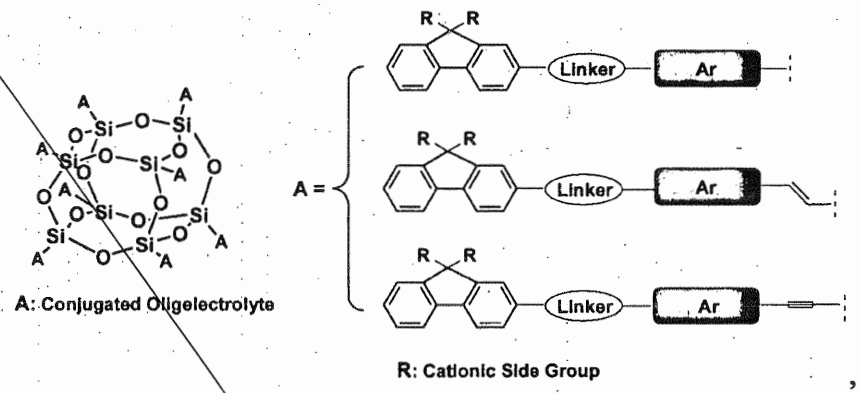
CLAIMS

What is claimed is:

1. A compound represented by the following structural formula:



or an acceptable salt thereof; wherein:

Ar is an optionally substituted aromatic group;

Linker is a single bond, double bond, triple bond, $-CR^1{}_m-$; wherein R^1 is hydrogen, halogen, hydroxy, amino, C_1-C_6alkyl, C_1-C_6alkenyl, C_1-C_6alkynyl, or C_1-C_6alkoxy; wherein the alkyl, alkenyl, alkynyl or alkoxy may be optionally substituted with halogen, hydroxy, C_1-C_4alkoxy or amino; and

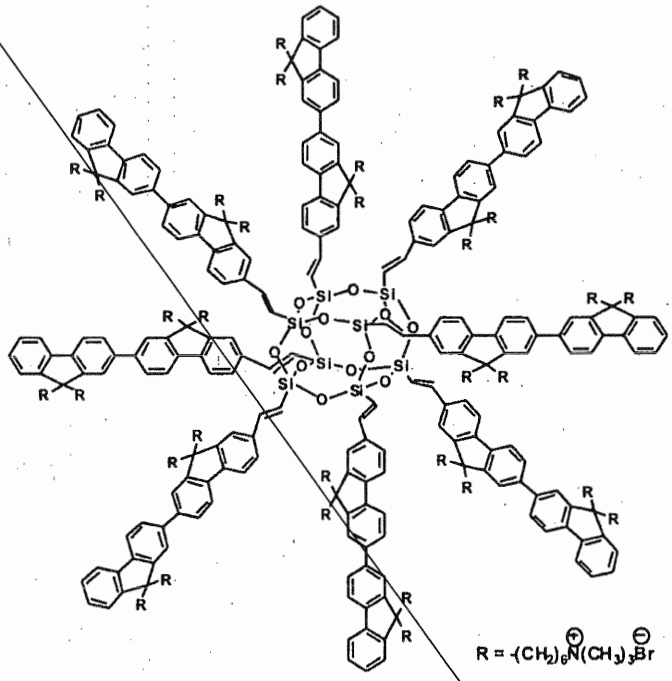
each R is independently hydrogen, a cationic alkyl side group or a cationic oligo(ethylene oxide) group.

2. The compound of Claim 1, wherein Ar is selected from the group consisting of fluorene, benzene, biphenyl, pyridine, bipyridinium, triphenylamine, anthracene, thiophene, carbazole, and benzothiadiazole.

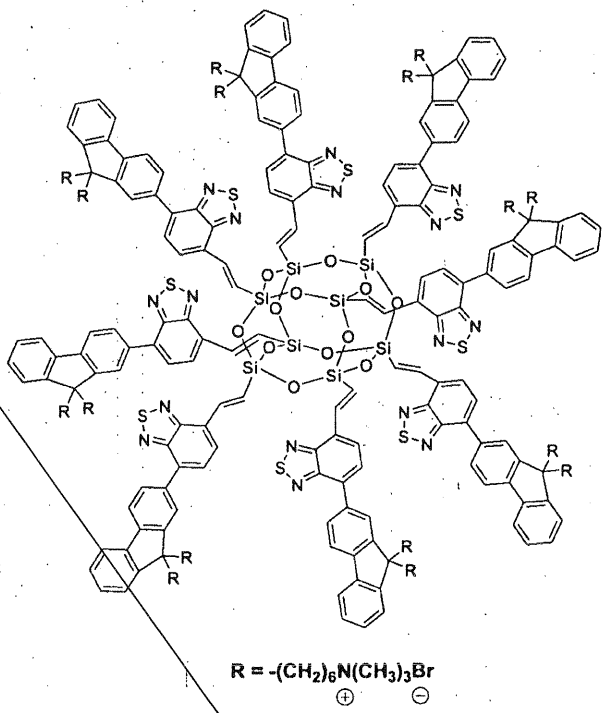
3. The compound of Claim 1, wherein each R is independently selected from the group consisting of hydrogen, $-(CH_2)_nNMe_3X$; and $-(CH_2O)_nNMe_3X$); wherein X is an anionic counterion and n is 3 to 13.

4. The compound of Claim 3, wherein X is selected from Br^-, I^-, BF_4^-, $CF_3SO_3^-$, ammonium hexafluorophosphate, and tetrakis[3,5-bis(trifluoromethyl)phenyl]borate.

