 120 H^+ resin to give a clear solution, which was filtered through a cotton plug, washed thoroughly with MeOH and evaporated in vacuum to give a yellowish gum. The yellowish gum was taken in diethyl Et_2O and triturated to provide a pale yellowish solid. The ether layer was then decanted (3 X 3ml). The pale yellowish solid was triturated with DCM to give a white solid, which was then dried under vacuum to yield target **10*** as white powder (0.05g, 91 %). ^{1}H NMR (400 MHz, CD_3OD) δ 7.49 - 7.06 (m, 20H), 5.14 (d, *J* = 9.5 Hz, 2H), 4.68 - 4.51 (m, 6H), 4.47 - 4.37 (m, 3H), 4.27 - 4.17 (m, 1 H), 3.96 - 3.34 (m, 23H), 3.30 - 3.19 (m, 2H). LCMS (ESI): calculated for $C_{55}H_{66}NO_{25}$ [M - H]$^+$, 1140.39, found 1140.2.

Example 11: Synthesis of (2S,3S,4S,5R,6R)-6-(((2R,3S,4R,5R,6R)-6-(2-aminoethoxy)-4,5-dihydroxy-2-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)oxy)-4-(((2S,3R,4R,5S,6R)-5-(((2R,3R,4S,5S,6S)-6-carboxy-3,4,5-trihydroxytetrahydro-2H-pyran-2-yl)oxy)-3,4-dihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-2-yl)oxy)-3,5-dihydroxytetrahydro-2H-pyran-2-carboxylic acid (11*)

[0085] A mixture of tetrasaccharide **10*** (50 mg) and 10% Pd/C (100 mg) in MeOH (2 mL) was stirred at rt under hydrogen for 18 h. The RM was then filtered through PTFE hydrophobic filters and washed thoroughly with methanol, water-methanol, and later with NH_4OH in methanol. Evaporation of the filtrate and drying under vacuum provided target **11*** as white glassy film (23 mg, 71 %).
^{1}H NMR (400 MHz, D_2O) δ 4.84 (d, *J* = 8.0 Hz, 1 H), 4.56 (d, *J* = 8.0 Hz, 2H), 4.53 (d, *J* = 7.9 Hz, 1 H), 4.14 (dt, *J* = 11.5, 4.9 Hz, 1 H), 4.04 - 3.92 (m, 3H), 3.89 - 3.75 (m, 5H), 3.72 - 3.49 (m, 10H), 3.43 - 3.34 (m, 3H), 3.29 (t, *J* = 5.1 Hz, 2H). ^{13}C NMR (101 MHz, D_2O) δ 175.4, 175.2, 102.3, 102.2, 102.0, 101.8, 82.7, 78.9, 78.6, 75.7, 75.2, 74.8, 74.7, 74.1, 73.1, 72.9, 72.7, 71.6, 70.1, 65.7, 60.0 39.3. HRMS (ESI): calculated for $C_{26}H_{44}NO_{23}$ [M + H]$^+$, 738.23, found 738.27.

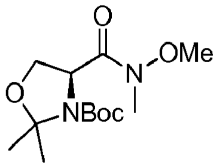
Example 12: Synthesis of (2S,3R,5R,6R)-5-(((4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tert-butyldimethylsilyl)oxy)-2-phenylhexahydropyranophenyl hexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-6-((benzyloxy)methyl)-2-(ethylthio) tetrahydro-2H-pyran-3,4-diyl dibenzoate (12*)

[0086] A mixture of (2S,3R,4S,5R,6R)-6-((benzyloxy)methyl)-2-(ethylthio)-5-hydroxytetrahydro-2H-pyran-3,4-diyl dibenzoate (4.00 g, 7.654 mmol, 1.0 eq.) and (4aR,6R,7R,8aR)-8-((tert-butyldimethylsilyl)oxy)-2-phenyl-6-(2,2,2-trichloro-1-iminoethoxy)hexahydropyrano[3,2-d][1,3]dioxin-7-yl benzoate (6.28 g, 9.95 mmol, 1.3 eq.) in DCM (140 mL) was stirred under an Ar atmosphere for 30 min. The reaction mixture was cooled (-20 °C) and TMSOTf (0.16 mL, 0.880 mmol, 0.115 eq.) was added. After stirring for 45 min, the reaction mixture was quenched by the addition of Et_3N (1.0 mL). The organic solution was concentrated under *vacuo*. The resulting dark yellow oil was purified by flash chromatography over silica gel (EtOAc/hexanes, 1/3, v/v) to give (2S,3R,5R,6R)-5-(((4aR,6S,7R,8S,8aR)-7-(benzoyloxy)-8-((tertbutyldimethylsilyl)oxy)-2-phenylhexahydro pyranophenylhexahydropyrano[3,2-d][1,3]dioxin-6-yl)oxy)-6-((benzyloxy)methyl)-2-(ethylthio)tetrahydro-2H-pyran-3,4-diyl dibenzoate **12*** (6 g, 79%) as a colorless solid:
R_f = 0.5 (EtOAc/hexanes, 3/7, v/v). ^{1}H NMR (400 MHz, $CDCl_3$) δ -0.19 (s, 3H), -0.11 (s, 3H), 0.63 (s, 9H), 1.20 (t, *J* = 7.4 Hz, 3H), 2.67 (m, 2H), 3.15 (td, *J* = 9.7 Hz, 4.9 Hz, 2H), 3.28 (t, *J* = 9.2 Hz, 1 H), 3.53 - 3.37 (m, 1 H), 3.74 - 3.55 (m, 1 H), 3.79 (t, *J* = 9.0 Hz, 1 H), 4.19 (t, *J* = 9.5 Hz, 1 H), 4.37 (d, *J* = 12.2 Hz, 1 H), 4.57 (d, *J* = 10.0 Hz, 1H), 4.59(dd, *J* = 15.1, 9.0 Hz, 2H), 4.67 (d, *J* = 12.2 Hz, 1H), 5.12(dd, *J* = 8.9, 8.2 Hz, 1 H), 5.21 (s, 1 H), 5.41 (t, *J* = 9.8 Hz, 1 H), 5.63 (t, *J* = 9.3 Hz, 1 H), 7.29 - 7.72 (m, 19H), 7.88 - 8.03 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 165.27, 165.07, 164.45, 138.16, 137.00, 133.14, 133.10, 132.97, 130.21, 129.79, 129.77, 129.75, 129.34, 128.99, 128.51, 128.38, 128.28, 128.22, 128.05, 128.02, 127.99, 126.21, 101.57, 101.06, 83.39, 81.05, 78.70, 77.43, 77.11, 76.80, 75.41, 74.93, 74.52, 73.49, 72.90, 70.59, 67.86, 67.45, 65.97, 25.43, 24.08, 17.80, 14.85, -4.20, -4.97.

<u>B. Synthesis of the glycosphingolipid</u>

Example 13: Synthesis of (*S*)-3-(*tert*-Butoxycarbonyl)-*N*-methoxy-2,2, *N*-trimethyloxazolidine-4-carboxamide (13*)

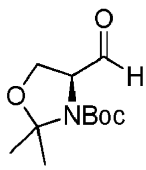
[0087]



[0088] To a solution of L-Boc-serine (12.33 g, 60.1 mmol) in DCM (240 mL) were added *N*,O-dimethylhydroxylamine hydrochloride (6.04 g, 61.9 mmol) and *N*-methylmorpholine (6.8 mL, 61.9 mmol) at 0 °C. To this solution was added *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (11.86 g, 61.9 mmol) portionwise over a period of 20 min. and the solution was stirred for another 1 h. Then, aqueous HCl solution (1.0 M, 30 mL) was added and the aqueous layer was extracted with CH_2Cl_2 (2 x 100 mL). The combined organic layers were washed with saturated aqueous $NaHCO_3$ solution (30 mL) and the aqueous layer was again extracted with CH_2Cl_2 (100 mL). The combined organic layers were dried over $MgSO_4$ and the solvent was removed *in vacuo* to obtain the corresponding Weinreb amide (14.07 g, 94%) as white solid.
R_f = 0.3 (EtOAc);
^{1}H NMR (250 MHz, $CDCl_3$) δ 5.60 (d, *J* = 6.0 Hz, 1 H), 4.77 (br s, 1 H), 1.42 (s, 9 H), 3.80 (d, *J* = 3.3 Hz, 2 H), 3.76 (s, 3 H), 3.21 (s, 3 H), 2.66 (br s, 1 H).
The crude product was dissolved in acetone (180 mL) to which 2,2-dimethoxypropane (57 mL) and $BF_3 \cdot Et_2O$ (0.5 mL) were added. The orange solution was stirred for 90 min. at r.t. and then quenched with Et_3N (1.2 mL) and solvents removed *in vacuo.* The crude product was purified by flash column chromatography on silica gel (gradient EtOAc/cyclohexane = 1:2 → 1:1) to yield isopropylidene-protected Weinreb amide **13*** (15.32 g, 89% over two steps) as a white solid. The NMR spectra consist of two sets of signals due to the presence of rotamers.
$[\alpha]_D^{r.t.}$ = -30.9 (c = 1, $CHCl_3$); R_f = 0.45 (Hexanes/EtOAc = 1:1); IR (film) ν_{max} 2976, 2938, 1702, 1682, 1364, 1167, 1098, 998, 848, 768, 716; ^{1}H NMR (250 MHz, *$CDCl_3$)* δ 4.77 (dd, *J* = 9.8, 2.8 Hz, 1 H), 4.70 (dd, 7.5, 3.8, Hz, 1 H), 4.18 (dd, *J* = 7.5, 4.0 Hz, 1 H), 4.15 (dd, *J* = 7.8, 3.8 Hz, 1 H), 3.95 (dd, *J* = 9.3, 3.0 Hz, 1 H), 3.91 (dd, *J* = 9.0, 3.5 Hz), 3.72 (s, 3 H), 3.68 (s, 3 H), 3.19 (s, 6 H), 1.68 (s, 3 H), 1.66 (s, 3 H), 1.54 (s, 3 H), 1.50 (s, 3 H), 1.47 (s, 9 H), 1.39 (s, 9 H); ^{13}C NMR (101 MHz, $CDCl_3$) δ 171.4, 170.7, 152.2, 151.4, 95.1, 94.5, 80.6, 80.0, 66.2, 66.0, 61.3, 61.3, 57.9, 57.8, 28.5, 28.4, 25.8, 25.5, 24.8, 24.6; HR ESI Calcd for $C_{13}H_{24}N_2O_5$ [M+Na$^+$]: 311.1577 found: 311.1582.

Example 14: Synthesis of *tert*-Butyl (*S*)-4-formyl-2,2-dimethyloxazolidine-3-carboxylate (14*)

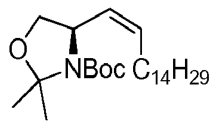
[0089]



[0090] To a solution of Weinreb amide **13*** (8.00 g, 27.7 mmol) in THF (100 mL) at 0°C were added $LiAlH_4$ (1.0 M in THF, 13.9 mL, 13.9 mmol) dropwise and the solution was stirred for 1 h at 0 °C. After 1 h, the solution was cooled to -10 °C and $KHSO_4$ (1M, 70 mL) was added carefully and the solution was diluted with Et_2O (170 mL). The mixture was allowed to warm to r.t. and stirred for 30 min. The organic layer was separated, dried over $MgSO_4$, filtered and the solvent was removed *in vacuo* to yield *Garner's* aldehyde **14*** as a pale yellow oil (6.24 g, > 95% purity by ^{1}H NMR). The NMR spectra consist of two sets of signals due to the presence of rotamers. ^{1}H NMR (250 MHz, $CDCl_3$) δ 9.58 (d, J = 0.8 Hz, 1 H), 9.52 (d, J = 2.5 Hz, 1 H), 4.32 (m, 1 H), 4.16 (m, 1 H), 4.06 (m, 4 H), 1.53-1.63 (m, 12 H), 1.49 (s, 9 H), 1.40 (s, 9 H). All spectral data in good accordance with reported data *(Synthesis* **1998**, 1707). The crude product was used in the subsequent reaction without further purification.

Example 15: Synthesis of (4R,1'Z)-3-(tert-Butoxycarbonyl)-2,2-dimethyl-4-(1'-hexadecenyl)oxazolidine (15*)

[0091]



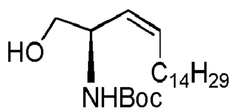
[0092] n-BuLi (1.6 M in hexane, 25.2 mL, 40.3 mmol) was added dropwise to pentadecyl-triphenylphosphonium bromide **16*** (24.03 g, 43.4 mmol) in anhydrous THF (220 mL) at -78 °C. The resulting orange solution was allowed to warm to 0 °C and stirred for another 30 min. The solution was then cooled to -78 °C and *Garner's* aldehyde **14*** (6.23 g, 27.2 mmol) in anhydrous THF (30 mL) was added slowly. After being stirred for 2 h at r.t., the reaction was diluted with sat. aq. NH_4Cl solution (35 mL) and the layers were separated. The aqueous layer was extracted with CH_2Cl_2 (3 x 35 mL) and the combined organic extracts were washed with saturated aqueous NaCl solution (50 mL), dried over $MgSO_4$ and concentrated *in vacuo.* Purification by flash column chromatography on silica (EtOAc/Hexanes = 1:2) gel gave (Z)-olefin **15*** as a pale yellow oil (11.27 g, 78%).
$[\alpha]_D^{r.t.}$ = +45.2 (c = 1, $CHCl_3$); R_f = 0.40 (EtOAc/Hexanes = 1:2); IR (film) ν_{max} 2923, 2854, 1699, 1457, 1382, 1251, 1175, 1093, 1056, 850, 768 cm^{-1}; ^1H NMR (250 MHz, *$CDCl_3$*) δ 5.27-5.40 (m, 2 H), 4.58 (br s, 1 H), 4.02 (dd, *J* = 6.3, 8.8 Hz, 1 H), 3.61 (dd, *J* = 3.3, 8.5 Hz, 1 H), 1.96 (br s, 2 H), 1.23-1.56 (m, 39 H), 0.85 (t, *J* = 7 Hz, 3 H); ^{13}C NMR (101 MHz, *$CDCl_3$*) δ 152.1, 130.9, 130.4, 94.1, 79.8, 69.2, 54.7, 32.1, 29.9, 29.8, 29.8, 29.8, 29.7, 29.6, 29.5, 29.4, 28.6, 28.6, 27.6, 22.8, 14.2; HR ESI Calcd for $C_{26}H_{49}NO_3$ [M+Na+]: 446.3605 found: 446.3614. All spectral data were in good accordance with reported data (*Synthesis* **2004**, 847).
The desired (Z)-olefin can easily be distinguished from the undesired (*E*)-olefin byproduct, when considering the olefinic protons in the ^1H NMR spectrum: **Z-15*** ^1H NMR (250 MHz, *$CDCl_3$*) δ 4.05 (dd, *J* = 6.3, 8.6 Hz, I H), 3.64 (dd, *J* = 3.3, 8.6 Hz, 1 H) cf. *E*-**15*** ^1H NMR (250 MHz, *$CDCl_3$*) δ4.01 (dd, *J* = 6.1, 8.7 Hz, 1 H), 3.71 (dd, *J* = 2.1, 8.7 Hz, 1 H).

