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(54) Title: ULTRA BRIGHT DIMERIC OR POLYMERIC DYES AND METHODS FOR PREPARATION OF THE SAME

(57) Abstract: Dimeric and/or polymeric dyes and compounds and methods for preparation of the same are disclosed.

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ULTRA BRIGHT DIMERIC OR POLYMERIC DYES AND METHODS FOR PREPARATION OF THE SAME

BACKGROUND

Field

Embodiments of the present invention are generally directed to methods for preparation of dimeric and polymeric fluorescent or colored dyes and compounds useful for the same.

Description of the Related Art

Fluorescent and/or colored dyes are known to be particularly suitable for applications in which a highly sensitive detection reagent is desirable. Dyes that are able to preferentially label a specific ingredient or component in a sample enable the researcher to determine the presence, quantity and/or location of that specific ingredient or component. In addition, specific systems can be monitored with respect to their spatial and temporal distribution in diverse environments.

Fluorescence and colorimetric methods are extremely widespread in chemistry and biology. These methods give useful information on the presence, structure, distance, orientation, complexation and/or location for biomolecules. In addition, time-resolved methods are increasingly used in measurements of dynamics and kinetics. As a result, many strategies for fluorescence or color labeling of biomolecules, such as nucleic acids and protein, have been developed. Since analysis of biomolecules typically occurs in an aqueous environment, the focus has been on development and use of water soluble dyes.

Highly fluorescent or colored dyes are desirable since use of such dyes increases the signal to noise ratio and provides other related benefits. Accordingly, attempts have been made to increase the signal from known fluorescent and/or colored moieties. For example, dimeric and polymeric compounds comprising two or more fluorescent and/or colored moieties have been prepared in anticipation that such compounds would result in brighter dyes. However, as a result of intramolecular

fluorescence quenching, the known dimeric and polymeric dyes have not achieved the desired increase in brightness.

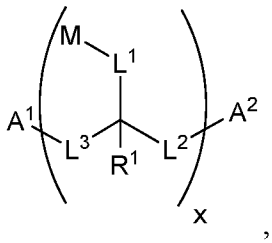
There is thus a need in the art for methods for preparation of water soluble dyes having an increased molar brightness. Ideally, such dyes and biomarkers should be intensely colored or fluorescent and should be available in a variety of colors and fluorescent wavelengths. The present invention fulfills this need and provides further related advantages.

BRIEF SUMMARY

In brief, embodiments of the present invention are generally directed to compounds useful as water soluble, fluorescent and/or colored dyes and/or probes that enable visual detection of analyte molecules, such as biomolecules, as well as reagents for their preparation. Methods for visually detecting analyte molecules using the dyes are also described. Further embodiments include methods and compounds useful for preparation of such fluorescent and/or colored dyes.

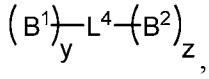
The water soluble, fluorescent or colored dyes of embodiments of the invention are intensely colored and/or fluorescent and can be readily observed by visual inspection or other means. In some embodiments the compounds may be observed without prior illumination or chemical or enzymatic activation. By appropriate selection of the dye, as described herein, visually detectable analyte molecules of a variety of colors may be obtained.

In one embodiment, is provided a method for preparing a dimeric or polymeric dye, the method comprising reacting a first and second compound of structure (I):



(I)

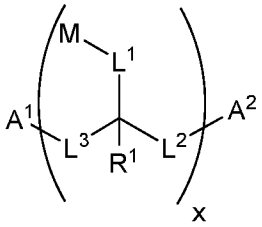
with a compound of structure (II):



(II)

wherein A^1, A^2, B^1, B^2, L^1, L^2, L^3, L^4, M, R^1, x, y and z are as defined herein.

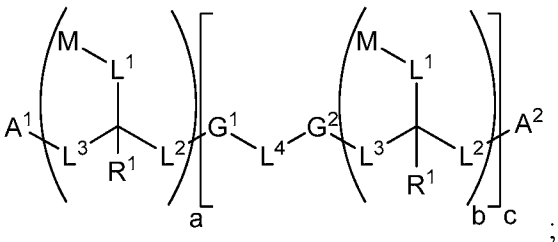
In a different embodiment is provided a method for preparing a dimeric or polymeric dye, the method comprising reacting a first compound of structure (I):



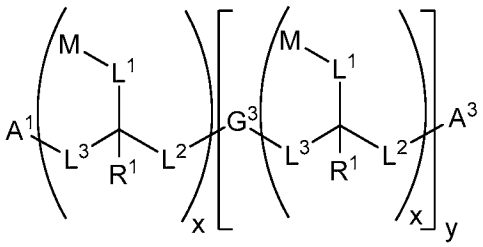
(I)

with a second compound of structure (I), wherein A^1, A^2, L^1, L^2, L^3, M, R^1 and x are as defined herein.

Other embodiments are directed to a compound having one of the following structures (III), (IV) or (V):

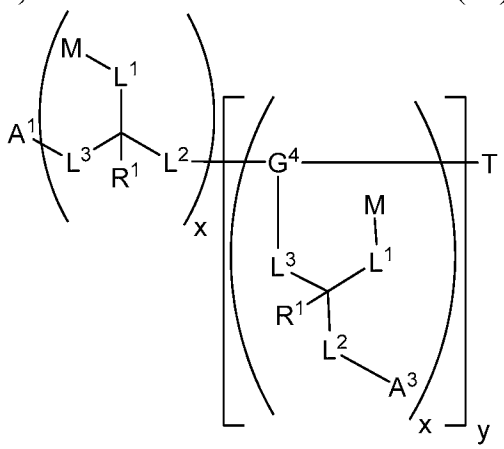


(III)



(IV)

or



(V)

wherein A^1, A^2,A3, G^1, G^2, G3, G4, L^1, L^2, L^3, L^4, M, R^1, T, a, b, c, x and y are as defined herein.

In another embodiment, a method for staining a sample is provided, the method comprises adding to said sample a compound of structure (III), (IV) or (V) in an amount sufficient to produce an optical response when said sample is illuminated at an appropriate wavelength.

In still other embodiments, the present disclosure provides a method for visually detecting an analyte molecule, comprising:

(a) providing a compound of (III), (IV) or (V); and

(b) detecting the compound by its visible properties.

Other disclosed methods include a method for visually detecting a biomolecule, the method comprising:

(a) admixing a compound of structure (III), (IV) or (V) with one or more biomolecules; and

(b) detecting the compound by its visible properties.

Other embodiments provide a method for visually detecting an analyte, the method comprising:

(a) providing a compound of structure (III), (IV) or (V), wherein A^1 or A^2 comprises a linker comprising a covalent bond to a targeting moiety having specificity for the analyte;

(b) admixing the compound and the analyte, thereby associating the targeting moiety and the analyte; and

(c) detecting the compound by its visible properties.

Other embodiments are directed to a composition comprising a compound of structure (III), (IV) or (V) and one or more analyte molecule, such as a biomolecule. Use of such compositions in analytical methods for detection of the one or more biomolecules is also provided.

These and other aspects of the invention will be apparent upon reference to the following detailed description.

DETAILED DESCRIPTION

In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention.

However, one skilled in the art will understand that the invention may be practiced without these details.

Unless the context requires otherwise, throughout the present specification and claims, the word "comprise" and variations thereof, such as, "comprises" and "comprising" are to be construed in an open, inclusive sense, that is, as "including, but not limited to".

Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

"Amino" refers to the $-NH_2$ group.

"Carboxy" refers to the $-CO_2H$ group.

"Cyano" refers to the $-CN$ group.

"Formyl" refers to the $-C(=O)H$ group.

"Hydroxy" or "hydroxyl" refers to the $-OH$ group.

"Imino" refers to the $=NH$ group.

"Nitro" refers to the $-NO_2$ group.

"Oxo" refers to the $=O$ substituent group.

"Sulfhydryl" refers to the $-SH$ group.

"Thioxo" refers to the $=S$ group.

"Alkyl" refers to a straight or branched hydrocarbon chain group consisting solely of carbon and hydrogen atoms, containing no unsaturation, having from one to twelve carbon atoms (C_1-C_{12} alkyl), one to eight carbon atoms (C_1-C_8 alkyl) or one to six carbon atoms (C_1-C_6 alkyl), and which is attached to the rest of the molecule by a single bond, *e.g.*, methyl, ethyl, *n*-propyl, 1-methylethyl (*iso*-propyl), *n*-butyl, *n*-pentyl, 1,1-dimethylethyl (*t*-butyl), 3-methylhexyl, 2-methylhexyl, and the like. Unless stated otherwise specifically in the specification, alkyl groups are optionally substituted.

"Alkylene" or "alkylene chain" refers to a straight or branched divalent hydrocarbon chain linking the rest of the molecule to a radical group, consisting solely of carbon and hydrogen, containing no unsaturation, and having from one to twelve carbon atoms, *e.g.*, methylene, ethylene, propylene, *n*-butylene, ethenylene, propenylene, *n*-butenylene, propynylene, *n*-butynylene, and the like. The alkylene chain is attached to the rest of the molecule through a single bond and to the radical group through a single bond. The points of attachment of the alkylene chain to the rest of the molecule and to the radical group can be through one carbon or any two carbons within the chain. Unless stated otherwise specifically in the specification, alkylene is optionally substituted.

"Alkenylene" or "alkenylene chain" refers to a straight or branched divalent hydrocarbon chain linking the rest of the molecule to a radical group, consisting solely of carbon and hydrogen, containing at least one carbon-carbon double bond and having from two to twelve carbon atoms, *e.g.*, ethenylene, propenylene, *n*-butenylene, and the like. The alkenylene chain is attached to the rest of the molecule through a single bond and to the radical group through a double bond or a single bond. The points of attachment of the alkenylene chain to the rest of the molecule and to the radical group can be through one carbon or any two carbons within the chain. Unless stated otherwise specifically in the specification, alkenylene is optionally substituted.

"Alkynylene" or "alkynylene chain" refers to a straight or branched divalent hydrocarbon chain linking the rest of the molecule to a radical group, consisting solely of carbon and hydrogen, containing at least one carbon-carbon triple bond and having from two to twelve carbon atoms, *e.g.*, ethenylene, propenylene, *n*-butenylene, and the like. The alkynylene chain is attached to the rest of the molecule through a single bond and to the radical group through a double bond or a single bond. The points of attachment of the alkynylene chain to the rest of the molecule and to the radical group can be through one carbon or any two carbons within the chain. Unless stated otherwise specifically in the specification, alkynylene is optionally substituted.

"Alkylether" refers to any alkyl group as defined above, wherein at least one carbon-carbon bond is replaced with a carbon-oxygen bond. The carbon-oxygen bond may be on the terminal end (as in an alkoxy group) or the carbon oxygen bond

may be internal (*i.e.*, C-O-C). Alkylethers include at least one carbon oxygen bond, but may include more than one. For example, polyethylene glycol (PEG) is included within the meaning of alkylether. Unless stated otherwise specifically in the specification, an alkylether group is optionally substituted. For example, in some embodiments an alkylether is substituted with an alcohol or $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I).

"Alkoxy" refers to a group of the formula $-OR_a$ where R_a is an alkyl group as defined above containing one to twelve carbon atoms. Unless stated otherwise specifically in the specification, an alkoxy group is optionally substituted.

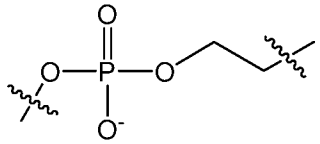
"Alkoxyalkylether" refers to a group of the formula $-OR_aR_b$ where R_a is an alkylene group as defined above containing one to twelve carbon atoms, and Rb is an alkylether group as defined herein. Unless stated otherwise specifically in the specification, an alkoxyalkylether group is optionally substituted, for example substituted with an alcohol or $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I).

"Heteroalkyl" refers to an alkyl group, as defined above, comprising at least one heteroatom (*e.g.*, N, O, P or S) within the alkyl group or at a terminus of the alkyl group. In some embodiments, the heteroatom is within the alkyl group (*i.e.*, the heteroalkyl comprises at least one carbon-$[heteroatom]_x$-carbon bond, where x is 1, 2 or 3). In other embodiments, the heteroatom is at a terminus of the alkyl group and thus serves to join the alkyl group to the remainder of the molecule (*e.g.*, M1-H-A), where M1 is a portion of the molecule, H is a heteroatom and A is an alkyl group). Unless stated otherwise specifically in the specification, a heteroalkyl group is optionally substituted. Exemplary heteroalkyl groups include ethylene oxide (e.g., polyethylene oxide), optionally including phosphorous-oxygen bonds, such as phosphodiester bonds.

"Heteroalkoxy" refers to a group of the formula $-OR_a$ where R_a is a heteroalkyl group as defined above containing one to twelve carbon atoms. Unless stated otherwise specifically in the specification, a heteroalkoxy group is optionally substituted.

"Heteroalkylene" refers to an alkylene group, as defined above, comprising at least one heteroatom (*e.g.*, N, O, P or S) within the alkylene chain or at a

terminus of the alkylene chain. In some embodiments, the heteroatom is within the alkylene chain (*i.e.*, the heteroalkylene comprises at least one carbon-[heteroatom]-carbon bond, where x is 1, 2 or 3). In other embodiments, the heteroatom is at a terminus of the alkylene and thus serves to join the alkylene to the remainder of the molecule (*e.g.*, M1-H-A-M2, where M1 and M2 are portions of the molecule, H is a heteroatom and A is an alkylene). Unless stated otherwise specifically in the specification, a heteroalkylene group is optionally substituted. Exemplary heteroalkylene groups include ethylene oxide (e.g., polyethylene oxide) and the "C" linking group illustrated below:



"C linker"

Multimers of the above C-linker are included in various embodiments of heteroalkylene linkers.

"Heteroalkenylene" is a heteroalkylene, as defined above, comprising at least one carbon-carbon double bond. Unless stated otherwise specifically in the specification, a heteroalkenylene group is optionally substituted.

"Heteroalkynylene" is a heteroalkylene comprising at least one carbon-carbon triple bond. Unless stated otherwise specifically in the specification, a heteroalkynylene group is optionally substituted.

"Heteroatomic" in reference to a "heteroatomic linker" refers to a linker group consisting of one or more heteroatoms. Exemplary heteroatomic linkers include single atoms selected from the group consisting of O, N, P and S, and multiple heteroatoms for example a linker having the formula $-P(O^-)(=O)O-$ or $-OP(O^-)(=O)O-$ and multimers and combinations thereof.

"Phosphate" refers to the $-OP(=O)(R_a)R_b$ group, wherein R_a is OH, O^- or OR_c; and R_b is OH, O^-, OR_c, a thiophosphate group or a further phosphate group, wherein R_c is a counter ion (*e.g.*, Na+ and the like).

"Phosphoalkyl" refers to the $-OP(=O)(R_a)R_b$ group, wherein R_a is OH, O^- or OR_c; and R_b is −Oalkyl, wherein R_c is a counter ion (*e.g.*, Na+ and the like). Unless stated otherwise specifically in the specification, a phosphoalkyl group is

optionally substituted. For example, in certain embodiments, the −Oalkyl moiety in a phosphoalkyl group is optionally substituted with one or more of hydroxyl, amino, sulfhydryl, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether, thiophosphoalkylether or $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I).

"Phosphoalkylether" refers to the $-OP(=O)(R_a)R_b$ group, wherein R_a is OH, O^- or OR_c; and R_b is −Oalkylether, wherein R_c is a counter ion (*e.g.*, Na+ and the like). Unless stated otherwise specifically in the specification, a phosphoalkylether group is optionally substituted. For example, in certain embodiments, the -Oalkylether moiety in a phosphoalkylether group is optionally substituted with one or more of hydroxyl, amino, sulfhydryl, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether, thiophosphoalkylether or $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I).

"Thiophosphate" refers to the $-OP(=R_a)(R_b)R_c$ group, wherein R_a is O or S, R_b is OH, O^-, S^-, OR_d or SR_d; and R_c is OH, SH, O^-, S^-, OR_d, SR_d, a phosphate group or a further thiophosphate group, wherein R_d is a counter ion (*e.g.*, Na+ and the like) and provided that: i) R_a is S; ii) R_b is S^- or SR_d; iii)R_c is SH, S^- or SR_d; or iv) a combination of i), ii) and/or iii).

"Thiophosphoalkyl" refers to the $-OP(=R_a)(R_b)R_c$ group, wherein R_a is O or S, R_b is OH, O^-, S^-, OR_d or SR_d; and R_c is −Oalkyl, wherein R_d is a counter ion (*e.g.*, Na+ and the like) and provided that: i) R_a is S; ii) R_b is S^- or SR_d; or iii)R_a is S and R_b is S^- or SR_d. Unless stated otherwise specifically in the specification, a thiophosphoalkyl group is optionally substituted. For example, in certain embodiments, the −Oalkyl moiety in a thiophosphoalkyl group is optionally substituted with one or more of hydroxyl, amino, sulfhydryl, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether, thiophosphoalkylether or $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I).

"Thiophosphoalkylether" refers to the $-OP(=R_a)(R_b)R_c$ group, wherein R_a is O or S, R_b is OH, O^-, S^-, OR_d or SR_d; and R_c is −Oalkylether, wherein R_d is a counter ion (*e.g.*, Na+ and the like) and provided that: i) R_a is S; ii) R_b is S^- or SR_d; or iii)R_a is S and R_b is S^- or SR_d. Unless stated otherwise specifically in the specification,

a thiophosphoalkylether group is optionally substituted. For example, in certain embodiments, the -Oalkylether moiety in a thiophosphoalkyl group is optionally substituted with one or more of hydroxyl, amino, sulfhydryl, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether, thiophosphoalkylether or $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I).

"Carbocyclic" refers to a stable 3- to 18-membered aromatic or non-aromatic ring comprising 3 to 18 carbon atoms. Unless stated otherwise specifically in the specification, a carbocyclic ring may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems, and may be partially or fully saturated. Non-aromatic carbocyclyl radicals include cycloalkyl, while aromatic carbocyclyl radicals include aryl. Unless stated otherwise specifically in the specification, a carbocyclic group is optionally substituted.

"Cycloalkyl" refers to a stable non-aromatic monocyclic or polycyclic carbocyclic ring, which may include fused or bridged ring systems, having from three to fifteen carbon atoms, preferably having from three to ten carbon atoms, and which is saturated or unsaturated and attached to the rest of the molecule by a single bond. Monocyclic cycloalkyls include, for example, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptly, and cyclooctyl. Polycyclic cycloalkyls include, for example, adamantyl, norbornyl, decalinyl, 7,7-dimethyl-bicyclo-[2.2.1]heptanyl, and the like. Unless stated otherwise specifically in the specification, a cycloalkyl group is optionally substituted.

"Aryl" refers to a ring system comprising at least one carbocyclic aromatic ring. In some embodiments, an aryl comprises from 6 to 18 carbon atoms. The aryl ring may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems. Aryls include, but are not limited to, aryls derived from aceanthrylene, acenaphthylene, acephenanthrylene, anthracene, azulene, benzene, chrysene, fluoranthene, fluorene, *as*-indacene, *s*-indacene, indane, indene, naphthalene, phenalene, phenanthrene, pleiadene, pyrene, and triphenylene. Unless stated otherwise specifically in the specification, an aryl group is optionally substituted.

