



(86) Date de dépôt PCT/PCT Filing Date: 2005/01/18
 (87) Date publication PCT/PCT Publication Date: 2005/08/04
 (45) Date de délivrance/Issue Date: 2013/04/02
 (85) Entrée phase nationale/National Entry: 2006/07/20
 (86) N° demande PCT/PCT Application No.: EP 2005/000428
 (87) N° publication PCT/PCT Publication No.: 2005/070967
 (30) Priorité/Priority: 2004/01/22 (US60/538,348)

(51) Cl.Int./Int.Cl. *C07K 16/30* (2006.01),
A61K 39/395 (2006.01), *A61P 35/00* (2006.01)
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 (54) Title: ANTI-CANCER ANTIBODIES WITH REDUCED COMPLEMENT FIXATION

(57) **Abrégé/Abstract:**

The invention provides modified antibodies directed against GD2 that have diminished complement fixation relative to antibody-dependent, cell-mediated cytotoxicity, which is maintained. The modified antibodies of the invention may be used in the treatment of tumors such as neuroblastoma, glioblastoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, retinoblastoma, and other cancers of neuroectodermal origin.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
4 August 2005 (04.08.2005)

PCT

(10) International Publication Number
WO 2005/070967 A3

(51) International Patent Classification⁷: **C07K 16/30**,
A61P 35/00, A61K 39/395

AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(21) International Application Number:
PCT/EP2005/000428

(22) International Filing Date: 18 January 2005 (18.01.2005)

(25) Filing Language: English

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(26) Publication Language: English

(30) Priority Data:
60/538,348 22 January 2004 (22.01.2004) US

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Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

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(88) Date of publication of the international search report:
1 December 2005

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ANTI-CANCER ANTIBODIES WITH REDUCED COMPLEMENT FIXATION

(57) Abstract: The invention provides modified antibodies directed against GD2 that have diminished complement fixation relative to antibody-dependent, cell-mediated cytotoxicity, which is maintained. The modified antibodies of the invention may be used in the treatment of tumors such as neuroblastoma, glioblastoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, retinoblastoma, and other cancers of neuroectodermal origin.



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ANTI-CANCER ANTIBODIES WITH REDUCED COMPLEMENT FIXATIONRelated Applications

- 5 [0001] This application claims priority to and the benefit of U.S. Provisional Application No. 60/538,348, filed January 22, 2004.

Field of the Invention

- 10 [0002] The invention relates generally to the field of anti-cancer antibodies for targeting tumor cells. More specifically, the invention relates to anti-GD2 antibodies for targeting tumor cells expressing the glycolipid GD2.

Background of the Invention

- 15 [0003] A common method of treating cancer involves using antibodies to attack tumor cells by specifically targeting tumor cell associated antigens. One specific example of this method involves using anti-GD2 antibodies targeted against GD2, a glycolipid which is highly expressed in certain tumor cells, such as glioblastoma, melanoma, small-cell lung carcinoma, and neuroblastoma. Specifically, anti-GD2 antibodies, such as
20 14.18, have been tested against neuroblastoma and osteosarcoma tumors (Yu *et al.*, J. Clin. Oncol., [1998]; 16: 2169-80), with encouraging results. However, because GD2 is also expressed in nerve endings, pain is a serious side effect of anti-GD2 antibody treatment (Kushner *et al.*, J. Clin. Oncol., [2001]; 19: 4189-94; Frost *et al.*, Cancer, [1997]; 80: 317-33; Yu *et al.*, J. Clin. Oncol., [1998]; 16: 2169-80). Thus, there is a need
25 in the art for antibodies directed against GD2 that exhibit reduced side effects, while maintaining effectiveness in treating cancers that express the GD2 glycolipid.

Summary of the Invention

- 30 [0003] The invention relates to proteins comprising antibody moieties in which the proteins bind to the GD2 glycolipid and induce antibody-dependent cell-mediated cytotoxicity (ADCC), but have reduced complement fixation. When administered to patients, the antibodies and related proteins of the invention generally result in patients experiencing lower pain levels when compared to pain levels generated by administration of the corresponding proteins not modified in accordance with the invention. As a result,

in some treatment modalities, patient suffering is alleviated and quality of life is improved. In other treatment modalities, the dose of the therapeutic protein of the invention is higher than the corresponding antibody-based protein without the modifications of the invention.

5 [0005] In one embodiment of the invention, antibody-based proteins comprising an Fc region and a variable region capable of binding GD2 are used. In a further embodiment the Fc region is derived from IgG, more specifically IgG1. In further embodiments, the antibody-based proteins of the invention may include CH1 domains and/or CL domains. However, the presence of CH1 domains or CL domains is optional and not necessary. In
10 a further embodiment, the variable region of the antibody based protein is connected to an Fc region by a linker, more specifically a polypeptide linker. The polypeptide linker may comprise glycine and/or serine. In one embodiment, the linker has the polypeptide sequence GGGGSGGGGSGGGGSGGGGS (SEQ ID NO:10). In a further embodiment, the variable region is at least 60%, 70%, 80%, or 90% identical to the variable region of
15 the canonical 14.18 antibody (Yu *et al.*, J. Clin. Oncol., [1998]; 16: 2169-80; U.S. Patent Application Publication No. 2003-0157054-A1).

[0006] In another class of embodiments, modifications to the antibody-based proteins of the invention that enhance antibody-dependent cell-mediated cytotoxicity (ADCC) relative to complement fixation may also be used. In a preferred embodiment, the Fc
20 region has a modification that reduces or abolishes complement fixation, *e.g.*, relative to levels of ADCC. In another embodiment, the Fc region of IgG1 has been modified by the mutation Lys322Ala. Other mutations that reduce complement fixation may be used, and the mutations may be amino acid substitutions as well as deletions or insertions of amino acids. In a further embodiment, the invention provides proteins with enhanced levels of
25 bisected N-linked oligosaccharide in the Fc moiety of an anti-GD2-based protein. In a further embodiment, the invention also provides protein production methods that enhance the formation of bisected N-linked oligosaccharides in the Fc moiety of an anti-GD2-based protein. In a particular embodiment, anti-GD2 antibodies are expressed in the rat-derived cell line YB2/0, which results in antibodies having higher ADCC activity than
30 anti-GD2 antibodies expressed from most other cell lines.

In summary the invention relates to the following issues:

- A polypeptide comprising a variable region of an anti-GD2 antibody and an Fc region of an immunoglobulin (Ig), wherein the Fc region possesses one or more amino acid residue substitutions, which cause a decrease or elimination of complement fixation (CDC).
- 5 • A corresponding polypeptide, wherein the decrease of CDC is relative to antibody-dependent cell-mediated cytotoxicity (ADCC).
- A corresponding polypeptide, wherein the Fc region comprises a CH1 domain and optionally and preferably a CL domain
- A corresponding polypeptide, wherein the Ig is IgG, preferably IgG1.
- 10 • A corresponding polypeptide, wherein the Fc region is modified at least at one position, preferably between positions 315 and 330, more preferably at least at position 322, most preferably only at position 322.
- A corresponding polypeptide, wherein the modification is a K322A mutation.
- A corresponding polypeptide, wherein the variable regions are derived from human mAb
15 14.18, preferably comprising the amino acid sequence of SEQ ID NO:5.
- The antibody 14.18, having at least an amino acid substitution at position 322, preferably a K322A substitution.
- A corresponding polypeptide, further comprising enhanced levels of bisected N-linked oligosaccharides in the Fc moiety as compared to a wild-type anti-GD2 antibody
20 polypeptide.
- A corresponding polypeptide or antibody having an enhanced ADCC activity, obtainable by producing said polypeptide / antibody in YB2/0 cells.
- A DNA molecule coding for a polypeptide or antibody as specified above and in the claims.
- An expression cell comprising the said DNA molecule, preferably a YB2/0.
- 25 • A pharmaceutical composition comprising in an effective amount a polypeptide or antibody as specified above together with a pharmaceutically effective carrier, diluent or excipient.
- The use of a polypeptide or antibody for the manufacture of a medicament for the treatment of cancer, preferably selected from the group consisting of neuroblastoma, glioblastoma,
30 osteosarcoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, and retinoblastoma.
- A method for producing an anti-GD2 antibody having an enhanced ADCC and a decreased or eliminated CDC, the method comprising expressing a polypeptide,

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which comprises a variable region of an anti-GD2 antibody and an Fc region of an IgG1, in YB2/0 cells, wherein the Fc region possesses at least one amino acid residue substitution at position 322.

5 • A corresponding method, wherein the amino acid substitution is K322A.

• A corresponding method, wherein the variable regions of the polypeptide are derived from human mAb 14.18, preferably comprising the amino acid sequence of SEQ ID NO:5.

10 In a particular embodiment, the invention relates to an immunoglobulin polypeptide comprising a variable region of an anti-GD2 antibody, a CL domain and a Fc region of an immunoglobulin IgG1, that comprises a CH1 domain and possesses a K322A mutation to decrease or eliminate complement fixation (CDC), wherein the heavy chain of the immunoglobulin polypeptide comprises the amino acid sequence as depicted in SEQ ID NO: 5, and the light chain of the immunoglobulin polypeptide
15 comprises the amino acid sequence of SEQ ID NO: 2.

In another embodiment, the invention relates to a DNA molecule encoding a polypeptide as described herein.