Example 16:Synthesis of pentadecyltriphenylphosphonium bromide (16*)

[0093] A solution of 1-bromopentadecane (30.0 g, 103 mmol) and triphenylphosphine (27.02 g, 103 mmol) in MeCN (200 mL) was refluxed at 80 °C for five days. After removal of the solvent *in vacuo,* Et_2O (30 mL) was added and the resulting white precipitate was filtered off, washed with Et_2O and dried on high vacuum for 24 h to give pentadecyltriphenylphosphonium bromide (**16***) (49.66 g, 87%) as a white powder.

Example 17: Synthesis of (2R,3Z)-2-(tert-Butoxycarbonyl)amino-3-octadecen-1-ol (17*)

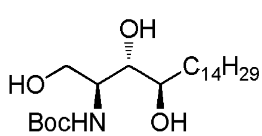
[0094]



[0095] *Para*-Toluensulfonic acid (371 mg, 1.95 mmol) was added to a stirred solution of (Z)-olefin **15*** (5.00 g, 12.2 mmol) in MeOH/water (50 mL total, ratio = 9:1 v/v) and the mixture was stirred for 68 h. The reaction mixture was concentrated *in vacuo* to yield a white solid, which was re-dissolved in CH_2Cl_2 (100 mL). The solution was washed with brine (30 mL), dried over $MgSO_4$ and the solvent was removed *in vacuo.* Purification by flash column chromatography on silica gel (gradient cyclohexane/EtOAc = 4:1 → 2:1) afforded alcohol **17*** as a white solid (2.71 g, 59%). All spectral data were in good accordance with reported data (*Synthesis* **2004**, 847).

Example 18: Synthesis of (2S,3S,4R)-2-(tert-Butoxycarbonyl)amino-1,3,4-octadecanetriol (18*)

[0096]

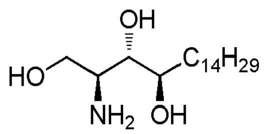


[0097] Alcohol **17*** (1.50 g, 3.91 mmol) was dissolved in *t*-BuOH/water (38 mL total, ratio 1:1) and methanesulfonamide

(371 mg, 3.91 mmol) was added. The reaction mixture was cooled to 0 °C and AD-mix-β (5.48 g) was added. The resulting mixture was stirred at 0 °C for 41 h and another 7 h at r.t., then it was quenched by the addition of solid Na_2SO_3 (6.0 g) and left to stir for 30 min. Extraction with EtOAc (3 x 40 mL) followed. The organic extracts were washed with NaOH (1 M, 20 mL), water (20 mL) and saturated aqueous NaCl solution (20 mL), dried over $MgSO_4$ and solvents were removed *in vacuo.* Purification by flash column chromatography on silica gel (gradient EtOAc/cyclohexane = 1:1 → 2:1) provided triol **18*** as a white solid (1.05 g, 64%). All spectral data were in good accordance with reported data (*Synthesis* **2004**, 847).

Example 19: Synthesis of (2*S*,3*S*,4*R*)-2-aminooctadecane-1,3,4-triol (19*)

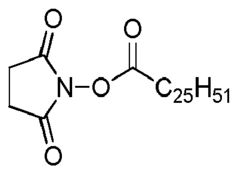
[0098]



[0099] Triol **18*** (60 mg, 0.14 mmol) was dissolved in TFA/H_2O (20:1, 0.6 mL) and stirred at r.t. for 30 min. The solution was diluted with CH_2Cl_2 (1.5 mL) and then carefully neutralized (to pH ~ 8) with saturated aqueous $NaHCO_3$ solution (10 mL) upon which precipitation of a white solid occurred. The white solid removed by filtration, washed with water (3 x 10 mL) and dried under reduced pressure. Recrystallization from MeCN yielded phytosphingosine **19*** as a white powder (38 mg, 82%). All spectral data were in good accordance with reported data (*Synthesis* **2004,** 847).

Example 20: Synthesis of hexacosanoic N-hydroxysuccinimidyl ester (20*)

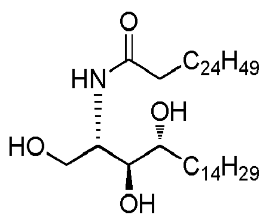
[0100]



[0101] To a solution of hexacosanoic acid (121 mg, 0.304 mmol) in CH_2Cl_2 (4 mL) were added 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (0.058 mL, 0.33 mmol) and *N*-hydroxysuccinimide (42 mg, 0.37 mmol). The reaction mixture was heated to 40 °C, stirred for 3 h and then quenched with water (4 mL). The solution was diluted with Et_2O (8 mL) and the two layers were separated. The aqueous phase was extracted with Et_2O (8 mL) and the combined organic layers were washed with saturated aqueous NaCl solution (5 mL), dried over $MgSO_4$ and filtered. After removal of the solvent *in vacuo*, *N*-hydroxysuccinimidyl ester **20*** was obtained as a white solid (85 mg, 57%).

Example 21: Synthesis of *N*-((2S,3S,4R)-1,3,4-trihydroxyoctadecan-2-yl)heptacosanamide (21*)

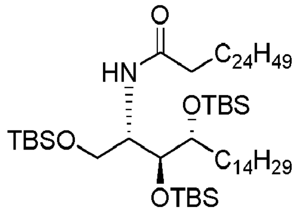
[0102]



[0103] To a solution of phytosphingosine **19*** (15 mg, 0.047 mmol) in anhydrous THF (1 mL) was added succinimidyl ester **20*** (34 mg, 0.071 mmol) and Et_3N (24 μL, 0.14 mmol). The solution was heated to 50 °C and stirred for 20 h. EtOAc (5 mL) was added and the resulting suspension was centrifuged (30 min., 3000 rpm). The white precipitate was removed by filtration and dried under reduced pressure to yield amide **21*** (29 mg, 88%).

Example 22: Synthesis of (2*S*,3*S*,4*R*)-1,3,4-Tri-t-butyl-dimethylsilyloxy-2-hexacosanoylamino-1-octadecane (22*)

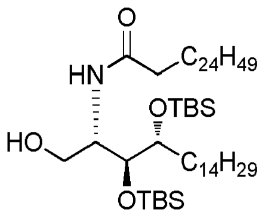
[0104]



[0105] To a stirred suspension of amide **21*** (25 mg, 0.036 mmol) in CH_2Cl_2 (1.2 mL) was added TBSOTf (43 μL, 0.18 mmol) and 2,6-lutidine (65 μL, 0.054 mmol) at 0 °C. The reaction mixture was stirred at r.t. for 2 h. The reaction was quenched with MeOH (0.2 mL). The mixture was diluted with Et_2O (2 mL) and washed with saturated aqueous $NaHCO_3$ solution (1 mL) and saturated aqueous NaCl solution (1 mL). The organic layer was dried over $MgSO_4$, filtered and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (cyclohexane/Et_2O = 15:1) to give TBS protected ceramide **22*** as a colorless oil (27 mg, 71%). All spectral data were in good accordance with reported data (*Synthesis* **2004**, 847).

Example 23: Synthesis of (2*S*,3*S*,4R)-3,4-Bis-*tert*-butyldimethylsilyloxy-2-hexacosanoylamino-4-octadecanol (23*)

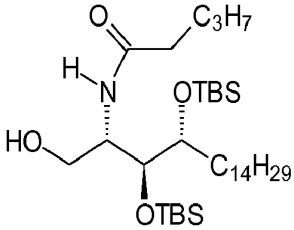
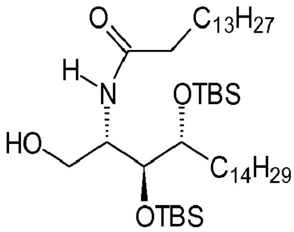
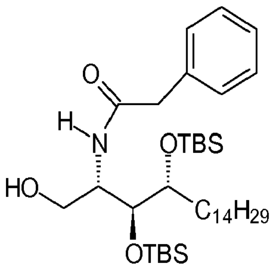
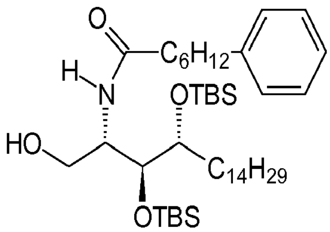
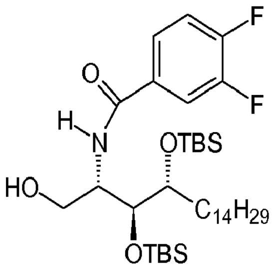
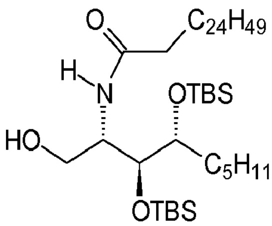
[0106]



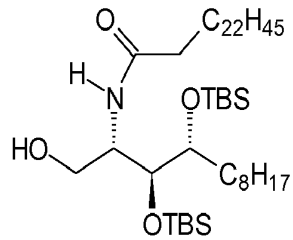
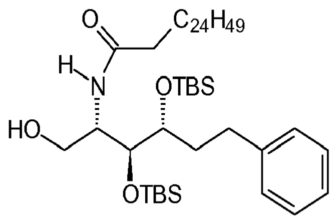
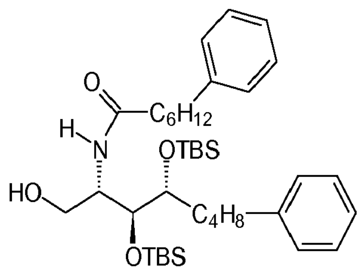
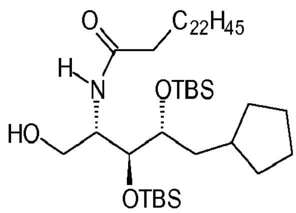
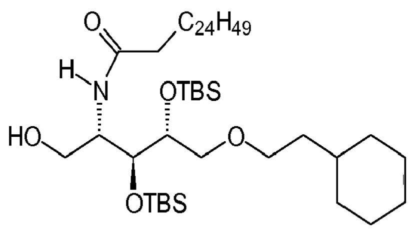
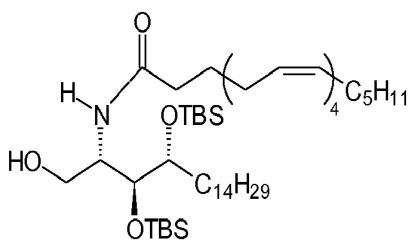
[0107] To a solution of ceramide **22*** (90 mg, 0,087 mmol) in THF (2 mL) was added TFA (40 μL, 0.519 mmol) in water (0.5 mL, 27.8 mmol) at -10 °C. The reaction mixture was left to warm to 10 °C over a period of 2 h. Then, the reaction mixture was quenched by the addition of saturated aqueous $NaHCO_3$ solution until neutral pH was reached. The resulting mixture was diluted with Et_2O (10 mL), washed with water (10 mL), saturated aqueous $NaHCO_3$ (10 mL), saturated aqueous NaCl solution (10 mL), and dried over $MgSO_4$. The solvent was removed *in vacuo* and the crude product was purified by flash column chromatography on silica gel (gradient EtOAc/cyclohexane = 10:1 → 5:1) to yield alcohol **23*** (68 mg, 85%) as a colorless oil.

$[\alpha]_D^{r.t.}$ = -11.6 (*c* = 1, $CHCl_3$); R_f = 0.3 (cyclohexane/EtOAc = 4:1); IR (film) ν_{max} 3285, 2920, 2851, 1645, 1465, 1253, 1034, 835, 776, 721, 680 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 6.27 (d, *J* = 7.8 Hz, 1 H), 4.21 (dd, *J* = 11.3, 3.0 Hz, 1 H), 4.06 (td, *J* = 6.5, 3.2 Hz, 1H), 3.91 (t, *J* = 2.8 Hz, 1 H), 3.76 (td, *J* = 6.4, 2.6 Hz, 1 H), 3.59 (dd, *J* = 11.3, 3.7 Hz, 1H), 3.15 (dd, *J* = 9.0, 3.3 Hz, 1 H), 2.20 - 2.16 (m, 2H), 1.67 - 1.47 (m, 6H), 1.45 - 1.16 (m, 68H), 0.92 (s, 9H), 0.90 (s, 9H), 0.87 (t, *J* = 6.9 Hz, 6H), 0.11 (s, 6H), 0.08 (s, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 172.62, 77.42, 76.36, 63.62, 51.3, 36.93, 34.42, 31.92, 29.80, 29.70, 29.63, 29.53, 29.48, 29.37, 26.00, 25.94, 25.81, 25.60, 22.69, 18.14, 18.12, 14.13, -3.76, -4.08, -4.53, -4.91; HR ESI Calcd for $C_{56}H_{117}NO_4Si_2$ $[M+Na^+]$: 924.8594 found: 924.8604.

