

SPECIFIC SITES FOR MODIFYING ANTIBODIES TO MAKE IMMUNOCONJUGATES

FIELD OF THE INVENTION

Due to the importance of antibodies for various therapeutic applications, there is a need for robust methods to selectively modify antibodies to introduce improved properties or additional functions. The application discloses specific sites for attaching moieties to antibodies for making modified antibodies, such as for use in preparation of antibody-drug conjugates (ADCs). The selective conjugation sites are located on constant regions of the antibody and thus are useful with various antibodies.

BACKGROUND

The value of methods for modifying antibodies is well known, and many methods for conjugation of antibodies to attach various “payload” moieties have been developed. Many of these methods rely upon the natural occurrence of specific reactive amino acid residues on the antibody, such as lysine and cysteine, which can be used to attach a payload. However, relying on the native amino acids is not always desirable, because the location and amount of payload attached depend on the number and position of those reactive amino acids: too many or too few such residues make it difficult to efficiently control loading of the payload onto the antibody. In addition, placement of the reactive amino acids may make it difficult to get complete conjugation, resulting in heterogeneous products during conjugation. Heterogeneity of a pharmaceutical active ingredient, for example, is typically undesirable because it compounds the unpredictability of administering a drug to a heterogeneous population of subjects: it is far preferable to administer a homogeneous product, and far more difficult to fully characterize and predict behavior of a heterogeneous one. Site-specific conjugation of a cytotoxic drug to an antibody through, for example, engineered cysteine residues results in homogenous immunoconjugates that exhibit improved therapeutic index (Junutula *et al.*, (2008) Nat Biotechnol. 26(8):925-932)).

Antibodies have been engineered to add certain residues like cysteine in specific positions where these residues can be used for conjugation (Lyons *et al.*, (1990) Protein Eng., 3:703-708), but the value of specific substitutions can vary with certain antibodies, as engineered cysteine might interfere with folding of the antibody and oxidation of the proper intra-molecular disulfide bonds (Voynov *et al.*, (2010) Bioconjug. Chem. 21(2):385-392).

Because engineered cysteines in antibodies expressed in mammalian cells are modified through disulfide bonds with glutathione (GSH) and/or cysteine during their biosynthesis (Chen *et al.* (2009) *mAbs* 1:6, 563-571), the modified cysteine(s) in the antibody drug conjugate product as initially

expressed is unreactive to thiol reactive reagents. Activation of the engineered cysteine(s) requires reduction of the GSH and/or cysteine adduct (which typically results in reduction of all inter-chain disulfide bonds of the antibody), followed by reoxidation and reformation of the native, inter-chain disulfide bonds prior to conjugation (Junutula *et al.*, (2008) Nat. Biotechnol. 26(8):925-32). Some of the sites where cysteine has been inserted interfere with the process of reoxidation and subsequently result in undesirable, non-homogeneous conjugation products. It is therefore important to identify sites on the antibody where the introduced cysteine does not interfere with the reoxidation process prior to the conjugation with a thiol reactive reagent such as maleimide or bromo-, chloro- or iodo-acetamide groups.

Conjugation of cysteine residues with bromo-acetamide, iodo-acetamide or chloro-acetamide results in the formation of a stable thioether linkage. (Alley *et al.*, (2008) Bioconjug Chem. 19(3):759-65). However, the chemistry is less efficient than maleimide conjugation chemistry. Since forming such thiol-maleimide linkages is a popular and highly efficient method to use when attaching a payload or linker to cysteine, there is a need to identify cysteine substitution sites on an antibody where maleimide linkages can be used. More importantly, site-specifically conjugated immunoconjugates can exhibit improved therapeutic index, thus there remains a need to identify specific privileged sites for cysteine substitution in antibodies that enables conjugation of payloads onto antibodies to form efficiently, and that provide conjugates having high stability. The instant application provides such privileged cysteine substitution sites that give improved antibodies for conjugation purposes and immunoconjugates comprising such improved antibodies.

SUMMARY OF THE INVENTION

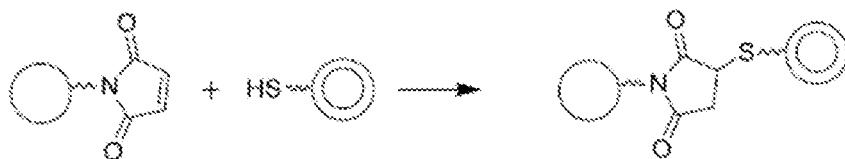
The application provides specific sites in the constant region of an antibody or antibody fragment at which cysteine ("Cys") replacement of the native amino acid on a parental antibody or antibody fragment can be performed in order to provide a Cys residue for attachment of a chemical moiety (e.g., payload/drug moiety) to form an immunoconjugate with good efficiency and stability. The application further provides engineered antibodies or antibody fragments having one or more Cys residues in one or more of these specific sites, as well as immunoconjugates made from such engineered antibodies or antibody fragments.

Methods for inserting Cys at specific locations of an antibody are known in the art, see, *e.g.*, WO 2011/005481. However, the current application discloses specific sites in the constant region of antibodies or antibody fragments where replacing one or more native amino acids of a parental antibody or antibody fragment with Cys provides one or more of the following advantages: Good reactivity to promote efficient immunoconjugation; reduced propensity for loss of payload when a Cys-maleimide

conjugation linker is used; a reduced tendency to form undesired disulfide linkages, such as cross-linking between antibodies or the formation of non-native intramolecular disulfide bonds; and low hydrophobicity of the resulting ADC.

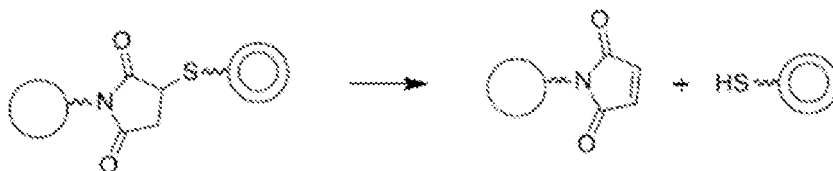
The specific privileged sites for Cys replacement of native amino acids in the constant region of a parental antibody or antibody fragment are selected to provide efficient conjugation while minimizing undesired effects. First, the specific sites for modification are selected so that replacing the native amino acid of a parental antibody or antibody fragment with Cys in one or more of the selected locations provides antibodies or antibody fragments that are readily conjugated on the new cysteine. The specific locations are selected to be sufficiently surface-accessible to allow the sulfhydryl of the cysteine residue to be reactive towards electrophiles in aqueous solutions. The identification of suitable sites for Cys replacement of native amino acids of a parental antibody or antibody fragment involved analyzing surface exposure of the native amino acids based on crystal structure data. Because the sites described herein are sufficiently accessible and reactive, they can be used to form immunoconjugates via chemistry that is well known in the art for modifying naturally-occurring cysteine residues. Conjugation of the replacement Cys residues thus uses conventional methods.

Selected modification sites can show a low propensity for reversal of conjugation when thiol-maleimide moieties are used in the conjugation. The thiol-maleimide conjugation reaction is often highly selective and extremely efficient, and may be used either to attach a payload to the thiol of a cysteine residue of a protein or as a linker elsewhere in the linkage between protein and payload. For example, a maleimide can be attached to a protein (*e.g.*, an antibody or antibody fragment), and a payload having an attached thiol can be added to the maleimide to form a conjugate:



Accordingly, in this conjugation step, the protein (*e.g.*, an antibody or antibody fragment) could be either the single circle or the double circle; the other would represent the payload. The immunoconjugate stability information here specifically relates to conjugation of the substituted cysteine by reaction with a maleimide group. In some embodiments, the thiol is from a cysteine on the protein (*e.g.*, an antibody or antibody fragment), so the double circle represents the protein and the single circle represents a payload.

While the thiol-maleimide reaction is often used for making conjugates, reversal of the conjugation step as depicted below can result in loss of payload or scrambling of payload with other thiol-containing species:



It has been reported that some sites for cysteine substitution provide more stable maleimide conjugates than others, presumably because the local chemical environment at certain points on the antibody surface around a new cysteine can promote the hydrolysis of the succinimide ring and hence prevent reversal of the thiol-maleimide linkage in the immunoconjugate (Shen *et al.* (2012), Nat. Biotechnol. 30(2):184-9). The identification of the advantageous sites for meeting this criterion involved inserting Cys in place of many of the native amino acids having suitable surface exposure, making immunoconjugates containing a thiol-maleimide linkage, and assessing stability of the immunoconjugate in order to eliminate sites where the stability of the conjugate was reduced by the local microenvironment around destabilizing sites. Because of this, the chemistry that can be used to attach linkers and payloads to the replacement Cys residues is not limited by the stability problems associated with the reversibility of thiol-maleimide conjugates that is discussed above. A number of methods can be used to form conjugates at cysteine, including maleimide conjugation. The sites for cysteine substitution described herein promote stability of the antibody conjugate product when using one of the most common conjugation methods, making these sites advantageous for antibody engineering, because the modified antibody can be used with the well-known and highly efficient maleimide conjugation methodology.

Selected sites can be positioned so as to minimize undesired disulfide formation that may interfere with formation of a homogeneous conjugate. When antibodies or antibody fragments containing engineered cysteines are produced in mammalian cells, the Cys residues are typically present as disulfides to a free Cys amino acid or to glutathione (Chen *et al.*, (2009) mAbs 16, 353-571). To free the Cys residues for conjugation with thiol reactive groups, the antibody or antibody fragment needs to be reduced, breaking all of the disulfide bonds. The antibody or antibody fragment is then reoxidized under conditions that facilitate formation of the native disulfides that stabilize the antibody or antibody fragment. Upon reoxidation, cysteine residues that are too prominently exposed on the surface of the antibody or antibody fragment can form disulfides by reaction with Cys on another antibody or antibody fragment ("inter-antibody disulfides"), or by forming undesired intra-antibody disulfides. It has been

found that cysteine residues placed in the specific sites described herein are suitably accessible to be available for efficient conjugation, but are sufficiently shielded or suitably positioned to reduce or eliminate formation of inter-antibody and intra-antibody disulfide bonds that would otherwise occur during the reduction / reoxidation procedures typically needed when expressing cys-modified antibodies.

5 Similarly, after re-oxidation some sites were found to produce non-homogenous conjugation products that appear to be due to the location of the new Cys residue engineered into the protein, and the specific sites identified herein are ones where such heterogeneity is minimized.

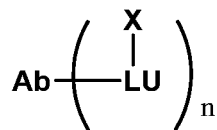
Conjugating drug payloads at sites where they are sequestered from solvent interactions and attachment can increase the hydrophobicity of the antibody upon payload attachment is preferred as
10 reducing hydrophobicity of a protein therapeutic is generally considered beneficial because it might reduce aggregation and clearance from circulation. Selecting attachment sites that result in minimal changes in hydrophobicity might be particularly beneficial when 4, 6 or 8 payloads are attached per antibody, or when particularly hydrophobic payloads are used.

Sites for Cys incorporation were evaluated using these and additional methods described in the
15 Examples herein, leading to the selection of preferred sites for Cys incorporation for engineering antibodies or antibody fragments to introduce Cys as a site for conjugation, especially for making ADCs. Additional details regarding the selection of the specific sites for replacing a natural amino acid of an antibody with Cys are provided herein.

Cysteine substitution sites are located in the constant region of an antibody or antibody fragment,
20 and are identified herein using standard numbering conventions. It is well known, however, that portions or fragments of antibodies can be used for many purposes instead of intact full-length antibodies, and also that antibodies can be modified in various ways that affect numbering of sites in the constant region even though they do not substantially affect the functioning of the constant region. For example, insertion of an S6 tag (a short peptide) into a loop region of an antibody has been shown to allow activity of the
25 antibody to be retained, even though it would change the numbering of many sites in the antibody. Accordingly, while the preferred cysteine substitution sites described herein are identified by a standard numbering system based on intact antibody numbering, the application includes the corresponding sites in antibody fragments or in antibodies containing other modifications, such as peptide tag insertion. The corresponding sites in those fragments or modified antibodies are thus preferred sites for cysteine
30 substitution in fragments or modified antibodies, and references to the cysteine substitution sites by number include corresponding sites in modified antibodies or antibody fragments that retain the function of the relevant portion of the full-length antibody.

A corresponding site in an antibody fragment or modified antibody can readily be identified by aligning a segment of the antibody fragment or modified antibody with the full-length antibody to identify the site in the antibody fragment or modified antibody that matches one of the preferred cysteine substitution sites of the invention. Alignment may be based on a segment long enough to ensure that the segment matches the correct portion of the full-length antibody, such as a segment of at least 20 amino acid residues, or at least 50 residues, or at least 100 residues, or at least 150 residues. Alignment may also take into account other modifications that may have been engineered into the antibody fragment or modified antibody, thus differences in sequence due to engineered point mutations in the segment used for alignment, particularly for conservative substitutions, would be allowed. Thus, for example, an Fc domain can be excised from an antibody, and would contain amino acid residues that correspond to the cysteine substitution sites described herein, despite numbering differences: sites in the Fc domain corresponding to the cysteine substitution sites of the present disclosure would also be expected to be advantageous sites for cysteine substitution in the Fc domain, and are included in the scope of this application.

In one embodiment, the application provides an immunoconjugate of Formula (I):



wherein Ab represents an antibody or antibody fragment comprising at least one cysteine residue at one of the preferred cysteine substitution sites described herein;

LU is a linker unit as described herein;

X is a payload or drug moiety;

and n is an integer from 1 to 16.

Typically in compounds of Formula (I), LU is attached to a cysteine at one of the cysteine substitution sites described herein, X is a drug moiety such as an anticancer drug, and n is 2-8 when Ab is an antibody, or n can be 1-8 when Ab is an antibody fragment.

In an embodiment, the application provides an immunoconjugate comprising a modified antibody or antibody fragment thereof and a drug moiety, wherein said modified antibody or antibody fragment comprises a substitution of one or more amino acids with cysteine on its constant region chosen from

positions 121, 124, 152, 171, 174, 258, 292, 333, 360, and 375 of a heavy chain of said antibody or antibody fragment, and wherein said positions are numbered according to the EU system.

5 In an embodiment, the application provides an immunoconjugate comprising a modified antibody or antibody fragment thereof and a drug moiety, wherein said modified antibody or antibody fragment comprises a substitution of one or more amino acids with cysteine on its constant region chosen from positions 107, 108, 142, 145, 159, 161, and 165 of a light chain of said antibody or antibody fragment, wherein said positions are numbered according to the EU system, and wherein said light chain is human kappa light chain.

10 In an embodiment, the application provides an immunoconjugate comprising a modified antibody or antibody fragment thereof and a drug moiety, wherein said modified antibody or antibody fragment comprises a substitution of one or more amino acids with cysteine on its constant region chosen from positions 143, 147, 159, 163, and 168 of a light chain of said antibody or antibody fragment, wherein said positions are numbered according to the Kabat system, and wherein said light chain is human lambda light chain.

15 In an embodiment, the application provides a modified antibody or antibody fragment thereof comprising a substitution of one or more amino acids with cysteine at the positions described herein. The sites for cysteine substitution are in the constant regions of the antibody and are thus applicable to a variety of antibodies, and the sites are selected to provide stable and homogeneous conjugates. The modified antibody or fragment can have two or more cysteine substitutions, and these substitutions can
20 be used in combination with other antibody modification and conjugation methods as described herein.

In an embodiment, the application provides pharmaceutical compositions comprising the immunoconjugate disclosed above, and methods to use the immunoconjugates.

In an embodiment, the application provides a nucleic acid encoding the modified antibody or antibody fragment described herein having at least one cysteine substitution at a site described herein.
25 The application further provides host cells comprising these nucleic acids and methods to use the nucleic acid or host cells to express and produce the antibodies or fragments described herein.

In an embodiment, the application provides a method to select an amino acid of an antibody that is suitable for replacement by cysteine to provide a good site for conjugation, comprising:

(1) identifying amino acids in the constant region of the antibody that have a suitable surface exposure to provide a set of initial candidate sites;

(2) for each initial candidate site, expressing an antibody wherein the native amino acid at that site is replaced by cysteine;

5 (3) for each expressed antibody, determining whether the expressed protein is substantially homogeneous after reduction and reoxidation to provide an antibody having a free cysteine at the initial candidate site,

(4) for each expressed protein that is substantially homogeneous and functional, conjugating the cysteine at the initial candidate site with a maleimide moiety and determining whether the thiol-
10 maleimide linkage is stable at that site;

(5) removing from the set of initial candidate sites those sites for which the expressed antibody is not substantially homogeneous and functional, and those wherein the thiol-maleimide linkage is destabilized, to provide a set of advantaged sites for cysteine substitution.

Optionally, the method further comprises a step of determining the melting temperature for the
15 conjugate of each advantaged cysteine substitution site, and eliminating from the set any sites where cysteine substitution and conjugation causes the melting temperature to differ by 5°C or more from that of the native antibody.

In an embodiment, the application provides a method to produce an immunoconjugate, which comprises attaching a Linker Unit (LU) or a Linker Unit-Payload combination (-LU-X) to a cysteine
20 residue in an antibody or antibody fragment, wherein the cysteine is located at a cysteine substitution site selected from 121, 124, 152, 171, 174, 258, 292, 333, 360, and 375 of a heavy chain of said antibody or antibody fragment, and positions 107, 108, 142, 145, 159, 161, and 165 of a light chain of said antibody or antibody fragment, wherein said positions are numbered according to the EU system.

Other aspects and embodiments of the application are described in greater detail herein.

25 The following are embodiments of the present application.

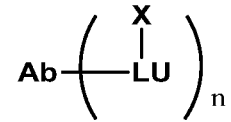
1. An immunoconjugate comprising a modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more

amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from position 360 of an antibody heavy chain, and position 107 of an antibody kappa light chain, wherein said positions are numbered according to the EU system.

- 5 2. An immunoconjugate comprising a modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from positions 152 and 375 of an antibody heavy chain, wherein said positions are numbered according to the EU system.
- 10 3. An immunoconjugate comprising a modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 48 and a kappa light chain constant region comprising SEQ ID NO: 61.
4. An immunoconjugate comprising a modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 131.
- 15 5. The immunoconjugates of any of embodiments 1-4 wherein the immunoconjugate further comprises a drug moiety.
6. The immunoconjugates of any of embodiments 1-5 wherein the drug antibody ratio is about 4.
7. The immunoconjugate of any of embodiments 1-6, wherein said drug moiety is attached to the modified antibody or antibody fragment through the sulfur of said cysteine and an optional linker.
- 20 8. The immunoconjugate of embodiments 1-7, wherein said drug moiety is connected to said sulfur of said cysteine through a cleavable or non-cleavable linker.
9. The immunoconjugate of embodiments 8, wherein said drug moiety is connected to said sulfur of said cysteine through a non-cleavable linker.
10. The immunoconjugate of embodiments 7-9, wherein said immunoconjugate comprises a thiol-maleimide linkage.
- 25 11. The immunoconjugate of embodiment 10, wherein said immunoconjugate comprises a $-S-CH_2-C(=O)-$ linkage or a disulfide linkage.

12. The immunoconjugate of embodiment 11, wherein said drug moiety is a cytotoxic agent.
13. The immunoconjugate of embodiment 12, wherein said drug moiety is selected from the group consisting of taxanes, DNA-alkylating agents (e.g., CC-1065 analogs), anthracyclines, tubulysin analogs, duocarmycin analogs, auristatin E, auristatin F, maytansinoids and Eg5 inhibitors .
- 5 14. The immunoconjugate of any of embodiments 1-13, wherein said antibody is a monoclonal antibody.
15. The immunoconjugate of any of embodiments 1-13, wherein said antibody is a chimeric antibody.
16. The immunoconjugate of embodiments 1-13, wherein said antibody is a humanized or fully human antibody.
- 10 17. The immunoconjugate of any of embodiments 14-16, wherein said antibody is a bispecific or multi-specific antibody.
18. The immunoconjugate of any of embodiments 1-17, wherein said antibody or antibody fragment specifically binds to a cell surface marker on a tumor.
19. A pharmaceutical composition comprising the immunoconjugate of any of embodiments 1-18.
- 15 20. The modified antibody or antibody fragment of any of embodiments 1-19, further comprising at least one Pcl or unnatural amino acid substitution or a peptide tag for enzyme-mediated conjugation and/or combinations thereof.
21. A nucleic acid encoding the modified antibody or antibody fragment of embodiments 1-4.
- 20 22. A host cell comprising the nucleic acid of embodiment 21.
23. A method of producing a modified antibody or antibody fragment comprising incubating the host cell of embodiment 22 under suitable conditions for expressing the antibody or antibody fragment, and isolating said antibody or antibody fragment.
24. A method to produce an immunoconjugate, which comprises attaching a Linker Unit (LU) or a Linker Unit-Payload combination (-LU-X) to a cysteine residue in an antibody or antibody fragment of any of embodiments 1-4
- 25

25. The method of embodiment 24, wherein the immunoconjugate is of Formula (I):



wherein Ab represents an antibody or antibody fragment comprising at least one cysteine residue at one of the preferred cysteine substitution sites described herein;

LU is a linker unit as described herein;

X is a payload or drug moiety;

and n is an integer from 1 to 16.

26. A modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from position 360 of an antibody heavy chain, and position 107 of an antibody kappa light chain, wherein said positions are numbered according to the EU system.

27. A modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from positions 152 and 375 of an antibody heavy chain, wherein said positions are numbered according to the EU system.

28. A modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 48 and a kappa light chain constant region comprising SEQ ID NO: 61.

29. A modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 131.

Definitions

The term “amino acid” refers to canonical, synthetic, and unnatural amino acids, as well as amino acid analogs and amino acid mimetics that function in a manner similar to the canonical amino acids. Canonical amino acids are proteinogenous amino acids encoded by the genetic code and include alanine,

arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline serine, threonine, tryptophan, tyrosine, valine, as well as selenocysteine, pyrrolysine and its analog pyrroline-carboxy-lysine. Amino acid analogs refer to compounds that have the same basic chemical structure as a canonical amino acid, *i.e.*, an α -carbon that is bound to a hydrogen, a carboxyl group, an amino group, and an R group, *e.g.*, citrulline, homoserine, norleucine, methionine sulfoxide, methionine methyl sulfonium. Such analogs have modified R groups (*e.g.*, norleucine) or modified peptide backbones, but retain the same basic chemical structure as a canonical amino acid.

Amino acid mimetics refer to chemical compounds that have a structure that is different from the general chemical structure of an amino acid, but that function in a manner similar to a canonical amino acid. The term "unnatural amino acid", as used herein, is intended to represent amino acid structures that cannot be generated biosynthetically in any organism using unmodified or modified genes from any organism, whether the same or different. In addition, such "unnatural amino acids" typically require a modified tRNA and a modified tRNA synthetase (RS) for incorporation into a protein. This tRNA/RS pair preferentially incorporates the unnatural amino acid over canonical amino acids. Such orthogonal tRNA/RS pair is generated by a selection process as developed by Schultz *et al.* (see, *e.g.*, Liu *et al.*, (2010) *Annu. Rev. Biochem.* 79:413-444) or a similar procedure. The term "unnatural amino acid" does not include the natural occurring 22nd proteinogenic amino acid pyrrolysine (Pyl) as well as its demethylated analog pyrroline-carboxy-lysine (Pcl), because incorporation of both residues into proteins is mediated by the unmodified, naturally occurring pyrrolysyl-tRNA/tRNA synthetase pair and because Pyl and Pcl are generated biosynthetically (see, *e.g.*, Ou *et al.*, (2011) *Proc. Natl. Acad. Sci. USA*, 108:10437-10442; Cellitti *et al.*, (2011) *Nat. Chem. Biol.* 27;7(8):528-30). See also U.S. provisional application 61/76236, incorporated by reference, that sites specific amino acid residues in antibody light and heavy chains that can be substituted with Pcl.

The term "antibody" as used herein refers to a polypeptide of the immunoglobulin family that is capable of binding a corresponding antigen non-covalently, reversibly, and in a specific manner. For example, a naturally occurring IgG antibody is a tetramer comprising at least two heavy (H) chains (also referred to as "antibody heavy chain") and two light (L) chains (also referred to as "antibody light chain") inter-connected by disulfide bonds. Each heavy chain is comprised of a heavy chain variable region (abbreviated herein as V_H) and a heavy chain constant region. The heavy chain constant region is comprised of three domains, CH1, CH2 and CH3. Each light chain is comprised of a light chain variable region (abbreviated herein as V_L) and a light chain constant region. The light chain constant region is

comprised of one domain, C_L. The V_H and V_L regions can be further subdivided into regions of hyper variability, termed complementarity determining regions (CDR), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is composed of three CDRs and four FRs arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, and FR4. The variable regions of the heavy and light chains contain a binding domain that interacts with an antigen. The constant regions of the antibodies may mediate the binding of the immunoglobulin to host tissues or factors, including various cells of the immune system (*e.g.*, effector cells) and the first component (C1q) of the classical complement system.

The term “antibody” includes, but is not limited to, monoclonal antibodies, human antibodies, humanized antibodies, camelid antibodies, chimeric antibodies, and anti-idiotypic (anti-Id) antibodies (including, *e.g.*, anti-Id antibodies to antibodies of the present disclosure). The antibodies can be of any isotype/class (*e.g.*, IgG, IgE, IgM, IgD, IgA and IgY), or subclass (*e.g.*, IgG1, IgG2, IgG3, IgG4, IgA1 and IgA2).

Both the light and heavy chains are divided into regions of structural and functional homology. The terms “constant” and “variable” are used functionally. In this regard, it will be appreciated that the variable domains of both the light (V_L) and heavy (V_H) chain portions determine antigen recognition and specificity. Conversely, the constant domains of the light chain (C_L) and the heavy chain (CH1, CH2 or CH3) confer important biological properties such as secretion, transplacental mobility, Fc receptor binding, complement binding, and the like. By convention, the numbering of the constant region domains increases as they become more distal from the antigen binding site or amino-terminus of the antibody. The N-terminus is a variable region and at the C-terminus is a constant region; the CH3 and C_L domains actually comprise the carboxy-terminal domains of the heavy and light chain, respectively.

The term “antibody fragment” as used herein refers to either an antigen binding fragment of an antibody or a non-antigen binding fragment (*e.g.*, Fc) of an antibody. The term “antigen binding fragment”, as used herein, refers to one or more portions of an antibody that retain the ability to specifically interact with (*e.g.*, by binding, steric hindrance, stabilizing/destabilizing, spatial distribution) an epitope of an antigen. Examples of binding fragments include, but are not limited to, single-chain Fvs (scFv), disulfide-linked Fvs (sdFv), Fab fragments, F(ab') fragments, a monovalent fragment consisting of the V_L, V_H, C_L and CH1 domains; a F(ab)₂ fragment, a bivalent fragment comprising two Fab fragments linked by a disulfide bridge at the hinge region; a Fd fragment consisting of the V_H and CH1 domains; a Fv fragment consisting of the V_L and V_H domains of a single arm of an antibody; a dAb

fragment (Ward *et al.*, Nature 341:544-546, 1989), which consists of a V_H domain; and an isolated complementarity determining region (CDR), or other epitope-binding fragments of an antibody.

Furthermore, although the two domains of the Fv fragment, V_L and V_H, are coded for by separate genes, they can be joined, using recombinant methods, by a synthetic linker that enables them to be made as a single protein chain in which the V_L and V_H regions pair to form monovalent molecules (known as single chain Fv ("scFv"); see, *e.g.*, Bird *et al.*, *Science* 242:423-426, 1988; and Huston *et al.*, *Proc. Natl. Acad. Sci.* 85:5879-5883, 1988). Such single chain antibodies are also intended to be encompassed within the term "antigen binding fragment." These antigen binding fragments are obtained using conventional techniques known to those of skill in the art, and the fragments are screened for utility in the same manner as are intact antibodies.

Antigen binding fragments can also be incorporated into single domain antibodies, maxibodies, minibodies, nanobodies, intrabodies, diabodies, triabodies, tetrabodies, v-NAR and bis-scFv (see, *e.g.*, Hollinger and Hudson, *Nature Biotechnology* 23:1126-1136, 2005). Antigen binding fragments can be grafted into scaffolds based on polypeptides such as fibronectin type III (Fn3) (see U.S. Pat. No. 6,703,199, which describes fibronectin polypeptide monobodies).

Antigen binding fragments can be incorporated into single chain molecules comprising a pair of tandem Fv segments (V_H-CH1-V_H-CH1) which, together with complementary light chain polypeptides, form a pair of antigen binding regions (Zapata *et al.*, *Protein Eng.* 8:1057-1062, 1995; and U.S. Pat. No. 5,641,870).

The term "monoclonal antibody" or "monoclonal antibody composition" as used herein refers to polypeptides, including antibodies and antibody fragments that have substantially identical amino acid sequence or are derived from the same genetic source. This term also includes preparations of antibody molecules of single molecular composition. A monoclonal antibody composition displays a single binding specificity and affinity for a particular epitope.

The term "human antibody", as used herein, includes antibodies having variable regions in which both the framework and CDR regions are derived from sequences of human origin. Furthermore, if the antibody contains a constant region, the constant region also is derived from such human sequences, *e.g.*, human germline sequences, or mutated versions of human germline sequences or antibody containing consensus framework sequences derived from human framework sequences analysis, for example, as described in Knappik *et al.*, *J. Mol. Biol.* 296:57-86, 2000).

The human antibodies of the application may include amino acid residues not encoded by human sequences (*e.g.*, mutations introduced by random or site-specific mutagenesis *in vitro* or by somatic mutation *in vivo*, or a conservative substitution to promote stability or manufacturing).

The term “humanized” antibody, as used herein, refers to an antibody that retains the reactivity of a non-human antibody while being less immunogenic in humans. This can be achieved, for instance, by retaining the non-human CDR regions and replacing the remaining parts of the antibody with their human counterparts. See, *e.g.*, Morrison *et al.*, *Proc. Natl. Acad. Sci. USA*, 81:6851-6855 (1984); Morrison and Oi, *Adv. Immunol.*, 44:65-92 (1988); Verhoeven *et al.*, *Science*, 239:1534-1536 (1988); Padlan, *Molec. Immun.*, 28:489-498 (1991); Padlan, *Molec. Immun.*, 31(3):169-217 (1994).

The term “recognize” as used herein refers to an antibody or antigen binding fragment thereof that finds and interacts (*e.g.*, binds) with its epitope, whether that epitope is linear or conformational. The term “epitope” refers to a site on an antigen to which an antibody or antigen binding fragment of the present disclosure specifically binds. Epitopes can be formed both from contiguous amino acids or noncontiguous amino acids juxtaposed by tertiary folding of a protein. Epitopes formed from contiguous amino acids are typically retained on exposure to denaturing solvents, whereas epitopes formed by tertiary folding are typically lost on treatment with denaturing solvents. An epitope typically includes at least 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 amino acids in a unique spatial conformation. Methods of determining spatial conformation of epitopes include techniques in the art, for example, x-ray crystallography and 2-dimensional nuclear magnetic resonance (see, *e.g.*, Epitope Mapping Protocols in Methods in Molecular Biology, Vol. 66, G. E. Morris, Ed. (1996)).

The term “affinity” as used herein refers to the strength of interaction between antibody and antigen at single antigenic sites. Within each antigenic site, the variable region of the antibody “arm” interacts through weak non-covalent forces with antigen at numerous sites; the more interactions, the stronger the affinity.

The term “isolated antibody” refers to an antibody that is substantially free of other antibodies having different antigenic specificities. An isolated antibody that specifically binds to one antigen may, however, have cross-reactivity to other antigens. Moreover, an isolated antibody may be substantially free of other cellular material and/or chemicals.

The term “conservatively modified variant” applies to both amino acid and nucleic acid sequences. With respect to particular nucleic acid sequences, conservatively modified variants refers to those nucleic acids which encode identical or essentially identical amino acid sequences, or where the

nucleic acid does not encode an amino acid sequence, to essentially identical sequences. Because of the degeneracy of the genetic code, a large number of functionally identical nucleic acids encode any given protein. For instance, the codons GCA, GCC, GCG and GCU all encode the amino acid alanine. Thus, at every position where an alanine is specified by a codon, the codon can be altered to any of the
5 corresponding codons described without altering the encoded polypeptide. Such nucleic acid variations are "silent variations," which are one species of conservatively modified variations. Every nucleic acid sequence herein which encodes a polypeptide also describes every possible silent variation of the nucleic acid. One of skill will recognize that each codon in a nucleic acid (except AUG, which is ordinarily the only codon for methionine, and TGG, which is ordinarily the only codon for tryptophan) can be modified
10 to yield a functionally identical molecule. Accordingly, each silent variation of a nucleic acid that encodes a polypeptide is implicit in each described sequence.

For polypeptide sequences, "conservatively modified variants" include individual substitutions, deletions or additions to a polypeptide sequence which result in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino
15 acids are well known in the art. Such conservatively modified variants are in addition to and do not exclude polymorphic variants, interspecies homologs, and alleles of the present disclosure. The following eight groups contain amino acids that are conservative substitutions for one another: 1) Alanine (A), Glycine (G); 2) Aspartic acid (D), Glutamic acid (E); 3) Asparagine (N), Glutamine (Q); 4) Arginine (R), Lysine (K); 5) Isoleucine (I), Leucine (L), Methionine (M), Valine (V); 6)
20 Phenylalanine (F), Tyrosine (Y), Tryptophan (W); 7) Serine (S), Threonine (T); and 8) Cysteine (C), Methionine (M) (see, *e.g.*, Creighton, Proteins (1984)). In some embodiments, the term "conservative sequence modifications" are used to refer to amino acid modifications that do not significantly affect or alter the binding characteristics of the antibody containing the amino acid sequence.

The term "optimized" as used herein refers to a nucleotide sequence has been altered to encode
25 an amino acid sequence using codons that are preferred in the production cell or organism, generally a eukaryotic cell, for example, a yeast cell, a *Pichia* cell, a fungal cell, a *Trichoderma* cell, a Chinese Hamster Ovary cell (CHO) or a human cell. The optimized nucleotide sequence is engineered to retain completely or as much as possible the amino acid sequence originally encoded by the starting nucleotide sequence, which is also known as the "parental" sequence.

30 The terms "percent identical" or "percent identity," in the context of two or more nucleic acids or polypeptide sequences, refers to two or more sequences or subsequences that are the same. Two sequences are "substantially identical" if two sequences have a specified percentage of amino acid

residues or nucleotides that are the same (*i.e.*, 60% identity, optionally 65%, 70%, 75%, 80%, 85%, 90%, 95%, or 99% identity over a specified region, or, when not specified, over the entire sequence), when compared and aligned for maximum correspondence over a comparison window, or designated region as measured using one of the following sequence comparison algorithms or by manual alignment and visual inspection. Optionally, the identity exists over a region that is at least about 30 nucleotides (or 10 amino acids) in length, or more preferably over a region that is 100 to 500 or 1000 or more nucleotides (or 20, 50, 200 or more amino acids) in length.

For sequence comparison, typically one sequence acts as a reference sequence, to which test sequences are compared. When using a sequence comparison algorithm, test and reference sequences are entered into a computer, subsequence coordinates are designated, if necessary, and sequence algorithm program parameters are designated. Default program parameters can be used, or alternative parameters can be designated. The sequence comparison algorithm then calculates the percent sequence identities for the test sequences relative to the reference sequence, based on the program parameters.

A “comparison window”, as used herein, includes reference to a segment of any one of the number of contiguous positions selected from the group consisting of from 20 to 600, usually about 50 to about 200, more usually about 100 to about 150 in which a sequence may be compared to a reference sequence of the same number of contiguous positions after the two sequences are optimally aligned. Methods of alignment of sequences for comparison are well known in the art. Optimal alignment of sequences for comparison can be conducted, *e.g.*, by the local homology algorithm of Smith and Waterman, *Adv. Appl. Math.* 2:482c (1970), by the homology alignment algorithm of Needleman and Wunsch, *J. Mol. Biol.* 48:443 (1970), by the search for similarity method of Pearson and Lipman, *Proc. Natl. Acad. Sci. USA* 85:2444 (1988), by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package, Genetics Computer Group, 575 Science Dr., Madison, WI), or by manual alignment and visual inspection (see, *e.g.*, Brent *et al.*, *Current Protocols in Molecular Biology*, 2003).

Two examples of algorithms that are suitable for determining percent sequence identity and sequence similarity are the BLAST and BLAST 2.0 algorithms, which are described in Altschul *et al.*, *Nuc. Acids Res.* 25:3389-3402, 1977; and Altschul *et al.*, *J. Mol. Biol.* 215:403-410, 1990, respectively. Software for performing BLAST analyses is publicly available through the National Center for Biotechnology Information. This algorithm involves first identifying high scoring sequence pairs (HSPs) by identifying short words of length W in the query sequence, which either match or satisfy some positive-valued threshold score T when aligned with a word of the same length in a database sequence. T

is referred to as the neighborhood word score threshold (Altschul *et al.*, *supra*). These initial neighborhood word hits act as seeds for initiating searches to find longer HSPs containing them. The word hits are extended in both directions along each sequence for as far as the cumulative alignment score can be increased. Cumulative scores are calculated using, for nucleotide sequences, the parameters M (reward score for a pair of matching residues; always > 0) and N (penalty score for mismatching residues; always < 0). For amino acid sequences, a scoring matrix is used to calculate the cumulative score. Extension of the word hits in each direction are halted when: The cumulative alignment score falls off by the quantity X from its maximum achieved value; the cumulative score goes to zero or below, due to the accumulation of one or more negative-scoring residue alignments; or the end of either sequence is reached. The BLAST algorithm parameters W, T, and X determine the sensitivity and speed of the alignment. The BLASTN program (for nucleotide sequences) uses as defaults a word length (W) of 11, an expectation (E) or 10, M=5, N=-4 and a comparison of both strands. For amino acid sequences, the BLASTP program uses as defaults a word length of 3, and expectation (E) of 10, and the BLOSUM62 scoring matrix (see Henikoff and Henikoff, (1989) Proc. Natl. Acad. Sci. USA 89:10915) alignments (B) of 50, expectation (E) of 10, M=5, N=-4, and a comparison of both strands.

The BLAST algorithm also performs a statistical analysis of the similarity between two sequences (see, *e.g.*, Karlin and Altschul, Proc. Natl. Acad. Sci. USA 90:5873-5787, 1993). One measure of similarity provided by the BLAST algorithm is the smallest sum probability (P(N)), which provides an indication of the probability by which a match between two nucleotide or amino acid sequences would occur by chance. For example, a nucleic acid is considered similar to a reference sequence if the smallest sum probability in a comparison of the test nucleic acid to the reference nucleic acid is less than about 0.2, more preferably less than about 0.01, and most preferably less than about 0.001.

The percent identity between two amino acid sequences can also be determined using the algorithm of E. Meyers and W. Miller, Comput. Appl. Biosci. 4:11-17, 1988) which has been incorporated into the ALIGN program (version 2.0), using a PAM120 weight residue table, a gap length penalty of 12 and a gap penalty of 4. In addition, the percent identity between two amino acid sequences can be determined using the Needleman and Wunsch, J. Mol. Biol. 48:444-453, 1970) algorithm which has been incorporated into the GAP program in the GCG software package (available at www.gcg.com), using either a Blossom 62 matrix or a PAM250 matrix, and a gap weight of 16, 14, 12, 10, 8, 6, or 4 and a length weight of 1, 2, 3, 4, 5, or 6.

Other than percentage of sequence identity noted above, another indication that two nucleic acid sequences or polypeptides are substantially identical is that the polypeptide encoded by the first nucleic

acid is immunologically cross reactive with the antibodies raised against the polypeptide encoded by the second nucleic acid, as described below. Thus, a polypeptide is typically substantially identical to a second polypeptide, for example, where the two peptides differ only by conservative substitutions. Another indication that two nucleic acid sequences are substantially identical is that the two molecules or
5 their complements hybridize to each other under stringent conditions, as described below. Yet another indication that two nucleic acid sequences are substantially identical is that the same primers can be used to amplify the sequence.

The term “nucleic acid” is used herein interchangeably with the term “polynucleotide” and refers to deoxyribonucleotides or ribonucleotides and polymers thereof in either single- or double-stranded
10 form. The term encompasses nucleic acids containing known nucleotide analogs or modified backbone residues or linkages, which are synthetic, naturally occurring, and non-naturally occurring, which have similar binding properties as the reference nucleic acid, and which are metabolized in a manner similar to the reference nucleotides. Examples of such analogs include, without limitation, phosphorothioates, phosphoramidates, methyl phosphonates, chiral-methyl phosphonates, 2-O-methyl ribonucleotides,
15 peptide-nucleic acids (PNAs).

Unless otherwise indicated, a particular nucleic acid sequence also implicitly encompasses silent variants thereof (*e.g.*, degenerate codon substitutions) and complementary sequences, as well as the sequence explicitly indicated. Specifically, as detailed below, degenerate codon substitutions may be achieved by generating sequences in which the third position of one or more selected (or all) codons is
20 substituted with mixed-base and/or deoxyinosine residues (Batzer *et al.*, (1991) Nucleic Acid Res. 19:5081; Ohtsuka *et al.*, (1985) J. Biol. Chem. 260:2605-2608; and Rossolini *et al.*, (1994) Mol. Cell. Probes 8:91-98).

The term “operably linked” in the context of nucleic acids refers to a functional relationship between two or more polynucleotide (*e.g.*, DNA) segments. Typically, it refers to the functional
25 relationship of a transcriptional regulatory sequence to a transcribed sequence. For example, a promoter or enhancer sequence is operably linked to a coding sequence if it stimulates or modulates the transcription of the coding sequence in an appropriate host cell or other expression system. Generally, promoter transcriptional regulatory sequences that are operably linked to a transcribed sequence are physically contiguous to the transcribed sequence, *i.e.*, they are *cis*-acting. However, some
30 transcriptional regulatory sequences, such as enhancers, need not be physically contiguous or located in close proximity to the coding sequences whose transcription they enhance.

The terms “polypeptide” and “protein” are used interchangeably herein to refer to a polymer of amino acid residues. The terms apply to canonical amino acid polymers as well as to non-canonical amino acid polymers. Unless otherwise indicated, a particular polypeptide sequence also implicitly encompasses conservatively modified variants thereof.

5 The term “immunoconjugate” or “antibody conjugate” as used herein refers to the linkage of an antibody or an antibody fragment thereof with another agent, such as a chemotherapeutic agent, a toxin, an immunotherapeutic agent, an imaging probe, a spectroscopic probe, and the like. The linkage can be through one or multiple covalent bonds, or non-covalent interactions, and can include chelation. Various linkers, many of which are known in the art, can be employed in order to form the immunoconjugate.

10 Additionally, the immunoconjugate can be provided in the form of a fusion protein that may be expressed from a polynucleotide encoding the immunoconjugate. As used herein, “fusion protein” refers to proteins created through the joining of two or more genes or gene fragments which originally coded for separate proteins (including peptides and polypeptides). Fusion proteins may be created by joining at the N- or C-terminus, or by insertions of genes or gene fragments into permissible regions of one of the partner

15 proteins. Translation of the fusion gene results in a single protein with functional properties derived from each of the original proteins.

 The term “subject” includes human and non-human animals. Non-human animals include all vertebrates, *e.g.*, mammals and non-mammals, such as non-human primates, sheep, dog, cow, chickens, amphibians, and reptiles. Except when noted, the terms “patient” or “subject” are used herein

20 interchangeably.

 The term “cytotoxin”, or “cytotoxic agent” as used herein, refer to any agent that is detrimental to the growth and proliferation of cells and may act to reduce, inhibit, or destroy a cell or malignancy.

 The term “anti-cancer agent” as used herein refers to any agent that can be used to treat a cell proliferative disorder such as cancer, including but not limited to, cytotoxic agents, chemotherapeutic agents, radiotherapy and radiotherapeutic agents, targeted anti-cancer agents, and immunotherapeutic agents.

25 agents.

 The term “drug moiety” or “payload” are used interchangeably and refers to a chemical moiety that is conjugated to the antibody or antibody fragment of the present disclosure, and can include any moiety that is useful to attach to an antibody or antibody fragment. For example, a drug moiety or

30 payload can be an anti-cancer agent, an anti-inflammatory agent, an antifungal agent, an antibacterial agent, an anti-parasitic agent, an anti-viral agent, an anesthetic agent. In certain embodiments a drug

moiety is selected from a V-ATPase inhibitor, a HSP90 inhibitor, an IAP inhibitor, an mTor inhibitor, a microtubule stabilizer, a microtubule destabilizers, an auristatin, a dolastatin, a maytansinoid, a MetAP (methionine aminopeptidase), an inhibitor of nuclear export of proteins CRM1, a DPPIV inhibitor, an inhibitor of phosphoryl transfer reactions in mitochondria, a protein synthesis inhibitor, a kinase inhibitor, a CDK2 inhibitor, a CDK9 inhibitor, a proteasome inhibitor, a kinesin inhibitor, an HDAC inhibitor, an Eg5 inhibitor a DNA damaging agent, a DNA alkylating agent, a DNA intercalator, a DNA minor groove binder and a DHFR inhibitor. Suitable examples include auristatins such as MMAE and MMAF; calicheamycins such as gamma-calicheamycin; and maytansinoids such as DM1 and DM4. Methods for attaching each of these to a linker compatible with the antibodies and method of the present disclosure are known in the art. See, *e.g.*, Singh *et al.*, (2009) Therapeutic Antibodies: Methods and Protocols, vol. 525, 445-457. In addition, a payload can be a biophysical probe, a fluorophore, a spin label, an infrared probe an affinity probe, a chelator, a spectroscopic probe, a radioactive probe, a lipid molecule, a polyethylene glycol, a polymer, a spin label, DNA, RNA, a protein, a peptide, a surface, an antibody, an antibody fragment, a nanoparticle, a quantum dot, a liposome, a PLGA particle, a saccharide or a polysaccharide, a reactive functional group, or a binding agent that can connect the conjugate to another moiety, surface, etc.