"Heterocyclic" refers to a stable 3- to 18-membered aromatic or non-aromatic ring comprising one to twelve carbon atoms and from one to six heteroatoms selected from the group consisting of nitrogen, oxygen and sulfur. Unless stated otherwise specifically in the specification, the heterocyclic ring may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems; and the nitrogen, carbon or sulfur atoms in the heterocyclic ring may be optionally oxidized; the nitrogen atom may be optionally quaternized; and the heterocyclic ring may be partially or fully saturated. Examples of aromatic heterocyclic rings are listed below in the definition of heteroaryls (*i.e.,* heteroaryl being a subset of heterocyclic). Examples of non-aromatic heterocyclic rings include, but are not limited to, dioxolanyl, thienyl[1,3]dithianyl, decahydroisoquinolyl, imidazolinyl, imidazolidinyl, isothiazolidinyl, isoxazolidinyl, morpholinyl, octahydroindolyl, octahydroisoindolyl, 2-oxopiperazinyl, 2-oxopiperidinyl, 2-oxopyrrolidinyl, oxazolidinyl, piperidinyl, piperazinyl, 4-piperidonyl, pyrrolidinyl, pyrazolidinyl, pyrazolopyrimidinyl, quinuclidinyl, thiazolidinyl, tetrahydrofuryl, trioxanyl, trithianyl, triazinanyl, tetrahydropyranyl, thiomorpholinyl, thiamorpholinyl, 1-oxo-thiomorpholinyl, and 1,1-dioxo-thiomorpholinyl. Unless stated otherwise specifically in the specification, a heterocyclic group is optionally substituted.

"Heteroaryl" refers to a 5- to 14-membered ring system comprising one to thirteen carbon atoms, one to six heteroatoms selected from the group consisting of nitrogen, oxygen and sulfur, and at least one aromatic ring. For purposes of certain embodiments of this invention, the heteroaryl radical may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems; and the nitrogen, carbon or sulfur atoms in the heteroaryl radical may be optionally oxidized; the nitrogen atom may be optionally quaternized. Examples include, but are not limited to, azepinyl, acridinyl, benzimidazolyl, benzthiazolyl, benzindolyl, benzodioxolyl, benzofuranyl, benzooxazolyl, benzothiazolyl, benzothiadiazolyl, benzo[*b*][1,4]dioxepinyl, 1,4-benzodioxanyl, benzonaphthofuranyl, benzoxazolyl, benzodioxolyl, benzodioxinyl, benzopyranyl, benzopyranonyl, benzofuranyl, benzofuranonyl, benzothienyl (benzothiophenyl), benzotriazolyl, benzo[4,6]imidazo[1,2-*a*]pyridinyl, benzoxazolinonyl, benzimidazolthionyl, carbazolyl,

cinnolinyl, dibenzofuranyl, dibenzothiophenyl, furanyl, furanonyl, isothiazolyl, imidazolyl, indazolyl, indolyl, indazolyl, isoindolyl, indolinyl, isoindolinyl, isoquinolyl, indolizinyl, isoxazolyl, naphthyridinyl, oxadiazolyl, 2-oxoazepinyl, oxazolyl, oxiranyl, 1-oxidopyridinyl, 1-oxidopyrimidinyl, 1-oxidopyrazinyl, 1-oxidopyridazinyl, 1-phenyl-1*H*-pyrrolyl, phenazinyl, phenothiazinyl, phenoxazinyl, phthalazinyl, pteridinyl, pteridinonyl, purinyl, pyrrolyl, pyrazolyl, pyridinyl, pyridinonyl, pyrazinyl, pyrimidinyl, pryrimidinonyl, pyridazinyl, pyrrolyl, pyrido[2,3-*d*]pyrimidinonyl, quinazolinyl, quinazolinonyl, quinoxalinyl, quinoxalinonyl, quinolinyl, isoquinolinyl, tetrahydroquinolinyl, thiazolyl, thiadiazolyl, thieno[3,2-*d*]pyrimidin-4-onyl, thieno[2,3-*d*]pyrimidin-4-onyl, triazolyl, tetrazolyl, triazinyl, and thiophenyl (i.e. thienyl). Unless stated otherwise specifically in the specification, a heteroaryl group is optionally substituted.

"Fused" refers to a ring system comprising at least two rings, wherein the two rings share at least one common ring atom, for example two common ring atoms. When the fused ring is a heterocyclyl ring or a heteroaryl ring, the common ring atom(s) may be carbon or nitrogen. Fused rings include bicyclic, tricyclic, tertracyclic, and the like.

The term "substituted" used herein means any of the above groups (*e.g.*, alkyl, alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, alkoxy, alkylether, alkoxyalkylether, heteroalkyl, heteroalkoxy, phosphoalkyl, phosphoalkylether, thiophosphoalkyl, thiophosphoalkylether, carbocyclic, cycloalkyl, aryl, heterocyclic and/or heteroaryl) wherein at least one hydrogen atom (*e.g.*, 1, 2, 3 or all hydrogen atoms) is replaced by a bond to a non-hydrogen atoms such as, but not limited to: a halogen atom such as F, Cl, Br, and I; an oxygen atom in groups such as hydroxyl groups, alkoxy groups, and ester groups; a sulfur atom in groups such as thiol groups, thioalkyl groups, sulfone groups, sulfonyl groups, and sulfoxide groups; a nitrogen atom in groups such as amines, amides, alkylamines, dialkylamines, arylamines, alkylarylamines, diarylamines, N-oxides, imides, and enamines; a silicon atom in groups such as trialkylsilyl groups, dialkylarylsilyl groups, alkyldiarylsilyl groups, and triarylsilyl groups; and other heteroatoms in various other groups. "Substituted" also means any of the above groups

in which one or more hydrogen atoms are replaced by a higher-order bond (*e.g.*, a double- or triple-bond) to a heteroatom such as oxygen in oxo, carbonyl, carboxyl, and ester groups; and nitrogen in groups such as imines, oximes, hydrazones, and nitriles. For example, "substituted" includes any of the above groups in which one or more hydrogen atoms are replaced with $-NR_gR_h$, $-NR_gC(=O)R_h$, $-NR_gC(=O)NR_gR_h$, $-NR_gC(=O)OR_h$, $-NR_gSO_2R_h$, $-OC(=O)NR_gR_h$, $-OR_g$, $-SR_g$, $-SOR_g$, $-SO_2R_g$, $-OSO_2R_g$, $-SO_2OR_g$, $=NSO_2R_g$, and $-SO_2NR_gR_h$. "Substituted also means any of the above groups in which one or more hydrogen atoms are replaced with $-C(=O)R_g$, $-C(=O)OR_g$, $-C(=O)NR_gR_h$, $-CH_2SO_2R_g$, $-CH_2SO_2NR_gR_h$. In the foregoing, R_g and R_h are the same or different and independently hydrogen, alkyl, alkoxy, alkylamino, thioalkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, heterocyclyl, *N*-heterocyclyl, heterocyclylalkyl, heteroaryl, *N*-heteroaryl and/or heteroarylalkyl. "Substituted" further means any of the above groups in which one or more hydrogen atoms are replaced by a bond to an amino, cyano, hydroxyl, imino, nitro, oxo, thioxo, halo, alkyl, alkoxy, alkylamino, thioalkyl, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, heterocyclyl, *N*-heterocyclyl, heterocyclylalkyl, heteroaryl, *N*-heteroaryl and/or heteroarylalkyl group. In some embodiments, the optional substituent is $-OP(=R_a)(R_b)R_c$, wherein each of R_a, R_b and R_c is as defined for compounds of structure (I). In addition, each of the foregoing substituents may also be optionally substituted with one or more of the above substituents.

"Conjugation" refers to the overlap of one p-orbital with another p-orbital across an intervening sigma bond. Conjugation may occur in cyclic or acyclic compounds. A "degree of conjugation" refers to the overlap of at least one p-orbital with another p-orbital across an intervening sigma bond. For example, 1, 3-butadine has one degree of conjugation, while benzene and other aromatic compounds typically have multiple degrees of conjugation. Fluorescent and colored compounds typically comprise at least one degree of conjugation.

"Fluorescent" refers to a molecule which is capable of absorbing light of a particular frequency and emitting light of a different frequency. Fluorescence is well-known to those of ordinary skill in the art.

"Colored" refers to a molecule which absorbs light within the colored spectrum (*i.e.*, red, yellow, blue and the like).

A "linker" refers to a contiguous chain of at least one atom, such as carbon, oxygen, nitrogen, sulfur, phosphorous and combinations thereof, which connects a portion of a molecule to another portion of the same molecule or to a different molecule, moiety or solid support (*e.g.*, microparticle). Linkers may connect the molecule via a covalent bond or other means, such as ionic or hydrogen bond interactions.

The term "biomolecule" refers to any of a variety of biological materials, including nucleic acids, carbohydrates, amino acids, polypeptides, glycoproteins, hormones, aptamers and mixtures thereof. More specifically, the term is intended to include, without limitation, RNA, DNA, oligonucleotides, modified or derivatized nucleotides, enzymes, receptors, prions, receptor ligands (including hormones), antibodies, antigens, and toxins, as well as bacteria, viruses, blood cells, and tissue cells. The visually detectable biomolecules of the invention (*e.g.*, compounds of structure (I) having a biomolecule linked thereto) are prepared, as further described herein, by contacting a biomolecule with a compound having a reactive group that enables attachment of the biomolecule to the compound via any available atom or functional group, such as an amino, hydroxy, carboxyl, or sulfhydryl group on the biomolecule.

A "reactive group" is a moiety capable of reacting with a second reactive groups (*e.g.*, a "complementary reactive group") to form one or more covalent bonds, for example by a displacement, oxidation, reduction, addition or cycloaddition reaction. Exemplary reactive groups are provided in Table 1, and include for example, nucleophiles, electrophiles, dienes, dienophiles, aldehyde, oxime, hydrazone, alkyne, amine, azide, acylazide, acylhalide, nitrile, nitrone, sulfhydryl, disulfide, sulfonyl halide, isothiocyanate, imidoester, activated ester, ketone, α,β-unsaturated carbonyl, alkene, maleimide, α-haloimide, epoxide, aziridine, tetrazine, tetrazole, phosphine, biotin, thiirane and the like.

The terms "visible" and "visually detectable" are used herein to refer to substances that are observable by visual inspection, without prior illumination, or

chemical or enzymatic activation. Such visually detectable substances absorb and emit light in a region of the spectrum ranging from about 300 to about 900 nm. Preferably, such substances are intensely colored, preferably having a molar extinction coefficient of at least about 40,000, more preferably at least about 50,000, still more preferably at least about 60,000, yet still more preferably at least about 70,000, and most preferably at least about 80,000 $M^{-1}cm^{-1}$. The compounds of embodiments of the invention may be detected by observation with the naked eye, or with the aid of an optically based detection device, including, without limitation, absorption spectrophotometers, transmission light microscopes, digital cameras and scanners. Visually detectable substances are not limited to those which emit and/or absorb light in the visible spectrum. Substances which emit and/or absorb light in the ultraviolet (UV) region (about 10 nm to about 400 nm), infrared (IR) region (about 700 nm to about 1 mm), and substances emitting and/or absorbing in other regions of the electromagnetic spectrum are also included with the scope of "visually detectable" substances.

For purposes of embodiments of the invention, the term "photostable visible dye" refers to a chemical moiety that is visually detectable, as defined hereinabove, and is not significantly altered or decomposed upon exposure to light. Preferably, the photostable visible dye does not exhibit significant bleaching or decomposition after being exposed to light for at least one hour. More preferably, the visible dye is stable after exposure to light for at least 12 hours, still more preferably at least 24 hours, still yet more preferably at least one week, and most preferably at least one month. Nonlimiting examples of photostable visible dyes suitable for use in the compounds and methods of the invention include azo dyes, thioindigo dyes, quinacridone pigments, dioxazine, phthalocyanine, perinone, diketopyrrolopyrrole, quinophthalone, and truarycarbonium.

As used herein, the term "perylene derivative" is intended to include any substituted perylene that is visually detectable. However, the term is not intended to include perylene itself. The terms "anthracene derivative", "naphthalene derivative", and "pyrene derivative" are used analogously. In some preferred embodiments, a derivative (*e.g.*, perylene, pyrene, anthracene or naphthalene derivative) is an imide, bisimide or hydrazamimide derivative of perylene, anthracene, naphthalene, or pyrene.

The visually detectable molecules of various embodiments of the invention are useful for a wide variety of analytical applications, such as biochemical and biomedical applications, in which there is a need to determine the presence, location, or quantity of a particular analyte (e.g., biomolecule). In another aspect, therefore, the invention provides a method for visually detecting a biomolecule, comprising: (a) providing a biological system with a visually detectable biomolecule comprising the compound of structure (I) linked to a biomolecule; and (b) detecting the biomolecule by its visible properties. For purposes of the invention, the phrase "detecting the biomolecule by its visible properties" means that the biomolecule, without illumination or chemical or enzymatic activation, is observed with the naked eye, or with the aid of a optically based detection device, including, without limitation, absorption spectrophotometers, transmission light microscopes, digital cameras and scanners. A densitometer may be used to quantify the amount of visually detectable biomolecule present. For example, the relative quantity of the biomolecule in two samples can be determined by measuring relative optical density. If the stoichiometry of dye molecules per biomolecule is known, and the extinction coefficient of the dye molecule is known, then the absolute concentration of the biomolecule can also be determined from a measurement of optical density. As used herein, the term "biological system" is used to refer to any solution or mixture comprising one or more biomolecules in addition to the visually detectable biomolecule. Nonlimiting examples of such biological systems include cells, cell extracts, tissue samples, electrophoretic gels, assay mixtures, and hybridization reaction mixtures.

"Solid support" refers to any solid substrate known in the art for solid-phase support of molecules, for example a "microparticle" refers to any of a number of small particles useful for attachment to compounds of the invention, including, but not limited to, glass beads, magnetic beads, polymeric beads, nonpolymeric beads, and the like. In certain embodiments, a microparticle comprises polystyrene beads.

A "solid support reside" refers to the functional group remaining attached to a molecule when the molecule is cleaved from the solid support. Solid support residues are known in the art and can be easily derived based on the structure of the solid support and the group linking the molecule thereto.

A "targeting moiety" is a moiety that selectively binds or associates with a particular target, such as an analyte molecule. "Selectively" binding or associating means a targeting moiety preferentially associates or binds with the desired target relative to other targets. In some embodiments the compounds disclosed herein include linkages to targeting moieties for the purpose of selectively binding or associating the compound with an analyte of interest (i.e., the target of the targeting moiety), thus allowing detection of the analyte. Exemplary targeting moieties include, but are not limited to, antibodies, antigens, nucleic acid sequences, enzymes, proteins, cell surface receptor antagonists, and the like. In some embodiments, the targeting moiety is a moiety, such as an antibody, that selectively binds or associates with a target feature on or in a cell, for example a target feature on a cell membrane or other cellular structure, thus allowing for detection of cells of interest. Small molecules that selectively bind or associate with a desired analyte are also contemplated as targeting moieties in certain embodiments. One of skill in the art will understand other analytes, and the corresponding targeting moiety, that will be useful in various embodiments.

"Base pairing moiety" refers to a heterocyclic moiety capable of hybridizing with a complementary heterocyclic moiety via hydrogen bonds (*e.g.*, Watson-Crick base pairing). Base pairing moieties include natural and unnatural bases. Non-limiting examples of base pairing moieties are RNA and DNA bases such adenosine, guanosine, thymidine, cytosine and uridine and analogues thereof.

Embodiments of the invention disclosed herein are also meant to encompass all compounds of structure (I) or (II) being isotopically-labelled by having one or more atoms replaced by an atom having a different atomic mass or mass number. Examples of isotopes that can be incorporated into the disclosed compounds include isotopes of hydrogen, carbon, nitrogen, oxygen, phosphorous, fluorine, chlorine, and iodine, such as ^{2}H, ^{3}H, ^{11}C, ^{13}C, ^{14}C, ^{13}N, ^{15}N, ^{15}O, ^{17}O, ^{18}O, ^{31}P, ^{32}P, ^{35}S, ^{18}F, ^{36}Cl, ^{123}I, and ^{125}I, respectively.

Isotopically-labeled compounds of structure (I) or (II) can generally be prepared by conventional techniques known to those skilled in the art or by processes analogous to those described below and in the following Examples using an appropriate isotopically-labeled reagent in place of the non-labeled reagent previously employed.

"Stable compound" and "stable structure" are meant to indicate a compound that is sufficiently robust to survive isolation to a useful degree of purity from a reaction mixture, and formulation into an efficacious therapeutic agent.

"Optional" or "optionally" means that the subsequently described event or circumstances may or may not occur, and that the description includes instances where said event or circumstance occurs and instances in which it does not. For example, "optionally substituted alkyl" means that the alkyl group may or may not be substituted and that the description includes both substituted alkyl groups and alkyl groups having no substitution.

"Salt" includes both acid and base addition salts.

"Acid addition salt" refers to those salts which are formed with inorganic acids such as, but not limited to, hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid and the like, and organic acids such as, but not limited to, acetic acid, 2,2-dichloroacetic acid, adipic acid, alginic acid, ascorbic acid, aspartic acid, benzenesulfonic acid, benzoic acid, 4-acetamidobenzoic acid, camphoric acid, camphor-10-sulfonic acid, capric acid, caproic acid, caprylic acid, carbonic acid, cinnamic acid, citric acid, cyclamic acid, dodecylsulfuric acid, ethane-1,2-disulfonic acid, ethanesulfonic acid, 2-hydroxyethanesulfonic acid, formic acid, fumaric acid, galactaric acid, gentisic acid, glucoheptonic acid, gluconic acid, glucuronic acid, glutamic acid, glutaric acid, 2-oxo-glutaric acid, glycerophosphoric acid, glycolic acid, hippuric acid, isobutyric acid, lactic acid, lactobionic acid, lauric acid, maleic acid, malic acid, malonic acid, mandelic acid, methanesulfonic acid, mucic acid, naphthalene-1,5-disulfonic acid, naphthalene-2-sulfonic acid, 1-hydroxy-2-naphthoic acid, nicotinic acid, oleic acid, orotic acid, oxalic acid, palmitic acid, pamoic acid, propionic acid, pyroglutamic acid, pyruvic acid, salicylic acid, 4-aminosalicylic acid, sebacic acid, stearic acid, succinic acid, tartaric acid, thiocyanic acid, *p*-toluenesulfonic acid, trifluoroacetic acid, undecylenic acid, and the like.

"Base addition salt" refers to those salts which are prepared from addition of an inorganic base or an organic base to the free acid. Salts derived from inorganic bases include, but are not limited to, sodium, potassium, lithium, ammonium, calcium, magnesium, iron, zinc, copper, manganese, aluminum salts and the like. Salts

derived from organic bases include, but are not limited to, salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as ammonia, isopropylamine, trimethylamine, diethylamine, triethylamine, tripropylamine, diethanolamine, ethanolamine, deanol, 2-dimethylaminoethanol, 2-diethylaminoethanol, dicyclohexylamine, lysine, arginine, histidine, caffeine, procaine, hydrabamine, choline, betaine, benethamine, benzathine, ethylenediamine, glucosamine, methylglucamine, theobromine, triethanolamine, tromethamine, purines, piperazine, piperidine, *N*-ethylpiperidine, polyamine resins and the like. Particularly preferred organic bases are isopropylamine, diethylamine, ethanolamine, trimethylamine, dicyclohexylamine, choline and caffeine.

Crystallizations may produce a solvate of the compounds described herein. Embodiments of the present invention include all solvates of the described compounds. As used herein, the term "solvate" refers to an aggregate that comprises one or more molecules of a compound of the invention with one or more molecules of solvent. The solvent may be water, in which case the solvate may be a hydrate. Alternatively, the solvent may be an organic solvent. Thus, the compounds of the present invention may exist as a hydrate, including a monohydrate, dihydrate, hemihydrate, sesquihydrate, trihydrate, tetrahydrate and the like, as well as the corresponding solvated forms. The compounds of the invention may be true solvates, while in other cases the compounds of the invention may merely retain adventitious water or another solvent or be a mixture of water plus some adventitious solvent.

