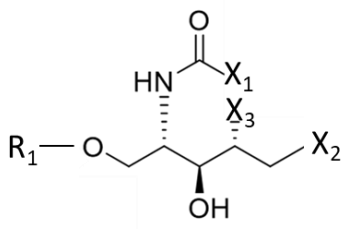
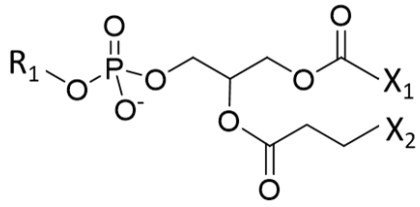
Claims

1. A compound for forming a lipid nanoparticle, wherein the compound comprises the formula:



Formula 1; or



Formula 2;

wherein R_1 comprises a formula of R_2-R_A-, wherein R_A is an attachment group and R_2 is a substituted or non-substituted glycosyl group, and further wherein the attachment group comprises an aryl and an alkylamide, having a structure of –aryl-alkyl-NH-C(O)–, and the aryl moiety attaches to R_2;

wherein X_1 and X_2 are each independently hydrogen, C_{1-30} alkyl, C_{1-30} alkenyl, C_{1-30} alkynyl, aryl, aryloxy, or a substituted version thereof, or $–(CH_2)nX_4$, n is 0 to 30, and X_4 is hydrogen, aryl, aryloxy, heterocyclic group, or a substituted version thereof, provided that when X_4 is a heterocyclic group, the heterocyclic group comprises 1 to 3 heteroatoms, selected from the group consisting of O, S, and N, or a combination thereof; and

wherein X_3 is hydrogen, C_{1-6} alkyl, or hydroxyl.

2. The compound of claim 1, wherein the aryl of R_A has 1 to 3 substituents, and the substituent is C_{1-6} alkyl, halide, or C_{1-6} alkyl halide.

3. The compound of claim 1 or claim 2, wherein R_A further comprises a polyethylene glycol (PEG) moiety having 2 to 72 (OCH_2CH_2) subunits.

4. The compound of any one of claims 1 to 3, wherein the glycosyl group comprises (1) mannoside, fucoside, or a combination thereof and/or (2) a mono-mannoside, a di-mannoside, or a tri-mannoside.

5. The compound of claim 4, wherein the glycosyl group comprises a tri-mannoside, and the tri-mannoside is a α-1,3-α-1,6-trimannoside.

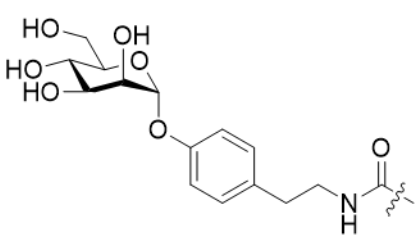
6. The compound of any one of claims 1 to 5, wherein R_1 is a substituted glycosyl group, wherein the glycosyl group comprises 1 to 6 substituents, wherein the substituent is C_{1-6} alkyl, C_{1-6} alkenyl, halogen, C_{1-6} alkyl halide, C_{1-6} alkoxy, amine, nitro, C_{1-6} alkyl amine, amide, azido, aryl, cycloalkyl, heterocycloalkyl, sulfite, or a substituted version thereof, or a combination thereof.

7. The compound of claim 6, wherein the substituent of the glycosyl group is selected from the group consisting of aryl, 5-membered cycloalkyl, 6-membered cycloalkyl, 5-membered heterocycloalkyl, and 6-membered heterocycloalkyl, and a substituted version thereof, which comprises 1 to 6 substituents selected from the group consisting of C_{1-6} alkyl, halogen, C_{1-6} alkyl halide, C_{1-6} alkoxy, amine, nitro, C_{1-6} alkyl amine, amide, azido, carboxyl, hydroxyl, aryl, cycloalkyl, heterocycloalkyl, or a substituted version thereof, or a combination thereof.