The term “drug antibody ratio” (also referred to as “DAR”), refers to the number or payload or drug moieties linked to an antibody of the immunoconjugate. For example a drug antibody of ratio of 2 means that average of two drug moieties bound to an each antibody in a sample of immunoconjugates. Some individual immunoconjugates will in a sample with a drug antibody ratio of two might have none or only one drug moiety linked; others immunoconjugates in that sample will have two, three, four, or even more moieties on individual antibody. But the average in the sample will be two. There are different methods known in the art for measuring drug antibody ratios of immunoconjugates.

In an embodiment of this application, the DAR in a sample of immunoconjugates can be “homogenous”. A “homogenous conjugation sample” is a sample with a narrow distribution of DAR. As an illustrative embodiment, in a homogenous conjugation sample having a DAR of 2, can contain within that sample antibodies that are not conjugated, and some antibodies having more than two moieties conjugated at about a DAR of two. “Most of the sample” means have at least over 70%, or at least over 80% or at least over 90% of the antibodies in the sample will be conjugated to two moieties.

As an illustrative embodiment, a homogenous conjugation sample having a DAR of 4, can contain within that sample antibodies that have more than four moieties or fewer than four moieties conjugated to each antibody at about a DAR of four. “Most of the sample” means have at least over

70%, or at least over 80% or at least over 90% of the antibodies in the sample will be conjugated to four moieties.

As an illustrative embodiment, a homogenous conjugation sample having a DAR of 6, can contain within that sample antibodies that have more than six moieties or fewer than six moieties
5 conjugated to each antibody at about a DAR of six. “Most of the sample” means have at least over 70%, or at least over 80% or at least over 90% of the antibodies in the sample will be conjugated to six moieties.

As an illustrative embodiment, a homogenous conjugation sample having a DAR of 8, can contain within that sample antibodies that has some antibodies having more than eight moieties of fewer
10 than either moieties conjugated to each antibody at about a DAR of eight. “Most of the sample” means have at least over 70%, or at least over 80% or at least over 90% of the antibodies in the sample will be conjugated to eight moieties.

An immunoconjugate having a “drug antibody ratio of about 2” refers to sample of immunoconjugates where in the drug antibody ratio can range from about 1.6-2.4 moieties/antibody, 1.8-
15 2.3 moieties/antibody, or 1.9-2.1 moieties/antibody.

An immunoconjugate having a “drug antibody ratio of about 4” refers to sample of immunoconjugates where in the drug antibody ratio can range from about 3.4-4.4 moieties/antibody, 3.8-
4.3 moieties/antibody, or 3.9-4.1 moieties/antibody.

An immunoconjugate having a “drug antibody ratio of about 6” refers to sample of
20 immunoconjugates where in the drug antibody ratio can range from about 5.1-6.4 moieties/antibody, 5.8-6.3 moieties/antibody, or 5.9-6.1 moieties/antibody.

An immunoconjugate having a “drug antibody ratio of about 8” refers to sample of immunoconjugates where in the drug antibody ratio can range from about 7.6-8.4 moieties/antibody, 7.8-
8.3 moieties/antibody, or 7.9-8.1 moieties/antibody.

25 “Tumor” refers to neoplastic cell growth and proliferation, whether malignant or benign, and all pre-cancerous and cancerous cells and tissues.

The term “anti-tumor activity” means a reduction in the rate of tumor cell proliferation, viability, or metastatic activity. A possible way of showing anti-tumor activity is to show a decline in growth rate of abnormal cells that arises during therapy or tumor size stability or reduction. Such activity can be
30 assessed using accepted *in vitro* or *in vivo* tumor models, including but not limited to xenograft models,

allograft models, MMTV models, and other known models known in the art to investigate anti-tumor activity.

The term “malignancy” refers to a non-benign tumor or a cancer. As used herein, the term “cancer” includes a malignancy characterized by deregulated or uncontrolled cell growth. Exemplary
5 cancers include: carcinomas, sarcomas, leukemias, and lymphomas.

The term “cancer” includes primary malignant tumors (*e.g.*, those whose cells have not migrated to sites in the subject's body other than the site of the original tumor) and secondary malignant tumors (*e.g.*, those arising from metastasis, the migration of tumor cells to secondary sites that are different from the site of the original tumor).

As used herein, the term “an optical isomer” or “a stereoisomer” refers to any of the various stereo isomeric configurations which may exist for a given compound of the present application and includes geometric isomers. It is understood that a substituent may be attached at a chiral center of a carbon atom. The term “chiral” refers to molecules which have the property of non-superimposability on their mirror image partner, while the term “achiral” refers to molecules which are superimposable on their
15 mirror image partner. Therefore, the present disclosure includes enantiomers, diastereomers or racemates of the compound. “Enantiomers” are a pair of stereoisomers that are non- superimposable mirror images of each other. A 1:1 mixture of a pair of enantiomers is a “racemic” mixture. The term is used to designate a racemic mixture where appropriate. “Diastereoisomers” are stereoisomers that have at least two asymmetric atoms, but which are not mirror-images of each other. The absolute stereochemistry is
20 specified according to the Cahn-Ingold-Prelog R-S system. When a compound is a pure enantiomer the stereochemistry at each chiral carbon may be specified by either *R* or *S*. Resolved compounds whose absolute configuration is unknown can be designated (+) or (-) depending on the direction (dextro- or levorotatory) which they rotate plane polarized light at the wavelength of the sodium D line. Certain compounds described herein contain one or more asymmetric centers or axes and may thus give rise to
25 enantiomers, diastereomers, and other stereoisomeric forms that may be defined, in terms of absolute stereochemistry, as (*R*)- or (*S*)-.

Depending on the choice of the starting materials and procedures, the compounds can be present in the form of one of the possible isomers or as mixtures thereof, for example as pure optical isomers, or as isomer mixtures, such as racemates and diastereoisomer mixtures, depending on the number of
30 asymmetric carbon atoms. The present application is meant to include all such possible isomers, including racemic mixtures, diastereomeric mixtures and optically pure forms. Optically active (*R*)- and

(*S*)-isomers may be prepared using chiral synthons or chiral reagents, or may be resolved using conventional techniques. If the compound contains a double bond, the substituent may be E or Z configuration. If the compound contains a disubstituted cycloalkyl, the cycloalkyl substituent may have a cis- or trans-configuration. All tautomeric forms are also intended to be included.

5 As used herein, the terms “salt” or “salts” refers to an acid addition or base addition salt of a compound of the present application. “Salts” include in particular “pharmaceutical acceptable salts”. The term “pharmaceutically acceptable salts” refers to salts that retain the biological effectiveness and properties of the compounds of this application and, which typically are not biologically or otherwise undesirable. In many cases, the compounds of the present application are capable of forming acid and/or
10 base salts by virtue of the presence of amino and/or carboxyl groups or groups similar thereto.

Pharmaceutically acceptable acid addition salts can be formed with inorganic acids and organic acids, e.g., acetate, aspartate, benzoate, besylate, bromide/hydrobromide, bicarbonate/carbonate, bisulfate/sulfate, camphorsulfonate, chloride/hydrochloride, chlorotheophyllinate, citrate, ethandisulfonate, fumarate, gluceptate, gluconate, glucuronate, hippurate, hydroiodide/iodide,
15 isethionate, lactate, lactobionate, laurylsulfate, malate, maleate, malonate, mandelate, mesylate, methylsulfate, naphthoate, napsylate, nicotinate, nitrate, octadecanoate, oleate, oxalate, palmitate, pamoate, phosphate/hydrogen phosphate/dihydrogen phosphate, polygalacturonate, propionate, stearate, succinate, sulfosalicylate, tartrate, tosylate and trifluoroacetate salts.

Inorganic acids from which salts can be derived include, for example, hydrochloric acid,
20 hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid, and the like.

Organic acids from which salts can be derived include, for example, acetic acid, propionic acid, glycolic acid, oxalic acid, maleic acid, malonic acid, succinic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, toluenesulfonic acid, sulfosalicylic acid, and the like. Pharmaceutically acceptable base addition salts can be formed with
25 inorganic and organic bases.

Inorganic bases from which salts can be derived include, for example, ammonium salts and metals from columns I to XII of the periodic table. In certain embodiments, the salts are derived from sodium, potassium, ammonium, calcium, magnesium, iron, silver, zinc, and copper; particularly suitable salts include ammonium, potassium, sodium, calcium and magnesium salts.

30 Organic bases from which salts can be derived include, for example, primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines, basic

ion exchange resins, and the like. Certain organic amines include isopropylamine, benzathine, choline, diethanolamine, diethylamine, lysine, meglumine, piperazine and tromethamine.

The pharmaceutically acceptable salts of the present application can be synthesized from a basic or acidic moiety, by conventional chemical methods. Generally, such salts can be prepared by reacting free acid forms of these compounds with a stoichiometric amount of the appropriate base (such as Na, Ca, Mg, or K hydroxide, carbonate, bicarbonate or the like), or by reacting free base forms of these compounds with a stoichiometric amount of the appropriate acid. Such reactions are typically carried out in water or in an organic solvent, or in a mixture of the two. Generally, use of non-aqueous media like ether, ethyl acetate, ethanol, isopropanol, or acetonitrile is desirable, where practicable. Lists of additional suitable salts can be found, e.g., in "Remington's Pharmaceutical Sciences", 20th ed., Mack Publishing Company, Easton, Pa., (1985); and in "Handbook of Pharmaceutical Salts: Properties, Selection, and Use" by Stahl and Wermuth (Wiley-VCH, Weinheim, Germany, 2002).

Any formula given herein is also intended to represent unlabeled forms as well as isotopically labeled forms of the compounds. Isotopically labeled compounds have structures depicted by the formulas given herein except that one or more atoms are replaced by an atom having a selected atomic mass or mass number. Examples of isotopes that can be incorporated into compounds of the application include isotopes of hydrogen, carbon, nitrogen, oxygen, phosphorous, fluorine, and chlorine, such as ^2H , ^3H , ^{11}C , ^{13}C , ^{14}C , ^{15}N , ^{18}F , ^{31}P , ^{32}P , ^{35}S , ^{36}Cl , ^{125}I respectively. The present disclosure includes various isotopically labeled compounds as defined herein, for example those into which radioactive isotopes, such as ^3H and ^{14}C , or those into which non-radioactive isotopes, such as ^2H and ^{13}C are present. Such isotopically labeled compounds are useful in metabolic studies (with ^{14}C), reaction kinetic studies (with, for example ^2H or ^3H), detection or imaging techniques, such as positron emission tomography (PET) or single-photon emission computed tomography (SPECT) including drug or substrate tissue distribution assays, or in radioactive treatment of patients. In particular, an ^{18}F or labeled compound may be particularly desirable for PET or SPECT studies. Isotopically-labeled compounds of formula (I) can generally be prepared by conventional techniques known to those skilled in the art or by processes analogous to those described in the accompanying Examples and Preparations using an appropriate isotopically-labeled reagents in place of the non-labeled reagent previously employed.

Further, substitution with heavier isotopes, particularly deuterium (i.e., ^2H or D) may afford certain therapeutic advantages resulting from greater metabolic stability, for example increased *in vivo* half-life or reduced dosage requirements or an improvement in therapeutic index. It is understood that deuterium in this context is regarded as a substituent of a compound of the formula (I). The

concentration of such a heavier isotope, specifically deuterium, may be defined by the isotopic enrichment factor. The term "isotopic enrichment factor" as used herein means the ratio between the isotopic abundance and the natural abundance of a specified isotope. If a substituent in a compound of this application is denoted deuterium, such compound has an isotopic enrichment factor for each designated deuterium atom of at least 3500 (52.5% deuterium incorporation at each designated deuterium atom), at least 4000 (60% deuterium incorporation), at least 4500 (67.5% deuterium incorporation), at least 5000 (75% deuterium incorporation), at least 5500 (82.5% deuterium incorporation), at least 6000 (90% deuterium incorporation), at least 6333.3 (95% deuterium incorporation), at least 6466.7 (97% deuterium incorporation), at least 6600 (99% deuterium incorporation), or at least 6633.3 (99.5% deuterium incorporation).

As used herein, the term "pharmaceutically acceptable carrier" includes any and all solvents, dispersion media, coatings, surfactants, antioxidants, preservatives (*e.g.*, antibacterial agents, antifungal agents), isotonic agents, absorption delaying agents, salts, preservatives, drug stabilizers, binders, excipients, disintegration agents, lubricants, sweetening agents, flavoring agents, dyes, and the like and combinations thereof, as would be known to those skilled in the art (see, for example, Remington's Pharmaceutical Sciences, 18th Ed. Mack Printing Company, 1990, pp. 1289- 1329). Except insofar as any conventional carrier is incompatible with the active ingredient, its use in the therapeutic or pharmaceutical compositions is contemplated.

The term "a therapeutically effective amount" of a compound of the present application refers to an amount of the compound of the present application that will elicit the biological or medical response of a subject, for example, reduction or inhibition of an enzyme or a protein activity, or ameliorate symptoms, alleviate conditions, slow or delay disease progression, or prevent a disease, etc. In one non-limiting embodiment, the term "a therapeutically effective amount" refers to the amount of a compound of the present application that, when administered to a subject, is effective to at least partially alleviate, inhibit, prevent and/or ameliorate a condition, or a disorder or a disease, or at least partially inhibit activity of a targeted enzyme or receptor.

As used herein, the term "inhibit", "inhibition" or "inhibiting" refers to the reduction or suppression of a given condition, symptom, or disorder, or disease, or a significant decrease in the baseline activity of a biological activity or process.

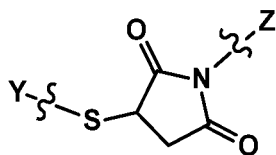
As used herein, the term "treat", "treating" or "treatment" of any disease or disorder refers in one embodiment, to ameliorating the disease or disorder (*i.e.*, slowing or arresting or reducing the development of the disease or at least one of the clinical symptoms thereof). In another embodiment

“treat”, “treating” or “treatment” refers to alleviating or ameliorating at least one physical parameter including those which may not be discernible by the patient. In yet another embodiment, “treat”, “treating” or “treatment” refers to modulating the disease or disorder, either physically, (*e.g.*, stabilization of a discernible symptom), physiologically, (*e.g.*, stabilization of a physical parameter), or both. In yet another embodiment, “treat”, “treating” or “treatment” refers to preventing or delaying the onset or development or progression of the disease or disorder.

As used herein, a subject is “in need of” a treatment if such subject would benefit biologically, medically or in quality of life from such treatment.

As used herein, the term “a,” “an,” “the” and similar terms used in the context of the present application (especially in the context of the claims) are to be construed to cover both the singular and plural unless otherwise indicated herein or clearly contradicted by the context.

The term “thiol-maleimide” as used herein describes a group formed by reaction of a thiol with maleimide, having this general formula



where Y and Z are groups to be connected via the thiol-maleimide linkage and can be linker units, and can be attached to antibodies or payloads. In some instances, Y is an engineered antibody according to the application, and the sulfur atom shown in the formula is from a cysteine at one of the substitution sites described herein; while Z represents a linker unit connected to a payload.

“Linker Unit” (LU) as used herein refers to a covalent chemical connection between two moieties, such as an antibody and a payload. Each LU can be comprised of one or more components described herein as L₁, L₂, L₃, L₄, L₅ and L₆. The linker unit can be selected to provide suitable spacing between the connected moieties, or to provide certain physicochemical properties, or to allow cleavage of the linker unit under certain conditions.

“Cleavable” as used herein refers to a linker or linker unit (LU) that connects two moieties by covalent connections, but breaks down to sever the covalent connection between the moieties under physiological conditions. Cleavage may be enzymatic or non-enzymatic, but generally releases a payload from an antibody without degrading the antibody.

“Non-cleavable” as used herein refers to a linker or linker unit (LU) that is not susceptible to breaking down under physiological conditions. While the linker may be modified physiologically, it keeps the payload connected to the antibody until the antibody is substantially degraded, *i.e.*, the antibody degradation precedes cleavage of the linker *in vivo*.

5 “Cyclooctyne” as used herein refers to an 8-membered ring containing a carbon-carbon triple bond (acetylene). The ring is optionally fused to one or two phenyl rings, which may be substituted with 1-4 C₁₋₄ alkyl, C₁₋₄ alkoxy, halo, hydroxyl, COOH, COOL₁, -C(O)NH-L₁, O-L₁, or similar groups, and which may contain N, O or S as a ring member. In preferred embodiments, cyclooctyne can be a C₈ hydrocarbon ring, particularly an isolated ring that is saturated aside from the triple bond, and may be
10 substituted with F or Hydroxy, and may be linked to a linker or LU via -O-, -C(O), C(O)NH, or C(O)O.

“Cyclooctene” as used herein refers to an 8-membered ring containing at least one double bond, especially a trans-double bond. The ring is optionally fused to one or two phenyl rings, which may be substituted with 1-4 C₁₋₄ alkyl, C₁₋₄ alkoxy, halo, hydroxyl, COOH, COOL₁, -C(O)NH-L₁, O-L₁, or similar groups, and which may contain N, O or S as a ring member. In preferred embodiments, cyclooctene can
15 be an isolated C₈ hydrocarbon ring that is saturated aside from the trans double bond and is optionally substituted with F or Hydroxy, and may be linked to a linker or LU via -O-, -C(O), C(O)NH, or C(O)O.

All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (*e.g.* “such as”) provided herein is intended merely to better illuminate the application and does
20 not pose a limitation on the scope of the application otherwise claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts an amino acid sequence alignment of constant regions of trastuzumab (SEQ ID NO:155), human IgG1 (SEQ ID NO:151), IgG2 (SEQ ID NO:152), IgG3 (SEQ ID NO:153) and IgG4 (SEQ ID NO:154).

25 Figure 2 is a graph depicting cell killing activity of antibody drug conjugates comprising a cKIT antibody that has two cys mutations in its constant regions on cells that express cKIT. The antibody is conjugated to a linker-payload complex that inhibits Eg5. The square data points are for immunoconjugates comprising Compound A in Table 5; the triangle data points are for immunoconjugates comprising Compound B in Table 5; the square data points are for immunoconjugates
30 comprising Compound C in Table 5.

Figure 3 depicts graphs illustrating the activity of immunoconjugates comprising cysteine-engineered cKIT antibodies in H526 tumor mouse xenograft models at dosages of 5 mg/kg (Figure 3A) and 10 mg/kg (Figure 3B) and an immunoconjugate comprising wild type cKIT antibody administered at dosages of 5.9 mg/kg (Figure 3A) and 11.8 mg/kg (Figure 3B).

5 Figure 4 is a graph depicting *in vivo* efficacy of anti-Her2 immunoconjugates conjugated with Eg5 inhibitor in a Her2 positive MDA-MB-231 clone 16 breast cancer xenograft model in mice.

Figure 5 is a graph depicting *in vivo* efficacy of anti-Her2 immunoconjugates conjugated with Eg5 inhibitor in a Her2 positive MDA-MB-453 breast cancer xenograft model in mice.

10 Figure 6 is a graph depicting *in vivo* efficacy of anti-Her2 immunoconjugates conjugated with Eg5 inhibitor in a Her2 positive HCC1954 breast cancer xenograft model in mice.

Figure 7 is a graph depicting results from an *in vivo* efficacy study of anti-cKIT ADCs conjugated with Compound F, in H526 tumor xenograft model in mice. Compound F was conjugated to cysteine-engineered or wild type cKIT antibodies. An anti-Her2 immunoconjugate was included as a non-binding control.

15 Figure 8 is a graph depicting results from pharmacokinetic studies of antibody anti-cKIT-HC-E152C-S375C-Compound F (Figure 8A) and antibody anti-cKIT-Compound F (Figure 8B) ADCs in naïve mice at a dose of 1 mg/kg.

20 Figure 9 is a graph depicting *in vivo* efficacy of anti-cKIT immunoconjugates conjugated to two different compounds to two different cysteine-engineered antibodies in a H526 tumor xenograft model in mice.

DETAILED DESCRIPTION

The present application provides methods of site-specific labeling of antibodies or antibody fragments by replacing one or more amino acids of a parental antibody or antibody fragment at specific positions with cysteine amino acids ("Cys"), such that the engineered antibodies or antibody fragments
25 are capable of conjugation to various agents (*e.g.*, cytotoxic agents). The present application also provides immunoconjugates that are produced by using the methods described herein.

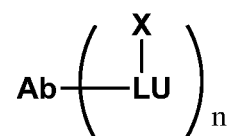
When a cysteine is engineered into a parental antibody or antibody fragment, the modified antibody or antibody fragment is first recovered from the expression medium with cysteine or glutathione (GSH) attached at the engineered cysteine site(s) via a disulfide linkage (Chen *et al.*, (2009) mAbs 16,
30 353-571). The attached cysteine or GSH is then removed in a reduction step, which also reduces all

native inter-chain disulfide bonds of the parental antibody or antibody fragment. In a second step these disulfide bonds are re-oxidized before conjugation occurs. The present disclosure shows that when cysteine is engineered at certain sites, the re-oxidation step does not proceed well, presumably due to formation of the incorrect disulfide bonds. Accordingly, the present application provides unique sets of sites on the antibody heavy chain constant region and antibody light chain constant region, respectively, where Cys substitution as described herein produces modified antibodies or antibody fragments that perform well in the re-oxidation process, and also produce stable and well behaved immunoconjugates.

The site-specific antibody labeling according to the present application can be achieved with a variety of chemically accessible labeling reagents, such as anti-cancer agents, fluorophores, peptides, sugars, detergents, polyethylene glycols, immune potentiators, radio-imaging probes, prodrugs, and other molecules.

Accordingly, the present application provides methods of preparation of homogeneous immunoconjugates with a defined drug-to-antibody ratio for use in cancer therapy and other indications as well as imaging reagents. The present application also provides immunoconjugates prepared thereby, as well as pharmaceutical compositions comprising these immunoconjugates. The methods of the instant application can be used in combination with other conjugation methods known in the art.

The following enumerated embodiments represent certain aspects and variations of the application:



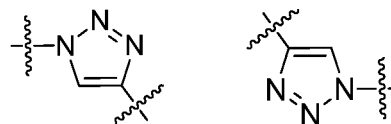
wherein Ab represents an antibody or antibody fragment comprising at least one cysteine residue at one of the preferred cysteine substitution sites described herein;

LU is a linker unit as described herein;

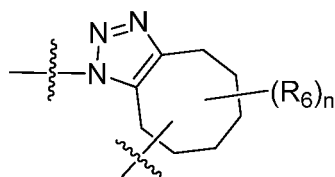
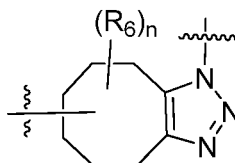
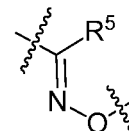
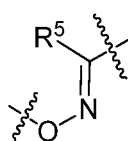
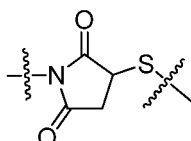
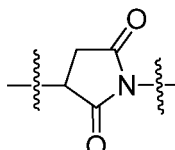
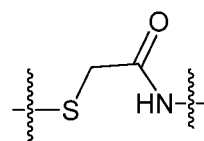
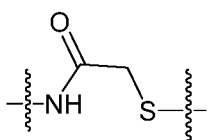
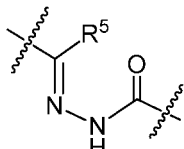
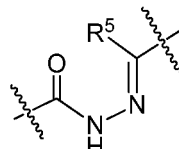
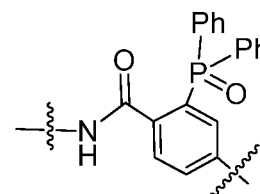
X is a payload or drug moiety;

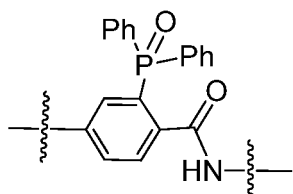
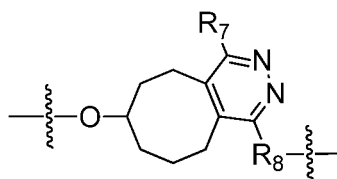
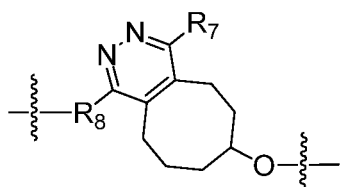
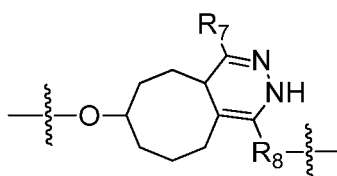
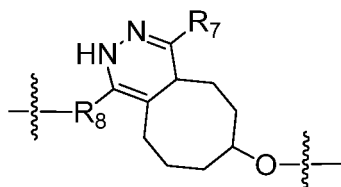
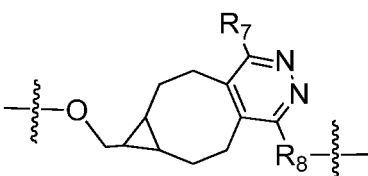
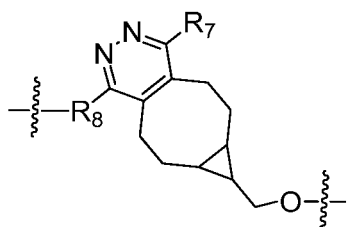
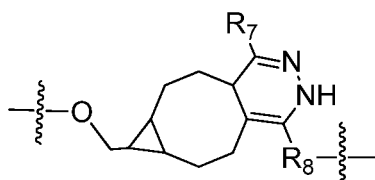
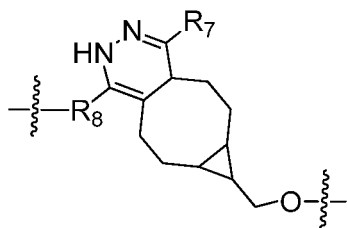
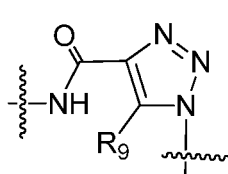
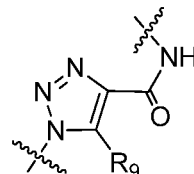
and n is an integer from 1 to 16. In these embodiments, n is preferably about 2, about 4, about 6, or about 8. LU is typically a group of formula $-\text{L}_1-\text{L}_2-\text{L}_3-\text{L}_4-\text{L}_5-\text{L}_6-$, wherein L_1 , L_2 , L_3 , L_4 , L_5 and L_6 are independently selected from $-\text{A}_1-$, $-\text{A}_1\text{X}^2-$ and $-\text{X}^2-$; wherein:

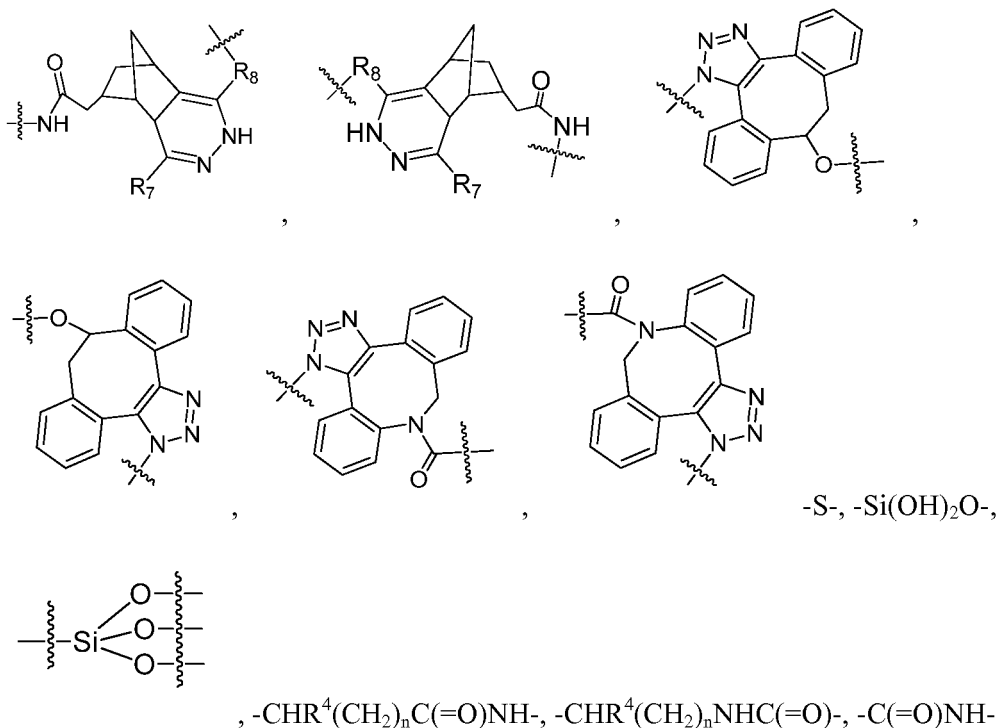
A_1 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_n-$, $-(O(CH_2)_n)_m-$, $-(O(C(R^4)_2)_n)_m-$,
 $((CH_2)_nO)_m-$, $-((C(R^4)_2)_nO)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, $-((C(R^4)_2)_nO)_m(C(R^4)_2)_n-$,
 $(CH_2)_nC(=O)NH-$, $-(C(R^4)_2)_nC(=O)NH-$, $-(CH_2)_nNHC(=O)-$, $-(C(R^4)_2)_nNHC(=O)-$,
 $NHC(=O)(CH_2)_n-$, $NHC(=O)(C(R^4)_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-C(=O)NH(C(R^4)_2)_nS-$,
 $S(CH_2)_nC(=O)NH-$, $S(C(R^4)_2)_nC(=O)NH-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$
 $, -C(=O)NH(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-C(=O)(CH_2)_n-$, $-C(=O)(C(R^4)_2)_n-$, $-(CH_2)_nC(=O)-$,
 $-(C(R^4)_2)_nC(=O)-$, $-(CH_2)_n(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$
 $, -(C(R^4)_2)_n(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNHC(=O)(CH_2)_n-$
 $, -(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$
 $, -(C(R^4)_2)_nNH((C(R^4)_2)_nO)_m(C(R^4)_2)_n-$, $-(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$,
 or $-(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$;



each X^2 is independently selected from a bond, R^8 ,







NHC(=O)-;

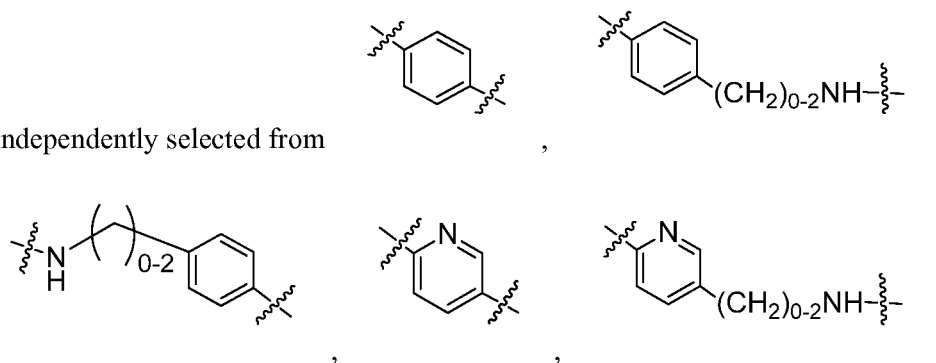
5 each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,

each R⁵ is independently selected from H, C₁₋₄alkyl, phenyl or C₁₋₄alkyl substituted with 1 to 3 -OH groups;

10 each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;

R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;

R⁸ is independently selected from





In some of these embodiments, the immunoconjugate comprises a group of the formula



10

In any of the foregoing embodiments, the cysteine substitution site may be a position that corresponds to one of the sites identified by a position number, even though the position of the site in the sequence has been changed by a modification or truncation of the full-length antibody. Corresponding sites can be readily identified by alignment of an antibody or fragment with a full-length antibody.

15

Site-specific Labeling

34

Edelman *et al.*, (1969) Proc. Natl. Acad. USA 63:78-85, except that the lambda light chain is numbered according to the Kabat numbering system as set forth in Kabat *et al.*, (1991) Fifth Edition. NIH Publication No. 91-3242. Human IgG1 constant region is used as a representative throughout the application. However, the present application is not limited to human IgG1; corresponding amino acid

positions can be readily deduced by sequence alignment. For example, Figure 1 shows sequence alignment of antibody trastuzumab wild type heavy chain constant region (the sequence of which is STKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSGDSFFLYSKLTVDKSRWQQGNVDFSCVMHEALHNHYTQKSLSLSPG (SEQ ID NO:155)), human IgG1 (the sequence of which is

STKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTTPVLDSGDSFFLYSKLTVDKSRWQQGNVDFSCVMHEALHNHYTQKSLSLSPG (SEQ ID NO:151)), IgG2 (the sequence of which is

STKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSNFGTQTYTCNVNHHKPSNTKVDKTKVERKCCVECPAPVAGPSVFLFPPKPKDTLMI SRTPEVTCVVVDVSHEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTFRVSVLTVVHQDWLNGKEYKCKVSNKGLPAPIEKTISKTKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDISVEWESNGQPENNYKTTTPMLDSGDSFFLYSKLTVDKSRWQQGNVDFSCVMHEALHNHYTQKSLSLSPG (SEQ ID NO:152)), IgG3 (the sequence of which is

STKGPSVFPLAPCSRSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYTCNVNHHKPSNTKVDKRVELKTPLGDTHTCPRCPEPKSCDTPPPCPRCPEPKSCDTPPPCPRCPEPKSCDTPPPCPRCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVQFKWYVDGVEVHNAKTKPREEQYNSTFRVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKTKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESSGQPENNYNTTPPMLDSGDSFFLYSKLTVDKSRWQQGNIFSCVMHEALHNRFTQKSLSLSPG (SEQ ID NO:152)),

and IgG4 (the sequence of which is

STKGPSVFPLAPCSRSTSESTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYTCNVNHHKPSNTKVDKRVESKYGPPCPCPAPEFLGGPSVFLFPPKPKDTLMI

SRTPEVTCVVVDVSQEDPEVQFNWYVDGVEVHNAKTKPREEQFNSTYRVVSVLTVLHQDWLN
 GKEYKCKVSNKGLPSSIEKTISKAKGQPREPQVYTLPPSQEEMTKNQVSLTCLVKGFYPSDIAVE
 WESNGQPENNYKTTTPVLDSGDSFFLYSRLTVDKSRWQEGNVFSCSVMHEALHNHYTQKSLSL
 SLG (SEQ ID NO:153)) heavy chain constant regions, so that an identified Cys engineering site in the
 5 IgG1 constant region can be readily identified for IgG2, IgG3, and IgG4 as shown in Figure 1. For the
 light chain constant region, IgG1, IgG2, IgG3 and IgG4 are the same (the full-length wild type light chain
 sequence of human antibody trastuzumab is
 DIQMTQSPSSLSASVGDRVTITCRASQDVNTAVAWYQQKPGKAPKLLIYSASFLYSGVPSRFSGS
 RSGTDFTLTISSLQPEDFATYYCQQHYTTPPTFGQGTKVEIKRTVAAPSVFIFPPSDEQLKSGTASV
 10 VCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKDSSTYLSSTLTLSKADYEKHKVYACE
 VTHQGLSSPVTKSFNRGEC (SEQ ID NO:90)).

Table 1 below lists the amino acid positions in the constant region of the heavy chain of an
 antibody that can be replaced by a cysteine. Table 2A lists the amino acid positions in the constant
 region of the kappa light chain of an antibody that can be replaced by a cysteine. Table 2B lists the
 15 amino acid positions in the constant region of the lambda light chain of an antibody that can be replaced
 by a cysteine.

Table 1. Identified cysteine substitution sites in the heavy chain constant region of human IgG1 (Sites
 numbered according to EU numbering system).

EU number	Residue	Surface accessibility [Å ²]	Selected HC Cys	SEQ ID NO.
117	SER	128.0	HC-S117C	2
119	SER	79.1	HC-S119C	3
121	LYS	135.9	HC-K121C	4
124	SER	40.2	HC-S124C	5
132	SER	34.4	HC-S132C	6
134	SER	123.3	HC-S134C	7
136	SER	182.9	HC-S136C	8
139	THR	32.9	HC-T139C	9
152	GLU	52.1	HC-E152C	10
153	PRO	89.1	HC-P153C	11
155	THR	69.0	HC-T155C	12
157	SER	39.0	HC-S157C	13
164	THR	125.4	HC-T164C	14
165	SER	183.2	HC-S165C	15

EU number	Residue	Surface accessibility [Å ²]	Selected HC Cys	SEQ ID NO.
169	THR	60.0	HC-T169C	16
171	PRO	33.3	HC-P171C	17
174	LEU	68.1	HC-L174C	18
176	SER	161.9	HC-S176C	19
177	SER	68.1	HC-S177C	20
189	PRO	86.4	HC-P189C	21
191	SER	126.8	HC-S191C	22
195	THR	111.3	HC-T195C	23
197	THR	89.8	HC-T197C	24
205	LYS	217.1	HC-K205C	25
207	SER	50.0	HC-S207C	26
212	ASP	97.0	HC-D212C	27
246	LYS	55.1	HC-K246C	28
258	GLU	42.1	HC-E258C	29
269	GLU	189.2	HC-E269C	30
274	LYS	137.8	HC-K274C	31
286	ASN	119.4	HC-N286C	32
288	LYS	181.8	HC-K288C	33
290	LYS	177.0	HC-K290C	34
292	ARG	251.5	HC-R292C	35
293	GLU	83.3	HC-E293C	36
294	GLN	73.5	HC-E294C	37
320	LYS	55.0	HC-K320C	38
322	LYS	78.3	HC-K322C	39
326	LYS	212.7	HC-K326C	40
330	ALA	96.3	HC-A330C	41
333	GLU	84.7	HC-E333C	42
334	LYS	49.6	HC-K334C	43
335	THR	70.1	HC-T335C	44
337	SER	15.1	HC-S337C	45
344	ARG	98.2	HC-R344C	46
355	ARG	249.4	HC-R355C	47
360	LYS	113.9	HC-K360C	48
362	GLN	40.8	HC-Q362C	49
375	SER	28.9	HC-S375C	50
382	GLU	21.8	HC-E382C	51
389	ASN	189.5	HC-N389C	52

EU number	Residue	Surface accessibility [Å ²]	Selected HC Cys	SEQ ID NO.
390	ASN	36.4	HC-N390C	53
392	LYS	81.8	HC-K392C	54
393	THR	35.8	HC-T393C	55
398	LEU	110.9	HC-L398C	56
400	SER	81.3	HC-S400C	57
413	ASP	79.6	HC-D413C	58
415	SER	69.0	HC-S415C	59
422	VAL	80.8	HC-V422C	60

SEQ ID NO:1

EVQLVESGGGLVQPGGSLRLSCAASGFNIKDTYIHWVRQAPGKGLEWVARIYPTNGYTRYADSV
KGRFTISADTSKNTAYLQMNSLRAEDTAVYYCSRWGGDGFYAMDYWGQGTLLTVSSASTKGPS
VFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPS
SSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT
PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKE
YKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWES
NGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO:2

CASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS
LSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK
KDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS
DIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ
KSLSLSPGK

SEQ ID NO:3

SACTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS
LSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK
KDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS
DIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ
KSLSLSPGK

SEQ ID NO:4

SASTCGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL
SSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK
DTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ
DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD
IAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS
LSLSPGK

SEQ ID NO:5

SASTKGPCVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS
LSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK
KDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH
QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS
DIAVEWESNGQPENNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ
KSLSLSPGK

SEQ ID NO:6 SASTKGPSVFPLAPSSCKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK
SEQ ID NO:7 SASTKGPSVFPLAPSSCKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK
SEQ ID NO:8 SASTKGPSVFPLAPSSKSTCGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK
SEQ ID NO:9 SASTKGPSVFPLAPSSKSTSGGCAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK
SEQ ID NO:10 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPCPVTVSWNSGALTSGVHTFPAVLQSSGLYS SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK
SEQ ID NO:11 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPECVTVSWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK
SEQ ID NO:12 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVCVSWNSGALTSGVHTFPAVLQSSGLYS SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKP DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK

<p>SEQ ID NO:13</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVCWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO:14</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALCSGVHTFPAVLQSSGLYS SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:15</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO:16</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHCFPAVLQSSGLYS SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:17</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFCAVLQSSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO:18</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVCQSSGLYS SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:19</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQCSGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQ KSLSLSPGK</p>

<p>SEQ ID NO:20</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSCGLYS LSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK KDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLH QDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPS DIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO:21</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVCSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:22</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSCSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:23</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGCQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:24</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQCYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:25</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK</p>
<p>SEQ ID NO:26</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPCNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK</p>

<p>SEQ ID NO:27</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVKKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:28</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:29</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPCVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:30</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHCDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:31</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVCFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:32</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHCAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:33</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNACTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>

<p>SEQ ID NO:34</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTCPRREQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:35</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPCEEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:36</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPRCEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:37</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPRECQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:38</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYCCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:39</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCCVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:40</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>

<p>SEQ ID NO:41</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPCPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:42</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPICKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:43</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIECTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:44</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKCISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:45</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTICKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:46</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPCPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:47</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSCEEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK</p>

<p>SEQ ID NO:48</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTCNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:49</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNCVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:50</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:51</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWCSNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:52</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPECNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:53</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENCYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:54</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYCTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>

SEQ ID NO:55 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKCTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQK SLSLSPGK
SEQ ID NO:56 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPVCDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQK SLSLSPGK
SEQ ID NO:57 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPVLDCDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQK SLSLSPGK
SEQ ID NO:58 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPVLDSGSDGSFFLYSKLTVCKSRWQQGNVFSCSVMHEALHNHYTQKS LSLSPGK
SEQ ID NO:59 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPVLDSGSDGSFFLYSKLTVDKCRWQQGNVFSCSVMHEALHNHYTQK LSLSPGK
SEQ ID NO:60 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSL SSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPK DTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSD IAVEWESNGQPENNYKTTPVLDSGSDGSFFLYSKLTVDKSRWQQGNCFSCSVMHEALHNHYTQKS LSLSPGK

Table 2A. Identified cysteine substitution sites in the kappa light chain constant region of human IgG1 (Sites numbered according to EU numbering system).

EU number	Residue	Surface accessibility [Å ²]	Selected LC Cys	SEQ ID NO.
107	LYS	90	LC-K107C	61
108	ARG	49	LC-R108C	62

EU number	Residue	Surface accessibility [Å ²]	Selected LC Cys	SEQ ID NO.
109	THR	148	LC-T109C	63
112	ALA	50	LC-A112C	64
114	SER	39	LC-S114C	65
122	ASP	90	LC-D122C	66
123	GLU	51	LC-E123C	67
129	THR	41	LC-T129C	68
142	ARG	55	LC-R142C	69
143	GLU	117	LC-E143C	70
145	LYS	160	LC-K145C	71
152	ASN	157	LC-N152C	72
154	LEU	117	LC-L154C	73
156	SER	122	LC-S156C	74
159	SER	22	LC-S159C	75
161	GLU	66	LC-E161C	76
165	GLU	74	LC-E165C	77
168	SER	170	LC-S168C	78
169	LYS	241	LC-K169C	79
170	ASP	48	LC-D170C	80
182	SER	59	LC-S182C	81
183	LYS	131	LC-K183C	82
188	LYS	201	LC-K188C	83
190	LYS	167	LC-K190C	84
191	VAL	58	LC-V191C	85
197	THR	38	LC-T197C	86
199	GLN	127	LC-Q199C	87
203	SER	110	LC-S203C	88
206	THR	70	LC-T206C	89

SEQ ID NO:61

CRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD
STYLSSTLTLSKADYEEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:62

KCTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD
STYLSSTLTLSKADYEEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:63

KRCVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD
STYLSSTLTLSKADYEEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:64 KRTVACPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:65 KRTVAAPCVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSK DSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:66 KRTVAAPSVFIFPPSCEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:67 KRTVAAPSVFIFPPSDCQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:68 KRTVAAPSVFIFPPSDEQLKSGCASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:69 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPCAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:70 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPRCAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:71 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREACVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:72 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDCALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:73 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNACQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:74 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQCGNSQESVTEQDSK DSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:75 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNCQESVTEQDSK DSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:76 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQCSVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:77 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTCQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:78 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDCK DSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:79 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSCD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:80 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKC STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO:81 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:82 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:83 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYECHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:84 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHCYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:85 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKCYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:86 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVCHQGLSSPVTKSFNRGEC
SEQ ID NO:87 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHCGLSSPVTKSFNRGEC
SEQ ID NO:88 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSCPVTKSFNREGC
SEQ ID NO:89 KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTEQDSKD STYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVCKSFNRGEC

Table 2B. Identified cysteine substitution sites on the lambda light chain of human IgG1.

Kabat number	Residue	Surface accessibility [Å ²]	Selected LC Cys	SEQ ID NO.
143	ALA	82	LC-A143C	92
145	THR	106	LC-T145C	93
147	ALA	14	LC-A147C	94
156	LYS	233	LC-K156C	95
159	VAL	28	LC-V159C	96
163	THR	157	LC-T163C	97
168	SER	166	LC-S168C	98

SEQ ID NO:91 (Constant Region of human lambda light chain) QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVKAGVETTTPSKQSN NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:92 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGCVTVAWKADSSPVKAGVETTTPSKQSN NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:93 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVCVAWKADSSPVKAGVETTTPSKQSN

NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:94 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVCWKADSSPVKAGVETTTTPSKQSN NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:95 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVCAGVETTTTPSKQSN NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:96 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVKAGCETTTTPSKQSN NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:97 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVKAGVETTCPSKQSN NKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS
SEQ ID NO:98 QPKAAPSVTLFPPSSEELQANKATLVCLISDFYPGAVTVAWKADSSPVKAGVETTTTPSKQC NNKYAASSYLSLTPEQWKSHRSYSCQVTHEGSTVEKTVAPTECS

Because of the high sequence homology of constant regions of IgG1, IgG2, IgG3 and IgG4 antibodies, findings of the present application are not limited to any specific antibodies or antibody fragments.

