CLAIMS

1. A method of synthesizing a hydrolysate of a peptide-attached pillar[5]arene, the method comprising:

forming a pillar[5]arene substituted with carboxyl groups;

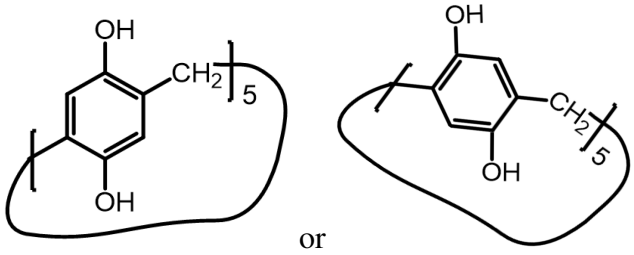
mixing the pillar[5]arene substituted with carboxyl groups and a tripeptide in an organic solvent to form the peptide-attached pillar[5]arene, wherein the tripeptide has a terminal -NH_2 group and a terminal ester, wherein the tripeptide comprises NH_2-L-Phe-L-Phe-L-Phe-O-methyl, NH_2-L-Phe-L-Phe-L-Phe-O-ethyl, or NH_2-L-Phe-L-Phe-L-Phe-O-propyl, wherein the peptide-attached pillar[5]arene comprises a diastereomeric mixture having a diastereomer pR of the peptide-attached pillar[5]arene and a diastereomer pS of the peptide-attached pillar[5]arene, wherein the diastereomer pR has a different solubility in acetone compared to the diastereomer pS;

isolating the diastereomer pR from the diastereomer pS based on the solubility difference in acetone; and

subjecting the diastereomer pR to hydrolysis in the presence of a base to obtain the hydrolysate of the peptide-attached pillar[5]arene, wherein the hydrolysate of the peptide-attached pillar[5]arene consists of a pR planar configuration.

2. The method of claim 1, wherein forming the pillar[5]arene substituted with carboxyl groups comprises mixing 1,4-dimethoxybenzene and a paraformaldehyde in the presence of trifluoroacetic acid to form 1,4-dimethoxypillar[5]arene.

3. The method of claim 1 or 2, wherein forming the pillar[5]arene substituted with carboxyl groups comprises forming a pillar[5]arene represented by the formula:



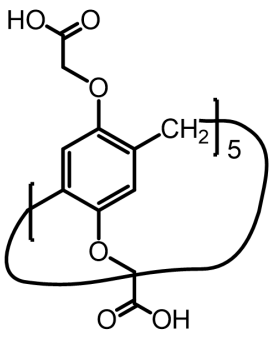
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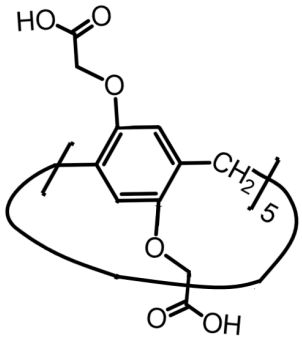
4. The method of claim 3, wherein forming the pillar[5]arene substituted with carboxyl groups comprises mixing the pillar[5]arene and an ~~alkyl~~ethyl bromoacetate in the presence of potassium iodide to form ethoxycarbonylmethoxy-substituted pillar[5]arene.

~~5. The method of claim 4, wherein the alkyl bromoacetate comprises butyl bromoacetate, ethyl bromoacetate, methyl bromoacetate, or propyl bromoacetate.~~

~~6~~5. The method of claim 4~~ or 5~~, wherein forming the pillar[5]arene substituted with carboxyl groups comprises mixing the ethoxycarbonylmethoxy-substituted pillar[5]arene and a basic solution comprising sodium hydroxide to form the pillar[5]arene substituted with carboxyl groups.

~~7~~6. The method of claim 1 or 2, wherein the pillar[5]arene substituted with carboxyl groups is represented by the formula:



or


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~~8~~7. The method of any one of claims 1 to ~~7~~6, wherein mixing the pillar[5]arene substituted with carboxyl groups and the tripeptide comprises mixing the pillar[5]arene substituted with carboxyl groups and the tripeptide at a temperature ranging from 45 to 70°C for 12 to 180 hours under an inert atmosphere.

~~9~~8. The method of any one of claims 1 to ~~8~~7, wherein the organic solvent comprises anhydrous dimethylformamide, 4-dimethylaminopyridine and N-ethyl-N'-(3-dimethylaminopropyl)carbodiimide hydrochloride.