5. The compound of Claim 1, wherein the compound is represented by the following structural formula:



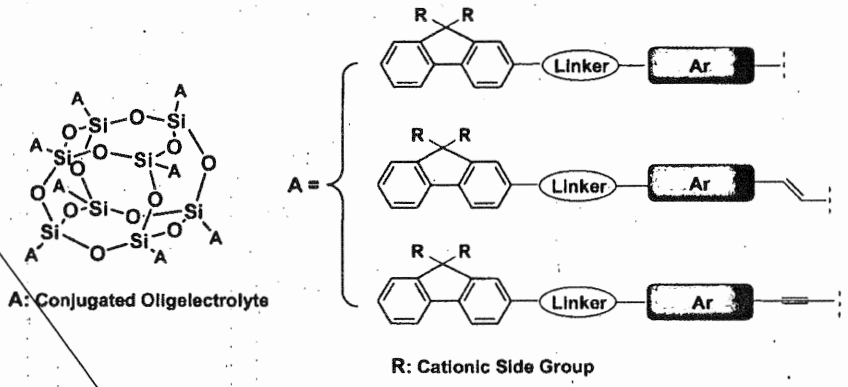
6. The compound of Claim 1, wherein the compound is represented by the following structural formula:



7. A composition comprising a compound of Claims 1-6 and a carrier.

8. A method of imaging the nucleus in a cell, comprising the steps of:
exposing the cell to a polyhedral oligomeric silsesquioxane compound;
allowing the polyhedral oligomeric silsesquioxane compound to bind to the nucleus;
and assaying the cell to determine the location of the polyhedral oligomeric silsesquioxane compound within or on the cell.

9. The method of Claim 8, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



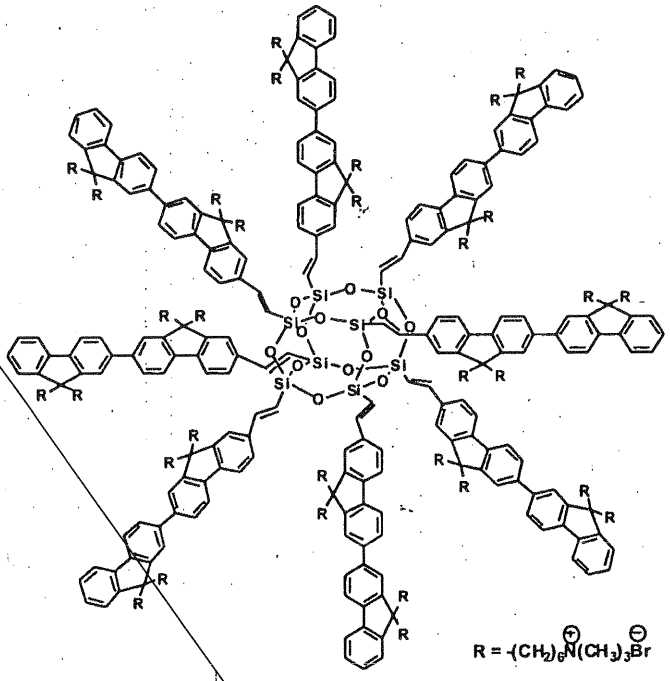
or an acceptable salt thereof; wherein:

Ar is an aromatic group;

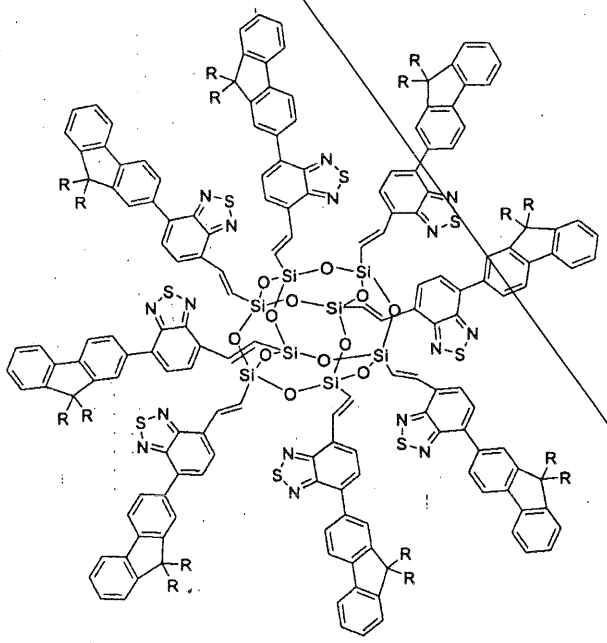
Linker is a single bond, double bond, triple bond, $-CR^1{}_m-$; wherein R^1 is hydrogen, halogen, hydroxy, amino, C_1-C_6alkyl, C_1-C_6alkenyl, C_1-C_6alkynyl, or C_1-C_6alkoxy; wherein the alkyl, alkenyl, alkynyl or alkoxy may be optionally substituted with halogen, hydroxy, C_1-C_4alkoxy or amino; and

each R is independently hydrogen, a cationic alkyl side group or a cationic oligo(ethylene oxide) group.