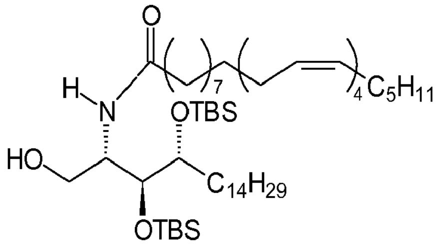
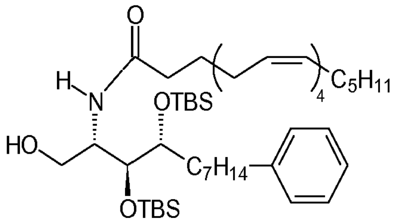
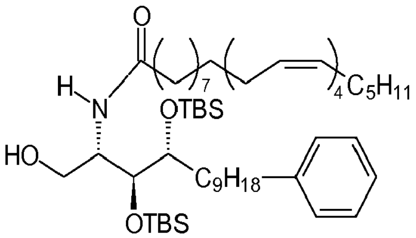
[0108] Alcohols **23*a**-**23*o** were synthesized according to the procedure described at example 15-23 starting from common aldehyde **14***:

Comp.	Structure	HRMS
23*a		$C_{35}H_{75}NO_4Si_2$ Calc.: 631.1544 [M+H$^+$] Found: 631.1521
23*b		$C_{45}H_{95}NO_4Si_2$ Calc.: 771.4206 [M+H$^+$] Found: 771.4181
23*c		$C_{38}H_{73}NO_4Si_2$ Calc.: 665.1707 [M+H$^+$] Found: 665.1733
23*d		$C_{43}H_{83}NO_4Si_2$ Calc.: 735.3038 [M+H$^+$] Found: 735.3001
23*e		$C_{37}H_{69}F_2NO_4Si_2$ Calc.: 687.1250 [M+H$^+$] Found: 687.1212
23*f		$C_{47}H_{99}NO_4Si_2$ Calc.: 799.4738 [M+H$^+$] Found: 799.4791

(continued)

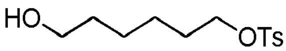
Comp.	Structure	HRMS
23*g		$C_{48}H_{101}NO_4Si_2$ Calc.: 813.5004 [M+H$^+$] Found: 813.4962
23*h		$C_{50}H_{97}NO_4Si_2$ Calc.: 833.4901 [M+H$^+$] Found: 833.4913
23*i		$C_{39}H_{67}NO_4Si_2$ Calc.: 671.1338 [M+H$^+$] Found: 671.1306
23*j		$C_{46}H_{95}NO_4Si_2$ Calc.: 783.4313 [M+H$^+$] Found: 783.4281
23*k		$C_{51}H_{105}NO_5Si_2$ Calc.: 869.5638 [M+H$^+$] Found: 869.5604
23*l		$C_{50}H_{97}NO_4Si_2$ Calc.: 833.4901 [M+H$^+$] Found: 833.4887

(continued)

Comp.	Structure	HRMS
23*m		$C_{56}H_{109}NO_4Si_2$ Calc.: 917.6498 [M+H$^+$] Found: 917.6528
23*n		$C_{49}H_{87}NO_4Si_2$ Calc.: 811.4000 [M+H$^+$] Found: 811.4063
23*o		$C_{57}H_{103}NO_4Si_2$ Calc.: 923.6129 [M+H$^+$] Found: 923.6097

Example 24: Synthesis of 6-hydroxyhexyl 4-methylbenzenesulfonate (24*)

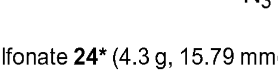
[0109]



[0110] To a solution of hexane-1,6-diol (10.0 g, 85 mmol) in DCM (200 mL) was added 4-methylbenzene-1-sulfonyl chloride (17.8 g, 93 mmol) dissolved in pyridine (100 mL) at 5° C dropwise over 15 min. The reaction mixture was warmed to r.t. over the period of 5 h. Solvents were removed *in vacuo* and the crude was purified by silica flash column chromatography (gradient hexanes/EtOAc = 1:0 → 1:1) to afford monotosylated hexanediol **24*** (6.5 g, 28%) as a colorless oil. R_f = 0.55 (Hexanes/EtOAc = 1:1); IR (film) ν_{max} 3381, 2935, 2862, 1598, 1461, 1352, 1172, 959, 921, 813, 661 cm^{-1}; ^{1}H NMR (400 MHz, *CDCl$_3$)* δ 7.76 - 7.71 (m, 2H), 7.29 (dt, *J* = 4.3, 1.2 Hz, 2H), 3.97 (t, *J* = 6.5 Hz, 2H), 3.55 (t, *J* = 6.5 Hz, 2H), 2.40 (s, 3H), 1.65 - 1.56 (m, 2H), 1.55 (s, 1H), 1.52 - 1.41 (m, 2H), 1.36-1.18 (m, 4H); ^{13}C NMR (101 MHz, *CDCl$_3$)* δ 144.7, 133.1, 129.8, 127.8, 70.5, 62.6, 32.4, 28.7, 25.1, 25.0, 21.6; HR ESI Calcd for $C_{13}H_{20}O_4S$ [M+Na$^+$]: 295.0975 found: 295.0968.

Example 25: Synthesis of 6-azidohexan-1-ol (25*)

[0111]

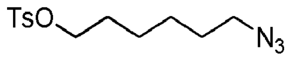


[0112] 6-Hydroxyhexyl 4-methylbenzenesulfonate **24*** (4.3 g, 15.79 mmol) was dissolved in DMF (23 mL) and sodium azide (1.75 g, 26.8 mmol) was added. The mixture was heated to 55 °C and after 16 h it was cooled to r.t. and diluted with water (150 mL). The mixture was extracted three times with CH_2Cl_2 and washed with saturated aqueous NaCl solution. The organic layer was dried over $MgSO_4$ and solvents were removed *in vacuo.* The crude product was purified by silica flash column chromatography on silica gel (gradient hexanes/EtOAc = 1:0 → 1:1) to afford 6-azidohexan-1-ol

25* (2.2 g, 97%) as a colorless oil.
R_f = 0.50 (Hexanes/EtOAc = 2:1); IR (film) v_{max} 3329, 2935, 2891, 2090, 1256, 1349, 1258, 1055, 910, 731 cm^{-1}; ^1H NMR(400 MHz, *CDCl₃*)δ 3.63(t, *J*=6.5Hz, 2H), 3.25 (t, J = 6.9 Hz, 2H), 1.64 - 1.51 (m, 4H), 1.43 - 1.32 (m, 4H); ^{13}C NMR (101 MHz, *$CDCl_3$*) δ 62.8, 51.5, 32.6, 28.9, 26.6, 25.4; HR ESI Calcd for $C_6H_{13}N_3O$ [M+Na$^+$]: 166.0951 found: 166.0945.

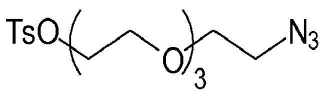
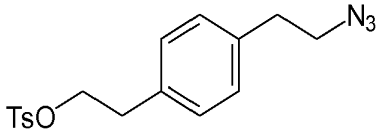
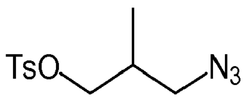
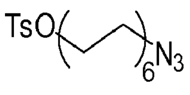
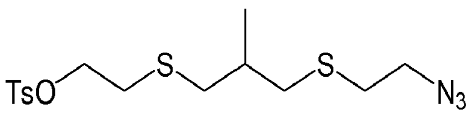
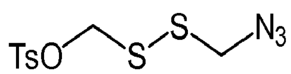
Example 26: Synthesis of 6-azidohexyl 4-methylbenzenesulfonate (26*)

[0113]



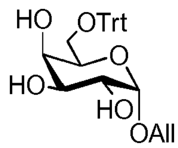
[0114] To a solution of 6-azidohexan-1-ol **25*** (2.7 g, 18.9 mmol) in pyridine (70 mL) was added 4-methylbenzene-1-sulfonyl chloride (4.0 g, 21.0 mmol). The reaction mixture was left to stir for 5 h at r.t. after which the solvent was removed *in vacuo* and the crude product was dissolved in CH_2Cl_2, washed with water and dried over $MgSO_4$. Solvents were removed *in vacuo* and the crude product was purified by silica flash column chromatography on silica gel (gradient hexanes/EtOAc = 1:0 → 1:1) to afford azide **26*** (5.0 g, 89%) as a colorless oil.
R_f = 0.50 (Hexanes/EtOAc = 3:1); IR (film) v_{max} 2938, 2863, 2092, 1598, 1455, 1356, 1258, 1174, 1097, 956, 919, 813, 724, 662 cm^{-1}; ^1H NMR (400 MHz, *$CDCl_3$*) δ; 7.85 - 7.67 (m, 2H), 7.33 (dd, *J* = 8.5, 0.6 Hz, 2H), 4.01 (t, *J* = 6.4 Hz, 2H), 3.21 (t, *J* = 6.9 Hz, 2H), 2.43 (s, 3H), 1.71 - 1.57 (m, 2H), 1.52 (dd, *J* = 9.1, 4.9 Hz, 2H), 1.38 - 1.12 (m, 4H); ^{13}C NMR (101 MHz, *$CDCl_3$*) δ 144.8, 133.2, 129.9, 127.9, 70.4, 51.3, 28.7, 28.7, 26.1, 25.0, 21.7; HR ESI Calcd for $C_{13}H_{19}N_3O_3S$ [M+Na$^+$]: 320.1045 found: 320.1057.

[0115] Azides **26*a-26*f** were synthesized following the procedure described in **examples 24-26** starting from the corresponding commercially available diols.

comp.	structure	HRMS
26*a		$C_{15}H_{23}N_3SO_6$ Calc.: 374.4344 [M+H$^+$] Found: 374.4388
26*b		$C_{17}H_{19}N_3SO_3$ Calc.: 346.4259 [M+H$^+$] Found: 346.4212
26*c		$C_{11}H_{15}N_3SO_3$ Calc.: 270.3297 [M+H$^+$] Found: 270.3229
26*d		$C_{19}H_{31}N_3SO_3$ Calc.: 382.5426 [M+H$^+$] Found: 382.5461
26*e		$C_{15}H_{23}N_3S_3O_3$ Calc.: 390.5683 [M+H$^+$] Found: 390.5662
26*f		$C_9H_{11}N_3S_3O_3$ Calc.: 306.4086 [M+H$^+$] Found: 306.4041

Example 27: Synthesis of allyl 6-O-trityl-α-D-galactopyranoside (27*)

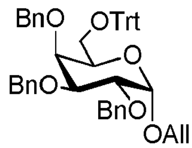
[0116]



[0117] 1-O-Allyl-galactoside (*Org. Lett.* 2002, 4, 489) (4 g, 18.2 mmol) was dissolved in pyridine (18 mL). To the solution was added trityl chloride (6.58 g, 23.6 mmol) and the mixture was stirred at r.t. for 18 h after which the solvent was removed *in vacuo*. The crude product was purified by flash column chromatography on silica gel (CH_2Cl_2/MeOH = 10:1) to yield pyranoside **27*** (7.0 g, 83%) as colorless oil.
$[\alpha]_D^{r.t.}$ = +60.0 (*c* = 1, $CHCl_3$); R_f = 0.8 (CH_2Cl_2/MeOH = 5:1); IR (film) v_{max} 3402, 2929, 1491, 1449, 1218, 1152, 1070, 1032, 746, 703 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 7.51-7.18 (m, 15H), 5.99-5.88 (m, 1H), 5.25 (ddq, *J* = 35.9, 10.4, 1.4 Hz, 2H), 4.95 (d, *J* = 3.8 Hz, 1 H), 4.25 (ddt, *J* = 12.8, 5.4, 1.4 Hz, 1H), 4.05 (ddt, *J* = 12.8, 6.3, 1.3 Hz, 1 H), 3.96 (s, 1 H), 3.89 (t, *J* = 5.8 Hz, 1 H), 3.81 (d, J = 5.7 Hz, 1 H), 3.75 (d, *J* = 9.8 Hz, 1H), 3.47 (s, 1 H), 3.43 (dd, *J* = 9.8, 6.1 Hz, 1 H), 3.32 (dd, *J* = 9.8, 5.3 Hz, 1 H), 2.86 (d, *J* = 2.1 Hz, 1 H), 2.71 (d, *J* = 8.1 Hz, 1 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 143.8, 133.7, 128.6, 127.8, 127.1, 117.8, 97.5, 86.9, 71.2, 69.8, 69.5, 69.5, 68.5, 63.3; HR ESI Calcd for $C_{25}H_{25}O_5$ $[M+Na^+]$: 485.1935 found: 485.1941.

Example 28: Synthesis of allyl 2,3,4-tri-O-benzyl-6-O-trityl-α-D-galactopyranoside (28*)

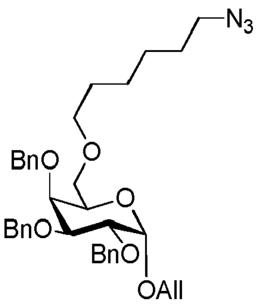
[0118]



[0119] To a solution of allyl 6-O-trityl-α/β-D-galactopyranoside **27*** (3.7 g, 8.0 mmol) in DMF (32 mL) was added sodium hydride (60% in mineral oil, 1.50 g, 36.0 mmol) portionwise at r.t. After 1 h benzyl bromide (4.2 mL, 35.2 mmol) was added. The reaction mixture was left to stir for 48 h after which it was quenched by the addition of MeOH (5 mL). The mixture was diluted with Et_2O and extracted twice from saturated aqueous $NaHCO_3$. The combined organic layer was washed with water (3 x 100 mL) and saturated aqueous NaCl solution and dried over $MgSO_4$. The solvent was removed *in vacuo* and the crude product was over a plug of silica gel (hexanes/EtOAc = 2:1, silica gel was neutralized with 1% NEt_3) to yield the benzyl ether **28*** (5.5 g) as a pale yellow oil which was used in the subsequent step without further purification.

Example 29: Synthesis of allyl 6-(6'-azidohexyl)-2,3,4-*tri-O*-benzyl-α-D-galactopyranoside (29*)

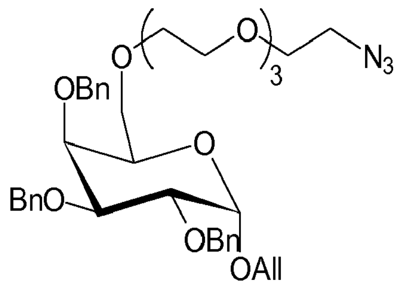
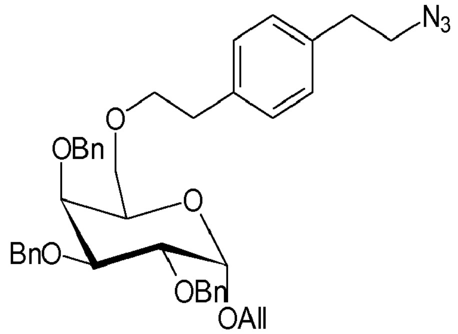
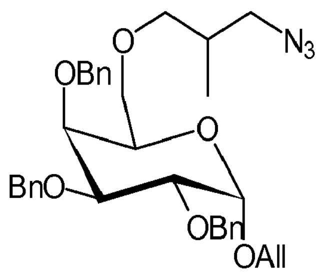
[0120]



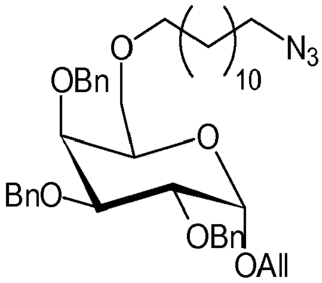
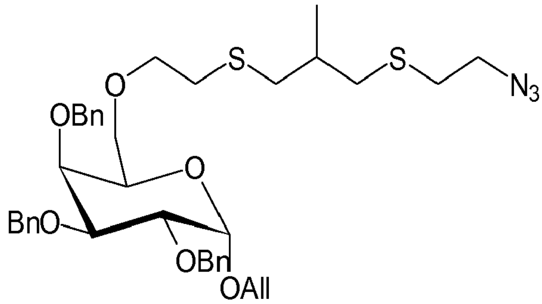
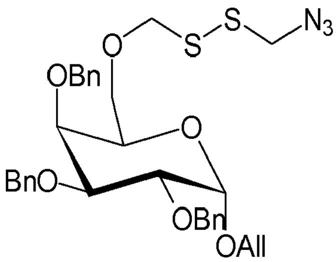
[0121] A solution of allyl 2,3,4-*tri*-O-benzyl-6-O-trityl-α-D-galactopyranoside **28*** (5.00 g, 6.82 mmol) and triethyl silane (5.45 mL, 34.1 mmol) in CH_2Cl_2 (68 mL) was cooled to 0 °C. To the stirred solution was added trifluoroacetic acid (2.6 mL, 34.1 mmol) dropwise. The mixture was quenched after 15 min. with saturated aqueous $NaHCO_3$ solution and extracted with CH_2Cl_2. The crude product was filtered over a plug of silica gel. All silane and trityl residues were removed with 10:1 hexanes/EtOAc and the product was eluted with EtOAc to yield allyl 2,3,4-tri-O-benzyl-α-D-galactopyranoside (3.0 g) as a pale yellow oil, which was used without further purification in the subsequent reaction.

