WHAT IS CLAIMED IS:

1. A method for detecting an abasic site, the method comprising:

flowing a solution over a substrate having a plurality of oligonucleotides coupled thereto,

at least one of the oligonucleotides comprising an abasic site,

the solution comprising a fluorophore coupled to a reactive group;

reacting the reactive group with the abasic site to couple the fluorophore to the abasic site; and

detecting the abasic site using fluorescence from the fluorophore.

2. The method of claim 1, wherein:

(i) the abasic site is generated by damage to the oligonucleotide; and/or

(ii) nucleotide bases adjacent to the abasic site inhibit non-radiative energy dissipation from the respective fluorophore coupled to the abasic site.

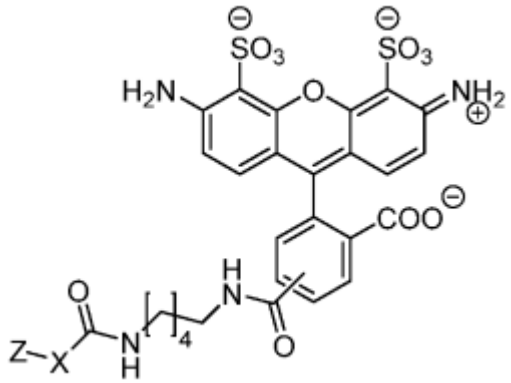
3. The method of claim 1 or claim 2, wherein the fluorophore comprises a molecular rotor dye comprising π-conjugated components separated by a rotatable C-C bond;

optionally wherein:

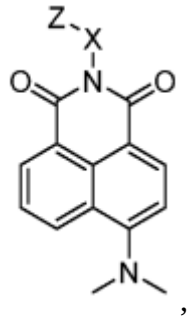
(i) nucleotide bases adjacent to the abasic site restrict rotation of the C-C bond and align the π-conjugated components with one another; and/or

(ii) the molecular rotor dye coupled to the reactive group is selected from the group consisting of 9-(2-carboxy-2-cyanovinyl)-julolidine (CCVJ1), (Z)-4-(3,5-difluoro-4-hydroxybenzylidene)-1,2-dimethyl-1-H-imidazol-5(4H)-one (DFHBI), and 1-methyl-4-[(3-methyl-2(3*H*)-benzothiazolylidene)methyl]quidolimium (thiazole orange).

4. The method of claim 1 or claim 2, wherein the fluorophore coupled to the reactive group is selected from the group consisting of:



and



,

where X is a linker and Z is the reactive group.

5. The method of any one of claims 1 to 4, wherein:

(i) the abasic site comprises an aldehyde; and/or

(ii) the reactive group comprises a hydroxylamine group or a hydrazine group; and/or

(iii) reacting the reactive group with the abasic site forms an oxime linkage.

6. A composition comprising:

a substrate having a plurality of oligonucleotides coupled thereto,

at least one of the oligonucleotides comprising an abasic site; and

a fluorophore coupled to the abasic site, the abasic site being detectable using fluorescence from the fluorophore.

7. The composition of claim 6, wherein:

(i) the abasic site is generated by damage to the oligonucleotide; and/or

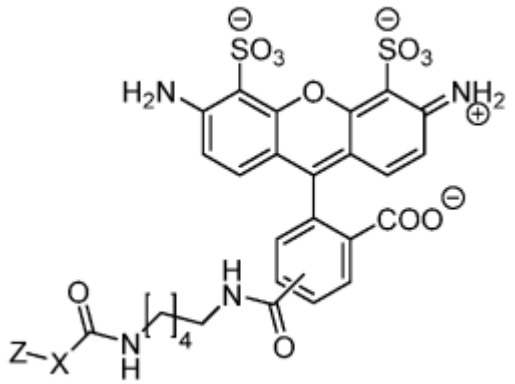
(ii) nucleotide bases adjacent to the abasic site inhibit non-radiative energy dissipation from the respective fluorophore coupled to the abasic site.

8. The composition of any claim 6 or claim 7, wherein the fluorophore comprises a molecular rotor dye comprising π-conjugated components separated by a rotatable C-C bond; optionally wherein:

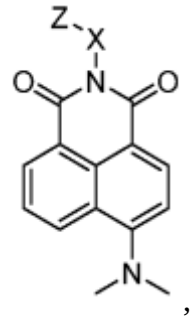
(i) nucleotide bases adjacent to the abasic site restrict rotation of the C-C bond and align the π-conjugated components with one another; and/or

(ii) the molecular rotor dye coupled to the reactive group is selected from the group consisting of 9-(2-carboxy-2-cyanovinyl)-julolidine (CCVJ1), (Z)-4-(3,5-difluoro-4-hydroxybenzylidene)-1,2-dimethyl-1-H-imidazol-5(4H)-one (DFHBI), and 1-methyl-4-[(3-methyl-2(3*H*)-benzothiazolylidene)methyl]quidolimium (thiazole orange).

9. The composition of claim 6 or claim 7, wherein the fluorophore coupled to the reactive group is selected from the group consisting of:



and



,

where X is a linker and Z is the reactive group.

10. The composition of any one of claims 7 to 9, wherein:

(i) the abasic site comprises an aldehyde; and/or

(ii) the reactive group comprises a hydroxylamine group or a hydrazine group; and/or

(iii) reacting the reactive group with the abasic site forms an oxime linkage.