In another embodiment, the invention relates to an expression cell comprising the DNA molecule as described herein.

20 In another embodiment, the invention relates to a pharmaceutical composition comprising in an effective amount a polypeptide as described herein together with a pharmaceutically effective carrier, diluent or excipient.

In another embodiment, the invention relates to use of a polypeptide as described herein for the manufacture of a medicament for reducing pain in cancer
25 therapy.

In another embodiment, the invention relates to use of a polypeptide as described herein for reducing pain in cancer therapy.

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In another embodiment, the invention relates to use of an immunoglobulin polypeptide comprising a variable region of an anti-GD2 antibody, a CL domain and a Fc region of an immunoglobulin IgG1, that comprises a CH1 domain and possesses a K322A mutation as represented in SEQ ID NO: 5 to decrease or eliminate complement fixation (CDC) while maintaining antibody-dependent cell-mediated cytotoxicity (ADCC) for the manufacture of a medicament for reducing pain in cancer therapy.

In another embodiment, the invention relates to use of an immunoglobulin polypeptide comprising a variable region of an anti-GD2 antibody, a CL domain and a Fc region of an immunoglobulin IgG1, that comprises a CH1 domain and possesses a K322A mutation as represented in SEQ ID NO: 5 to decrease or eliminate complement fixation (CDC) while maintaining antibody-dependent cell-mediated cytotoxicity (ADCC) for reducing pain in cancer therapy.

Brief Description of the Drawings

15 **[0007]** Figure 1 depicts the wild-type amino acid sequence of the human 14.18 IgG1 mature heavy chain (SEQ ID NO:1).

[0008] Figure 2 depicts an amino acid sequence of the human 14.18 IgG1 mature heavy chain with a K322A mutation (SEQ ID NO:5). The substituted alanine residue at 322 is underlined.

20 **[0009]** Figure 3 depicts the amino acid sequence of the mature human 14.18 IgG1 light chain. (SEQ ID NO:2)

[0010] Figure 4 depicts a nucleic acid sequence (SEQ ID NO:3), with introns, encoding a human 14.18 IgG1 mature heavy chain.

25 **[0011]** Figure 5 depicts a nucleic acid sequence (SEQ ID NO:4), with introns, encoding a human 14.18 IgG1 mature light chain.

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[0012] Figure 6 depicts the results of an antibody-dependent cellular cytotoxicity assay performed on GD2 expressing M-21 cells. The x-axis indicates the concentration of antibody in ng/ml while the y-axis indicates the percent lysis of target cells.

5 **[0013]** Figure 7 depicts the results of an antibody-dependent cellular cytotoxicity assay performed on GD2 expressing LN-229 cells. The x-axis indicates the concentration of antibody in ng/ml while the y-axis indicates the percent lysis of target cells.

[0014] Figure 8 depicts the results of an antibody-dependent cellular
10 cytotoxicity assay performed on non-GD2 expressing EpCAM+ A431 cells. The x-axis indicates the concentration of antibody in ng/ml while the y-axis indicates the percent lysis of target cells.

[0015] Figure 9 depicts the results of a complement dependent cytotoxicity
15 assay performed on GD2 expressing M-21 cells. The x-axis indicates the concentration of antibody in ng/ml while the y-axis indicates the percent lysis of target cells.

[0016] Figure 10 depicts the results of a complement-dependent cytotoxicity assay performed on GD2 expressing LN-229 cells. The x-axis indicates the concentration of antibody in ng/ml while the y-axis indicates the percent lysis of target cells.

[0017] Figure 11 depicts the amino acid sequence of the mature fusion protein human
5 14.18 sFv(VL-VH)-Fc (SEQ ID NO:9) which is an sFv antigen binding portion connected via a polypeptide linker with the amino acid sequence GGGGSGGGGSGGGGSGGGGS (SEQ ID NO:10) to an Fc fragment consisting of hinge, CH2 and CH3 domains of IgG1.

[0018] Figure 12 depicts a nucleic acid sequence encoding the mature human 14.18 sFv(VL-VH)-Fc antibody construct (SEQ ID NO:8) of Figure 10.

10

Detailed Description of the Invention

[0019] The GD2 glycolipid is expressed on a variety of tumor types, but is essentially not expressed in normal tissues, with the exception of some expression at nerve endings. Antibodies directed against the GD2 glycolipid antigen have been tested in cancer
15 patients with some success. However, presumably because of the expression of GD2 in neurons, pain is a major side effect of anti-GD2 antibody treatment, and is consequently a dose-limiting toxicity. The present invention provides anti-GD2 antibodies and related molecules that induce less pain.

[0020] As used herein, the term glycolipid GD2 or GD2 antigen is defined as a glycolipid
20 capable of specific binding to an anti-GD2 antibody as defined herein. The term anti-GD2 antibody is defined as an antibody capable of specific binding to the antigen glycolipid GD2. As used herein, the terms "bind specifically," "specifically bind," and "specific binding" are understood to mean that the antibody has a binding affinity for a particular antigen of at least about 10^6 M^{-1} , more preferably, at least about 10^7 M^{-1} , more
25 preferably at least about 10^8 M^{-1} , and most preferably at least about 10^{10} M^{-1} .

[0021] As used herein, the terms "antibody" is understood to mean (i) an intact antibody (for example, a monoclonal antibody or polyclonal antibody), (ii) antigen binding portions thereof, including, for example, an Fab fragment, an Fab' fragment, an (Fab')₂ fragment, an Fv fragment, a single chain antibody binding site, an sFv, (iii) bi-specific
30 antibodies and antigen binding portions thereof, and (iv) multi-specific antibodies and antigen binding portions thereof. Furthermore, the term "antibody" encompasses any of an Fab fragment, an Fab' fragment, an (Fab')₂ fragment, an Fv fragment, a single chain antibody binding site, or an sFv fragment linked to an Fc fragment or any portion of an Fc

fragment. The linkage can be accomplished through use of linker peptide sequences known in the art. An antibody of the invention may be naturally occurring or synthetic, such as a recombinant antibody.

[0022] As used herein, the term "immunoglobulin" is understood to mean a naturally occurring or synthetically produced polypeptide homologous to an intact antibody (for example, a monoclonal antibody or polyclonal antibody) or fragment or portion thereof, such as an antigen-binding portion thereof. Immunoglobulin according to the invention may be from any class such as IgA, IgD, IgG, IgE, or IgM. IgG immunoglobulins can be of any subclass such as IgG1, IgG2, IgG3, or IgG4. The term immunoglobulin also encompasses polypeptides and fragments thereof derived from immunoglobulins. Immunoglobulins can be naturally occurring or synthetically produced, such as recombinant immunoglobulins.

[0023] The constant region of an immunoglobulin is defined as a naturally-occurring or synthetically-produced polypeptide homologous to the immunoglobulin C-terminal region, and can include a CH1 domain, a hinge, a CH2 domain, a CH3 domain, or a CH4 domain, separately or in any combination. As used herein, "Fc portion" encompasses domains derived from the constant region of an anti-GD2 antibody, including a fragment, analog, variant, mutant or derivative of the constant region. Suitable immunoglobulins include IgG1, IgG2, IgG3, IgG4, and other classes. The constant region of an immunoglobulin is defined as a naturally-occurring or synthetically-produced polypeptide homologous to the immunoglobulin C-terminal region, and can include a CH1 domain, a hinge, a CH2 domain, a CH3 domain, or a CH4 domain, separately or in any combination. In the present invention, the Fc portion typically includes at least a CH2 domain. For example, the Fc portion can include hinge-CH2-CH3. Alternatively, the Fc portion can include all or a portion of the hinge region, the CH2 domain and/or the CH3 domain and/or CH4 domain.

[0024] The term variable fragment or Fv as used herein is defined as a naturally occurring or synthetically produced polypeptide homologous to the heavy chain variable region and/or the light chain variable region. More specifically, an Fv can be an sFv or single chain variable fragment wherein the heavy chain variable region and the light chain variable region are linked together by a polypeptide moiety. Such polypeptide linker sequences are known in the art.

[0025] Anti-tumor activity of antibodies generally occurs via either complement dependent cytotoxicity (CDC or complement fixation) or through anti-body dependent cell-mediated cytotoxicity (ADCC). These two activities are known in the art as “effector functions” and are mediated by antibodies, particularly of the IgG class. All of the IgG subclasses (IgG1, IgG2, IgG3, IgG4) mediate ADCC and complement fixation to some extent, with IgG1 and IgG3 being most potent for both activities (Chapter 3, Table 3 in Paul, Essential Immunology 4th Ed., p. 62). ADCC is believed to occur when Fc receptors on natural killer (NK) cells bind to the Fc region of antibodies bound to antigen on a cell’s surface. Fc receptor binding signals the NK cell to kill the target cell. CDC is believed to occur by multiple mechanisms; one mechanism is initiated when an antibody binds to an antigen on a cell’s surface. Once the antigen-antibody complex is formed, the C1q molecule is believed to bind the antigen-antibody complex. C1q then cleaves itself to initiate a cascade of enzymatic activation and cleavage of other complement proteins which then bind the target cell surface and facilitate its death through, for example, cell lysis and/or ingestion by a macrophage.