Embodiments of the compounds of the invention (e.g., compounds of structure I, II, III, IV or V), or their salts, tautomers or solvates may contain one or more asymmetric centers and may thus give rise to enantiomers, diastereomers, and other stereoisomeric forms that may be defined, in terms of absolute stereochemistry, as (*R*)- or (*S*)- or, as (D)- or (L)- for amino acids. Embodiments of the present invention are meant to include all such possible isomers, as well as their racemic and optically pure forms. Optically active (+) and (-), (*R*)- and (*S*)-, or (D)- and (L)- isomers may be prepared using chiral synthons or chiral reagents, or resolved using conventional techniques, for example, chromatography and fractional crystallization. Conventional

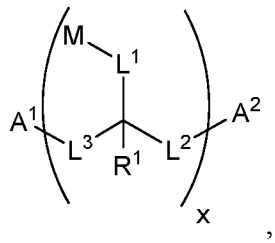
techniques for the preparation/isolation of individual enantiomers include chiral synthesis from a suitable optically pure precursor or resolution of the racemate (or the racemate of a salt or derivative) using, for example, chiral high pressure liquid chromatography (HPLC). When the compounds described herein contain olefinic double bonds or other centers of geometric asymmetry, and unless specified otherwise, it is intended that the compounds include both E and Z geometric isomers. Likewise, all tautomeric forms are also intended to be included.

A "stereoisomer" refers to a compound made up of the same atoms bonded by the same bonds but having different three-dimensional structures, which are not interchangeable. The present invention contemplates various stereoisomers and mixtures thereof and includes "enantiomers", which refers to two stereoisomers whose molecules are nonsuperimposeable mirror images of one another.

A "tautomer" refers to a proton shift from one atom of a molecule to another atom of the same molecule. The present invention includes tautomers of any said compounds. Various tautomeric forms of the compounds are easily derivable by those of ordinary skill in the art.

The chemical naming protocol and structure diagrams used herein are a modified form of the I.U.P.A.C. nomenclature system, using the ACD/Name Version 9.07 software program and/or ChemDraw Ultra Version 11.0 software naming program (CambridgeSoft). Common names familiar to one of ordinary skill in the art are also used.

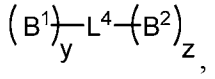
In one embodiment is provided a method ("Method 1") for preparing a dimeric or polymeric dye, the method comprising reacting a first and second compound of structure (I):



,

(I)

with a compound of structure (II):



(II)

wherein:

A^1 and A^2 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a first functional group having complementary reactivity to B^1, B^2 or both, provided at least one of A^1 and A^2 is a moiety comprising a first functional group having complementary reactivity to B^1, B^2 or both, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

B^1 and B^2 are each independently a second functional group having complementary reactivity to the first functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (I);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety; and

x, y and z are independently an integer of 1 or greater,

thereby: i) forming a first bond between the first compound of structure (I) and the compound of structure (II) by reaction of B^1 with the first functional group of the first compound of structure (I); and ii) forming a second bond between the second compound of structure (I) and the compound of structure (II) by reaction of B^2 with the first functional group of the second compound of structure (I).

In other embodiments of Method 1:

A^1 and A^2 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (I) or a moiety comprising a first functional group having complementary reactivity to B^1, B^2 or both, provided at least one of A^1 and A^2 is a moiety comprising a first functional group having complementary reactivity to B^1, B^2 or both, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

B^1 and B^2 are each independently a second functional group having complementary reactivity to the first functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

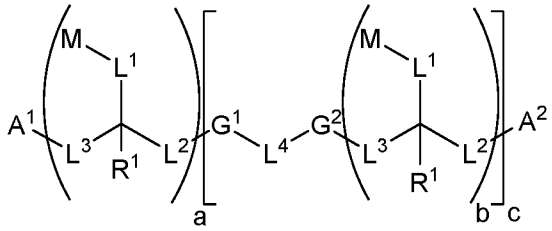
R^1 is, at each occurrence, independently H, alkyl or alkoxy;

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety; and

x, y and z are independently an integer of 1 or greater.

In some embodiments of Method 1, the dimeric or polymeric dye has the following structure (III):



(III)

wherein:

A^1 and A^2 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a first functional group having complementary reactivity to B^1, B^2 or both, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^1 and G^2 are each independently moieties comprising functional groups resulting from reaction of the first functional group with B^1 or B^2, respectively;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety for at least one integral value of a and b;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q′;

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (III);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety; and

a, b and c are independently an integer of 1 or greater.

In other embodiments of structure (III):

A^1 and A^2 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (III) or a first functional group having complementary reactivity to B^1, B^2 or both, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^1 and G^2 are each independently moieties comprising functional groups resulting from reaction of the first functional group with B^1 or B^2, respectively;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety for at least one integral value of a and b;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety; and

a, b and c are independently an integer of 1 or greater.

In different embodiments of Method 1, A^1 and A^2 are each independently a first functional group having complementary reactivity to B^1, B^2 or both. For example, in some embodiments A^1, A^2 are each independently a nucleophilic functional group. The nucleophilic functional group can, in some embodiments, be amino, alkylamino, sulfhydryl or hydroxyl.

In other embodiments of Method 1, B^1 and B^2 are each independently an electrophilic functional group. In some embodiments the electrophilic functional group is an acid halide, N-hydroxysuccinimide ester, isocycanate, isothiocyanate, epoxide, halide, tosylate, mesylate, triflate, maleimide, phosphate or alkene.

In some different embodiments of Method 1, A^1, A^2 are each independently an electrophilic functional group. For example, in some embodiments the electrophilic functional group is an N-hydroxysuccinimide ester, phenolate ester, halide, tosylate, mesylate, phosphate or triflate.

In other different embodiments of Method 1, B^1 and B^2 are each independently nucleophilic functional group. In certain embodiments, the nucleophilic functional group is amino, alkylamino, sulfhydryl or hydroxyl.

In yet more embodiments of Method 1, A^1, A^2, B^1 and B^2 are each independently nucleic acid sequences, and A^1 is complementary to B^1, and A^2 is complementary to B^2.

In some more embodiments of Method 1, A^1 and A^2 are each independently an alkyne and B^1 and B^2 are each independently an azide.

In other embodiments of Method 1, A^1 and A^2 are each independently an azide and B^1 and B^2 are each independently an alkyne.

In still more embodiments of Method 1, at least one of A^1 and A^2 comprises a cycloaddition reactive functional group, and each of B^1 and B^2 are complementary cycloaddition reactive functional groups. For example, in some embodiments each cycloaddition reactive functional group comprises an alkene.

In more embodiments of Method 1, A^1 and A^2 comprise an aryl halide, and each of B^1 and B^2 are alkene or alkyne functional groups.

In other different embodiments of Method 1, A^1 and A^2 comprise a boronic acid or boronic ester, and each of B^1 and B^2 are aryl halide or alkyl halide functional groups.

In some embodiments of Method 1, A^1 and A^2 comprise an alkylstannane or arylstannane, and each of B^1 and B^2 are aryl halide or alkyl halide functional groups.

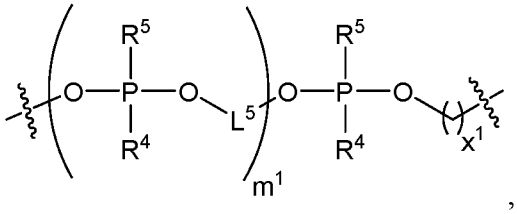
In some other different embodiments of Method 1, A^1 and A^2 comprise an amine, and each of B^1 and B^2 are aryl halide or alkyl halide functional groups.

In still other different embodiments, G^1 and G^2 each independently comprise an amide, urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-

alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, phosphodiester, alkene, alkyne or a triazole.

In any of the foregoing embodiments of Method 1, L^4 is alkylene.

In other of any of the foregoing embodiments of Method 1, L^3, at each occurrence, independently has the following structure:



,

wherein:

R^4 is, at each occurrence, independently OH, SH, O^-, S^-, OR_d or SR_d;

R^5 is, at each occurrence, independently oxo, thioxo or absent;

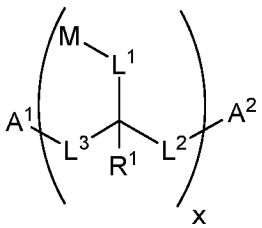
m^1 and x^1 are, at each occurrence, independently an integer from 0 to 10; and

L^5 is an alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, carbocyclic or heterocyclic linker. For example, in some embodiments heteroalkylene is alkylene oxide, such as a polyethylene oxide.

In other embodiments of Method 1, L^3 is, at each occurrence, independently an amino acid or peptide linker.

In more embodiments of Method 1, L^3 is, at each occurrence, independently a linker comprising one or more charged moieties.

In another aspect, the invention provides a method ("Method 2") for preparing a dimeric or polymeric dye, the method comprising reacting a first compound of structure (I):



(I)

with a second compound of structure (I), wherein:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

A^2 is a moiety comprising the second functional group, wherein the second functional group has reactivity complementary to itself or reactivity complementary to the first functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q′;

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (I);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

x is an integer of 1 or greater,

thereby forming a bond between the first and second compounds of structure (I) by reaction of: i) the first functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I); or ii) the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I).

In other embodiments of Method 2:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (I) or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

A^2 is a moiety comprising the second functional group, wherein the second functional group has reactivity complementary to itself or reactivity complementary to the first functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

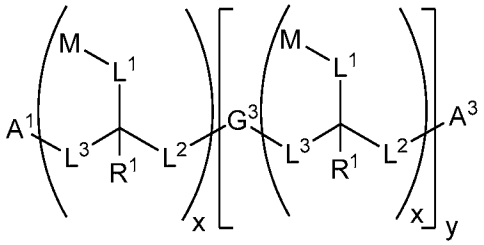
R^1 is, at each occurrence, independently H, alkyl or alkoxy;

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

x is an integer of 1 or greater,

thereby forming a bond between the first and second compounds of structure (I) by reaction of: i) the first functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I); or ii) the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I).

In some embodiments of Method 2, the bond is formed between the first and second compounds of structure (I) by reaction of the first functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I). For example, in some embodiments the dimeric or polymeric dye has the following structure (IV):



(IV)

wherein:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

A^3 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (I) or a moiety comprising the second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^3 is a moiety comprising a functional group resulting from reaction of the first functional group with the second functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (IV);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

In other embodiments of structure (IV):

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (IV) or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

A^3 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (I) or a moiety comprising the second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH,

O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^3 is a moiety comprising a functional group resulting from reaction of the first functional group with the second functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

In any of the foregoing embodiments of Method 1 or Method 2, A^1, A^2 an A^3 are independently selected from a moiety comprising a functional groups for use in a reaction selected from amine/carboxylate condensation, 3+2 cycloaddition and other cycloaddition reactions, ring opening metathesis, olefin cross metathesis, Staudinger reaction, aromatic diazonium reactions; thiol-ene reaction; Diels-Alder reaction, Hydrazine/Hydrazide/Hydroxylamine condensation to carbonyls; Sonogashira reaction, Heck coupling, Suzuki coupling, Stille coupling, Glaser coupling and Amine/epoxide ring opening. Such functional groups will be apparent to one of ordinary skill in the art.

In different embodiment of Method 2, the first functional group is a nucleophilic functional group. For example, the nucleophilic functional group may be amino, alkylamino, sulfhydryl or hydroxyl in various embodiments.

In other embodiments of Method 2, the second functional group is an electrophilic functional group. For example, the electrophilic functional group may be an acid halide, N-hydroxysuccinimide ester, isocycanate, isothiocyanate, epoxide, halide, tosylate, mesylate, triflate, maleimide, phosphate or alkene in various embodiments.

In other embodiments of Method 2, the first and second functional groups are each independently nucleic acid sequences, and the first functional group is complementary to the second functional group.

In different embodiments of Method 2, the first functional group is an alkyne and the second functional group is an azide.

In some other embodiments of Method 2, the first functional group is a cycloaddition reactive functional group, and the second functional group is a complementary cycloaddition reactive functional group.

In other embodiments of Method 2, the first functional group is an aryl halide, and the second functional group is an alkene or alkyne functional group.

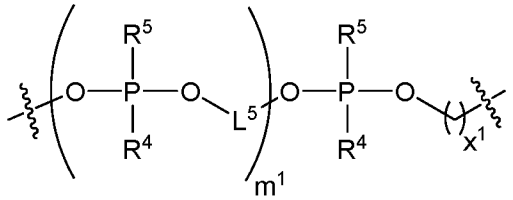
In still more embodiments of Method 2, the first functional group is a boronic acid or boronic ester, and the second functional group is an aryl halide or alkyl halide functional group.

In yet more embodiments of Method 2, the first functional group is an alkylstannane or arylstannane, and the second functional group is an aryl halide or alkyl halide functional group.

In some other different embodiments of Method 2, the first functional group is an amine, and the second functional group is an aryl halide or alkyl halide functional group.

In some embodiments of Method 2, G^3 comprises an amide, urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, phosphodiester, alkene, alkyne or a triazole.

In any of the foregoing embodiments of Method 2, L^3, at each occurrence, independently has the following structure:



,

wherein:

R^4 is, at each occurrence, independently OH, SH, O^-, S^-, OR_d or SR_d;

R^5 is, at each occurrence, independently oxo, thioxo or absent;

m^1 and x^1 are, at each occurrence, independently an integer from 0 to 10; and

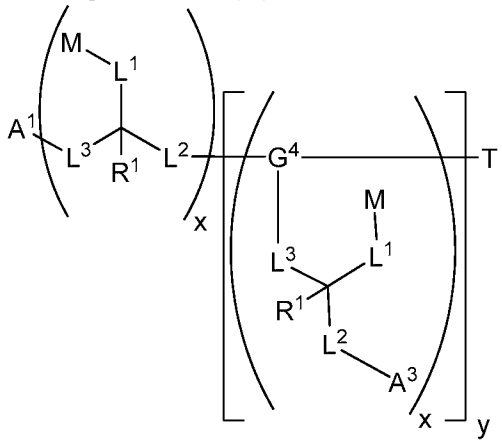
L^5 is an alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, carbocyclic or heterocyclic linker. For example, in some embodiments heteroalkylene is alkylene oxide, such as a polyethylene oxide.

In other of the foregoing embodiments of Method 2, L^3 is, at each occurrence, independently an amino acid or peptide linker.

In still other of the foregoing embodiments of Method 2, L^3 is, at each occurrence, independently a linker comprising one or more charged moieties.

In other embodiments of Method 2, the bond is formed between the first and second compounds of structure (I) by reaction of the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I).

In some other specific embodiments of Method 2, the dimeric or polymeric dye has the following structure (V):



(V)

wherein:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

T is absent or a polymer terminating group;

G^4 is a moiety comprising a functional group resulting from reaction of the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I);

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (V);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

In other embodiments of structure (V):

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (V) or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

T is absent or a polymer terminating group;

G^4 is a moiety comprising a functional group resulting from reaction of the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I);

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

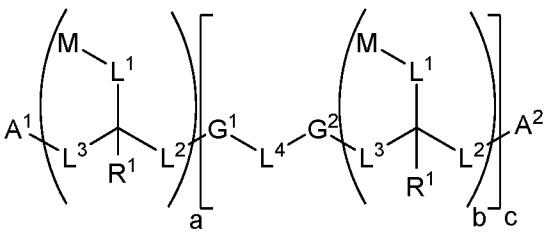
L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

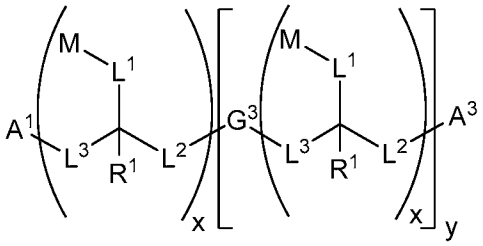
For example, in some embodiments of Method 2, each second functional group is a cycloaddition reactive functional group. In other embodiments, each second functional group is an acrylate functional group.

In some different embodiments, the invention provides compounds. The compounds can be prepared according to the foregoing methods or other methods known in the art. For example, in some embodiments is provided a compound having one of the following structures (III), (IV) or (V):



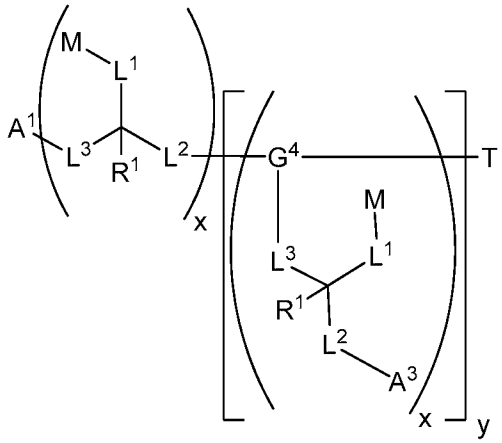
(III)

;



(IV)

or



(V)

wherein:

A^1, A^2 and A^3 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a functional group capable of forming G^1, G^2, G^3 or G^4 upon reaction with a moiety comprising complementary functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^1, G^2, G^3 and G^4 are each independently moieties comprising a urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, alkene, alkyne or triazole functional group;

T is absent or a polymer terminating group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety for at least one integral value of a and b;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q′;

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (I);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety;

a, b and c are independently an integer of 1 or greater;

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

In other embodiments of structures (III), (IV) or (V):

A^1, A^2 and A^3 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (III), (IV) or (V) or a moiety comprising a functional group capable of forming G^1, G^2, G^3 or G^4 upon reaction with a moiety comprising complementary functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^1, G^2, G^3 and G^4 are each independently moieties comprising a urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, alkene, alkyne or triazole functional group;

T is absent or a polymer terminating group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety for at least one integral value of a and b;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety;

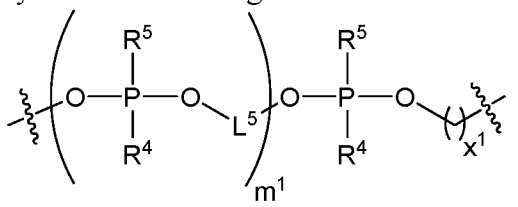
a, b and c are independently an integer of 1 or greater;

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

In some embodiments of the foregoing compounds, L^4 is alkylene.

In other embodiments of the foregoing compounds L^3, at each occurrence, independently has the following structure:



,

wherein:

R^4 is, at each occurrence, independently OH, SH, O^-, S^-, OR_d or SR_d;

R^5 is, at each occurrence, independently oxo, thioxo or absent;

m^1 and x^1 are, at each occurrence, independently an integer from 0 to 10; and

L^5 is an alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, carbocyclic or heterocyclic linker. For example, in some embodiments heteroalkylene is alkylene oxide, such as a polyethylene oxide.

In some embodiments of the foregoing compounds, L^3 is, at each occurrence, independently an amino acid or peptide linker.

In some other embodiments of the foregoing compounds L^3 is, at each occurrence, independently a linker comprising one or more charged moieties.

In other embodiments of the compounds, R^1 is H.

In still different embodiments of the compounds, A^1, A^2 and A^3 are each independently OH or $-OP(=R_a)(R_b)R_c$.

M is selected based on the desired optical properties, for example based on a desired color and/or fluorescence emission wavelength. In some embodiments, M

is the same at each occurrence; however, it is important to note that each occurrence of M need not be an identical M, and certain embodiments include compounds wherein M is not the same at each occurrence. For example, in some embodiments each M is not the same and the different M moieties are selected to have absorbance and/or emissions for use in fluorescence resonance energy transfer (FRET) methods. For example, in such embodiments the different M moieties are selected such that absorbance of radiation at one wavelength causes emission of radiation at a different wavelength by a FRET mechanism. Exemplary M moieties can be appropriately selected by one of ordinary skill in the art based on the desired end use. Exemplary M moieties for FRET methods include fluorescein and 5-TAMRA (5-carboxytetramethylrhodamine, succinimidyl ester) dyes.