10. The method of Claim 8, where the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



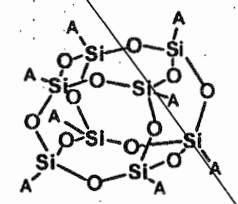
11. The method of Claim 8, where the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



12. The method of Claim 8, wherein the cells are assayed using fluorescence spectroscopy.

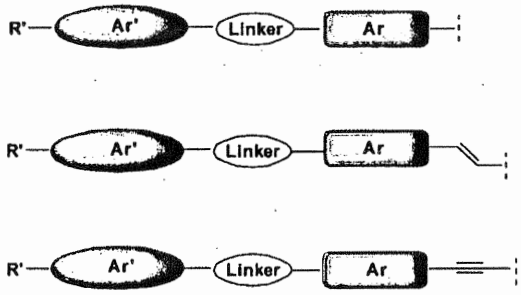
13. The method of Claim 12, wherein the fluorescence spectroscopy is two photon fluorescence spectroscopy.

14. A compound represented by the following structural formula:



A: Conjugated Oligelectrolyte

A =

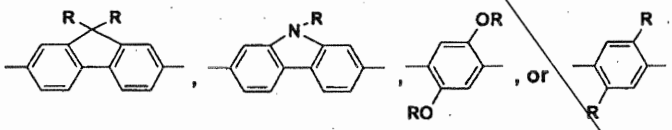


, or

an acceptable salt thereof; wherein



Each is independently selected from:



;

Each Ar is independently an optionally substituted aromatic group;

Each R is independently a cationic, anionic, or neutral alkyl group or a cationic, anionic, or neutral oligo(ethylene oxide) group;

Each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$;

Each R' is independently H or a terminal reactive group.

15. The compound of Claim 14, wherein the cationic alkyl group is $-(CH_2)_nNMe_3X$, where n = 3 – 13); the cationic oligo(ethylene oxide) group is $-(CH_2CH_2O)_nNMe_3X$, where n = 2 – 100); wherein X is selected from Br^-,

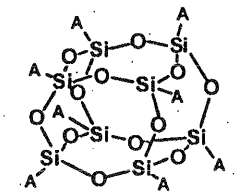
I^-, BF_4^-, $CF_3SO_3^-$, ammonium hexafluorophosphate, and tetrakis[3,5-bis(trifluoromethyl)phenyl]borate.

16. The compound of Claim 14, wherein neutral group is oligo(ethylene oxide) or poly(ethylene oxide).

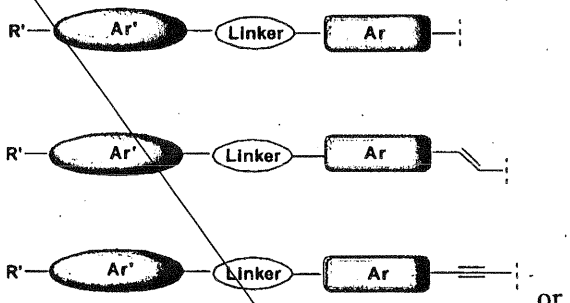
17. The compound of Claim 14, wherein
the anionic group is selected from $-(CH_2)_n X'$ or $-(CH_2CH_2O)_nX'$;
X' is selected from $SO_3^{2-}Y_2$, $PO_3^{2-}Y_2$, and CO_2^-Y;
Y is Na^+ and K^+.

18. The compound of Claim 14, wherein the terminal reactive group is selected from COOH, NH_2, CHO and SH.

19. The method of Claim 8, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



A =

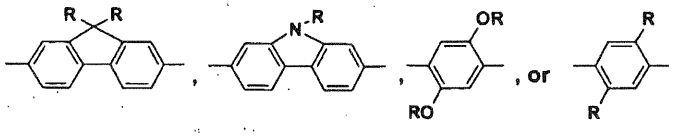


, or

an acceptable salt thereof; wherein



Each is independently selected from:



;

Each Ar is independently an optionally substituted aromatic group;

Each R is independently a cationic, anionic, or neutral alkyl group or a cationic, anionic, or neutral oligo(ethylene oxide) group;

Each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$;

Each R' is independently H or a terminal reactive group.

20. A method of quantifiying a biomolecule, comprising the steps of:

exposing the biomolecule to a polyhedral oligomeric silsesquioxane compound;

allowing the polyhedral oligomeric silsesquioxane compound to bind to the biomolecule;

and assaying the polyhedral oligomeric silsesquioxane compound, thereby quantifying the biomolecule.

21. The method of Claim 14, wherein the biomolecule is immobilized on a nanoparticle.

22. A method to detect a biological molecule, comprising the steps of:

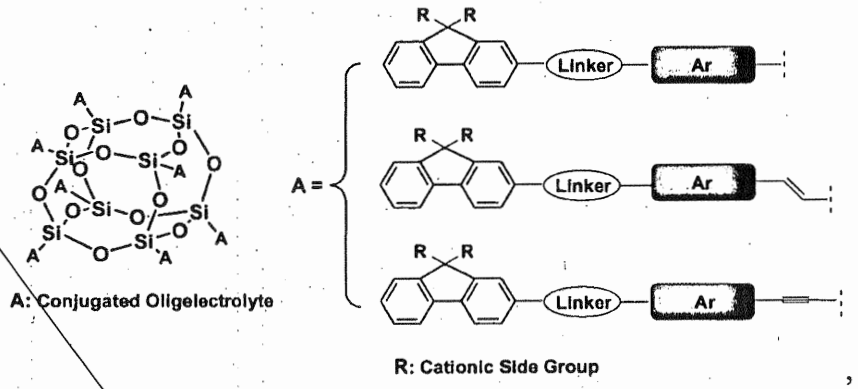
immobilizing an aptamer on a solid support;

incubating the immobilized aptamer with a test solution;

exposing the test solution to a polyhedral oligomeric silsesquioxane compound; and

measuring the fluorescence of the test solution, thereby detecting the biological molecule.