[0026] A key insight of the invention is that CDC causes the side effect of pain. Without wishing to be bound by theory, neurons may be particularly sensitive to complement fixation because this process involves the creation of channels in a cell membrane, allowing an uncontrolled ion flux. In pain-sensing neurons, even a small amount of complement fixation may be significant to generate action potentials. Thus, any amount of CDC resulting from anti-GD2 antibody binding on neurons will result in pain. According to the invention, it is advantageous to reduce complement fixation so as to reduce the level of side effects in a patient.

[0027] However, if one reduces or eliminates CDC, effective anti-tumor activity of the anti-GD2 antibody requires that levels of ADCC be maintained or even increased. A second key finding of the invention is that the antitumor activity of anti-GD2 antibodies results primarily from ADCC, and not substantially from complement fixation. Therefore, a key aspect of the invention is that it is possible to reduce or eliminate CDC function of an anti-GD2 antibody without eliminating the anti-tumor capabilities of the anti-GD2 antibody. In other words, an anti-GD2 antibody modified to reduce or eliminate complement fixation will still have anti-tumor capabilities and therefore can be effective at treating tumor growth. Consequently, the invention provides mutations in anti-GD2 antibodies that reduce complement fixation to a great extent while having a

minimal effect on ADCC, such as mutation of lysine 322 to alanine (K322A) or another amino acid (Thommesen *et al.*, Mol. Immunol., [2000]; 37(16): 995-1004).

[0028] The anti-GD2 antibodies of the invention can be produced using recombinant expression vectors known in the art. The term "expression vector" refers to a replicable
5 DNA construct used to express DNA encoding the desired anti-GD2 antibody and including a transcriptional unit of (1) genetic element(s) having a regulatory role in gene expression, for example, promoters, operators, or enhancers, operatively linked to (2) a DNA sequence encoding the desired anti-GD2 antibody which is transcribed into mRNA and translated into protein, and (3) appropriate transcription and translation initiation and
10 termination sequences. The choice of promoter and other regulatory elements generally varies according to the intended host cell.

[0029] In a preferred example, the nucleic acid encoding the modified anti-GD2 antibody is transfected into a host cell using recombinant DNA techniques. In the context of the present invention, the foreign DNA includes a sequence encoding the inventive proteins.
15 Suitable host cells include prokaryotic, yeast or higher eukaryotic cells.

[0030] The recombinant anti-GD2 antibodies can be expressed in yeast hosts, preferably from *Saccharomyces* species, such as *S. cerevisiae*. Yeasts of other genera such as *Pichia* or *Kluyveromyces* may also be employed. Yeast vectors will generally contain an origin of replication from a yeast plasmid or an autonomously replicating sequence (ARS), a
20 promoter, DNA encoding the anti-GD2 antibody, as well as sequences for polyadenylation, transcription termination, and a selection gene. Suitable promoter sequences in yeast vectors include the promoters for metallothionein, 3-phosphoglycerate kinase or other glycolytic enzymes, such as enolase, glyceraldehyde-3-phosphate dehydrogenase, hexokinase, pyruvate decarboxylase, phosphofructokinase, glucose-4-
25 phosphate isomerase, 3-phosphoglycerate mutase, pyruvate kinase, triosephosphate isomerase, phosphoglucose isomerase and glucokinase.

[0031] Various mammalian or insect cell culture systems can be employed to express the recombinant protein of the invention. Baculovirus systems for production of proteins in insect cells are well known in the art. Examples of suitable mammalian host cell lines
30 include NS/O cells, L cells, C127, 3T3, Chinese hamster ovary (CHO), HeLa, and BHK cell lines. Additional suitable mammalian host cells include CV-1 cells (ATCC CCL70) and COS-7 cells, both derived from monkey kidney. Another suitable monkey kidney cell line, CV-1/EBNA, was derived by transfection of the CV-1 cell line with a gene encoding

Epstein-Barr virus nuclear antigen-1 (EBNA-1) and with a vector containing CMV regulatory sequences (McMahan *et al.*, EMBO J., [1991]; 10: 2821-32). The EBNA-1 gene allows for episomal replication of expression vectors, such as HAV-EO or pDC406, that contain the EBV origin of replication.

5 [0032] According to this invention, a particularly useful cell line for expression of anti-GD2 antibodies is the YB2/0 cell line (Shinkawa *et al.*, J. Biol. Chem., [2003]; 278: 3466-3473). Antibodies produced from this cell line have enhanced ADCC. When produced from this cell line, antibodies of the invention have a different N-linked oligosaccharide than the oligosaccharide seen in antibodies produced from other cell lines described
10 above. Particular embodiments of the invention include anti-GD2 antibodies with non-mutant constant regions produced in YB2/0, as well as anti-GD2 antibodies with constant regions bearing mutations that reduce complement fixation, such as Lys322Ala, also produced in YB2/0 cells.

[0033] Mammalian expression vectors can include non-transcribed elements such as an
15 origin of replication, a suitable promoter and enhancer linked to the gene to be expressed, and other 5' or 3' flanking non-transcribed sequences, and 5' or 3' non-translated sequences, such as necessary ribosome binding sites, a poly-adenylation site, splice donor and acceptor sites, and transcriptional termination sequences. Commonly used promoters and enhancers are derived from Polyoma, Adenovirus 2, Simian Virus 40 (SV40), and
20 human cytomegalovirus. DNA sequences derived from the SV40 viral genome, for example, SV40 origin, early and late promoter, enhancer, splice, and polyadenylation sites may be used to provide the other genetic elements required for expression of a heterologous DNA sequence.

[0034] When secretion of the modified antibody from the host cell is desired, the
25 expression vector can include DNA encoding signal or leader peptides, preferably placed N-terminally to both heavy and light chains. In the present invention the native signal sequences of the antibody V regions can be used, or alternatively, a heterologous signal sequence may be added, such as the signal sequence from interleukin-4.

[0035] The present invention also provides a process for preparing the recombinant
30 proteins of the present invention including culturing a host cell transformed with an expression vector comprising a DNA sequence that encodes the anti-GD2 antibody under conditions that promote expression. The desired protein is then purified from culture media or cell extracts. For example, supernatants from expression systems that secrete

recombinant protein into the culture medium can be first concentrated using a commercially available protein concentration filter, for example, an Amicon or Millipore Pellicon ultrafiltration unit. Following the concentration step, the concentrate can be applied to a suitable purification matrix, as known in the art.

5 [0036] An "isolated" or "purified" modified anti-GD2 antibody or biologically active portion thereof is substantially free of cellular material or other contaminating proteins from the cell or tissue source from which the modified anti-GD2 antibody is derived, or substantially free from chemical precursors or other chemicals when chemically synthesized. The language "substantially free of cellular material" includes preparations
10 of modified anti-GD2 antibody in which the protein is separated from cellular components of the cells from which it is isolated or recombinantly produced. In one embodiment, the language "substantially free of cellular material" includes preparations of modified anti-GD2 antibody having less than about 30% (by dry weight) of non-antibody (also referred to herein as a "contaminating protein"), more preferably less than
15 about 20% of non-antibody protein, still more preferably less than about 10% of non-antibody protein, and most preferably less than about 5% non-antibody protein. When the modified anti-GD2 antibody or biologically active portion thereof is purified from a recombinant source, it is also preferably substantially free of culture medium, *i.e.*, culture medium represents less than about 20%, more preferably less than about 10%, and most
20 preferably less than about 5% of the volume of the protein preparation.

[0037] The term "substantially pure modified anti-GD2 antibody" refers to a preparation in which the modified anti-GD2 antibody constitutes at least 60%, 70%, 80%, 90%, 95% or 99% of the proteins in the preparation.

25 Methods of Treatment Using Anti-GD2 Antibody Proteins

[0038] The modified anti-GD2 antibodies of the invention are useful in treating cancers, such as GD2-expressing cancers. Such cancers include, but are not limited to, neuroblastoma, glioblastoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, retinoblastoma, and other cancers of neuroectodermal origin.

30

Administration

[0039] The modified anti-GD2 antibodies of the invention can be incorporated into a pharmaceutical composition suitable for administration. Such compositions typically

comprise the modified anti-GD2 antibodies and a pharmaceutically-acceptable carrier. As used herein the language "pharmaceutically-acceptable carrier" is intended to include any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents, and the like, compatible with pharmaceutical administration. The use of such media and agents for pharmaceutically active substances is well known in the art.

[0040] A pharmaceutical composition of the invention is formulated to be compatible with its intended route of administration. Examples of routes of administration include parenteral, *e.g.*, intravenous, intradermal, subcutaneous, oral (*e.g.*, inhalation), transdermal (topical), transmucosal, and rectal administration. Solutions or suspensions used for parenteral, intradermal, or subcutaneous application can include the following components: a sterile diluent such as water for injection, saline solution, fixed oils, polyethylene glycols, glycerine, propylene glycol or other synthetic solvents; antibacterial agents such as benzyl alcohol or methyl parabens; antioxidants such as ascorbic acid or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates; and agents for the adjustment of tonicity such as sodium chloride or dextrose. pH can be adjusted with acids or bases, such as hydrochloric acid or sodium hydroxide. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic.

[0041] Medicaments that contain the modified anti-GD2 antibodies of the invention can have a concentration of 0.01 to 100% (w/w), though the amount varies according to the dosage form of the medicaments.