5 In one embodiment, the present application provides immunoconjugates comprising a modified antibody or an antibody fragment thereof, and a drug moiety, wherein said modified antibody or antibody fragment thereof comprises a substitution of one or more (*e.g.*, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10) amino acids on its heavy chain constant region

10 In an embodiment of the present application, the amino acid substitution described herein is cysteine comprising a thiol group. In some aspects of the present application, the thiol group is utilized for chemical conjugation, and is attached to a linker unit (LU) and/or drug moiety. In some embodiments, the immunoconjugates of the present application comprise a drug moiety selected from the group consisting of a V-ATPase inhibitor, a HSP90 inhibitor, an IAP inhibitor, an mTor inhibitor, a microtubule stabilizer, a microtubule destabilizers, an auristatin, a dolastatin, a maytansinoid, a MetAP
15 (methionine aminopeptidase), an inhibitor of nuclear export of proteins CRM1, a DPPIV inhibitor, proteasome inhibitors, an inhibitors of phosphoryl transfer reactions in mitochondria, a protein synthesis inhibitor, a kinase inhibitor, a CDK2 inhibitor, a CDK9 inhibitor, an kinesin inhibitor, an HDAC inhibitor, an Eg5 inhibitor, a DNA damaging agent, a DNA alkylating agent, a DNA intercalator, a DNA minor groove binder and a DHFR inhibitor. In some embodiments, the immunoconjugates of the present
20 application comprise a drug moiety that is an anti-cancer agent. The modified antibody or antibody fragments of the present application can be any formats known in the art, such as a monoclonal, chimeric, humanized, fully human, bispecific, or multispecific antibody or antibody fragment thereof.

According to the present application, the modified antibody heavy chain and/or light chain (or antibody fragment thereof) may contain 1, 2, 3, 4, 5, 6, 7, 8, or more cysteine substitutions in its constant regions. In one embodiment, the modified antibodies or antibody fragments contain 2, 4, 6, 8, or more cysteine substitutions in its constant regions. In some embodiments, the modified antibody, antibody
5 fragment or immunoconjugate thereof comprises four or more Cys substitutions.

In one embodiment, the parental antibody (antibody without cysteine substitution) is an IgG, IgM, IgE, or IgA antibody. In a specific embodiment, the parental antibody is an IgG1 antibody. In another specific embodiment, the parental antibody is an IgG2, IgG3, or IgG4 antibody.

The present application also provides modified antibodies or antibody fragments thereof
10 comprising a substitution of one or more amino acids on its heavy chain constant region chosen from positions identified in Table 1. In some embodiments, the present application provides modified antibodies or antibody fragments thereof comprising a substitution of one or more amino acids on its light chain constant region chosen from positions identified in Table 2A or Table 2B. In other embodiments, the modified antibodies or antibody fragment thereof comprise one or more amino acids on its heavy
15 chain constant region chosen from positions identified in Table 1 and one or more amino acids on its light chain constant region chosen from positions identified in Table 2A.

In certain embodiments, the modified antibodies or antibody fragments provided herein are labeled using the methods of the present application in combination with other conjugation methods known in the art including, but not limited to, chemoselective conjugation through lysine, histidine,
20 tyrosine, formyl-glycine, pyrrolysine, pyrroline-carboxy-lysine, unnatural amino acids, and protein tags for enzyme-mediated conjugation (e.g., S6 tags).

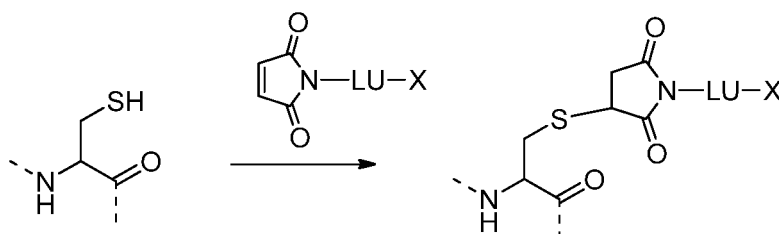
2. Conjugation Chemistry

The conjugated antibody or antibody fragment thereof provided herein is produced by post-translational modification of at least one cysteine residue that was incorporated into the antibody or
25 antibody fragment thereof as described above by site-specific labeling methods. The conjugated antibody or antibody fragment can be prepared by methods known in the art for conjugation of a payload of interest to cysteine residues that occur naturally in proteins, and by methods described for conjugation to proteins engineered to contain an additional cysteine residue substituted for another amino acid of a natural protein sequence.

30 In certain embodiments the modified antibodies or antibody fragment thereof provided herein are conjugated using known methods wherein the incorporated cysteine (cys) is conjugated to a maleimide

derivative as Scheme Ia below. Modified antibodies of the present application that undergo this type of conjugation contain a thiol-maleimide linkage.

Scheme Ia. Conjugation via thiol-maleimide adduct formation.



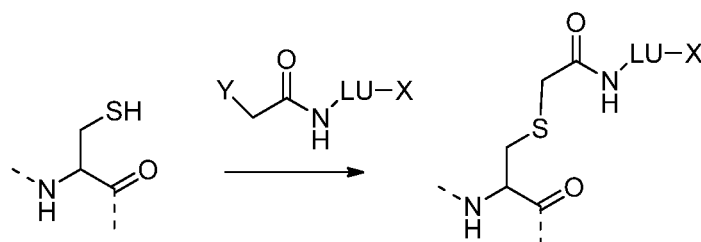
5 where:

LU is a Linker Unit (LU), and

X is a payload or drug moiety.

In other embodiments, the Cys incorporated into the modified antibodies or antibody fragment is conjugated by reaction with an alpha-halo carbonyl compound such as a chloro-, bromo-, or iodo-acetamide as shown in Scheme Ib below. It is understood that other leaving groups besides halogen, such as tosylate, triflate and other alkyl or aryl sulfonates, can be used as the leaving group Y. While Scheme Ib depicts reaction of a Cys thiol with an alpha-halo acetamide, the method includes any alkylation of a sulfur of an incorporated Cys with a group of the formula Y-CHR-C(=O)-, where R is H or C₁₋₄ alkyl, Y is a leaving group (typically Cl, Br, or I, and optionally an alkylsulfonate or arylsulfonate); it is not limited to amides.

Scheme Ib. Conjugation via reaction with an alpha-halo carbonyl compound.



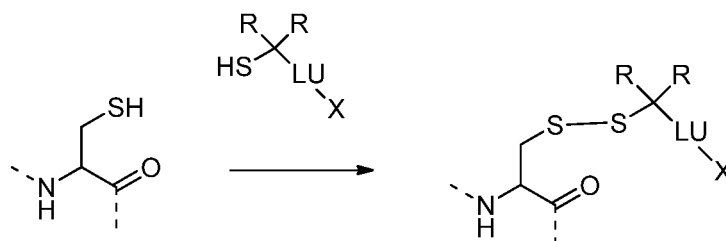
Y is a leaving group (Cl, Br, I, OTs, OTf, and the like)

LU is a linker unit

X is a payload or drug moiety

Alternatively, the Cys incorporated into the modified antibodies or antibody fragment can be conjugated by reaction with an external thiol under conditions that induce formation of a disulfide bond between the external thiol and the sulfur atom of the incorporated cysteine residue as shown in Scheme Ic below. In these examples, R can be H; however, compounds where one or both R groups represent an alkyl group, e.g., Methyl, have been found to increase the stability of the disulfide.

Scheme Ic. Conjugation via disulfide formation.



each R is independently H or C₁₋₄ alkyl
 LU is a linker unit
 X is a payload or drug moiety

By way of example only, such post-translational modifications are illustrated in Schemes (Ia)-(Ic) above, where the starting structure represents a cysteine incorporated into a light chain or heavy chain of an antibody at one of the specific sites identified herein. Methods for performing each of these conjugation methods are well known in the art. An antibody can be modified by these methods in its light chains, or its heavy chains, or in both light and heavy chains. An antibody in which each light chain or each heavy chain has been modified to contain a single incorporated cysteine will generally contain two conjugation sites, since an antibody typically contains two light and two heavy chains.

Upon conjugation, the modified antibodies of the present application typically contain 1-12, frequently 2-8, and preferably 2, 4 or 6 -LU-X (Linker Unit-Payload) moieties. In some embodiments, an antibody light or heavy chain is modified to incorporate two new Cys residues at two of the specific sites identified herein for Cys substitutions (or alternatively one Cys is incorporated in the light chain and one in the heavy chain), so the tetrameric antibody ultimately contains four conjugation sites. Similarly the antibody can be modified by replacement of 3 or 4 of its native amino acids with Cys at the specific sites identified herein, in light chain or heavy chain or a combination thereof, resulting in 6 or 8 conjugation sites in the tetrameric antibody.

X in these conjugates represents a payload, which can be any chemical moiety that is useful to attach to an antibody. In some embodiments, X is a drug moiety selected from a cytotoxin, an anti-cancer agent, an anti-inflammatory agent, an antifungal agent, an antibacterial agent, an anti-parasitic agent, an anti-viral agent, an immune potentiator, and an anesthetic agent or any other therapeutic, or biologically active moiety or drug moiety. In other embodiments, X is a label such as a biophysical probe, a fluorophore, an affinity probe, a spectroscopic probe, a radioactive probe, a spin label, or a quantum dot. In other embodiments, X is a chemical moiety that modifies the antibody's physicochemical properties such as a lipid molecule, a polyethylene glycol, a polymer, a polysaccharide, a liposome, or a chelator. In other embodiments, X is a functional or detectable biomolecule such as a nucleic acid, a ribonucleic acid, a protein, a peptide (e.g., an enzyme or receptor), a sugar or polysaccharide, an antibody, or an antibody fragment. In other embodiments, X is an anchoring moiety such as a nanoparticle, a PLGA particle, or a surface, or any binding moiety for specifically binding the conjugate to another moiety, such as a histidine tag, poly-G, biotin, avidin, streptavidin, and the like. In other embodiments, X is a reactive functional group that can be used to attach the antibody conjugate to another chemical moiety, such as a drug moiety, a label, another antibody, another chemical moiety, or a surface.

The Linker Unit (LU) can be any suitable chemical moiety that covalently attaches the thiol-reactive group (e.g., maleimide, alpha-halo carbonyl, vinyl carbonyl (e.g., acrylate or acrylamide), vinyl sulfone, vinylpyridine, or thiol) to a payload. Many suitable LUs are known in the art. For example, LU can be comprised of one, two, three, four, five, six, or more than six linkers referred to herein as L₁, L₂, L₃, L₄, L₅ and L₆. In certain embodiments the LU comprises a linker selected from a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or any combination thereof, and the LU optionally contains a self-immolative spacer.

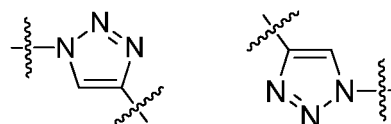
In some embodiments, LU is a group of the formula -L₁-L₂-L₃-L₄- or -L₁-L₂-L₃-L₄-L₅-L₆-. Linking groups L₁, L₂, L₃, L₄, L₅ and L₆ for use in LU include alkylene groups -(CH₂)_n- (where n is 1-20, typically 1-10 or 1-6), ethylene glycol units -(CH₂CH₂O)_n- (where n is 1-20, typically 1-10 or 1-6), amides -C(=O)-NH- or -NH-C(=O)-, esters -C(=O)-O- or -O-C(=O)-, rings having two available points of attachment such as divalent phenyl, C₃₋₈ cycloalkyl or C₄₋₈ heterocyclyl groups, amino acids -NH-CHR*-C(=O)- or -C(=O)-CHR*-NH-, where R* is the side chain of a known amino acid (frequently one of the canonical amino acids, but also including e.g. norvaline, norleucine, homoserine, homocysteine, phenylglycine, citrulline, and other named alpha-amino acids), polypeptides of known amino acids (e.g., dipeptides, tripeptides, tetrapeptides, etc.), thiol-maleimide linkages (from addition of -SH to maleimide), -S-CR₂- and other thiol ethers such as -S-CR₂-C(=O)- or -C(=O)-CR₂-S-, where R is as defined above for

Scheme Ic, $-\text{CH}_2-\text{C}(=\text{O})-$, and disulfides $(-\text{S}-\text{S}-)$, as well as combinations of any of these with other linkers described below, e.g., a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or a linker that comprises a self-immolative spacer.

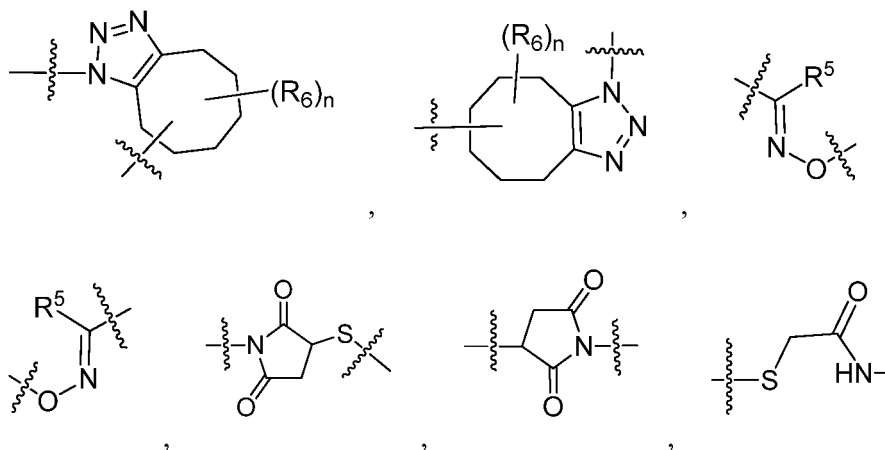
5 In some embodiments when LU is $-\text{L}_1-\text{L}_2-\text{L}_3-\text{L}_4-\text{L}_5-\text{L}_6-$, L_1 , L_2 , L_3 , L_4 , L_5 and L_6 can be selected from:

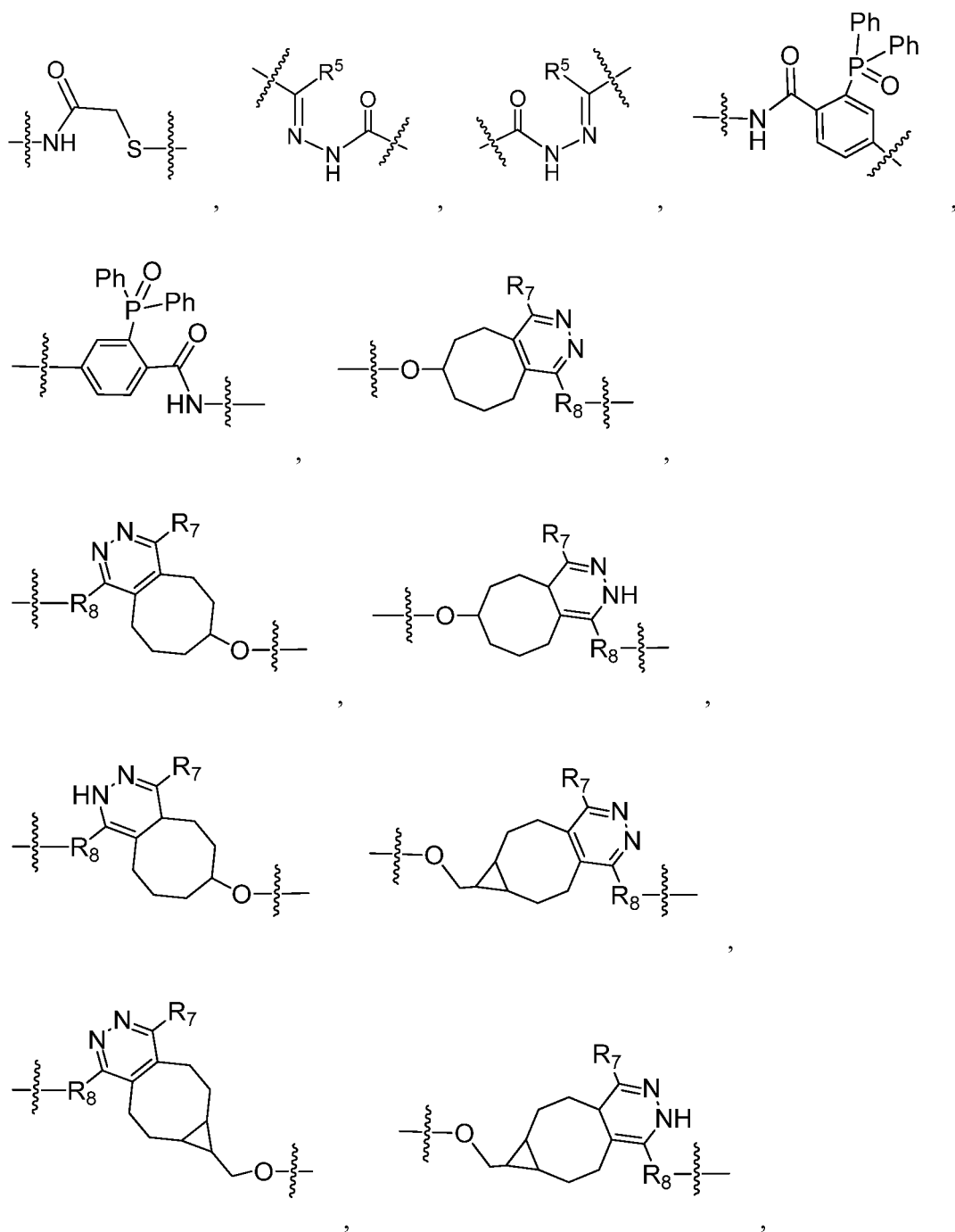
$-\text{A}_1-$, $-\text{A}_1\text{X}^2-$ and $-\text{X}^2-$; wherein:

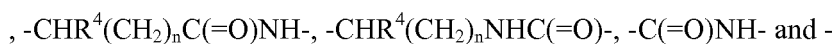
A_1 is $-\text{C}(=\text{O})\text{NH}-$, $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n-$, $-\text{C}(=\text{O})\text{NH}(\text{C}(\text{R}^4)_2)_n-$, $-(\text{O}(\text{CH}_2)_n)_m-$, $-(\text{O}(\text{C}(\text{R}^4)_2)_n)_m-$,
 $((\text{CH}_2)_n\text{O})_m-$, $-((\text{C}(\text{R}^4)_2)_n\text{O})_m-$, $-((\text{CH}_2)_n\text{O})_m(\text{CH}_2)_n-$, $-((\text{C}(\text{R}^4)_2)_n\text{O})_m\text{C}(\text{R}^4)_2-$,
 10 $(\text{CH}_2)_n\text{C}(=\text{O})\text{NH}-$, $-(\text{C}(\text{R}^4)_2)_n\text{C}(=\text{O})\text{NH}-$, $-(\text{CH}_2)_n\text{NHC}(=\text{O})-$, $-(\text{C}(\text{R}^4)_2)_n\text{NHC}(=\text{O})-$,
 $\text{NHC}(=\text{O})(\text{CH}_2)_n-$, $\text{NHC}(=\text{O})(\text{C}(\text{R}^4)_2)_n-$, $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{S}-$, $-\text{C}(=\text{O})\text{NH}(\text{C}(\text{R}^4)_2)_n\text{S}-$,
 $\text{S}(\text{CH}_2)_n\text{C}(=\text{O})\text{NH}-$, $\text{S}(\text{C}(\text{R}^4)_2)_n\text{C}(=\text{O})\text{NH}-$, $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{NHC}(=\text{O})(\text{CH}_2)_n-$,
 $-\text{C}(=\text{O})\text{NH}(\text{C}(\text{R}^4)_2)_n\text{NHC}(=\text{O})(\text{C}(\text{R}^4)_2)_n-$, $-\text{C}(=\text{O})(\text{CH}_2)_n-$, $-\text{C}(=\text{O})(\text{C}(\text{R}^4)_2)_n-$, $-(\text{CH}_2)_n\text{C}(=\text{O})-$,
 $-(\text{C}(\text{R}^4)_2)_n\text{C}(=\text{O})-$, $-(\text{CH}_2)_n(\text{O}(\text{CH}_2)_n)_m\text{NHC}(=\text{O})(\text{CH}_2)_n-$
 15 $-(\text{C}(\text{R}^4)_2)_n(\text{O}(\text{C}(\text{R}^4)_2)_n)_m\text{NHC}(=\text{O})(\text{C}(\text{R}^4)_2)_n-$, $-(\text{CH}_2)_n\text{NHC}(=\text{O})(\text{CH}_2)_n-$,
 $-(\text{C}(\text{R}^4)_2)_n\text{NHC}(=\text{O})(\text{C}(\text{R}^4)_2)_n-$, $-(\text{CH}_2)_n\text{NH}((\text{CH}_2)_n\text{O})_m(\text{CH}_2)_n-$,
 $-(\text{C}(\text{R}^4)_2)_n\text{NH}((\text{C}(\text{R}^4)_2)_n\text{O})_m(\text{C}(\text{R}^4)_2)_n-$, $-(\text{O}(\text{CH}_2)_n)_m\text{NHC}(=\text{O})(\text{CH}_2)_n-$,
 or $-(\text{O}(\text{C}(\text{R}^4)_2)_n)_m\text{NHC}(=\text{O})(\text{C}(\text{R}^4)_2)_n-$;



each X^2 is independently selected from a bond, R^8 ,





 $\text{NHC}(=\text{O})-$;

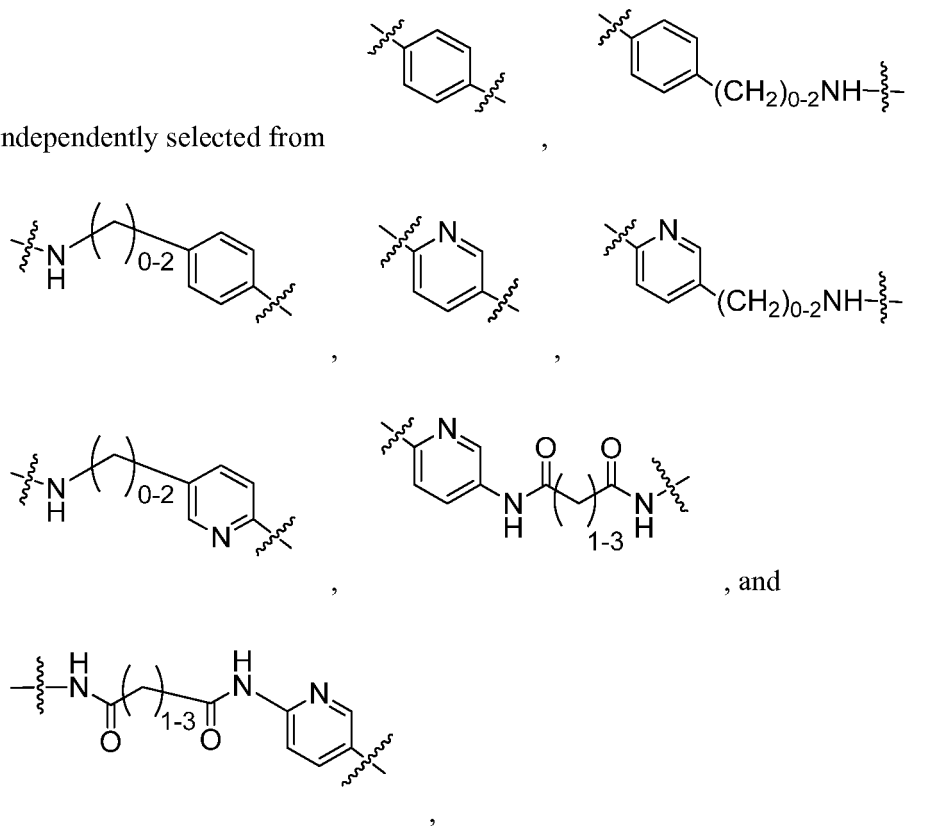
C(=O)OH and -OH,

OH groups;

each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;

R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;

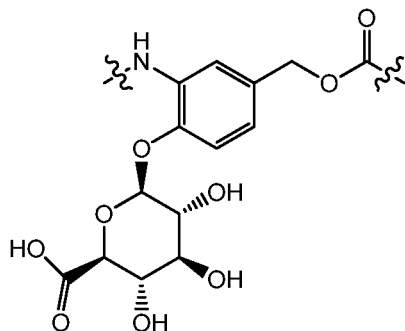
R^8 is independently selected from



- 5 R^9 is independently selected from H and C_{1-6} haloalkyl;
 each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and
 each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9.

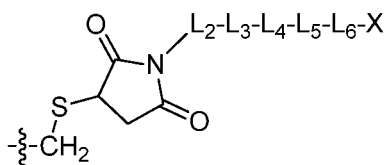
In some embodiments, at least one of L_1 , L_2 , L_3 , L_4 , L_5 and L_6 is a stable, or non-cleavable, linker.

- 10 In some embodiments, at least one of L_1 , L_2 , L_3 , L_4 , L_5 and L_6 is a cleavable linker, which may be chemically cleavable (hydrazones, disulfides) or enzymatically cleavable. In some embodiments, the enzymatically cleavable linker is one readily cleaved by a peptidase: The Val-Cit linker (valine-citrulline), a dipeptide of two known amino acids, is one such linker. In other embodiments, the enzymatically cleavable linker is one that is triggered by activity of a glucuronidase:



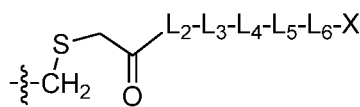
is an example of such a linker, which also comprises a self-immolative spacer that falls apart spontaneously under physiological conditions once glucuronidase cleaves the glycosidic linkage.

In some embodiments, the immunoconjugate of the present application comprises a modified
 5 cysteine residue of the formula IIA or IIB:



IIA

or



IIB

wherein $-\text{CH}_2\text{-S}-$ represents the side chain of Cys incorporated at one of the selected Cys substitution sites described herein, and $\text{L}_2 - \text{L}_6$ and X represent linking groups and payloads, respectively, as further described herein. In some embodiments of IIA, L_2 is a bond. In some embodiments of IIB, L_2 is NH or
 10 O. In some embodiments of both IIA and IIB, L_3 is selected from $(\text{CH}_2)_{1-10}$ and $(\text{CH}_2\text{CH}_2\text{O})_{1-6}$. L_4 , L_5 and L_6 are additional optional linkers selected from those described herein. In certain embodiments, L_6 can be a carbonyl (C=O) or a linker that comprises a self-immolative spacer.

In certain embodiments the Linker Unit (LU) is $-\text{L}_1-\text{L}_2-\text{L}_3-\text{L}_4-$, wherein:

L_1 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable
 15 linker, a photo-stable linker or a photo-cleavable linker;

L_2 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;

L_3 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker, and

L_4 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or a linker that comprises a self-immolative spacer.

In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

L_1 is a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;

L_2 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;

L_3 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker, and

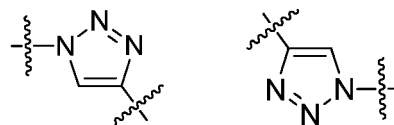
L_4 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or a linker that comprises a self-immolative spacer.

In some of the embodiments of LU at least one of L_1 , L_2 , L_3 , L_4 , L_5 and L_6 is a cleavable linker, and LU is considered cleavable. Similarly, in some of the embodiments of LU at least one of L_1 , L_2 , L_3 , L_4 , L_5 and L_6 is a non-cleavable linker. In certain of these embodiments, each linker of LU is non-cleavable, and LU is considered non-cleavable.

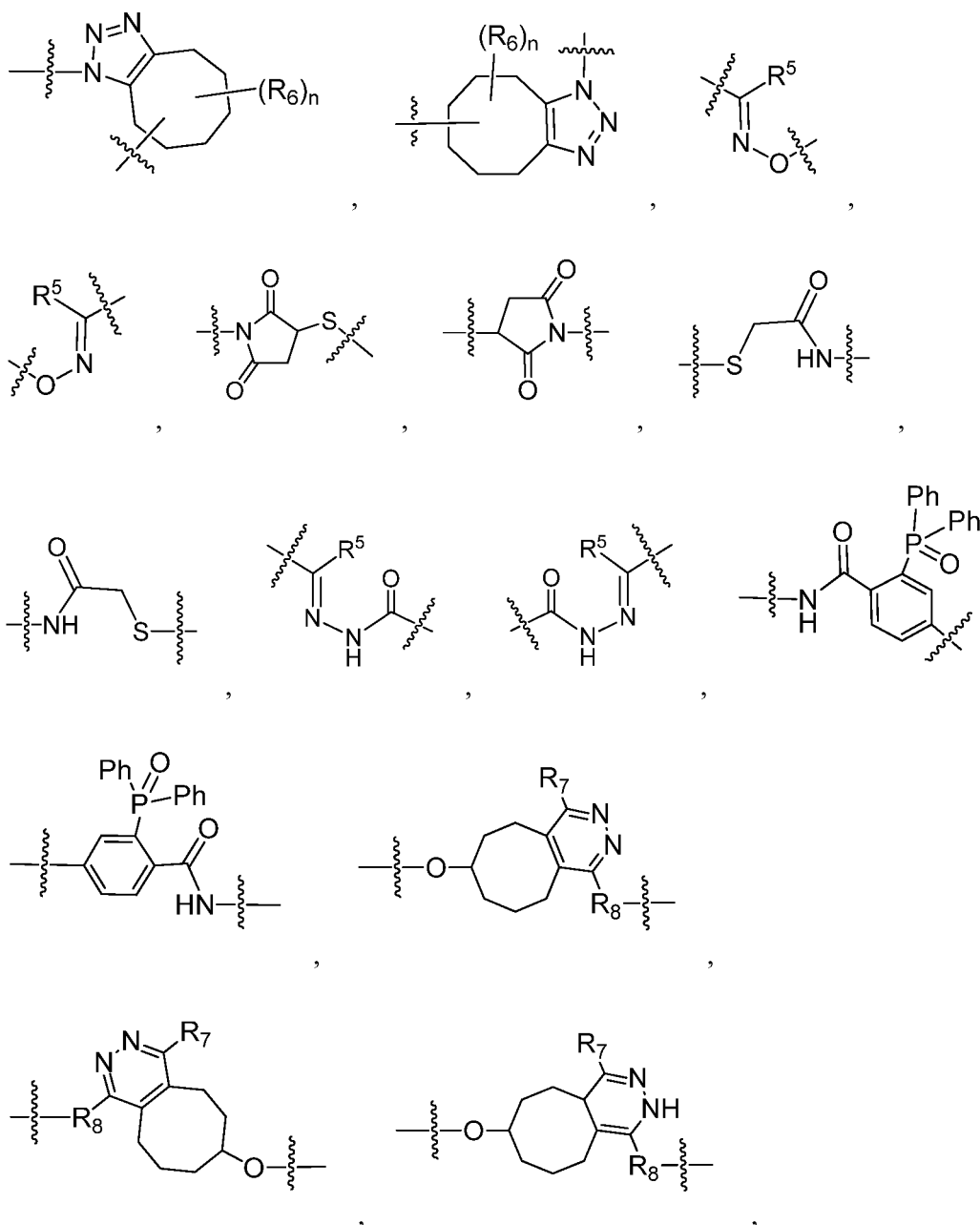
In some of the foregoing embodiments wherein LU is $-L_1-L_2-L_3-L_4-$, at least one of L_1 , L_2 , L_3 and L_4 is a linker selected from $-A_1-$, $-A_1X^2-$ and $-X^2-$; wherein:

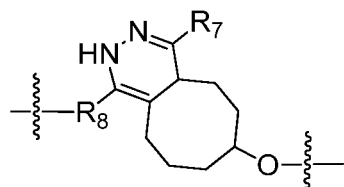
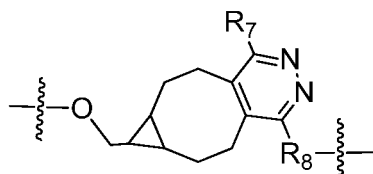
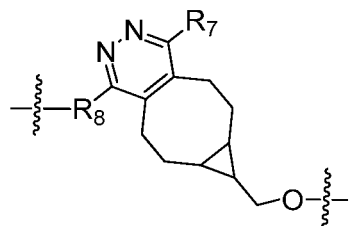
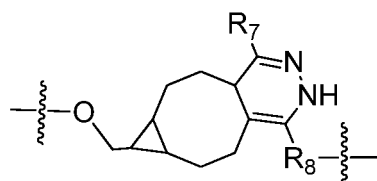
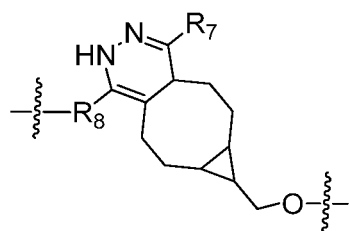
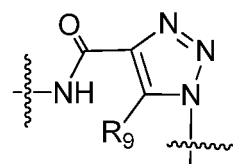
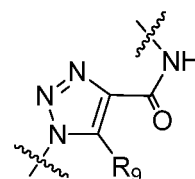
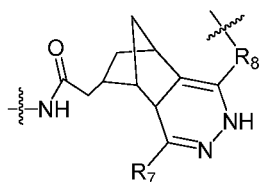
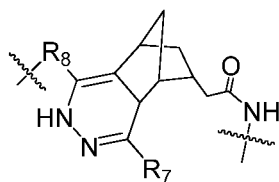
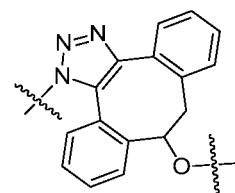
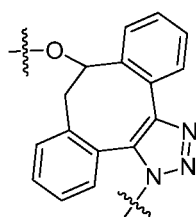
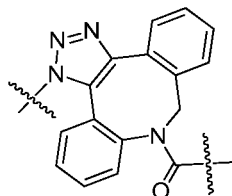
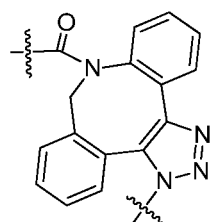
A_1 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_n-$, $-(O(CH_2)_n)_m-$, $-(O(C(R^4)_2)_n)_m-$, $-((CH_2)_nO)_m-$, $-((C(R^4)_2)_nO)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, $-(((C(R^4)_2)_nO)_mC(R^4)_2)_n-$, $-(CH_2)_nC(=O)NH-$, $-(C(R^4)_2)_nC(=O)NH-$, $-(CH_2)_nNHC(=O)-$, $-(C(R^4)_2)_nNHC(=O)-$, $-NHC(=O)(CH_2)_n-$, $-NHC(=O)(C(R^4)_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-C(=O)NH(C(R^4)_2)_nS-$, $-S(CH_2)_nC(=O)NH-$, $-S(C(R^4)_2)_nC(=O)NH-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-C(=O)(CH_2)_n-$, $-C(=O)(C(R^4)_2)_n-$, $-(CH_2)_nC(=O)-$, $-(C(R^4)_2)_nC(=O)-$, $-(CH_2)_n(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$, $-(C(R^4)_2)_n(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNHC(=O)(CH_2)_n-$, $-(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$

, $-(C(R^4)_2)_nNH((C(R^4)_2)_nO)_m(C(R^4)_2)_n-$, $-(O(CH_2)_n)NHC(=O)(CH_2)_n-$,
or $-(O(C(R^4)_2)_n)NHC(=O)(C(R^4)_2)_n-$;



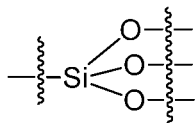
each X^2 is independently selected from a bond, R^8 ,





5

-S-, -Si(OH)₂O-,



, $-\text{CHR}^4(\text{CH}_2)_n\text{C}(=\text{O})\text{NH}-$, $-\text{CHR}^4(\text{CH}_2)_n\text{NHC}(=\text{O})-$, $-\text{C}(=\text{O})\text{NH}-$ and $-\text{NHC}(=\text{O})-$;

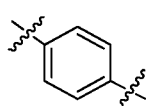
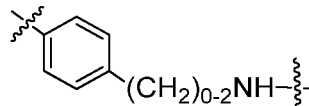
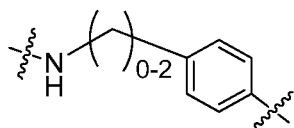
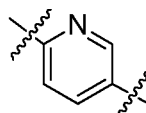
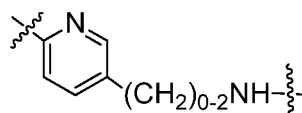
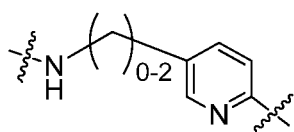
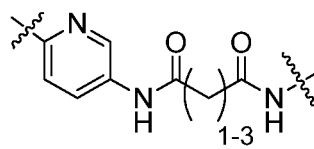
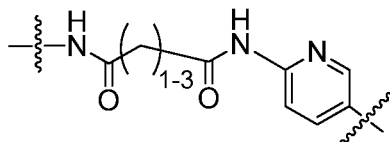
each R^4 is independently selected from H, C_{1-4} alkyl, side chains of known amino acids, $-\text{C}(=\text{O})\text{OH}$ and $-\text{OH}$,

5 each R^5 is independently selected from H, C_{1-4} alkyl, phenyl or C_{1-4} alkyl substituted with 1 to 3 $-\text{OH}$ groups;

each R^6 is independently selected from H, fluoro, benzyloxy substituted with $-\text{C}(=\text{O})\text{OH}$, benzyl substituted with $-\text{C}(=\text{O})\text{OH}$, C_{1-4} alkoxy substituted with $-\text{C}(=\text{O})\text{OH}$ and C_{1-4} alkyl substituted with $-\text{C}(=\text{O})\text{OH}$;

10 R^7 is independently selected from H, C_{1-4} alkyl, phenyl, pyrimidine and pyridine;

R^8 is independently selected



;

15 R^9 is independently selected from H and C_{1-6} haloalkyl;

each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and

each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9.

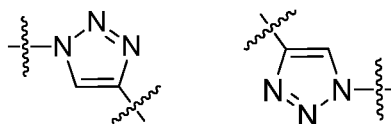
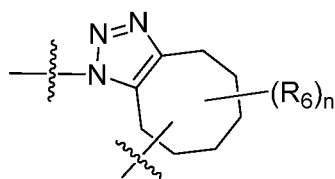
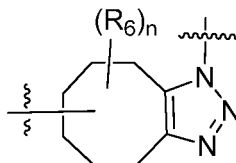
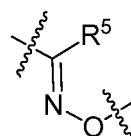
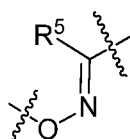
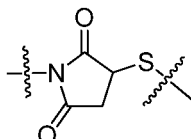
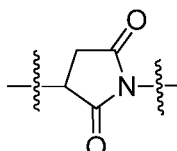
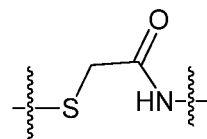
In these embodiments, the other linkers of LU are independently selected from a bond, $-A^1-$, $-A_1X^2-$, $-X^2-$, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker and a linker that comprises a self-immolative spacer.

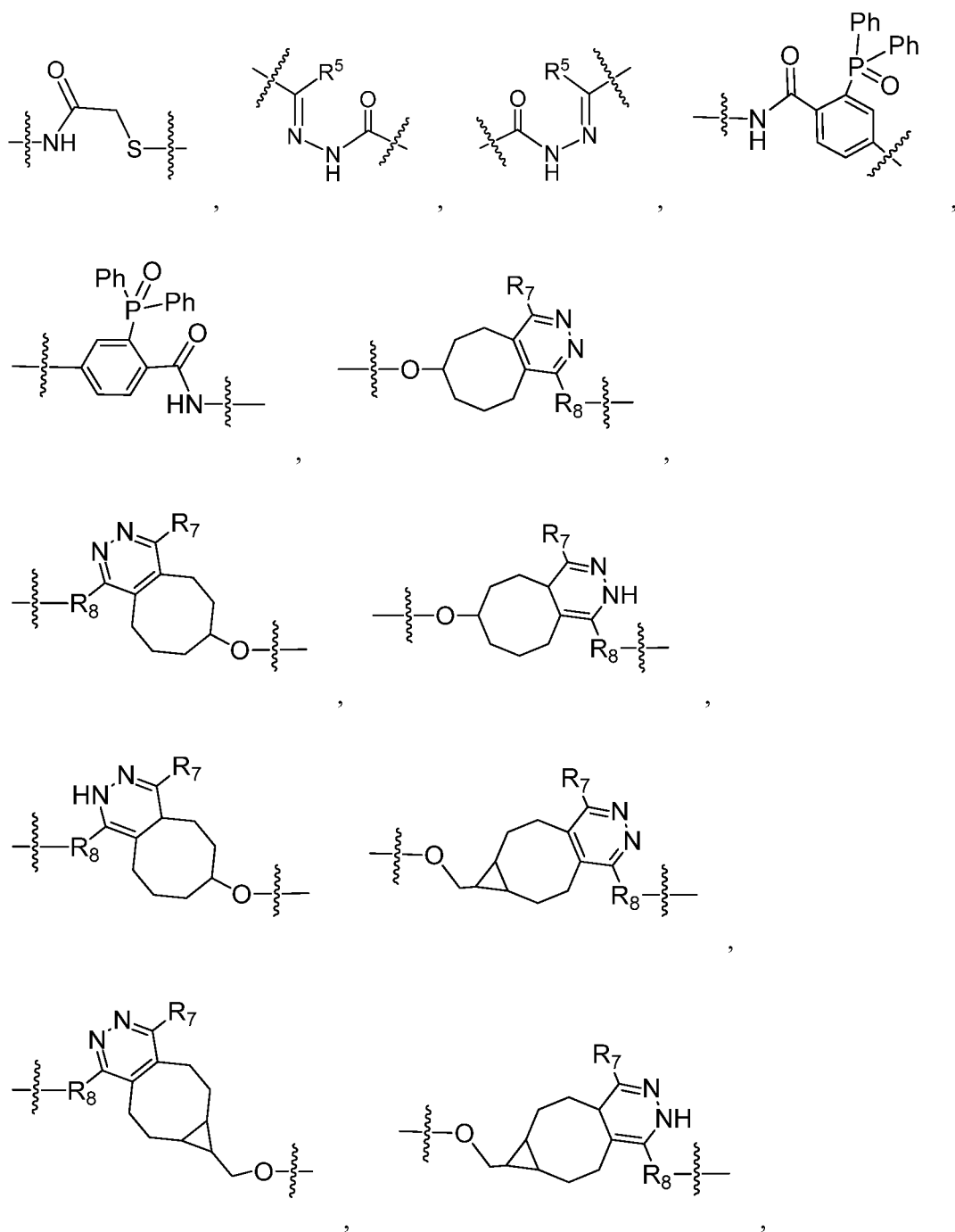
5 In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

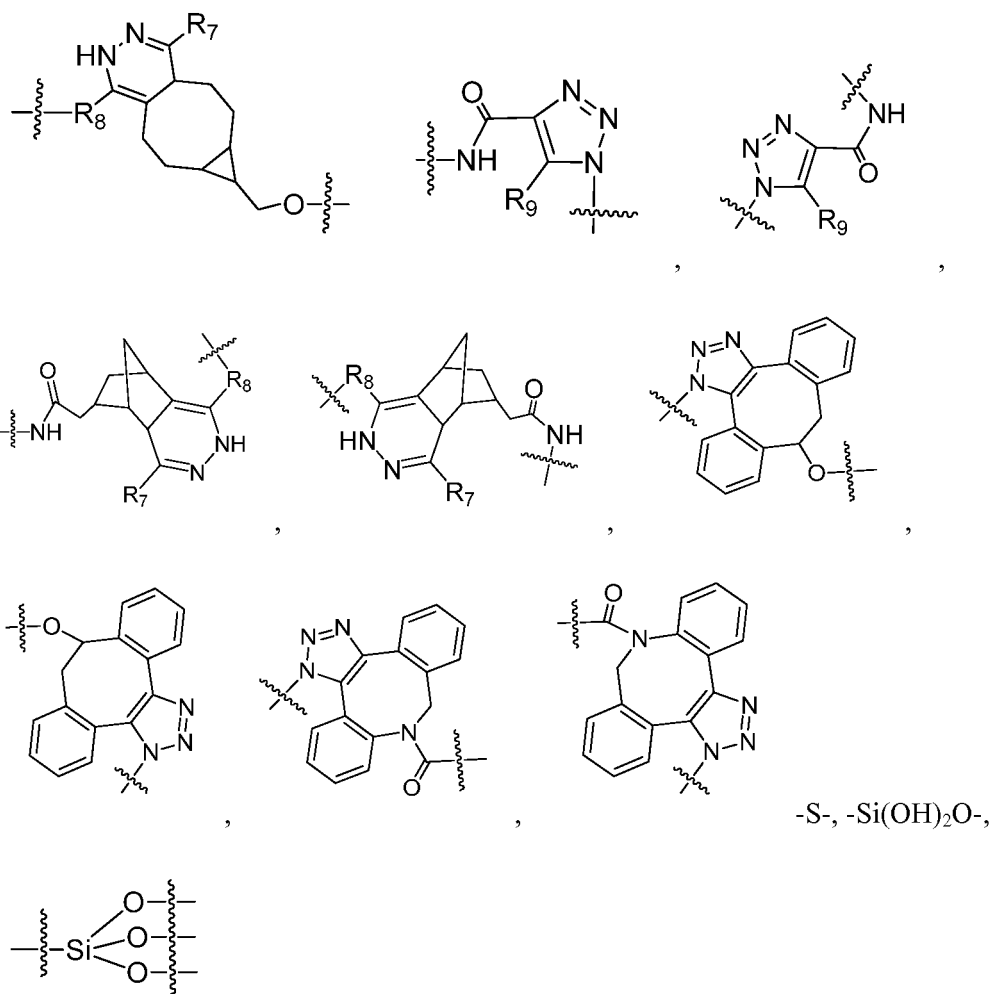
L_1 is a bond, $-A_1-$, $-A_1X^2-$ or $-X^2-$; where:

A_1 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_n-$, $-(O(CH_2)_n)_m-$, $-(O(C(R^4)_2)_n)_m-$, $-((CH_2)_nO)_m-$, $-((C(R^4)_2)_nO)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, $-(((C(R^4)_2)_nO)_mC(R^4)_2)_n-$, $-(CH_2)_nC(=O)NH-$, $-(C(R^4)_2)_nC(=O)NH-$, $-(CH_2)_nNHC(=O)-$, $-(C(R^4)_2)_nNHC(=O)-$, $-NHC(=O)(CH_2)_n-$, $-NHC(=O)(C(R^4)_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-C(=O)NH(C(R^4)_2)_nS-$, $-S(CH_2)_nC(=O)NH-$, $-S(C(R^4)_2)_nC(=O)NH-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-C(=O)(CH_2)_n-$, $-C(=O)(C(R^4)_2)_n-$, $-(CH_2)_nC(=O)-$, $-(C(R^4)_2)_nC(=O)-$, $-(CH_2)_n(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$, $-(C(R^4)_2)_n(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNHC(=O)(CH_2)_n-$, $-(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$, $-(C(R^4)_2)_nNH((C(R^4)_2)_nO)_m(C(R^4)_2)_n-$, $-(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$, or $-(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$;

each X^2 is independently selected from a bond, R^8







-S-, -Si(OH)₂O-,

, -CHR⁴(CH₂)_nC(=O)NH-, -CHR⁴(CH₂)_nNHC(=O)-, -C(=O)NH- and -

5 NHC(=O)-;

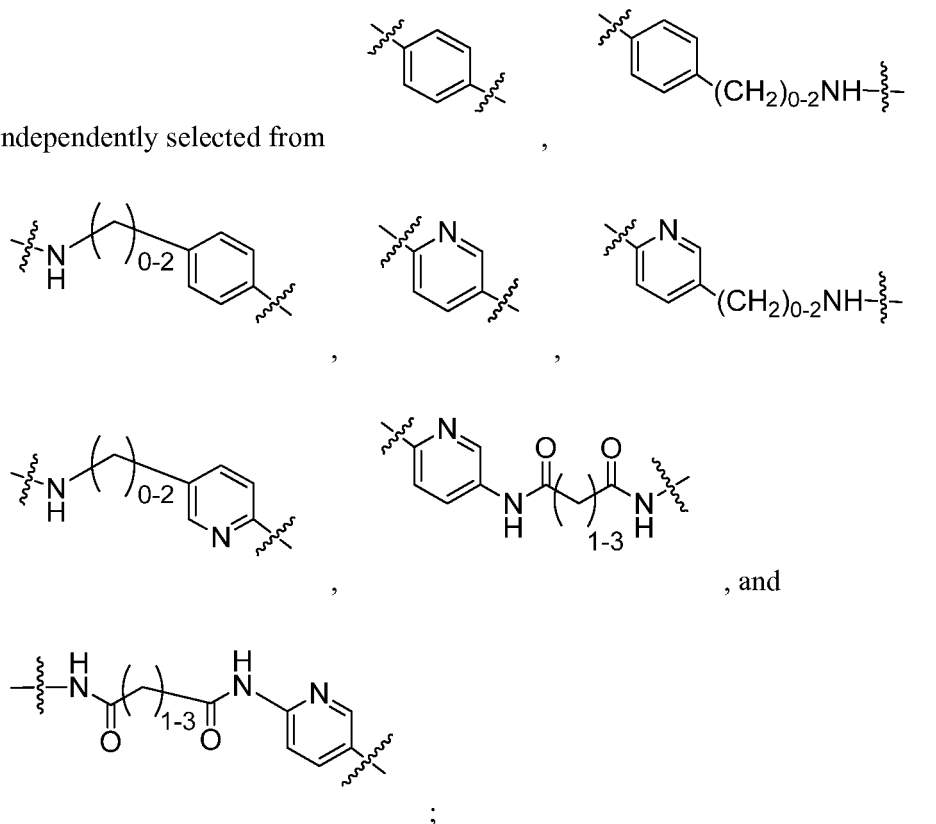
each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,

each R⁵ is independently selected from H, C₁₋₄alkyl, phenyl or C₁₋₄alkyl substituted with 1 to 3 -OH groups;

10 each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;

R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;

R^8 is independently selected from



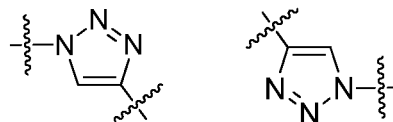
- 5 R^9 is independently selected from H and C_{1-6} haloalkyl;
 each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and
 each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9;
- L_2 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;
- 10 L_3 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker, and
- L_4 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or a linker that comprises a self-immolative spacer.
- 15 In certain embodiments, L_1 is $C(=O)-CH_2CH_2-NH-C(=O)-CH_2CH_2-S-$, so LU is $-C(=O)-CH_2CH_2-NH-C(=O)-CH_2CH_2-S-L_2-L_3-L_4-$.