8. The compound of claim 6, wherein the substituent of the glycosyl group is a substituted or non-substituted aryl, optionally the substituent of the glycosyl group is a phenyl substituted with OH, CH_3, NH_2, CF_3, OCH_3, F, Br, Cl, NO_2, N_3, or a combination thereof.

9. The compound of claim 6, wherein the heterocycloalkyl comprises 1 to 3 heteroatoms, selected from the group consisting of O, S, and N.

10. The compound of any one of claims 1 to 9, wherein R_1 is selected from the group consisting of: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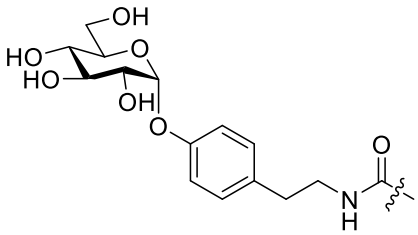
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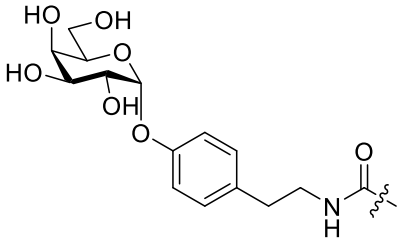
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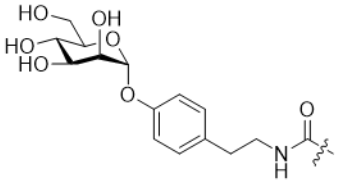
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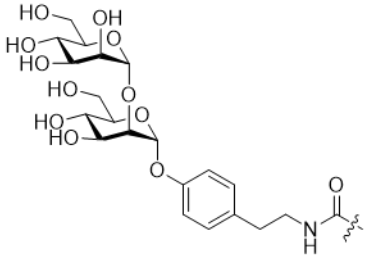
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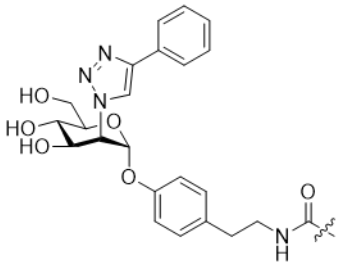
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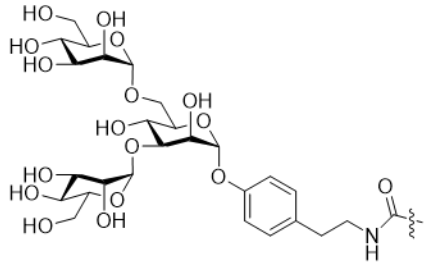

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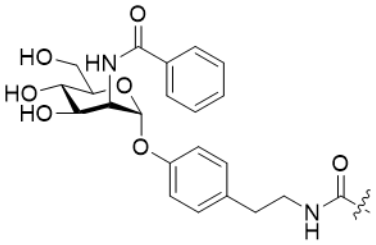

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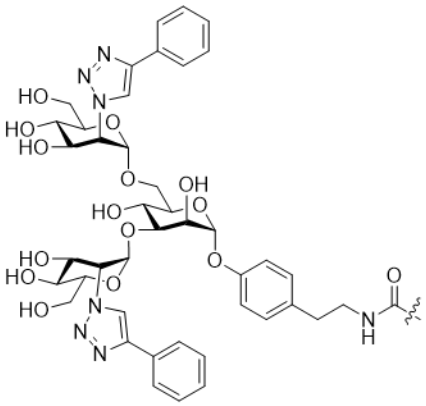

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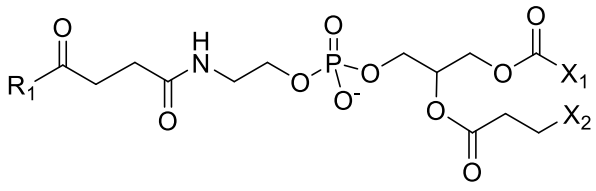
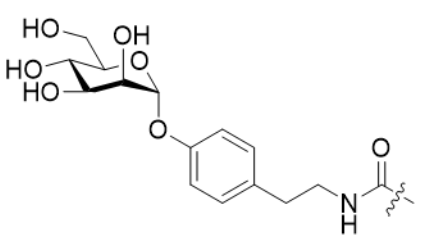
11. The compound of any one of claims 1 to 10, wherein the compound is of Formula 1.