[0042] Administration dose depends on the body weight of the patients, the seriousness of the disease, and the doctor's opinion. However, it is generally advisable to administer about 0.01 to about 10 mg/kg body weight a day, preferably about 0.02 to about 2 mg/kg/day in case of injection, and more preferably about 0.5 mg/kg/day. The dose can be administered once or several times daily according to the seriousness of the disease and the doctor's opinion.

[0043] Compositions of the invention are useful when co-administered with one or more other therapeutic agents, for example, chemotherapeutic agents that are standard treatment in cancer therapy.

EXAMPLES

EXAMPLE 1. Expression of an Anti-GD2 Antibody with a Mutation that Reduced Complement Fixation.

5 [00043] An expression plasmid that expresses the heavy and light chains of the human 14.18 anti-GD2 antibody with reduced complement fixation due to mutation was constructed as follows. The expression plasmid for the 14.18 anti-GD2 antibody was pdHL7-hu14.18. pdHL7 was derived from pdHL2 (Gillies *et al.*, J. Immunol. Methods, [1989]; 125: 191-202), and uses the cytomegalovirus enhancer-promoter for the
10 transcription of both the immunoglobulin light and heavy chain genes. The K322A mutation in the CH2 region was introduced by overlapping Polymerase Chain Reactions (PCR) using pdHL7-hu14.18 plasmid DNA as template. The sequence of the forward primer was 5'-TAC AAG TGC GCT GTC TCC AAC (SEQ ID NO:6), where the underlined GCT encodes the K322A substitution, and the sequence of the reverse primer
15 was 5'-T GTT GGA GAC AGC GCA CTT GTA (SEQ ID NO:7), where the underlined AGC is the anticodon of the introduced alanine residue. The PCR product was cloned and, after sequence confirmation, the DNA containing the K322A mutation was excised as a 190 base-pair (bp) Sac II - Nae I restriction fragment (the restriction sites Sac II and Nae I are located about 90 bp upstream and 100 bp downstream, respectively, of the
20 K322A mutation), which was then used to replace the corresponding fragment containing the K322 wild-type in the pdHL7-hu14.18 to give pdHL7-hu14.18(K322A). The expression vector for the 14.18(K322A) antibody, pdHL7-hu14.18(K322A), was constructed in a manner analogous to the construction of pdHL7-hu14.18. However, one skilled in the art may choose from a number of acceptable vectors to express hu14.18
25 K322A.

EXAMPLE 2. Transfection and Expression of the Anti-GD2 Antibody.

[00044] Electroporation was used to introduce the DNA encoding the anti-GD2 antibody described above into a mouse myeloma NS/0 cell line or the YB2/0 cell line. To
30 perform electroporation, cells were grown in Dulbecco's modified Eagle's medium supplemented with 10% heat-inactivated fetal bovine serum, 2 mM glutamine and penicillin/streptomycin. About 5×10^6 cells were washed once with PBS and resuspended in 0.5 ml PBS. 10 μ g of linearized plasmid DNA encoding the modified anti-GD2 antibody of Example 1 was then incubated with the cells in a Gene Pulser Cuvette (0.4 cm

electrode gap, BioRad) on ice for 10 min. Electroporation was performed using a Gene Pulser (BioRad, Hercules, CA) with settings at 0.25 V and 500 μ F. Cells were allowed to recover for 10 min on ice, after which they were resuspended in growth medium and plated onto two 96 well plates.

5 [00045] Stably transfected clones were selected by their growth in the presence of 100 nM methotrexate (MTX), which was added to the growth medium two days post-transfection. The cells were fed two to three more times on every third day, and MTX-resistant clones appeared in 2 to 3 weeks. Supernatants from clones were assayed by anti-Fc ELISA to identify clones that produced high amounts of the anti-GD2 antibody. High
10 producing clones were isolated and propagated in growth medium containing 100 nM MTX. Typically, a serum-free growth medium, such as H-SFM or CD medium (Life Technologies), was used.

EXAMPLE 3. Biochemical Analysis of the Anti-GD2 Antibody.

15 [00046] Routine SDS-PAGE characterization was used to assess the integrity of the modified antibodies. The modified anti-GD2 antibodies were captured on Protein A Sepharose beads (Repligen, Needham, MA) from the tissue culture medium into which they were secreted, and were eluted by boiling in protein sample buffer, with or without a reducing agent such as β -mercaptoethanol. The samples were separated by SDS-PAGE
20 and the protein bands were visualized by Coomassie staining. Results from SDS-PAGE showed that the modified anti-GD2 antibody proteins analyzed were present substantially as a single band, indicating that there was not any significant amount of degradation.

EXAMPLE 4. Antibody-Dependent Cell-Mediated Cytotoxicity (ADCC) and 25 Complement-Dependent Cytotoxicity (CDC) of Antibodies of the Invention.

[00047] To demonstrate that the modified antibodies of the invention had the desired properties, the ability of the antibodies to mediate ADCC was examined using standard procedures, essentially as described by Idusogie *et al.* (*J. Immunol.*, [2000]; 164: 4178-4184). Antibodies were tested against two GD2-positive, EpCAM-negative cell lines (M-
30 21 and LN-229) and, as a control, one GD2-negative, EpCAM-positive cell line (A431) using human PBMCs as effector cells in a standard chromium release assay. All antibodies had a human IgG1 isotype.

[00048] Human IgG2 versions of 14.18 anti-GD2 antibody expressed in NS/0 cells; 14.18 with the K322A mutation, expressed in NS/0 cells; 14.18 with the K322A mutation, expressed in YB2/0 cells; and 14.18 configured as a single-chain Fv fused to an Fc, expressed in NS/0 cells; were assayed to determine their ADCC activity by measuring
5 the percent of target M-21 cells lysed according to standard methods described previously. The KS-1/4 antibody, which does not bind target cells, was also assayed to serve as a control. As shown in Figure 6, the K322A variant grown in YB2/0 cells had the highest overall levels of ADCC as compared to all other antibody constructs tested.

[00049] The same constructs were also tested in a similar assay using LN-229 GD2
10 expressing cells as the target cells. The KS-1/4 antibody was used as a control. As shown in Figure 7, the K322A variant grown in YB2/0 cells had the highest overall levels of ADCC as compared to all other antibody constructs tested.

[00050] As a control, the ADCC activity of the same anti-GD2 antibodies was tested against A431 cells which do not express the glycolipid GD2. As would be expected, the
15 anti-GD2 antibodies showed little, if no activity, whereas the KS-1/4 antibody which is known to have ADCC activity against EpCAM expressing cells demonstrated increasing activity as concentrations of the antibody increased. (See Figure 8). This indicates that the levels of lysis achieved in the assay of anti-GD2 antibody with M-21 cells in the previous assay need not be adjusted for any background levels of lysis activity.

[00051] In order to test the ability of anti-GD2 antibodies ability to mediate
20 complement dependent cytotoxicity (CDC), human IgG1 versions of 14.18 expressed in NS/0 cells; two samples of 14.18 with the K322A mutation, expressed in NS/0 cells; 14.18 with the K322A mutation, expressed in YB2/0 cells; and 14.18 configured as a single-chain Fv fused to an Fc, expressed in NS/0 cells. Anti-GD2 antibodies of the
25 invention were examined in M-21 and LN-229 cell lysis assays according to standard procedures, essentially as described by Idusogie *et al.* (*J. Immunol.*, [2000]; 164: 4178-4184). A 1:10 dilution of human complement was used. The KS-1/4 antibody, which does not bind to the target cells, was again used as a control.

[00052] It was found that complement fixation mediated by the antibodies of the
30 invention was profoundly reduced. As shown in Figure 9, only 14.18 grown in NS/0 cells had levels of complement fixation at low concentrations, whereas those antibodies containing the K322A mutation exhibited little or no CDC activity at low concentrations. As shown in Figure 10, only 14.18 anti-GD2 antibodies grown in NS/0 cells demonstrated

complement fixation activity against LN229 cells, as measured by the percent of target cells lysed. The K322A variants all demonstrated little or no CDC activity at any concentration.

[00053] Taken together, the results of the ADCC and CDC assays indicate that certain
5 modified anti-GD2 antibodies of the invention mediate ADCC, but have significantly reduced levels of complement fixation, especially as compared to typical anti-GD2 antibodies that have been used in human clinical trials.

10 EXAMPLE 5. Treatment of Mice Bearing GD2-Expressing Tumors with Modified Anti-GD2 Antibodies.

[00054] To demonstrate the efficacy of the modified anti-GD2 antibodies of the invention, the modified antibody of Example 1 is tested in a mouse model of melanoma or neuroblastoma. Hu/SCID beige mice are used. The SCID and beige mutations
15 suppress the normal mouse immune system, so that human immune cells can be added to reconstitute the immune system. Human peripheral blood mononucleocytes (PBMCs) are used. It is necessary to use human immune cells because the Fc region of human IgG1 is not recognized by murine Fc receptors to achieve ADCC.

[00055] Cells expressing GD2 are then implanted into the mice. For example, cells are
20 implanted subcutaneously, and their growth is monitored twice per week with calipers to estimate tumor volume. As a model of neuroblastoma, the GD2-expressing cell line NXS2 is used (Greene *et al.*, Proc. Natl. Acad. Sci. USA, [1975]; 72: 4923-27). As a model of melanoma, the cell line B16, modified to express GD2 is used (Haraguchi *et al.*, Proc. Natl. Acad. Sci. USA, [1994]; 91: 10455-59).