M may be attached to the remainder of the molecule from any position (i.e., atom) on M. One of skill in the art will recognize means for attaching M to the remainder of molecule. Exemplary methods include the "click" reactions described herein.

In some embodiments, M is a fluorescent or colored moiety. Any fluorescent and/or colored moiety may be used, for examples those known in the art and typically employed in colorimetric, UV, and/or fluorescent assays may be used. Examples of M moieties which are useful in various embodiments of the invention include, but are not limited to: Xanthene derivatives (e.g., fluorescein, rhodamine, Oregon green, eosin or Texas red); Cyanine derivatives (e.g., cyanine, indocarbocyanine, oxacarbocyanine, thiacarbocyanine or merocyanine); Squaraine derivatives and ring-substituted squaraines, including Seta, SeTau, and Square dyes; Naphthalene derivatives (e.g., dansyl and prodan derivatives); Coumarin derivatives; oxadiazole derivatives (e.g., pyridyloxazole, nitrobenzoxadiazole or benzoxadiazole); Anthracene derivatives (e.g., anthraquinones, including DRAQ5, DRAQ7 and CyTRAK Orange); Pyrene derivatives such as cascade blue; Oxazine derivatives (e.g., Nile red, Nile blue, cresyl violet, oxazine 170); Acridine derivatives (e.g., proflavin, acridine orange, acridine yellow); Arylmethine derivatives: auramine, crystal violet, malachite green; and Tetrapyrrole derivatives (e.g., porphin, phthalocyanine or bilirubin). Other exemplary M moieties include: Cyanine dyes, xanthate dyes (e.g.,

Hex, Vic, Nedd, Joe or Tet); Yakima yellow; Redmond red; tamra; texas red and alexa fluor® dyes.

In still other embodiments of any of the foregoing, M comprises three or more aryl or heteroaryl rings, or combinations thereof, for example four or more aryl or heteroaryl rings, or combinations thereof, or even five or more aryl or heteroaryl rings, or combinations thereof. In some embodiments, M comprises six aryl or heteroaryl rings, or combinations thereof. In further embodiments, the rings are fused. For example in some embodiments, M comprises three or more fused rings, four or more fused rings, five or more fused rings, or even six or more fused rings.

In some embodiments, M is cyclic. For example, in some embodiments M is carbocyclic. In other embodiment, M is heterocyclic. In still other embodiments of the foregoing, M, at each occurrence, independently comprises an aryl moiety. In some of these embodiments, the aryl moiety is multicyclic. In other more specific examples, the aryl moiety is a fused-multicyclic aryl moiety, for example which may comprise at least 3, at least 4, or even more than 4 aryl rings.

In other embodiments of any of the foregoing methods or compounds, M, at each occurrence, independently comprises at least one heteroatom. For example, in some embodiments, the heteroatom is nitrogen, oxygen or sulfur.

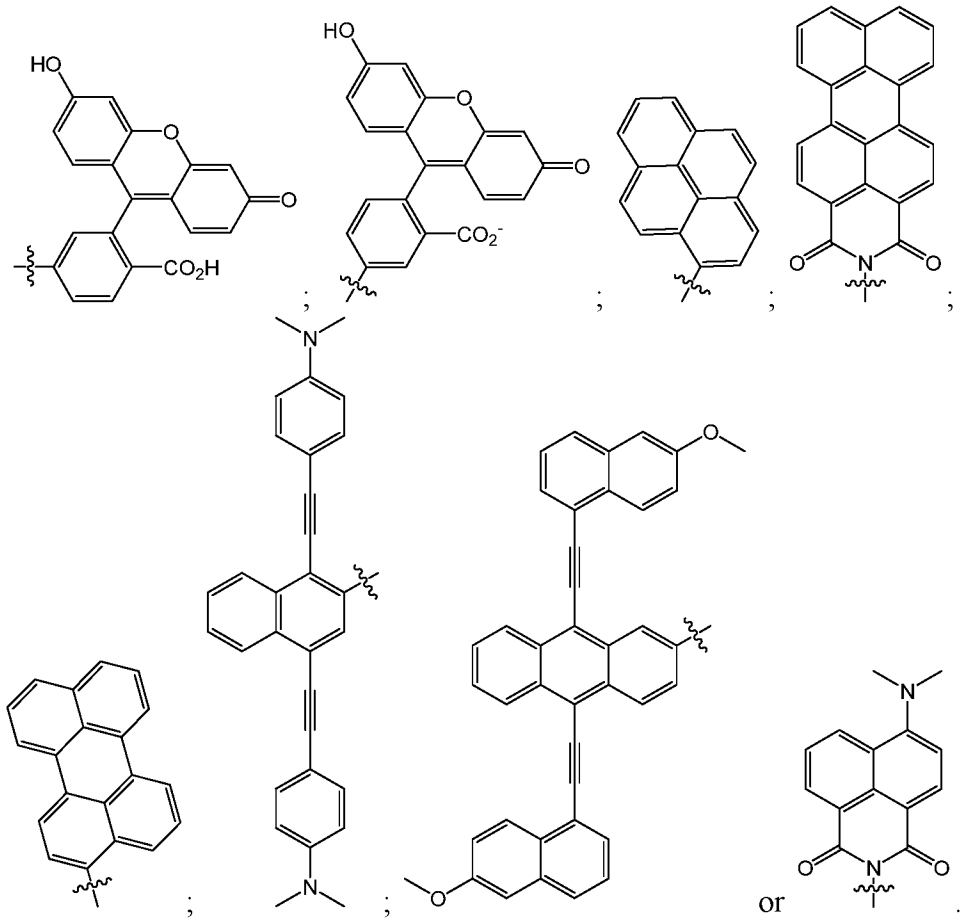
In still more embodiments of any of the foregoing, M, at each occurrence, independently comprises at least one substituent. For example, in some embodiments the substituent is a fluoro, chloro, bromo, iodo, amino, alkylamino, arylamino, hydroxy, sulfhydryl, alkoxy, aryloxy, phenyl, aryl, methyl, ethyl, propyl, butyl, isopropyl, t-butyl, carboxy, sulfonate, amide, or formyl group.

In some even more specific embodiments of the foregoing, M, at each occurrence, independently is a dimethylaminostilbene, quinacridone, fluorophenyl-dimethyl-BODIPY, his-fluorophenyl-BODIPY, acridine, terrylene, sexiphenyl, porphyrin, benzopyrene, (fluorophenyl-dimethyl-difluorobora-diaza-indacene)phenyl, (bis-fluorophenyl-difluorobora-diaza-indacene)phenyl, quaterphenyl, bi-benzothiazole, ter-benzothiazole, bi-naphthyl, bi-anthracyl, squaraine, squarylium, 9, 10-ethynylanthracene or ter-naphthyl moiety. In other embodiments, M is, at each occurrence, independently p-terphenyl, perylene, azobenzene, phenazine,

phenanthroline, acridine, thioxanthrene, chrysene, rubrene, coronene, cyanine, perylene imide, or perylene amide or a derivative thereof. In still more embodiments, M is, at each occurrence, independently a coumarin dye, resorufin dye, dipyrromethene boron difluoride dye, ruthenium bipyridyl dye, energy transfer dye, thiazole orange dye, polymethine or N-aryl-1,8-naphthalimide dye.

In still more embodiments of any of the foregoing, M at each occurrence is the same. In other embodiments, each M is different. In still more embodiments, one or more M is the same and one or more M is different.

In some embodiments, M is pyrene, perylene, perylene monoimide or 6-FAM or a derivative thereof. In some other embodiments, M has one of the following structures:



; ; ; ; ; ; or .

Although M moieties comprising carboxylic acid groups are depicted in the anionic form (CO_2^-) above, one of skill in the art will understand that this will vary depending on pH, and the protonated form (CO_2H) is included in various embodiments.

In still other embodiments of any of the foregoing methods or compounds, Q is, at each occurrence, independently a moiety comprising a reactive group capable of forming a covalent bond with an analyte molecule or a solid support. In other embodiments, Q is, at each occurrence, independently a moiety comprising a reactive group capable of forming a covalent bond with a complementary reactive group Q′.

The type of Q group and connectivity of the Q group to the remainder of the compound is not limited, provided that Q comprises a moiety having appropriate reactivity for forming the desired bond.

In certain embodiments, Q is a moiety which is not susceptible to hydrolysis under aqueous conditions, but is sufficiently reactive to form a bond with a corresponding group on an analyte molecule or solid support (e.g., an amine, azide or alkyne).

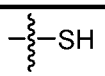
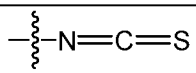
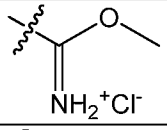
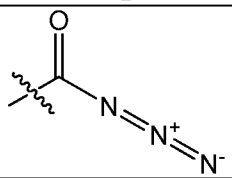
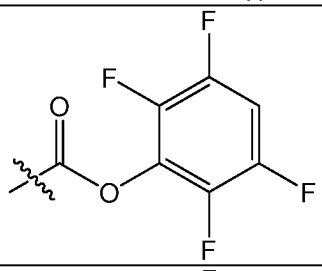
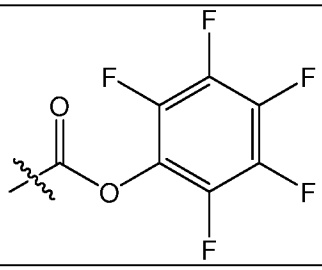
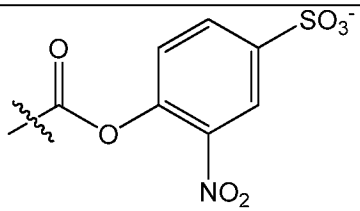
In certain embodiments of the methods and compounds, Q comprises groups commonly employed in the field of bioconjugation. For example in some embodiments, Q comprises a nucleophilic reactive group, an electrophilic reactive group or a cycloaddition reactive group. In some more specific embodiments, Q comprises a sulfhydryl, disulfide, activated ester, isothiocyanate, azide, alkyne, alkene, diene, dienophile, acid halide, sulfonyl halide, phosphine, α-haloamide, biotin, amino or maleimide functional group. In some embodiments, the activated ester is an N-succinimide ester, imidoester or polyflourophenyl ester. In other embodiments, the alkyne is an alkyl azide or acyl azide.

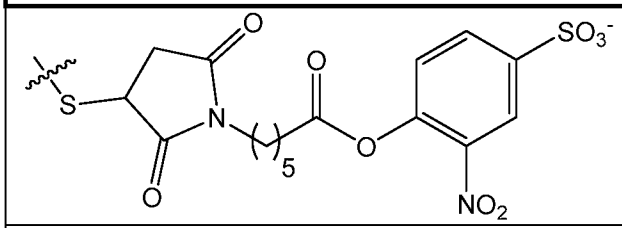
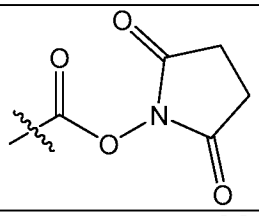
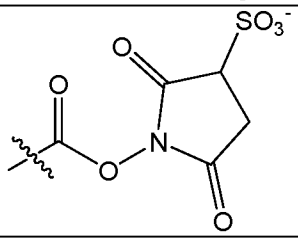
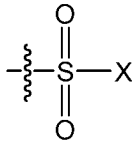
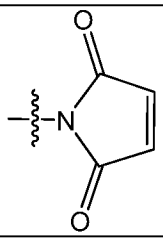
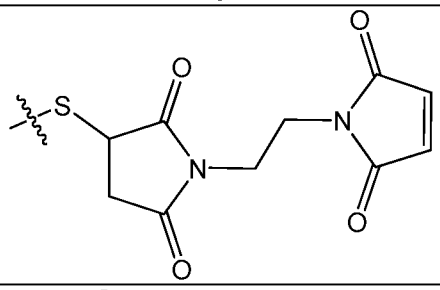
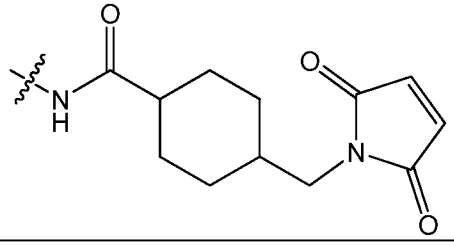
The Q groups can be conveniently provided in protected form to increase storage stability or other desired properties, and then the protecting group removed at the appropriate time for conjugation with, for example, a targeting moiety or analyte. Accordingly, Q groups include “protected forms” of a reactive group, including any of the reactive groups described above and in the Table 1 below. A “protected form” of Q refers to a moiety having lower reactivity under predetermined reaction conditions relative to Q, but which can be converted to Q under conditions, which preferably do not degrade or react with other portions of the compound of structure (I). One of skill in the art can derive appropriate protected forms of Q based on the particular Q and

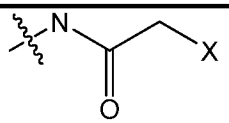
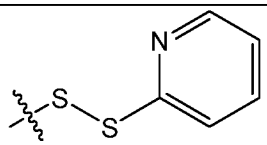
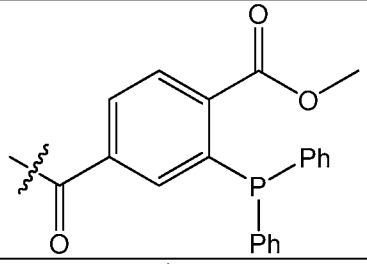
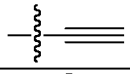
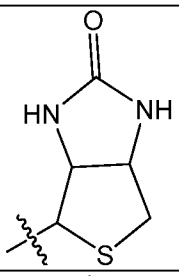
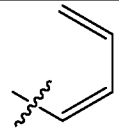
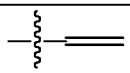
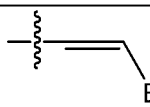
desired end use and storage conditions. For example, when Q is SH, a protected form of Q includes a disulfide, which can be reduce to reveal the SH moiety using commonly known techniques and reagents.

Exemplary Q moieties are provided in Table I below.

Table 1. Exemplary Q Moieties

Structure	Class
	Sulfhydryl
	Isothiocyanate
	Imidoester
	Acyl Azide
	Activated Ester
	Activated Ester
	Activated Ester

Structure	Class
	Activated Ester
	Activated Ester
	Activated Ester
 X = halo	Sulfonyl halide
	Maleimide
	Maleimide
	Maleimide

Structure	Class
 X = halo	α-haloimide
	Disulfide
	Phosphine
	Azide
	Alkyne
	Biotin
	Diene
	Alkene/dienophile
 EWG = eletron withdrawing group	Alkene/dienophile
$-NH_2$	Amino

It should be noted that in some embodiments, wherein Q is SH, the SH moiety will tend to form disulfide bonds with another sulfhydryl group on another compound. Accordingly, some embodiments include the foregoing compounds, which are in the form of disulfide dimers, the disulfide bond being derived from SH Q groups.

In some specific embodiments, the compound is a compound selected from Table 2 and/or compounds prepared therefrom (e.g., Compounds 1, 1', 1'', 2, 3, 3', 4, 4', 5 and 5'). The compounds in Table 2 were prepared according to the procedures set forth in the Examples.

The presently disclosed dye compounds are "tunable," meaning that by proper selection of the variables (e.g., M, a, b, c, x, y, m^1 and/or L4) in any of the foregoing compounds, one of skill in the art can arrive at a compound having a desired and/or predetermined molar fluorescence (molar brightness). The tunability of the compounds allows the user to easily arrive at compounds having the desired fluorescence and/or color for use in a particular assay or for identifying a specific analyte of interest. Molar fluorescence in certain embodiments can be expressed in terms of the fold increase or decrease relative to the fluorescence emission of the parent fluorophore (e.g., monomer). In some embodiments the molar fluorescence of the present compounds is 1.1x, 1.5x, 2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x 10x or even higher relative to the parent fluorophore.

For ease of illustration, various compounds comprising phosphorous moieties (*e.g.*, phosphate and the like) are depicted in the anionic state (*e.g.*, $-OPO(OH)O^-$, $-OPO_3^{2-}$). One of skill in the art will readily understand that the charge is dependent on pH and the uncharged (*e.g.*, protonated or salt, such as sodium or other cation) forms are also included in the scope of embodiments of the invention.

Compositions comprising any of the foregoing compounds and one or more analyte molecules (e.g., biomolecules) are provided in various other embodiments. In some embodiments, use of such compositions in analytical methods for detection of the one or more analyte molecules are also provided.

In still other embodiments, the compounds are useful in various analytical methods. For example, in certain embodiments the disclosure provides a method of staining a sample, the method comprising adding to said sample a compound of structure (III), (IV) or (V), for example wherein one of A^1, A^2 and A^3 is a linker comprising a covalent bond to an analyte molecule (e.g., biomolecule) or solid support, and another one of A^1, A^2 and A^3 is H, OH, alkyl, alkoxy, alkylether or

$-OP(=R_a)(R_b)R_c$, in an amount sufficient to produce an optical response when said sample is illuminated at an appropriate wavelength.

In some embodiments of the foregoing methods, A^1 is a linker comprising a covalent linkage to an analyte molecule, such as a biomolecule. For example, a nucleic acid, amino acid or a polymer thereof (*e.g.*, polynucleotide or polypeptide). In still more embodiments, the biomolecule is an enzyme, receptor, receptor ligand, antibody, glycoprotein, aptamer or prion.

In yet other embodiments of the foregoing method, A^1 is a linker comprising a covalent linkage to a solid support such as a microparticle. For example, in some embodiments the microparticle is a polymeric bead or nonpolymeric bead.

In even more embodiments, said optical response is a fluorescent response.

In other embodiments, said sample comprises cells, and some embodiments further comprise observing said cells by flow cytometry.

In still more embodiments, the method further comprises distinguishing the fluorescence response from that of a second fluorophore having detectably different optical properties.

In other embodiments, the disclosure provides a method for visually detecting an analyte molecule, such as a biomolecule, comprising:

(a) providing a compound of structure (III), (IV) or (V), for example, wherein one of A^1, A^2 and A^3 is a linker comprising a covalent bond to the analyte molecule, and the other of A^1, A^2 and A^3 is H, OH, alkyl, alkoxy, alkylether or $-OP(=R_a)(R_b)R_c$; and

(b) detecting the compound by its visible properties.

In some embodiments the analyte molecule is a nucleic acid, amino acid or a polymer thereof (*e.g.*, polynucleotide or polypeptide). In still more embodiments, the analyte molecule is an enzyme, receptor, receptor ligand, antibody, glycoprotein, aptamer or prion.

In other embodiments, a method for visually detecting an analyte molecule, such as a biomolecule is provided, the method comprising:

(a) admixing any of the foregoing compounds with one or more analyte molecules; and

(b) detecting the compound by its visible properties.

In other embodiments is provided a method for visually detecting an analyte molecule, the method comprising:

(a) admixing a compound of structure (III), (IV) or (V), wherein A^1, A^2 or A^3 is Q or a linker comprising a covalent bond to Q, with the analyte molecule;

(b) forming a conjugate of the compound and the analyte molecule; and

(c) detecting the conjugate by its visible properties.

Other embodiments provide a method for visually detecting an analyte, the method comprising:

(a) providing a compound of structure (III), (IV) or (V), wherein A^1 or A^2 comprises a linker comprising a covalent bond to a targeting moiety having specificity for the analyte;

(b) admixing the compound and the analyte, thereby associating the targeting moiety and the analyte; and

(c) detecting the compound by its visible properties.

In addition to the above methods, embodiments of the disclosed compounds (e.g., compounds of structure (III), (IV) or (V)) find utility in various disciplines and methods, including but not limited to: imaging in endoscopy procedures for identification of cancerous and other tissues; single-cell and/or single molecule analytical methods, for example detection of polynucleotides with little or no amplification; cancer imaging, for example by conjugating a disclosed compound to an antibody or sugar or other moiety that preferentially binds cancer cells; imaging in surgical procedures; binding of histones for identification of various diseases; drug delivery, for example by replacing the M moiety in a disclosed compound with an active drug moiety; and/or contrast agents in dental work and other procedures, for example by preferential binding of the disclosed compound to various flora and/or organisms.