To a solution of allyl 2,3,4-*tri*-O-benzyl-α-D-galactopyranoside (1.0 g, 2.04 mmol) in DMF (10 mL) was added sodium hydride (60% in mineral oil, 0.12 g, 3.1 mmol) at 0 °C. After 15 min, the mixture was warmed to r.t. and stirred for another 1 h. Then, 6-azidohexyl 4-methylbenzenesulfonate **26*** (0.9 g, 3.1 mmol) was added and the reaction mixture was stirred at r.t. for a further 8 h after which the mixture was quenched by the addition of MeOH (2 mL). After dilution with DCM, saturated aqueous NH_4Cl solution was added and the mixture was extracted with DCM. The combined organic layer was washed with water and saturated aqueous NaCl solution. The organic layer was dried over $MgSO_4$, the solvent was removed *in vacuo* and the crude product was purified by flash column chromatography on silica gel (gradient hexanes/EtOAc = 1:0 → 1:1) to yield azide **29*** (1.0 g, 68% over three steps) as a colorless oil. $[\alpha]_D^{r.t.}$ = +25.4 (c = 1, $CHCl_3$); R_f = 0.65 (Hexanes/EtOAc = 4:1); IR (film) ν_{max} 2933, 2863, 2094, 1497, 1454, 1358, 1177, 1098, 1059, 926, 816, 736, 697 cm^{-1}; ^1H NMR (400 MHz, *$CDCl_3$*) δ 7.94 - 7.16 (m, 15H), 5.95 (dddd, *J* = 17.1, 10.3, 6.6, 5.2 Hz, 1H), 5.31 (dq, *J* = 17.2, 1.6 Hz, 1 H), 5.21 (ddd, *J* = 10.3, 2.8, 1.1 Hz, 1H), 5.01 - 4.58 (m, 7H), 4.17 (ddt, *J* = 13.0, 5.2, 1.4 Hz, 1 H), 4.09 - 3.99 (m, 3H), 3.98 - 3.90 (m, 2H), 3.50 - 3.18 (m, 6H), 1.72 - 1.47 (m, 4H), 1.44 - 1.30 (m, 4H); ^{13}C NMR (75 MHz, *$CDCl_3$*) δ 138.9, 138.8, 138.6, 134.0, 129.8, 128.3, 128.3, 128.2, 128.1, 128.0, 127.9, 127.6, 127.5, 127.4, 117.9, 96.3, 79.1, 76.5, 75.3, 74.7, 73.3, 73.3, 71.3, 70.3, 69.5, 69.4, 68.2, 51.4, 51.2, 29.6, 28.8, 28.7, 28.6, 26.6, 26.1, 25.7, 25.0, 21.6. HR ESI Calcd for $C_{36}H_{45}N_3O_6$ [M+Na+]: 638.3201 found: 638.3229.

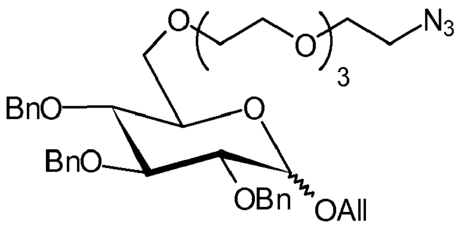
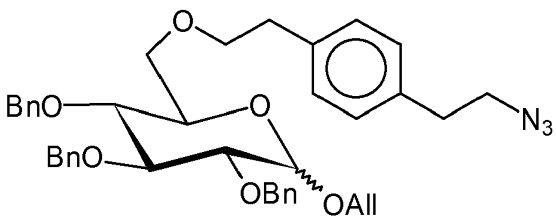
[0122] Azides **29*a-29*f** were obtained starting from allyl 2,3,4-tri-O-benzyl-α-D-galactopyranoside and intermediates **26*a-26*f**.

comp.	structure	HRMS
29*a		$C_{38}H_{50}N_3O_9$ Calc.: 693.8278 [M+H+] Found: 693.8241
29*b		$C_{36}H_{46}N_3O_6$ Calc.: 617.7764 [M+H+] Found: 617.7721
29*c		$C_{34}H_{42}N_3O_6$ Calc.: 589.7231 [M+H+] Found: 589.7274

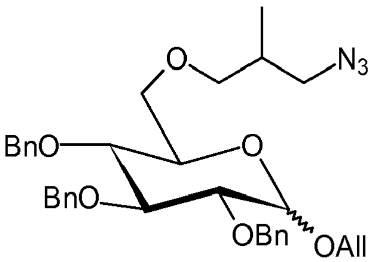
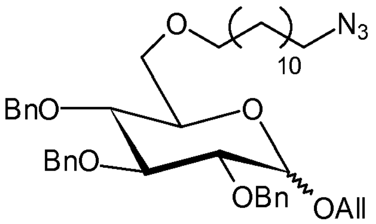
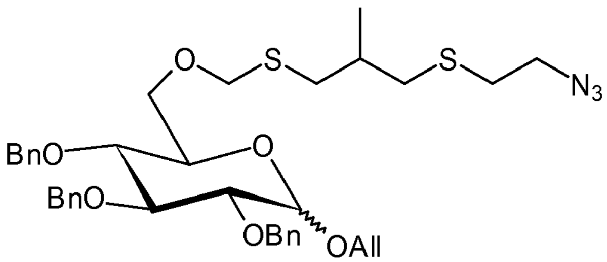
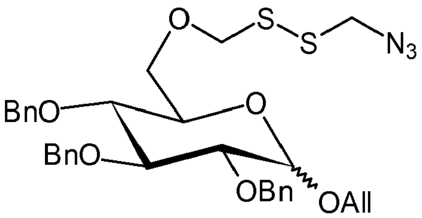
(continued)

comp.	structure	HRMS
29*d		$C_{42}H_{58}N_3O_6$ Calc.: 701.9361 [M+H$^+$] Found: 701.9400
29*e		$C_{38}H_{50}N_3S_2O_6$ Calc.: 709.9618 [M+H$^+$] Found: 709.9651
29*f		$C_{32}H_{38}N_3S_2O_6$ Calc.: 625.8021 [M+H$^+$] Found: 625.7996

[0123] In a similar manner, the analogues in glucose series **29**a-29**f** were obtained starting from allyl 2,3,4-*tri*-O-benzyl-α-D-glucopyranoside and intermediates **26*a-26*f.**

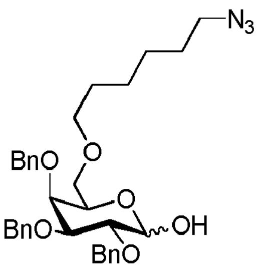
comp.	structure	mass spec
29a**		$C_{38}H_{50}N_3O_9$ Calc.: 693.8278 [M+H$^+$] Found: 693.8241
29b**		$C_{36}H_{46}N_3O_6$ Calc.: 617.7764 [M+H$^+$] Found: 617.7721

(continued)

comp.	structure	mass spec
29**c**		$C_{34}H_{42}N_3O_6$ Calc.: 589.7231 [M+H$^+$] Found: 589.7274
29**d**		$C_{42}H_{58}N_3O_6$ Calc.: 701.9361 [M+H$^+$] Found: 701.9400
29**e**		$C_{38}H_{50}N_3S_2O_6$ Calc.: 709.9618 [M+H$^+$] Found: 709.9651
29**f**		$C_{32}H_{38}N_3S_2O_6$ Calc.: 625.8021 [M+H$^+$] Found: 625.7996

Example 30: Synthesis of 6-(6'-azidohexyl)-2,3,4-tri-O-benzyl-α/β-D-galactopyranose (30*)

[0124]

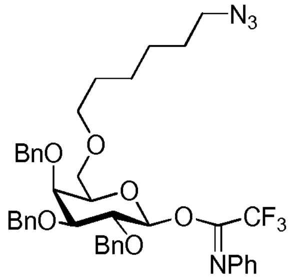


[0125] Allyl 6-(6'-azidohexyl)-2,3,4-*tri*-O-benzyl-α-D-galactopyranoside **29*** (1.4 g, 2.3 mmol) was dissolved in MeOH (16 mL) and $PdCl_2$ (0.21 g, 1.17 mmol) was added to the solution at r.t. The mixture was stirred at for 4 h after which the mixture was filtered over celite and the solvent was removed *in vacuo.* The crude product was purified by flash column chromatography (gradient hexanes/EtOAc = 1:0 → 1:1) to yield lactol **30*** (1.2 g, 88%) as a colorless oil.
R_f = 0.50 (Hexanes/EtOAc = 2:1); IR (film) ν_{max} 3414, 2933, 2862, 2093, 1454, 1255, 1060, 910, 733, 696 cm^{-1}; ^{1}H NMR (400 MHz, *CDCl$_3$*) δ 7.45 - 7.20 (m, 30H), 5.33 - 5.27 (m, 1 H), 5.01 - 4.90 (m, 3H), 4.85 - 4.71 (m, 7H), 4.66 (ddd, *J* = 16.7, 11.5, 6.0 Hz, 3H), 4.18 - 4.09 (m, 1H), 4.05 (dd, *J* = 9.2, 3.6 Hz, 1 H), 3.96 (s, 2H), 3.93 (d, *J* = 2.8 Hz, 1 H),

3.88 (d, J = 2.8 Hz, 1 H), 3.78 (dd, J = 9.6, 7.5 Hz, 1 H), 3.63 - 3.52 (m, 3H), 3.52 - 3.37 (m, 5H), 3.37 - 3.28 (m, 2H), 3.28 - 3.21 (m, 5H), 1.65 - 1.49 (m, 8H), 1.42 - 1.24 (m, 8H); ^{13}C NMR (101 MHz, *CDCl$_3$*) δ 138.8, 138.7, 138.5, 138.4, 128.5, 128.5, 128.4, 128.3, 128.3, 128.3, 128.3, 128.1, 127.9, 127.7, 127.7, 127.7, 127.6, 127.6, 97.9, 92.0, 82.3, 80.9, 78.8, 76.7, 75.2, 74.9, 74.8, 74.7, 73.8, 73.7, 73.6, 73.1, 73.1, 71.5, 71.4, 69.6, 69.6, 69.5, 51.5, 29.5, 28.9, 26.6, 25.8; HR ESI Calcd for $C_{33}H_{41}N_3O_6$ [M+Na$^+$]: 598.2883 found: 598.2869.

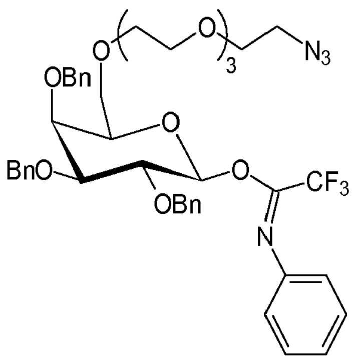
Example 31: Synthesis of 6-(6'-Azidohexyl)-2,3,4-tri-O-benzyl-β-D-galactopyranosyl N-phenyl trifluoroacetimidate (31*)

[0126]

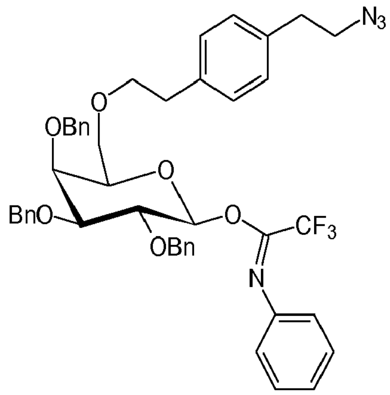
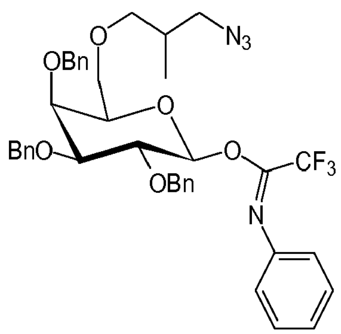
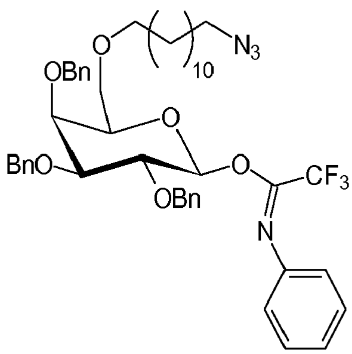
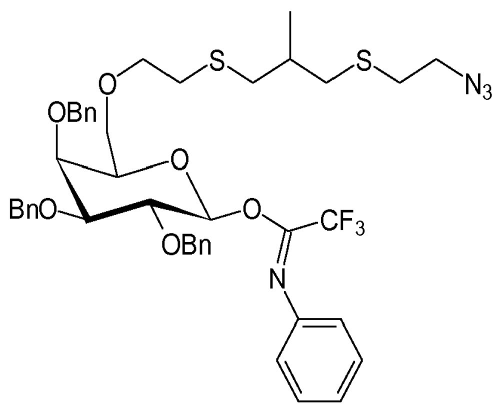


[0127] To a solution of 6-(6'-azidohexyl)-2,3,4-tri-O-benzyl-α/β-D-galactopyranose **30*** (400 mg, 0.70 mmol) in DCM (7 mL) was added cesium carbonate (340 mg, 1.04 mmol). To the mixture was added 2,2,2-trifluoro-N-phenylacetimidoyl chloride (216 mg, 1.04 mmol) and the reaction mixture was stirred at r.t. for 3.5 h after which it was filtered over celite and washed with DCM. The solvent was removed *in vacuo* and the crude product was purified by flash column chromatography on silica gel (gradient hexanes/EtOAc = 10:1 → 1:1) to yield the imidate **31*** (490 mg, 94%) as a colorless oil. $[\alpha]_D^{r.t.}$ = +60.8 (c = 0.4, $CHCl_3$); R_f = 0.80 (Hexanes/EtOAc = 2:1); IR (film) ν_{max} 3064, 2934, 2865, 2094, 1717, 1598, 1454, 1321, 1207, 1099, 1027, 910, 734, 696 cm^{-1}; ^{1}H NMR (400 MHz, *CDCl$_3$*) δ 7.45 - 6.60 (m, 20H), 5.56 (s, 1 H), 4.90 (d, J = 11.5 Hz, 1 H), 4.75 (s, J = 1.5 Hz, 2H), 4.68 (s, J = 12.4 Hz, 2H), 4.58 (d, J = 11.6 Hz, 1H), 4.00 (t, J = 8.7 Hz, 1 H), 3.84 (d, J = 2.4 Hz, 1 H), 3.58 - 3.39 (m, 4H), 3.34 (dt, J = 9.3, 6.5 Hz, 1 H), 3.23 (dt, J = 9.3, 6.5 Hz, 1 H), 3.14 (t, J = 6.9 Hz, 2H), 1.52 - 1.38 (m, 4H), 1.32 - 1.16 (m, 4H); ^{13}C NMR (101 MHz, *CDCl$_3$*) δ 138.6, 138.3, 138.2, 128.8, 128.6, 128.5, 128.4, 128.4, 128.3, 128.0, 127.9, 127.8, 127.7, 124.3, 119.4, 82.3, 78.3, 77.4, 77.2, 76.8, 75.7, 74.9, 74.6, 73.4, 73.2, 71.4, 68.7, 51.5, 29.7, 28.9, 26.7, 25.8; HR ESI Calcd for $C_{41}H_{45}F_3N_4O_6$ [M+Na$^+$]: 769.3183 found: 769.3239.