25 [00056] Subcutaneous tumors are allowed to grow to a size of about 25 to 200 cubic millimeters, and treatment is initiated. Because the serum half-life of the modified antibodies of the invention is several days, animals are treated only one to three times per week. It is found that the volumes of tumors in mice treated with either vehicle or a control antibody increase rapidly, while the volumes of mice treated with the modified
30 antibodies of the invention increase more slowly, or are stabilized, or in some cases shrink.

EXAMPLE 6. Determination of the Maximum Tolerated Dose in a Phase I Clinical Trial.

- [00057] To determine the maximum tolerated dose of a modified anti-GD2 antibody of the invention, a Phase I clinical trial is performed essentially as described in Yu *et al.* (J. Clin. Oncol., [1998]; 16: 2169-80). The maximum tolerated dose of the human IgG1-based chimeric 14.18 antibody reported by Yu *et al.* was found to be about 20 mg/m².
- 5 The maximum tolerated dose of the modified anti-GD2 antibody of the invention is found to be higher than 20 mg/m².

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CLAIMS:

1. An immunoglobulin polypeptide comprising a variable region of an anti-GD2 antibody, a CL domain and a Fc region of an immunoglobulin IgG1, that comprises a CH1 domain and possesses a K322A mutation to decrease or eliminate
5 complement fixation (CDC), wherein the heavy chain of the immunoglobulin polypeptide comprises the amino acid sequence as depicted in SEQ ID NO: 5, and the light chain of the immunoglobulin polypeptide comprises the amino acid sequence of SEQ ID NO: 2.
2. A polypeptide according to claim 1, wherein the antibody-dependent
10 cell-mediated cytotoxicity (ADCC) is maintained.
3. A polypeptide according to claim 1, eliciting an enhanced ADCC activity, obtained by producing said polypeptide in YB2/0 cells.
4. A DNA molecule encoding a polypeptide of any one of the claims 1 to 3.
5. An expression cell comprising the DNA molecule of claim 4.
- 15 6. The cell of claim 5, wherein the cell is a YB2/0 cell.
7. A pharmaceutical composition comprising in an effective amount a polypeptide of any one of the claims 1 – 3 together with a pharmaceutically effective carrier, diluent or excipient.
8. Use of a polypeptide of any one of the claims 1 to 3 for the manufacture
20 of a medicament for reducing pain in cancer therapy.
9. The use of claim 8, wherein the cancer is selected from the group consisting of neuroblastoma, glioblastoma, osteosarcoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, and retinoblastoma.
10. Use of an immunoglobulin polypeptide comprising a variable region of
25 an anti-GD2 antibody, a CL domain and a Fc region of an immunoglobulin IgG1, that

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comprises a CH1 domain and possesses a K322A mutation as represented in SEQ ID NO: 5 to decrease or eliminate complement fixation (CDC) while maintaining antibody-dependent cell-mediated cytotoxicity (ADCC) for the manufacture of a medicament for reducing pain in cancer therapy.

- 5 11. Use of a polypeptide of any one of claims 1 to 3 for reducing pain in cancer therapy.
12. The use of claim 11, wherein the cancer is selected from the group consisting of neuroblastoma, glioblastoma, osteosarcoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, and retinoblastoma.
- 10 13. Use of an immunoglobulin polypeptide comprising a variable region of an anti-GD2 antibody, a CL domain and a Fc region of an immunoglobulin IgG1, that comprises a CH1 domain and possesses a K322A mutation as represented in SEQ ID NO: 5 to decrease or eliminate complement fixation (CDC) while maintaining antibody-dependent cell-mediated cytotoxicity (ADCC) for reducing pain in cancer
15 therapy.
14. The composition of claim 7 for use in reducing pain in cancer therapy.
15. The composition of claim 14, wherein the cancer is selected from the group consisting of neuroblastoma, glioblastoma, osteosarcoma, melanoma, small-cell lung carcinoma, B-cell lymphoma, renal carcinoma, and retinoblastoma.

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Hu14.18 IgG1 Mature Heavy Chain

EVQLVQSGAEVEKPGASVKISCKASGSSFTGYNMNWVRQNIGKSLEWIGAIDPYYGGTSYNQKF
KGRATLTVDKSTSTAYMHLKSLRSEDVAVYYCVSGMEYWGQGTSVTVSSASTKGPSVFPLAPSS
KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQ
TYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVT
CVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCAVS
NKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPE
NNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSVMSVHEALHNHYTQKLSLSLSPGK
(SEQ ID NO: 1)

FIG. 1

Hu14.18 IgG1 Mature Heavy Chain with K322A Mutation

EVQLVQSGAEVEKPGASVKISCKASGSSFTGYNMNWVRQNIGKSLEWIGAIDPYYGGTSYNQKF
KGRATLTVDKSTSTAYMHLKSLRSEDVAVYYCVSGMEYWGQGTSVTVSSASTKGPSVFPLAPSS
KSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVLQSSGLYSLSSVVTVPSSSLGTQ
TYICNVNHKPSNTKVDKRVEPKSCDKTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVT
CVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCAVS
NAALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPE
NNYKTTTPVLDSDGSFFLYSKLTVDKSRWQQGNVFSVMSVHEALHNHYTQKLSLSLSPGK
(SEQ ID NO: 5)

FIG. 2

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Hu14.18 IgG1 Mature Light Chain

DVVMTQTPLSLPVTPGEPASISCRSSQSLVHRNGNTYLHWYLQKPGQSPKLLIHKVSNRFSGVP
DRFSGSGSGTDFTLKISRVEAEDLGVYFCSQSTHVPPLTFGAGTKLELKRTVAAPSVFIFPPSD
EQLKSGTASVCLLNNFYPRKAKVQWKVDNALQSGNSQESVTEQDSKDSSTYSLSSTLTLSKADY
EKHKVYACEVTHQGLSSPVTKSFNRGEC (SEQ ID NO: 2)

FIG. 3

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Hu14.18 IgG1 Mature Heavy chain Coding Sequence, with Introns:

GAGGTGCAGCTGGTGCAGTCCGGCGCCGAGGTGGAGAAGCCCGGCGCCTCCGTGAAGATCTCCT
GCAAGGCCTCCGGCTCCTCCTTCAACGGCTACAACATGAACTGGGTGCGCCAGAACATCGGCAA
GTCCCTGGAGTGGATCGGCGCCATCGACCCCTACTACGGCGGCACCTCCTACAACCAGAAGTTC
AAGGGCCGCGCCACCCTGACCGTGGACAAGTCCACCTCCACCGCCTACATGCACCTGAAGTCCC
TGCCTCCGAGGACACCGCCGTGTACTACTGCGTGTCCGGCATGGAGTACTGGGGCCAGGGCAC
CTCCGTGACCGTGTCTCCGGTAAGCTTTTCTGGGGCAGGCCAGGCCTGACCTTGGCTTTGGGG
CAGGGAGGGGGCTAAGGTGAGGCAGGTGGCGCCAGCCAGGTGCACACCCAATGCCCATGAGCCC
AGACACTGGACGCTGAACCTCGCGGACAGTTAAGAACCAGGGGCCTCTGCGCCCTGGGCCAG
CTCTGTCCCACACCGCGGTACATGGCACCACCTCTCTTGCAGCCTCCACCAAGGGCCCATCGG
TCTTCCCCCTGGCACCCCTCCTCCAAGAGCACCTCTGGGGGCACAGCGGCCCTGGGCTGCCTGGT
CAAGGACTACTTCCCCGAACCGGTGACGGTGTCTGGAAGTCAAGCGCCCTGACCAGCGGCGTG
CACACCTTCCCGGCTGTCTACAGTCTCAGGACTCTACTCCCTCAGCAGCGTGGTGACCGTGC
CCTCCAGCAGCTTGGGCACCCAGACCTACATCTGCAACGTGAATCACAAGCCAGCAACACCAA
GGTGGACAAGAGAGTTGGTGAGAGGCCAGCACAGGGAGGGAGGGTGTCTGCTGGAAGCCAGGCT
CAGCGCTCCTGCCTGGACGCATCCCGGCTATGCAGTCCAGTCCAGGGCAGCAAGGCAGGCCCC
GTCTGCCTCTTCAACCGGAGGCCTCTGCCCCGCCCACTCATGCTCAGGGAGAGGGTCTTCTGGC
TTTTTCCCCAGGCTCTGGGCAGGCACAGGCTAGGTGCCCTAACCCAGGCCCTGCACACAAAGG
GGCAGGTGCTGGGCTCAGACCTGCCAAGAGCCATATCCGGGAGGACCCTGCCCTGACCTAAGC
CCACCCCAAAGGCCAAACTCTCCACTCCCTCAGCTCGGACACCTTCTCTCCTCCAGATTCCAG
TAACTCCCAATCTTCTCTCTGCAGAGCCCAAATCTTGTGACAAAACCTCACACATGCCACCGTG
CCCAGGTAAGCCAGCCCAGGCCTCGCCCTCCAGCTCAAGGCGGGACAGGTGCCCTAGAGTAGCC
TGCATCCAGGGACAGGCCCCAGCCGGGTGCTGACACGTCCACCTCCATCTCTTCCCTCAGCACCT
GAACTCCTGGGGGGACCGTCAGTCTTCTCTTCCCCCAAACCCAAGGACACCCTCATGATCT
CCCGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACGAAGACCCTGAGGTCAAGTT
CAACTGGTACGTGGACGGCGTGGAGGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTAC
AACAGCACGTACCGTGTGGTCAGCGTCTCACCGTCTTGCACCAGGACTGGCTGAATGGCAAGG
AGTACAAGTGCCTGTCTCAACAAAGCCCTCCAGCCCCATCGAGAAAACCATCTCCAAGC
CAAAGGTGGGACCCGTGGGGTGCAGGGCCACATGGACAGAGGCCGGCTCGGCCACCCTCTGC
CCTGAGAGTGACCGTGTACCAACCTCTGTCCCTACAGGGCAGCCCCGAGAACCACAGGTGTAC
ACCCTGCCCCCATCACGGGAGGAGATGACCAAGAACCAGGTGAGCCTGACCTGCCTGGTCAAAG
GCTTCTATCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGGAGAACAACTACAA
GACCACGCCTCCCGTGTGGACTCCGACGGCTCCTTCTTCTCTATAGCAAGCTCACCGTGGAC
AAGAGCAGGTGGCAGCAGGGGAACGTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAACC
ACTACACGCAGAAGAGCCTCTCCCTGTCCCCGGGTAAA (SEQ ID NO: 3)