23. A compound represented by the following structural formula:



,

or an acceptable salt thereof; wherein:

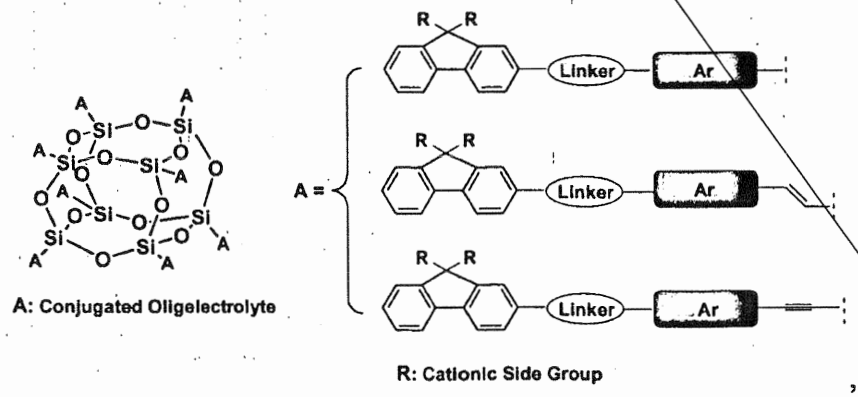
Ar is an optionally substituted aromatic group;

Each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R is independently hydrogen, a cationic alkyl side group or a cationic oligo(ethylene oxide) group.

24. The compound of Claim 23, wherein the cationic alkyl group is $-(CH_2)_nNMe_3X$, where n = 3 – 13); the cationic oligo(ethylene oxide) group is $-(CH_2CH_2O)_nNMe_3X$, where n = 2 – 100); wherein X is selected from Br^-, I^-, BF_4^-, $CF_3SO_3^-$, ammonium hexafluorophosphate, and tetrakis[3,5-bis(trifluoromethyl)phenyl]borate.

25. The method of Claim 8, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



,

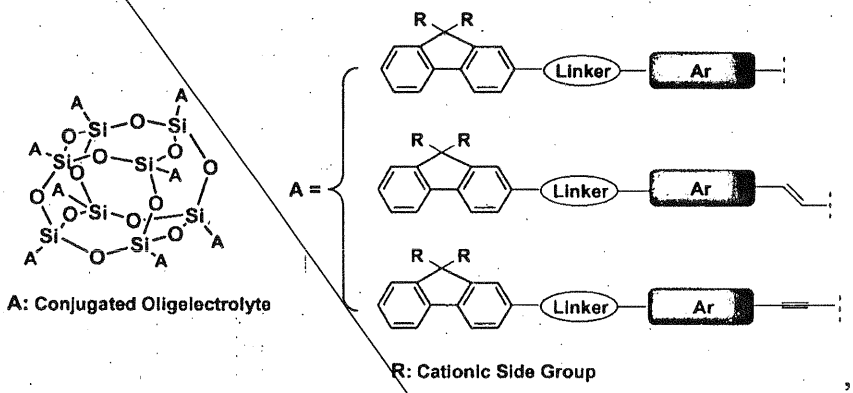
or an acceptable salt thereof; wherein:

Ar is an optionally substituted aromatic group;

Each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R is independently hydrogen, a cationic alkyl side group or a cationic oligo(ethylene oxide) group.

26. The method of Claim 22, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



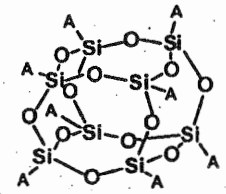
or an acceptable salt thereof; wherein:

Ar is an optionally substituted aromatic group;

Each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

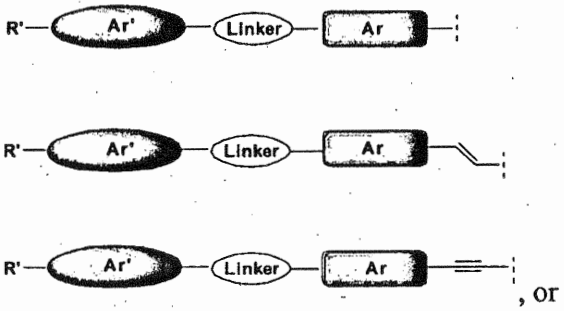
each R is independently hydrogen, a cationic alkyl side group or a cationic oligo(ethylene oxide) group.

27. The method of Claim 22, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



A: Conjugated Oligelectrolyte

A =

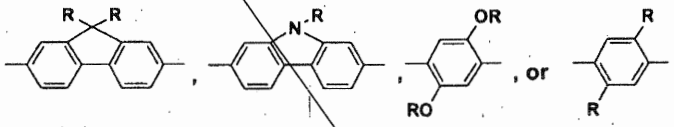


, or

an acceptable salt thereof; wherein



Each is independently selected from:



;

Each Ar is independently an optionally substituted aromatic group;

Each R is independently a cationic, anionic, or neutral alkyl group or a cationic, anionic, or neutral oligo(ethylene oxide) group;

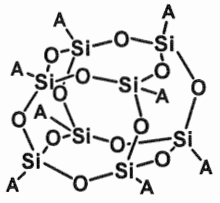
Each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$;

Each R' is independently H or a terminal reactive group.