11. A method, comprising:

preparing a solution comprising (i) glycosylases, (ii) oligonucleotides, and (iii) fluorophores coupled to reactive groups;

generating, using the glycosylases, abasic sites in the oligonucleotides in the solution;

reacting the reactive groups with the abasic sites to couple the fluorophores to the abasic sites;

measuring activity of the glycosylases using fluorescence from the fluorophores coupled to the abasic sites; and

using the glycosylases in a sequencing-by-synthesis operation.

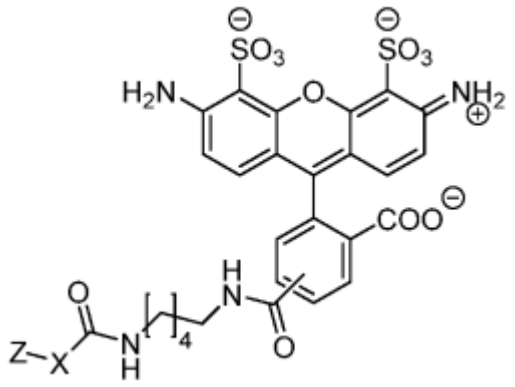
12. The method of claim 11, wherein nucleotide bases adjacent to the abasic site inhibit non-radiative energy dissipation from the respective fluorophore coupled to the abasic site.

13. The method of claim 11 or claim 12, wherein the fluorophore comprises a molecular rotor dye comprising π-conjugated components separated by a rotatable C-C bond; optionally wherein:

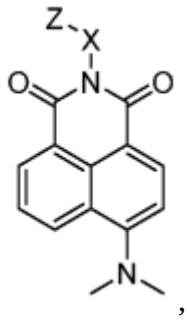
(i) nucleotide bases adjacent to the abasic site restrict rotation of the C-C bond and align the π-conjugated components with one another; and/or

(ii) the molecular rotor dye coupled to the reactive group is selected from the group consisting of 9-(2-carboxy-2-cyanovinyl)-julolidine (CCVJ1), (Z)-4-(3,5-difluoro-4-hydroxybenzylidene)-1,2-dimethyl-1-H-imidazol-5(4H)-one (DFHBI), and 1-methyl-4-[(3-methyl-2(3*H*)-benzothiazolylidene)methyl]quidolimium (thiazole orange).

14. The method of claim 11 or claim 12, wherein the fluorophore coupled to the reactive group is selected from the group consisting of:



and



,

where X is a linker and Z is the reactive group.

15. The method of any one of claims 11 to 14, wherein:

(i) the abasic site comprises an aldehyde; and/or

(ii) the reactive group comprises a hydroxylamine group or a hydrazine group; and/or

(iii) reacting the reactive group with the abasic site forms an oxime linkage.

16. A solution for measuring glycosylase activity, the solution comprising:

(i) glycosylases, (ii) oligonucleotides, and (iii) fluorophores coupled to reactive groups,

the oligonucleotides comprising abasic sites generated by the glycosylases in the solution,

the fluorophores being coupled to the abasic sites, and

the abasic sites being detectable using fluorescence from the fluorophores.

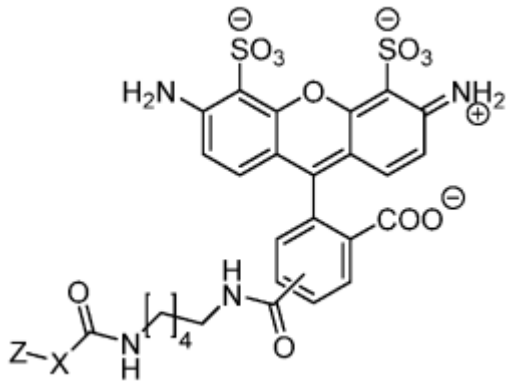
17. The solution of claim 16, wherein nucleotide bases adjacent to the abasic site inhibit non-radiative energy dissipation from the respective fluorophore coupled to the abasic site.

18. The solution of claim 16 or claim 17, wherein the fluorophore comprises a molecular rotor dye comprising π-conjugated components separated by a rotatable C-C bond; optionally wherein:

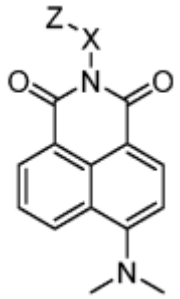
(i) nucleotide bases adjacent to the abasic site restrict rotation of the C-C bond and align the π-conjugated components with one another; and/or

(ii) the molecular rotor dye coupled to the reactive group is selected from the group consisting of 9-(2-carboxy-2-cyanovinyl)-julolidine (CCVJ1), (Z)-4-(3,5-difluoro-4-hydroxybenzylidene)-1,2-dimethyl-1-H-imidazol-5(4H)-one (DFHBI), and 1-methyl-4-[(3-methyl-2(3*H*)-benzothiazolylidene)methyl]quidolimium (thiazole orange).

19. The solution of claim 16 or claim 17, wherein the fluorophore coupled to the reactive group is selected from the group consisting of:



and



,

where X is a linker and Z is the reactive group.

20. The solution of any one of claims 16 to 19, wherein:

(i) the abasic site comprises an aldehyde; and/or

(ii) the reactive group comprises a hydroxylamine groupor a hydrazine group; and/or

(iii) reacting the reactive group with the abasic site forms an oxime linkage.