FIG. 4

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Hu14.18 IgG1 Mature Light chain Coding Sequence, with Introns:

GACGTGGTGATGACCCAGACCCCCCTGTCCCTGCCCGTGACCCCCGGCGAGCCCGCCTCCATCT
CCTGCAGATCTAGTCAGAGTCTTGTACACCGTAATGGAAACACCTATTTACATTGGTACCTGCA
GAAGCCAGGCCAGTCTCCAAAGCTCCTGATTCACAAAGTTTCCAACCGATTTTCTGGGGTCCCA
GACAGGTTTCAGTGGCAGTGGATCAGGGACAGATTTCACACTCAAGATCAGCAGAGTGGAGGCTG
AGGATCTGGGAGTTTATTTCTGTTCTCAAAGTACACATGTTCCCTCCGCTCACGTTCCGGTGCTGG
GACCAAGCTGGAGCTGAAACGTATTAGTGTGTCAGGGTTTCAAGAGGGACTAAAGACATGTC
AGCTATGTGTGACTAATGGTAATGTCACTAAGCTGCGGGATCCCGCAATTCTAAACTCTGAGGG
GGTCCGATGACGTGGCCATTCTTTGCCCTAAAGCATTGAGTTTACTGCAAGGTCAGAAAAGCATG
CAAAGCCCTCAGAATGGCTGCAAAGAGCTCCAACAAAACAATTTAGAACTTTATTAAGGAATAG
GGGGAAGCTAGGAAGAACTCAAACATCAAGATTTTAAATACGCTTCTTGGTCTCCTTGCTAT
AATTATCTGGGATAAGCATGCTGTTTTCTGTCTGTCCCTAACATGCCCTGTGATTATCCGCAA
CAACACACCCAAGGGCAGAACTTTGTTACTTAAACACCATCCTGTTTGCTTCTTTCCTCAGGAA
CTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCTGGAAGTGC
CTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACAGTGGAAAGGTGGAT
AACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTACAGAGCAGGACAGCAAGGACAGCACCT
ACAGCCTCAGCAGCACCTGACGCTGAGCAAAGCAGACTACGAGAAACACAAAGTCTACGCCTG
CGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGT
(SEQ ID NO: 4)

FIG. 5

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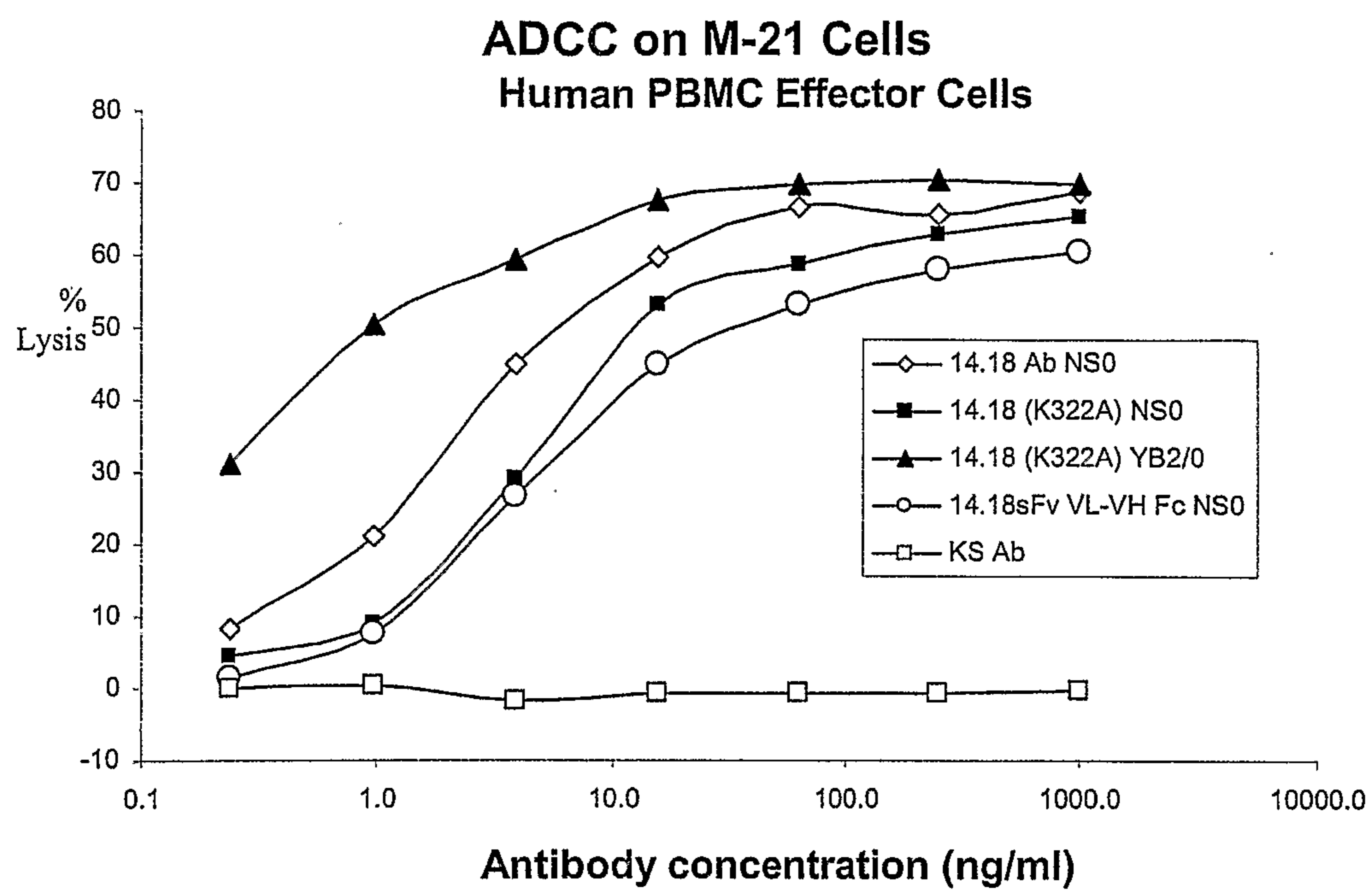