12. The compound of any one of claims 1 to 10, wherein the compound is of Formula 3:



Formula 3; and

wherein R_1 is selected from the group consisting of: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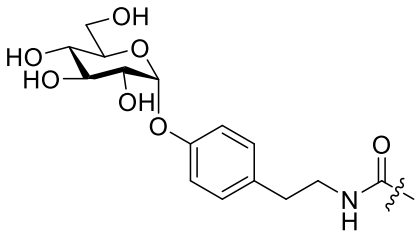
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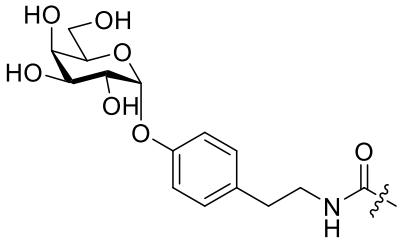
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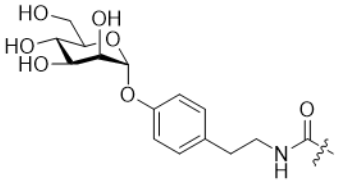
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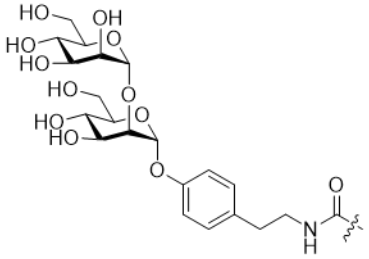
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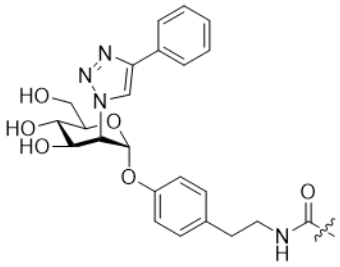
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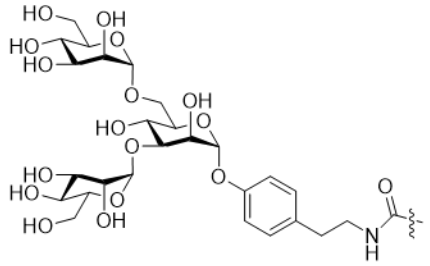

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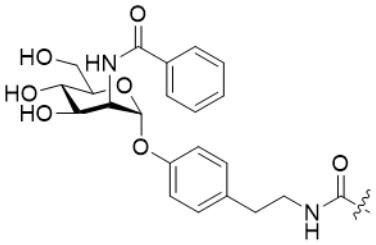

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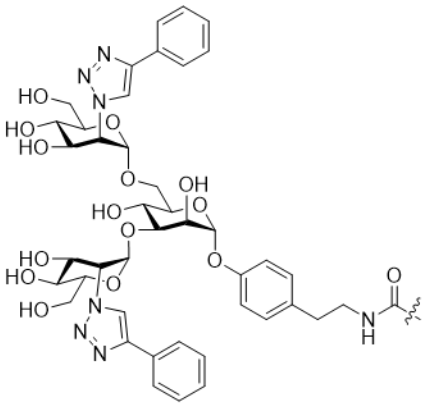

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13. The compound of any one of claims 1 to 12, wherein at least one of X_1 and X_2 comprises a saturated hydrocarbon chain, comprising at least 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 26, 28, or 30 carbons.

14. The compound of any one of claims 1 to 13, wherein X_1 and X_2 are each independently hydrogen, C_{4-30} alkyl, C_{4-30} alkenyl, C_{4-30} alkynyl, aryl, aryloxy, or a substituted version thereof, or

–$(CH_2)nX_4$, n is 4 to 30, and X_4 is hydrogen, aryl, aryloxy, heterocyclic group, or a substituted version thereof, provided that when X_4 is a heterocyclic group, the heterocyclic group comprises 1 to 3 heteroatoms, selected from the group consisting of O, S, and N, or a combination thereof.