It is understood that any embodiment of the disclosed compounds, as set forth above, and any specific choice set forth herein for the variables in the compounds, as set forth above, may be independently combined with other embodiments and/or variables of the compounds to form embodiments of the invention not specifically set forth above. In addition, in the event that a list of choices is listed for any particular variable in a particular embodiment and/or claim, it is understood that each individual choice may be deleted from the particular embodiment and/or claim and that the remaining list of choices will be considered to be within the scope of the invention.

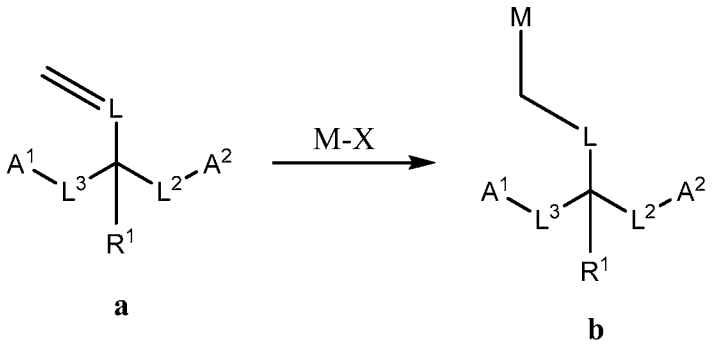
It is understood that in the present description, combinations of substituents and/or variables of the depicted formulae are permissible only if such contributions result in stable compounds.

It will also be appreciated by those skilled in the art that in the process described herein the functional groups of intermediate compounds may need to be protected by suitable protecting groups. Such functional groups include hydroxy, amino, mercapto and carboxylic acid. Suitable protecting groups for hydroxy include trialkylsilyl or diarylalkylsilyl (for example, *t*-butyldimethylsilyl, *t*-butyldiphenylsilyl or trimethylsilyl), tetrahydropyranyl, benzyl, and the like. Suitable protecting groups for amino, amidino and guanidino include *t*-butoxycarbonyl, benzyloxycarbonyl, and the like. Suitable protecting groups for mercapto include -C(O)-R" (where R" is alkyl, aryl or arylalkyl), *p*-methoxybenzyl, trityl and the like. Suitable protecting groups for carboxylic acid include alkyl, aryl or arylalkyl esters. Protecting groups may be added or removed in accordance with standard techniques, which are known to one skilled in the art and as described herein. The use of protecting groups is described in detail in Green, T.W. and P.G.M. Wutz, *Protective Groups in Organic Synthesis* (1999), 3rd Ed., Wiley. As one of skill in the art would appreciate, the protecting group may also be a polymer resin such as a Wang resin, Rink resin or a 2-chlorotrityl-chloride resin.

Furthermore, embodiments of compounds of the invention which exist in free base or acid form can be converted to their salts by treatment with the appropriate inorganic or organic base or acid by methods known to one skilled in the art. Salts of the compounds of the invention can be converted to their free base or acid form by standard techniques.

The following Reaction Schemes illustrate exemplary methods of making compounds of this invention. It is understood that one skilled in the art may be able to make these compounds by similar methods or by combining other methods known to one skilled in the art. It is also understood that one skilled in the art would be able to make, in a similar manner as described below, other disclosed compounds not specifically illustrated below by using the appropriate starting components and modifying the parameters of the synthesis as needed. In general, starting components may be obtained from sources such as Sigma Aldrich, Lancaster Synthesis, Inc., Maybridge, Matrix Scientific, TCI, and Fluorochem USA, etc. or synthesized according to sources known to those skilled in the art (see, for example, Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 5th edition (Wiley, December 2000)) or prepared as described in this invention.

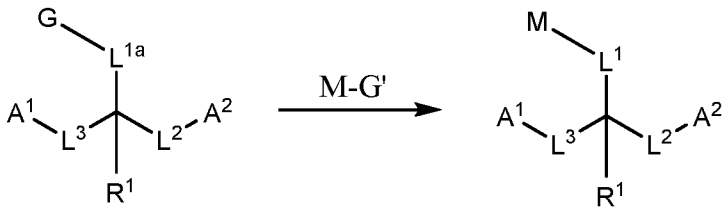
Reaction Scheme I



a **b**

Reaction Scheme I illustrates an exemplary method for preparing an intermediate useful for preparation of compounds of structure (I), where R^1, L^2, L^3 and M are as defined above, A^1 and A^2 are as defined above or are protected variants thereof and L is an optional linker. Referring to Reaction Scheme 1, compounds of structure **a** can be purchased or prepared by methods well-known to those of ordinary skill in the art. Reaction of a with M-X, where x is a halogen such as bromo, under Suzuki coupling conditions known in the art results in compounds of structure **b**. Compounds of structure **b** can be used for preparation of further compounds as described below.

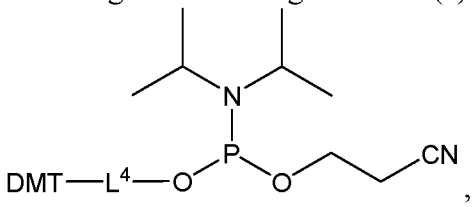
Reaction Scheme II



c **d**

Reaction Scheme II illustrates an alternative method for preparation of intermediates useful for preparation of the disclosed compounds. Referring to reaction Scheme II, where L^1, L^2, L^3, and M are as defined above, and A^1 and A^2 are as defined above or are protected variants thereof, a compound of structure **c**, which can be purchased or prepared by well-known techniques, is reacted with M-G' to yield compounds of structure d. Here, G and G' represent functional groups having complementary reactivity (*i.e.*, functional groups which react to form a covalent bond, such as alkyne and azide). G' may be pendant to M or a part of the structural backbone of M. G may be any number of functional groups described herein, such as alkyne.

The compounds may be prepared from one of structures b or d by reaction under well-known automated DNA synthesis conditions with a phosphoramidite compound having the following structure (**e**):



,

(**e**)

wherein A is as defined herein and each L is independently an optional linker.

DNA synthesis methods are well-known in the art. Briefly, two alcohol groups, for example R^2 and R^3 in intermediates **b** or **d** above, are functionalized with a dimethoxytrityl (DMT) group and a 2-cyanoethyl-N,N-diisopropylamino phosphoramidite group, respectively. The phosphoramidite group is coupled to an alcohol group, typically in the presence of an activator such as tetrazole, followed by oxidation of the phosphorous atom with iodine. The dimethoxytrityl group can be removed with acid (*e.g.*, chloroacetic acid) to expose the free alcohol, which can be

reacted with a phosphoramidite group. The 2-cyanoethyl group can be removed after oligomerization by treatment with aqueous ammonia.

Preparation of the phosphoramidites used in the oligomerization methods is also well-known in the art. For example, a primary alcohol (*e.g.*, A^2) can be protected as a DMT group by reaction with DMT-Cl. A secondary alcohol (*e.g.*, A^1) is then functionalized as a phosphoramidite by reaction with an appropriate reagent such as 2-cyanoethyl N,N-dissopropylchlorophosphoramidite. Methods for preparation of phosphoramidites and their oligomerization are well-known in the art and described in more detail in the examples.

The compounds are prepared by oligomerization of intermediates **b** or **d** and **e** according to the well-known phophoramidite chemistry described above. The desired number of repeating units is incorporated into the molecule by repeating the phosphoramidite coupling the desired number of times.

The following examples are provided for purposes of illustration, not limitation.

EXAMPLES

General Methods

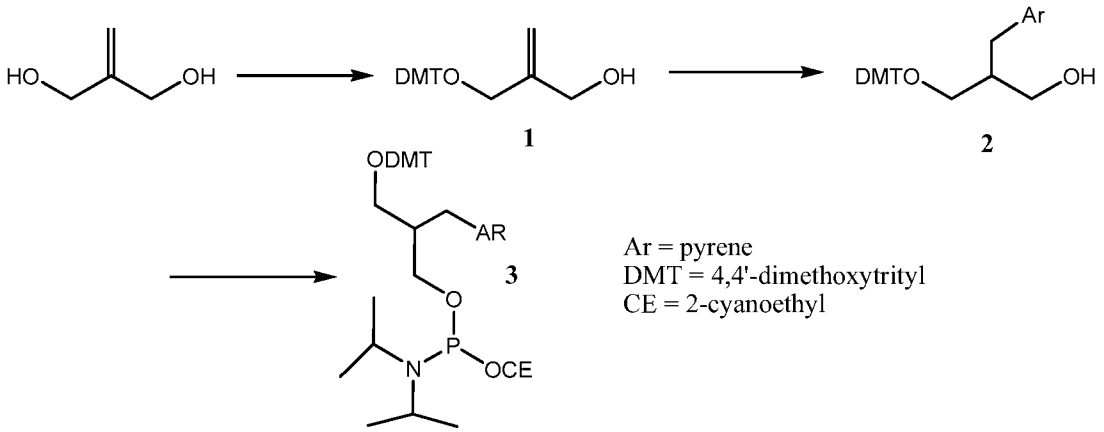
Mass spectral analysis was performed on a Waters/Micromass Quattro micro MS/MS system (in MS only mode) using MassLynx 4.1 acquisition software. Mobile phase used for LC/MS on dyes was 100 mM 1,1,1,3,3,3-hexafluoro-2-propanol (HFIP), 8.6 mM triethylamine (TEA), pH 8. Phosphoramidites and precursor molecules were also analyzed using a Waters Acquity UHPLC system with a 2.1mm x 50mm Acquity BEH-C18 column held at 45°C, employing an acetonitrile/water mobile phase gradient. Molecular weights for monomer intermediates were obtained using tropylium cation infusion enhanced ionization on a Waters/Micromass Quattro micro MS/MS system (in MS only mode). Excitation and emission profiles experiments were recorded on a Cary Eclipse spectra photometer.

All reactions were carried out in oven dried glassware under a nitrogen atmosphere unless otherwise stated. Commercially available DNA synthesis reagents were purchased from Glen Research (Sterling, VA). Anhydrous pyridine, toluene, dichloromethane, diisopropylethyl amine, triethylamine, acetic acid, pyridine, and THF

were purchased from Aldrich. All other chemicals were purchase from Aldrich or TCI and were used as is with no additional purification.

EXAMPLE 1

SYNTHESIS OF PHOSPHORAMIDITE DYE MONOMERS



1-O-(4,4'-dimethoxytrityl-2-methylene-1,3-propanediol(1). Into a dry 500 mL round bottom flask was put a stir bar. After flushing with nitrogen, dry pyridine (240 mL) was added, and the flask was cooled in an ice bath for 15 minutes. Upon cooling DMTrCl (7.65g, 22.5 mmol) was added after which the flask was stirred overnight in a refrigerator at 4°C under a nitrogen atmosphere. Several drops of methanol were then added and the reaction was concentrated *in vacuo* to a viscous gum. The resulting gum was dissolved in EtOAc (200 mL) and washed with $NaHCO_3$ (250 mL) and sat. NaCl (250 mL). The organic layer was dried over Na_2SO_4 and concentrated in *vacuo* to a viscous gum. The isolated crude product wash then purified by silica gel column chromatography eluting with a gradient of EtOAc:hexanes (25:75 v/v) – (1:1 v/v) to give **1** as a clear gum (5.21g, 60%). ^{1}H NMR was recorded and found to be consistent with the structure of compound **1**.

1-*O*-(4,4'-dimethoxytrityl)-2-hydroxymethyl-3-pyrenylpropanol(2). Into a dry 250 mL round bottom flask fitted with a condenser was put a stir bar. The flask was purged with nitrogen, and dry THF (40 mL) and compound **1** (5.0g, 12.8 mmol) were added. 0.5 M 9-BBN in THF (65 mL, 32 mmol) was added via syringe and the reaction was heated to reflux for 12 hrs. After allowing the reaction to cool to room temperature, 3M

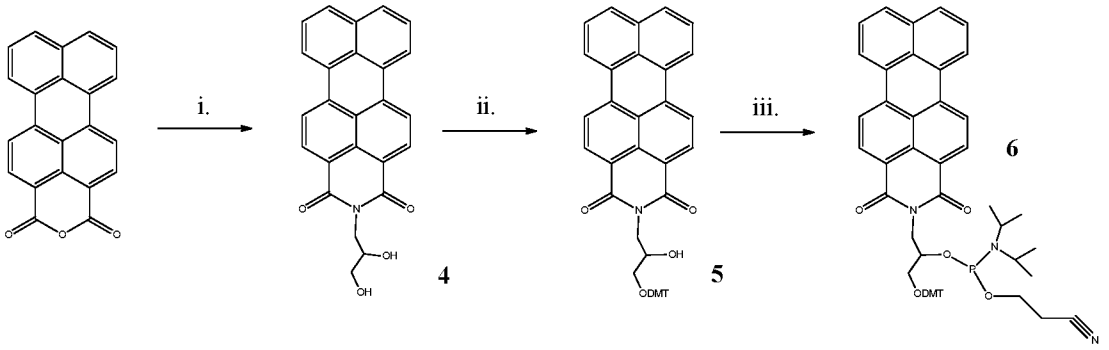
K_2CO_3 (11 ml) and dry DMF (100 mL) were added. 1-Bromopyrene (2.0 g, 6.5 mmol) and $PdCl_2$(dppf) (0.65g, 0.8 mmol) were added, and the solution was allowed to stir for 15 hrs at room temperature. The reaction mixture was poured into CH_2Cl_2 (300 mL) and washed with H_2O (500 mL). The aqueous layer was then back extracted with additional CH_2Cl_2 (200 mL). The combined organic layers were washed with sat. NaCl (300 mL), dried over Na_2SO_4, and concentrated *in vacuo* to a viscous gum. The isolated crude product wash then purified by silica gel column chromatography eluting with a gradient of EtOAc:hexanes (25:75 v/v) – (1:1 v/v) to give **2** as a clear gum (3.0g, 79%). The ^{1}H NMR spectrum was recorded and found to be consistent with the structure of compound **2**.

1-*O*-(4,4'-dimethoxytrityl)-2-methylpyrene-3-*O*-(2-cyanoethyl-*N,N*-diisopropyl) propane phosphoramidite (3). Into a dry 100 mL round bottom flask was put a stir bar. After purging the flask with nitrogen, CH_2Cl_2 (20 mL) and compound **2** (0.30g, 0.50 mmol) were added. *N,N*-Diisopropylethylamine (0.88 mL, 5.0 mmol) and 2-cyanoethyl diisopropychlorophosphoramidite (0.45 mL, 2.0 mmol) were added via syringe. After 1 hour of stirring at room temperature, the reaction was determined to be complete by TLC analysis. The crude reaction mixture was then purified directly by silica gel column chromatography eluting with a gradient of EtOAc:hexanes:TEA (22.5:72.5:5 v/v/v) to give **3** as a white foam (0.28g, 70%). The ^{31}P NMR spectrum was recorded and found to be consisted with the structure of compound **3**: Purity was determined by HPLC analysis with detection at 254 and 340 nm.

Other compounds with different Ar groups (e.g., any of the "M" groups described herein) were prepared in an analogous manner.

EXAMPLE 2

SYNTHESIS OF PERYLENE CARBODIIMIDE DYE MONOMER



***N*-(2,3-propanediol) perylenemonoimide(4).** Into a dry 200 mL round bottom flask fitted with a condenser was put a stir bar and perylene monoanhydride[1] (1.83g, 5.67 mmol). After adding 3-amino-1,2-propanediol (1.1g, 2.1 mmol) and imidazole (14.3g, 0.21 mol), the vessel was heated to 140 °C in an oil bath for 15 hours. The reaction was allowed to cool to room temperature and then 10% HCl was added (500mL). The resulting deep red precipitate was collected by filtration, washed well with water and dried at 180°C for several hours to yield 4 as a deep red solid (1.95g, 86%).

***N*-(3-*O*-(4,4'-dimethoxytrityl-2-hydroxypropane) perylenemonoimide(5).** Into a dry 200 mL round bottom flask was put a stir bar. After purging the flask with nitrogen, dry pyridine (120 mL), compound **4** (0.44g, 1.1 mmol), and dimethoxytritylchloride (0.45g, 1.3 mmol) were all added, and the reaction was allowed to stir at room temperature for 48 hours. Several drops of methanol were then added, and the reaction was concentrated *in vacuo* to a viscous gum. The resulting gum was dissolved in CH_2Cl_2 (200 mL) and washed with sat. NaCl (200 mL). The aqueous layer was washed with in CH_2Cl_2 (3x100mL). The combined organic layers were dried over Na_2SO_4 and concentrated *in vacuo* to a viscous gum. The isolated crude product wash then purified by silica gel column chromatography eluting with a gradient of EtOAc: CH_2Cl_2 (0:100 v/v) – (2:3 v/v) to give **5** as a red foam (0.25g, 50%).

***N*-(3-*O*-(4,4'-dimethoxytrityl-2-*O*-(2-cyanoethyl-*N*,*N*-diisopropylamino phosphoramidite) perylene -monoimide (6).** Into a dry 50 mL round bottom flask was put a stir bar. After purging the flask with nitrogen, CH_2Cl_2 (5 mL) and compound

5 (0.25g, 0.36 mmol) were added. *N,N*-diisopropylethylamine (0.24 mL, 1.79 mmol) and 2-cyanoethyl *N,N*-diisopropychlorophosphoramidite (0.16 mL, 0.72 mmol) were added via syringe. After 1 hour of stirring at room temperature, the reaction was determined to be complete by TLC analysis. The crude reaction mixture was then purified directly by silica gel column chromatography eluting with CH_2Cl_2:TEA (95:5 v/v) to give **6** as a dark red foam (0.26g, 80%). The purified compound was analyzed by RP-HPLC with observation at 254 and 500 nm. Two diastereomers were found to be present.

Other dye monomers with different M groups were prepared in an analogous manner.

EXAMPLE 3

SYNTHESIS OF OLIGOMER DYES

Oligomer dyes were synthesized on an Applied Biosystems 394 DNA/RNA synthesizer or on GE AKTÄ 10 OligoPilot on either 1 μmol or 10 μmol scales and possessed a 3'-phosphate group. Dyes were synthesized directly on CPG beads or on polystyrene solid support. The dyes were synthesized in the 3' to 5' direction by standard solid phase DNA methods. Coupling methods employed standard β-cyanoethyl phosphoramidite chemistry conditions. Different number of "m" repeating units were incorporated by repeating the synthesis cycle the desired number of times with an appropriate phosphoramidite. All phosphoramidite monomers were dissolved in acetonitrile /dichloromethane (0.1 M solutions), and were added in successive order using the following synthesis cycles: 1) removal of the 5'-dimethoxytrityl protecting group with dichloroacetic acid in toluene, 2) coupling of the next phosphoramidite with activator reagent in acetonitrile, 3) oxidation with iodine/pyridine/water, and 4) capping with acetic anhydride/1-methylimidizole/acetonitrile. The synthesis cycle was repeated until the 5' Oligofluoroside was assembled. At the end of the chain assembly, the monomethoxytrityl (MMT) group or dimthoxytrityl (DMT) group was removed with dichloroacetic acid in dichloromethane or dichloroacetic acid in toluene.