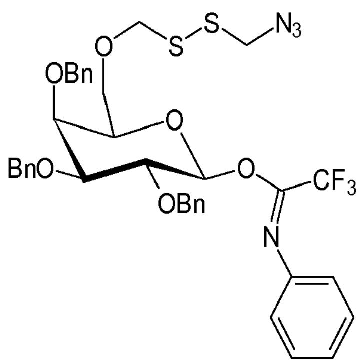
[0128] Starting from hemiacetals **29*a-29*f,** imidate donors **31*a-31*f** were synthesized according to the procedures described in **examples 30** and **31**.

comp.	structure	HRMS
31*a		$C_{43}H_{50}F_3N_4O_9$ Calc.: 824.8834 [M+H$^+$] Found: 824.8804

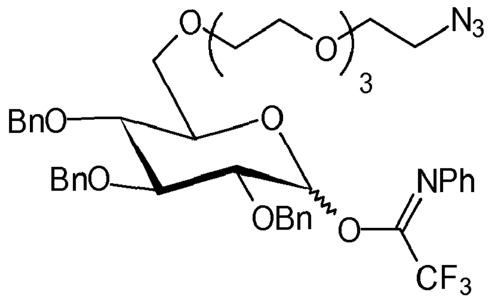
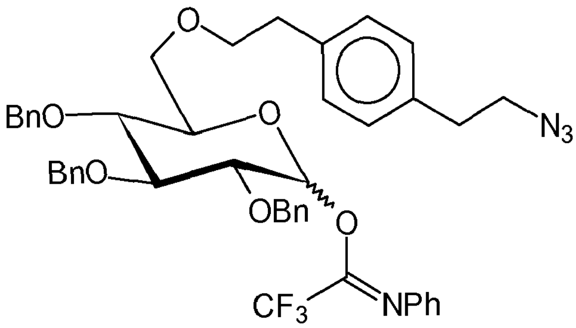
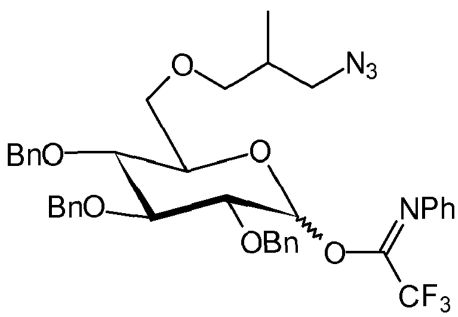
(continued)

comp.	structure	HRMS
31*b		$C_{41}H_{46}F_3N_4O_6$ Calc.: 748.8320 [M+H$^+$] Found: 748.8299
31*c		$C_{39}H_{42}F_3N_4O_6$ Calc.: 720.7788 [M+H$^+$] Found: 720.7712
31*d		$C_{47}H_{58}F_3N_4O_6$ Calc.: 832.9917 [M+H$^+$] Found: 832.9977
31*e		$C_{43}H_{50}F_3N_4S_2O_6$ Calc.: 841.0174 [M+H$^+$] Found: 841.0108

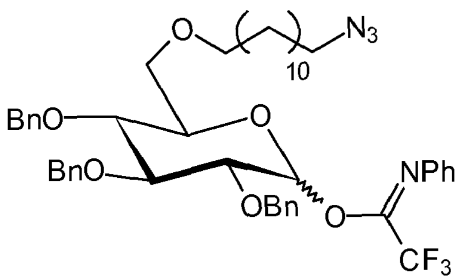
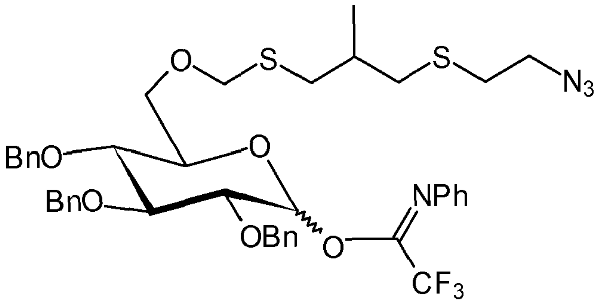
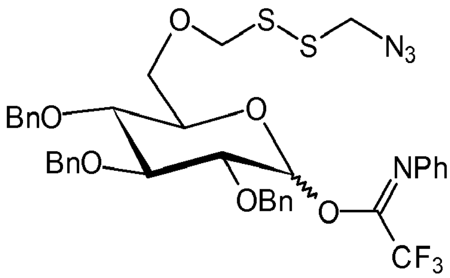
(continued)

comp.	structure	HRMS
31*f		$C_{37}H_{38}F_3N_4S_2O_6$ Calc.: 756.8577 [M+H+] Found: 756.8506

[0129] In a similar manner, imidate donors in glucose series **31**a-31**f** were accessed starting from the corresponding hemiacetals **29**a-29**f.**

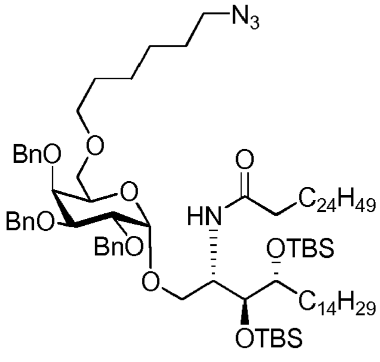
comp.	structure	HRMS
31**a		$C_{43}H_{50}F_3N_4O_9$ Calc.: 824.8834 [M+H+] Found: 824.8804
31**b		$C_{41}H_{46}F_3N_4O_6$ Calc.: 748.8320 [M+H+] Found: 748.8299
31**c		$C_{39}H_{42}F_3N_4O_6$ Calc.: 720.7788 [M+H+] Found: 720.7712

(continued)

comp.	structure	HRMS
31d**		$C_{47}H_{58}F_3N_4O_6$ Calc.: 832.9917 [M+H+] Found: 832.9977
31e**		$C_{43}H_{50}F_3N_4S_2O_6$ Calc.: 841.0174 [M+H+] Found: 841.0108
31f**		$C_{37}H_{38}F_3N_4S_2O_6$ Calc.: 756.8577 [M+H+] Found: 756.8506

Example 32: Synthesis of (2S,3S,4R)-3,4-Bis-tert-butyldimethylsilyloxy-2-hexacosanoylamino-1-(6-(6'-azido-hexyl)-2,3,4-tri-O-benzyl)-α-D-galactopyranosyl)octadecane (32*)

[0130]

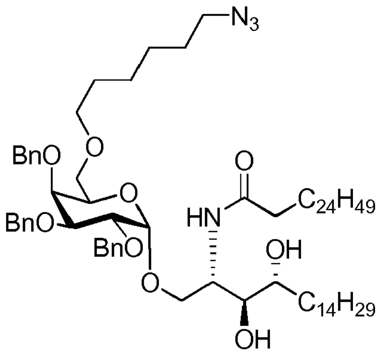


[0131] Nucleophile **23*** (156 mg, 0.169 mmol) and glycosylating agent **31*** (189 mg, 0.253 mmol) were co-evaporated with toluene three times and dried on high vacuum for 3 h after which they were dissolved in Et_2O (2 mL) and THF (0.4 mL) and cooled to - 40 °C. To the mixture was added TMSOTf (9.0 μL, 0.051 mmol) and the solution was warmed to -10 °C over the period of 3 h. The reaction was quenched by the addition of NEt_3 (0.05 mL) and solvents were removed *in vacuo* and the crude product was purified by silica flash column chromatography (gradient hexanes/EtOAc = 10:1 → 4:1) to afford glycoside **32*** (180 mg, 72% α-anomer) as a white foam.
$[\alpha]_D^{r.t.}$ = +18.9 (c = 1, $CHCl_3$); R_f = 0.46 (Hexanes/EtOAc = 6.5:1); IR (film) ν_{max} 3328, 2925, 2854, 2096, 1731, 1656,

1452, 1348, 1246, 1156, 1099, 1058, 835, 777, 696 cm^{-1}; ^1H NMR (400 MHz, *$CDCl_3$*) δ 7.39 - 7.27 (m, 15H), 5.99 (d, *J* = 7.07 Hz, 1 H), 4.95 (d, *J* = 11.5 Hz, 1 H), 4.83 (d, *J* = 3.7 Hz, 1 H), 4.81 - 4.59 (m, 6H), 4.11 - 4.08 (m, 1 H), 4.04 (dd, *J* = 10.1, 3.6 Hz, 1 H), 3.96 - 3.82 (m, 6H), 3.65 (ddd, *J* = 7.0, 5.1, 1.85 Hz, 1 H), 3.50 - 3.45 (m, 1 H), 3.40 (dq, *J* = 6.7, 4.0 Hz, 1 H), 3.33 - 3.27 (m, 1 H), 3.25 (t, *J* = 6.9 Hz, 2H), 2.02 - 1.98 (m, 2H), 1.62 - 1.49 (m, 8H), 1.30 - 1.23 (m, 72H), 0.91 - 0.87 (m, 24H), 0.07 (s, 3H), 0.06 (s, 3H), 0.03 (s, 6H). ^{13}C NMR (101 MHz, *$CDCl_3$*) δ 173.1, 138.8, 138.7, 138.6, 128.33, 128.30, 128.2, 128.1, 127.8, 127.6, 127.50, 127.46, 127.3, 100.2, 79.1, 77.20, 76.57, 75.7, 75.6, 74.9, 74.8, 73.4, 72.9, 71.4, 69.7, 69.4, 69.0, 51.8, 51.4, 36.8, 33.2, 31.9, 29.9, 29.74, 29.71, 29.66, 29.60, 29.5, 29.4, 28.8, 26.6, 26.14, 26.09, 25.7, 25.6, 22.7, 18.3, 18.2, 14.1, -3.7, - 3.9, -4.6, -4.9; HR ESI Calcd for $C_{89}H_{156}N_4O_9Si_2$ [M+Na$^+$]: 1505.1333 found: 1505.1388.

Example 33: Synthesis of (2*S*,3*S*,4*R*)-2-hexacosanoy)amino-1-(6-(6'-azidohexyl)-2,3,4-tri-*O*-benzyl-α-D-galactopyranosyl)octadecane-3,4-diol (33*)

[0132]



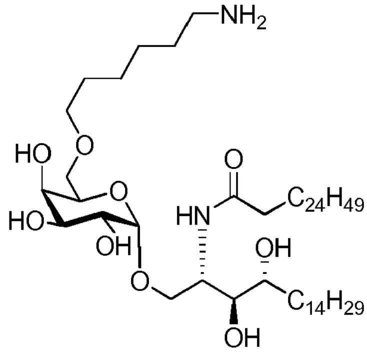
[0133] To a solution of bis-TBS ether **32*** (16.0 mg, 10.8 μmol) in THF (1 mL) was added a solution of TBAF (1 M in THF, 0.150 mL, 0.15 mmol) slowly. After 3.5 h the reaction mixture was diluted with CH_2Cl_2 (10 mL). Solvents were removed *in vacuo* and crude product was purified by silica flash column chromatography (gradient hexanes/EtOAc = 1:0 → 1:1) to afford diol **33*** (10.5 mg, 78%) as a clear oil.

$[\alpha]_D^{r.t.}$ = +121.9 (*c* = 0.2, $CHCl_3$); R_f = 0.40 (Hexanes/EtOAc = 2:1); IR (film) ν_{max} 3329, 2919, 2851, 2096, 1640, 1543, 1467, 1455, 1350, 1094, 1046, 907, 730, 696 cm^{-1};

^1H NMR (400 MHz, *$CDCl_3$*) δ 7.32 - 7.18 (m, 15H), 6.34 (d, J = 7.91 Hz, 1 H), 4.88-4.51 (m, 7H), 4.15 (m, 1 H), 3.98-3.96 (m, 1 H), 3.88 - 3.74 (m, 5H), 3.41 - 3.21 (m, 6H), 3.17 (t, J = 6.5 Hz, 2H), 2.19 - 2.08 (t, *J* = 7.05 Hz, 2H), 1.53 - 1.35 (m, 8H), 1.31 - 1.18 (m, 72 H), 0.81 (m, 6H); ^{13}C NMR (101 MHz, *$CDCl_3$*) δ 173.0, 138.5, 138.3, 137.8, 128.44, 128.39, 128.2, 128.1, 128.1, 127.9, 127.62, 127.60, 127.4, 99.1, 79.3, 76.2, 76.0, 74.7, 74.5, 74.2, 73.2, 72.7, 71.4, 69.8, 51.3, 49.5, 36.7, 31.9, 29.7, 29.5, 29.4, 29.4, 29.3, 28.8, 26.5, 25.9, 25.7, 25.7, 22.7, 14.1; HR ESI Calcd for $C_{77}H_{128}N_4O_9$ [M+Na$^+$]: 1275.9574 found: 1275.9536.