CLAIMS

What is claimed is:

1. A compound represented by the following structural formula:

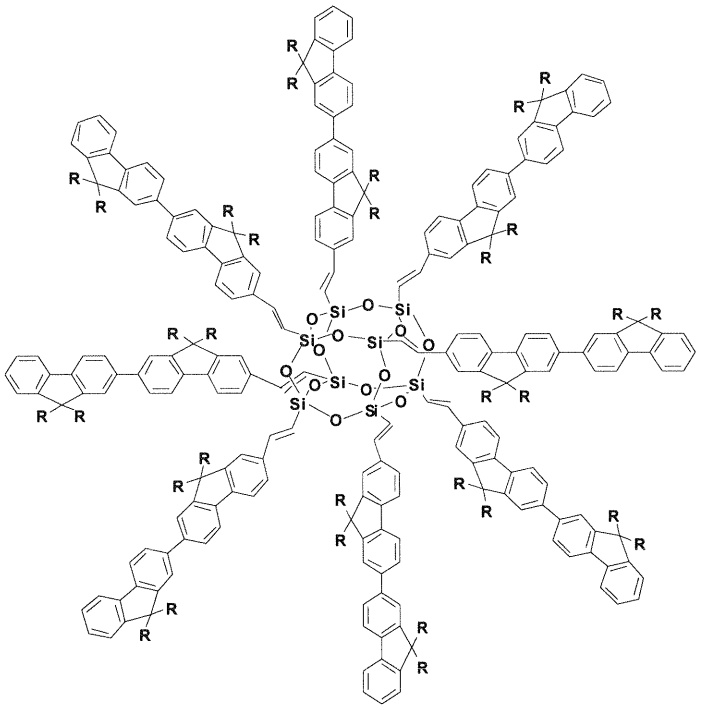

A
Si
O
A
Si
O
A
Si
O

2. The compound of Claim 1, wherein Ar is selected from the group consisting of fluorene, benzene, biphenyl, pyridine, bipyridinium, triphenylamine, anthracene, thiophene, carbazole, and benzothiadiazole.

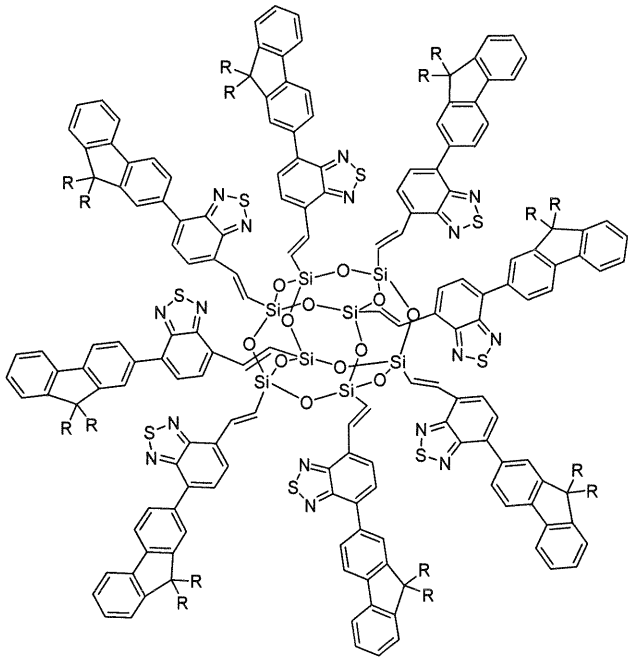
3. The compound of Claim 1, wherein each R is independently selected from the group consisting of hydrogen, $-(CH_2)_nNMe_3X$ and $-(CH_2CH_2O)_nNMe_3X$; wherein X is an anionic counterion and n is 3 to 13.

4. The compound of Claim 3, wherein X is selected from Br^-, I^-, BF_4^-, $CF_3SO_3^-$, ammonium hexafluorophosphate, and tetrakis[3,5-bis(trifluoromethyl)phenyl]borate.

5. The compound of Claim 1, wherein the compound is



, or



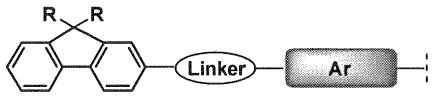
,

wherein R represents $-(CH_2)_6N^+(CH_3)_3Br^-$.

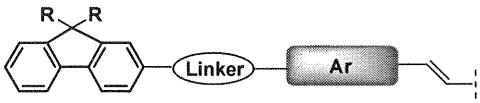
6. A method of imaging the nucleus in a cell, comprising the steps of:

exposing the cell to a polyhedral oligomeric silsesquioxane compound comprising a polycyclic compound consisting of a silicon/oxygen cage surrounded by tunable organic substitution groups attached to silicon atoms of the silicon/oxygen cage;

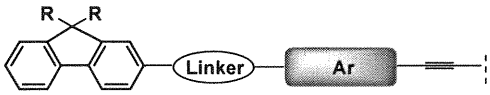
(i) wherein the tunable organic substitution groups are independently selected from the following structural formulae:



,



, and



, wherein:

Ar is an optionally substituted aromatic group;

Linker is a single bond, double bond, triple bond, $-CR^1{}_m-$; wherein R^1 is hydrogen, a halogen, a hydroxy group, an amino group, a C_1-C_6 alkyl group, a C_2-C_6 alkenyl group, a C_2-C_6 alkynyl group, or a C_1-C_6 alkoxy group; wherein the alkyl, alkenyl, alkynyl, or alkoxy groups may be optionally substituted with a halogen, a hydroxy group, a C_1-C_4 alkoxy group, or an amino group; and

each R is independently hydrogen, a cationic alkyl side group, a cationic oligo(ethylene oxide) group or a cationic poly(ethylene oxide) group, provided that at least one R is not hydrogen; or