The dyes were cleaved from the solid support and deprotected as follows:

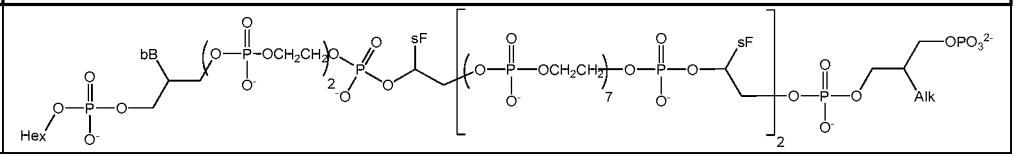
A 1 mL micropipettor was used to add 450µL of concentrated NH_4OH to ~25 mg of reacted CPG solid support in a 1.5 mL Eppendorf tube. The slurry was mixed briefly using a Vortex mixer and allowed to settle before placing (open) on a 55°C heating block until gas formation (and bubbling) started to diminish, at which point the tube was tightly closed. Heat treatment was for 2 hours (+/- 15 minutes) and tubes were then removed to cool to room temperature. The tube and its contents were spun in a centrifuge at its maximum speed (13400 rpm) for 1 minute, and then the supernatant was removed with a glass pipette and placed into a second, labeled, 1.5mL Eppendorf tube, taking care not to include the support. The support was washed and spun-down 2x with ~150µL of acetonitrile to help maximize dye removal, and the washings were carefully removed from support and added to the labeled secondary tubes. Clarified supernatant was dried completely in a CentriVap concentrator at 40°C to remove NH_4OH.

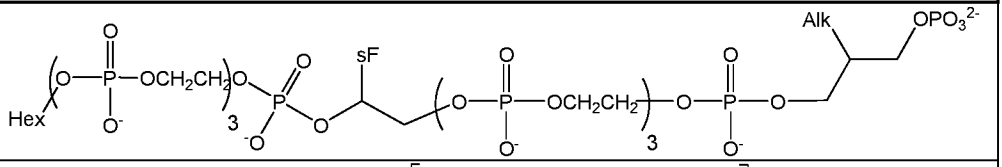
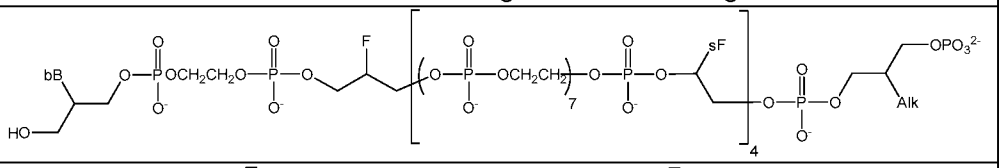
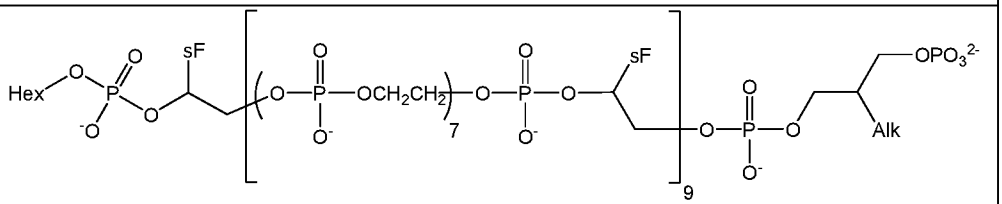
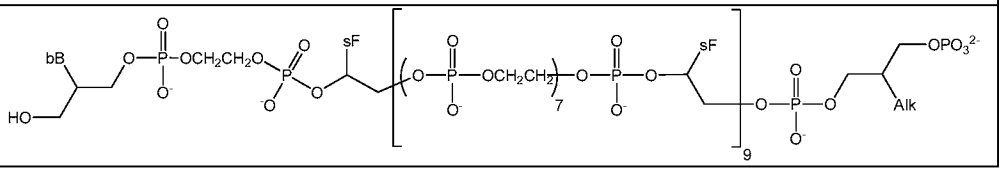
EXAMPLE 4

SYNTHESIS OF OLIGOMER DYES

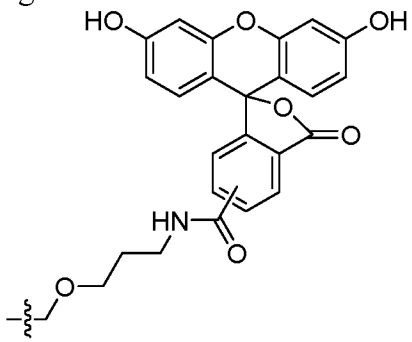
The compounds in Table 2 were prepared according to the above general procedures and used for preparation of higher polymeric dyes according to the procedures which follow. For ease of illustration, the compounds are often depicted schematically in the following examples; however, it is understood that the schematics represent the specific compounds depicted in Table 2.

Table 2. Exemplary Compounds

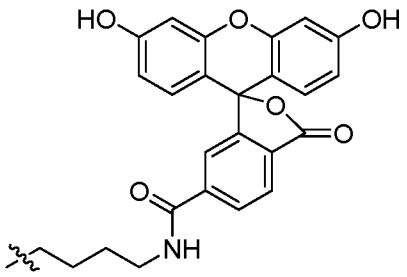
No.	Structure
1	

No.	Structure
2	
3	
4	
5	

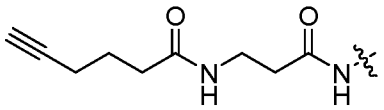
The abbreviations in Table 2 and throughout the application represent the following structures:



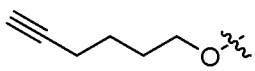
sF : solketal FAM



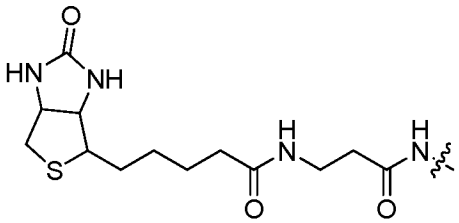
F : FAM derivative commercial



Alk : Alkyne



Hex : Hexynyl

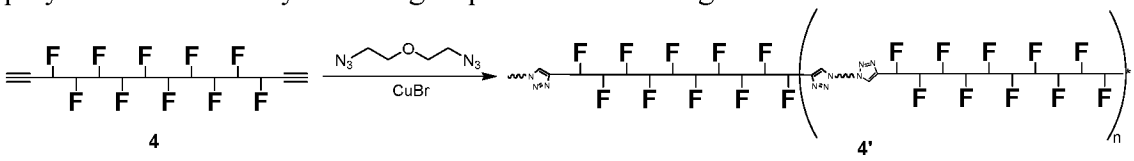


bB : Biotin

EXAMPLE 5

POLYMERIZATION OF COMPOUND 4

Compound 4 was polymerized using triazole chemistry according to the following scheme, wherein 4 represents compound 4 above, 4' represents a dimer or polymer of 4 linked by triazole groups and n is an integer of 1 or more:

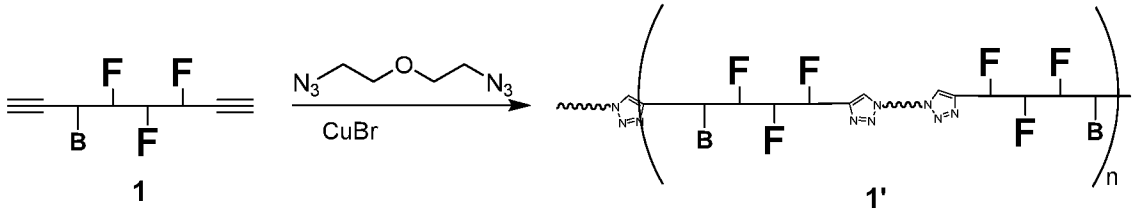


In a 200μL polypropylene tube was placed sodium phosphate buffer (8.8μL, 150mM, pH=7.2) and a solution of compound 4 (2.25μL, 5mM in water). To this was added a solution of 1,5-diazido-3-oxapentane (1.0μL, 7.5mM in water) and copper bromide (3.0μL, 100mM in DMSO). The tube was capped, vortexed and then heated to 85°C for 36h. The reaction mixture was examined by analytical SEC (column : Superdex 200 Increase 5/150GL (28-9409-45), Isocratic elution with 100% PBS buffer, flow rate : 0.25mL/min, UV monitoring at 280 and 494 nm, run time : 17min). The HPLC chromatogram showed an earlier eluting peak (relative to starting material), indicating formation of compound 4'.

EXAMPLE 6

POLYMERIZATION OF COMPOUND 1

Compound 1 was polymerized using triazole chemistry according to the following scheme, wherein 1 represents compound 1 above, 1' represents a dimer or polymer of 1 linked by triazole groups and n is an integer of 1 or more:



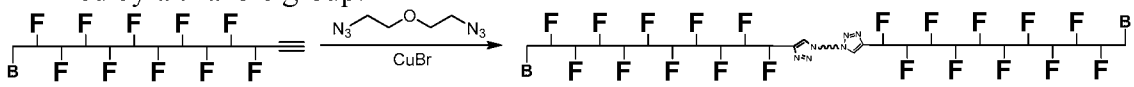
In a 200μL polypropylene tube was placed 50/50 DMSO/water (3.0μL) and a solution of 1 (4.0μL, 12.5mM). To this was added a solution of 1,5-diazido-3-oxapentane (2.0μL, 25mM in water) and copper bromide (1.0μL, 50mM in DMSO). The tube was capped and vortexed. The tube was placed in a commercial microwave

and irradiated for 4min at 450 watts (1/2 power) and then allowed to stand for 1min. This cycle was repeated seven times. The mixture was analyzed by LC/MS and analytical SEC. The data was consistent with formation of a higher molecular weight species (i.e., 1').

EXAMPLE 7

DIMERIZATION OF COMPOUND 5

Compound 5 was dimerized using triazole chemistry according to the following scheme, wherein 5 represents compound 5 above and 5' represents a dimer of 5 linked by a triazole group:



5 5'

Compound 5 was purified by a semiprep SEC column (Column : Superdex 200, isocratic elution with PBS, flow rate 10mL/min, monitor at 494nm). Fractions were examined by SDS-PAGE gel (4-20% Tris-Gly, Invitrogen) and pooled according to purity. In a 200µL polypropylene tube was placed sodium phosphate buffer (1.4µL, 600mM, pH=7.2) and a solution of purified compound 5 (5.56µL, 1.8mM). To this was added a solution of 1,5-diazido-3-oxapentane (1.0µL, 5mM in water) and copper bromide (2.0µL, 100mM in DMSO). The tube was capped, vortexed and allowed to incubate at room temperature overnight. The reaction mixture was examined by analytical SEC (column : Superdex 200 Increase 5/150GL (28-9409-45), Isocratic elution with 100% PBS buffer, flow rate : 0.25mL/min, UV monitoring at 280 and 494 nm, run time : 17min).

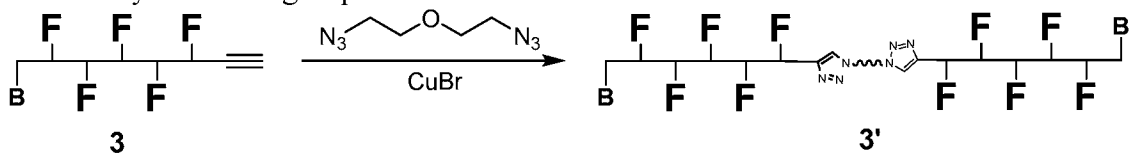
Analysis by SDS-PAGE and SEC confirmed formation of the dimer 5'.

EXAMPLE 8

DIMERIZATION OF COMPOUND 3

Compound 3 was dimerized using triazole chemistry according to the following scheme, wherein 3 represents compound 3 above and 3' represents a dimer of

3 linked by a triazole group:

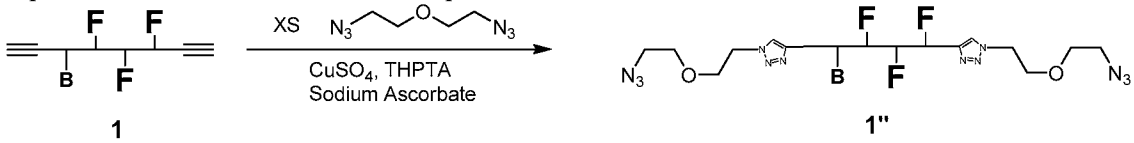


In a 200μL polypropylene tube was placed sodium phosphate buffer (9.5μL, 150mM, pH=7.2) and a solution of 3 (3.0μL, 5mM in water). To this was added a solution of 1,5-diazido-3-oxapentane (1.0μL, 7.5mM in water) and copper bromide (1.5μL, 100mM in DMSO). The tube was capped, vortexed and incubated for 72h. The reaction mixture was examined by analytical SEC (column : Superdex 200 Increase 5/150GL (28-9409-45), Isocratic elution with 100% PBS buffer, flow rate : 0.25mL/min, UV monitoring at 280 and 494 nm, run time : 17min). The SEC trace showed formation of a new, earlier eluting peak, consistent with formation of dimer 3'.

EXAMPLE 9

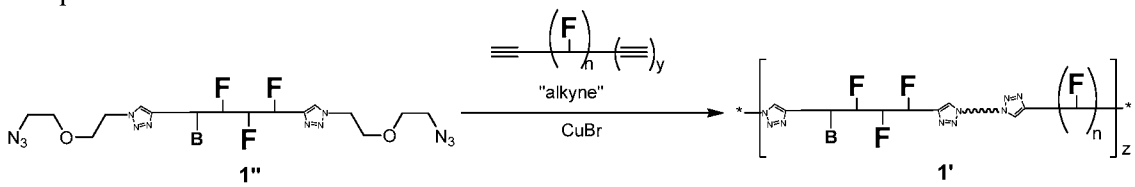
PREPARATION OF AZIDO-MODIFIED COMPOUND 1 AND POLYMERIZATION THEREOF

Compound 1 was modified to include azide groups at both termini according to the following scheme, wherein 1 represents compound 1 above and 1'' represents the azido modified compound 1:



In a 200μL polypropylene tube was placed sodium phosphate buffer (14.4μL, 200mM, pH=7.2), a solution of 1 (1.2μL, 12.5mM in water) and a solution of 1,5-diazido-3-oxapentane (6.0μL, 50mM in water). In a separate tube, aqueous solutions of copper sulfate (3.0μL, 20mM), tris(3-hydroxypropyltriazolylmethyl)amine, (THPTA, 2.4μL, 50mM in water) and sodium ascorbate (3.0μL, 100mM) were combined and mixed. The entire contents of the copper solution were added the azide-alkyne solution, the tube capped, mixed and allowed to incubate overnight at room temperature. The reaction was diluted to 75μLwith water and desalted (Pierce Zeba mini desalting column 7K MWCO (cat#89882)). Concentration determination was made on a nanodrop (e=22500 1/M cm).

Azido-modified compound 1 was polymerized using triazole chemistry as follows, wherein 1' represents a polymer of 1 and "alkyne" represents any one of compounds 1-5.



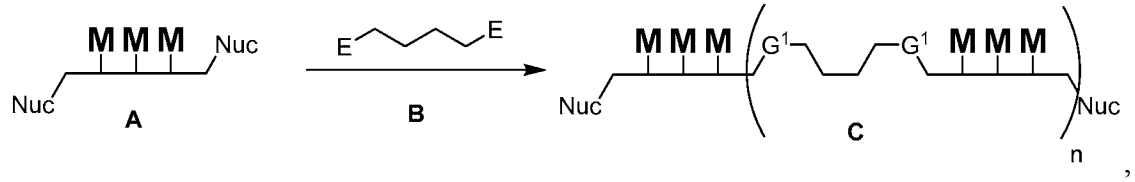
A series of FAM-phosphate alkynes (e.g., compounds 1-5) were reacted with the azide modified compound 1 as follows:

In a 200μL polypropylene tube was placed sodium phosphate buffer (8.3μL, 300mM, pH=7.2) and a solution of 1'' (2.5μL, 30μM). To this was added a solution of 1 (1.2μL, 63μM) and copper bromide (3.0μL, 100mM in DMSO). The tube was capped, vortexed and incubated overnight. The reaction mixture was examined by analytical SEC (column : Superdex 200 Increase 5/150GL (28-9409-45), Isocratic elution with 100% PBS buffer, flow rate : 0.25mL/min, UV monitoring at 280 and 494 nm, run time : 17min). Compounds 2-5 were reacted with 1'' in an analogous manner. In each instance, analytical SEC indicated formation of compound 1'

EXAMPLE 10

NUCLEOPHILIC POLYMERIZATIONS

Analogues of compounds 1-5 including nucleophilic groups at both termini (represented by A below) are prepared and reacted with a bis electrophile (represented by B below) to form a dimer or higher polymer (represented by C below) according to the following scheme:



,

where nuc is a nucleophile, E is an electrophile and n is an integer of one or more. Exemplary nucleophiles, complementary electrophiles and the resulting product "G^1" are provided in Table 3.

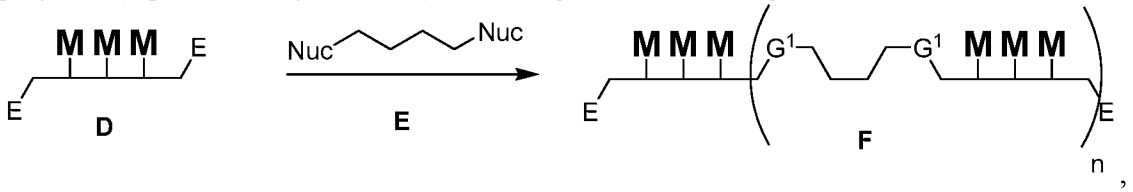
Table 3. Nucleophiles, Electrophiles and Products

Nucleophile (Nuc)	Electrophile (E)	Product (G^1)
NH_2	Acid Chloride, NHS ester	Amide
NH_2, NHR, SH, OH; R = alkyl	NCO, NCS	Urea, Carbamate, Urethane, Thio-Carbamate
NH_2, NHR, SH, OH; R = alkyl	Epoxide	Amino-alcohol, Thio-ether-alcohol, ether-alcohol
NH_2, NHR, SH, R = alkyl	Alkyl Halide, Alkyl tosylate, Mesylate, Triflate	Amine, Thio-ether
SH	Maleimide	Alkyl sulfide
SH	Alkene	

EXAMPLE 11

ELECTROPHILIC POLYMERIZATIONS

In a manner analogous to Example 10, analogues of compounds 1-5 including electrophilic groups at both termini (represented by D below) are prepared and reacted with a bis nucleophile (represented by E below) to form a dimer or higher polymer (represented by F below) according to the following scheme:



where nuc is a nucleophile, E is an electrophile and n is an integer of one or more. Exemplary nucleophiles, complementary electrophiles and the resulting product "G^1" are provided in Table 4.