In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

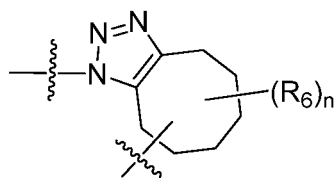
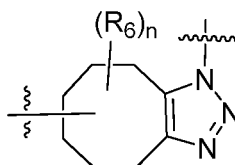
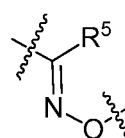
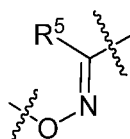
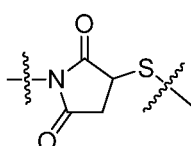
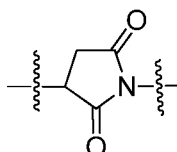
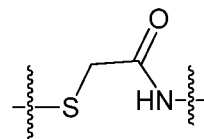
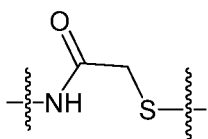
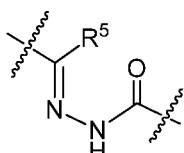
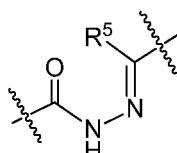
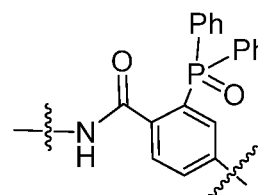
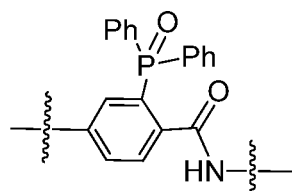
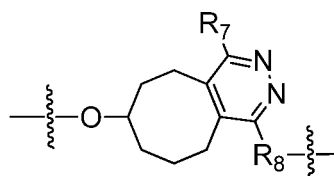
L_1 is a bond, $-A_1-$, $-A_1X^2-$ or $-X^2-$; where:

A₁ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
 (CH₂)_nC(=O)NH-, -(CH₂)_nNHC(=O)-, -NHC(=O)(CH₂)_n-, -C(=O)NH(CH₂)_nS-, -
 S(CH₂)_nC(=O)NH-, -C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -C(=O)(CH₂)_n-, -(CH₂)_nC(=O)-, -
 (CH₂)_n(O(CH₂)_n)_mNHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)(CH₂)_n-, -
 (CH₂)_nNH((CH₂)_nO)_m(CH₂)_n-, or -(O(CH₂)_n)_mNHC(=O)(CH₂)_n-;

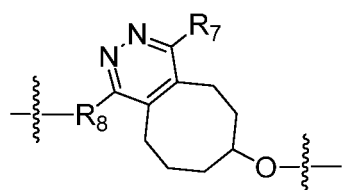
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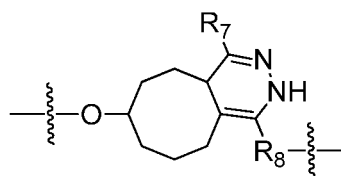
each X² is independently selected from a bond, R⁸



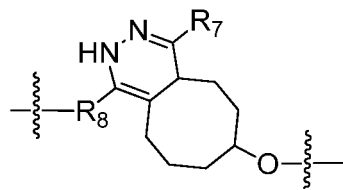
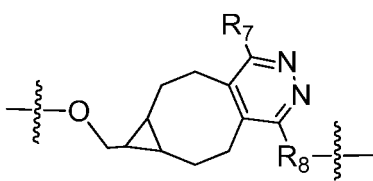
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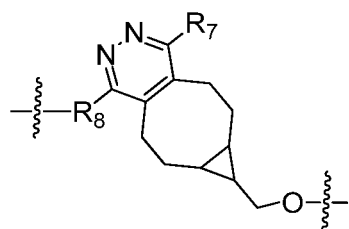
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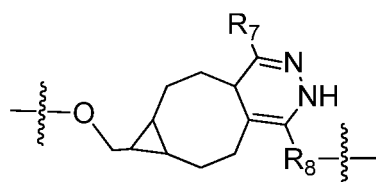
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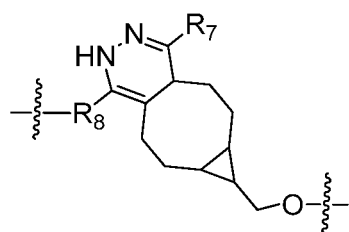
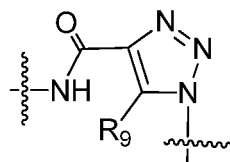
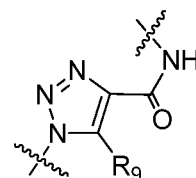
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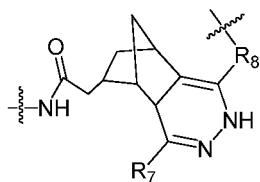


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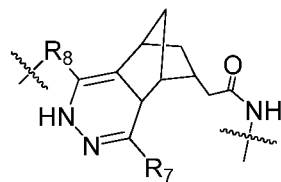


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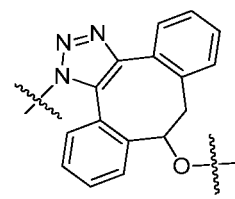
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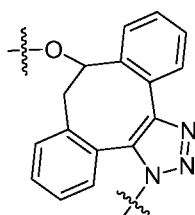
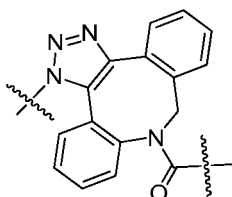
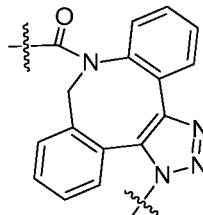
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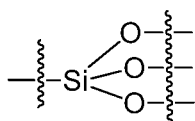
,



,



-S-, -Si(OH)₂O-,



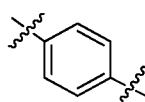
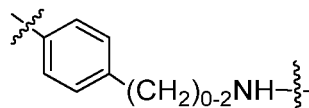
, -CHR⁴(CH₂)_nC(=O)NH-, -CHR⁴(CH₂)_nNHC(=O)-, -C(=O)NH- and -NHC(=O)-;

each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,

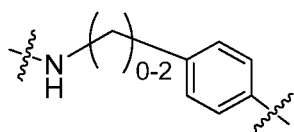
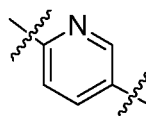
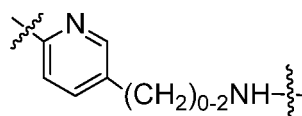
each R⁵ is independently selected from H, C₁₋₄alkyl, phenyl or C₁₋₄alkyl substituted with 1 to 3 -OH groups;

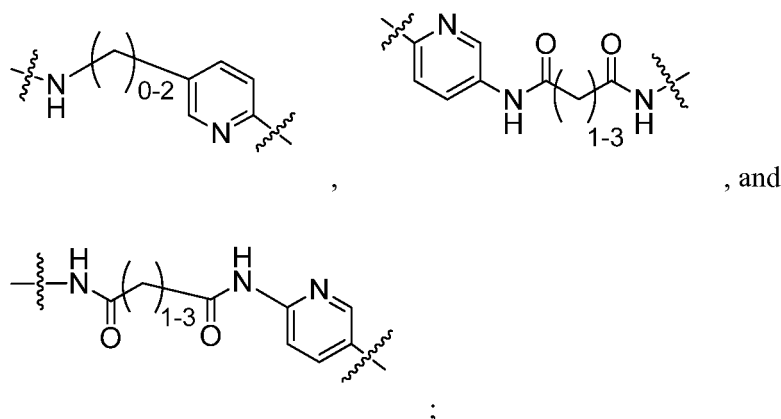
each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;

R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;



R⁸ is independently selected





R^9 is independently selected from H and C_{1-6} haloalkyl;

each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and

5 each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9;

L_2 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;

L_3 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;

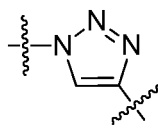
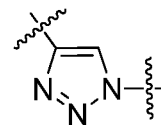
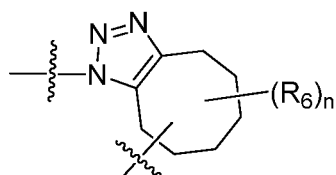
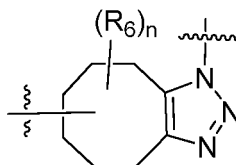
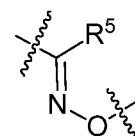
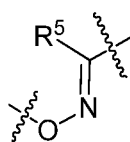
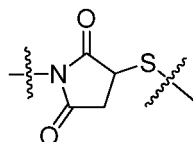
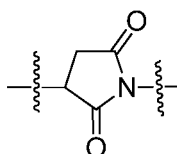
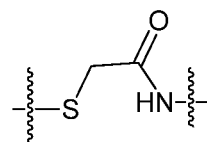
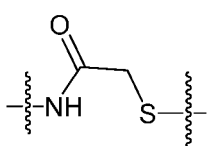
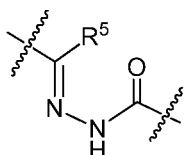
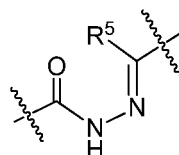
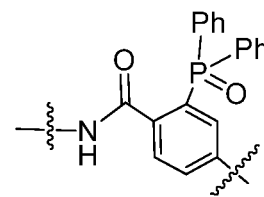
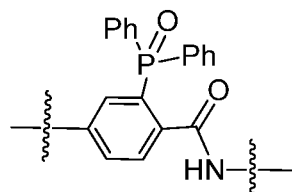
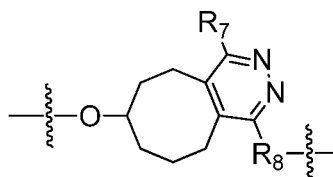
10 L_4 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or a linker that comprises a self-immolative spacer.

In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

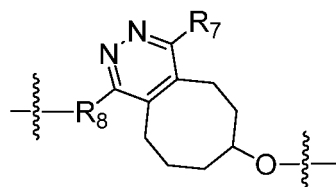
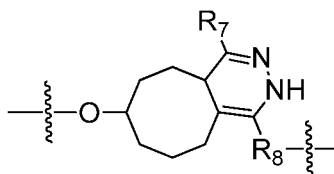
L_1 is a bond, $-A_1-$, $-A_1X^2-$ or $-X^2-$; where:

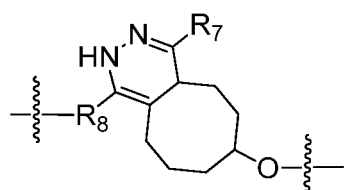
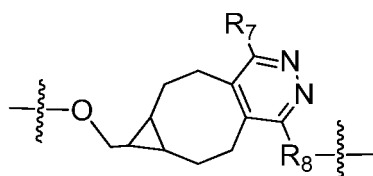
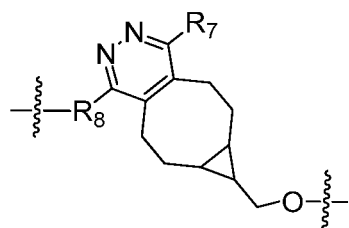
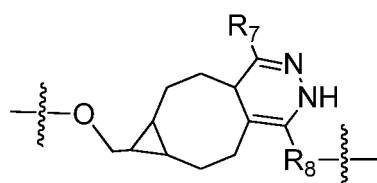
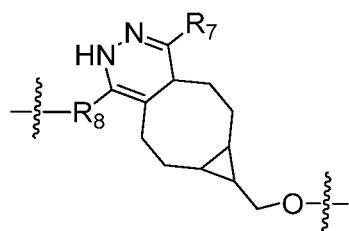
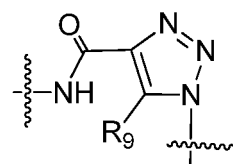
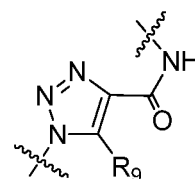
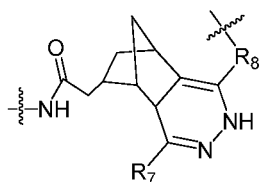
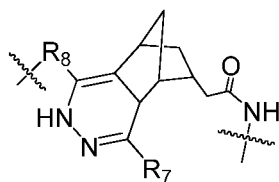
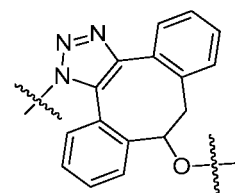
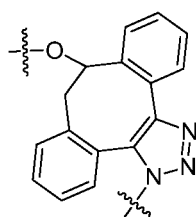
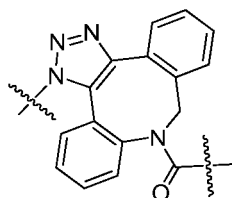
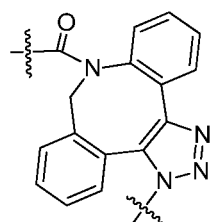
15 A_1 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-(O(CH_2)_n)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, $-NHC(=O)(CH_2)_n-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$, $-(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$ or $-(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$;

each X^2 is independently selected from a bond, R^8



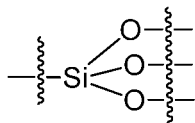
5





5

-S-, -Si(OH)₂O-,



, $-\text{CHR}^4(\text{CH}_2)_n\text{C}(=\text{O})\text{NH}-$, $-\text{CHR}^4(\text{CH}_2)_n\text{NHC}(=\text{O})-$, $-\text{C}(=\text{O})\text{NH}-$ and $-\text{NHC}(=\text{O})-$;

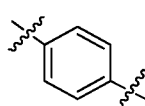
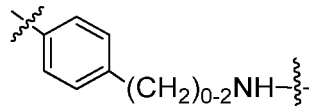
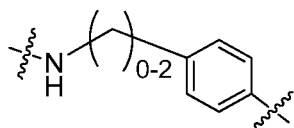
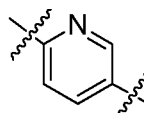
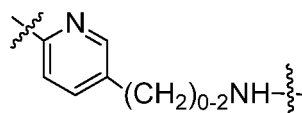
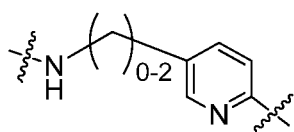
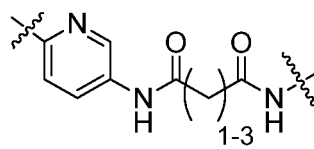
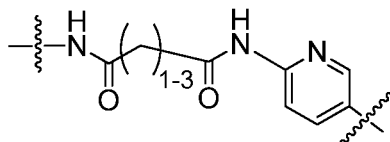
each R^4 is independently selected from H, C_{1-4} alkyl, side chains of known amino acids, $-\text{C}(=\text{O})\text{OH}$ and $-\text{OH}$,

5 each R^5 is independently selected from H, C_{1-4} alkyl, phenyl or C_{1-4} alkyl substituted with 1 to 3 $-\text{OH}$ groups;

each R^6 is independently selected from H, fluoro, benzyloxy substituted with $-\text{C}(=\text{O})\text{OH}$, benzyl substituted with $-\text{C}(=\text{O})\text{OH}$, C_{1-4} alkoxy substituted with $-\text{C}(=\text{O})\text{OH}$ and C_{1-4} alkyl substituted with $-\text{C}(=\text{O})\text{OH}$;

10 R^7 is independently selected from H, C_{1-4} alkyl, phenyl, pyrimidine and pyridine;

R^8 is independently selected



;

15 R^9 is independently selected from H and C_{1-6} haloalkyl;

each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and

each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9;

L_2 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker;

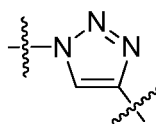
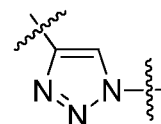
L_3 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker or a photo-cleavable linker, and

5 L_4 is a bond, a non-enzymatically cleavable linker, a non-cleavable linker, an enzymatically cleavable linker, a photo-stable linker, a photo-cleavable linker or a linker that comprises a self-immolative spacer.

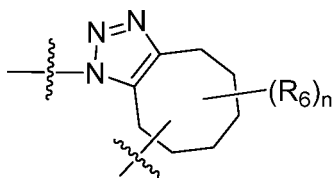
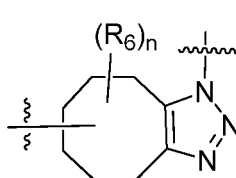
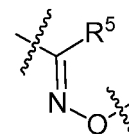
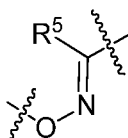
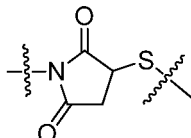
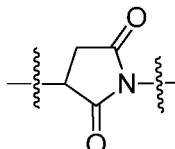
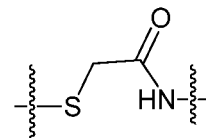
In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

L_1 is a bond, $-A_1-$, $-A_1X^2-$ or $-X^2-$; where:

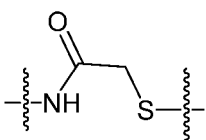
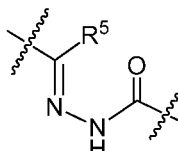
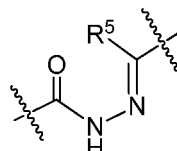
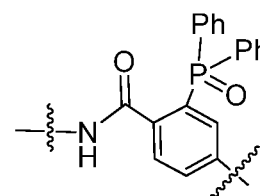
10 A_1 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-(O(CH_2)_n)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, $-NHC(=O)(CH_2)_n-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$, $-(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$ or $-(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$;

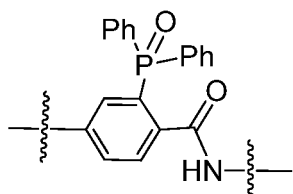
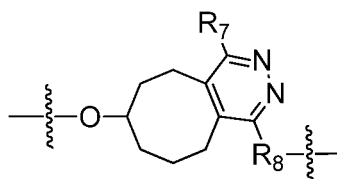
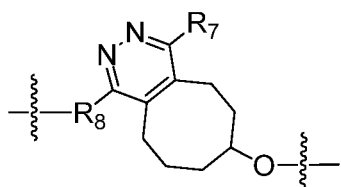
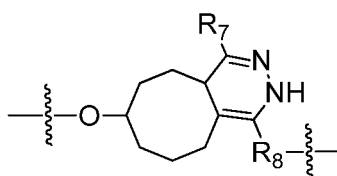
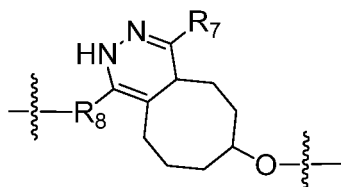
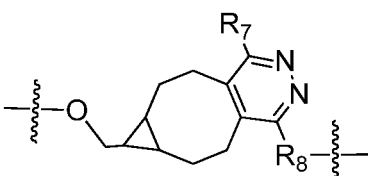
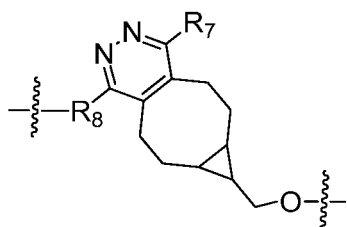
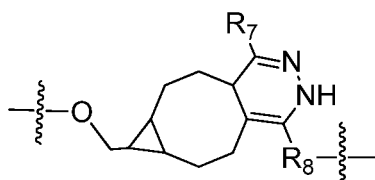
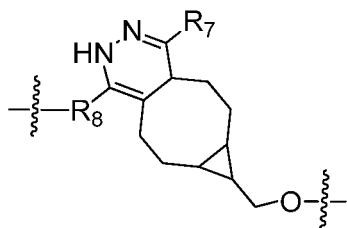
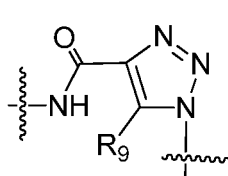
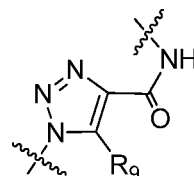


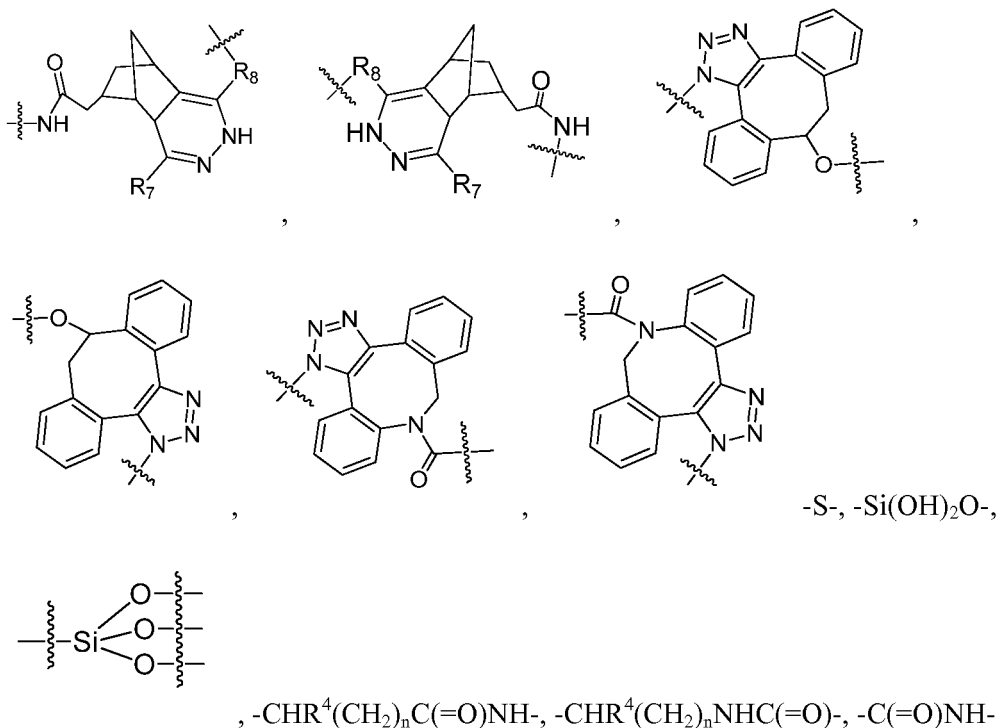
each X^2 is independently selected from a bond, R^8



15







NHC(=O)-;

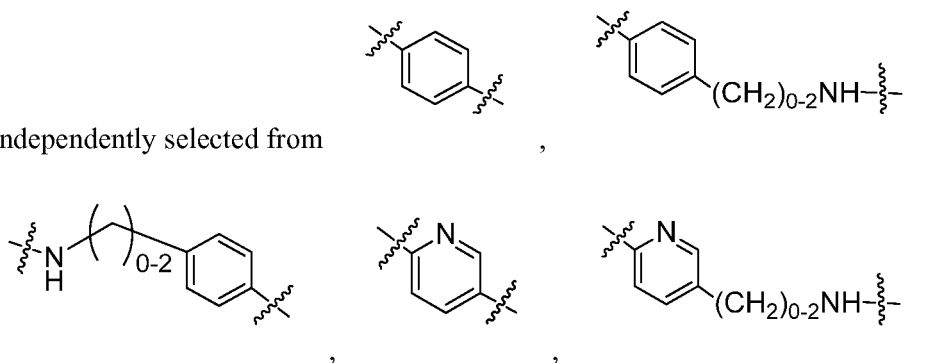
5 each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,

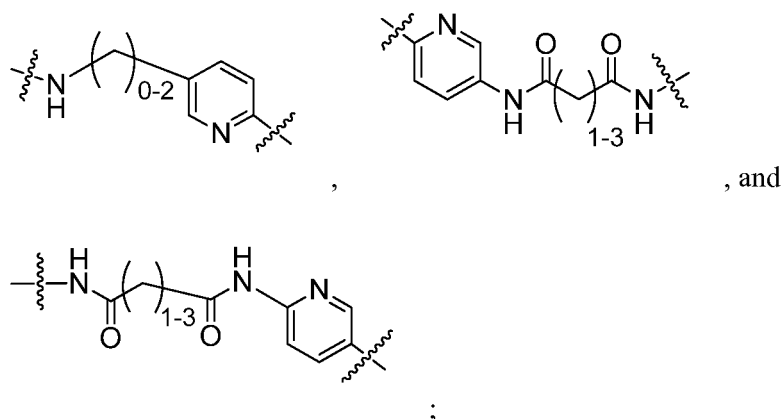
each R⁵ is independently selected from H, C₁₋₄alkyl, phenyl or C₁₋₄alkyl substituted with 1 to 3 -OH groups;

10 each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;

R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;

R⁸ is independently selected from





R^9 is independently selected from H and C_{1-6} haloalkyl;

each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and

5 each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9;

L_2 is a bond, a non-enzymatically cleavable linker or a non-cleavable linker;

L_3 is a bond, a non-enzymatically cleavable linker or a non-cleavable linker;

L_4 is a bond, an enzymatically cleavable linker or a linker that comprises a self-immolative spacer.

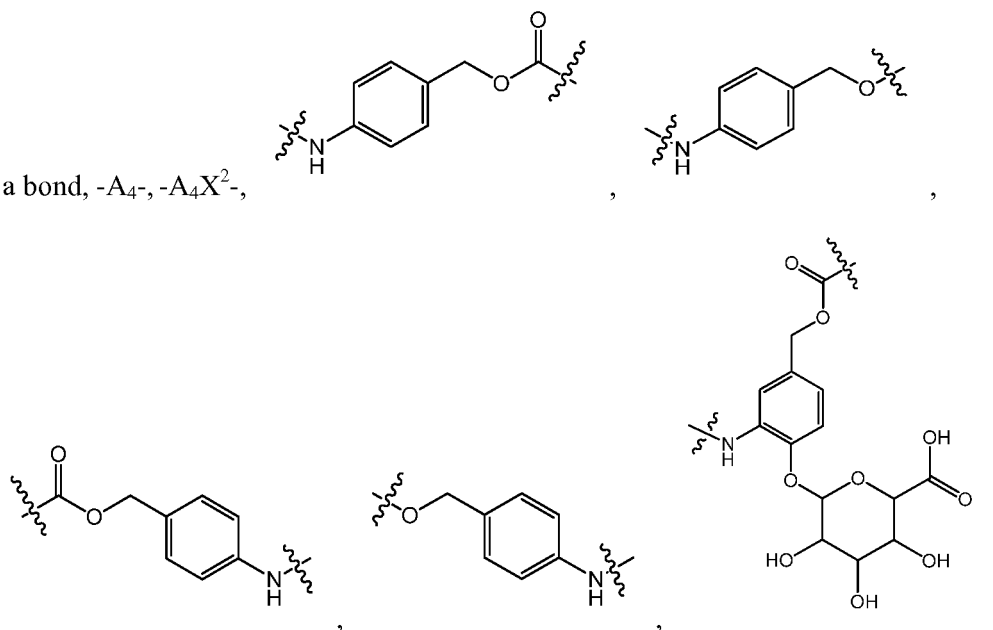
In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

10 L_1 is a bond, $-A_1-$, $-A_1X^2-$ or $-X^2-$;

L_2 is a bond, $-A_2-$, or $-A_2X^2-$;

L_3 is a bond, $-A_3-$, or $-A_3X^2-$;

L_4 is a bond, $-A_4-$, $-A_4X^2-$,

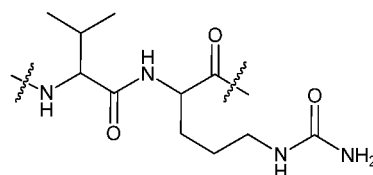




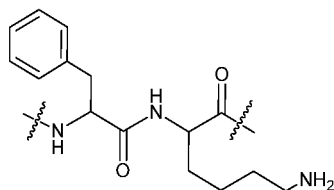
10

15

$(C(R^4)_2)_n C(=O)NR^4$ -, $-(CH_2)_n NHC(=O)$ -, $-(C(R^4)_2)_n NHC(=O)$ -, $-NHC(=O)(CH_2)_n$ -,
 $-NHC(=O)(C(R^4)_2)_n$ -, $-C(=O)NH(CH_2)_n S$ -, $-C(=O)NH(C(R^4)_2)_n S$ -, $-S(CH_2)_n C(=O)NH$ -,
 $-S(C(R^4)_2)_n C(=O)NH$ -, $-(CH_2)_n S$ -, $-(C(R^4)_2)_n S$ -, $-S(CH_2)_n$ -, $-S(C(R^4)_2)_n$ -, $-(CH_2)_n NH$ -, $-(C(R^4)_2)_n NH$ -,
 $-C(=O)NH(CH_2)_n NHC(=O)(CH_2)_n$ -, $-C(=O)NH(C(R^4)_2)_n NHC(=O)(C(R^4)_2)_n$ -, $-C(=O)(CH_2)_n$ -,
 $-C(=O)(C(R^4)_2)_n$ -, $-(CH_2)_n C(=O)$ -, $-(C(R^4)_2)_n C(=O)$ -, $-(CH_2)_n (O(CH_2)_m)_n NHC(=O)(CH_2)_n$ -,
 $-(C(R^4)_2)_n (O(C(R^4)_2)_m)_n NHC(=O)(C(R^4)_2)_n$ -, $-(CH_2)_n (O(CH_2)_m)_n OC(=O)NH(CH_2)_n$ -,
 $-(C(R^4)_2)_n (O(C(R^4)_2)_m)_n OC(=O)NH(C(R^4)_2)_n$ -, $-(CH_2)_n NHC(=O)(CH_2)_n$ -,
 $-(C(R^4)_2)_n NHC(=O)(C(R^4)_2)_n$ -, $-(CH_2)_n NH((CH_2)_n O)_m (CH_2)_n$ -, $-(C(R^4)_2)_n NH((C(R^4)_2)_n O)_m (C(R^4)_2)_n$ -,

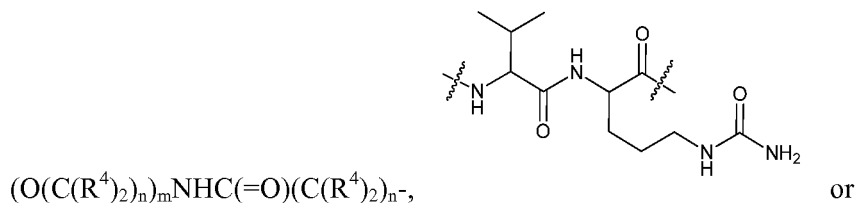
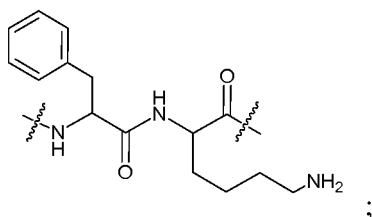


$(O(CH_2)_m)_n NHC(=O)(CH_2)_n$ -, $-(O(C(R^4)_2)_m)_n NHC(=O)(C(R^4)_2)_n$ -,

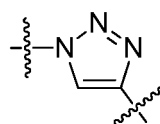
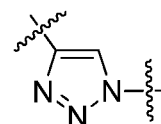


10 or;

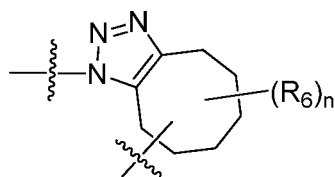
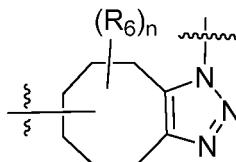
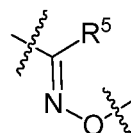
A_3 is $-C(=O)NH$ -, $-C(=O)NH(CH_2)_n$ -, $-C(=O)NH(C(R^4)_2)_n$ -, $-(O(CH_2)_m)_n$ -, $-(O(C(R^4)_2)_m)_n$ -,
 $-((CH_2)_n O)_m$ -, $-((C(R^4)_2)_n O)_m$ -, $-((CH_2)_n O)_m (CH_2)_n$ -, $-(((C(R^4)_2)_n O)_m C(R^4)_2)_n$ -, $-(CH_2)_n C(=O)NH$ -,
 $-(C(R^4)_2)_n C(=O)NH$ -, $-(CH_2)_n NHC(=O)$ -, $-(C(R^4)_2)_n NHC(=O)$ -, $-NHC(=O)(CH_2)_n$ -,
 $-NHC(=O)(C(R^4)_2)_n$ -, $-C(=O)NH(CH_2)_n S$ -, $-C(=O)NH(C(R^4)_2)_n S$ -, $-S(CH_2)_n C(=O)NH$ -,
 $-S(C(R^4)_2)_n C(=O)NH$ -, $-(CH_2)_n S$ -, $-(C(R^4)_2)_n S$ -, $-S(CH_2)_n$ -, $-S(C(R^4)_2)_n$ -,
 $-C(=O)NH(CH_2)_n NHC(=O)(CH_2)_n$ -, $-C(=O)NH(C(R^4)_2)_n NHC(=O)(C(R^4)_2)_n$ -, $-C(=O)(CH_2)_n$ -,
 $-C(=O)(C(R^4)_2)_n$ -, $-(CH_2)_n C(=O)$ -, $-(C(R^4)_2)_n C(=O)$ -, $-(CH_2)_n (O(CH_2)_m)_n NHC(=O)(CH_2)_n$ -,
 $-(C(R^4)_2)_n (O(C(R^4)_2)_m)_n NHC(=O)(C(R^4)_2)_n$ -, $-(CH_2)_n (O(CH_2)_m)_n OC(=O)NH(CH_2)_n$ -,
 $-(C(R^4)_2)_n (O(C(R^4)_2)_m)_n OC(=O)NH(C(R^4)_2)_n$ -, $-(CH_2)_n (O(CH_2)_m)_n OC(=O)$ -,
 $-(C(R^4)_2)_n (O(C(R^4)_2)_m)_n OC(=O)$ -, $-(CH_2)_n (O(CH_2)_m)_n C(=O)$ -, $-(C(R^4)_2)_n (O(C(R^4)_2)_m)_n C(=O)$ -,
 $-(CH_2)_n NHC(=O)(CH_2)_n$ -, $-(C(R^4)_2)_n NHC(=O)(C(R^4)_2)_n$ -, $-(O(CH_2)_m)_n NHC(=O)(CH_2)_n$ -,

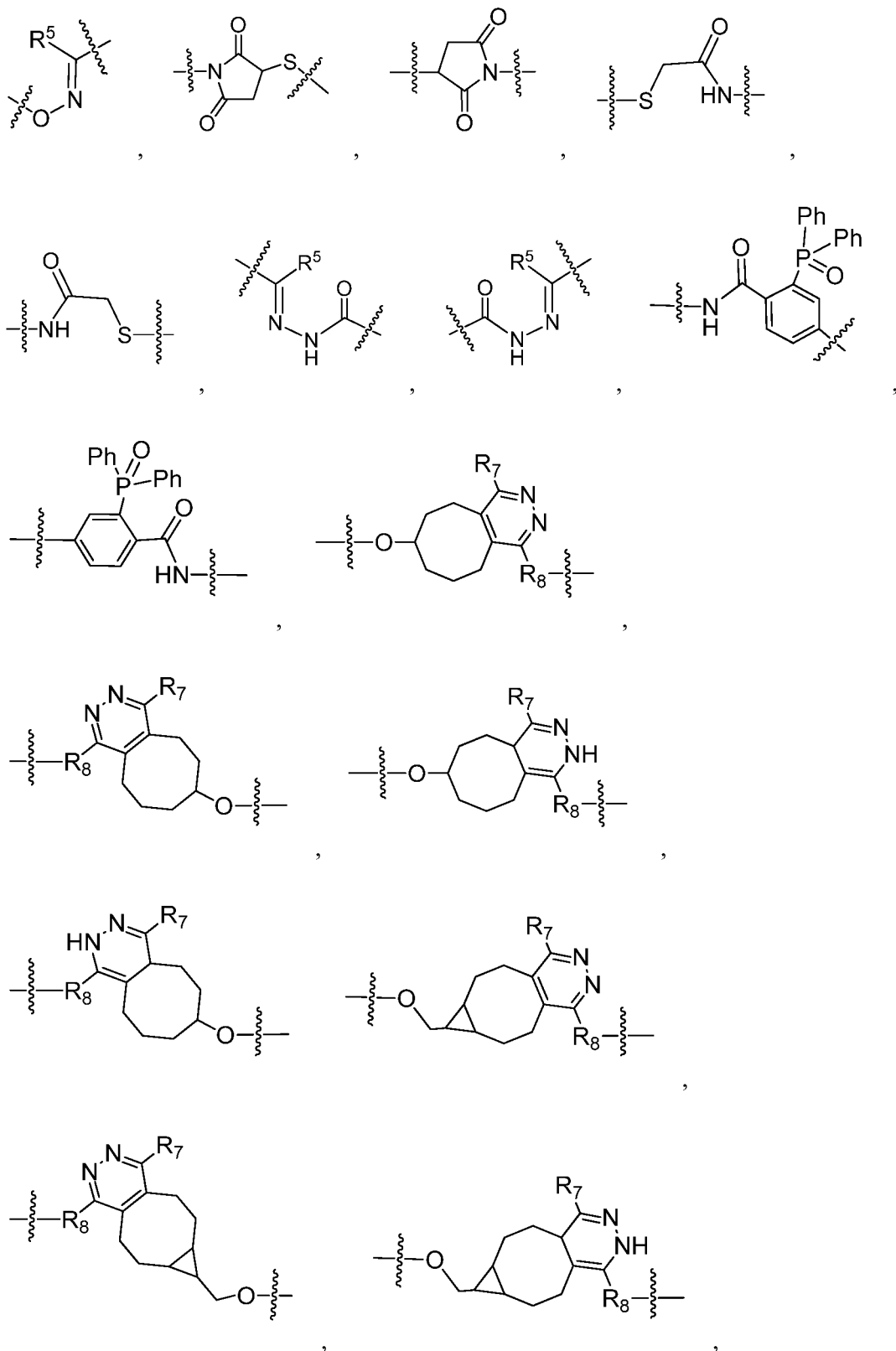


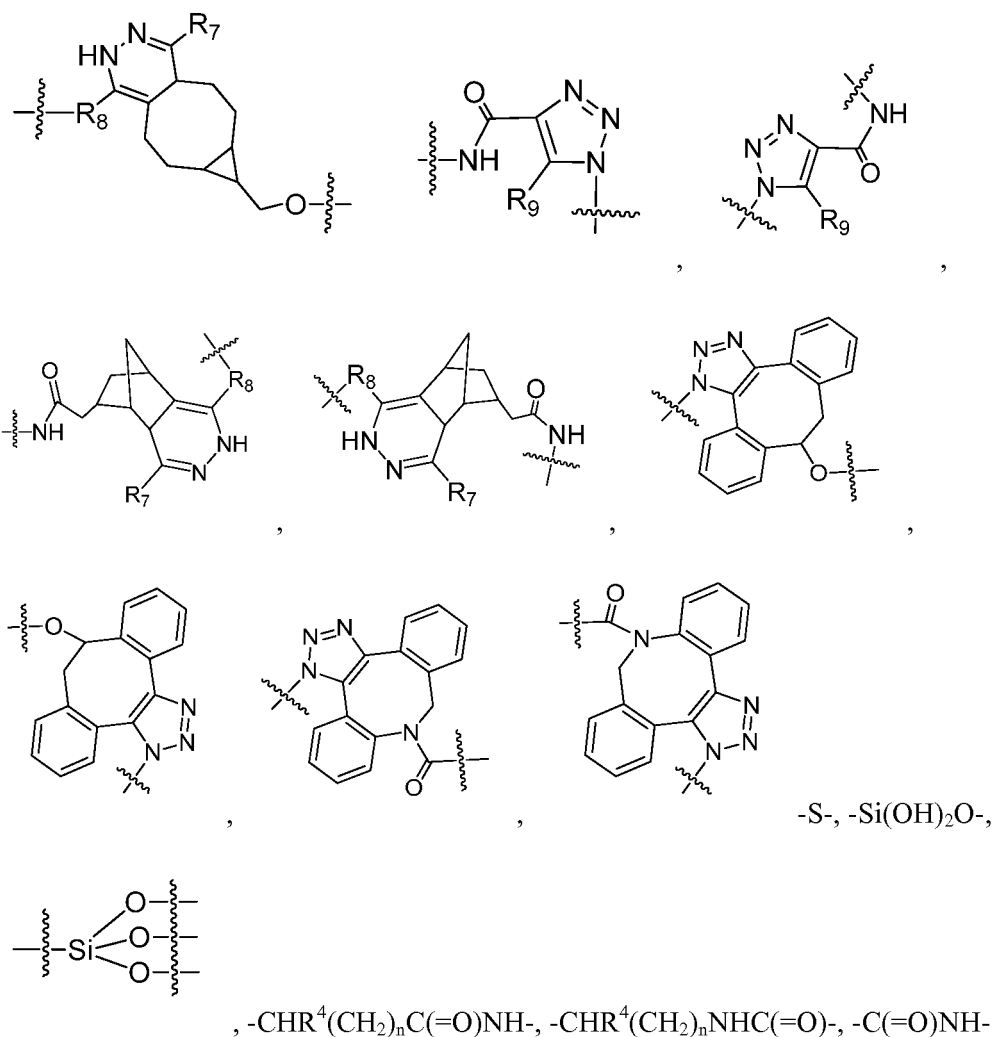
- A_4 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_n-$, $-(O(CH_2)_n)_m-$, $-(O(C(R^4)_2)_n)_m-$, $-((CH_2)_nO)_m-$, $-((C(R^4)_2)_nO)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, $-(((C(R^4)_2)_nO)_mC(R^4)_2)_n-$, $-(CH_2)_nC(=O)NH-$, $-(C(R^4)_2)_nC(=O)NH-$, $-(CH_2)_nNHC(=O)-$, $-(C(R^4)_2)_nNHC(=O)-$, $-NHC(=O)(CH_2)_n-$, $-NHC(=O)(C(R^4)_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-C(=O)NH(C(R^4)_2)_nS-$, $-S(CH_2)_nC(=O)NH-$, $-S(C(R^4)_2)_nC(=O)NH-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$, $-C(=O)NH(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-C(=O)(CH_2)_n-$, $-C(=O)(C(R^4)_2)_n-$, $-(CH_2)_nC(=O)-$, $-(C(R^4)_2)_nC(=O)-$, $-(CH_2)_n(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$, $-(C(R^4)_2)_n(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNHC(=O)(CH_2)_n-$, $-(C(R^4)_2)_nNHC(=O)(C(R^4)_2)_n-$, $-(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$, $-(C(R^4)_2)_nNH((C(R^4)_2)_nO)_m(C(R^4)_2)_n-$, $-(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$, or $-(O(C(R^4)_2)_n)_mNHC(=O)(C(R^4)_2)_n-$;



each X^2 is independently selected from a bond, R^8







5 NHC(=O)-;

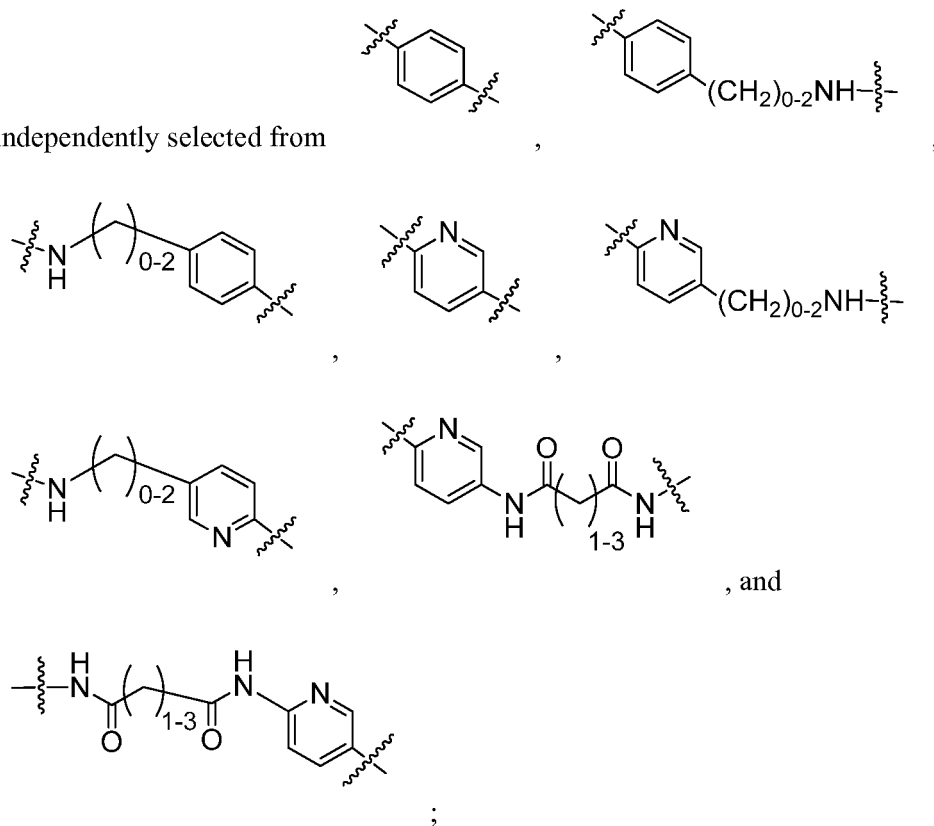
each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,

each R⁵ is independently selected from H, C₁₋₄alkyl, phenyl or C₁₋₄alkyl substituted with 1 to 3 -OH groups;

10 each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;

R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;

R^8 is independently selected from



- 5 R^9 is independently selected from H and C₁₋₆haloalkyl;
 each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and
 each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9.