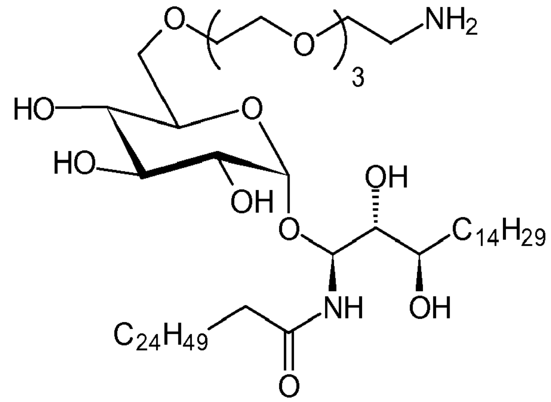
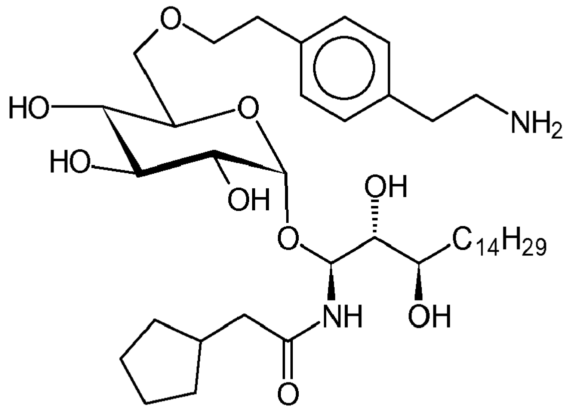
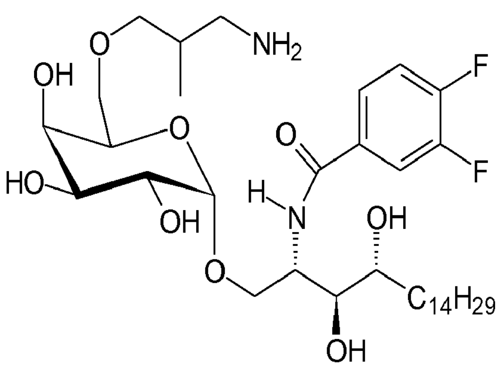
Example 34: Synthesis of (2S,3S,4R)-1-(6-(6'-aminohexyl)-α-D-galactopyranosyl)-2-hexacosanoylaminooctadecane-3,4-diol (34*)

[0134]

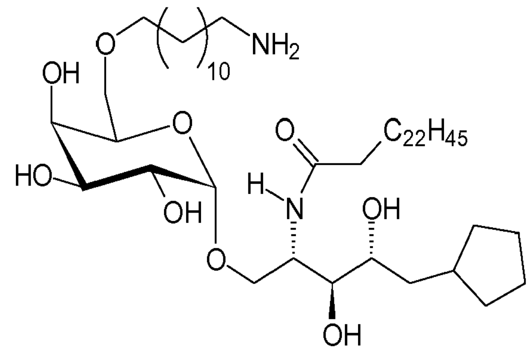
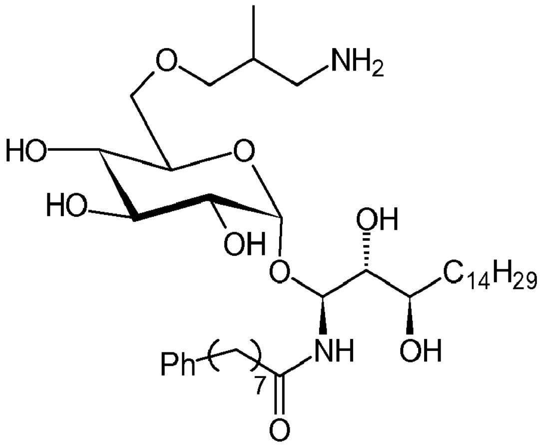
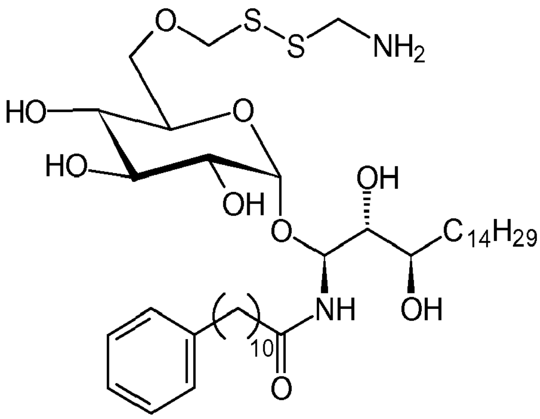
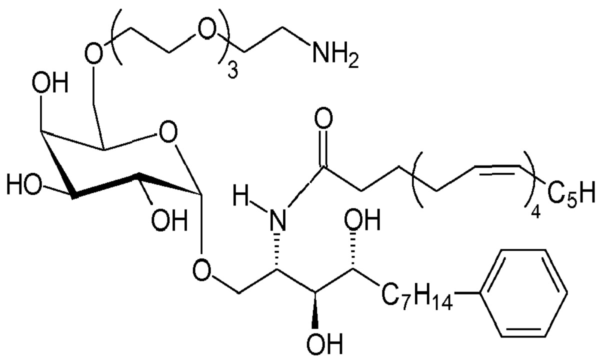


[0135] To a solution diol **33*** (55 mg, 0.044 mmol) in EtOH (0.5 mL) and chloroform (0.15 mL) was added $Pd(OH)_2$ on charcoal (10% w/w, wet 38 mg). The solution was stirred at r.t. under an atmosphere of Ar for 15 min. after which H_2 gas was inserted into the suspension and the mixture was hydrogenated for 12 h. The mixture was filtered over celite and thoroughly washed with CH_2Cl_2, THF and MeOH. Solvents were removed *in vacuo* and the crude was purified by silica flash column chromatography on silica gel (CH_2Cl_2/MeOH = 4:1) to afford linker equipped glycosphingolipid **34*** (38 mg, 90%) as a pale yellow powder.
$[\alpha]_D^{r.t.}$ = +66.1 (c = 1.0, Pyridine); R_f = 0.44 (CH_2Cl_2/MeOH = 4:1);
IR (film) ν_{max} 3292, 2918, 2850, 1640, 1539, 1468, 1304, 1073, 1038, 970, 721cm^{-1}; ^{1}H NMR (400 MHz, *d-pyr*) δ 8.88 (d, *J* = 8.5 Hz, 1 H), 5.54 (d, *J* = 2.5 Hz, 1 H), 5.24-5.21 (m, 1H), 4.62-4.55 (m, 3H), 4.44-4.32 (m, 5H), 4.00-3.92 (m, 2H), 3.31-3.26 (m, 2H), 2.56 (t, *J* = 7.4 Hz, 2H), 2.22-2.18 (m, 1H), 2.00-1.90 (m, 2H), 1.90-1.78 (m, 4H), 1.73-1.60 (m, 1H), 1.55-1.47 (m, 2H), 1.44-1.20 (m, 70H), 0.87 (m, 6H); ^{13}C NMR (101 MHz, *d-pyr*) δ 173.2, 100.4 (J_{CH}= 169 Hz), 76.0, 72.2, 71.0, 70.9, 70.7, 70.6, 70.3, 69.6, 67.5, 50.4, 39.6, 36.5, 33.9, 31.8, 30.1, 29.9, 29.7, 29.68, 29.65, 29.62, 29.59, 29.5, 29.48, 29.28, 27.8, 26.3, 26.19, 26.17, 25.6, 22.6, 14.0; HR ESI Calcd for $C_{56}H_{112}N_2O_9$ [M+H$^+$]: 957.8441 found: 957.8468.

[0136] The following glycosphingolipids were prepared in a similar manner.

Comp.	Structure	HRMS
34a**		$C_{56}H_{112}N_2O_{12}$ Calc.: 1006.4947 [M+H$^+$] Found: 1006.5003
34b**		$C_{40}H_{70}N_2O_9$ Calc.: 723.9918 [M+H$^+$] Found: 723.9921
34*c		$C_{35}H_{61}F_2N_2O_9$ Calc.: 692.8730 [M+H$^+$] Found: 692.8707

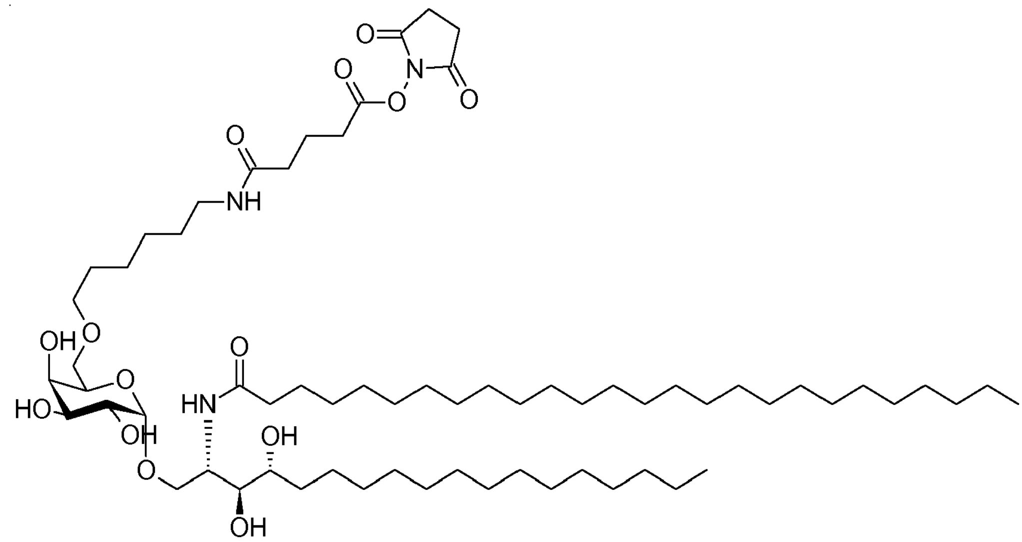
(continued)

Comp.	Structure	HRMS
34*d		$C_{52}H_{103}N_2O_9$ Calc.: 901.3922 $[M+H^+]$ Found: 901.3958
34e**		$C_{41}H_{74}N_2O_9$ Calc.: 740.0343 $[M+H^+]$ Found: 740.0332
34f**		$C_{42}H_{76}N_2O_9S_2$ Calc.: 818.1908 $[M+H^+]$ Found: 818.2003
34*g		$C_{51}H_{87}N_2O_{12}$ Calc.: 921.2527 $[M+H^+]$ Found: 921.2500

C. Synthesis of conjugates

Example 35: Synthesis of 2,5-dioxopyrrolidin-1-yl 5-((6-(((2R,3R,4S,5R,6S)-6-(((2S,3S,4R)-2-hexacosanamido-3,4-dihydroxyoctadecyl)oxy)-3,4,5-trihydroxytetrahydro-2H-pyran-2-yl)methoxy)hexyl)amino)-5-oxopentanoate (35*)

[0137]

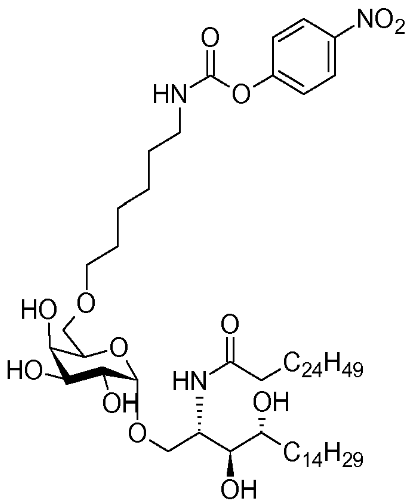


[0138] To glycosphingolipid **34*** (10 mg, 10.44 μmol) in $CHCl_3$:MeOH:Et_3N mixture (1:1:0.1, 7 ml) was added excess glutaric anhydride (14.9 mg, 131 μmol) in one portion and left to stir at the r.t.. After three days the completion of the reaction was indicated by the disappearance of the starting material mass on the LCMS, the reaction mixture was evaporated to dryness and the resultant residue was triturated with dichloromethane to give intermediate carboxylic acid (8 mg, 71.5 %) as a white powder.
IR (film) ν_{max} 3300, 2918, 2850, 1718, 1637, 1539, 1466, 1304, 1073, 1038, 970, 719cm^{-1}; ^{1}H NMR (400 MHz, Pyridine-d_5) δ 8.45 - 8.33 (m, 2H), 5.53 (d, *J* = 3.8 Hz, 1 H), 5.29 - 5.18 (m, 1H), 4.63 (ddd, *J* = 13.0, 9.9, 4.5 Hz, 2H), 4.46 (t, *J* = 6.1 Hz, 1 H), 4.44 - 4.25 (m, 5H), 4.02 (ddd, *J* = 39.8, 9.9, 6.0 Hz, 2H), 3.46 (dq, *J* = 13.3, 6.6 Hz, 4H), 2.66 (t, *J* = 7.3 Hz, 2H), 2.57 (t, J = 7.3 Hz, 2H), 2.44 (t, *J* = 7.5 Hz, 2H), 2.37 - 2.21 (m, 3H), 1.97 - 1.74 (m, 4H), 1.75 - 1.62 (m, 1 H), 1.61 - 1.50 (m, 4H), 1.47 - 1.06 (m, 65H), 0.86 (t, *J* = 6.6 Hz, 6H); ^{13}C NMR (101 MHz, pyridine) δ 172.78, 101.07, 76.28, 72.14, 71.08, 70.59, 70.44, 70.36, 69.79, 68.33, 50.90, 39.26, 36.43, 35.49, 33.94, 31.76, 30.03, 29.80, 29.74, 29.68, 29.64, 29.55, 29.47, 29.42, 29.25, 26.80, 26.14, 26.04, 25.83, 22.57, 21.73, 13.91; MALDI-TOF (THAP, RN) [M-H]$^-$calcd 1069.861, found 1069.642

[0139] To a solution of intermediate carboxylic acid (1.45 mg, 1.36 μmol) in DMSO:THF (1:1, 500 μL) was added N-hydroxysuccinimide (0.18 mg, 1.61 μmol) in one portion, followed by a solution of 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (1.3 mg, 6.78 μmol). After five days, disappearance of the starting material mass in LCMS indicated the completion of the reaction. 2-Mercaptoethanol (20 μL) was then added to the reaction mixture to quench the 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride. NHS ester activated carboxylic acid **35*** was used without any purification for coupling to the SP-3 capsular polysaccharide related saccharides:
HRMS (ESI) $C_{35}H_{122}N_3O_{14}$ [M+H]$^+$ calcd 1167.8921, found 1168.8931.