15. The compound of claim 14, wherein X_1 and X_2 are each independently hydrogen, C_{8-30} alkyl, C_{8-30} alkenyl, C_{8-30} alkynyl, aryl, aryloxy, or a substituted version thereof, or

–$(CH_2)nX_4$, n is 8 to 30, and X_4 is hydrogen, aryl, aryloxy, heterocyclic group, or a substituted version thereof, provided that when X_4 is a heterocyclic group, the heterocyclic group comprises 1 to 3 heteroatoms, selected from the group consisting of O, S, and N, or a combination thereof.

16. The compound of any one of claims 1 to 15, provided that when one of X_1 and X_2 is hydrogen, the other one is not hydrogen, or when one of X_1 and X_2 is $C_{15\text{-}30}$ alkyl, the other one is –$(CH_2)nX_4$.

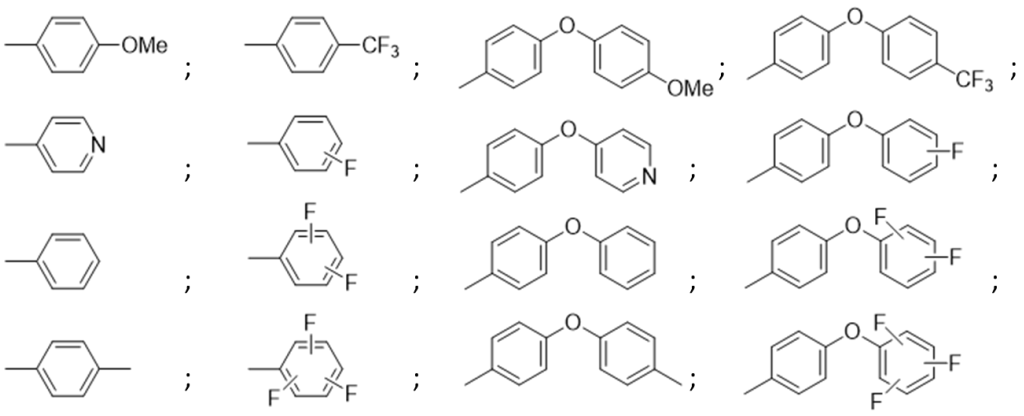
17. The compound of any one of claims 1 to 16, wherein X_4 is an aryl, aryloxy, heterocyclic group, cycloalkyl, heterocycloalkyl, or a combination thereof, and wherein X_4 comprises 0 to 6 substituents, selected from the group consisting of $C_{1\text{-}6}$ alkyl, halogen, $C_{1\text{-}6}$ alkyl halogen, and $C_{1\text{-}6}$ alkoxy.

18. The compound of claim 17, wherein the substituent of X_4 is CH_3, CF_3, F, or OCH_3.

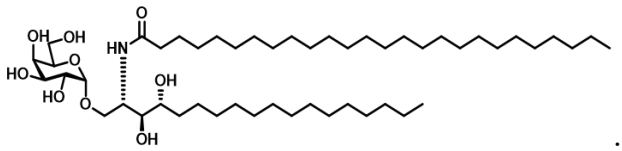
19. The compound of claim 17 or claim 18, wherein X_4 comprises 1 to 3 substituents.

20. The compound of claim 17, wherein X_4 is -R_3-O-R_4, wherein R_3 and R_4 are each independently aryl, heterocyclic group, cycloalkyl, heterocycloalkyl, each comprising 0 to 6 substituents selected from the group consisting of $C_{1\text{-}6}$ alkyl, halogen, $C_{1\text{-}6}$ alkyl halogen, and $C_{1\text{-}6}$ alkoxy.