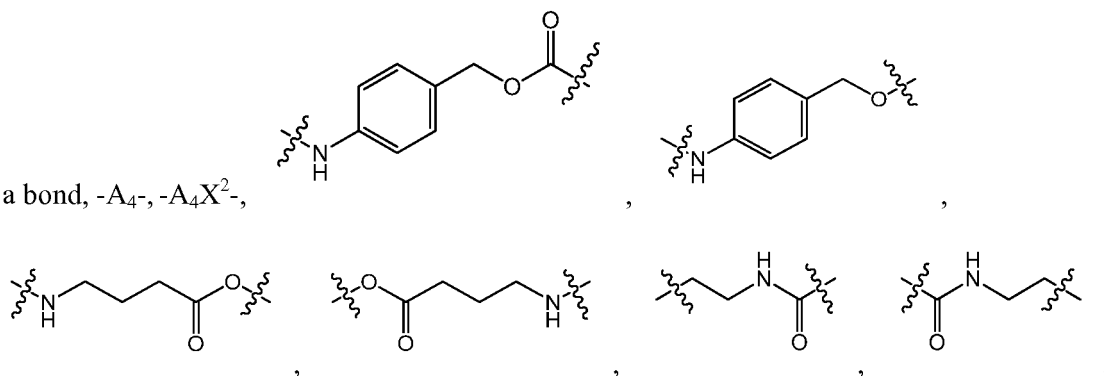
In certain embodiments the Linker Unit (LU) is -L₁-L₂-L₃-L₄-, wherein

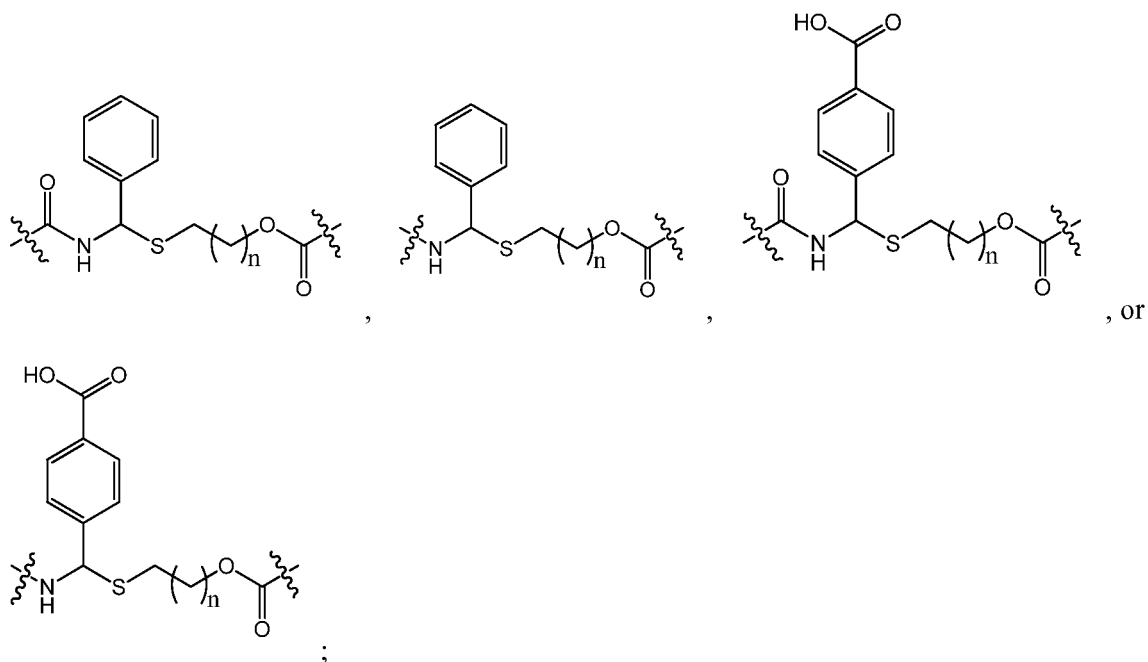
L₁ is a bond, -A₁-, -A₁X²- or -X²-;

- 10 L₂ is a bond, -A₂-, or -A₂X²-;

L₃ is a bond, -A₃-, or -A₃X²-;

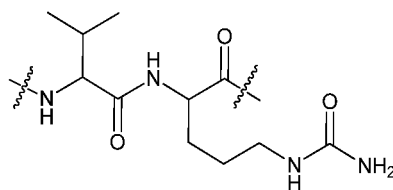
L₄ is a bond, -A₄-, -A₄X²-,





A₁ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
 (CH₂)_nC(=O)NH-, -NHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)-, -C(=O)NH(CH₂)_nS-, -S(CH₂)_nC(=O)NH-, -
 5 C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -C(=O)(CH₂)_n-, -(CH₂)_nC(=O)-, -
 (CH₂)_n(O(CH₂)_n)_mNHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)(CH₂)_n-, -(CH₂)_nNH((CH₂)_nO)_m(CH₂)_n- or -
 (O(CH₂)_n)_mNHC(=O)(CH₂)_n-;

A₂ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
 (CH₂)_nC(=O)NH-, -NHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)-, -C(=O)NH(CH₂)_nS-, -S(CH₂)_nC(=O)NH-, -
 10 C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -C(=O)(CH₂)_n-, -(CH₂)_nC(=O)-, -
 (CH₂)_n(O(CH₂)_n)_mNHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)(CH₂)_n-, -(CH₂)_nNH((CH₂)_nO)_m(CH₂)_n-, -

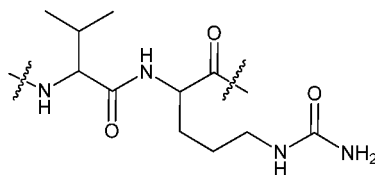


(O(CH₂)_n)_mNHC(=O)(CH₂)_n- or

;

A₃ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
 (CH₂)_nC(=O)NH-, -NHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)-, -C(=O)NH(CH₂)_nS-, -S(CH₂)_nC(=O)NH-, -
 15 C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -C(=O)(CH₂)_n-, -(CH₂)_nC(=O)-, -

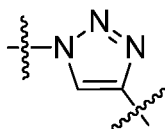
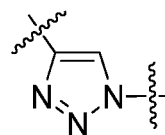
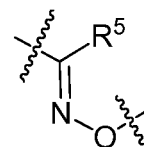
$(\text{CH}_2)_n(\text{O}(\text{CH}_2)_n)_m\text{NHC}(=\text{O})(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{NHC}(=\text{O})(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{NH}((\text{CH}_2)_n\text{O})_m(\text{CH}_2)_n$ -, -



$(\text{O}(\text{CH}_2)_n)_m\text{NHC}(=\text{O})(\text{CH}_2)_n$ - or

;

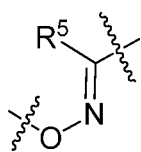
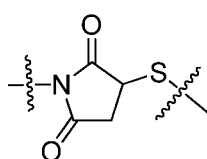
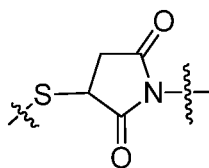
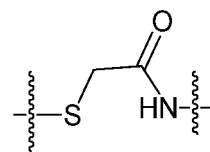
A₄ $-\text{C}(=\text{O})\text{NH}-$, $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n$ -, $-(\text{O}(\text{CH}_2)_n)_m$ -, $-((\text{CH}_2)_n\text{O})_m$ -, $-((\text{CH}_2)_n\text{O})_m(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{C}(=\text{O})\text{NH}-$,
 $-\text{NHC}(=\text{O})(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{NHC}(=\text{O})$ -, $-\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{S}-$, $-\text{S}(\text{CH}_2)_n\text{C}(=\text{O})\text{NH}-$, -
 5 $\text{C}(=\text{O})\text{NH}(\text{CH}_2)_n\text{NHC}(=\text{O})(\text{CH}_2)_n$ -, $-\text{C}(=\text{O})(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{C}(=\text{O})$ -, -
 $(\text{CH}_2)_n(\text{O}(\text{CH}_2)_n)_m\text{NHC}(=\text{O})(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{NHC}(=\text{O})(\text{CH}_2)_n$ -, $-(\text{CH}_2)_n\text{NH}((\text{CH}_2)_n\text{O})_m(\text{CH}_2)_n$ - or -
 $(\text{O}(\text{CH}_2)_n)_m\text{NHC}(=\text{O})(\text{CH}_2)_n$ -;



each X² is independently selected from a bond,

,

,



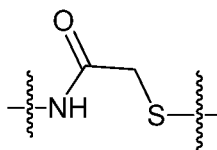
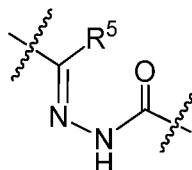
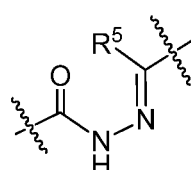
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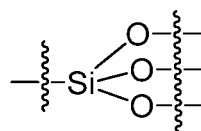


, -S-, -Si(OH)₂O-,

10

,

,



, -CHR⁴(CH₂)_nC(=O)NH-, -CHR⁴(CH₂)_nNHC(=O)-, -C(=O)NH- and -

NHC(=O)-;

each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,

each R^5 is independently selected from H, C_{1-4} alkyl, phenyl or C_{1-4} alkyl substituted with 1 to 3 -OH groups;

each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and

each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9.

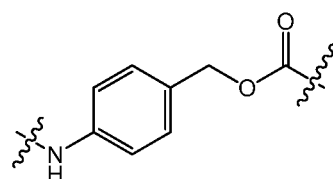
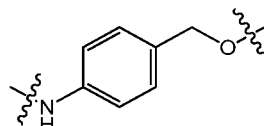
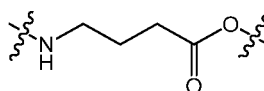
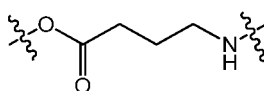
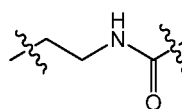
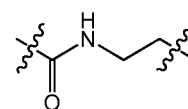
5 In certain embodiments the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, wherein

L_1 is a bond, $-A_1-$, $-A_1X^2-$ or $-X^2-$;

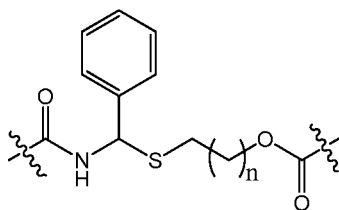
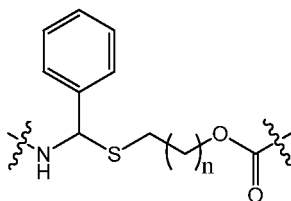
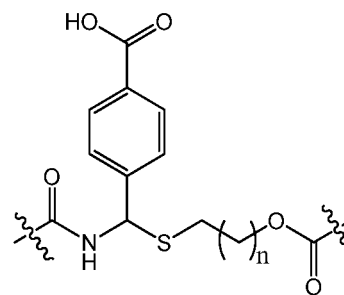
L_2 is a bond, $-A_2-$, or $-A_2X^2-$;

L_3 is a bond, $-A_3-$, or $-A_3X^2-$;

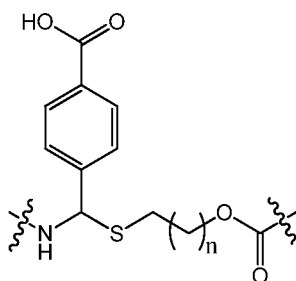
L_4 is a bond, $-A_4-$, $-A_4X^2-$,



10



, or



;

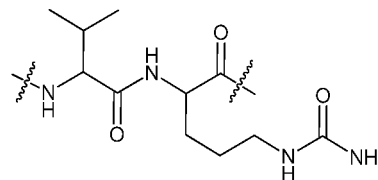
A_1 is $-C(=O)NH-$, $-C(=O)NH(CH_2)_n-$, $-C(=O)NH(CH_2)_nS-$, $-(O(CH_2)_n)_m-$, $-((CH_2)_nO)_m(CH_2)_n-$, -

$NHC(=O)(CH_2)_n-$, $-(CH_2)_nNHC(=O)-$, $-C(=O)NH(CH_2)_nNHC(=O)(CH_2)_n-$, -

$(CH_2)_nNH((CH_2)_nO)_m(CH_2)_n-$ or $-(O(CH_2)_n)_mNHC(=O)(CH_2)_n-$;

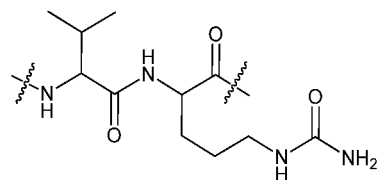
15

A₂ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -C(=O)NH(CH₂)_nS-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
NHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)-, -C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -



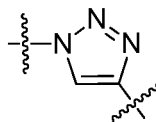
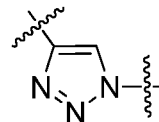
(CH₂)_nNH((CH₂)_nO)_m(CH₂)_n-, -(O(CH₂)_n)_mNHC(=O)(CH₂)_n- or ;

A₃ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -C(=O)NH(CH₂)_nS-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
5 NHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)-, -C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -

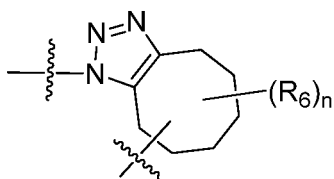
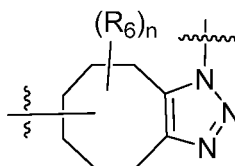
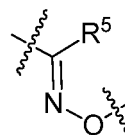
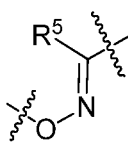
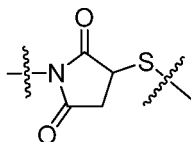
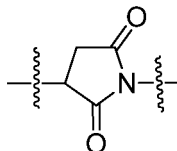
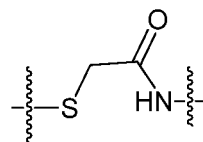


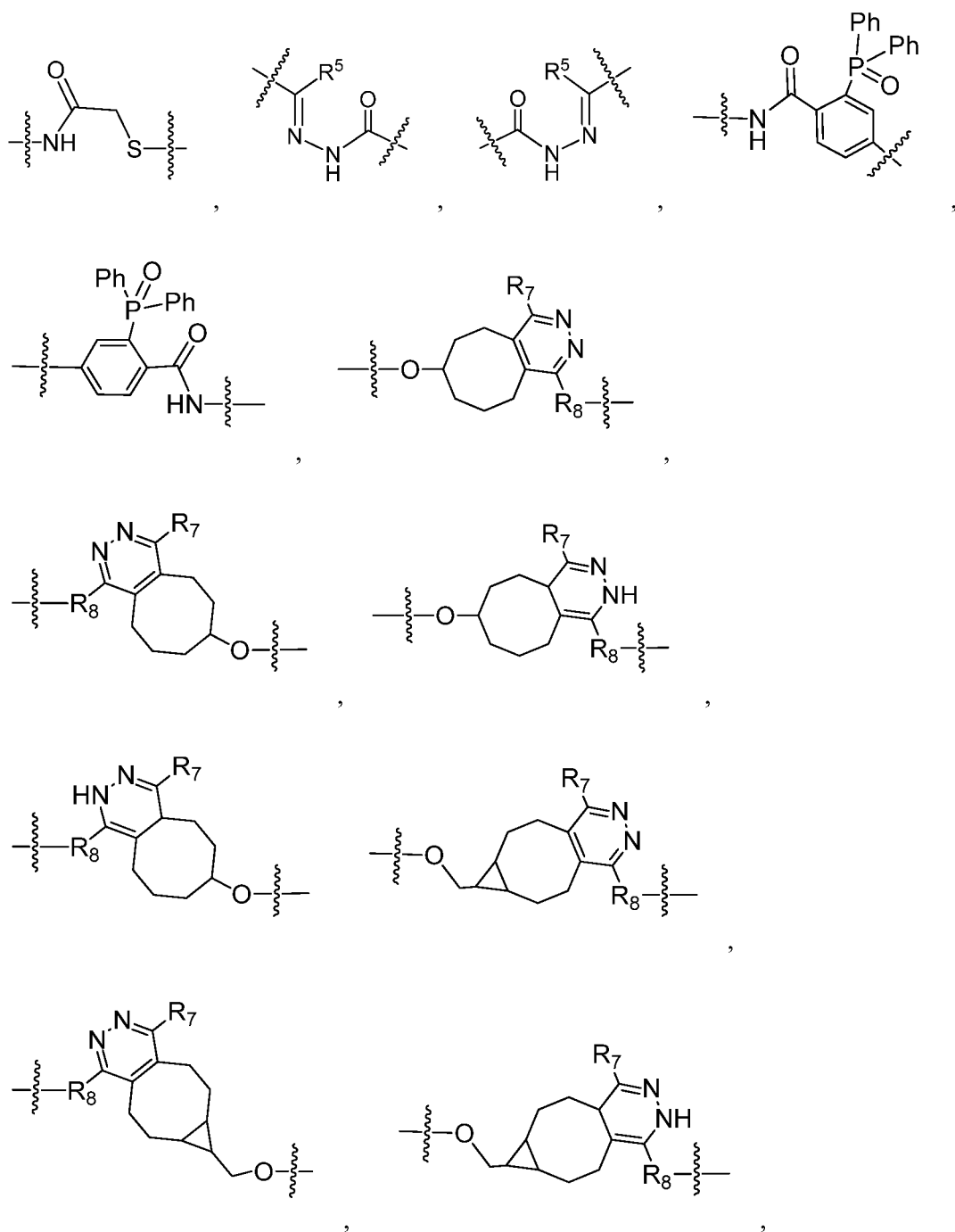
(CH₂)_nNH((CH₂)_nO)_m(CH₂)_n-, -(O(CH₂)_n)_mNHC(=O)(CH₂)_n- or ;

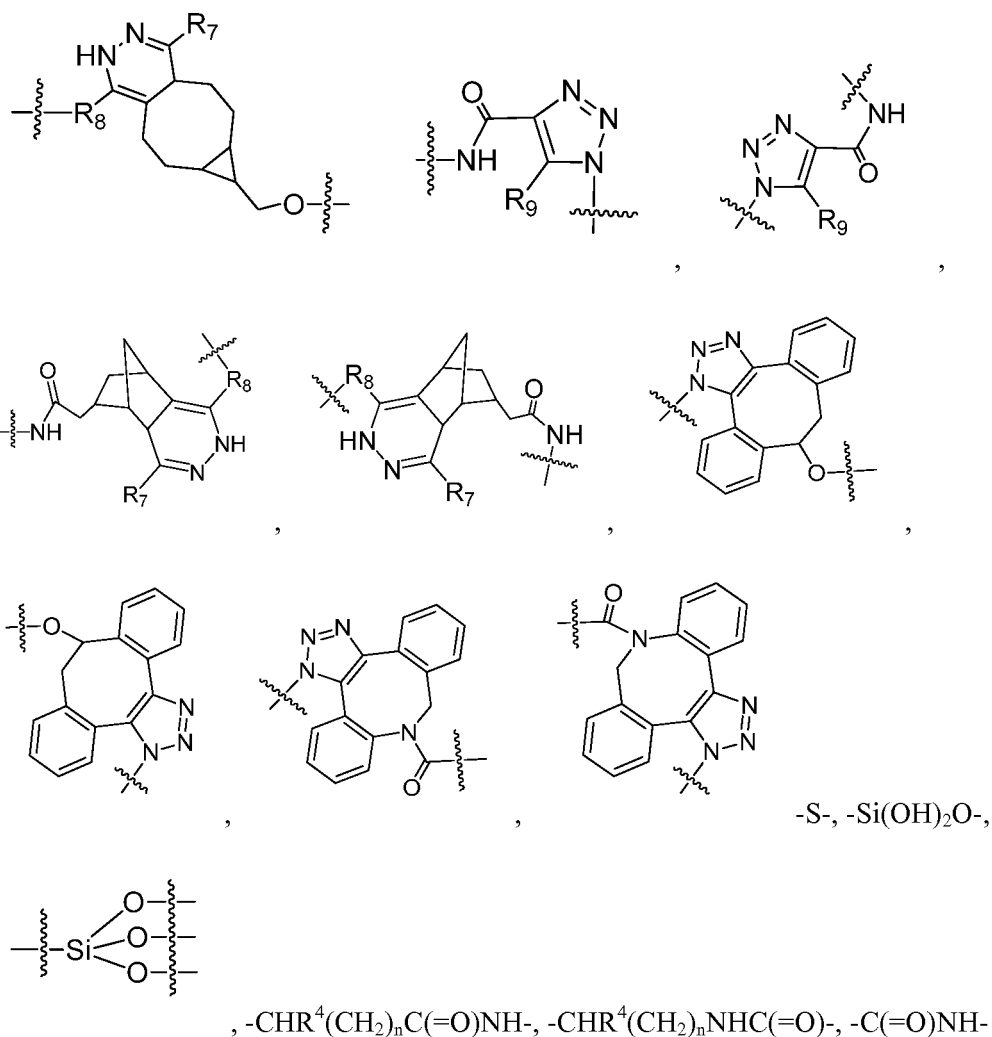
A₄ is -C(=O)NH-, -C(=O)NH(CH₂)_n-, -C(=O)NH(CH₂)_nS-, -(O(CH₂)_n)_m-, -((CH₂)_nO)_m(CH₂)_n-, -
NHC(=O)(CH₂)_n-, -(CH₂)_nNHC(=O)-, -C(=O)NH(CH₂)_nNHC(=O)(CH₂)_n-, -
(CH₂)_nNH((CH₂)_nO)_m(CH₂)_n- or -(O(CH₂)_n)_mNHC(=O)(CH₂)_n-;



10 each X² is independently selected from a bond, R⁸ , ,

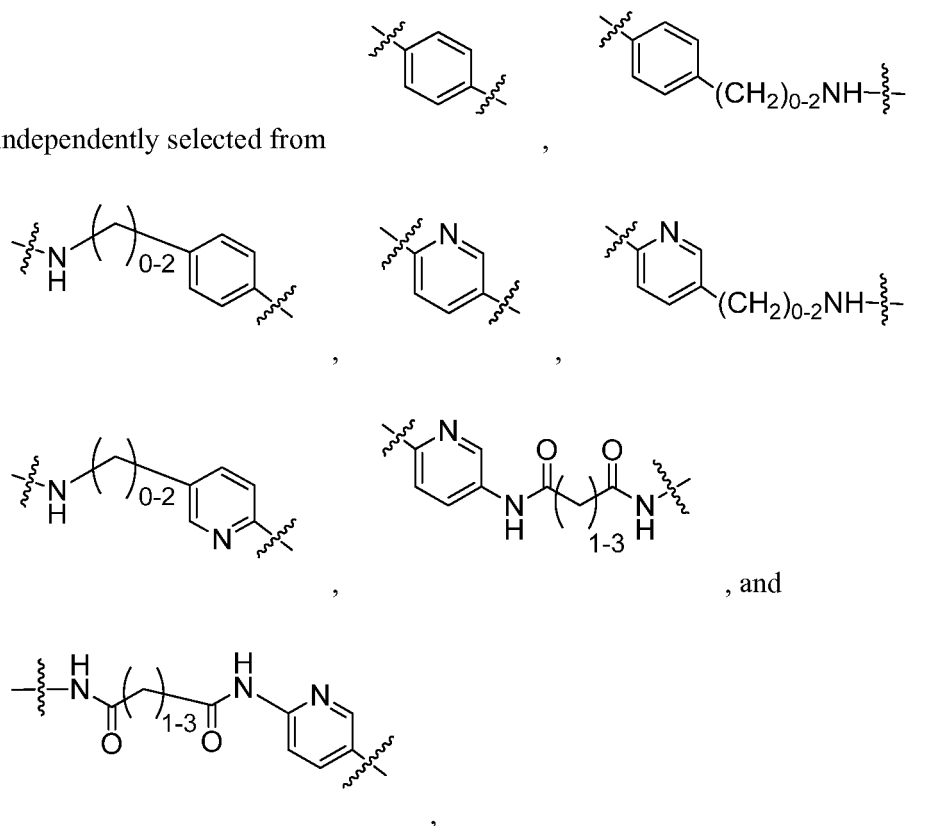






- 5 NHC(=O)-;
- each R⁴ is independently selected from H, C₁₋₄alkyl, side chains of known amino acids, -C(=O)OH and -OH,
- each R⁵ is independently selected from H, C₁₋₄alkyl, phenyl or C₁₋₄alkyl substituted with 1 to 3 -OH groups;
- 10 each R⁶ is independently selected from H, fluoro, benzyloxy substituted with -C(=O)OH, benzyl substituted with -C(=O)OH, C₁₋₄alkoxy substituted with -C(=O)OH and C₁₋₄alkyl substituted with -C(=O)OH;
- R⁷ is independently selected from H, C₁₋₄alkyl, phenyl, pyrimidine and pyridine;

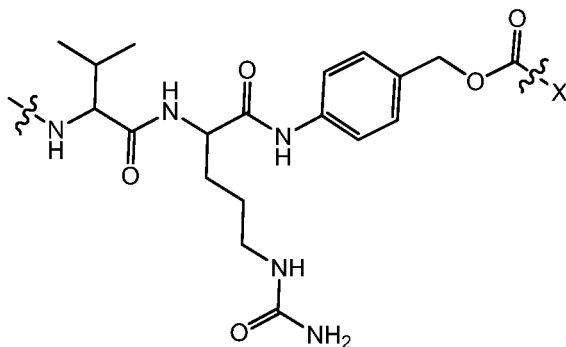
R^8 is independently selected from



- 5 R^9 is independently selected from H and C_{1-6} haloalkyl;
 each n is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9, and
 each m is independently selected from 1, 2, 3, 4, 5, 6, 7, 8 and 9.

In one embodiment, L_1 is $-(CH_2)_{1-10}-C(=O)-$, e.g., $-(CH_2)_5-C(=O)-$; and L_2 , L_3 and L_4 each represent a bond.

- 10 In certain embodiments LU comprises a val-cit linker of this formula, wherein X represents a payload, typically a drug moiety such as one having anticancer activity:



When $L_4-L_5-L_6$ is a val-cit linker as shown above, L_3 is preferably $-(CH_2)_{2-6}-C(=O)-$.

In certain embodiments the X group is a maytansinoid such as DM1 or DM4, or a dolastatin analog or derivative such as dolastatin 10 or 15 and auristatins MMAF or MMAE, or a calicheamicin such as N-acetyl- γ -calicheamicin, or a label or dye such as rhodamine or tetramethylrhodamine.

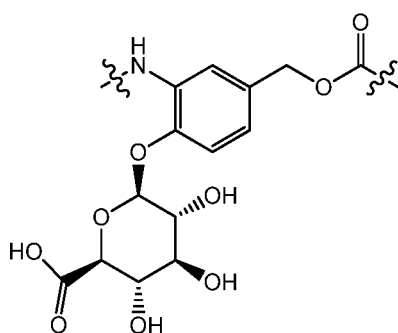
As used herein, a "linker" is any chemical moiety that is capable of connecting an antibody or a fragment thereof to an X group (payload) to form an immunoconjugate. Linkers can be susceptible to cleavage, such as, acid-induced cleavage, light-induced cleavage, peptidase-induced cleavage, esterase-induced cleavage, and disulfide bond cleavage, at conditions under which the compound or the antibody remains active. Alternatively, linkers can be substantially resistant to cleavage. A linker may or may not include a self-immolative spacer.

Non-limiting examples of the non-enzymatically cleavable linkers as used herein to conjugate an X^1 group to the modified antibodies or antibody fragment thereof provided herein include, acid-labile linkers, linkers containing a disulfide moiety, linkers containing a triazole moiety, linkers containing a hydrazone moiety, linkers containing a thioether moiety, linkers containing a diazo moiety, linkers containing an oxime moiety, linkers containing an amide moiety and linkers containing an acetamide moiety.

Non-limiting examples of the enzymatically cleavable linkers as used herein to conjugate an X group to the modified antibodies or antibody fragment thereof provided herein include, but are not limited to, linkers that are cleaved by a protease, linkers that are cleaved by an amidase, and linkers that are cleaved by β -glucuronidase or another glycosidase.

In certain embodiments, such enzyme cleavable linkers are linkers which are cleaved by cathepsin, including cathepsin Z, cathepsin B, cathepsin H and cathepsin C. In certain embodiments the

enzymatically cleavable linker is a dipeptide cleaved by cathepsin, including dipeptides cleaved by cathepsin Z, cathepsin B, cathepsin H or cathepsin C. In certain embodiments the enzymatically cleavable linker is a cathepsin B-cleavable peptide linker. In certain embodiments the enzymatically cleavable linker is a cathepsin B-cleavable dipeptide linker. In certain embodiments the enzymatically cleavable dipeptide linker is valine-citrulline or phenylalanine-lysine. Other non-limiting examples of the enzymatically cleavable linkers as used herein conjugate an X group to the modified antibodies or antibody fragment thereof provided herein include, but are not limited to, linkers which are cleaved



by β -glucuronidase, e.g.,

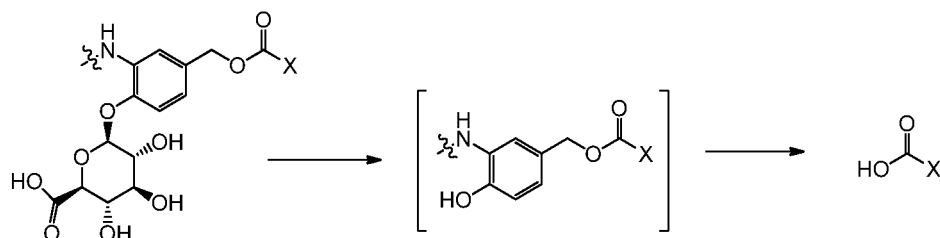
10 See Ducry *et al*, Bioconjugate Chem, (2010) vol. 21(1), 5-13.

“Self-immolative spacers” are bifunctional chemical moieties covalently linked at one terminus to a first chemical moiety and at the other terminus to a second chemical moiety, thereby forming a stable tripartate molecule. A linker can comprise a self-immolative spacer bonded to a third chemical moiety that is cleavable from the spacer either chemically or enzymatically. Upon cleavage of a bond between the self-immolative spacer and the first chemical moiety or the third chemical moiety, self-immolative spacers undergo rapid and spontaneous intramolecular reactions and thereby separate from the second chemical moiety. These intramolecular reactions generally involve electronic rearrangements such as 1,4, or 1,6, or 1,8 elimination reactions or cyclizations to form highly favored five- or six-membered rings. In certain embodiments of the present application, the first or third moiety is an enzyme cleavable group, and this cleavage results from an enzymatic reaction, while in other embodiments the first or third moiety is an acid labile group and this cleavage occurs due to a change in pH. As applied to the present application, the second moiety is the “Payload” group as defined herein. In certain embodiments, cleavage of the first or third moiety from the self-immolative spacer results from cleavage by a proteolytic enzyme, while in other embodiments it results from cleavage by a hydrolase. In certain

embodiments, cleavage of the first or third moiety from the self-immolative spacer results from cleavage by a cathepsin enzyme or a glucuronidase.

In certain embodiments, the enzyme cleavable linker is a peptide linker and the self-immolative spacer is covalently linked at one of its ends to the peptide linker and covalently linked at its other end to a drug moiety. This tripartite molecule is stable and pharmacologically inactive in the absence of an enzyme, but which is enzymatically cleavable by enzyme at a bond covalently linking the spacer moiety and the peptide moiety. The peptide moiety is cleaved from the tripartate molecule which initiates the self-immolating character of the spacer moiety, resulting in spontaneous cleavage of the bond covalently linking the spacer moiety to the drug moiety, to thereby effect release of the drug in pharmacologically active form.

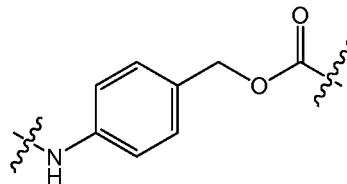
In other embodiments, a linker comprises a self-immolative spacer that connects to the peptide, either directly or indirectly at one end, and to a payload at the other end; and the spacer is attached to a third moiety that can be cleaved from the spacer enzymatically, such as by a glucuronidase. Upon cleavage of the third moiety, the spacer degrades or rearranges in a way that causes the payload to be released. An example of a linker with this type of self-immolative spacer is this glucuronidase-cleavable linker, where hydrolysis of the acetal catalyzed by glucuronidase releases a phenolic compound that spontaneously decomposes under physiological conditions:



Non-limiting examples of the self-immolative spacer optionally used in the conjugation of an X^1 group to the modified antibodies or antibody fragment thereof provided herein include, but are not limited to, moieties which include a benzyl carbonyl moiety, a benzyl ether moiety, a 4-aminobutyrate moiety, a hemithioaminal moiety or a N-acylhemithioaminal moiety.

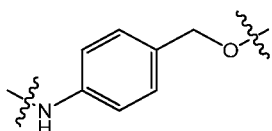
Other examples of self-immolative spacers include, but are not limited to, p-aminobenzylloxycarbonyl groups, aromatic compounds that are electronically similar to the p-aminobenzylloxycarbonyl group, such as 2-aminoimidazol-5-methanol derivatives and ortho or para-aminobenzylacetals. In certain embodiments, self-immolative spacers used herein which undergo

cyclization upon amide bond hydrolysis, include substituted and unsubstituted 4-aminobutyric acid amides and 2-aminophenylpropionic acid amides.

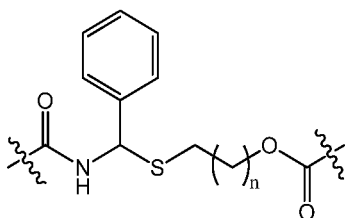


In certain embodiments, the self-immolative spacer is

or

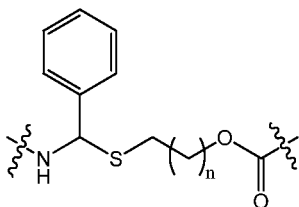


, while in other embodiments the self-immolative spacer is

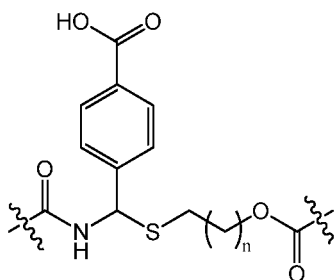


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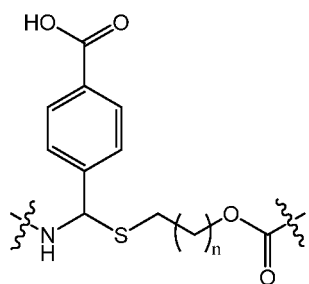
, where n is 1 or 2. In other embodiments the self-immolative spacer is



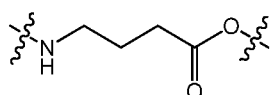
, where n is 1 or 2. In other embodiments the self-immolative spacer is



, where n is 1 or 2. In other embodiments the self-immolative spacer is



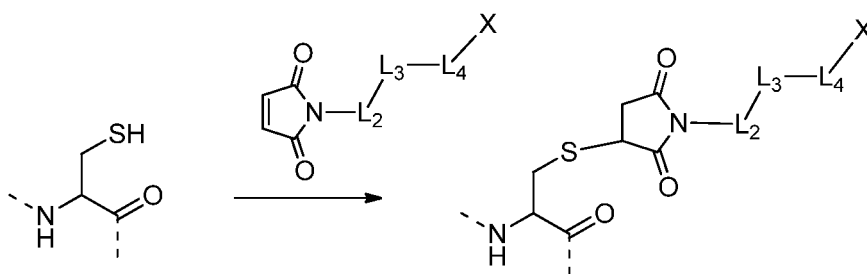
, where n is 1 or 2. In other embodiments the self-immolative spacer is



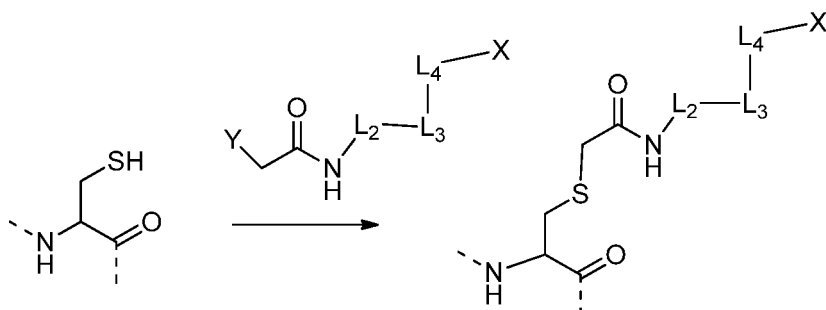
, where n is 1 or 2.

Schemes (2a-2c) illustrate the post-translational modification of the modified antibodies or antibody fragment thereof provided herein wherein the Linker Unit (LU) is $-L_1-L_2-L_3-L_4-$, and L1 in each case is the group that reacts with the new Cys.

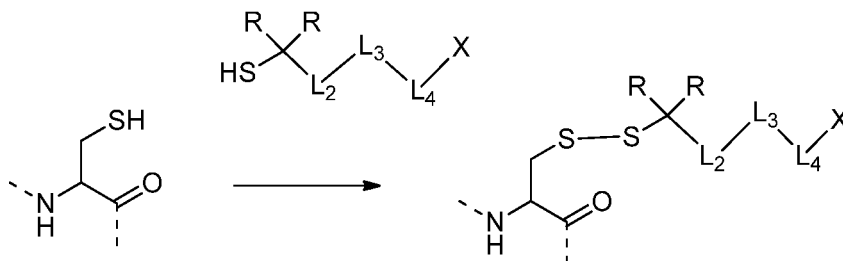
Scheme 2a.



Scheme 2b.



Scheme 3c.



In each of Schemes 2a-2c, the starting material is the replacement Cys residue in an antibody or antibody fragment modified as described herein, where the dashed bonds indicate connection to adjoining residues of the antibody or antibody fragment; each R is H or C₁₋₄ alkyl, typically H or methyl; L₂, L₃ and L₄ are components of the linking unit LU, such as those described above; X is the payload; and the group connecting L₂ to the sulfur of the substitute Cys of the present application is L₁.

In some embodiments of the present application, X is a reactive functional group that can be used to connect the conjugated antibody to another chemical moiety, by interacting with a suitable complementary functional group. Table 3 depicts some examples of reactive functional groups that X can represent, along with a complementary functional group that can be used to connect a conjugate comprising X to another compound. Methods for using X to connect to the corresponding complementary functional group are well known in the art. Connections using azide are typically done using ‘Click’ or copper-free click chemistry; reactions involving hydrazines, alkoxyamines or acyl hydrazines typically proceed through the formation of a Schiff base with one of the carbonyl functional groups.