Example 36: Synthesis of 4-nitrophenyl (6-(((2R,3R,4S,5R,6S)-6-(((2S,3S,4R)-2-hexacosanamido-3,4-dihydroxyoctadecyl)oxy)-3,4,5-trihydroxytetrahydro-2H-pyran-2-yl)methoxy)hexyl)carbamate (36*)

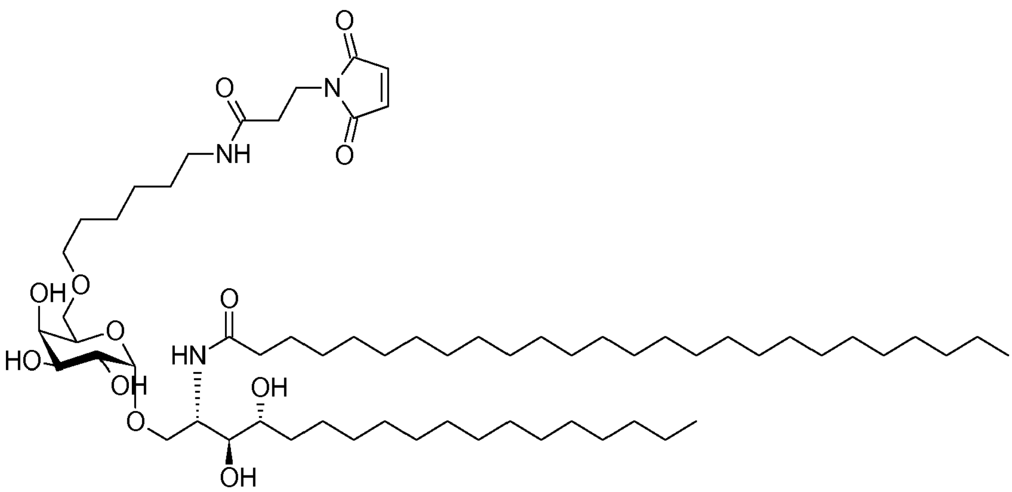
[0140]



[0141] Glycosphingolipid **34*** (3.9 mg, 4.1 μmol) was dissolved in 0.5 mL of dry pyridine, then to it was added bis(4-nitrophenyl) carbonate (6.1 mg, 20 μmol), followed by Et_3N (25 μl, 0.179 mmol). The resulting yellow solution was stirred at rt overnight, then concentrated *in vacuo* and purified by column chromatography on silica gel, using a gradient of 0-5-10-20 % MeOH in DCM, yielding 3.6 mg (3.2 μmol, 79% yield) of glycosphingolipid **36*** as a pale yellow oil. ^{1}H NMR (400 MHz, pyridine) δ 9.02 (t, *J* = 5.6 Hz, 1 H), 8.49 (d, *J* = 8.7 Hz, 1 H), 8.26 (d, *J* = 9.2 Hz, 2H), 7.54 (d, *J* = 9.2 Hz, 2H), 5.56 (d, *J* = 3.8 Hz, 1 H), 5.26 (s, 2H), 4.67 (ddd, *J* = 13.1, 10.0, 4.5 Hz, 2H), 4.51 (t, *J* = 6.0 Hz, 1 H), 4.41 (dd, *J* = 9.0, 5.6 Hz, 2H), 4.35 (s, 2H), 4.10 (dd, *J* = 9.8, 5.7 Hz, 1 H), 4.02 (dd, *J* = 9.8, 6.5 Hz, 1 H), 3.52 (td, *J* = 9.2, 2.7 Hz, 2H), 3.45 (dd, *J* = 13.0, 6.9 Hz, 2H), 2.46 (t, *J* = 7.2 Hz, 2H), 2.36 - 2.23 (m, 1 H), 1.97-1.79(m,4H), 1.74 - 1.65 (m, 3H), 1.64 - 1.54 (m, 2H), 1.41 (d, *J* = 7.1 Hz, 5H), 1.34 - 1.22 (m, 65H), 0.87 (t, *J* = 6.7 Hz, 6H). ^{13}C NMR (101 MHz, pyridine) δ 171.70, 155.90, 152.65, 143.22, 123.92, 121.09, 100.02, 75.15, 71.05, 70.01, 69.98, 69.62, 69.41, 69.35, 68.71, 67.28, 49.83, 40.13, 35.35, 32.84, 30.69, 30.68, 28.95, 28.73, 28.62, 28.59, 28.57, 28.55, 28.50, 28.48, 28.46, 28.41, 28.34, 28.19, 28.18, 25.59, 25.08, 24.98, 24.75, 21.51, 12.85.
HRMS: expected $[M+Na]^+$ = 1144.8322, found: 1444.8373.

Example 37:Synthesis of *N*-((2S,3S,4R)-1-(((2S,3R,4S,5R,6R)-6-(((6-(3-(2,5-dioxo-2,5-dihydro-1H-pyrrol-1-yl)propanamido)hexyl)oxy)methyl)-3,4,5-trihydroxytetrahydro-2H-pyran-2-yl)oxy)-3,4-dihydroxyoctadecan-2-yl)hexacosanamide (37*)

[0142]

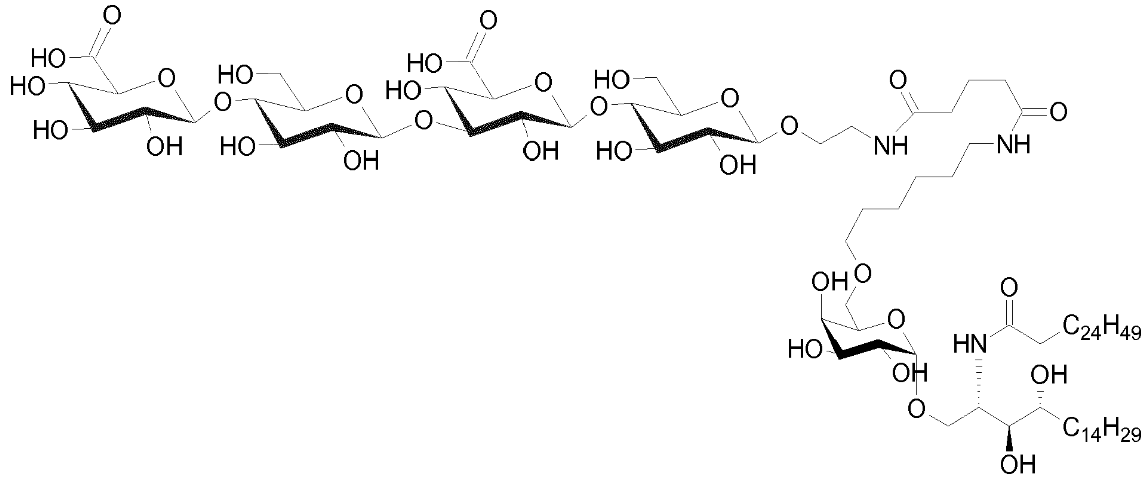


[0143] To a stirred solution of glycosphingolipid **34*** (11.4 mg, 12 μmol) and DIPEA (5.3 μL, 30 μmol) in $CHCl_3$ (1.2 mL) and MeOH (0.4 mL) was added at room temperature N-succinimidyl-3-maleimidopropionate (7.9 mg, 30 μmol). The mixture was stirred for 2 h at that temperature and concentrated. The residue was purified by trituration with EtOAc (3

mL) and MeOH (3 mL) to give maleimide **37*** (8.2 mg, 7.4 μmol) as a white solid.
^{1}H NMR (400 MHz, $CD_3OD/CDCl_3$ 1:3) δ 6.70 (s, 2H), 4.86 (d, *J* = 3.8 Hz, 1 H), 4.16 - 4.10 (m, 1 H), 3.92 - 3.80 (m, 3H), 3.79 - 3.72 (m, 3H), 3.71 - 3.57 (m, 4H), 3.46 (m, 4H), 3.09 (t, *J* = 7.1 Hz, 2H), 2.43 (t, *J* = 7.2 Hz, 2H), 2.20 - 2.11 (m, 2H), 1.66 - 1.15 (m, 82H), 0.83 (t, *J* = 6.8 Hz, 6H).

Example 38: Conjugation of saccharide **11*** to the glycosphingolipid **35* (38*)**

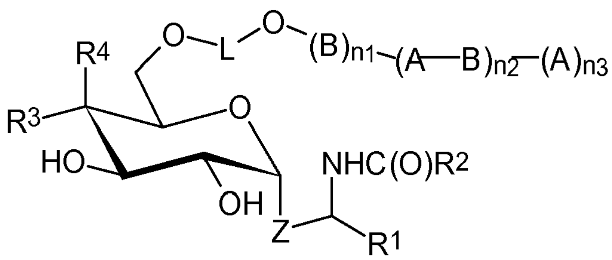
[0144]



[0145] To a solution of NHS ester activated glycosphingolipid **35*** (prepared as described at **example 35**) in DMSO:THF (1:1, 500 μL) was added a solution tetrasaccharide **11*** (1 mg, 1.36 μmol) in DMSO (100 μL). Diisopropylamine was added to increase the pH, until basic. After 3 days, the reaction mixture was lyophilized to dryness and the resultant residue was purified by LH20 size exclusion gel chromatography using chloroform:methanol:water (3.5: 3.5:1) as eluent collecting only the MALDI mass positive peaks for the conjugate mass, affording the conjugate **38*** (2 mg, 82%) as an off-white oil.
MALDI (THAP, RN) $C_{87}H_{158}N_3O_{34}$ $[M-H]^-$ calcd 1789.0727, found 1789.9430

Claims

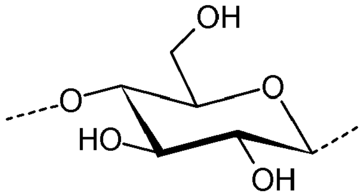
1. A conjugate of general formula (**I**)



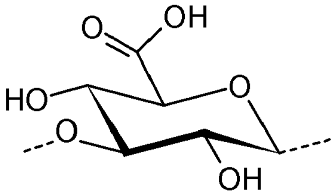
I

wherein

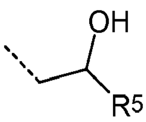
A is

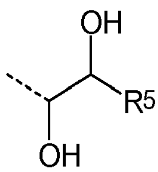


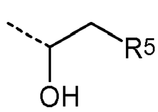
B is



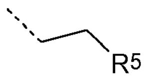
R^1 is selected from





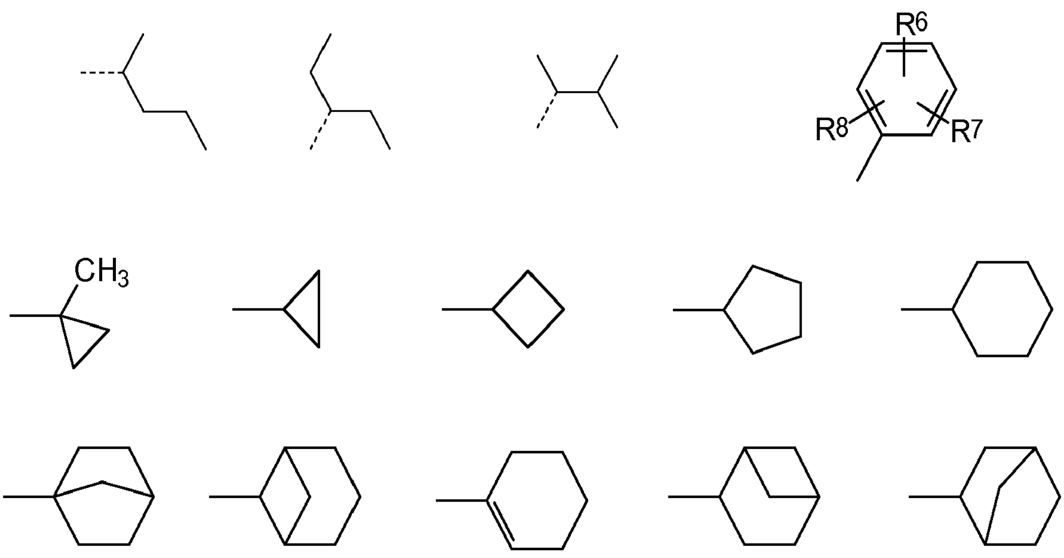


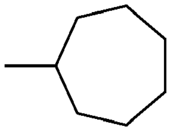
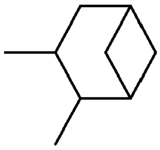
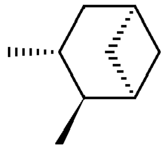
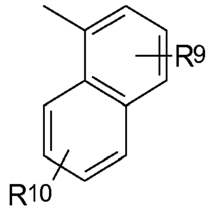
or

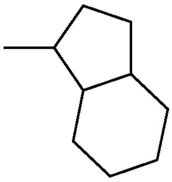
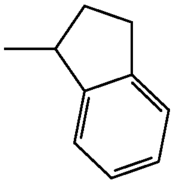
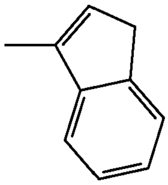
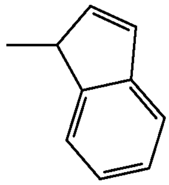


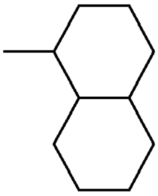
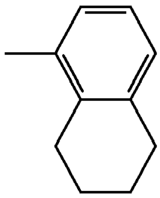
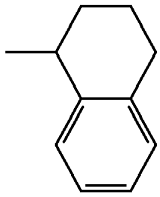
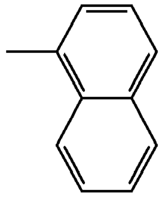
R^2 is $-(X^1)_{p1}-(X^2)_{p2}-(X^3)_{p3}-X^4$;
R^3 and R^4 are selected from -H and -OH and cannot be simultaneously the same;
R^5 is $-(Y^1)_{m1}-(Y^2)_{m2}-(Y^3)_{m3}-Y^4$;
Z represents $-O-CH_2-$, $-O-CH_2-CH_2-$, $-CH_2-CH_2-CH_2-$, or $-CH_2-CH=CH-$;

X^4 represents: -H, -iPr, -tBu, or -sBu,

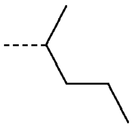
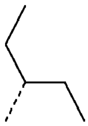
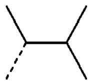
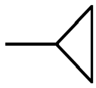
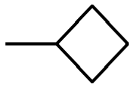
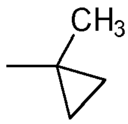


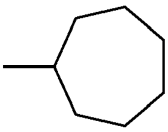
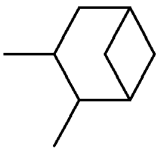
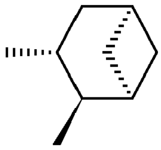
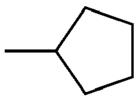
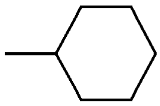
   

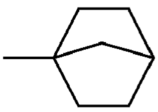
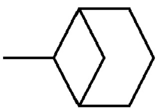
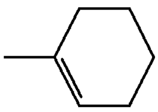
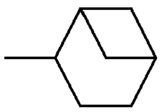
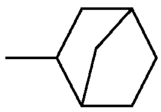
   

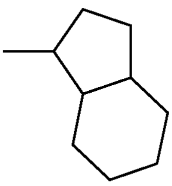
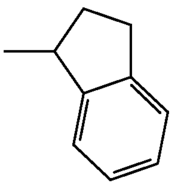
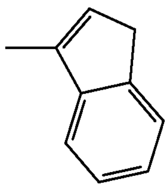
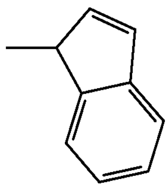
   

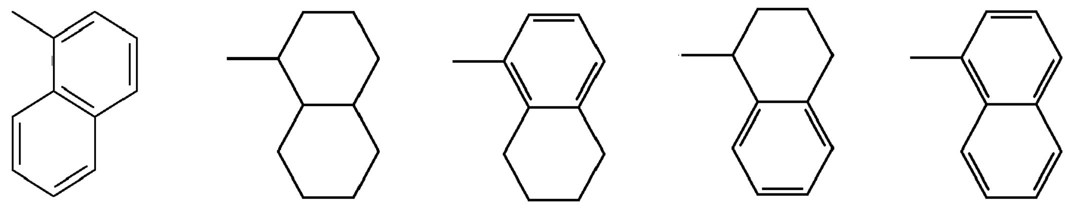
Y^4 is selected from: -H, -*i*Pr, -*t*Bu, -Ph, *s*Bu,