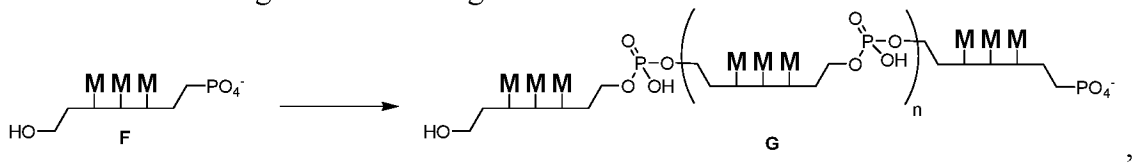
Table 4. Electrophiles, Nucleophiles and Products

Electrophile (E)	Nucleophile (Nuc)	Product (G^1)
NHS Ester, Phenolate Ester	NH_2, NHR, SH, R = alkyl	Amide, Thioester
Alkyl Halide, Alkyl Tosylate, Mesylate, Triflate	NHR, SH, R = alkyl	Amine, Thioether

EXAMPLE 12

POLYPHOSPHATE CONDENSATION

Analogues of compounds 1-5 including a phosphate group at least one terminus (represented by F below) are prepared and polymerized under heat and/or acid conditions according to the following scheme:



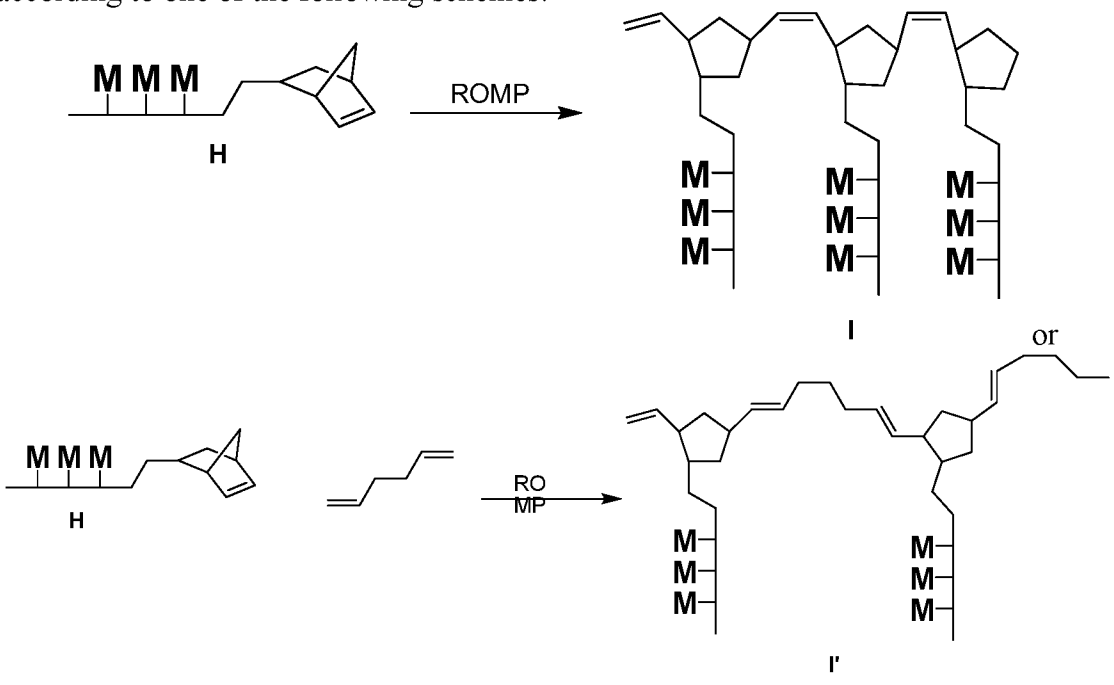
,

where n is an integer of one or more.

EXAMPLE 13

RING OPENING METATHESIS POLYMERIZATIONS (ROMP)

Analogues of compounds 1-5 including a cyclic olefin group at one terminus (represented by H below) are prepared and treated under ring opening metathesis conditions to form a dimer or higher polymer (represented by I and I' below) according to one of the following schemes:



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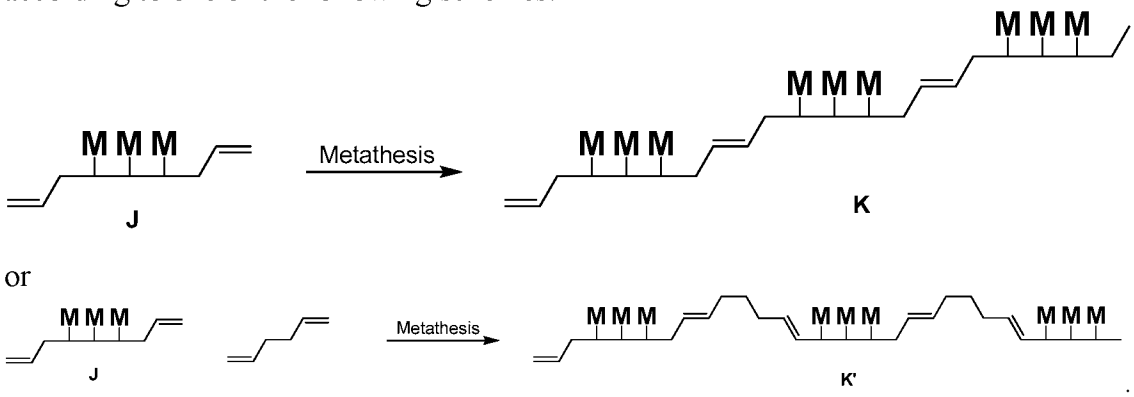
EXAMPLE 14

OLEFIN CROSS METATHESIS POLYMERIZATIONS (ROMP)

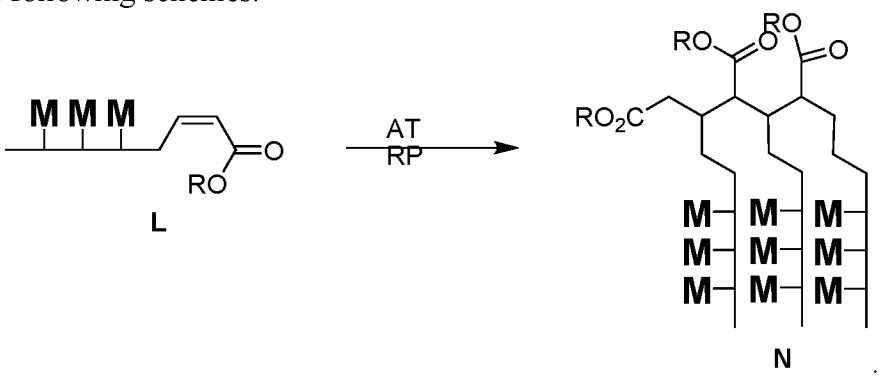
Analogues of compounds 1-5 including an alkene group at each terminus (represented by J below) are prepared and treated under ring opening metathesis conditions to form a dimer or higher polymer (represented by K and K' below) according to one of the following schemes:



EXAMPLE 15

ATOM TRANSFER RADICAL POLYMERIZATIONS (ATRP)

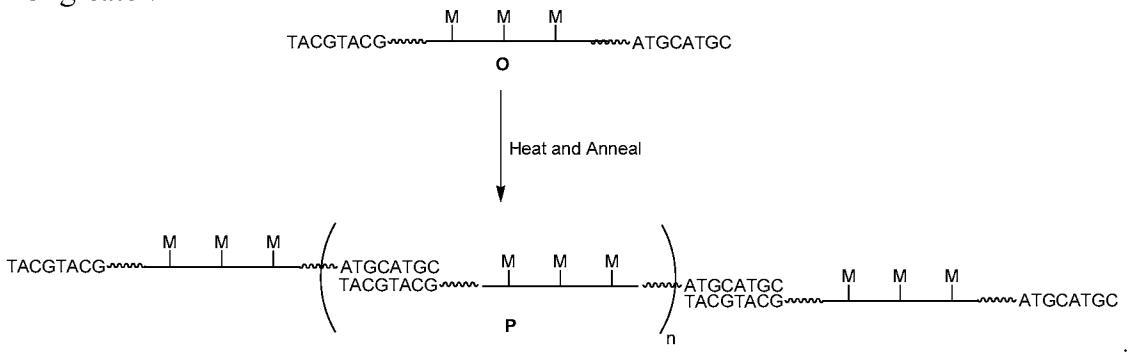
Analogues of compounds 1-5 including an acrylate group at one terminus (represented by L below, R=alkyl) are prepared and treated under ATRP conditions to form a dimer or higher polymer (represented by N below) according to one of the following schemes:



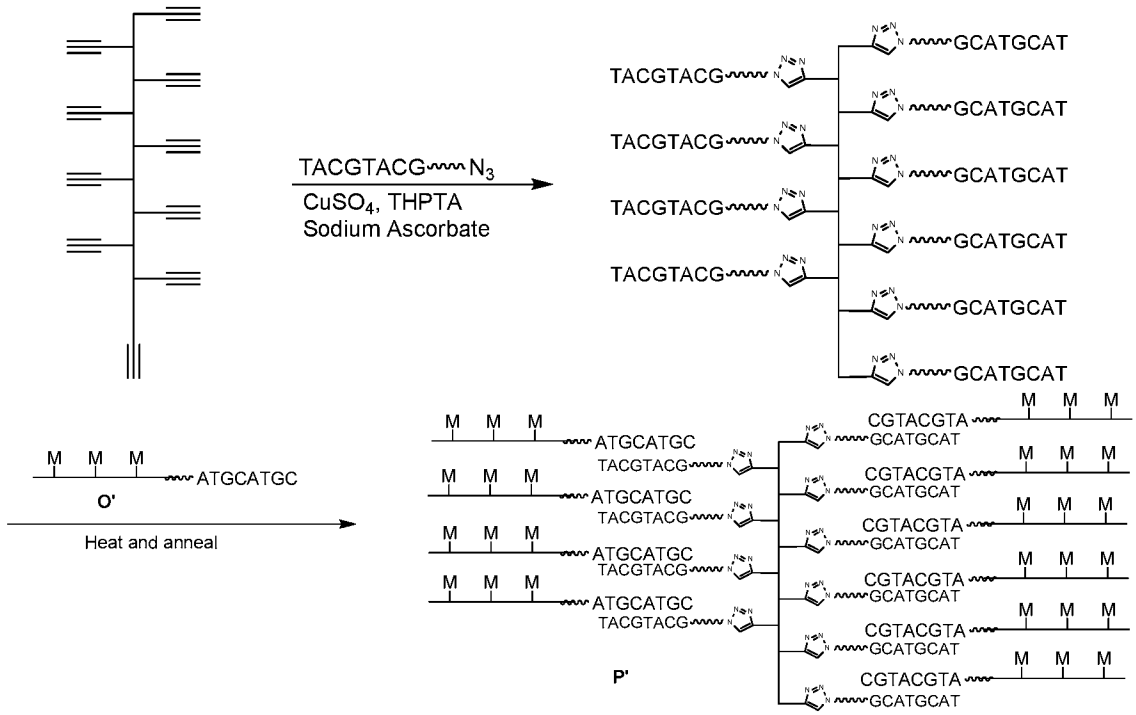
EXAMPLE 16

DNA BASE PAIRING

Analogues of compounds 1-5 including a DNA base sequence at both termini (represented by O) are prepared and annealed to form a dimer or higher polymer (represented by P below) according to the following scheme, wherein n is an integer of 0 or greater:



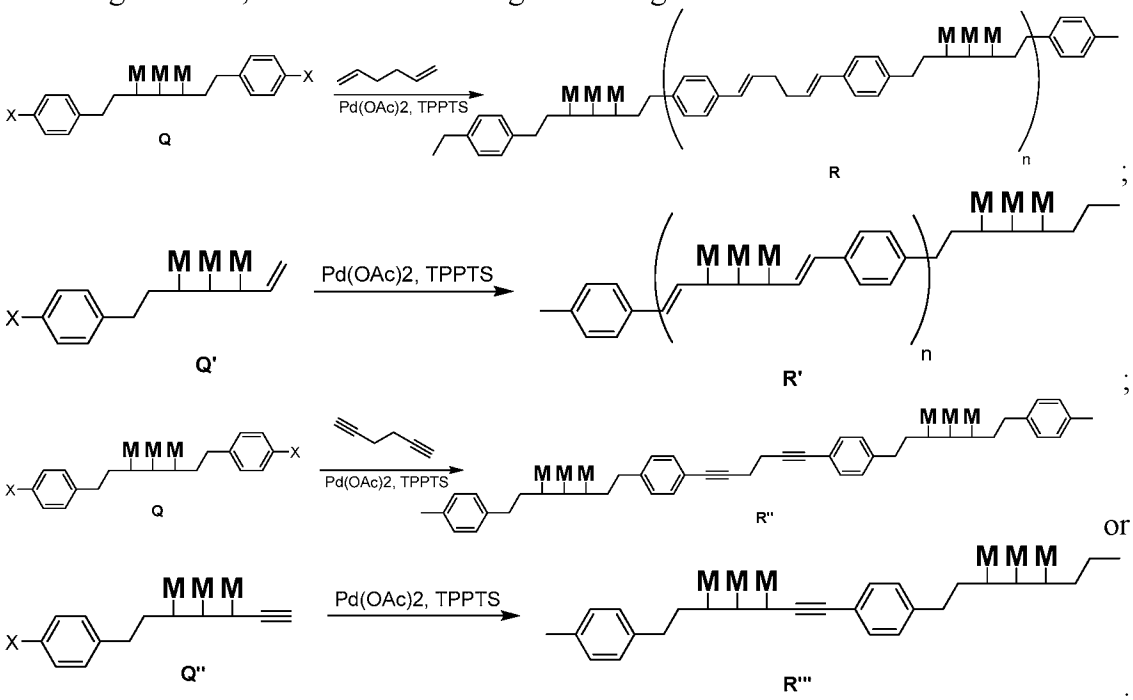
In a related embodiment, a polyalkyne is prepared and conjugated to a DNA sequence comprising a terminal azide to form a triazole/DNA-containing polymer as shown below. Separately, analogues of compounds 1-5 having a terminal DNA base sequence (O') are prepared and annealed to form P'.



EXAMPLE 17

PALLADIUM COUPLING REACTIONS

Analogues of compounds 1-5 including an appropriate group for palladium coupling reactions at one or both termini (represented by Q, Q' and Q'', X=halogen) are prepared and reacted under appropriate conditions to form a dimer or higher polymer (represented by R, R', R'' and R''' below) according to one of the following schemes, wherein n is an integer of 1 or greater:



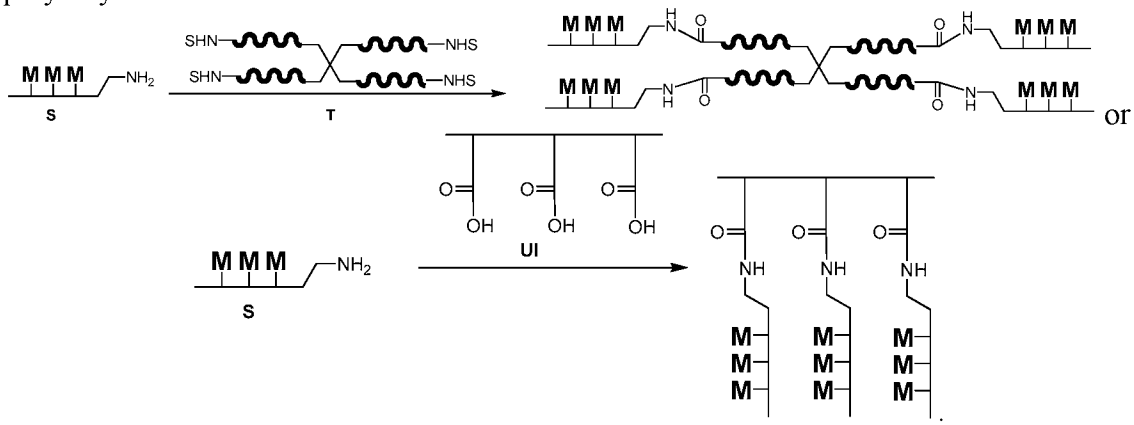
In related examples, analogues of compounds 1-5 including an appropriate group Suzuki (boronic acid/ester + aryl halide or alkyl halide), Stille (alkyl or aryl stannane + aryl or alkyl halide) or Buchwald (amine + aryl or alkyl halide) coupling are prepared and coupled with a complementary functional group, which may be present in the same compound or in a separate compound, to form dimer and higher polymers.

EXAMPLE 18

GRAFTING TO EXISTING POLYMERS

Analogues of compounds 1-5 including a reactive group (e.g., nucleophile, such as amino) for reaction with a complementary reactive group on a polymer (represented by S below) are prepared and reacted under appropriate

conditions to form a grafted polymer according to one of the following schemes, wherein T is an NHS-activated polyethylene glycol and U is a polyglutamic acid or polyacrylic acid:



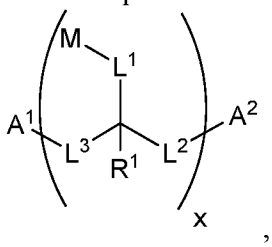
All of the U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification are incorporated herein by reference, in their entirety to the extent not inconsistent with the present description.

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

What is claimed is:

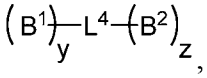
1. A method for preparing a dimeric or polymeric dye, the method comprising reacting a first and second compound of structure (I):



,

(I)

with a compound of structure (II):



,

(II)

wherein:

A^1 and A^2 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a first functional group having complementary reactivity to B^1, B^2 or both, provided at least one of A^1 and A^2 is a moiety comprising a first functional group having complementary reactivity to B^1, B^2 or both, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

B^1 and B^2 are each independently a second functional group having complementary reactivity to the first functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an

analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (I);

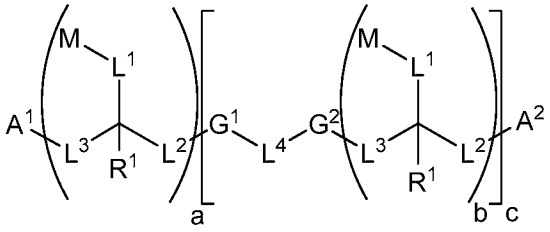
L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety; and

x, y and z are independently an integer of 1 or greater,

thereby: i) forming a first bond between the first compound of structure (I) and the compound of structure (II) by reaction of B^1 with the first functional group of the first compound of structure (I); and ii) forming a second bond between the second compound of structure (I) and the compound of structure (II) by reaction of B^2 with the first functional group of the second compound of structure (I).

2. The method of claim 1, wherein the dimeric or polymeric dye has the following structure (III):



(III)

wherein:

A^1 and A^2 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a first functional group having complementary reactivity to B^1, B^2 or both, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether,

alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^1 and G^2 are each independently moieties comprising functional groups resulting from reaction of the first functional group with B^1 or B^2, respectively;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety for at least one integral value of a and b;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (III);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety; and

a, b and c are independently an integer of 1 or greater.

3. The method of claim 1, wherein A^1 and A^2 are each independently a first functional group having complementary reactivity to B^1, B^2 or both.

4. The method of claim 3, wherein A^1, A^2 are each independently a nucleophilic functional group.

5. The method of claim 4, wherein the nucleophilic functional group is amino, alkylamino, sulfhydryl or hydroxyl.

6. The method of any one of claims 1 or 3-5, wherein B^1 and B^2 are each independently an electrophilic functional group.

7. The method of claim 6, wherein the electrophilic functional group is an acid halide, N-hydroxysuccinimide ester, isocycanate, isothiocyanate, epoxide, halide, tosylate, mesylate, triflate, maleimide, phosphate or alkene.

8. The method of claim 3, wherein A^1, A^2 are each independently an electrophilic functional group.

9. The method of claim 8, wherein the electrophilic functional group is an N-hydroxysuccinimide ester, phenolate ester, halide, tosylate, mesylate, phosphate or triflate.

10. The method of any one of claims 1, 8 or 9, wherein B^1 and B^2 are each independently nucleophilic functional group.

11. The method of claim 10, wherein the nucleophilic functional group is amino, alkylamino, sulfhydryl or hydroxyl.

12. The method of claim 1, wherein A^1, A^2, B^1 and B^2 are each independently nucleic acid sequences, and A^1 is complementary to B^1, and A^2 is complementary to B^2.

13. The method of claim 1, wherein A^1 and A^2 are each independently an alkyne and B^1 and B^2 are each independently an azide.

14. The method of claim 1, wherein A^1 and A^2 are each independently an azide and B^1 and B^2 are each independently an alkyne.

15. The method of claim 1, wherein at least one of A^1 and A^2 comprises a cycloaddition reactive functional group, and each of B^1 and B^2 are complementary cycloaddition reactive functional groups.

16. The method of claim 15, wherein each cycloaddition reactive functional group comprises an alkene.

17. The method of claim 1, wherein A^1 and A^2 comprise an aryl halide, and each of B^1 and B^2 are alkene or alkyne functional groups.

18. The method of claim 1, wherein A^1 and A^2 comprise a boronic acid or boronic ester, and each of B^1 and B^2 are aryl halide or alkyl halide functional groups.