(ii) wherein the tunable organic substitution groups are independently selected from the following structural formulae:



,



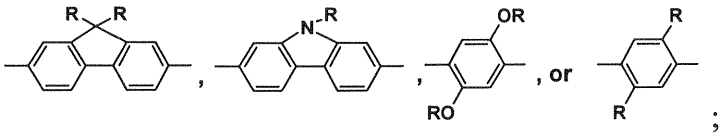
, and



, wherein:

each 

is independently selected from:



each Ar is independently an optionally substituted aromatic group;

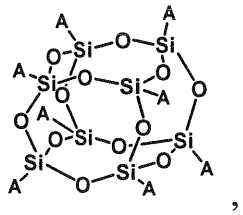
each R is independently a cationic or anionic alkyl group or a cationic or anionic oligo(ethylene oxide) group or a cationic or anionic poly(ethylene oxide) group;

each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$;

each R' is independently H or a terminal reactive group;

allowing the polyhedral oligomeric silsesquioxane compound to bind to the nucleus; and assaying the cell to determine the location of the polyhedral oligomeric silsesquioxane compound within or on the cell.

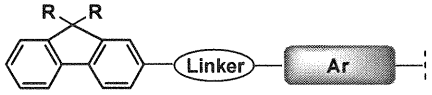
7. The method of Claim 6, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



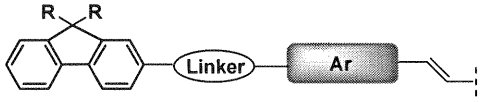
,

or an acceptable salt thereof; wherein:

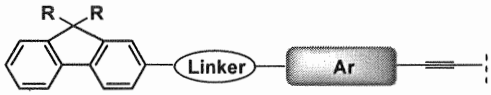
each A is one of the tunable organic substitution groups and is independently selected from the following structural formulae:



,



, and



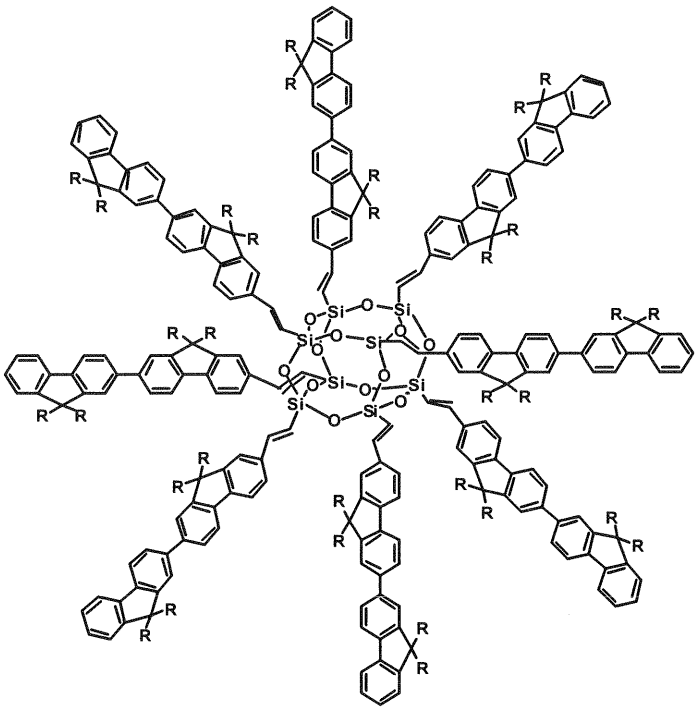
, wherein:

Ar is an optionally substituted aromatic group;

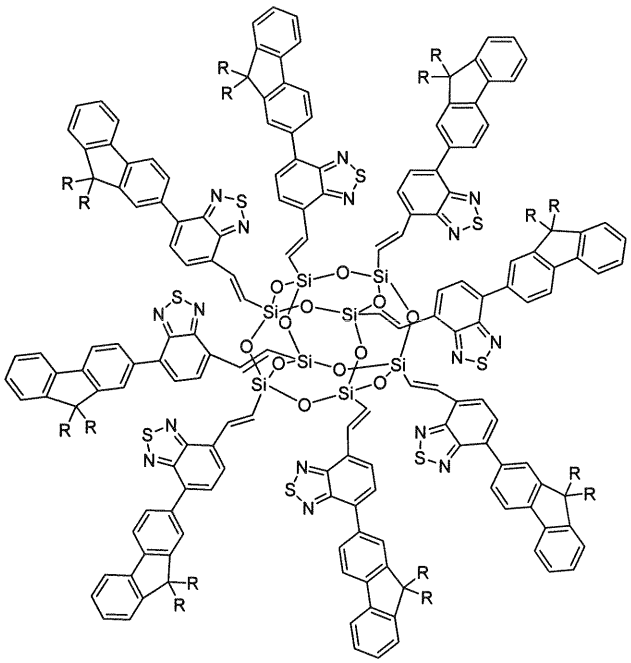
Linker is a single bond, double bond, triple bond, or $-CR^1{}_m-$; wherein R^1 is hydrogen, a halogen, a hydroxy group, an amino group, a C_1-C_6 alkyl group, a C_2-C_6 alkenyl group, a C_2-C_6 alkynyl group, or a C_1-C_6 alkoxy group; wherein the alkyl, alkenyl, alkynyl, or alkoxy group may be optionally substituted with a halogen, a hydroxy group, a C_1-C_4 alkoxy group, or an amino group; and

each R is independently hydrogen, a cationic alkyl side group, a cationic oligo(ethylene oxide) group or a cationic poly(ethylene oxide) group, provided that at least one R is not hydrogen.