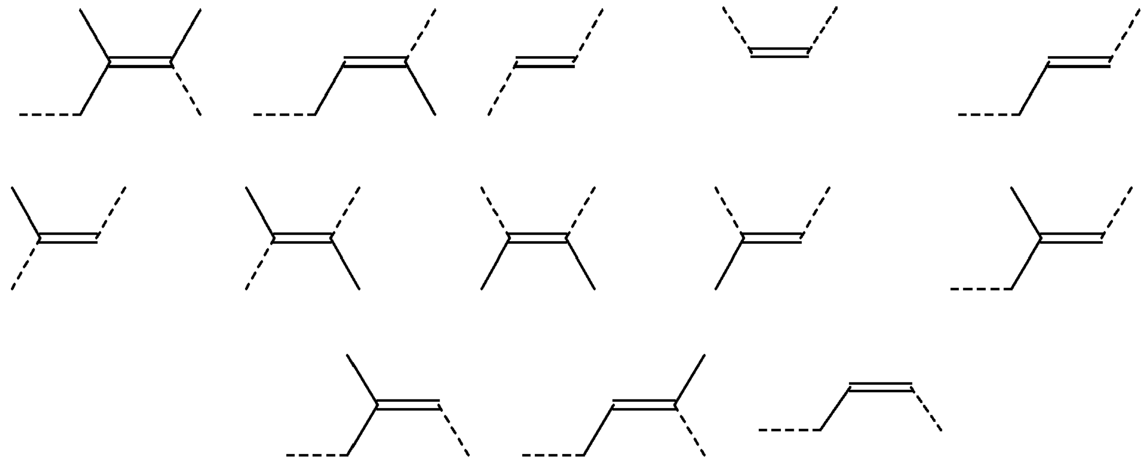
    

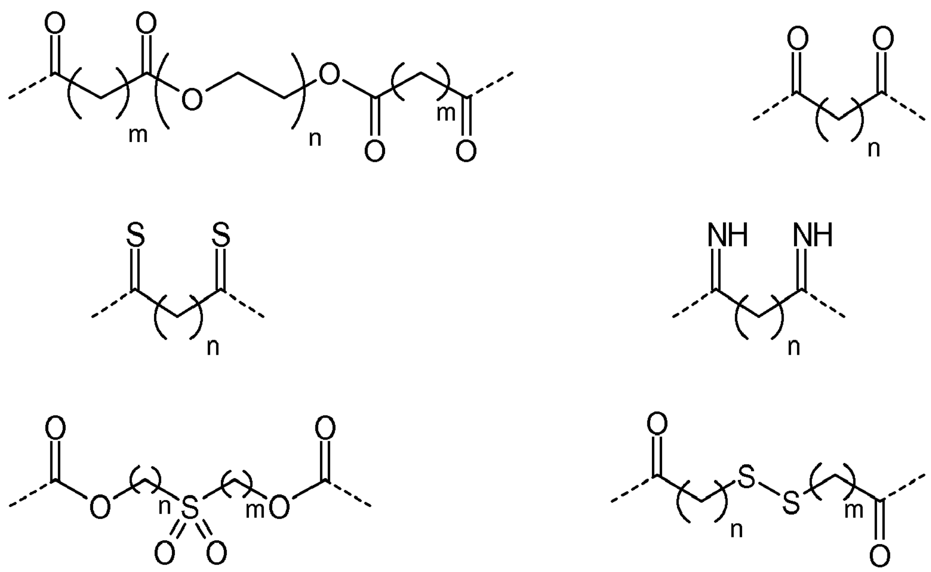


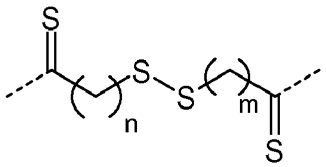
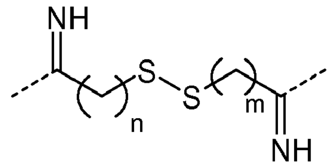
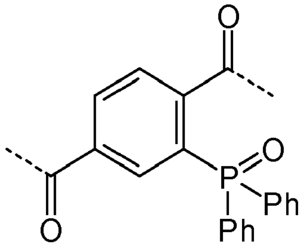
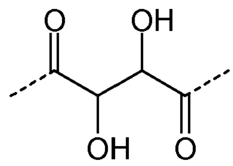
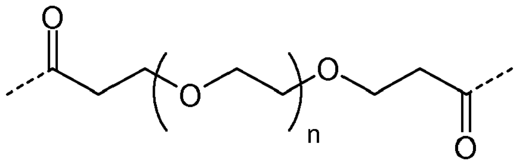
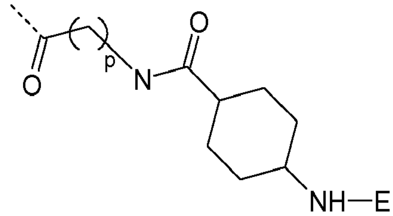
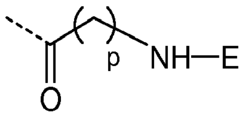
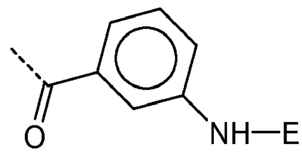
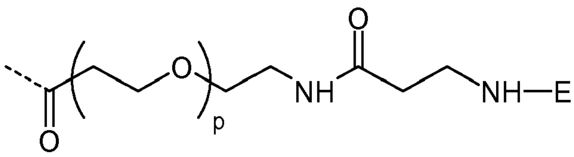
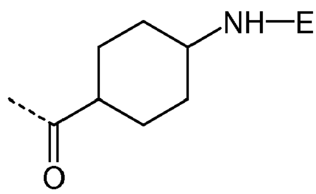
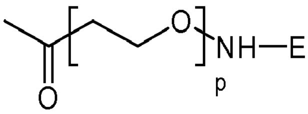
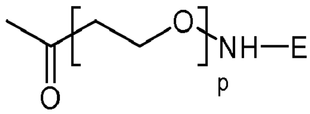
X^1, X^2, X^3, Y^1, Y^2, Y^3 are independently of each other selected from:

–CH_2–, –CH(OH)–, –$CH(CH_3)$–, –$CH(C_2H_5)$–, –$CH(C_3H_7)$–, –$CH(C_4H_9)$–,

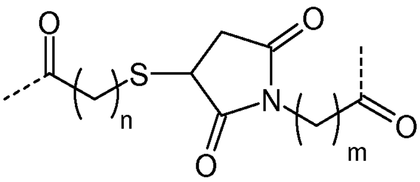
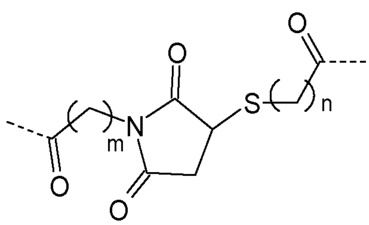


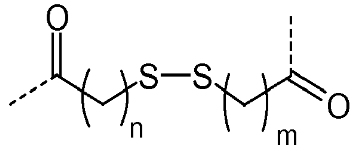
n2 is an integer from 1 to 20;
n1, n3 represent independently of each other an integer selected from 0 and 1;
L represents -L^1-NH-L^2-NH-L^3-;
L^1 represents -$L^{1'}$-$L^{1''}$-$L^{1'''}$- or -$L^{1'}$-$L^{1'''}$- or -$L^{1'}$-; and
L^3 represents -$L^{3'}$-$L^{3''}$-$L^{3'''}$- or -$L^{3'}$-$L^{3'''}$ or -$L^{3'}$-; and
$L^{1'}$, $L^{1''}$, $L^{1'''}$, $L^{3'}$, $L^{3''}$, $L^{3'''}$ are independently of each other selected from: -CH_2-, -C_2H_4-, -C_3H_6-, -C_4H_8-, -C_5H_{10}-, -C_6H_{12}-, -C_7H_{14}-, -C_8H_{16}-, -C_9H_{18}-, -$C_{10}H_{20}$-, -CR^9R^{10}-, -$CR^{11}R^{12}$-, -$CR^{13}R^{14}$-, -$CR^{15}R^{16}$-, -$CR^{17}R^{18}$-, -$CR^{19}R^{20}$-, -$(CH_2\text{-}CH_2\text{-}O)_o$-; -o-$C_6H_4$-, -*m*-$C_6H_4$-, -*p*-$C_6H_4$-, -$CH_2$-S-$CH_2$-, -$CH_2$-O-$CH_2$-, -S-, -O-;
L^2 is selected from: -C(O)-, -E-, -C(O)-NH-NH-C(O)-

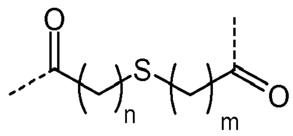


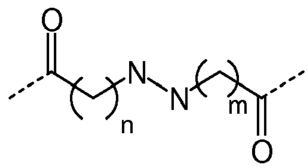













E is selected from







R^6, R^7 and R^8 are independently of each other selected from: -H, $-CH_3$, $-C_2H_5$, $-C_3H_7$, $-C_4H_9$, $-C_5H_{11}$, -Ph, -F, -Cl, -Br, -I;

R^9 to R^{20} represent independently of each other -H, $-OCH_3$, $-OC_2H_5$, $-OC_3H_7$, cyclo-C_3H_5, cyclo-C_4H_7, cyclo-C_5H_9, cyclo-C_6H_{11}, cyclo-C_7H_{13}, cyclo-C_8H_{15}, -Ph, $-CH_2$-Ph, $-CPh_3$, $-CH_3$, $-C_2H_5$, $-C_3H_7$, $-CH(CH_3)_2$, $-C_4H_9$, $-CH_2-CH(CH_3)_2$, $-CH(CH_3)-C_2H_5$, $-C(CH_3)_3$, $-C_5H_{11}$, $-CH(CH_3)-C_3H_7$, $-CH_2-CH(CH_3)-C_2H_5$, $-CH(CH_3)-CH(CH_3)_2$, $-C(CH_3)_2-C_2H_5$, $-CH_2-C(CH_3)_3$, $-CH(C_2H_5)_2$, $-C_2H_4-CH(CH_3)_2$, $-C_6H_{13}$, $-C_3H_6-CH(CH_3)_2$, $-C_2H_4-CH(CH_3)-C_2H_5$, $-CH(CH_3)-C_4H_9$, $-CH_2-CH(CH_3)-C_3H_7$, $-CH(CH_3)-CH_2-CH(CH_3)_2$, $-CH(CH_3)-CH(CH_3)-C_2H_5$, $-CH_2-CH(CH_3)-CH(CH_3)_2$, $-CH_2-C(CH_3)_2-C_2H_5$, $-C(CH_3)_2-C_3H_7$, $-C(CH_3)_2-CH(CH_3)_2$, $-C_2H_4-C(CH_3)_3$, $-CH(CH_3)-C(CH_3)_3$, $-C_7H_{15}$, $-C_8H_{17}$, $-C_6H_4-OCH_3$, $-CH_2-CH_2-OCH_3$, $-CH_2-OCH_3$, $-CH_2-C_6H_4-OCH_3$;

m, n, o, p, p1, p2, p3, m1, m2 and m3 represent independently of each other an integer from 0 to 30;

and enantiomers, stereoisomeric forms, mixtures of enantiomers, anomers, deoxy-forms, diastereomers, mixtures of diastereomers, prodrugs, tautomers, hydrates, solvates and racemates of the above mentioned compounds and pharmaceutically acceptable salts thereof.

2. The conjugate according to claim 1, wherein n1 is 0 and n3 is 1.

3. The conjugate according to claim 1, wherein n1 is 1 and n3 is 0.

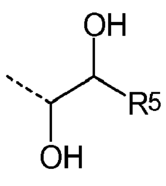
4. The conjugate according to claim 1, wherein n1 is 1 and n3 is 1.

5. The conjugate according to claim 1, wherein n1 is 0 and n3 is 0.

6. The conjugate according to any of the claims 1 - 5, wherein R^3 is -H and R^4 is -OH.

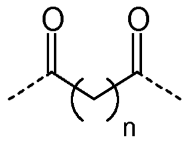
7. The conjugate according to any of the claims 1 - 6, wherein

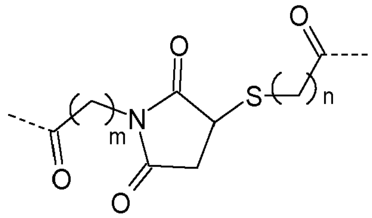
Z is selected from: $-O-CH_2-$ or $-O-CH_2-CH_2-$;
R^1 represents

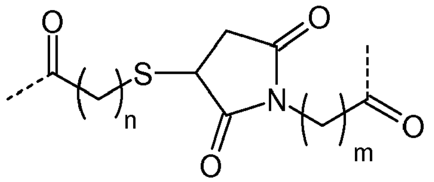


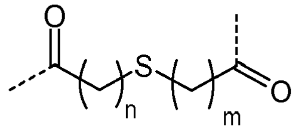
and
R^5 has the meaning as defined in claim 1.

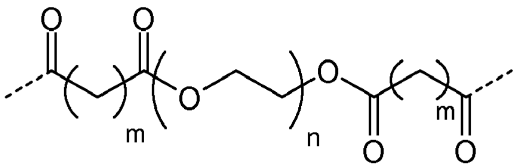
8. The conjugate according to any of the claims 1 - 7, wherein L^2 is selected from:





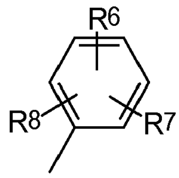




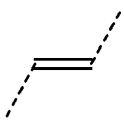
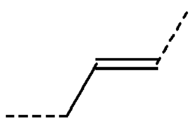
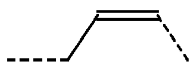


and m and n represent independently of each other an integer from 0 to 30.

9. The conjugate according to any of the claims 1 - 8, wherein X^4 is selected from:

–H, –*i*Pr, –*t*Bu,  ;

Y^4 is selected from: -H, -*i*Pr, -*t*Bu, or -Ph;
X^1, X^2, X^3, Y^1, Y^2, Y^3 are independently of each other selected from: $-CH_2-$, -CH(OH)-, $-CH(CH_3)-$, $-CH(C_2H_5)-$, $-CH(C_3H_7)-$, $-CH(C_4H_9)-$,

    ;

and R^6, R^7 and R^8 have the meanings as defined in claim 1.

10. The conjugate according to any of the claims 1 - 9, wherein R^6, R^7 and R^8 are independently of each other selected from -H, -F, -Cl, -Br, -I.

11. The conjugate according to any of the claims 1 - 10 for use as pharmaceutically active agent in medicine.

12. The conjugate according to any of the claims 1 - 11 useful for raising a protective immune response in a human and/or animal host.

13. The conjugate according to any of the claims 1 - 12 useful for prevention and/or treatment of diseases associated with *Streptococcus pneumoniae* type 3.

14. The conjugate according to claim 13, wherein the disease associated with *Streptococcus pneumoniae* type 3 is selected from pneumonia, meningitis, otitis media, bacteremia and acute exacerbation of chronic bronchitis, sinusitis, arthritis and conjunctivitis.

15. A pharmaceutical composition comprising a conjugate according to any of the preceding claims together with at least one pharmaceutically acceptable acceptable carrier, excipient and/or diluent.

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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 5039

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	L. BAI ET AL: "Natural killer T (NKT)-B-cell interactions promote prolonged antibody responses and long-term memory to pneumococcal capsular polysaccharides", PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, vol. 110, no. 40, 16 September 2013 (2013-09-16), pages 16097-16102, XP055097661, ISSN: 0027-8424, DOI: 10.1073/pnas.1303218110 * the whole document * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) A61K
	-/--		

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	23 January 2014	Kukolka, Florian

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Application Number
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TECHNICAL FIELDS SEARCHED (IPC)

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