FIG. 6

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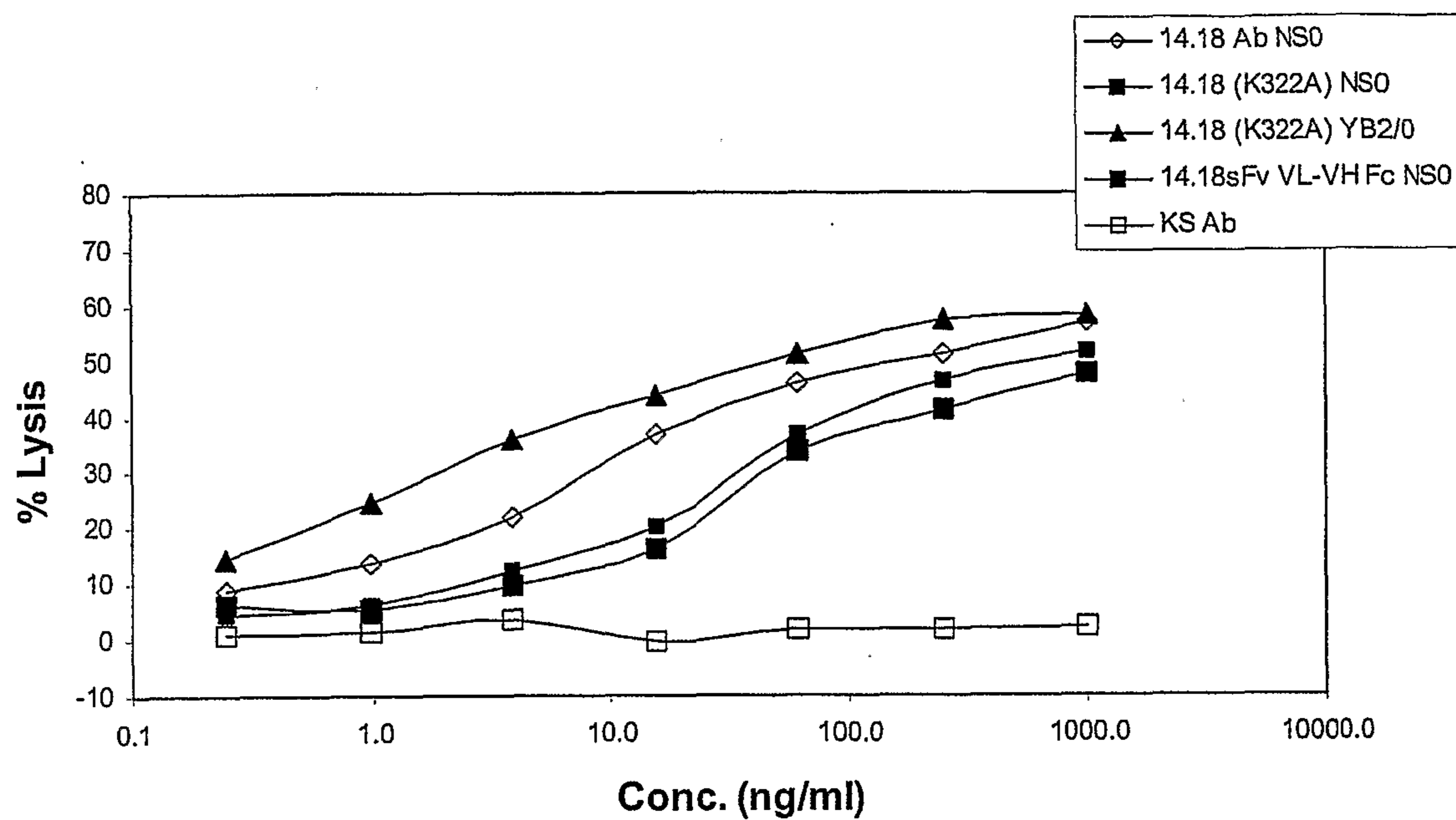
**ADCC on LN229 Cells
418-1563 Effector Cells**

FIG. 7

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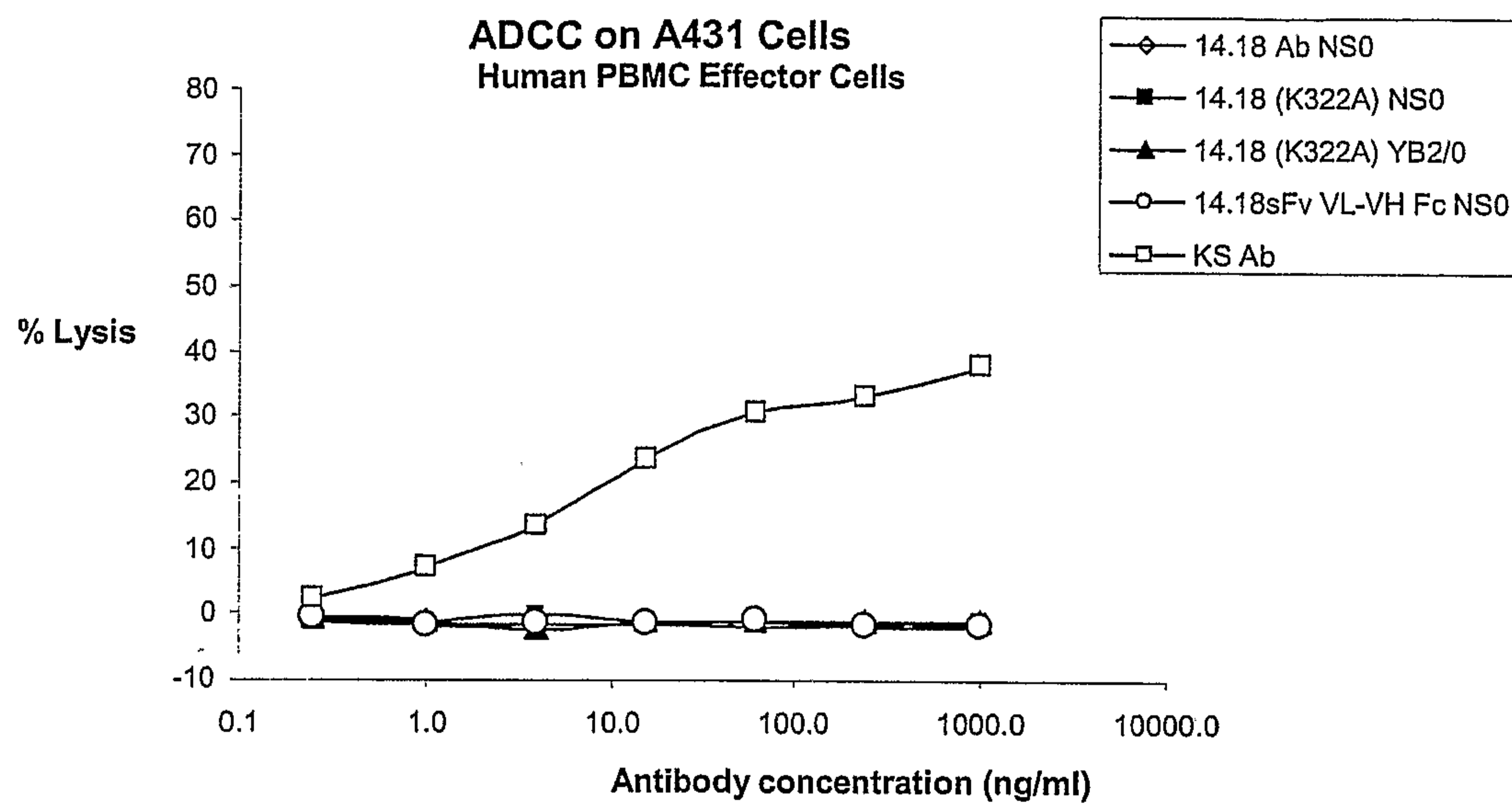


FIG. 8

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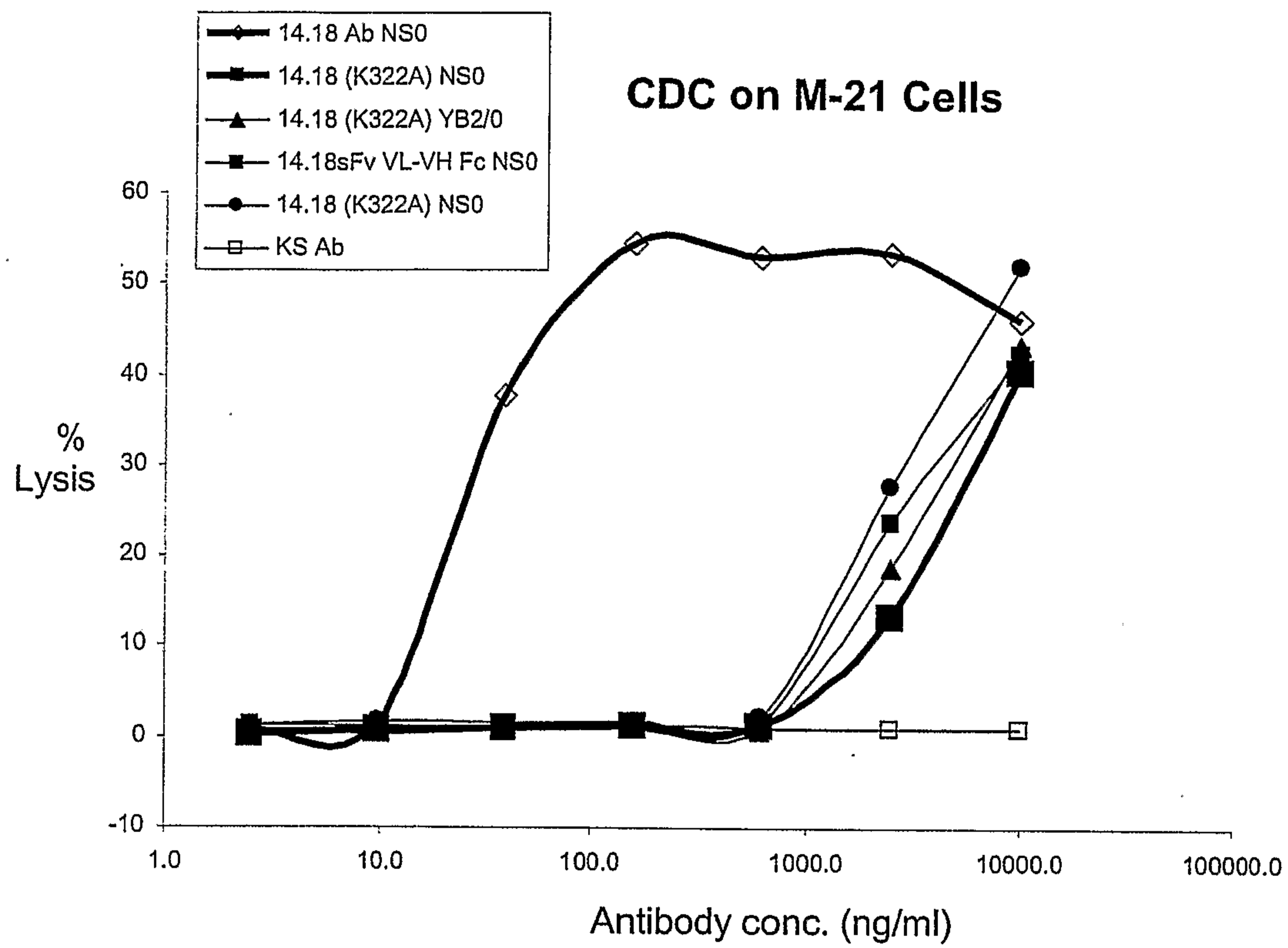