8. The method of Claim 6, where the polyhedral oligomeric silsesquioxane compound is



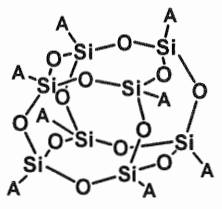
, or



,

wherein R represents $-(CH_2)_6N^+(CH_3)_3Br^-$.

9. A compound represented by the following structural formula:


A
Si
O
A
Si
O
A
Si
O

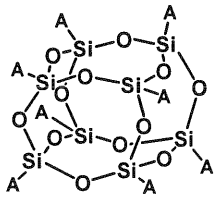
X' is selected from $SO_3^{2-}Y_2$, $PO_3^{2-}Y_2$, and $CO_2^{-}Y$;

Y is selected from Na^+ and K^+; and

n is 3-100.

12. The compound of Claim 9, wherein the terminal reactive group is selected from COOH, NH_2, CHO and SH.

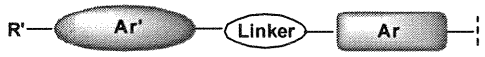
13. The method of Claim 6, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



,

or an acceptable salt thereof; wherein:

each A is one of the tunable organic substitution groups and is independently selected from the following structural formulae:



,



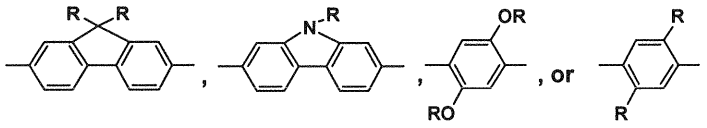
, and



, wherein:

each 

is independently selected from:



;

each Ar is independently an optionally substituted aromatic group;

each R is independently a cationic or anionic alkyl group, or a cationic or anionic oligo(ethylene oxide) group or a cationic or anionic poly(ethylene oxide) group;

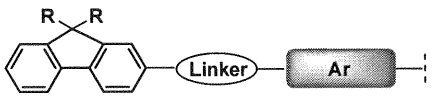
each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R' is independently H or a terminal reactive group.

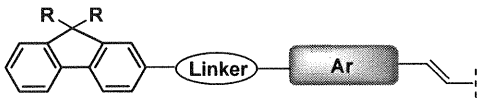
14. A method of quantifiying a biomolecule, comprising the steps of:

exposing the biomolecule to a polyhedral oligomeric silsesquioxane compound comprising a polycyclic compound consisting of a silicon/oxygen cage surrounded by tunable organic substitution groups attached to silicon atoms of the silicon/oxygen cage;

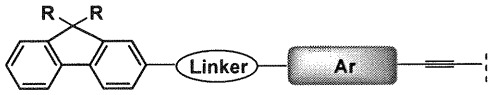
(i) wherein the tunable organic substitution groups are independently selected from the following structural formulae:



,



, and



, wherein:

Ar is an optionally substituted aromatic group;

Linker is a single bond, double bond, triple bond, or $-CR^1{}_m-$; wherein R^1 is hydrogen, a halogen, a hydroxy group, an amino group, a C_1-C_6 alkyl group, a C_2-C_6 alkenyl group, a C_2-C_6 alkynyl group, or a C_1-C_6 alkoxy group; wherein the alkyl, alkenyl, alkynyl, or alkoxy groups may be optionally substituted with a halogen, a hydroxy group, a C_1-C_4 alkoxy group or an amino group; and

each R is independently hydrogen, a cationic alkyl side group, a cationic oligo(ethylene oxide) group, or a cationic poly(ethylene oxide) group, provided that at least one R is not hydrogen; or

(ii) wherein the tunable organic substitution groups are independently selected from the following structural formulae:



,



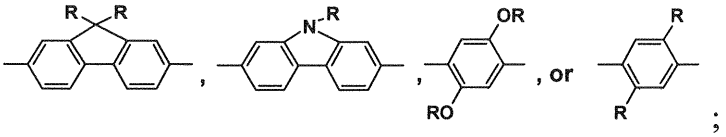
, and



, wherein:

each 

is independently selected from:



;

each Ar is independently an optionally substituted aromatic group;

each R is independently a cationic or anionic alkyl group, or a cationic or anionic oligo(ethylene oxide) group, or a cationic or anionic poly(ethylene oxide) group;

each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R' is independently H or a terminal reactive group;

allowing the polyhedral oligomeric silsesquioxane compound to bind to the biomolecule;

and assaying the polyhedral oligomeric silsesquioxane compound, thereby quantifying the biomolecule.