21. The compound of any one of claims 1 to 20, wherein X_4 is selected from the group consisting of:



22. The compound of any one of claims 1 to 21, selected from the group consisting of: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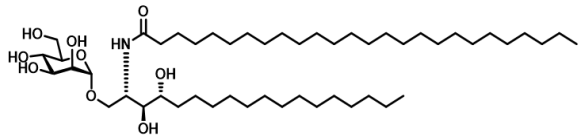
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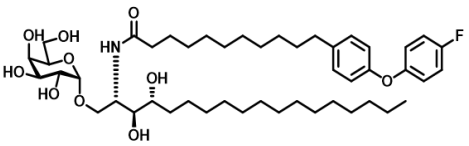
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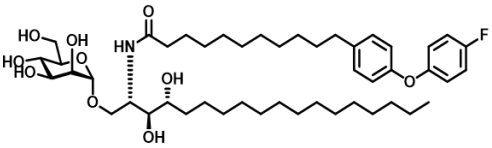
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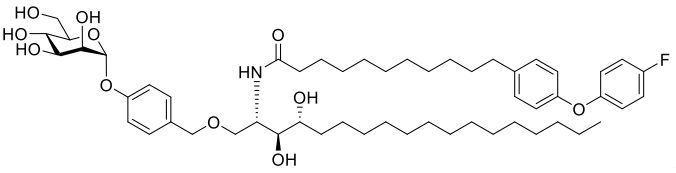
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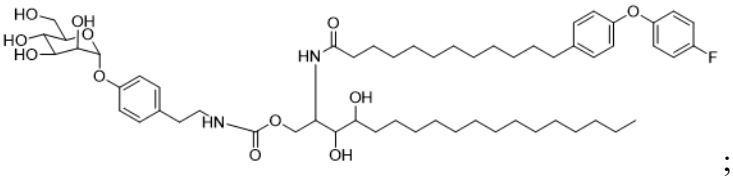
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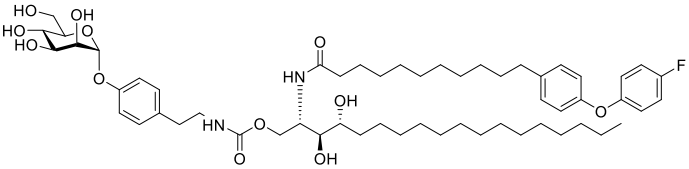
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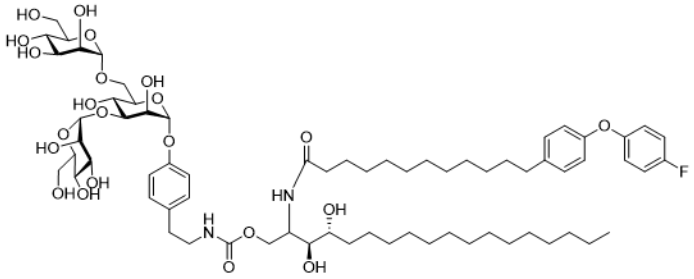

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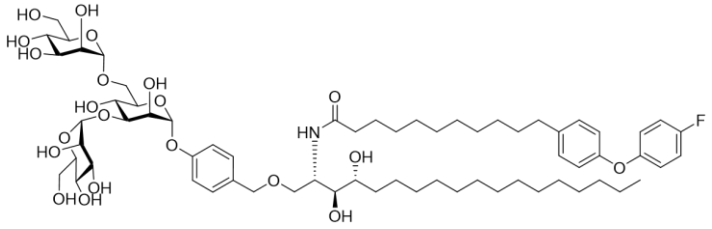

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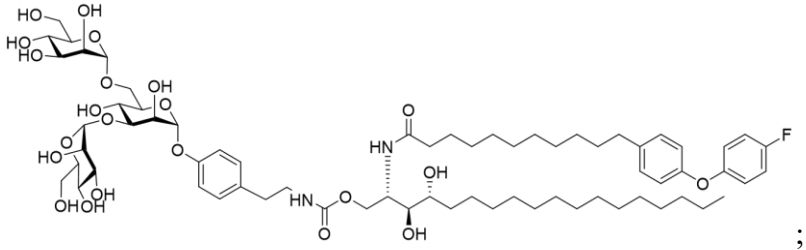