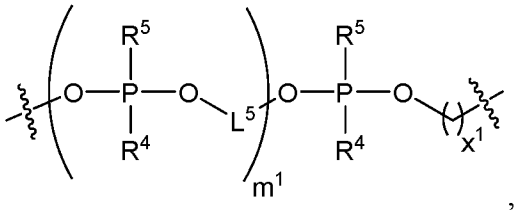
19. The method of claim 1, wherein A^1 and A^2 comprise an alkylstannane or arylstannane, and each of B^1 and B^2 are aryl halide or alkyl halide functional groups.

20. The method of claim 1, wherein A^1 and A^2 comprise an amine, and each of B^1 and B^2 are aryl halide or alkyl halide functional groups.

21. The method of claim 2, wherein G^1 and G^2 each independently comprise an amide, urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, phosphodiester, alkene, alkyne or a triazole.

22. The method of any one of claims 1-21, wherein L^4 is alkylene.

23. The method of any one of claims 1-22, wherein L^3, at each occurrence, independently has the following structure:



,

wherein:

R^4 is, at each occurrence, independently OH, SH, O^-, S^-, OR_d or SR_d;

R^5 is, at each occurrence, independently oxo, thioxo or absent;

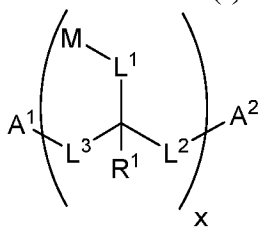
m^1 and x^1 are, at each occurrence, independently an integer from 0 to 10; and

L^5 is an alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, carbocyclic or heterocyclic linker.

24. The method of any one of claims 1-22, wherein L^3 is, at each occurrence, independently an amino acid or peptide linker.

25. The method of any one of claims 1-22, wherein L^3 is, at each occurrence, independently a linker comprising one or more charged moieties.

26. A method for preparing a dimeric or polymeric dye, the method comprising reacting a first compound of structure (I):



(I)

with a second compound of structure (I), wherein:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, L' or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

A^2 is a moiety comprising the second functional group, wherein the second functional group has reactivity complementary to itself or reactivity complementary to the first functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q′;

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (I);

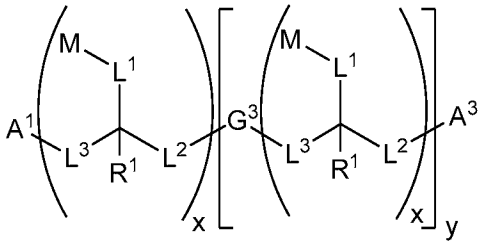
L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

x is an integer of 1 or greater,

thereby forming a bond between the first and second compounds of structure (I) by reaction of: i) the first functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I); or ii) the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I).

27. The method of claim 26, wherein the bond is formed between the first and second compounds of structure (I) by reaction of the first functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I).

28. The method of claim 27, wherein the dimeric or polymeric dye has the following structure (IV):



(IV)

wherein:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, L' or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

A^3 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a further compound of structure (I) or a moiety comprising the second functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, SR_d, alkyl, alkoxy, alkylether , alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^3 is a moiety comprising a functional group resulting from reaction of the first functional group with the second functional group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (IV);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

29. The method of any one of claims 27-28, wherein the first functional group is a nucleophilic functional group.

30. The method of claim 29, wherein the nucleophilic functional group is amino, alkylamino, sulfhydryl or hydroxyl.

31. The method of any one of claims 27-30, wherein the second functional group is an electrophilic functional group.

32. The method of claim 31, wherein the electrophilic functional group is an acid halide, N-hydroxysuccinimide ester, isocycanate, isothiocyanate, epoxide, halide, tosylate, mesylate, triflate, maleimide, phosphate or alkene.

33. The method of claim 27, wherein the first and second functional groups are each independently nucleic acid sequences, and the first functional group is complementary to the second functional group.

34. The method of claim 27, wherein the first functional group is an alkyne and the second functional group is an azide.

35. The method of claim 27, wherein the first functional group is a cycloaddition reactive functional group, and the second functional group is a complementary cycloaddition reactive functional group.

36. The method of claim 27, wherein the first functional group is an aryl halide, and the second functional group is an alkene or alkyne functional group.

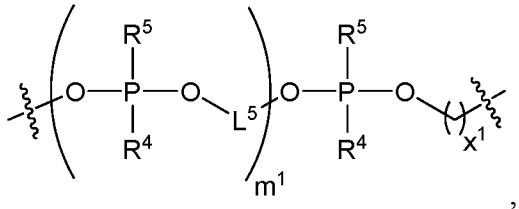
37. The method of claim 27, wherein the first functional group is a boronic acid or boronic ester, and the second functional group is an aryl halide or alkyl halide functional group.

38. The method of claim 27, wherein the first functional group is an alkylstannane or arylstannane, and the second functional group is an aryl halide or alkyl halide functional group.

39. The method of claim 27, wherein the first functional group is an amine, and the second functional group is an aryl halide or alkyl halide functional group.

40. The method of claim 28, wherein G^3 comprises an amide, urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, phosphodiester, alkene, alkyne or a triazole.

41. The method of any one of claims 26-40, wherein L^3, at each occurrence, independently has the following structure:



,

wherein:

R^4 is, at each occurrence, independently OH, SH, O^-, S^-, OR_d or SR_d;

R^5 is, at each occurrence, independently oxo, thioxo or absent;

m^1 and x^1 are, at each occurrence, independently an integer from 0 to 10; and

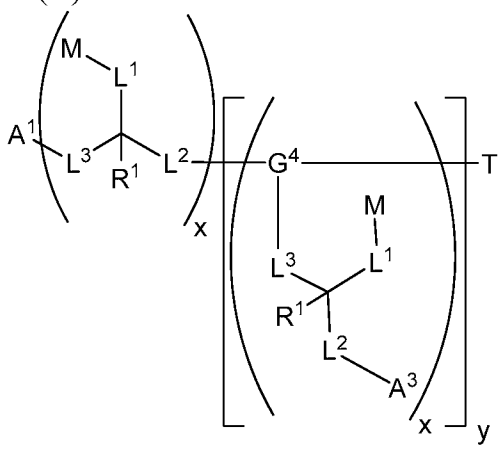
L^5 is an alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, carbocyclic or heterocyclic linker.

42. The method of any one of claims 26-40, wherein L^3 is, at each occurrence, independently an amino acid or peptide linker.

43. The method of any one of claims 26-40, wherein L^3 is, at each occurrence, independently a linker comprising one or more charged moieties.

44. The method of claim 26, wherein the bond is formed between the first and second compounds of structure (I) by reaction of the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I).

45. The method of claim 26, wherein the dimeric or polymeric dye has the following structure (V):



(V)

wherein:

A^1 is H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, a linker comprising a covalent bond to Q, L' or a moiety comprising a first functional group having complementary reactivity to a second functional group, wherein: R_a is O

or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

T is absent or a polymer terminating group;

G^4 is a moiety comprising a functional group resulting from reaction of the second functional group on the first compound of structure (I) and the second functional group on the second compound of structure (I);

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q′;

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (V);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties; and

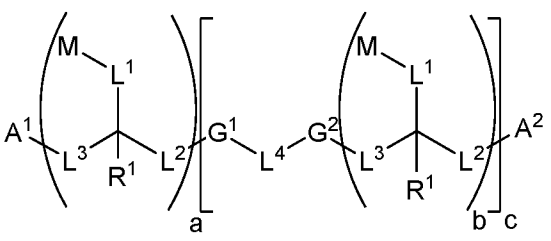
each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

46. The method of any one of claims 44 or 45, wherein each second functional group is a cycloaddition reactive functional group.

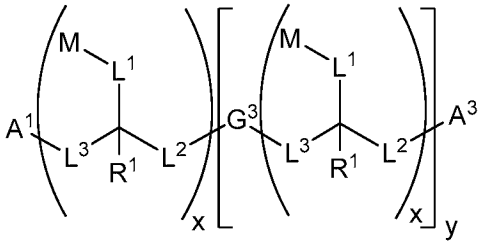
47. The method of any one of claims 44 or 45, wherein each second functional group is an acrylate functional group.

48. A compound having one of the following structures (III), (IV) or (V):



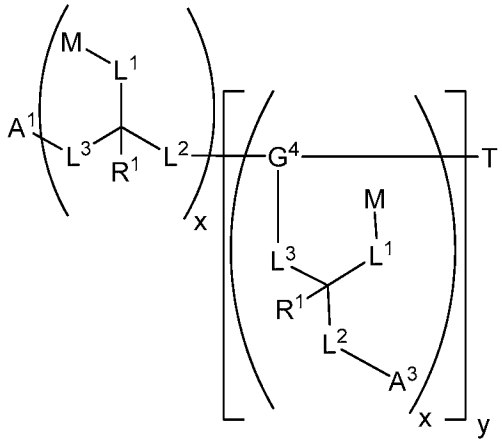
(III)

;



(IV)

or



(V)

wherein:

A^1, A^2 and A^3 are each independently H, OH, SH, alkyl, alkoxy, alkylthio, alkylether, $-OP(=R_a)(R_b)R_c$, Q, L' or a moiety comprising a functional group capable of forming G^1, G^2, G^3 or G^4 upon reaction with a moiety comprising complementary functional group, wherein: R_a is O or S; R_b is OH, SH, O^-, S^-, OR_d or SR_d; R_c is OH, SH, O^-, S^-, OR_d, OL', SR_d, alkyl, alkoxy, heteroalkyl, heteroalkoxy, alkylether, alkoxyalkylether, phosphate, thiophosphate, phosphoalkyl, thiophosphoalkyl, phosphoalkylether or thiophosphoalkylether; and R_d is a counter ion;

G^1, G^2, G^3 and G^4 are each independently moieties comprising a urea, carbamate, urethane, thiocarbamate, amino-alcohol, thioether-alcohol, ether-alcohol, amine, thioether, thioester, double-stranded nucleic acid, alkene, alkyne or triazole functional group;

T is absent or a polymer terminating group;

M is, at each occurrence, independently a fluorescent or colored dye moiety or Q, provided at least one occurrence of M is a fluorescent or colored dye moiety for at least one integral value of a and b;

R^1 is, at each occurrence, independently H, alkyl or alkoxy;

Q is, at each occurrence, independently a moiety comprising a reactive group, or protected analogue thereof, capable of forming a covalent bond with an analyte molecule, a targeting moiety, a solid support or a complementary reactive group Q';

L' is, at each occurrence, independently a linker comprising a covalent bond to Q, a linker comprising a covalent bond to a targeting moiety, a linker comprising a covalent bond to an analyte molecule, a linker comprising a covalent bond to a solid support, a linker comprising a covalent bond to a solid support residue, a linker comprising a covalent bond to a nucleoside or a linker comprising a covalent bond to a further compound of structure (I);

L^1, L^2 and L^3 are, at each occurrence, independently optional bivalent linker moieties;

L^4 is an optional multivalent linker moiety;

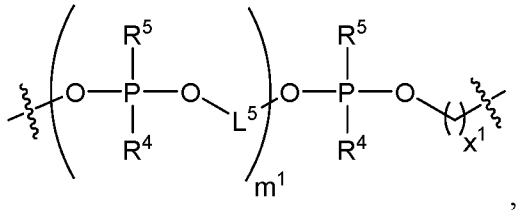
a, b and c are independently an integer of 1 or greater;

each x is independently an integer of 1 or greater; and

y is an integer of 1 or greater.

49. The compound of claim 48, wherein L^4 is alkylene.

50. The compound of claim 48 or 49, wherein L^3, at each occurrence, independently has the following structure:



,

wherein:

R^4 is, at each occurrence, independently OH, SH, O^-, S^-, OR_d or SR_d;

R^5 is, at each occurrence, independently oxo, thioxo or absent;

m^1 and x^1 are, at each occurrence, independently an integer from 0 to 10; and

L^5 is an alkylene, alkenylene, alkynylene, heteroalkylene, heteroalkenylene, heteroalkynylene, carbocyclic or heterocyclic linker.

51. The compound of claim 48 or 49, wherein L^3 is, at each occurrence, independently an amino acid or peptide linker.

52. The compound of claim 48 or 49, wherein L^3 is, at each occurrence, independently a linker comprising one or more charged moieties.

53. The compound of any one of claims 48-52, wherein R^1 is H.

54. The compound of any one of claims 48-53, wherein A^1, A^2 and A^3 are each independently OH or $-OP(=R_a)(R_b)R_c$.

55. The method of anyone of claims 1-47 or the compound of any one of claims 48-54, wherein M is fluorescent.

56. The method of anyone of claims 1-47 or the compound of any one of claims 48-54, wherein M is, at each occurrence, independently a dimethylaminostilbene, quinacridone, fluorophenyl-dimethyl-BODIPY, his-fluorophenyl-BODIPY, acridine, terrylene, sexiphenyl, porphyrin, benzopyrene, (fluorophenyl-dimethyl-difluorobora-diaza-indacene)phenyl, (bis-fluorophenyl-difluorobora-diaza-indacene)phenyl, quaterphenyl, bi-benzothiazole, ter-benzothiazole, bi-naphthyl, bi-anthracyl, squaraine, squarylium, 9, 10-ethynylanthracene or ter-naphthyl moiety.

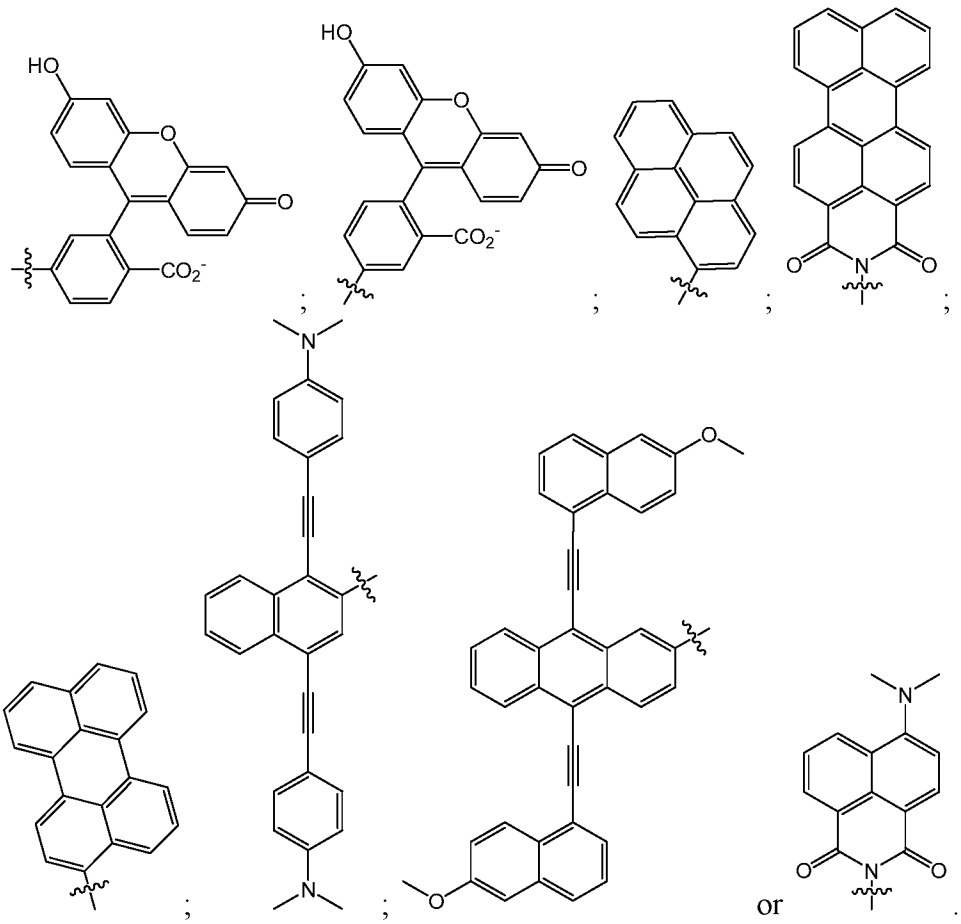
57. The method of anyone of claims 1-47 or the compound of any one of claims 48-54, wherein M is, at each occurrence, independently p-terphenyl,

perylene, azobenzene, phenazine, phenanthroline, acridine, thioxanthrene, chrysene, rubrene, coronene, cyanine, perylene imide, or perylene amide or derivative thereof.

58. The method of anyone of claims 1-47 or the compound of any one of claims 48-54, wherein M is, at each occurrence, independently a coumarin dye, resorufin dye, dipyrromethene boron difluoride dye, ruthenium bipyridyl dye, energy transfer dye, thiazole orange dye, polymethine or N-aryl-1,8-naphthalimide dye.

59. The method of anyone of claims 1-47 or the compound of any one of claims 48-54, wherein M is, at each occurrence, independently pyrene, perylene, perylene monoimide or 6-FAM or derivative thereof.

60. The method of anyone of claims 1-47 or the compound of any one of claims 48-54, wherein M, at each occurrence, independently has one of the following structures:



; ; ; ; ; ; or .

61. A compound selected from Table 2.

62. A method of staining a sample, comprising adding to said sample the compound of any one of claims 48-61 in an amount sufficient to produce an optical response when said sample is illuminated at an appropriate wavelength.

63. The method of claim 62, wherein said optical response is a fluorescent response.

64. The method of any one of claims 62-63, wherein said sample comprises cells.

65. The method of claim 64, further comprising observing said cells by flow cytometry.

66. The method of claim 63, further comprising distinguishing the fluorescence response from that of a second fluorophore having detectably different optical properties.

67. A method for visually detecting an analyte molecule, the method comprising:

(a) providing the compound of claim 48, wherein A^1, A^2 or A^3 is a linker comprising a covalent bond to the analyte molecule; and

(b) detecting the compound by its visible properties.

68. A method for visually detecting an analyte molecule, the method comprising:

(a) admixing the compound of claim 48, wherein A^1, A^2 or A^3 is Q or a linker comprising a covalent bond to Q, with the analyte molecule;

(b) forming a conjugate of the compound and the analyte molecule; and

(c) detecting the conjugate by its visible properties.

69. A composition comprising the compound of any one of claims 48-61 and one or more analyte molecules.

70. Use of the composition of claim 69 in an analytical method for detection of the one or more analyte molecules.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/044233

A. CLASSIFICATION OF SUBJECT MATTER
INV. C09B69/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/063186 A1 (BENSON SCOTT C [US] ET AL) 23 March 2006 (2006-03-23) figure 1; compounds 3a,3b figure 3; compound 7 figure 6; compounds 13,14a,14b ----- -/--	1,2, 8-11,21, 22,24, 26-28, 42,44, 45,48, 49,51, 53,55, 57,58, 62-64, 67-70

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 September 2017	06/10/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ketterer, Michael

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/044233

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WO 2015/109136 A2 (SONY CORP [JP]; SONY CORP AMERICA [US]) 23 July 2015 (2015-07-23) page 3, line 9 - page 5, line 14 page 26 - page 38, line 13 examples	1-70

X	GAO ET AL: "Modified DNA Analogues That Sense Light Exposure with Color Changes", JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, AMERICAN CHEMICAL SOCIETY, US, vol. 126, no. 40, 13 October 2004 (2004-10-13), pages 12748-12749, XP008152442, ISSN: 0002-7863, DOI: 10.1021/JA0469100 [retrieved on 2004-09-18] page 12748; figure 1	1,2, 8-11, 21-24, 26-28, 41,42, 44,45, 48-51, 53,55, 57,58, 62-64, 67-70

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/044233

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	CHI-KIN KOO ET AL: "Fluorescent DNA chemosensors: identification of bacterial species by their volatile metabolites", CHEMICAL COMMUNICATIONS, vol. 47, no. 41, 1 January 2011 (2011-01-01), page 11435, XP055174888, ISSN: 1359-7345, DOI: 10.1039/c1cc14871k figure 1	1,60, 67-70

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Information on patent family members

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