15. The method of Claim 14, wherein the biomolecule is immobilized on a nanoparticle.

16. A method to detect a biological molecule in a test solution, comprising the steps of:

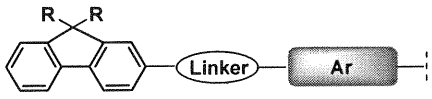
providing an aptamer capable of binding the biological molecule;

immobilizing the aptamer on a solid support;

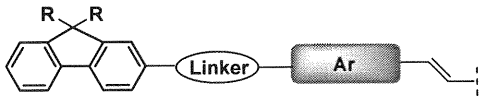
incubating the immobilized aptamer with the test solution;

exposing the test solution to a polyhedral oligomeric silsesquioxane compound comprising a polycyclic compound consisting of a silicon/oxygen cage surrounded by tunable organic substitution groups attached to silicon atoms of the silicon/oxygen cage;

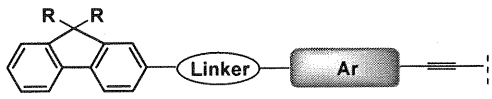
(i) wherein the tunable organic substitution groups are independently selected from the following structural formulae:



,



, and



, wherein:

Ar is an optionally substituted aromatic group;

each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and each R is independently hydrogen, a cationic alkyl side group, a cationic oligo(ethylene oxide) group, or a cationic poly(ethylene oxide) group, provided that at least one R is not hydrogen; or

(ii) wherein the tunable organic substitution groups are independently selected from the following structural formulae:



,



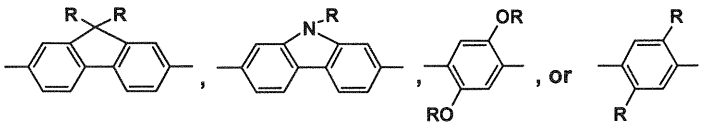
, and



, wherein:

each 

is independently selected from:



;

each Ar is independently an optionally substituted aromatic group;

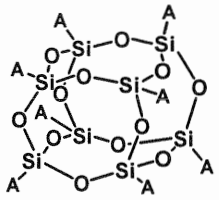
each R is independently a cationic or anionic alkyl group or a cationic or anionic oligo(ethylene oxide) group, or a cationic or anionic poly(ethylene oxide) group;

each Linker is a single bond, double bond, triple bond, $-CH_2-$, or $-CH_2CH_2-$; and

each R' is independently H or a terminal reactive group;

and measuring the fluorescence of the test solution, thereby detecting the biological molecule.

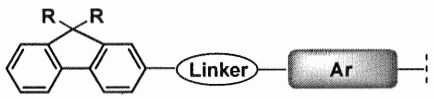
17. A compound represented by the following structural formula:



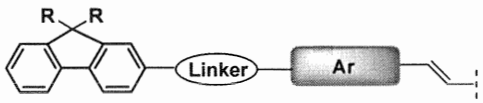
,

or an acceptable salt thereof; wherein:

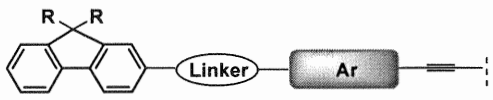
each A is a group independently selected from the following structural formulae:



,



, and



,

wherein:

Ar is an optionally substituted aromatic group;

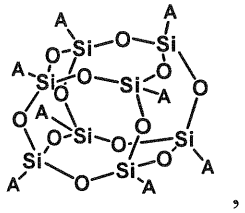
each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R is independently hydrogen, a cationic alkyl side group, a cationic oligo(ethylene oxide) group or a cationic poly(ethylene oxide) group, provided that at least one R is not hydrogen.

18. The compound of Claim 17, wherein the cationic alkyl group is $-(CH_2)_nNMe_3X$, where n = 3 – 13; the cationic oligo(ethylene oxide) group or cationic poly(ethylene

oxide) group is $-(CH_2CH_2O)_nNMe_3X$, where n = 2 – 100; wherein X is selected from Br^-, I^-, BF_4^-, $CF_3SO_3^-$, ammonium hexafluorophosphate, and tetrakis[3,5-bis(trifluoromethyl)phenyl]borate.

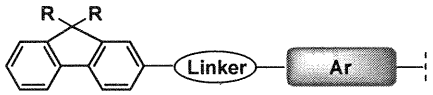
19. The method of Claim 16, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



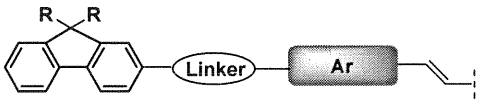
,

or an acceptable salt thereof; wherein:

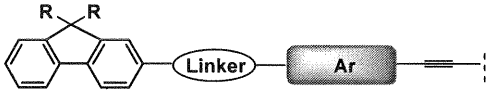
each A is one of the tunable organic substitution groups and is independently selected from the following structural formulae:



,



, and



,

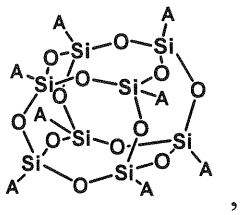
wherein:

Ar is an optionally substituted aromatic group;

each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R is independently hydrogen, a cationic alkyl side group, a cationic oligo(ethylene oxide) group or a cationic poly(ethylene oxide) group, provided that at least one R is not hydrogen.

20. The method of Claim 16, wherein the polyhedral oligomeric silsesquioxane compound is represented by the following structural formula:



or an acceptable salt thereof; wherein:

each A is one of the tunable organic substitution groups and is independently selected from the following structural formulae:



,

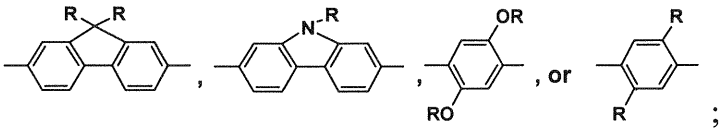


, and



, wherein:

each  is independently selected from:



, , , or ;

each Ar is independently an optionally substituted aromatic group;

each R is independently a cationic or anionic alkyl group, or a cationic or anionic oligo(ethylene oxide) group, or a cationic or anionic poly(ethylene oxide) group;

each Linker is a single bond, double bond, triple bond, $-CH_2-$ or $-CH_2CH_2-$; and

each R' is independently H or a terminal reactive group.