FIG. 9

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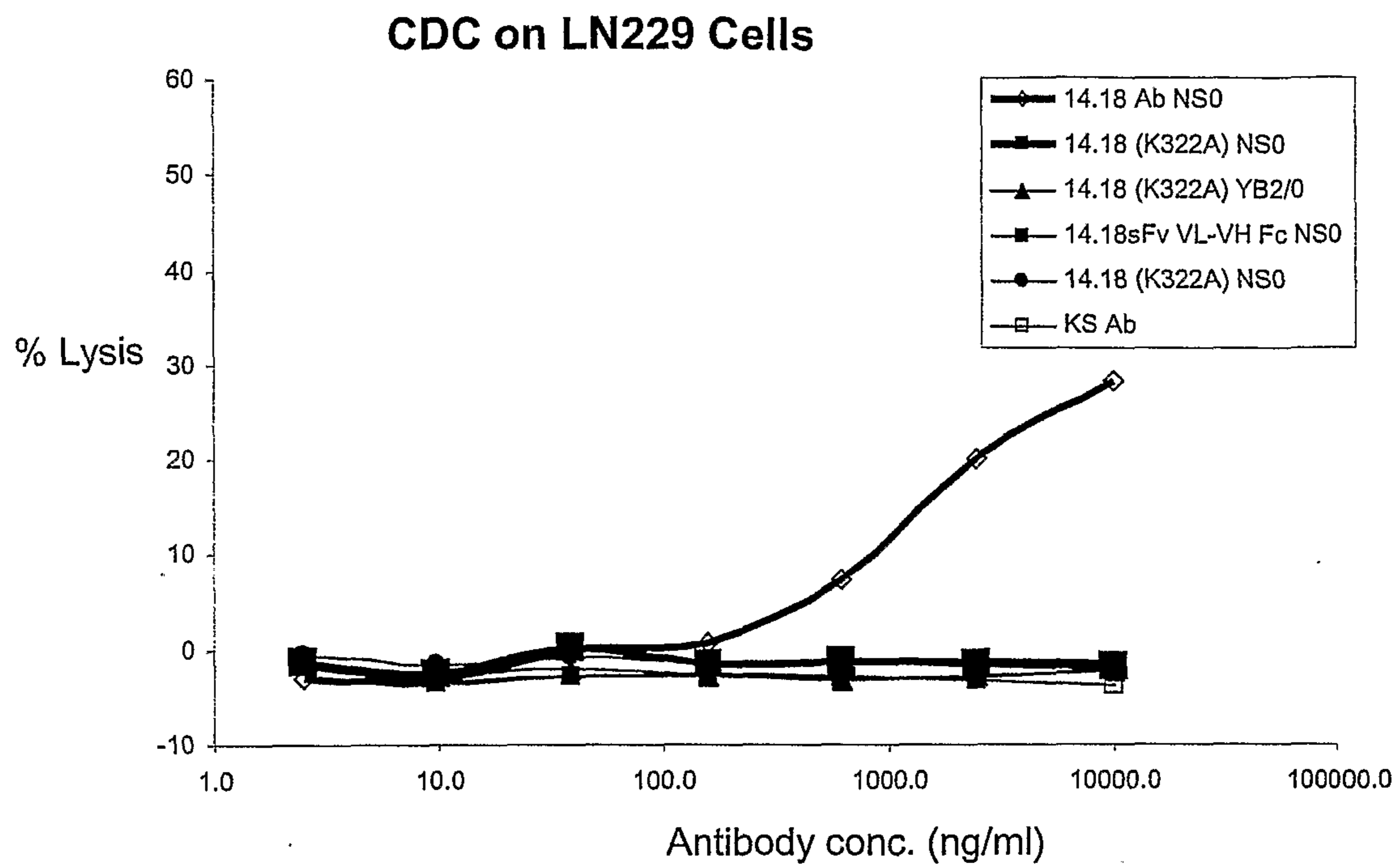


FIG. 10

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Amino Acid Sequence of the Mature Fusion Protein Human 14.18 sFv
(VL-VH) -Fc

DVVMTQTPLSLPVTTPGEPASISCRSSQSLVHRNGNTYLHWYLQKPGQSPKLLIHKVSNRFSGVP
DRFSGSGSGTDFTLKISRVEAEDLGVYFCSQSTHVPPLTFGAGTKLELKS GGGGSGGGGSGGGG
SGGGGSEVQLVQSGAEVEKPGASVKISCKASGSSFTGYNMNWVRQNI GKSLEWIG AIDPYYGGT
SYNQKFKGRATLTVDKSTSTAYMHLKSLRSED TAVYYCVSGMEYWGQGT SVTVSSEPKSCDKTH
TCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAK
TKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVY TLP
PSREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPVLDSDGSFFLYSKLTVDKSR
WQQGNV FSCSVMHEALHNHYTQKSLSLSPGK (SEQ ID NO:9)

FIG. 11

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DNA Sequence encoding the mature fusion protein Human 14.18 sFv (VL-VH)-Fc, with introns:

GACGTGGTGATGACCCAGACCCCCCTGTCCCTGCCCGTGACCCCCGGCGAGCCCGCCTCCATCT
CCTGCAGATCTAGTCAGAGTCTTGTACACCGTAATGGAAACACCTATTTACATTGGTACCTGCA
GAAGCCAGGCCAGTCTCCAAAGCTCCTGATTCACAAAGTTTCCAACCGATTTTCTGGGGTCCCA
GACAGGTTCAGTGGCAGTGGATCAGGGACAGATTTCACACTCAAGATCAGCAGAGTGGAGGCTG
AGGATCTGGGAGTTTATTTCTGTTCTCAAAGTACACATGTTCCCTCCGCTCACGTTCCGGTGCTGG
GACCAAGCTGGAGCTGAAATCCGGAGGCGGTGGGTCCGGAGGTGGCGGGTCTGGTGGTGGAGGC
AGCGGTGGTGGGGGATCCGAGGTGCAGCTGGTGCAGTCCGGCGCCGAGGTGGAGAAGCCCGGCG
CCTCCGTGAAGATCTCCTGCAAGGCCTCCGGCTCCTCCTTCAACCGCTACAACATGAACTGGGT
GCGCCAGAACATCGGCAAGTCCCTGGAGTGGATCGGCGCCATCGACCCCTACTACGGCGGCACC
TCCTACAACCAGAAGTTCAAGGGCCGCGCCACCCTGACCGTGGACAAGTCCACCTCCACCGCCT
ACATGCACCTGAAGTCCCTGCGCTCCGAGGACACCGCCGTGTAATACTGCGTGTCCGGCATGGA
GTAATAAGGAGGACCTCCGTGACCGTGTCTCCGAGCCCAAATCTTGTGACAAAACCTCAC
ACATGCCACCGTGCCAGGTAAGCCAGCCAGGCCTCGCCCTCCAGCTCAAGGCGGGACAGGT
GCCCTAGAGTAGCCTGCATCCAGGGACAGGCCCCAGCCGGGTGCTGACACGTCCACCTCCATCT
CTTCCTCAGCACCTGAACTCCTGGGGGGACCGTCAGTCTTCCTCTTCCCCCAAACCAAGGA
CACCTCATGATCTCCCGGACCCCTGAGGTACATGCGTGGTGGTGGACGTGAGCCACGAAGAC
CCTGAGGTCAAGTTCAACTGGTACGTGGACGGCGTGGAGGTGCATAATGCCAAGACAAAGCCGC
GGGAGGAGCAGTACAACAGCACGTACCGTGTGGTCCAGCGTCCCTCACCGTCCCTGCACCAGGACTG
GCTGAATGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGCCCTCCAGCCCCCATCGAGAAA
ACCATCTCAAAGCCAAAGGTGGGACCCGTGGGGTGGGAGGGCCACATGGACAGAGGCCGGCTC
GGCCACCCCTCTGCCCTGAGAGTGACCGCTGTACCAACCTCTGTCCCTACAGGGCAGCCCCGAG
AACCACAGGTGTACACCCTGCCCCCATCCCGGAGGAGATGACCAAGAACCAGGTGAGCCTGAC
CTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCG
GAGAACAACTACAAGACCACGCCTCCCGTGTGGACTCCGACGGCTCCTTCTTCTCTATAGCA
AGCTCACCGTGGACAAGAGCAGGTGGCAGCAGGGGAACGTCTTCTCATGCTCCGTGATGCATGA
GGCTCTGCACAACCACTACACGCAGAAGAGCCTCTCCCTGTCCCCGGGTAAATGA (SEQ ID
NO: 8)

FIG. 12