Table 3

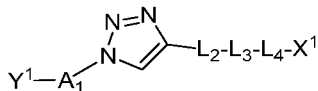
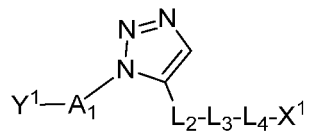
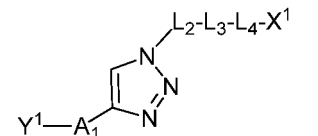
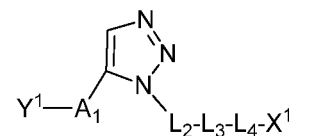
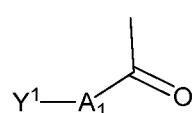
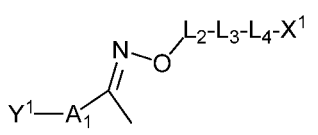
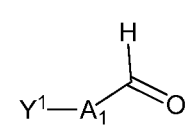
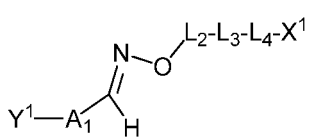
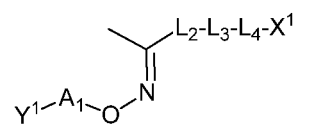
X	Complementary Reactive Functional Group for X
a thiol	a thiol, a maleimide, a haloacetamide, a vinyl sulfone, or a vinylpyridine
an azide	an alkene, alkyne, a phosphine-(thio)ester, a cyclooctyne, a cyclooctene or an oxanobornadiene
a phosphine-(thio)ester)	an azide
an oxanobornadiene	an azide or a tetrazine
an alkyne	an azide or a tetrazine

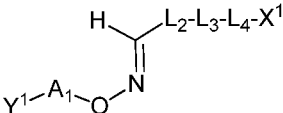
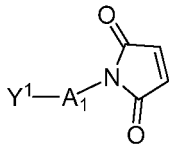
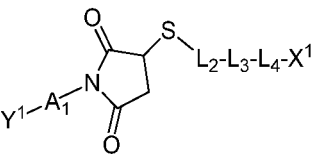
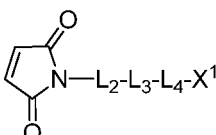
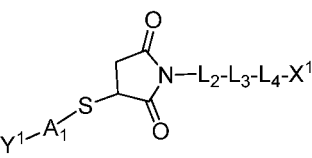
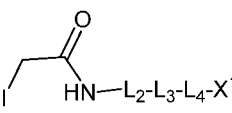
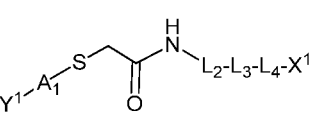
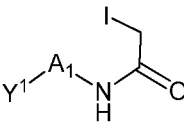
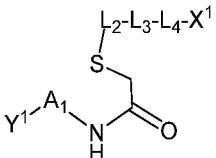
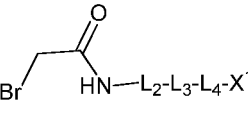
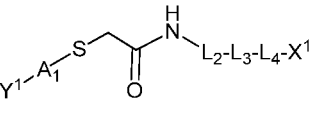
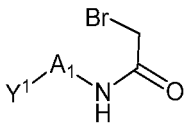
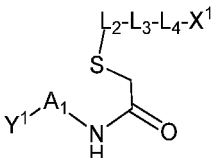
X	Complementary Reactive Functional Group for X
an alkene	a tetrazine
a cyclooctyne	an azide or a tetrazine
a cyclooctene	a tetrazine
a norbornene	a tetrazine
a tetrazine	a norbornene, an alkene, alkyne, a cyclooctyne or an oxanobornadiene
an aldehyde	a hydroxylamine, a hydrazine or $\text{NH}_2\text{-NH-C(=O)-}$
a ketone	a hydroxylamine, a hydrazine or $\text{NH}_2\text{-NH-C(=O)-}$
a hydroxylamine	an aldehyde or a ketone
a hydrazine	an aldehyde or a ketone
$\text{NH}_2\text{-NH-C(=O)-}$	an aldehyde or a ketone
a haloacetamide	a thiol
a thiol	a thiol
a maleimide	a thiol
a vinyl sulfone	a thiol
a vinylpyridine	a thiol

Exemplary products of the connections made using these components are depicted in Table 4, where Y^1 represents an antibody of the present application, A_1 represents a linking unit (LU) connecting the antibody to payload X^a , $-\text{L}_2\text{-L}_3\text{-L}_4-$ in Formula II-a represents a linker unit that can be present in a molecule to be connected to the conjugated antibody via X^a , and X^1 represents a payload. Payload X^a is a reactive functional group, and X^b on Formula II-a is the corresponding complementary functional group, and Formula II-a itself represents a molecule to be connected to the conjugated antibody. The third column in Table 4 depicts a product from reaction of X^a with X^b .

Table 4

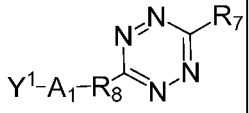
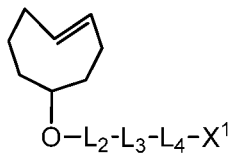
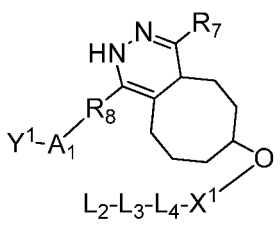
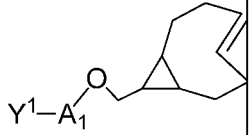
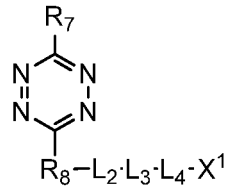
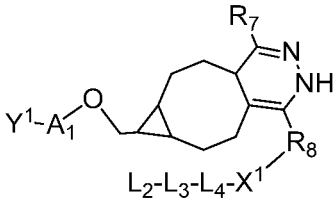
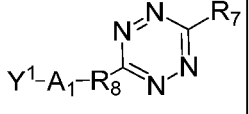
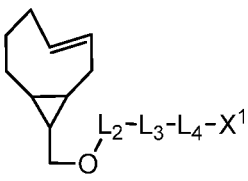
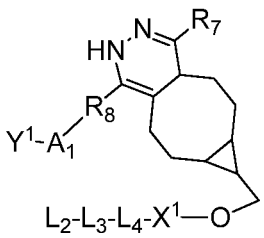
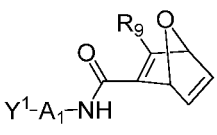
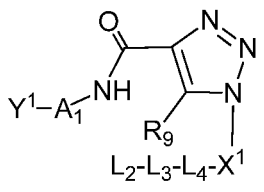
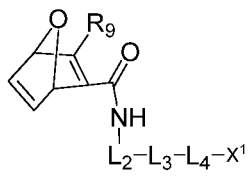
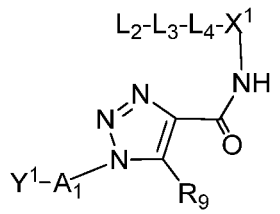
$\text{Y}^1\text{-A}_1\text{-X}^a$	$\text{X}^b\text{-L}_2\text{-L}_3\text{-L}_4\text{-X}^1$ Formula (II-a)	$\text{Y}^1\text{-A}_1\text{-X}^2\text{-L}_2\text{-L}_3\text{-L}_4\text{-X}^1$
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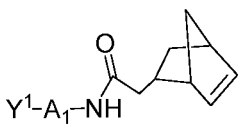
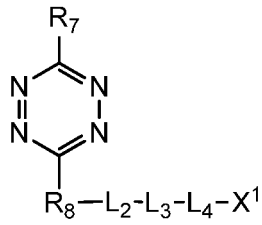
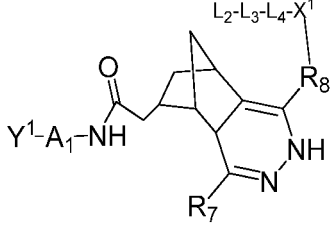
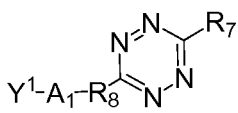
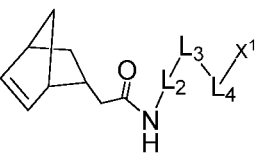
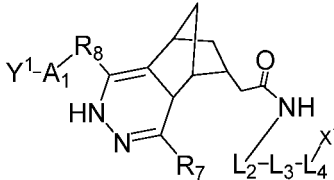
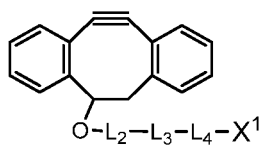
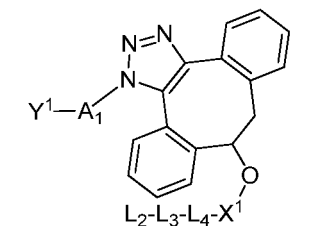
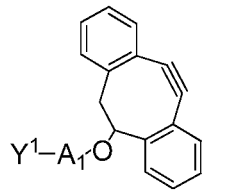
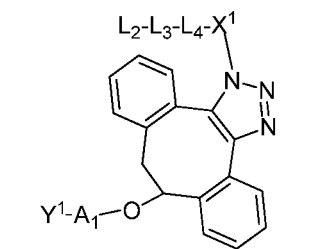
$Y^1-A_1-X^a$	$X^b-L_2-L_3-L_4-X^1$ Formula (II-a)	$Y^1-A_1-X^2-L_2-L_3-L_4-X^1$
$Y^1-A_1-N_3$	$HC\equiv C-L_2-L_3-L_4-X^1$	
$Y^1-A_1-N_3$	$HC\equiv C-L_2-L_3-L_4-X^1$	
$Y^1-A_1-C\equiv CH$	$N_3-L_2-L_3-L_4-X^1$	
$Y^1-A_1-C\equiv CH$	$N_3-L_2-L_3-L_4-X^1$	
	$NH_2-O-L_2-L_3-L_4-X^1$	
	$NH_2-O-L_2-L_3-L_4-X^1$	
$Y^1-A_1-O-NH_2$	$CH_3C(=O)-L_2-L_3-L_4-X^1$	

$Y^1-A_1-X^a$	$X^b-L_2-L_3-L_4-X^1$ Formula (II-a)	$Y^1-A_1-X^2-L_2-L_3-L_4-X^1$
$Y^1-A_1-O-NH_2$	$HC(=O)-L_2-L_3-L_4-X^1$	
	$HS-L_2-L_3-L_4-X^1$	
Y^1-A_1-SH		
Y^1-A_1-SH		
	$HS-L_2-L_3-L_4-X^1$	
Y^1-A_1-SH		
	$HS-L_2-L_3-L_4-X^1$	

$Y^1-A_1-X^a$	$X^b-L_2-L_3-L_4-X^1$ Formula (II-a)	$Y^1-A_1-X^2-L_2-L_3-L_4-X^1$
	$NH_2-NH-C(=O)-L_2-L_3-L_4-X^1$	
	$NH_2-NH-C(=O)-L_2-L_3-L_4-X^1$	
	$R_5C(=O)-L_2-L_3-L_4-X^1$	
	$HC(=O)-L_2-L_3-L_4-X^1$	
	$HS-L_2-L_3-L_4-X^1$	
$Y^1-A_1-N_3$		

$Y^1-A_1-X^a$	$X^b-L_2-L_3-L_4-X^1$ Formula (II-a)	$Y^1-A_1-X^2-L_2-L_3-L_4-X^1$
	$N_3-L_2-L_3-L_4-X^1$	
$Y^1-A_1-N_3$		
	$N_3-L_2-L_3-L_4-X^1$	
$Y^1-A_1-N_3$		$Y^1-A_1-NH-C(=O)-L_2-L_3-L_4-X^1$
	$N_3-L_2-L_3-L_4-X^1$	$Y^1-A_1-NH-C(=O)-L_2-L_3-L_4-X^1$

$Y^1-A_1-X^a$	$X^b-L_2-L_3-L_4-X^1$ Formula (II-a)	$Y^1-A_1-X^2-L_2-L_3-L_4-X^1$
		
		
		
	$N_3-L_2-L_3-L_4-X^1$	
$Y^1-A_1-N_3$		

$Y^1-A_1-X^a$	$X^b-L_2-L_3-L_4-X^1$ Formula (II-a)	$Y^1-A_1-X^2-L_2-L_3-L_4-X^1$
		
		
$Y^1-A_1-N_3$		
	$N_3-L_2-L_3-L_4-X^1$	

In certain embodiments, the modified antibody or antibody fragment thereof provided herein is conjugated with an “X group-to-antibody” (payload to antibody) ratio between about 1 and 16, such as 1-12, or 1, 2, 3, 4, 5, 6, 7, or 8, wherein the modified antibody or antibody fragment thereof contains 1, 2, 3, 4, 5, 6, 7, or 8 cysteine residues incorporated at the specific sites disclosed herein. For example, an “X group-to-antibody” ratio of 4 can be achieved by incorporating two Cys residues into the heavy chain of an antibody, which will contain 4 conjugation sites, two from each heavy chain. Immunoconjugates of

such antibodies will contain up to 4 payload groups, which may be alike or different and are preferably all alike. In another example, an "X group-to-antibody" ratio of 4 can be achieved by incorporating one Cys residue into the heavy chain and a second Cys residue into the light chain of an antibody resulting in 4 conjugation sites, two in the two heavy chains and two in the two light chains. A ratio 6, 8 or higher
5 can be achieved by combinations of 3, 4 or more cysteine substitutions of the present application in heavy and light chain of the antibody. Substituting multiple cysteine groups into an antibody can lead to inappropriate disulfide formation and other problems. Thus for loading more than 4 payload groups onto one antibody molecule, the methods of the present application can alternatively be combined with methods that do not rely upon reactions at cysteine sulfur, such as acylations at lysine, or conjugation via
10 S6 tags or Pcl methodology.

While the payload to antibody ratio has an exact value for a specific conjugate molecule, it is understood that the value will often be an average value when used to describe a sample containing many molecules, due to some degree of in homogeneity, typically in the conjugation step. The average loading for a sample of an immunoconjugate is referred to herein as the drug to antibody ratio, or DAR. In some
15 embodiments, the DAR is between about 4 to about 16, and typically is about 4, 5, 6, 7, 8. In some embodiments, at least 50% of a sample by weight is compound having the average ratio plus or minus 2, and preferably at least 50% of the sample is a conjugate that contains the average ratio plus or minus 1. Preferred embodiments include immunoconjugates wherein the DAR is about 2 or about 8, e.g., about 2, about 4, about 6 or about 8. In some embodiments, a DAR of 'about n' means the measured value for
20 DAR is within 10% of n (in Formula (I)).

3. Further Alteration of the Framework of Fc Region

The present application provides site-specific labeled immunoconjugates. The immunoconjugates of the present application may comprise modified antibodies or antibody fragments thereof that further comprise modifications to framework residues within V_H and/or V_L , e.g. to improve
25 the properties of the antibody. Typically such framework modifications are made to decrease the immunogenicity of the antibody. For example, one approach is to "back-mutate" one or more framework residues to the corresponding germline sequence. More specifically, an antibody that has undergone somatic mutation may contain framework residues that differ from the germline sequence from which the antibody is derived. Such residues can be identified by comparing the antibody framework sequences to
30 the germline sequences from which the antibody is derived. To return the framework region sequences to their germline configuration, the somatic mutations can be "back-mutated" to the germline sequence by,

for example, site-directed mutagenesis. Such "back-mutated" antibodies are also intended to be encompassed by the present application.

Another type of framework modification involves mutating one or more residues within the framework region, or even within one or more CDR regions, to remove T-cell epitopes to thereby reduce the potential immunogenicity of the antibody. This approach is also referred to as "deimmunization" and is described in further detail in U.S. Patent Publication No. 20030153043 by Carr *et al.*

In addition or alternative to modifications made within the framework or CDR regions, antibodies of the present application may be engineered to include modifications within the Fc region, typically to alter one or more functional properties of the antibody, such as serum half-life, complement fixation, Fc receptor binding, and/or antigen-dependent cellular cytotoxicity. Furthermore, an antibody of the present application may be chemically modified (*e.g.*, one or more chemical moieties can be attached to the antibody) or be modified to alter its glycosylation, again to alter one or more functional properties of the antibody. Each of these embodiments is described in further detail below.

In one embodiment, the hinge region of CH1 is modified such that the number of cysteine residues in the hinge region is altered, *e.g.*, increased or decreased. This approach is described further in U.S. Patent No. 5,677,425 by Bodmer *et al.* The number of cysteine residues in the hinge region of CH1 is altered to, for example, facilitate assembly of the light and heavy chains or to increase or decrease the stability of the antibody.

In another embodiment, the Fc hinge region of an antibody is mutated to decrease the biological half-life of the antibody. More specifically, one or more amino acid mutations are introduced into the CH2-CH3 domain interface region of the Fc-hinge fragment such that the antibody has impaired Staphylococcal protein A (SpA) binding relative to native Fc-hinge domain SpA binding. This approach is described in further detail in U.S. Patent No. 6,165,745 by Ward *et al.*

In yet other embodiments, the Fc region is altered by replacing at least one amino acid residue with a different amino acid residue to alter the effector functions of the antibody. For example, one or more amino acids can be replaced with a different amino acid residue such that the antibody has an altered affinity for an effector ligand but retains the antigen-binding ability of the parent antibody. The effector ligand to which affinity is altered can be, for example, an Fc receptor or the C1 component of complement. This approach is described in, *e.g.*, U.S. Patent Nos. 5,624,821 and 5,648,260, both by Winter *et al.*

In another embodiment, one or more amino acids selected from amino acid residues can be replaced with a different amino acid residue such that the antibody has altered C1q binding and/or reduced or abolished complement dependent cytotoxicity (CDC). This approach is described in, *e.g.*, U.S. Patent Nos. 6,194,551 by Idusogie *et al.*

5 In another embodiment, one or more amino acid residues are altered to thereby alter the ability of the antibody to fix complement. This approach is described in, *e.g.*, the PCT Publication WO 94/29351 by Bodmer *et al.* In a specific embodiment, one or more amino acids of an antibody or antibody fragment thereof of the present application are replaced by one or more allotypic amino acid residues. Allotypic amino acid residues also include, but are not limited to, the constant region of the heavy chain
10 of the IgG1, IgG2, and IgG3 subclasses as well as the constant region of the light chain of the kappa isotype as described by Jefferis *et al.*, MAb. 1:332-338 (2009).

In yet another embodiment, the Fc region is modified to increase the ability of the antibody to mediate antibody dependent cellular cytotoxicity (ADCC) and/or to increase the affinity of the antibody for an Fcγ receptor by modifying one or more amino acids. This approach is described in, *e.g.*, the PCT
15 Publication WO 00/42072 by Presta. Moreover, the binding sites on human IgG1 for FcγRI, FcγRII, FcγRIII and FcRn have been mapped and variants with improved binding have been described (see Shields *et al.*, J. Biol. Chem. 276:6591-6604, 2001).

In still another embodiment, the glycosylation of an antibody is modified. For example, an aglycosylated antibody can be made (*i.e.*, the antibody lacks glycosylation). Glycosylation can be altered
20 to, for example, increase the affinity of the antibody for antigen. Such carbohydrate modifications can be accomplished by, for example, altering one or more sites of glycosylation within the antibody sequence. For example, one or more amino acid substitutions can be made that result in elimination of one or more variable region framework glycosylation sites to thereby eliminate glycosylation at that site. Such aglycosylation may increase the affinity of the antibody for antigen. Such an approach is described in,
25 *e.g.*, U.S. Patent Nos. 5,714,350 and 6,350,861 by Co *et al.*

Additionally or alternatively, an antibody can be made that has an altered type of glycosylation, such as a hypofucosylated antibody having reduced amounts of fucosyl residues or an antibody having increased bisecting GlcNAc structures. Such altered glycosylation patterns have been demonstrated to increase the ADCC ability of antibodies. Such carbohydrate modifications can be accomplished by, for
30 example, expressing the antibody in a host cell with altered glycosylation machinery. Cells with altered glycosylation machinery have been described in the art and can be used as host cells in which to express recombinant antibodies of the present application to thereby produce an antibody with altered

glycosylation. For example, EP 1,176,195 by Hang *et al.* describes a cell line with a functionally disrupted FUT8 gene, which encodes a fucosyl transferase, such that antibodies expressed in such a cell line exhibit hypofucosylation. PCT Publication WO 03/035835 by Presta describes a variant CHO cell line, Lec13 cells, with reduced ability to attach fucose to Asn(297)-linked carbohydrates, also resulting in hypofucosylation of antibodies expressed in that host cell (see also Shields *et al.*, (2002) J. Biol. Chem. 277:26733-26740). PCT Publication WO 99/54342 by Umana *et al.* describes cell lines engineered to express glycoprotein-modifying glycosyl transferases (*e.g.*, beta(1,4)-N acetylglucosaminyltransferase III (GnTIII)) such that antibodies expressed in the engineered cell lines exhibit increased bisecting GlcNac structures which results in increased ADCC activity of the antibodies (see also Umana *et al.*, Nat. Biotech. 17:176-180, 1999).

In another embodiment, the antibody is modified to increase its biological half-life. Various approaches are possible. For example, one or more of the following mutations can be introduced: T252L, T254S, or T256F, as described in U.S. Patent No. 6,277,375 to Ward. Alternatively, to increase the biological half-life, the antibody can be altered within the CH1 or C_L region to contain a salvage receptor binding epitope taken from two loops of a CH2 domain of an Fc region of an IgG, as described in U.S. Patents 5,869,046 and 6,121,022 by Presta *et al.*

4. Antibody Conjugates

The present application provides site-specific labeling methods, modified antibodies and antibody fragments thereof, and immunoconjugates prepared accordingly. Using the methods of the present application, a modified antibody or antibody fragments thereof can be conjugated to a label, such as a drug moiety, *e.g.*, an anti-cancer agent, an autoimmune treatment agent, an anti-inflammatory agent, an antifungal agent, an antibacterial agent, an anti-parasitic agent, an anti-viral agent, or an anesthetic agent, or an imaging reagent, such as a chelator for PET imaging, or a fluorescent label, or a MRI contrast reagent. An antibody or antibody fragments can also be conjugated using several identical or different labeling moieties combining the methods of the present application with other conjugation methods.

In certain embodiments, the immunoconjugates of the present application comprise a drug moiety selected from a V-ATPase inhibitor, a HSP90 inhibitor, an IAP inhibitor, an mTor inhibitor, a microtubule stabilizer, a microtubule destabilizer, an auristatin, a dolastatin, a maytansinoid, a MetAP (methionine aminopeptidase), an inhibitor of nuclear export of proteins CRM1, a DPPIV inhibitor, proteasome inhibitors, an inhibitor of phosphoryl transfer reactions in mitochondria, a protein synthesis

inhibitor, a kinase inhibitor, a CDK2 inhibitor, a CDK9 inhibitor, an HDAC inhibitor, a DNA damaging agent, a DNA alkylating agent, a DNA intercalator, a DNA minor groove binder, topoisomerase inhibitors, RNA synthesis inhibitors, kinesin inhibitors, inhibitors of protein-protein interactions, an Eg5 inhibitor, and a DHFR inhibitor.

5 Further, the modified antibodies or antibody fragments of the present application may be conjugated to a drug moiety that modifies a given biological response. Drug moieties are not to be construed as limited to classical chemical therapeutic agents. For example, the drug moiety may be an immune modulator, such as an immune potentiator, a small molecule immune potentiator, a TLR agonist, a CpG oligomer, a TLR2 agonist, a TLR4 agonist, a TLR7 agonist, a TLR9 agonist, a TLR8 agonist, a T-
10 cell epitope peptide or a like. The drug moiety may also be an oligonucleotide, a siRNA, a shRNA, a cDNA or a like. Alternatively, the drug moiety may be a protein, peptide, or polypeptide possessing a desired biological activity. Such proteins may include, for example, a toxin such as abrin, ricin A, pseudomonas exotoxin, cholera toxin, or diphtheria toxin, a protein such as tumor necrosis factor, α -interferon, β -interferon, nerve growth factor, platelet derived growth factor, tissue plasminogen activator,
15 a cytokine, an apoptotic agent, an anti-angiogenic agent, or, a biological response modifier such as, for example, a lymphokine.

In one embodiment, the modified antibodies or antibody fragments of the present application are conjugated to a drug moiety, such as a cytotoxin, a drug (*e.g.*, an immunosuppressant) or a radiotoxin. Examples of cytotoxin include but not limited to, taxanes (see, *e.g.*, International (PCT) Patent
20 Application Nos. WO 01/38318 and PCT/US03/02675), DNA-alkylating agents (*e.g.*, CC-1065 analogs), anthracyclines, tubulysin analogs, duocarmycin analogs, auristatin E, auristatin F, maytansinoids, and cytotoxic agents comprising a reactive polyethylene glycol moiety (see, *e.g.*, Sasse *et al.*, J. Antibiot. (Tokyo), 53, 879-85 (2000), Suzawa *et al.*, Bioorg. Med. Chem., 8, 2175-84 (2000), Ichimura *et al.*, J. Antibiot. (Tokyo), 44, 1045-53 (1991), Francisco *et al.*, Blood (2003) (electronic publication prior to
25 print publication), U.S. Pat. Nos. 5,475,092, 6,340,701, 6,372,738, and 6,436,931, U.S. Patent Application Publication No. 2001/0036923 A1, Pending U.S. patent application Ser. Nos. 10/024,290 and 10/116,053, and International (PCT) Patent Application No. WO 01/49698), taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, tenoposide, colchicine, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-
30 dehydrotestosterone, glucocorticoids, and puromycin and analogs or homologs thereof. Therapeutic agents also include, for example, anti-metabolites (*e.g.*, methotrexate, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-fluorouracil decarbazine), ablating agents (*e.g.*, mechlorethamine, thiotepa chlorambucil,

meiphalan, carmustine (BSNU) and lomustine (CCNU), cyclophosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin, anthracyclines (*e.g.*, daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (*e.g.*, dactinomycin (formerly actinomycin), bleomycin, mithramycin, and anthramycin (AMC)), and anti-mitotic agents (*e.g.*, vincristine and vinblastine). (See *e.g.*, Seattle Genetics US20090304721).

Other examples of therapeutic cytotoxins that can be conjugated to the modified antibodies or antibody fragments of the present application include duocarmycins, calicheamicins, maytansines and auristatins, and derivatives thereof. An example of a calicheamicin antibody conjugate is commercially available (Mylotarg[™]; Wyeth-Ayerst).

For further discussion of types of cytotoxins, linkers and methods for conjugating therapeutic agents to antibodies, see also Saito *et al.*, (2003) *Adv. Drug Deliv. Rev.* 55:199-215; Trail *et al.*, (2003) *Cancer Immunol. Immunother.* 52:328-337; Payne, (2003) *Cancer Cell* 3:207-212; Allen, (2002) *Nat. Rev. Cancer* 2:750-763; Pastan and Kreitman, (2002) *Curr. Opin. Investig. Drugs* 3:1089-1091; Senter and Springer, (2001) *Adv. Drug Deliv. Rev.* 53:247-264.

According to the present application, modified antibodies or antibody fragments thereof can also be conjugated to a radioactive isotope to generate cytotoxic radiopharmaceuticals, referred to as radioimmunoconjugates. Examples of radioactive isotopes that can be conjugated to antibodies for use diagnostically or therapeutically include, but are not limited to, iodine¹³¹, indium¹¹¹, yttrium⁹⁰, and lutetium¹⁷⁷. Methods for preparing radioimmunoconjugates are established in the art. Examples of radioimmunoconjugates are commercially available, including Zevalin[™] (DEC Pharmaceuticals) and Bexxar[™] (Corixa Pharmaceuticals), and similar methods can be used to prepare radioimmunoconjugates using the antibodies of the present application. In certain embodiments, the macrocyclic chelator is 1,4,7,10-tetraazacyclododecane-N,N',N'',N'''-tetraacetic acid (DOTA) which can be attached to the antibody via a linker molecule. Such linker molecules are commonly known in the art and described in Denardo *et al.*, (1998) *Clin. Cancer Res.* 4(10):2483-90; Peterson *et al.*, (1999) *Bioconjug. Chem.* 10(4):553-7; and Zimmerman *et al.*, (1999) *Nucl. Med. Biol.* 26(8):943-50, each incorporated by reference in their entireties.

The present application further provides modified antibodies or fragments thereof that specifically bind to an antigen. The modified antibodies or fragments may be conjugated or fused to a heterologous protein or polypeptide (or fragment thereof, preferably to a polypeptide of at least 10, at least 20, at least 30, at least 40, at least 50, at least 60, at least 70, at least 80, at least 90 or at least 100 amino acids) to generate fusion proteins. In particular, the present application provides fusion proteins

comprising an antibody fragment described herein (*e.g.*, a Fab fragment, Fd fragment, Fv fragment, F(ab)₂ fragment, a V_H domain, a V_H CDR, a V_L domain or a V_L CDR) and a heterologous protein, polypeptide, or peptide.

In some embodiments, modified antibody fragments without antigen binding specificity, such as but not limited to, modified Fc domains with engineered cysteine residue(s) according to the present application, are used to generate fusion proteins comprising such an antibody fragment (*e.g.*, engineered Fc) and a heterologous protein, polypeptide, or peptide.

Additional fusion proteins may be generated through the techniques of gene-shuffling, motif-shuffling, exon-shuffling, and/or codon-shuffling (collectively referred to as “DNA shuffling”). DNA shuffling may be employed to alter the activities of antibodies of the present application or fragments thereof (*e.g.*, antibodies or fragments thereof with higher affinities and lower dissociation rates). See, generally, U.S. Patent Nos. 5,605,793, 5,811,238, 5,830,721, 5,834,252, and 5,837,458; Patten *et al.*, (1997) *Curr. Opin. Biotechnol.* 8:724-33; Harayama, (1998) *Trends Biotechnol.* 16(2):76-82; Hansson *et al.*, (1999) *J. Mol. Biol.* 287:265-76; and Lorenzo and Blasco, (1998) *Biotechniques* 24(2):308-313 (each of these patents and publications are hereby incorporated by reference in its entirety). Antibodies or fragments thereof, or the encoded antibodies or fragments thereof, may be altered by being subjected to random mutagenesis by error-prone PCR, random nucleotide insertion or other methods prior to recombination. A polynucleotide encoding an antibody or fragment thereof that specifically binds to an antigen may be recombined with one or more components, motifs, sections, parts, domains, fragments, etc. of one or more heterologous molecules.

Moreover, the modified antibodies or antibody fragments thereof of the present application can be conjugated to marker sequences, such as a peptide to facilitate purification. In preferred embodiments, the marker amino acid sequence is a hexa-histidine peptide, such as the tag provided in a pQE vector (QIAGEN, Inc., 9259 Eton Avenue, Chatsworth, CA, 91311), among others, many of which are commercially available. As described in Gentz *et al.*, (1989) *Proc. Natl. Acad. Sci. USA* 86:821-824, for instance, hexa-histidine provides for convenient purification of the fusion protein. Other peptide tags useful for purification include, but are not limited to, the hemagglutinin (“HA”) tag, which corresponds to an epitope derived from the influenza hemagglutinin protein (Wilson *et al.*, (1984) *Cell* 37:767), and the “FLAG” tag (A. Einhauser *et al.*, *J. Biochem. Biophys. Methods* 49: 455–465, 2001). According to the present application, antibodies or antibody fragments can also be conjugated to tumor-penetrating peptides in order to enhance their efficacy.

In other embodiments, modified antibodies or antibody fragments of the present application are conjugated to a diagnostic or detectable agent. Such immunoconjugates can be useful for monitoring or prognosing the onset, development, progression and/or severity of a disease or disorder as part of a clinical testing procedure, such as determining the efficacy of a particular therapy. Such diagnosis and detection can be accomplished by coupling the antibody to detectable substances including, but not limited to, various enzymes, such as, but not limited to, horseradish peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; prosthetic groups, such as, but not limited to, streptavidin/biotin and avidin/biotin; fluorescent materials, such as, but not limited to, Alexa Fluor 350, Alexa Fluor 405, Alexa Fluor 430, Alexa Fluor 488, Alexa Fluor 500, Alexa Fluor 514, Alexa Fluor 532, Alexa Fluor 546, Alexa Fluor 555, Alexa Fluor 568, Alexa Fluor 594, Alexa Fluor 610, Alexa Fluor 633, Alexa Fluor 647, Alexa Fluor 660, Alexa Fluor 680, Alexa Fluor 700, Alexa Fluor 750, umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; luminescent materials, such as, but not limited to, luminol; bioluminescent materials, such as but not limited to, luciferase, luciferin, and aequorin; radioactive materials, such as, but not limited to, iodine (^{131}I , ^{125}I , ^{123}I , and ^{121}I), carbon (^{14}C), sulfur (^{35}S), tritium (^3H), indium (^{115}In , ^{113}In , ^{112}In , and ^{111}In), technetium (^{99}Tc), thallium (^{201}Tl), gallium (^{68}Ga , ^{67}Ga), palladium (^{103}Pd), molybdenum (^{99}Mo), xenon (^{133}Xe), fluorine (^{18}F), ^{153}Sm , ^{177}Lu , ^{159}Gd , ^{149}Pm , ^{140}La , ^{175}Yb , ^{166}Ho , ^{90}Y , ^{47}Sc , ^{186}Re , ^{188}Re , ^{142}Pr , ^{105}Rh , ^{97}Ru , ^{68}Ge , ^{57}Co , ^{65}Zn , ^{85}Sr , ^{32}P , ^{153}Gd , ^{169}Yb , ^{51}Cr , ^{54}Mn , ^{75}Se , ^{64}Cu , ^{113}Sn , and ^{117}Sn ; and positron emitting metals using various positron emission tomographies, and non-radioactive paramagnetic metal ions.

Modified antibodies or antibody fragments of the present application may also be attached to solid supports, which are particularly useful for immunoassays or purification of the target antigen. Such solid supports include, but are not limited to, glass, cellulose, polyacrylamide, nylon, polystyrene, polyvinyl chloride or polypropylene.

5. Pharmaceutical Composition

To prepare pharmaceutical or sterile compositions including immunoconjugates, the immunoconjugates of the present application are mixed with a pharmaceutically acceptable carrier or excipient. The compositions can additionally contain one or more other therapeutic agents that are suitable for treating or preventing cancer (breast cancer, colorectal cancer, lung cancer, multiple myeloma, ovarian cancer, liver cancer, gastric cancer, pancreatic cancer, acute myeloid leukemia, chronic myeloid leukemia, osteosarcoma, squamous cell carcinoma, peripheral nerve sheath tumors (*e.g.*, schwannoma), head and neck cancer, bladder cancer, esophageal cancer, Barrett's esophageal cancer,

glioblastoma, clear cell sarcoma of soft tissue, malignant mesothelioma, neurofibromatosis, renal cancer, melanoma, prostate cancer, benign prostatic hyperplasia (BPH), gynacomastia, and endometriosis).

Formulations of therapeutic and diagnostic agents can be prepared by mixing with physiologically acceptable carriers, excipients, or stabilizers in the form of, *e.g.*, lyophilized powders, slurries, aqueous solutions, lotions, or suspensions (see, *e.g.*, Hardman *et al.*, Goodman and Gilman's The Pharmacological Basis of Therapeutics, McGraw-Hill, New York, N.Y., 2001; Gennaro, Remington: The Science and Practice of Pharmacy, Lippincott, Williams, and Wilkins, New York, N.Y., 2000; Avis, *et al.* (eds.), Pharmaceutical Dosage Forms: Parenteral Medications, Marcel Dekker, NY, 1993; Lieberman, *et al.* (eds.), Pharmaceutical Dosage Forms: Tablets, Marcel Dekker, NY, 1990; Lieberman, *et al.* (eds.) Pharmaceutical Dosage Forms: Disperse Systems, Marcel Dekker, NY, 1990; Weiner and Kotkoskie, Excipient Toxicity and Safety, Marcel Dekker, Inc., New York, N.Y., 2000).

Selecting an administration regimen for a therapeutic depends on several factors, including the serum or tissue turnover rate of the entity, the level of symptoms, the immunogenicity of the entity, and the accessibility of the target cells in the biological matrix. In certain embodiments, an administration regimen maximizes the amount of therapeutic delivered to the patient consistent with an acceptable level of side effects. Accordingly, the amount of biologic delivered depends in part on the particular entity and the severity of the condition being treated. Guidance in selecting appropriate doses of antibodies, cytokines, and small molecules is available (see, *e.g.*, Wawrzynczak, Antibody Therapy, Bios Scientific Pub. Ltd, Oxfordshire, UK, 1996; Kresina (ed.), Monoclonal Antibodies, Cytokines and Arthritis, Marcel Dekker, New York, N.Y., 1991; Bach (ed.), Monoclonal Antibodies and Peptide Therapy in Autoimmune Diseases, Marcel Dekker, New York, N.Y., 1993; Baert *et al.*, New Engl. J. Med. 348:601-608, 2003; Milgrom *et al.*, New Engl. J. Med. 341:1966-1973, 1999; Slamon *et al.*, New Engl. J. Med. 344:783-792, 2001; Beniaminovitz *et al.*, New Engl. J. Med. 342:613-619, 2000; Ghosh *et al.*, New Engl. J. Med. 348:24-32, 2003; Lipsky *et al.*, New Engl. J. Med. 343:1594-1602, 2000).

Determination of the appropriate dose is made by the clinician, *e.g.*, using parameters or factors known or suspected in the art to affect treatment or predicted to affect treatment. Generally, the dose begins with an amount somewhat less than the optimum dose and it is increased by small increments thereafter until the desired or optimum effect is achieved relative to any negative side effects. Important diagnostic measures include those of symptoms of, *e.g.*, the inflammation or level of inflammatory cytokines produced.

Actual dosage levels of the active ingredients in the pharmaceutical compositions of the present application may be varied so as to obtain an amount of the active ingredient which is effective to achieve

the desired therapeutic response for a particular patient, composition, and mode of administration, without being toxic to the patient. The selected dosage level will depend upon a variety of pharmacokinetic factors including the activity of the particular compositions of the present application employed, or the ester, salt or amide thereof, the route of administration, the time of administration, the rate of excretion of the particular compound being employed, the duration of the treatment, other drugs, compounds and/or materials used in combination with the particular compositions employed, the age, sex, weight, condition, general health and prior medical history of the patient being treated, and like factors known in the medical arts.

Compositions comprising antibodies or fragments thereof of the present application can be provided by continuous infusion, or by doses at intervals of, *e.g.*, one day, one week, or 1-7 times per week. Doses may be provided intravenously, subcutaneously, topically, orally, nasally, rectally, intramuscular, intracerebrally, or by inhalation. A specific dose protocol is one involving the maximal dose or dose frequency that avoids significant undesirable side effects.

For the immunoconjugates of the present application, the dosage administered to a patient may be 0.0001 mg/kg to 100 mg/kg of the patient's body weight. The dosage may be between 0.0001 mg/kg and 20 mg/kg, 0.0001 mg/kg and 10 mg/kg, 0.0001 mg/kg and 5 mg/kg, 0.0001 and 2 mg/kg, 0.0001 and 1 mg/kg, 0.0001 mg/kg and 0.75 mg/kg, 0.0001 mg/kg and 0.5 mg/kg, 0.0001 mg/kg to 0.25 mg/kg, 0.0001 to 0.15 mg/kg, 0.0001 to 0.10 mg/kg, 0.001 to 0.5 mg/kg, 0.01 to 0.25 mg/kg or 0.01 to 0.10 mg/kg of the patient's body weight. The dosage of the antibodies or fragments thereof of the present application may be calculated using the patient's weight in kilograms (kg) multiplied by the dose to be administered in mg/kg.

Doses of the immunoconjugates the present application may be repeated and the administrations may be separated by at least 1 day, 2 days, 3 days, 5 days, 10 days, 15 days, 30 days, 45 days, 2 months, 75 days, 3 months, or at least 6 months. In a specific embodiment, doses of the immunoconjugates of the present application are repeated every 3 weeks.

An effective amount for a particular patient may vary depending on factors such as the condition being treated, the overall health of the patient, the method route and dose of administration and the severity of side effects (see, *e.g.*, Maynard *et al.*, A Handbook of SOPs for Good Clinical Practice, Interpharm Press, Boca Raton, Fla., 1996; Dent, Good Laboratory and Good Clinical Practice, Urch Publ., London, UK, 2001).

The route of administration may be by, *e.g.*, topical or cutaneous application, injection or infusion by intravenous, intraperitoneal, intracerebral, intramuscular, intraocular, intraarterial, intracerebrospinal, intralesional, or by sustained release systems or an implant (see, *e.g.*, Sidman *et al.*, Biopolymers 22:547-556, 1983; Langer *et al.*, J. Biomed. Mater. Res. 15:167-277, 1981; Langer, Chem. Tech. 12:98-105, 1982; Epstein *et al.*, Proc. Natl. Acad. Sci. USA 82:3688-3692, 1985; Hwang *et al.*, Proc. Natl. Acad. Sci. USA 77:4030-4034, 1980; U.S. Pat. Nos. 6,350,466 and 6,316,024). Where necessary, the composition may also include a solubilizing agent and a local anesthetic such as lidocaine to ease pain at the site of the injection. In addition, pulmonary administration can also be employed, *e.g.*, by use of an inhaler or nebulizer, and formulation with an aerosolizing agent. See, *e.g.*, U.S. Pat. Nos. 6,019,968, 5,985,320, 5,985,309, 5,934,272, 5,874,064, 5,855,913, 5,290,540, and 4,880,078; and PCT Publication Nos. WO 92/19244, WO 97/32572, WO 97/44013, WO 98/31346, and WO 99/66903, each of which is incorporated herein by reference their entirety.

A composition of the present application may also be administered via one or more routes of administration using one or more of a variety of methods known in the art. As will be appreciated by the skilled artisan, the route and/or mode of administration will vary depending upon the desired results. Selected routes of administration for the immunoconjugates of the present application include intravenous, intramuscular, intradermal, intraperitoneal, subcutaneous, spinal or other parenteral routes of administration, for example by injection or infusion. Parenteral administration may represent modes of administration other than enteral and topical administration, usually by injection, and includes, without limitation, intravenous, intramuscular, intraarterial, intrathecal, intracapsular, intraorbital, intracardiac, intradermal, intraperitoneal, transtracheal, subcutaneous, subcuticular, intraarticular, subcapsular, subarachnoid, intraspinal, epidural and intrasternal injection and infusion. Alternatively, a composition of the present application can be administered via a non-parenteral route, such as a topical, epidermal or mucosal route of administration, for example, intranasally, orally, vaginally, rectally, sublingually or topically. In one embodiment, the immunoconjugates of the present application is administered by infusion. In another embodiment, the immunoconjugates of the present application is administered subcutaneously.

If the immunoconjugates of the present application are administered in a controlled release or sustained release system, a pump may be used to achieve controlled or sustained release (see Langer, supra; Sefton, CRC Crit. Ref Biomed. Eng. 14:20, 1987; Buchwald *et al.*, Surgery 88:507, 1980; Saudek *et al.*, N. Engl. J. Med. 321:574, 1989). Polymeric materials can be used to achieve controlled or sustained release of the therapies of the present application (see *e.g.*, Medical Applications of Controlled

Release, Langer and Wise (eds.), CRC Pres., Boca Raton, Fla., 1974; Controlled Drug Bioavailability, Drug Product Design and Performance, Smolen and Ball (eds.), Wiley, New York, 1984; Ranger and Peppas, J. Macromol. Sci. Rev. Macromol. Chem. 23:61, 1983; see also Levy *et al.*, Science 228:190, 1985; During *et al.*, Ann. Neurol. 25:351, 1989; Howard *et al.*, J. Neurosurg. 71:105, 1989; U.S. Pat. No. 5,679,377; U.S. Pat. No. 5,916,597; U.S. Pat. No. 5,912,015; U.S. Pat. No. 5,989,463; U.S. Pat. No. 5,128,326; PCT Publication No. WO 99/15154; and PCT Publication No. WO 99/20253. Examples of polymers used in sustained release formulations include, but are not limited to, poly(2-hydroxy ethyl methacrylate), poly(methyl methacrylate), poly(acrylic acid), poly(ethylene-co-vinyl acetate), poly(methacrylic acid), polyglycolides (PLG), polyanhydrides, poly(N-vinyl pyrrolidone), poly(vinyl alcohol), polyacrylamide, poly(ethylene glycol), polylactides (PLA), poly(lactide-co-glycolides) (PLGA), and polyorthoesters. In one embodiment, the polymer used in a sustained release formulation is inert, free of leachable impurities, stable on storage, sterile, and biodegradable. A controlled or sustained release system can be placed in proximity of the prophylactic or therapeutic target, thus requiring only a fraction of the systemic dose (see, *e.g.*, Goodson, in Medical Applications of Controlled Release, *supra*, vol. 2, pp. 115-138, 1984).

Controlled release systems are discussed in the review by Langer, Science 249:1527-1533, 1990). Any technique known to one of skill in the art can be used to produce sustained release formulations comprising one or more immunoconjugates of the present application. See, *e.g.*, U.S. Pat. No. 4,526,938, PCT publication WO 91/05548, PCT publication WO 96/20698, Ning *et al.*, Radiotherapy & Oncology 39:179-189, 1996; Song *et al.*, PDA Journal of Pharmaceutical Science & Technology 50:372-397, 1995; Cleek *et al.*, Pro. Int'l. Symp. Control. Rel. Bioact. Mater. 24:853-854, 1997; and Lam *et al.*, Proc. Int'l. Symp. Control Rel. Bioact. Mater. 24:759-760, 1997, each of which is incorporated herein by reference in their entirety.

If the immunoconjugates of the present application are administered topically, they can be formulated in the form of an ointment, cream, transdermal patch, lotion, gel, shampoo, spray, aerosol, solution, emulsion, or other form well-known to one of skill in the art. See, *e.g.*, Remington's Pharmaceutical Sciences and Introduction to Pharmaceutical Dosage Forms, 19th ed., Mack Pub. Co., Easton, Pa. (1995). For non-sprayable topical dosage forms, viscous to semi-solid or solid forms comprising a carrier or one or more excipients compatible with topical application and having a dynamic viscosity, in some instances, greater than water are typically employed. Suitable formulations include, without limitation, solutions, suspensions, emulsions, creams, ointments, powders, liniments, salves, and the like, which are, if desired, sterilized or mixed with auxiliary agents (*e.g.*, preservatives, stabilizers,

wetting agents, buffers, or salts) for influencing various properties, such as, for example, osmotic pressure. Other suitable topical dosage forms include sprayable aerosol preparations wherein the active ingredient, in some instances, in combination with a solid or liquid inert carrier, is packaged in a mixture with a pressurized volatile (*e.g.*, a gaseous propellant, such as FreonTM) or in a squeeze bottle.

5 Moisturizers or humectants can also be added to pharmaceutical compositions and dosage forms if desired. Examples of such additional ingredients are well-known in the art.

10 If the compositions comprising the immunoconjugates are administered intranasally, it can be formulated in an aerosol form, spray, mist or in the form of drops. In particular, prophylactic or therapeutic agents for use according to the present application can be conveniently delivered in the form of an aerosol spray presentation from pressurized packs or a nebulizer, with a suitable propellant (*e.g.*, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane, carbon dioxide or other suitable gas). In the case of a pressurized aerosol the dosage unit may be determined by providing a valve to deliver a metered amount. Capsules and cartridges (composed of, *e.g.*, gelatin) for use in an inhaler or insufflator may be formulated containing a powder mix of the compound and a suitable powder
15 base such as lactose or starch.