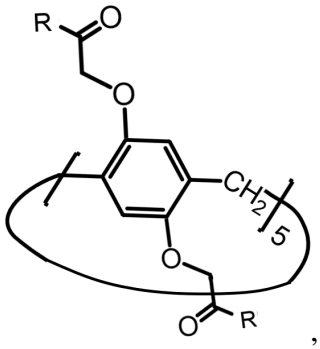
~~10. The method of any one of claims 1 to 9, wherein the tripeptide comprises NH_2-L-Phe-L-Phe-L-Phe-O-methyl, NH_2-L-Phe-L-Phe-L-Phe-O-ethyl, or NH_2-L-Phe-L-Phe-L-Phe-O-propyl.~~

~~11~~9. The method of any one of claims 1 to ~~10~~8, further comprising subjecting the peptide-attached pillar[5]arene to column chromatography to produce a fraction comprising the diastereomeric mixture of the peptide-attached pillar[5]arene, and filtering the diastereomeric mixture after mixing the diastereomeric mixture with acetone to obtain a residue and a filtrate, wherein the residue comprises the diastereomer pR and the filtrate comprises the diastereomer pS.

~~12~~10. The method of any one of claims 1 to ~~11~~9, wherein subjecting the diastereomer pR to hydrolysis comprises mixing the diastereomer pR and the base for 8 to 40 hours.

~~13~~11. The method of any one of claims 1 to ~~12~~10, wherein the base comprises lithium hydroxide, potassium hydroxide, or sodium hydroxide.

~~14~~12. A hydrolysate of a peptide-attached pillar[5]arene configured as a water channel in a liposomal membrane, wherein the hydrolysate of the peptide-attached pillar[5]arene is represented by the formula:



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wherein R represents a tripeptide having a terminal -NH- group and a terminal -COOH group, wherein the terminal -NH- group forms part of an amide linkage, ~~and~~

wherein the terminal -COOH group extends away from the amide linkage, and wherein the tripeptide comprises -NH-L-Phe-L-Phe-L-Phe-COOH.

~~15. The hydrolysate of claim 14, wherein the tripeptide comprises -NH-L-Phe-L-Phe-L-Phe-COOH.~~

~~16~~13. A method of synthesizing a liposomal membrane comprising a hydrolysate of a peptide-attached pillar[5]arene, the method comprising:

synthesizing a hydrolysate of a peptide-attached pillar[5]arene according to the method of any one of claims 1 to ~~13~~11;

mixing the hydrolysate and a plurality of lipids to form a mixture;

forming a liposomal film from the mixture;

contacting the liposomal film with a buffer to form a suspension comprising the hydrolysate and the plurality of lipids; and

extruding the suspension through a membrane to form the liposomal membrane, wherein the hydrolysate of the peptide-attached pillar[5]arene consists of a pR planar configuration.

~~17~~14. The method of claim ~~16~~13, wherein mixing the hydrolysate and the plurality of lipids comprises dissolving the hydrolysate in one or more organic solvents.

~~18~~15. The method of claim ~~17~~14, wherein the one or more organic solvents comprise chloroform and/or methanol.

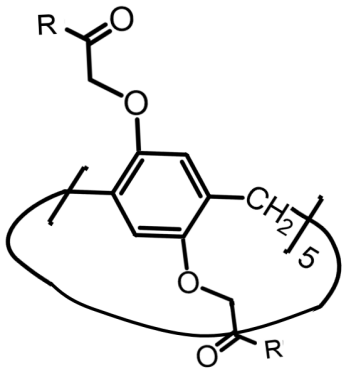
~~19~~16. The method of any one of claims ~~16~~13 to ~~18~~15, wherein the plurality of lipids comprise phosphatidylcholine and/or phosphatidylserine.

~~20~~17. The method of any one of claims ~~16~~13 to ~~19~~16, wherein mixing the hydrolysate and the plurality of lipids comprises mixing the hydrolysate and the plurality of lipids in a molar ratio of more than 0 and up to 0.02.

~~21~~18. The method of any one of claims ~~16~~13 to ~~20~~17, wherein the buffer comprises (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid), sodium chloride, and sodium azide.

~~22~~19. The method of any one of claims ~~16~~13 to ~~21~~18, wherein extruding the suspension comprises extruding the suspension for more than one time.

~~23~~20. A liposomal membrane comprising a plurality of lipids and at least one hydrolysate of a peptide-attached pillar[5]arene, wherein the at least one hydrolysate of the peptide-attached pillar[5]arene is represented by the formula:



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wherein R represents a tripeptide having a terminal -NH- group and a terminal -COOH group, wherein the terminal -NH- group forms an amide linkage with the carbonyl carbon, ~~and~~ wherein the terminal -COOH group extends away from the amide linkage, and wherein the tripeptide comprises -NH-L-Phe-L-Phe-L-Phe-COOH.

~~24. The liposomal membrane of claim 23, wherein the tripeptide comprises -NH-L-Phe-L-Phe-L-Phe-COOH.~~

~~25~~21. The liposomal membrane of claim ~~23 or 24~~20, wherein the plurality of lipids comprise phosphatidylcholine and/or phosphatidylserine.

~~26~~22. The liposomal membrane of ~~any one of~~ claim~~s~~ ~~23~~20 ~~to~~or ~~25~~21, wherein the hydrolysate and the plurality of lipids are present in a molar ratio of more than 0 and up to 0.02.

~~27~~23. The liposomal membrane of any one of claims ~~23~~20 to ~~26~~22, wherein the liposomal membrane comprises a unilamellar liposome.