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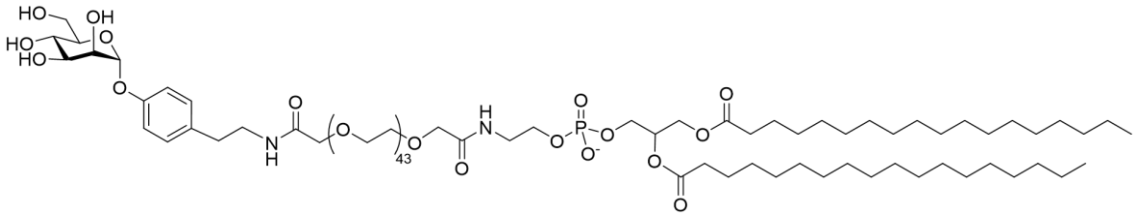

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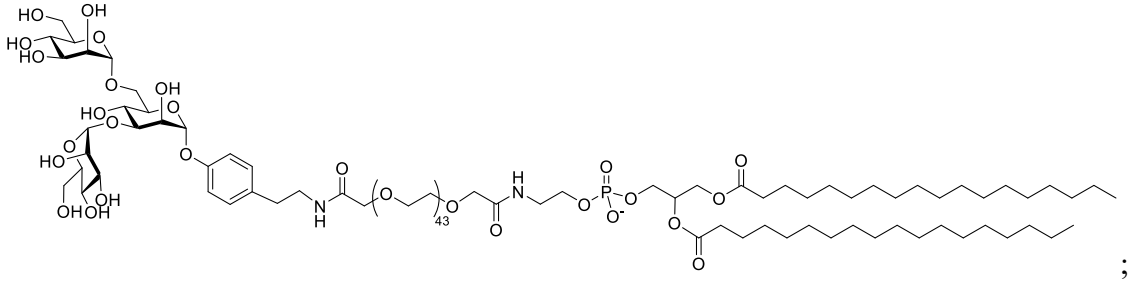

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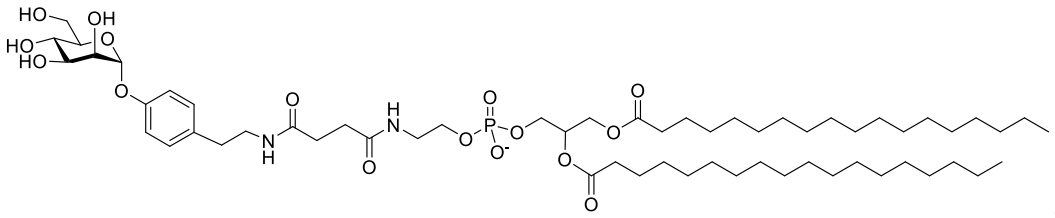

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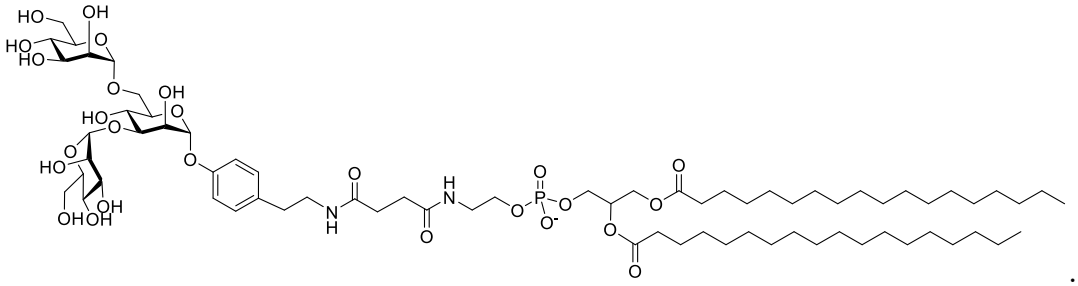

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23. The compound of any one of claims 1 to 22, wherein the compound is not glycolipid C34 or α-galactosylceramide.