20 Methods for co-administration or treatment with a second therapeutic agent, *e.g.*, a cytokine, steroid, chemotherapeutic agent, antibiotic, or radiation, are known in the art (see, *e.g.*, Hardman *et al.*, (eds.) (2001) Goodman and Gilman's The Pharmacological Basis of Therapeutics, 10th ed., McGraw-Hill, New York, N.Y.; Poole and Peterson (eds.) (2001) Pharmacotherapeutics for Advanced Practice: A Practical Approach, Lippincott, Williams & Wilkins, Phila., Pa.; Chabner and Longo (eds.) (2001) Cancer Chemotherapy and Biotherapy, Lippincott, Williams & Wilkins, Phila., Pa.). An effective amount of therapeutic may decrease the symptoms by at least 10%; by at least 20%; at least about 30%; at least 40%, or at least 50%.

25 Additional therapies (*e.g.*, prophylactic or therapeutic agents), which can be administered in combination with the immunoconjugates of the present application may be administered less than 5 minutes apart, less than 30 minutes apart, 1 hour apart, at about 1 hour apart, at about 1 to about 2 hours apart, at about 2 hours to about 3 hours apart, at about 3 hours to about 4 hours apart, at about 4 hours to about 5 hours apart, at about 5 hours to about 6 hours apart, at about 6 hours to about 7 hours apart, at about 7 hours to about 8 hours apart, at about 8 hours to about 9 hours apart, at about 9 hours to about 10
30 hours apart, at about 10 hours to about 11 hours apart, at about 11 hours to about 12 hours apart, at about 12 hours to 18 hours apart, 18 hours to 24 hours apart, 24 hours to 36 hours apart, 36 hours to 48 hours apart, 48 hours to 52 hours apart, 52 hours to 60 hours apart, 60 hours to 72 hours apart, 72 hours to 84

hours apart, 84 hours to 96 hours apart, or 96 hours to 120 hours apart from the immunoconjugates of the present application. The two or more therapies may be administered within one same patient visit.

In certain embodiments, the immunoconjugates of the present application can be formulated to ensure proper distribution *in vivo*. For example, the blood-brain barrier (BBB) excludes many highly hydrophilic compounds. To ensure that the therapeutic compounds of the present application cross the BBB (if desired), they can be formulated, for example, in liposomes. For methods of manufacturing liposomes, see, *e.g.*, U.S. Pat. Nos. 4,522,811; 5,374,548; and 5,399,331. The liposomes may comprise one or more moieties which are selectively transported into specific cells or organs, thus enhance targeted drug delivery (see, *e.g.*, Ranade, (1989) J. Clin. Pharmacol. 29:685). Exemplary targeting moieties include folate or biotin (see, *e.g.*, U.S. Pat. No. 5,416,016 to Low *et al.*); mannosides (Umezawa *et al.*, (1988) Biochem. Biophys. Res. Commun. 153:1038); antibodies (Bloeman *et al.*, (1995) FEBS Lett. 357:140; Owais *et al.*, (1995) Antimicrob. Agents Chemother. 39:180); surfactant protein A receptor (Briscoe *et al.*, (1995) Am. J. Physiol. 1233:134); p 120 (Schreier *et al.*, (1994) J. Biol. Chem. 269:9090); see also K. Keinänen; M. L. Laukkanen (1994) FEBS Lett. 346:123; J. J. Killion; I. J. Fidler (1994) Immunomethods 4:273.

The present application provides protocols for the administration of pharmaceutical composition comprising immunoconjugates of the present application alone or in combination with other therapies to a subject in need thereof. The therapies (*e.g.*, prophylactic or therapeutic agents) of the combination therapies of the present application can be administered concomitantly or sequentially to a subject. The therapy (*e.g.*, prophylactic or therapeutic agents) of the combination therapies of the present application can also be cyclically administered. Cycling therapy involves the administration of a first therapy (*e.g.*, a first prophylactic or therapeutic agent) for a period of time, followed by the administration of a second therapy (*e.g.*, a second prophylactic or therapeutic agent) for a period of time and repeating this sequential administration, *i.e.*, the cycle, in order to reduce the development of resistance to one of the therapies (*e.g.*, agents) to avoid or reduce the side effects of one of the therapies (*e.g.*, agents), and/or to improve, the efficacy of the therapies.

The therapies (*e.g.*, prophylactic or therapeutic agents) of the combination therapies of the present application can be administered to a subject concurrently.

The term "concurrently" is not limited to the administration of therapies (*e.g.*, prophylactic or therapeutic agents) at exactly the same time, but rather it is meant that a pharmaceutical composition comprising antibodies or fragments thereof of the present application are administered to a subject in a sequence and within a time interval such that the antibodies of the present application can act together

with the other therapy or therapies to provide an increased benefit than if they were administered otherwise. For example, each therapy may be administered to a subject at the same time or sequentially in any order at different points in time; however, if not administered at the same time, they should be administered sufficiently close in time so as to provide the desired therapeutic or prophylactic effect.

5 Each therapy can be administered to a subject separately, in any appropriate form and by any suitable route. In various embodiments, the therapies (*e.g.*, prophylactic or therapeutic agents) are administered to a subject less than 15 minutes, less than 30 minutes, less than 1 hour apart, at about 1 hour apart, at about 1 hour to about 2 hours apart, at about 2 hours to about 3 hours apart, at about 3 hours to about 4 hours
10 apart, at about 4 hours to about 5 hours apart, at about 5 hours to about 6 hours apart, at about 6 hours to about 7 hours apart, at about 7 hours to about 8 hours apart, at about 8 hours to about 9 hours apart, at about 9 hours to about 10 hours apart, at about 10 hours to about 11 hours apart, at about 11 hours to about 12 hours apart, 24 hours apart, 48 hours apart, 72 hours apart, or 1 week apart. In other embodiments, two or more therapies (*e.g.*, prophylactic or therapeutic agents) are administered to a within the same patient visit.

15 The prophylactic or therapeutic agents of the combination therapies can be administered to a subject in the same pharmaceutical composition. Alternatively, the prophylactic or therapeutic agents of the combination therapies can be administered concurrently to a subject in separate pharmaceutical compositions. The prophylactic or therapeutic agents may be administered to a subject by the same or different routes of administration.

20 The present application having been fully described, it is further illustrated by the following examples and claims, which are illustrative and are not meant to be further limiting.

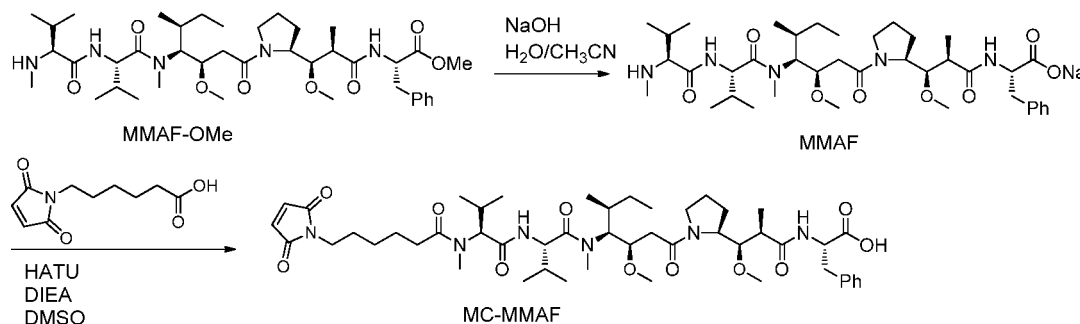
EXAMPLES

25 **Example 1. Payload Compounds.**

Table 5 below lists structures of various payload compounds used in making antibody drug conjugates as described in the Examples in this application. Compounds A-E and methods of synthesizing the compounds, are disclosed, for example, in PCT/US2014/024795, and Compound F is
30 disclosed, for example, in PCT/US2014/070800, both of which are incorporated herein by reference in their entirety. A synthetic method for Compound G is disclosed below.

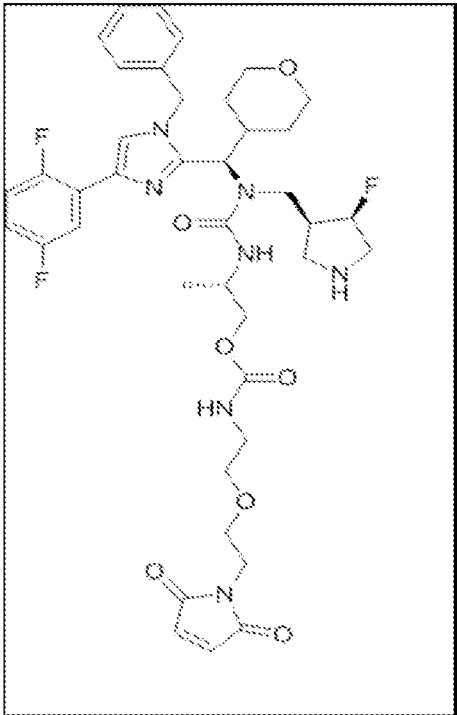
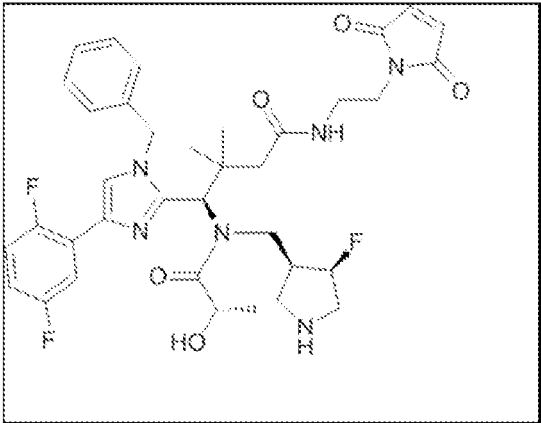
Compound G: Synthetic Procedure

Synthesis of (S)-2-((2R,3R)-3-((S)-1-((3R,4S,5S)-4-((S)-2-((S)-2-(6-(2,5-dioxo-2,5-dihydro-1H-pyrrol-1-yl)-N-methylhexanamido)-3-methylbutanamido)-N,3-dimethylbutanamido)-3-methoxy-5-methylheptanoyl)pyrrolidin-2-yl)-3-methoxy-2-methylpropanamido)-3-phenylpropanoic acid (**MC-MMAF**, **Compound G**)

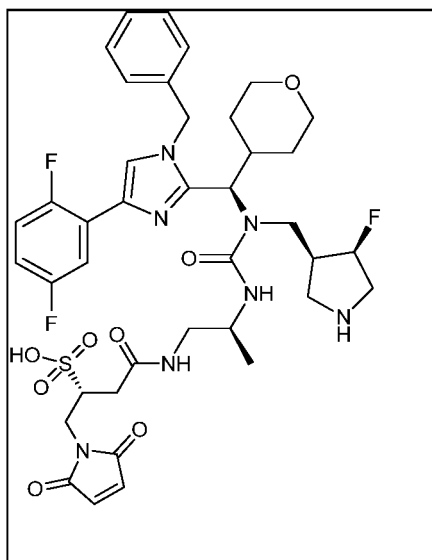


MMAF-OMe (135mg, Concoritis Biosystems) was dissolved in CH₃CN (10mL). To the resulting clear solution was added 5mL water, followed by 0.375mL of 1N aqueous sodium hydroxide (certified, Fisher Scientific). The reaction mixture was stirred magnetically at 21°C for 18 hours, at which time LCMS analysis indicated a complete reaction. The reaction mixture mixture was frozen and lyophilized, affording MMAF sodium salt. LCMS retention time 0.911 minutes. MS (ESI⁺) m/z 732.5 (M+1). The whole MMAF sodium salt thus obtained in previous reaction was dissolved in 10mL DMSO. In a separate reaction vessel, 6-(2,5-dioxo-2,5-dihydro-1H-pyrrol-1-yl)hexanoic acid (95mg) was treated with HATU (165mg) and DIEA (0.126mL) in 3.0mL DMSO at at 21°C for 25min. The whole reaction mixture of the activated ester was added to the solution of MMAF sodium salt, and The reaction mixture was stirred at the same temperature for 3 hours. The reaction mixture mixture was partitioned between 40mL of EtOAc and 20 mL of 5% aqueous citric acid. The organic layer was separated, and the aqueous layer was extracted with 20mL of EtOAc. The combined organic layers were washed with 10mL saturated aqueous NaCl, dried over anhydrous MgSO₄, filtered and concentrated under reduced pressure. The residue was purified on an ISCO CombiFlash instrument using an ISCO C18gold 15.5g column. The desired material was eluted with 50% CH₃CN in H₂O. The fractions containing the desired product was combined and lyophilized, affording compound as white solid. LCMS retention time 1.392 minutes. MS (ESI⁺) m/z 925.6 (M+1).

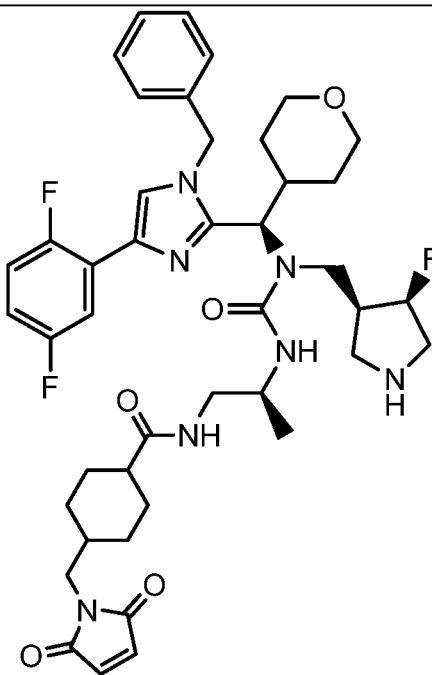
Table 5: Linker-payloads tested.

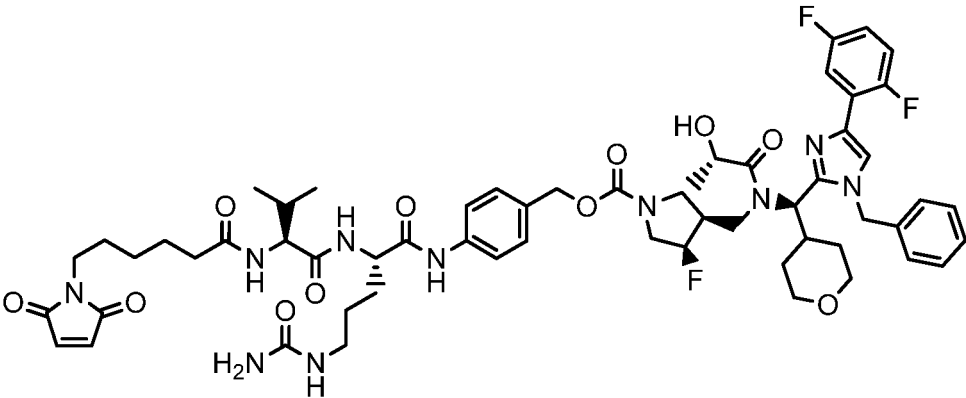
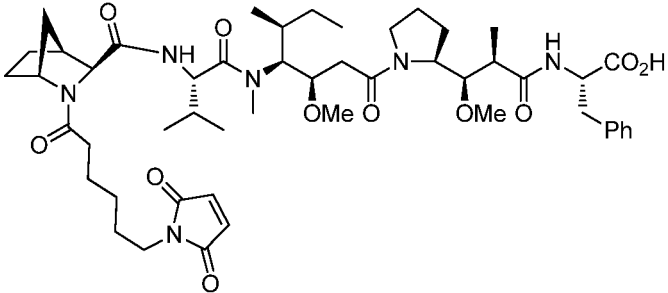
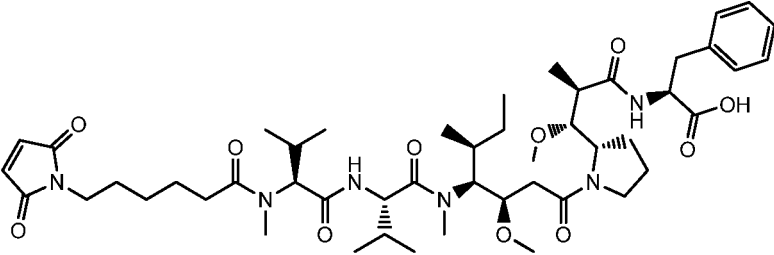
Compound	Structure
Compound A (Eg5 inhibitor)	
Compound B (Eg5 inhibitor)	

Compound C
(Eg5 inhibitor)



Compound D
(Eg5 inhibitor)



<p>Compound E (Eg5 inhibitor)</p>	
<p>Compound F (cytotoxic peptide)</p>	
<p>Compound G (MMAF)</p>	

Example 2. Preparation of trastuzumab Cys mutant antibodies.

DNA encoding variable regions of heavy and light chains of trastuzumab, an anti-HER2 antibody (the terms “trastuzumab,” “anti-HER2 antibody,” and “TBS” are used interchangeably

herein), were chemically synthesized and cloned into two mammalian expression vectors, pOG-HC and pOG-LC that contain constant regions of human IgG1 and human kappa light chain, resulting in two wild type constructs, pOG-trastuzumab HC and pOG-trastuzumab LC, respectively. In the vectors the expression of antibody heavy and light chain constructs in mammalian cells is driven by a CMV promoter. The vectors contain a synthetic 24 amino acid signal sequence:

MKTFILLWVLLLVIFLLPGATA (SEQ ID NO: 99), in the N-terminal of heavy chain or light chain to guide their secretion from mammalian cells. The signal sequence has been validated to be efficient in directing protein secretion in hundreds of mammalian proteins in 293 Freestyle™ cells.

Oligonucleotide directed mutagenesis was employed to prepare Cys mutant constructs in trastuzumab. Pairs of mutation primers were chemically synthesized for each Cys mutation site (Table 6). The sense and anti-sense mutation primer pairs were mixed prior to PCR amplification. PCR reactions were performed by using PfuUltra II Fusion HS DNA Polymerase (Stratagene) with pOG-trastuzumab HC and pOG-trastuzumab LC as the templates. After PCR reactions, the PCR products were confirmed on agarose gels, and treated with Dpn I followed by transformation in DH10b cells (Klock *et al.*, (2009) *Methods Mol Biol.* 498:91-103).

Table 6. DNA sequences of mutation primers used to prepare 11 individual Cys mutations heavy and light chains of human IgG1.

Mutation sites	Primer name	Sequence	SEQ ID NO.
LC-K107C	LC-CYS-S1	GTGGAGATCTGTGCAACGGTGGCCGCTCCCAGCGTGTTC A	100
	LC-CYS-A1	ACCGTTCGACAGATCTCCACCTTGGTACCCTGTCCGAAC	101
LC-S159C	LC-CYS-S18	AGCGGCAACTGTCAGGAGAGCGTCACCGAGCAGGACAG CAA	102
	LC-CYS-A18	CTCTCCTGACAGTTGCCGCTCTGCAGGGCGTTGTCCACC T	103
LC-E165C	LC-CYS-S20	GAGCGTCACCTGTCAGGACAGCAAGGACTCCACCTACA GC	104
	LC-CYS-A20	CTGTCCTGACAGGTGACGCTCTCCTGGCTGTTGCCGCTC T	105
HC-E152C	HC-CYS-S9	TACTTCCCCTGTCCCGTGACCGTGTCTGGAACAGCGGA	106
	HC-CYS-A9	GGTCACGGGACAGGGGAAGTAGTCCTTACCAGGCAGC	107
HC-P171C	HC-CYS-S16	CACACCTTCTGTGCCGTGCTGCAGAGCAGCGGCCTGTAC A	109
	HC-CYS-A16	CAGCACGGCACAGAAGGTGTGCACGCCGGAGGTCAGGG CT	110
HC-P247C	HC-CYS-	CTGTTCCCACCCAAGTGTAAGGACACCCTGATGATCAG	111

Mutation sites	Primer name	Sequence	SEQ ID NO.
	S247		
	HC-CYS-A247	CTTGGGTGGGAACAGGAACACGGAGGGTCCGCCCAG	112
HC-A327C	HC-CYS-S327	TGCAAGGTCTCCAACAAGTGTCTGCCAGCCCCCATCGA AAAG	113
	HC-CYS-A327	GTTGGAGACCTTGCACTTGTATTCTTGCCGTTTCAGCCA G	114
HC-K334C	HC-CYS-S46	CCCATCGAATGCACCATCAGCAAGGCCAAGGGCCAGCC A	115
	HC-CYS-A46	GCTGATGGTGCATTCGATGGGGGCTGGCAGGGCCTTGTT G	116
HC-A339C	HC-CYS-S339	CTTGCTGATGGTCTTTTCGATGGGGGCTGGCAGGGCCTT G	117
	HC-CYS-A339	AAGACCATCAGCAAGTGTAAAGGGCCAGCCACGGGAG	118
HC-K360C	HC-CYS-S52	AGCTGACCTGCAACCAGGTGTCCCTGACCTGTCTGGTGA	119
	HC-CYS-A52	CACCTGGTTGCAGGTCAGCTCGTCCCGGGATGGAGGCA GG	120
HC-Y373C	HC-CYS-S373	CTGGTGAAGGGCTTCTGTCCCAGCGACATCGCCGTGGA GTG	121
	HC-CYS-A373	GAAGCCCTTCACCAGACAGGTCAGGGACACCTGGTTCT TG	122
HC-S375C	HC-CYS-S54	TTCTACCCCTGCGACATCGCCGTGGAGTGGGAGAGCAA CG	123
	HC-CYS-A54	GGCGATGTGCGAGGGGTAGAAGCCCTTCACCAGACAGG TCA	124
HC-Y391C	HC-CYS-S391	AACAACCTGTAAGACCACACCTCCAGTGCTGGACAGCGA C	125
	HC-CYS-A391	GGTCTTACAGTTGTTCTCGGGCTGGCCGTTGCTCTCCCA C	126
HC-P396C	HC-CYS-S396	ACACCTTGTGTGCTGGACAGCGACGGCAGCTTCTTCCTG	127
	HC-CYS-A396	CAGCACACAAGGTGTGGTCTTGTAGTTGTTCTCGGGCTG	128

In some cases, two or more mutations were made in the same chain of trastuzumab.

Oligonucleotide directed mutagenesis was employed to prepare the multiple Cys mutant constructs using the same method as above but using a pOG-trastuzumab-Cys mutant plasmid as the template for serial rounds of mutagenesis.

- 5 Sequences of all Cys mutant constructs were confirmed by DNA sequencing. The encoded protein sequence of the constant region of the HC and LC Cys mutant IgG1 constructs are shown in Table 7 and Table 8, respectively. Amino acid residues in human IgG1 heavy chain and human

kappa light chain are numbered by EU numbering system (Edelman *et al*, (1969) *Proc Natl Acad Sci U S A*, 63:78-85).

5 Table 7. Amino acid sequences of the constant region of Cys mutant constructs in human IgG1 heavy chain. SEQ ID NO:1 is the sequence for full-length trastuzumab with the constant region underlined. Additional sequences are Cys mutant constructs in human IgG1 heavy chain, showing only the sequences of the constant region. The mutant cys positions are shown by bold and underlined text.

SEQ ID NO:1 EVQLVESGGGLVQPGGSLRLSCAASGFNIKDTYIHWVRQAPGKGLEWV ARIYPTNGYTRYADSVKGRFTISADTSKNTAYLQMNSLRAEDTAVYYC SRWGGDGFYAMDYWGQGLVTVSSASTKGPSVFPLAPSSKSTSGGTAA <u>LGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPS</u> <u>SSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPS</u> <u>VFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNA</u> <u>KTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKT</u> <u>ISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESN</u> <u>GQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCFSVMHEAL</u> <u>HNHYTQKSLSLSPGK</u>
SEQ ID NO:10 (Cysteine substitution at position 152) SASTKGPSVFPLAPSSKSTSGGTAAALGCLVKDYFPCPVTVSWNSGALTS GVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKK VEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVV DVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTK NQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSK LTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK
SEQ ID NO:18 (Cysteine substitution at position 174) SASTKGPSVFPLAPSSKSTSGGTAAALGCLVKDYFPEPVTVSWNSGALTS GVHTFPAVLCQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKK VEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVV DVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTK NQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSK LTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK
SEQ ID NO:42 (Cysteine substitution at position 333) SASTKGPSVFPLAPSSKSTSGGTAAALGCLVKDYFPEPVTVSWNSGALTS GVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKK VEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVV DVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPICKTISKAKGQPREPQVYTLPPSREEMT KNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYS KLTVDKSRWQQGNVFCFSVMHEALHNHYTQKSLSLSPGK

<p>SEQ ID NO:48 (Cysteine substitution at position 360)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTS GVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKK VEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVTV DVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTC NQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSK LTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO:50 (Cysteine substitution at position 375)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTS GVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKK VEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVTV DVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQ DWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTK NQVSLTCLVKGFYPCDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSK LTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 129: (Cysteine substitution at positions 334 and 375)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSG VHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEP KSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVTVDVSH EDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIECCTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPCDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSR WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 130 (Cysteine substitution at positions 334 and 392)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSG VHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEP KSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVTVDVSH EDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIECCTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPSDIAVEWESNGQPENNYCTTPPVLDSDGSFFLYSKLTVDKSR WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 131 (Cysteine substitution at positions 152 and 375)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPCTPVTVSWNSGALTSG VHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEP KSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVTVDVSH EDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNG KEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLT CLVKGFYPCDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSR WQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 132 (Cysteine substitution at positions 339 and 396)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVTVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKCKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKT TPCVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>

<p>SEQ ID NO: 133 (Cysteine substitution at positions 152 and 171)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPCPPTVSWNSGA LTSGVHTFCAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNT KVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTY RVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREP QVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYK TTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYT QKSLSLSPGK</p>
<p>SEQ ID NO: 134 (Cysteine substitution at positions 334 and 396)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPPTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCTVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVLTVLHQDWLNGKEYKCKVSNKALPAPIECISKAKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKT TPCVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO: 135 (Cysteine substitution at position 396)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPPTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCTVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKT TPCVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO: 136 (Cysteine substitution at positions 375 and 396)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPPTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCTVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNYKT TPCVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO: 137 (Cysteine substitution at positions 375 and 391)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPPTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCTVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNCCKT TPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>

<p>SEQ ID NO: 138 (Cysteine substitution at positions 391 and 396)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVELTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENN<u>CK</u>T TP<u>C</u>VLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO: 139 (Cysteine substitution at positions 152 and 396)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFP<u>C</u>PVTVSWNSGA LTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNT KVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTY RVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREP QVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYK TTP<u>C</u>VLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYT QKSLSLSPGK</p>
<p>SEQ ID NO: 140 (Cysteine substitution at positions 327 and 339)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVELTVLHQDWLNGKEYKCKVSNK<u>CL</u>PAPIEKTISK<u>CK</u>GQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKT TPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO: 141 (Cysteine substitution at position 391)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT EVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYR VVSVELTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQ VYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENN<u>CK</u>T TPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQ KSLSLSPGK</p>
<p>SEQ ID NO: 142 (Cysteine substitution at positions 152 and 339)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFP<u>C</u>PVTVSWNSGA LTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNT KVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRT PEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTY RVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISK<u>CK</u>GQPREP QVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYK TTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYT QKSLSLSPGK</p>

<p>SEQ ID NO: 143 (Cysteine substitution at positions 339 and 375)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTK VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKCKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 144 (Cysteine substitution at positions 152 and 327)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPCPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKCLPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 145 (Cysteine substitution at position 373)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFPCPSDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 146 (Cysteine substitution at positions 327 and 375)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKCLPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>
<p>SEQ ID NO: 147 (Cysteine substitution at position 247)</p> <p>SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKCKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK</p>

SEQ ID NO:150 (Constant region of the wild type heavy chain of anti-cKIT and anti-Her2 antibodies)
 SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGAL
 TSGVHTFPAVLQSSGLYSLSSVTVPSSSLGTQTYICNVNHKPSNTK
 VDKKVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSVMHEALHNHYTQKSLSLSPGK

Table 8. Amino acid sequences of the constant region of 3 human kappa light chain Cys mutant constructs. SEQ ID NO:90 sequence for full-length trastuzumab (human kappa light chain) with the constant region underlined. Additional sequences are the sequence ID numbers for Cys mutant constructs in the constant region of human kappa light chain.

SEQ ID NO:90 (anti-Her2 light chain) DIQMTQSPSSLSASVGDRVTITCRASQDVNTAVAWYQQKPGKAPKL LIYSASFLYSGVPSRFSGRSGTDFTLTISSLQPEDFATYYCQQHYTTP PTFGQGTKVEIKRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPRE <u>AKVQWKVDNALQSGNSQESVTEQDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC</u>
SEQ ID NO:61 (Cysteine substitution at position 107) <u>C</u> RTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNA LQSGNSQESVTEQDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:75 (Cysteine substitution at position 159) KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNAL QSGN <u>C</u> QESVTEQDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:77 (Cysteine substitution at position 165) KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNA LQSGNSQESVT <u>C</u> QDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:148 (Cysteine substitution at positions 159 and 165) KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNA LQSGN <u>C</u> QESVT <u>C</u> QDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVCKSFNRGEC
SEQ ID NO:149 (Constant region of wild type light chain for anti-Her2 and anti-cKIT) KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNA LQSGNSQESVTEQDSKDYSLSSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

Example 3. Transfer of the trastuzumab heavy chain and light chain Cys mutations to different antibodies.

For trastuzumab, all Cys mutations for the attachment of drug payloads were chosen to be in the constant region of its human IgG1 heavy and human kappa light chain. Because constant regions of antibodies are highly conserved in primary sequence and structure, Cys mutant residues that are identified as good payload attachment sites in the context of trastuzumab will also serve as preferred attachment residues in other antibodies. To demonstrate the transferability of these generic conjugation sites to other antibodies, we cloned a set of Cys mutations into an anti-cKIT antibody. The anti-cKIT antibody is an antibody with a human IgG1 heavy chain and a human kappa light chain that binds to the cKIT protein. The DNA encoding variable regions of antibody anti-cKIT were cloned into three selected pOG trastuzumab HC Cys mutant plasmid constructs and two selected pOG trastuzumab LC Cys mutant plasmid constructs (SEQ ID NOs listed in Table 9) to replace the variable regions of trastuzumab constructs in the plasmids as described in Example 2. As a result, the amino acid sequences of the heavy chain and light chain constant regions in corresponding five Cys constructs of the anti-cKIT antibody and of trastuzumab are identical. Subsequent examples show that these sites can be conjugated readily. Conversely, due to a high degree of similarity in primary sequences and in tertiary structures for different human IgG isotypes, Cys mutations on the kappa light chain of trastuzumab can readily be transferred to equivalent light chains on human antibodies containing different isotype heavy chains. In the same way, the sites identified in the constant region of IgG1 may be transferred to IgG2, IgG3 and IgG4.

Table 9. Sequence ID numbers of trastuzumab Cys constructs used for cloning of the variable region of the anti-cKIT antibody.

Sequence ID NO: of trastuzumab Cys construct
SEQ ID NO:48
SEQ ID NO:61
SEQ ID NO:77
SEQ ID NO:129
SEQ ID NO:131

Example 4. Expression and purification of Cys mutant antibodies in 293 Freestyle™ cells.

Antibody conjugates produced through conjugation to lysine residues or partially reduced native disulfide bonds often feature drug-to-antibody-ratios (DAR) of between 3 and 4. Cys

engineered antibodies more typically feature a DAR of 2. For certain indications, it may be desirable to produce ADCs with higher DAR which can in principle be achieved by introducing multiple Cys mutations in the antibody. As the number of Cys mutation increases, the likelihood that such mutations interfere with the required re-oxidation process during ADC preparation and hence result in heterogeneous products also increases. In this study, a large number of single site heavy and light chain Cys mutants with good re-oxidation behavior were identified. To demonstrate that several conjugation sites can be combined for the production of ADCs with DAR greater than two, several single site Cys constructs of light and heavy chain of trastuzumab and anti-cKIT antibody (Table 10) were co-expressed in 293 Freestyle™ cells.

Table 10. Sequence IDs for constant regions of Cys engineered antibodies resulting in ADCs with DAR of 4 or 6

.Cys-drug ADC (DAR=4 to 6)	LC SEQ ID NO	HC SEQ ID NO	Target DAR
anti-cKIT-HC-E152C-S375C	149	131	4
trastuzumab-HC-E152C-S375C	149	131	4
anti-cKIT-HC-K360C-LC-K107C	61	48	4
trastuzumab-HC-K360C-LC-K107C	61	48	4
trastuzumab-HC-A339C-P396C	149	132	4
trastuzumab-HC-E152C-LC-E165C	77	10	4
trastuzumab-HC-E152C-LC-S159C-E165C	148	10	6
trastuzumab-HC-E152C-P171C	149	133	4
trastuzumab-HC-K334C-P396C	149	134	4
trastuzumab-HC-K334C-S375C	149	129	4
anti-cKIT-HC-K334C-S375C-LC-E165C	77	129	6
trastuzumab-HC-P396C-LC-E165C	77	135	4
trastuzumab-HC-S375C-P396C	149	136	4
trastuzumab-HC-S375C-Y391C	149	137	4
trastuzumab-HC-Y391C-P396C	149	138	4
trastuzumab-LC-S159C-E165C	148	150	4

Cys mutant antibody were expressed in 293 Freestyle™ cells by co-transfecting heavy chain and light chain plasmids using transient transfection method as described previously (Meissner, *et al.*, *Biotechnol Bioeng.* 75:197-203 (2001)). The DNA plasmids used in co-transfection were prepared using Qiagen plasmid preparation kit according to manufacturer's protocol. 293 Freestyle™ cells were cultured in suspension in Freestyle™ expression media (Invitrogen) at 37°C under 5% CO₂. Three days before transfection, cells were split to 0.25 x 10⁶ cells/ml into fresh media. On the day of transfection, the cell density typically reached 1.5-2 x 10⁶

cells/ml. The cells were transfected with a mixture of heavy chain and light chain plasmids at the ratio of 1:1 using PEI method (Meissner, *et al.*, *Biotechnol Bioeng.* 75:197-203 (2001)). The transfected cells were further cultured for five days. The media from the culture was harvested by centrifugation of the culture at 2000 g for 20 min and filtered through 0.2 micrometer filters. The expressed antibodies were purified from the filtered media using Protein A-Sepharose™ (GE Healthcare Life Sciences). Antibody IgGs were eluted from the Protein A-Sepharose™ column by the elution buffer (pH 3.0) and immediately neutralized with 1 M Tris-HCl (pH 8.0) followed by a buffer exchange to PBS.

Expression levels of trastuzumab and anti-cKIT Cys mutant antibodies in transiently transfected 293 Freestyle™ are similar to that of wild type antibodies, with yields ranging from 12-25 mg/L, suggesting that single to triple point mutations in the selected sites did not significantly alter retention of the expressed antibody by the cells' secretion machinery. Analysis of the purified Cys mutant antibodies using non-reducing SDS PAGE indicates that the Cys mutant antibodies did not form oligomers disulfide-linked by the engineered cysteines.

Example 5. Reduction, re-oxidation and conjugation of Cys mutant antibodies with various payloads.

Because engineered Cys in antibodies expressed in mammalian cells are typically modified by adducts (disulfides) such as glutathione (GSH) and/or Cysteine during their biosynthesis (Chen *et al.* 2009), the modified Cys in the product as initially expressed is unreactive to thiol reactive reagents such as maleimido or bromo- or iodo-acetamide groups. To conjugate the engineered cysteine after expression, the glutathione or cysteine adducts need to be removed by reducing these disulfides, which generally entails reducing all of the disulfides in the expressed protein. This can be accomplished by first exposing the antibody to a reducing agent such as dithiothreitol (DTT) followed by a procedure that allows for the re-oxidation of all native disulfide bonds of the antibody to restore and/or stabilize the functional antibody structure. Accordingly, in order to reduce all native disulfide bonds and the disulfide bound between the cysteine or GSH adducts of the engineered cysteine residue, freshly prepared DTT was added to purified Cys mutants of trastuzumab and anti-cKIT antibody, to a final concentration of 10 or 20 mM DTT. After the antibody incubation with DTT at 37°C for 1 hour, the mixtures were dialyzed against PBS for three days with daily buffer exchange to remove DTT and re-oxidize the native disulfide bonds. The re-oxidation process was monitored by reverse-phase HPLC, which is able to separate full IgG from individual heavy and light chain molecules. The conjugation reaction mixtures were analyzed on a

PRLP-S 4000A column (50 mm x 2.1 mm, Agilent) heated to 80°C and elution of the column was carried out by a linear gradient of 30-60% acetonitrile in water containing 0.1% TFA at a flow rate of 1.5 ml/min. The elution of proteins from the column was monitored at 280 nm. Dialysis was allowed to continue until reoxidation was complete. Reoxidation restores intra-chain disulfides, while dialysis allows cysteines and glutathiones connected to the newly-introduced cysteine(s) to dialyze away.

After re-oxidation, the antibodies are ready for conjugation. Maleimide-containing compounds were added to re-oxidized antibodies in PBS buffer (pH 7.2) at ratios of typically 1.5:1, 2:1, or 10:1. The incubations were carried out from 1 hour to 24 hours. The conjugation process was monitored by reverse-phase HPLC, which is able to separate conjugated antibodies from non-conjugated ones in most cases. The elution of proteins from the column was monitored by UV absorbance at wavelengths of 280 nm, 254 nm and 215 nm.

When the conjugation mixtures were analyzed by reverse-phase HPLC, many Cys sites generated homogenous conjugation products, as suggested by uniform, single peak elution profiles, while some Cys sites generated heterogeneous conjugation products or showed only peaks matching the unconjugated antibodies.

The procedures described above involve reduction and re-oxidation of native disulfide bonds as well as the reduction of bonds between the cysteine and GSH adducts of the engineered cysteine residues. During the re-oxidation process, the engineered cysteine residue may interfere with reforming of the proper native disulfide bonds through a process of disulfide shuffling. This may lead to the formation of mismatched disulfide bonds, either between the engineered cysteine and a native cysteine residue or between incorrectly matched native disulfide bonds. Such mismatched disulfide bonds may affect the retention of the antibody on the reverse-phase HPLC column. The mismatch processes may also result in unpaired cysteine residues other than the desired engineered cysteine. Attachment of the maleimide-compound to different positions on the antibody affects the retention time differently (see discussion of homogeneously conjugated ADCs below). In addition, incomplete re-oxidation will leave the antibody with native cysteine residues that will react with maleimide-compound in addition to the desired conjugation with the engineered cysteine residue. Any process that hinders proper and complete formation of the native disulfide bonds will result in a complex HPLC profile upon conjugation to Cys reactive compounds. Although sites were chosen to be surface exposed, there may also be heterogeneity in the final product if the introduced free cysteine is not accessible to or is otherwise unable to interact

productively with the maleimide-drug in some or all conformations of the antibody. If the free cysteine is non-reactive, the final DAR will be lowered and the product likely to be a heterogeneous mixture of fully, partially, and unmodified Cys mutant antibody. In the case of an antibody with two or more introduced free cysteines, there can be additional complexity introduced if drug attachment at one site interferes (i.e. by steric crowding) with the binding of a second drug at a second site. Such competition will lead to lower final DAR and a heterogeneous product. If two introduced cysteines are very close and properly oriented, then they may also form a non-native disulfide bond rather than forming two free cysteines. In this case, the antibody will not be reactive towards a maleimide-drug compound and the result will be a lower final DAR or even a uniform unconjugated product. The yield of the uniform ADC as measured by UV absorption by RP-HPLC the unpurified reaction mixtures, varied depending on the Cys mutations as well as the linker-payload compound used. Using the reduction/re-oxidation protocol and conjugation procedures described above 26 of 45 multiple Cys mutant trastuzumab or anti-cKIT antibodies described here resulted in homogeneous conjugation products of acceptable final DAR (DAR 3.4-4.4 for double Cys mutant, 5.1-6.0 for triple Cys mutant, Table 11) for such small test conjugations. These Cys sites and drug combinations are advantageous when making ADCs.

Table 11. DAR calculated from RP-HPLC analysis and verified by LCMS of intact, reduced, deglycosylated antibody chains for 45 multiple Cys mutant antibody samples conjugated to various drug by the methods described above.

Cys mutant antibody	Linker-payload compound	Expected DAR	Observed DAR
trastuzumab-HC-A339C-P396C	Compound A	4.0	2.0
trastuzumab-HC-A329C-P396C	Compound G	4.0	3.6
trastuzumab-HC-A339C-P396C	Compound G	4.0	3.6
trastuzumab-HC-E152C-LC-E165C	Compound A	4.0	3.0
trastuzumab-HC-E152C-LC-E165C	Compound E	4.0	3.0
trastuzumab-HC-E152C-LC-E165C	Compound F	4.0	3.7
trastuzumab-HC-E152C-LC-E165C	Compound G	4.0	2.9
trastuzumab-HC-E152C-LC-S159C-E165C	Compound A	6.0	4.0
trastuzumab-HC-E152C-LC-S159C-E165C	Compound E	6.0	5.2
trastuzumab-HC-E152C-LC-S159C-E165C	Compound G	6.0	5.2
trastuzumab-HC-E152C-P174C	Compound A	4.0	1.9
trastuzumab-HC-E152C-P174C	Compound F	4.0	3.7
anti-cKIT-HC-E152C-S375C	Compound A	4.0	3.9
anti-cKIT-HC-E152C-S375C	Compound F	4.0	3.8
trastuzumab-HC-E152C-S375C	Compound A	4.0	3.7
trastuzumab-HC-E152C-S375C	Compound G	4.0	3.7
trastuzumab-HC-K334C-P396C	Compound A	4.0	0.6

trastuzumab-HC-K334C-P396C	Compound F	4.0	3.7
trastuzumab-HC-K334C-P396C	Compound G	4.0	3.5
trastuzumab-HC-K334C-S375C	Compound A	4.0	2.6
trastuzumab-HC-K334C-S375C	Compound F	4.0	3.8
trastuzumab-HC-K334C-S375C	Compound G	4.0	3.0
anti-cKIT-HC-K334C-S375C-LC-E165C	Compound E	6.0	5.8
anti-cKIT-HC-K334C-S375C-LC-E165C	Compound G	6.0	5.2
trastuzumab-HC-K334C-S375C-LC-E165C	Compound E	6.0	6.0
trastuzumab-HC-K334C-S375C-LC-E165C	Compound G	6.0	6.0
anti-KIT-HC-K360C-LC-K107C	Compound A	4.0	4.0
anti-KIT-HC-K360C-LC-K107C	Compound F	4.0	4.0
trastuzumab-HC-K360C-LC-K107C	Compound A	4.0	4.0
trastuzumab-HC-K360C-LC-K107C	Compound G	4.0	3.9
trastuzumab-HC-P396C-LC-E165C	Compound A	4.0	1.6
trastuzumab-HC-P396C-LC-E165C	Compound F	4.0	3.8
trastuzumab-HC-P396C-LC-E165C	Compound G	4.0	3.4
trastuzumab-HC-S375C-P396C	Compound A	4.0	0.0
trastuzumab-HC-S375C-P396C	Compound F	4.0	0.0
trastuzumab-HC-S375C-P396C	Compound G	4.0	0.0
trastuzumab-HC-S375C-Y391C	Compound A	4.0	2.3
trastuzumab-HC-S375C-Y391C	Compound G	4.0	3.2
trastuzumab-HC-Y391C-P396C	Compound A	4.0	0.0
trastuzumab-HC-Y391C-P396C	Compound F	4.0	3.6
trastuzumab-HC-Y391C-P396C	Compound G	4.0	2.9
trastuzumab-LC-S159C-E165C	Compound A	4.0	2.0
trastuzumab-LC-S159C-E165C	Compound D	4.0	3.5
trastuzumab-LC-S159C-E165C	Compound E	4.0	3.6

A subset of the 45 ADC samples in Table 11 were analyzed in details in various assays: Differential scanning fluorimetry (DSF) was used to measure thermal stability. Analytical size exclusion chromatograph (AnSEC) and multi-angle light scattering (MALS) were used to measure aggregation. *In vitro* antigen dependent cell killing potency was measured by cell viability assays and pharmacokinetics behavior was measured in mice. In general, the multiple Cys mutant ADCs showed thermal stability similar to single Cys mutant ADCs. The ADCs were predominantly monomeric as determined by analytical size exclusion chromatography.

Example 6. Preparation of anti-cKIT and trastuzumab Cys mutant ADCs conjugated with various compounds.

Antibody drug conjugates of trastuzumab and anti-cKIT cys mutant antibodies HC-E152C-S375C and HC-K360C-LC-K107C were prepared using several payloads as described above. Some of the properties of these ADCs are shown in Table 12. The *in vitro* cell killing potency of these ADCs was

tested as described in Example 7 and the results are summarized in Table 13 and Table 14. The compounds were further subjected to pharmacokinetic (PK) studies in naïve mice as described in Example 8. The PK properties are summarized in Table 15 and Table 16.

5 Table 12. Properties of anti-Her2 Cys mutant ADCs conjugated with various compounds.

ADC name ^a	DAR ^b	Aggregation (%) ^c
trastuzumab-HC-E152C-S375C-Compound A	3.8	0.4
trastuzumab-HC-E152C-S375C-Compound B	4.0	BLQ
trastuzumab-HC-E152C-S375C-Compound C	3.7	0.6
trastuzumab-HC-E152C-S375C-Compound F	3.8	0.3
trastuzumab-HC-K360C-LC-K107C-Compound A	3.9	3.8
trastuzumab-HC-K360C-LC-K107C-Compound B	3.8	2.0
trastuzumab-HC-K360C-LC-K107C-Compound C	4.0	5.1
trastuzumab-HC-K360C-LC-K107C-Compound F	3.8	3.5
anti-cKIT-HC-E152C-S375C-Compound A	3.9	BLQ
anti-cKIT-HC-E152C-S375C-Compound F	3.8	1.5
anti-cKIT-HC-K360C-LC-K107C-Compound A	4	BLQ
anti-cKIT-HC-K360C-LC-K107C-Compound F	4	1.5

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b Drug-to-antibody ratio according to reverse-phase HPLC.

^c Aggregation measured by analytical size exclusion chromatography; includes dimeric and oligomeric species. BLQ = below limit of quantitation.

Example 7. Cell proliferation assays to measure *In vitro* cell killing potency of Cys mutant ADCs.

Cells that naturally express target antigens or cell lines engineered to express target
 15 antigens are frequently used to assay the activity and potency of ADCs. For evaluation of the cell killing potency of trastuzumab ADCs *in vitro*, two engineered cell lines, MDA-MB231 clone 16 and clone 40, and HCC1954 cells were employed (Gazdar A, Rabinovsky R, Yefenof E, Gordon B, Vitetta ES. Breast Cancer Res Treat. (2000) 61:217-228). MDA-MB231 clone 16 cells stably express high copy numbers ($\sim 5 \times 10^5$ copies /cell) of recombinant human Her2 while clone 40
 20 expresses low copy numbers ($\sim 5 \times 10^3$ copies /cell) of human Her2. HCC1954 cells endogenously express high level ($\sim 5 \times 10^5$ copies /cell) of human Her2 in the surface. For determination of the cell killing potency of anti-cKIT ADCs, H526, KU812, CMK11-5 and Jurkat cells were used. While CMK11-5, H526 and KU812 cells express a high level of the antigen for the anti-cKIT antibody in the cell surface there is no detectable antigen expression in Jurkat cells. An antigen dependent
 25 cytotoxic effect should only kill cells that express sufficient antigen in the cell surface and not cells

lacking the antigen. The cell proliferation assays were conducted with Cell-Titer-Glo™ (Promega) five days after cells were incubated with various concentrations of ADCs (Riss *et al.*, (2004) Assay Drug Dev Technol. 2:51-62). In some studies, the cell based assays are high throughput and conducted in an automated system (Melnick *et al.*, (2006) Proc Natl Acad Sci U S A. 103:3153-3158).

Trastuzumab Cys mutant ADCs specifically killed Her2 expressing MDA-MB231 clone 16 and HCC1954 but not MDA-MB231 clone 40 cells that express Her2 at very low levels (Table 13). Trastuzumab ADCs prepared with Compound F also killed JimT1 cells. IC₅₀ of the trastuzumab Cys mutant ADCs varied by cell type and depending on the compound used (Table 13). Similarly, anti-cKIT Cys mutant ADCs displayed antigen-dependent cell killing in cell proliferation assays. Anti-cKIT Cys-drug ADCs killed antigen expressing NCI-H526, KU812 and CMK115 cells but not antigen negative Jurkat cells. The IC₅₀ of the anti-cKIT ADCs varied with cell type and compound used (Table 14).

Table 13. *In vitro* cell killing potency of anti-Her2 ADCs conjugated with various compounds.

ADC name ^a	IC ₅₀ (μM) ^b			
	MDA231-40	HCC1954	JimT1	MDA231-16
trastuzumab-HC-E152C-S375C-Compound A	6.7E-02	1.4E-04	4.8E-02	6.7E-02
trastuzumab-HC-E152C-S375C-Compound B	6.7E-02	1.6E-04	6.7E-02	2.6E-04
trastuzumab-HC-E152C-S375C-Compound C	6.7E-02	1.8E-04	5.6E-02	3.6E-04
trastuzumab-HC-E152C-S375C-Compound F	6.7E-02	1.6E-04	1.7E-04	1.8E-04
trastuzumab-HC-K360C-LC-K107C-Compound A	6.7E-02	1.7E-04	6.7E-02	4.5E-02
trastuzumab-HC-K360C-LC-K107C-Compound B	6.7E-02	8.3E-05	6.7E-02	6.7E-02
trastuzumab-HC-K360C-LC-K107C-Compound C	6.7E-02	1.7E-04	6.7E-02	4.5E-02
trastuzumab-HC-K360C-LC-K107C-Compound F	6.7E-02	5.4E-05	1.3E-04	8.1E-05

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b The highest concentration used in the assay was 6.7E-02 μM. IC₅₀ values of 6.7E-02 μM therefore refer to inactivity of the ADC in the assay.

Table 14. *In vitro* cell killing activity of anti-cKIT ADCs conjugated with various compounds.

ADC name ^a	IC ₅₀ (μM) ^b			
	Jurkat	H526	KU812	CMK115
anti-cKIT-HC-E152C-S375C-Compound A	6.7E-02	1.9E-04	6.7E-02	6.7E-02
anti-cKIT-HC-E152C-S375C-Compound F	6.7E-02	5.3E-05	5.7E-05	6.1E-05
anti-cKIT-HC-K360C-LC-K107C-Compound A	6.7E-02	2.0E-04	6.7E-02	6.7E-02
anti-cKIT-HC-K360C-LC-K107C-Compound F	5.2E-02	5.7E-05	6.1E-05	9.9E-05

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b The highest concentration used in the assay was 6.7E-02 μM. IC₅₀ values of 6.7E-02 μM therefore refer to inactivity of the ADC in the assay.

Example 8. Pharmacokinetic study of Cys mutant ADCs.

It has been demonstrated that a long serum half-life is critical for high *in vivo* efficacy of ADCs (Hamblett, *et al.*, “Effects of drug loading on the antitumor activity of a monoclonal antibody drug conjugate,” *Clin Cancer Res.*, 10:7063-7070 (2004); Alley *et al.*, *Bioconjug Chem.* 19:759-765 (2008)). Attaching a usually hydrophobic drug payload to an antibody can significantly affect the properties of an antibody, and this may lead to a fast clearance of the ADCs *in vivo* (Hamblett *et al.*, 2004) and poor *in vivo* efficacy. To evaluate the effects of different conjugation sites on clearance of multi-Cys-drug ADCs *in vivo*, pharmacokinetic studies in non-tumor bearing mice were carried out. To detect drug containing ADCs in murine plasma, an anti-MMAF antibody was generated. ELISA assays for the detection of ADCs were developed on a GyrosTM platform using an anti-human IgG (anti-hIgG) to capture human IgG molecules from the plasma and an anti-human IgG (anti-hIgG) antibody and an anti-MMAF antibody for signal generation in two separate assays. The two ELISA assays measure the serum concentration of the antibody and the “intact” ADC respectively as discussed in more detail below. Three mice per group were administered with a single dose of the Cys ADCs at 1 mg/kg. Eight plasma samples were collected over the course of three weeks and assayed by ELISA as described above. Standard curves were generated for each ADC separately using the same material as was injected into the mice. As measured by anti-hIgG ELISA, the Cys mutant ADCs (Tables 15 and 16) displayed a pharmacokinetic profile similar to unconjugated wild type antibodies, indicating that mutation and payload conjugation to these sites did not significantly affect the antibody’s clearance. To determine the chemical stability of the linkage between the maleimide payload and the antibody at the various Cys sites during circulation in mouse, ADC concentrations as measured by the anti-MMAF ELISA assay and as measured by the anti-hIgG ELISA assay were compared to each other for ADCs prepared with Compound F which is readily detected with the anti-MMAF ELISA (Tables 15 and 16). For these ADCs, values for the area-under-the-plasma-concentration-versus-time-curve (AUC) were calculated from measurements with the anti-MMAF (AUC-MMAF) and the anti-hIgG ELISA (AUC-IgG). Previous results for similar analyses suggest uncertainties of >25%. Since the ratio should remain near 1 if no drug loss occurs, a ratio >0.7 indicates that within the accuracy of the measurement, little drug loss was observed after administration in mice for trastuzumab and anti-cKIT ADCs prepared with Compound F (Tables 15 and 16).

To further understand the retention of ADC drug payloads especially for payloads that are not detectable by the anti-MMAF ELISA (such as Compounds A-E), samples were analyzed by immuno-

precipitation mass spectrometry (IP-MS). In particular, ADCs were affinity-purified from mouse serum collected through terminal bleeding and the drug payloads attached to ADCs were analyzed by MS analysis. In a typical process, 200 μ l of plasma was diluted with an equal amount of PBS containing 10 mM EDTA. To the dilution, 10 μ l of affinity resin (IgG Select Sepharose 6 Fast flow; GE Healthcare 17-0969-01; 50% slurry) was added. Incubation of the resin with the diluted plasma samples was performed for 1 hr at room temperature by applying mild agitation to avoid resin settling. The resin was then filtered off and washed two times with 200 μ l of PBS. To deglycosylate the antibody, 10 μ l of PNGase F (1 mg/mL, 1/2x TBS pH 7.4, 2.5 mM EDTA, 50% Glycerol) diluted with 10 μ l of PBS was added to the resin and the mixtures were incubated for 2-3 hrs at 37°C. After PNGase F was removed by washing the affinity resin twice with 200 μ l PBS, the sample was eluted twice from the affinity resin by adding 20 μ l of 1% formic acid and filtering off the resin. The combined eluates were diluted with 20 μ l of 6 M guanidine hydrochloride and 5 μ l of reduction buffer (0.66 M TCEP, 3.3 M ammonium acetate, pH 5). To effectively reduce the antibody, samples were incubated for at least 30 min at room temperature before analysis. LCMS was performed with an Agilent Technologies 6550-iFunnel QTOF MS / Agilent 1260 HPLC system. A standard reversed-phase chromatography was used for sample desalting with a PLRS column (8 μ m, 2.1 x 50 mm, 1000Å, Agilent) at a flow rate of 0.5 ml/min at 80°C. Elution was carried out using a linear gradient of 20%- to 60%-acetonitrile containing 0.1% formic acid in 6 min. Agilent Qualitative Analysis was used for processing of the spectral record and spectral deconvolution. For analysis the spectral record was summed over the time interval covering elution of all relevant species. Summed spectra were deconvoluted in charge state and images of the deconvoluted spectra were recorded. The values of peak intensity were extracted for assignable species. Assignments of DAR state and fragment species were made based on values of calculated mass from the sequence of the analyzed antibodies and the expected mass shifts of the conjugates with drug molecules. The average DAR was calculated using the relative peak heights of all DAR states across a distribution. Average antibody DAR was calculated as the sum of DARs from 2 average light chains and 2 average heavy chains.

The average DAR of ADCs purified from plasma after three weeks in mouse circulation, as measured by MS, was compared to the DAR in the original ADC preparations. "Payload retention" (Tables 15 and 16) was calculated from the ratio of the two DARs (DAR of ADC isolated from mouse plasma divided by the DAR of original ADC preparation), and represent the percentage of payloads retained on the ADC after three weeks in mouse circulation. Payload retention of ADCs as measured by MS is largely in agreement with results obtained by the aforementioned ELISA assay for ADCs prepared

with Compound F (Tables 15 and Table 16). The data indicate a high degree of stability of the drug-antibody linkage during circulation in mice over a three week period for the Cys ADCs described herein.

Table 15. Pharmacokinetic properties of anti-cKIT Cys mutant ADCs conjugated with various compounds.

ADC name ^a	AUC Payload ^b ($\mu\text{g/ml}\cdot\text{h}$)	AUC IgG ^c ($\mu\text{g/ml}\cdot\text{h}$)	AUC ratio (Payload AUC/IgG AUC)	Payload retention ^d
anti-cKit-HC-E152C-S375C-Compound A	n.a.	7016	n.a.	0.82
anti-cKit-HC-E152C-S375C-Compound F	2565	3912	0.66	0.64
anti-cKit-HC-K360C-LC-K107C-Compound A	n.a.	5112	n.a.	0.88
anti-cKit-HC-K360C-LC-K107C-Compound F	4582	5051	0.91	0.78

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b AUC readout by anti-MMAF ELISA.

^c AUC readout by anti-IgG ELISA.

^d Payload retention as measured by IP-MS after 3 weeks of circulation in mouse.

n.a.: not applicable. Anti-MMAF ELISA does not detect payload.

Table 16. Pharmacokinetic properties of anti-Her2 Cys mutant ADCs conjugated with various compounds.

ADC name ^a	AUC Payload ^b ($\mu\text{g/ml}\cdot\text{h}$)	AUC IgG ^c ($\mu\text{g/ml}\cdot\text{h}$)	AUC ratio (Payload AUC/IgG AUC)	Payload retention ^d
trastuzumab-HC-E152C-S375C-Compound A	n.a.	1859	n.a.	0.74
trastuzumab-HC-E152C-S375C-Compound B	n.a.	2172	n.a.	0.73
trastuzumab-HC-E152C-S375C-Compound C	n.a.	2506	n.a.	0.76
trastuzumab-HC-E152C-S375C-Compound F	1367	2414	0.57	0.50
trastuzumab-HC-K360C-LC-K107C-Compound A	n.a.	3870	n.a.	0.86
trastuzumab-HC-K360C-LC-K107C-Compound B	n.a.	3280	n.a.	0.91
trastuzumab-HC-K360C-LC-K107C-Compound C	n.a.	3258	n.a.	0.84
trastuzumab-HC-K360C-LC-K107C-Compound F	2622	3842	0.68	0.82

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b AUC readout by anti-MMAF ELISA.

^c AUC readout by anti-IgG ELISA.

^d Payload retention as measured by IP-MS after 3 weeks of circulation in mouse.

n.a.: not applicable. Anti-MMAF ELISA does not detect payload.

Example 9. Preparation and trastuzumab and anti-cKIT ADC conjugated with Eg5 Inhibitor.

Engineered Cys ADCs have been reported to be better tolerated in mice and rat animal models than ADCs made by conjugation to partially reduced native disulfides or through native lysine residues (Junutula *et al.*, (2008) *Nat Biotechnol.* 26(8):925-932). To evaluate differences in *in vivo* efficacy between ADCs conjugated through engineered Cys antibodies and ADCs conjugated to partially reduced native disulfide bonds (Doronina *et al.*, (2003) *Nat. Biotechnol.* 21, 778-784), Cys mutants of trastuzumab and the anti-cKIT antibody were expressed in 293 Freestyle™ cells and purified as described in Example 4 and ADCs were prepared as described in Example 5.

Eg5 linker-payload Compound A in Table 5 was conjugated to antibody anti-cKIT-HC-E152C-S375C double mutant (also referred to as cKitB, the immunoconjugates are referred to as cKitB—Cmpd A or cKitB—5B) and anti-cKIT-HC-K360C-LC-K107C double mutant (also referred to as cKitC, immunoconjugates are referred to as cKitC—Cmpd A or cKitC—5B) as well as wild type anti-cKIT antibody (immunoconjugates also referred to as cKitA—Cmpd A or cKitA—5B). (Residue Numbers are EU numbers). The sequences of the constant regions of the antibodies are set forth in Table 17.

Table 17: Sequence information for wild type and cys-substituted constant regions of antibodies.

SEQ ID NO:150 (Constant region of the heavy chain wild type of antibody anti-cKIT) SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSG SGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLG GPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQ YNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPS REEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVD KSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
SEQ ID NO:149 (Constant region of the light chain wild type of antibody anti-cKIT) KRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTE QDSKIDSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC
SEQ ID NO:50 (Constant region of the mutant heavy chain of antibody anti-cKIT with mutation HC-S375C) SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSG SGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLG GPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQ YNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPS REEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVD KSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK
SEQ ID NO:61 (Constant region of the mutant light chain of antibody anti-cKIT with mutation LC-K107C) CRTVAAPSVFIFPPSDEQLKSGTASVVCLLNNFYPREAKVQWKVDNALQSGNSQESVTE QDSKIDSTYLSSTLTLSKADYEKHKVYACEVTHQGLSSPVTKSFNRGEC

SEQ ID NO: 131 (Constant region of the mutant heavy chain of antibody anti-cKIT with mutations HC-E152C-S375C)

SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPCPVTVSWNSGALTSGVHTFPAVLQSG
 SGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLG
 GPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQ
 YNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPS
 REEMTKNQVSLTCLVKGFYPCDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVD
 KSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

SEQ ID NO: 48 (Constant region of mutant heavy chain antibody (anti-cKIT with mutation at HC-K360C))

SASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSG
 SGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDKKVEPKSCDKTHTCPPCPAPELLG
 GPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQ
 YNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPS
 REEMTCNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVD
 KSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

Specifically, reoxidized antibodies were conjugated with Compound A by incubating 5 mg/ml antibody with 0.35 mM Compound A for 1 hour in 50 mM sodium phosphate buffer (pH 7.2). The completeness of the reaction was monitored by RP-HPLC and a DAR of 3.9 and 4.0 were obtained for the cKitB and cKitC conjugates, respectively. DAR measurements were further verified by MS. ADCs were shown to be potent and *in vitro* cell killing assays and had pharmacokinetics properties similar to unconjugated antibody in non-tumor bearing mice.

The ADC with Compound A conjugated to the native disulfide bonds of cKitA was prepared as follows in a 2-step process. The antibody at a concentration of 5-10 mg/ml in PBS containing 2 mM EDTA, was first partially reduced for 1 hour at 37 °C with 50 mM mercaptoethylamine (added as a solid). After desalting and addition of 1% w/v PS-20 detergent, the partially reduced antibody (1-2 mg/ml) was reacted overnight at 4 °C with an amount of 0.5-1 mg of compound A, dissolved at 10 mg/ml in DMSO, per 10 mg antibody. The ADC was purified by Protein A chromatography. After base-line washing with PBS, the conjugate was eluted with 50 mM citrate, pH 2.7, 140 mM NaCl, neutralized and sterile filtered. The average DAR was 3.2.

Table 18: Properties of three anti-cKIT ADCs conjugated with Compound A.

ADC name ^a	DAR ^b	Aggregation ^c
Anti-cKIT-Compound A (cKitA-5B)	3.2	0.8%
anti-cKIT-HC-E152C-S375C-Compound A (cKitB-5B)	3.9	1.5%
anti-cKIT-HC-K360C-LC-K107C-Compound A (cKitC-5B)	4.0	3.2%

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b Drug-to-antibody ratio according to reverse-phase HPLC or HIC.

^c Aggregation measured by analytical size exclusion chromatography; includes dimeric and oligomeric species.

Similarly, immunoconjugates with the following combinations of payloads with anti-cKIT and trastuzumab mutated antibodies having cysteine substitutions were prepared and characterized by the same methods. Note that the engineered antibodies consistently provided DAR near 4, the expected loading if the four added cysteine residues per antibody complex are all conjugated to payload (Tables 18 and 19):

Table 19. Summary of anti-cKIT and trastuzumab Cys mutant ADCs with Eg5 inhibitor payloads.

ADC name ^a	Conc. (mg/ml)	DAR ^b	Aggregation (%) ^c	Endotoxin (Eu/mg)
trastuzumab-HC-E152C-S375C-Compound A (TBS--5B)	2	3.9	3.4	<0.1
trastuzumab-HC-E152C-S375C-Compound B (TBS--5E)	2	3.8	2	<0.1
trastuzumab-HC-E152C-S375C-Compound C (TBS--5D)	2	4	5.1	<0.1
anti-cKIT-HC-E152C-S375C-Compound A (cKitB--5B)	4	3.8	0	<0.1
anti-cKIT-HC-E152C-S375C-Compound B (cKitB--5E)	4	3.9	0.1	<0.1
anti-cKIT-HC-E152C-S375C-Compound C (cKitB--5D)	4	3.9	0.2	0.2
trastuzumab-HC-K360C-LC-K107C-Compound A (5B)	4	3.8	0.4	<0.1
trastuzumab-HC-K360C-LC-K107C-Compound B (5E)	4	4	0	0.1
trastuzumab-HC-K360C-LC-K107C-Compound C (5D)	3	3.7	0.6	<0.1

^a Name consists of a description of the mutated antibody and the name of the compound used in the chemical conjugation step.

^b Drug-to-antibody ratio according to reverse-phase HPLC.

^c Aggregation was measured analytical size exclusion chromatography; includes dimeric and oligomeric species.

Example 10. *In vitro* potency and *In vivo* efficacy of ADCs prepared with Eg5 inhibiting payloads.

Immunoconjugates were prepared from each of the Eg5 inhibiting linker-payload compounds shown in Table 5 conjugated with an anti-cKIT antibody (also referred to as cKitA) and HC-E152C-S375C Cys-mutated versions of anti-cKIT antibody (cKitB). The constant region for anti-cKIT (cKitA) wild type and Cys-substituted mutants are shown in Table 17 above. Conjugates having a drug to antibody ratio (DAR) between 3.5 and 4.0 were prepared for each payload by the methods described above. The immunoconjugates were tested for activity in a cell line expected to be recognized by antibodies to cKit.

Figure 2 shows inhibition of cell growth by immunoconjugates with the HC-E152C-S375C Cys-substituted cKIT immunoconjugates comprising Compounds A, B, and C. Jurkat cells are a cKIT negative cell line, and were not sensitive to the three anti-cKIT (cKitA) immunoconjugates. However, proliferation of H526 cells, a cKIT positive cell line, was inhibited by all three anti-cKIT (cKitA) conjugates with IC₅₀s ranging from 100 to 500 pM. The H526 cell line was selected as a xenograft model for *in vivo* efficacy studies.

In vivo xenograft tumor models simulate biological activity observed in humans and consist of grafting relevant and well characterized human primary tumors or tumor cell lines into immune-deficient nude mice. Studies on treatment of tumor xenograft mice with anti-cancer reagents have provided valuable information regarding *in vivo* efficacy of the tested reagents (Sausville and Burger, (2006) Cancer Res. 66:3351-3354).

All animal studies were conducted in accordance with the Guide for the Care and Use of Laboratory Animals (NIH publication; National Academy Press, 8th edition, 2001). H526 cells were implanted in nu/nu mice subcutaneously (Morton and Houghton, Nat Protoc. 2007;2:247-250). After the tumor size reached ~200 mm³, ADCs were administered into the mice by *i.v.* injection in a single dose. Tumor growth was measured periodically after ADC injection. An example of such an *in vivo* efficacy study is shown in Figure 3.

Figure 3 summarizes the activity of two ADCs made with cysteine-engineered anti-cKIT antibodies, namely anti-cKIT-HC-E152C-S375C-Compound A (cKitB-5B) and anti-cKIT-HC-K360C-LC-K107C-Compound A (cKitC-5B), which inhibited growth of H526 tumor xenografts in mice at doses of 5 mg/kg (Figure 3A) and 10 mg/kg (Figure 3B). Anti-cKIT-Compound A (cKitA-5B) prepared with the wild type antibody through partial reduction, because of lower DAR, was administered at higher doses to match the molar payload dose. 6 mice were injected per group for each ADC tested. No significant weight loss was observed associated with the ADC treatment in any group suggesting low systemic toxicity.

The cysteine-engineered anti- cKIT ADCs of Compound A were more active than the ADC prepared through partial reduction of the wild type antibody Anti-cKIT-Compound A (cKitA-5B). Thus, while immunoconjugates of Eg5 inhibitors were active with various cKit antibodies including unmodified ones, this demonstrates that protein engineering to introduce new cysteine residues into the constant
5 region and using the new cysteine residues as attachment points for the payload/linker group can provide improved immunoconjugates.

The Cys-substituted cKitA immunoconjugates were also tested in murine xenograft model. Both of the Cys substituted immunoconjugates showed greater activity than the nonsubstituted immunoconjugates, as measured by tumor volume post-implant.

Example 11: Dose dependent *in vivo* efficacy of an anti-Her2 ADC conjugated with an Eg5 inhibitor in the Her2 positive MDA-MB-231 clone 16 breast cancer model in mice.

The anti-tumor efficacy of the anti-Her2 ADC trastuzumab-HC-E152C-S375C-Compound A was prepared by conjugating trastuzumab HC-E152C-S375C Cys mutant antibody with Eg5 inhibitor
15 Compound A was evaluated in the Her2 positive MDA-MB-231 HER2 clone 16 breast cancer xenograft model. Female athymic nude-Foxn1 mice were implanted subcutaneously with 5×10^6 cells containing 50% Matrigel™ (BD Biosciences) in phosphate-buffered saline (PBS) solution. The total injection volume containing cells in suspension was 200 μ l. Mice were enrolled in the study 13 days post
20 implantation of tumor cells with average tumor volumes of $\sim 220\text{mm}^3$. After being randomly assigned to one of eight groups (n=5/group), mice were administered a single *i.v.* dose of PBS, a non-specific isotype control-HC-E152C-S375C-Compound A (10 mg/kg) or trastuzumab-HC-E152C-S375C-Compound A (2.5, 5 or 10 mg/kg). Tumor volumes (Figure 4) and body weights were measured at least twice weekly.

On Day 40 post-tumor cell implant, mice treated with a single administration of 2.5 mg/kg of trastuzumab-HC-E152C-S375C-Compound A had tumors that showed a percent mean change in tumor
25 volume compared to the vehicle control (T/C) of 8.22%. Mice treated with a single administration of 5 mg/kg and 10 mg/kg of trastuzumab-HC-E152C-S375C-Compound A had tumors that showed a regression in volume of 74.14% and 76.35%, respectively, both of which were statistically different from the vehicle alone and non-specific isotype ADC controls ($p < 0.05$, ANOVA, Tukey's post-hoc test). The treatments were well tolerated at all dose levels.

Table 20: TBS-HC-E152C-S375C-Compound A dose response in the Her2 positive MDA-MB-231 clone 16, breast cancer model in mice on Day 40.

Drug	Dose (mg/kg)	Schedule	Tumor Response			Host Response	
			Mean change of tumor volume vs control (T/C) (%)	Regression (%)	Mean change of tumor volume (mm ³ ±SEM)	Mean change of body weight (%±SEM)	Survival (Survivors /total)
Vehicle	0	Single dose IV	100	-	1112.82 ± 254.74	7.15 ± 6.63	5/5
Isotype Control-HC-E152C-S375C-Compound A	10	Single dose IV	81.54	-	907.35 ± 246.84	2.78 ± 2.05	5/5
TBS-HC-E152C-S375C-Compound A	2.5	Single dose IV	8.22	-	91.47 ± 99.08	2.92 ± 0.80	5/5
TBS-HC-E152C-S375C-Compound A	5	Single dose IV	-	74.14	-151.46 ± 25.52	4.01 ± 0.78	5/5
TBS-HC-E152C-S375C-Compound A	10	Single dose IV	-	76.35	-163.29 ± 20.63	0.52 ± 1.80	5/5

Example 12: *In vivo* efficacy of an anti-Her2 ADC conjugated with an Eg5 inhibitor in the Her2 positive MDA-MB-453 human breast cancer xenograft mouse model.

The anti-tumor efficacy of the anti-Her2 trastuzumab-HC-E152C-S375C-Compound A ADC was also evaluated in the Her2 positive MDA-MB-453 human breast cancer xenograft model. Female SCID beige mice were implanted subcutaneously with 5 x 10⁶ cells containing 50% Matrigel™ (BD Biosciences) in phosphate-buffered saline (PBS) solution. The total injection volume containing cells in suspension was 200 µl. Mice were enrolled in the study seven days post implantation of tumor cells with tumor volumes of approximately 168 mm³–216 mm³. After being randomly assigned to one of four groups (n=6/group), mice were administered a single i.v. dose of PBS, a non-specific isotype control-HC-E152C-S375C-Compound A (10 mg/kg) or trastuzumab-HC-E152C-S375C-Compound A (10 mg/kg). Tumor volumes (Figure 5) and body weights were measured at least twice weekly.

On Day 45 post-implant, mice treated with trastuzumab-HC-E152C-S375C-Compound A (10 mg/kg) had tumors that showed a regression in volume of 71.2%, which was statistically different from

the vehicle alone and non-specific isotype ADC controls ($p < 0.05$, ANOVA, Tukey's post-hoc test). The treatments were well tolerated at all dose levels.

Table 21: ADC efficacy of of trastuzumab-HC-E152C-S375C-Compound A at 10 mg/kg in the Her2 positive MDA-MB-453 human breast cancer xenograft mouse model on Day 45.

Drug	Dose (mg/kg)	Schedule	Tumor Response			Host Response	
			Mean change of tumor volume vs control (T/C) (%)	Regression (%)	Mean change of tumor volume (mm ³ ±SEM)	Mean change of body weight (%±SEM)	Survival (Survivors/total)
Vehicle	0	Single dose IV	100		654±69.5	12±1.93	6/6
Isotype Control-HC-E152C-S375C-Compound A	10	Single dose IV	128.3		827.9±96.7	11.1±0.85	6/6
Trastuzumab-HC-E152C-S375C-Compound A	10	Single dose IV	--	71.2	-138.5±22.2	11.7±3.8	6/6

5

Example 13: *In vivo* efficacy of an anti-Her2 ADC conjugated with an Eg5 inhibitor in the Her2 positive HCC1954 human breast cancer xenograft mouse model.

The anti-tumor efficacy of the anti-Her2 trastuzumab-HC-E152C-S375C-Compound A ADC was further evaluated in the Her2 positive HCC1954 breast cancer xenograft model. Female athymic nude-Foxn1 mice were implanted subcutaneously with 5×10^6 cells containing 50% Matrigel™ (BD Biosciences) in phosphate-buffered saline (PBS) solution. The total injection volume containing cells in suspension was 200 μ l. Mice were enrolled in the study 11 days post implantation with tumor volumes of approximately 148 mm³– 216 mm³. After being randomly assigned to one of four groups (n=6/group), mice were administered a single i.v. dose of PBS, a non-specific isotype control-HC-E152C-S375C-Compound A (10 mg/kg) or trastuzumab-HC-E152C-S375C-Compound A (10 mg/kg. Tumor volumes (Figure 6) and body weights were measured at least twice weekly.

On Day 45 post-implant, mice treated with trastuzumab-HC-E152C-S372C-Compound A (10 mg/kg) had tumors that showed a regression in volume of 63.0%, which was statistically different from

the vehicle alone and non-specific isotype ADC controls ($p < 0.05$, ANOVA, Tukey's post-hoc test). The treatments were well tolerated at all dose levels.

Table 22: ADC efficacy of trastuzumab-HC-E152C-S375C-Compound A at 10 mg/kg in the Her2 positive HCC1954 human breast cancer xenograft mouse model on Day 45.

Drug	Dose (mg/kg)	Schedule	Tumor Response			Host Response	
			Mean change of tumor volume vs control (T/C) (%)	Regression (%)	Mean change of tumor volume (mm ³ ±SEM)	Mean change of body weight (%±SEM)	Survival (Survivors/total)
Vehicle	0	Single dose IV	100		555.2±122.5	5.9±1.4	6/6
Isotype control antibody-HC-E152C-S375C-Compound A	10	Single dose IV	117.9		654.6±200.1	8.6±0.9	6/6
trastuzumab - HC-E152C-S375C-Compound A	10	Single dose IV	--	63.0	-112.0±15.95	8.0±1.4	6/6

Example 14: *In vivo* efficacy study comparing anti-cKIT Cys mutant ADCs to ADCs prepared by partial reduction of a non-engineered antibody. The *in vivo* efficacy of two anti-cKIT ADCs: anti-cKIT-HC-E152C-S375C-Compound F and anti-cKIT-Compound F, were compared in the H526 xenograft mouse model (Figure 7). The two ADCs were prepared with the same payload; Compound F (Table 5), conjugated to different Cys sites using two different methods. Conjugate anti-cKIT-HC-E152C-S375C-Compound F was prepared with a Cys mutant antibody, as described in Example 5 with Compound F conjugated to engineered Cys residues, HC-E152C and HC-S375C. Conjugate anti-cKIT-Compound F was prepared by applying the partial reduction method described in Example 9 to wild type anti-cKIT antibody with Compound F conjugated to native Cys residues. Anti-cKIT-Compound F had a slightly higher DAR (DAR 4.6) and aggregation (2.9%) than anti-cKIT-HC-E152C-S375C-Compound F (DAR 3.9, 0.6% aggregation). Pharmacokinetic studies in non-tumor bearing mice showed that the two ADCs retained the same payload to a very different extent during three weeks of circulation in mouse: As illustrated by ELISA (Figure 8A, Figure 8B) and as determined by IP-

MS (see Example 8), anti-cKIT-HC-E152C-S375C-Compound F displayed much better payload retention (56%) than anti-cKIT-Compound F (20%).

In the H526 xenograft model, the same dosage of anti-cKIT-HC-E152C-S375C-Compound F is more efficacious in inhibiting tumors than anti-cKIT-Compound F (Figure 7). Anti-Her2-HC-E152C-S375C-Compound F (see Table 12 for properties), whose antigen is not expressed in H526 cells, was included as control and did not show any tumor inhibiting activity.

Example 15. *In vivo* efficacy study comparing anti-cKIT Cys mutant ADCs conjugated at different sites with Compound F and Compound A.

In another example, the *in vivo* efficacy of anti-cKIT-HC-E152C-S375C-Compound F, anti-cKIT-HC-K360C-LC-K107C-Compound F, anti-cKIT-HC-E152C-S375C-Compound A, and anti-cKIT-HC-K360C-LC-K107C-Compound A ADCs were compared in the H526 xenograft model (Figure 9). The two payloads, Compound F and Compound A, were conjugated to different Cys sites using two different antibodies as described in Example 7. The properties of the ADCs are summarized in Table 12. The DAR measured was close to the theoretical DAR of 4 for all four conjugates and little aggregation was observed for the resulting ADCs (Table 12). Single doses of 3.5 mg/kg of the ADCs were injected *i.v.* into animals bearing H526 tumors. The results of tumor volume measurements in the H526 xenograft model are shown in Figure 9. In this model, the same dosage of anti-cKIT-Compound F ADC was more efficacious in inhibiting tumors than ADCs prepared with Compound A. There is not statistically significant difference in tumor inhibiting activity between ADCs conjugated to the two different sets of Cys mutants.

Example 16. Hydrophobicity of trastuzumab ADCs conjugated with Compound G.

To further optimize the selection of Cys mutants and mutant combinations for the preparation of ADCs with DAR 2, 4, 6 and greater, the properties of trastuzumab Cys mutant ADCs were analyzed with respect to hydrophobicity. Cys mutants ADCs conjugated with Compound G (MC-MMAF) were prepared as described above. The final DAR as determined experimentally as described were generally close to the target and are listed in Table 23 below. The hydrophobicity of these ADCs was measured by hydrophobic interaction chromatography as follows.

Analytical HIC data for trastuzumab Cys-MMAF ADCs were collected using a Tosoh Bioscience (King of Prussia, PA, USA) TSKgel Butyl-NPR column (100 mm × 4.6 mm, 2.5 μm) installed on an Agilent 1260 LC system (Santa Clara, CA, USA). The method consisted of a binary gradient of buffer A (20 mM His-HCl, 1.5 M ammonium sulfate, pH 6.0) and buffer B (20 mM His-

HCl, 15% isopropanol, pH 6.0). Samples were prepared by diluting approximately 20 µg of antibody (PBS) with 0.5 volume of 3 M ammonium sulfate. The gradient consisted of 5 min holding at 100% A, followed a linear gradient of 0 to 100% B over 30 min, a return to 100% A over 5 min, and finally re-equilibrating at initial conditions for 10 min prior to the next injection. The separation was
 5 monitored by UV absorption at 280 nm and analyzed using Chromelion software (Dionex).

Surprisingly, it was observed that the retention times of the DAR 4 ADCs varied greatly although the only difference is the site of Compound G attachment. In addition, the range of retention times overlapped substantially with the range observed for DAR 2 ADCs included for comparison (Table 23). HIC separates molecules on the basis of the hydrophobicity. All DAR 2 ADCs have a HIC retention
 10 time larger than that of unconjugated antibody (retention time = 45 min) which is to be expected when a hydrophobic drug molecule such as Compound G is attached to an antibody. However, attaching the payload at different sites increases the hydrophobicity of the ADC to various extents.

Table 23. DAR and analytical HIC retention times for trastuzumab-Cys-Compound G ADCs with DAR =
 15 2, 4, or 6.

Trastuzumab Cys mutation site	DAR	Retention time (min)
HC-E152C	1.8	15.5
HC-K334C-P396C	3.5	15.8
HC-P396C	2.0	15.9
HC-E152C-P396C	3.3	16.1
HC-E152C-LC-E165C	2.9	16.2
HC-A327C-A339C	3.5	16.2
LC-E165C-HC-P396C	3.4	16.3
HC-Y391C	2.0	16.4
HC-E152C-S375C	3.7	16.5
LC-E165C-HC-S375C	4.0	16.7
HC-E152C-A339C	3.7	17.1
HC-E152C-LC-R142C	3.8	17.1
HC-A339C-S375C	3.3	17.2
HC-E333C	1.9	17.2
HC-E152C-A327C	3.7	17.3

LC-E165C-HC-L174C	3.4	17.4
HC-S375C-Y391C	3.2	17.4
HC-A339C-P396C	3.6	17.5
LC-S159C-HC-E152C	3.8	17.5
HC-Y373C	2.0	17.7
LC-E165C-HC-K334C-S375C	6.0	18.1
HC-A327C-S375C	3.8	18.2
LC-E165C-HC-K334C-K392C	5.8	18.2
HC-P247C	2.0	18.9
LC-K107C-HC-K360C	3.9	21.5

The surprisingly large differences in retention times can be rationalized from the inspection of location of the attachment sites on the structure of an antibody: The retention times are higher if the drug payload is attached at an exposed site on the outside of an antibody, for example at HC-P247C where retention time of almost 19 min were measured. Conversely, if the payload is attached at an interior site such as the cavity formed between variable and CH1 domains (for example, HC-E152C) or the large opening between CH2 and CH3 domains of the antibody (for example, HC-P396C), the HIC retention time is below 16 min because the payload is partially sequestered from interacting with solvent and the HIC column. Likewise, for DAR 4 ADCs that include two relatively interior sites (for examples HC-E152C-P396C and HC-E152C-S375C), the retention time remains short, on the order of 15.5-16.5 min, while DAR 4 ADCs that include very exposed sites (for example, LC-K107C-HC-K360C) can show retention times greater than 21 min.

Reducing hydrophobicity of a protein drug including ADCs is generally considered beneficial because it may reduce aggregation and clearance from circulation. Conjugating drug payloads at sites where they are sequestered from solvent interactions and attachment minimally increases the hydrophobicity of the antibody upon drug attachment should be beneficial independent of the conjugation chemistry and payload class. Carefully selecting attachment sites that result in minimal changes in hydrophobicity may be particularly beneficial when 4, 6 or more drugs are attached per antibody, or when particularly hydrophobic payloads are used.

Example 17. Hydrophobicity of anti-Her2 Cys mutant ADCs conjugated with various compounds.

A subset of the trastuzumab-HC-E152C-S375C and trastuzumab-HC-K360C-LC-K107C ADCs prepared in Example 7 (see Table 12 for properties) were also characterized by hydrophobic interaction chromatography as described in detail below (Table 24). ADCs conjugated to the

combination of exposed Cys residues (positions HC-K360C-LC-K107C) are more hydrophobic than ADCs with drugs attached to the HC-E152C-S375C antibody. The effect is more pronounced for the Eg5 inhibitor payloads Compound A and Compound C compared to the cytotoxic peptide Compound F.

As discussed in Example 16, attaching drugs at sites where they are sequestered from solvent interactions such as HC-E152C-S375C appears to increase the hydrophobicity of the antibody to a lesser degree than when attached at more solvent exposed positions such as HC-K360C and LC-K107C. Although beneficial for many applications, particularly for the attachment of hydrophobic payloads, conjugating payloads at more solvent exposed positions will have beneficial utility in other applications.

Table 24: Hydrophobicity scores of various Cys mutant anti-Her2-ADCs conjugated with different payloads

ADC name ^a	Hydrophobicity score ^b
trastuzumab-HC-E152C-S375C-Compound F	0.91
trastuzumab-HC-E152C-S375C-Compound A	0.90
trastuzumab-HC-E152C-S375C-Compound C	0.87
trastuzumab-HC-K360C-LC-K107C-Compound F	0.51
trastuzumab-HC-K360C-LC-K107C-Compound A	0.33
trastuzumab-HC-K360C-LC-K107C-Compound C	0.31

^a Name consists of a description of the mutated antibody and a description of the compound used in the chemical conjugation step.

^b Hydrophobic Interaction Chromatography (HIC) measurements: The separation of the different species was carried out on a TSKgel Butyl-NPR column (4.6 mm ID x 35 mm L, Tosoh Bioscience) connected to an Agilent 1260 Infinity LC System (Agilent Technologies). The system was equilibrated firstly with mobile phase B (17 mM His/HCl, pH 6.0 containing 15% isopropanol) and subsequently with mobile phase A (20 mM His/HCl pH 6.0, containing 1.5 M (NH₄)₂SO₄) until a stable baseline was reached. 10 to 50 ug of sample, stored at 4°C in the auto-sampler, was injected and separated at a flow rate of 1.0 mL/min at a constant temperature of 25°C. Elution of species with different hydrophobicity was achieved using a gradient from 100% mobile phase A to 100% mobile phase B within 30 column volumes. Eluting species were detected at 280 nm and the retention time of the peak maximum was used to calculate the hydrophobicity index. This index is determined with respect to the linear regression (plot retention time vs. hydrophobicity index) of three reference molecules of defined hydrophobicity. This procedure allows compensating for potential run-to-run variability and variations due to differences between column batches and is independent of the exact absolute ammonium sulfate concentration. The lower the hydrophobicity index (= late elution from HIC), the more hydrophobic is the molecule and the higher is the risk of unfavorable behavior during production or storage of the drug substance and drug product.

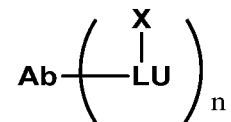
It is understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and the scope of the appended claims.

CLAIMS

- 5 1. An immunoconjugate comprising a modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from position 360 of an antibody heavy chain, and position 107 of an antibody kappa light chain, wherein said positions are numbered according to the EU system.
- 10 2. An immunoconjugate comprising a modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from positions 152 and 375 of an antibody heavy chain, wherein said positions are numbered according to the EU system.
- 15 3. An immunoconjugate comprising a modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 48 and a kappa light chain constant region comprising SEQ ID NO: 61.
4. An immunoconjugate comprising a modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 131.
- 20 5. The immunoconjugates of any of claims 1-4 wherein the immunoconjugate further comprises a drug moiety.
6. The immunoconjugates of any of claims 1-5 wherein the drug antibody ratio is about 4.
7. The immunoconjugate of any of claim 1-6, wherein said drug moiety is attached to the modified antibody or antibody fragment through the sulfur of said cysteine and an optional linker.
- 25 8. The immunoconjugate of claim 7, wherein said drug moiety is connected to said sulfur of said cysteine through a cleavable or non-cleavable linker.
9. The immunoconjugate of claim 8, wherein said drug moiety is connected to said sulfur of said cysteine through a non-cleavable linker.

10. The immunoconjugate of claim 7-9, wherein said immunoconjugate comprises a thiol-maleimide linkage.
11. The immunoconjugate of claim 10, wherein said immunoconjugate comprises a $-S-CH_2-C(=O)-$ linkage or a disulfide linkage.
- 5 12. The immunoconjugate of claim 11, wherein said drug moiety is a cytotoxic agent.
13. The immunoconjugate of claim 12, wherein said drug moiety is selected from the group consisting of taxanes, DNA-alkylating agents (e.g., CC-1065 analogs), anthracyclines, tubulysin analogs, duocarmycin analogs, auristatin E, auristatin F, maytansinoids, and Eg5 inhibitors .
- 10 14. The immunoconjugate of any of claims 1-13, wherein said antibody is a monoclonal antibody.
15. The immunoconjugate of any of claims 1-13, wherein said antibody is a chimeric antibody.
16. The immunoconjugate of claim 1-13, wherein said antibody is a humanized or fully human antibody.
- 15 17. The immunoconjugate of any of claims 14-16, wherein said antibody is a bispecific or multi-specific antibody.
18. The immunoconjugate of any of claims 1-17, wherein said antibody or antibody fragment specifically binds to a cell surface marker on a tumor.
19. A pharmaceutical composition comprising the immunoconjugate of any of claims 1-18.
- 20 20. The modified antibody or antibody fragment of any of claims 1-19, further comprising at least one Pcl or unnatural amino acid substitution or a peptide tag for enzyme-mediated conjugation and/or combinations thereof.
21. A nucleic acid encoding the modified antibody or antibody fragment of any of claims 1-4.
22. A host cell comprising the nucleic acid of claim 21.

23. A method of producing a modified antibody or antibody fragment comprising incubating the host cell of claim 22 under suitable conditions for expressing the antibody or antibody fragment, and isolating said antibody or antibody fragment.
24. A method to produce an immunoconjugate, which comprises attaching a Linker Unit (LU) or a Linker Unit-Payload combination (-LU-X) to a cysteine residue in an antibody or antibody fragment of any of claims 1-4
25. The method of claim 24, wherein the immunoconjugate is of Formula (I):



wherein Ab represents an antibody or antibody fragment comprising at least one cysteine residue at one of the preferred cysteine substitution sites described herein;

LU is a linker unit as described herein;

X is a payload or drug moiety;

and n is an integer from 1 to 16.

26. A modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from position 360 of an antibody heavy chain, and position 107 of an antibody kappa light chain, wherein said positions are numbered according to the EU system.
27. A modified antibody or antibody fragment thereof, wherein said modified antibody or antibody fragment comprises a combination of substitution of two or more amino acids with cysteine on its constant regions wherein the combinations comprise substitutions selected from positions 152 and 375 of an antibody heavy chain, wherein said positions are numbered according to the EU system.
28. A modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO: 48 and a kappa light chain constant region comprising SEQ ID NO: 61.

29. A modified antibody or antibody fragment thereof comprising a heavy chain constant region of SEQ ID NO:131.