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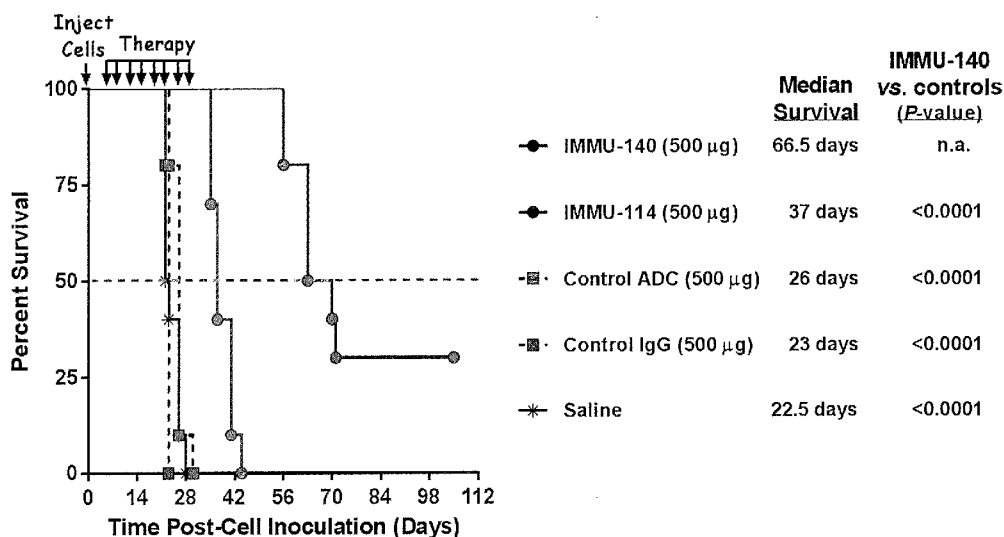
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FIG. 4



(57) Abstract: The present invention relates to therapeutic immunoconjugates comprising SN-38 attached to an anti-HLA-DR antibody or antigen-binding antibody fragment. The immunoconjugate may be administered at a dosage of between 3 mg/kg and 18 mg/kg, preferably 4, 6, 8, 9, 10, 12, 16 or 18 mg/kg, more preferably 8, 10 or 12 mg/kg. When administered at specified dosages and schedules, the immunoconjugate can reduce solid tumors in size, reduce or eliminate metastases and is effective to treat cancers resistant to standard therapies, such as radiation therapy, chemotherapy or immunotherapy. The methods and compositions are particularly useful for treating AML, ALL or multiple myeloma.



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**EFFICACY OF ANTI-HLA-DR ANTIBODY DRUG CONJUGATE IMMU-140  
(hL243-CL2A-SN-38) IN HLA-DR POSITIVE CANCERS**

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### CROSS REFERENCE TO RELATED APPLICATIONS

[01] This application is a continuation-in-part of U.S. Patent Application Serial No. 15/281,453, filed September 30, 2016, which was a divisional of U.S. Patent Application Serial No. 14/667,982 (now U.S. Patent No. 9,493,573), filed March 25, 2015, which was a divisional of U.S. Patent Application Serial No. 13/948,732 (now U.S. Patent No. 9,028,833), filed July 23, 2013, which claimed the benefit under 35 U.S.C. 119(e) of Provisional U.S. Patent Application Serial Nos. 61/749,548, filed January 7, 2013, and 61/736,684, filed December 13, 2012. This application is a continuation-in-part of U.S. Patent application Serial No. 15/484,308, filed April 11, 2017, which claimed the benefit under 35 U.S.C. 119(e) of Provisional U.S. Patent Application Serial Nos. 62/373,591, filed August 11, 2016, and 62/322,441, filed April 14, 2016. This application claims the benefit under 35 U.S.C. 119(e) of Provisional U.S. Patent Application Serial Nos. 62/373,591, filed August 11, 2016, and 62/428,231, filed November 30, 2016. The text of each priority application incorporated herein by reference in its entirety.

### SEQUENCE LISTING

[02] The instant application contains a Sequence Listing which has been submitted in ASCII format via EFS-Web and is hereby incorporated by reference in its entirety. Said ASCII copy, created on July 25, 2017, is named IMM369WO1\_SL.txt and is 9,661 bytes in size.

### FIELD OF THE INVENTION

[03] The present invention relates to therapeutic use of immunoconjugates of antibodies or antigen-binding antibody fragments and camptothecins, such as SN-38, with improved ability to target various cancer cells in human subjects. Preferably, the antibodies or fragments are anti-HLA-DR antibodies or fragments, such as hL243. In other preferred embodiments, the antibodies and therapeutic moieties are linked via an intracellularly-cleavable linkage that increases therapeutic efficacy. In more preferred embodiments, the immunoconjugates are administered at specific dosages and/or specific schedules of administration that optimize the therapeutic effect. The optimized dosages and schedules of administration of SN-38-conjugated anti-HLA-DR antibodies for human therapeutic use disclosed herein show unexpected superior efficacy that could not have been predicted from animal model studies, allowing effective treatment of cancers that are resistant to standard anti-cancer therapies, including the parental compound, irinotecan (CPT-11). The immunoconjugates may be administered alone or in combination with one or more other therapeutic agents, administered

before, concurrently with, or after the immunoconjugate. Exemplary therapeutic agents that may be used in combination with anti-HLA-DR include, but are not limited to proteasome inhibitors such as bortezomib, Bruton kinase inhibitors such as ibrutinib, or phosphoinositide-3-kinase inhibitors such as idelalisib. In preferred embodiments, the cancer to be treated is an HLA-DR positive cancer, such as B-cell lymphoma, B-cell leukemia, skin, esophageal, stomach, colon, rectal, pancreatic, lung, breast, ovarian, bladder, endometrial, cervical, testicular, melanoma, kidney, or liver cancer. More preferably, the cancer is AML (acute myelocytic leukemia), ALL (acute lymphocytic leukemia) or MM (multiple myeloma). Most preferably, the patient to be treated has relapsed from or shown resistance to at least one standard anti-cancer therapy, prior to treatment with the immunoconjugate. However, the person of ordinary skill will realize that in some embodiments the immunoconjugate may be employed in a front-line therapy.

#### BACKGROUND OF THE INVENTION

[04] For many years it has been an aim of scientists in the field of specifically targeted drug therapy to use monoclonal antibodies (MAbs) for the specific delivery of toxic agents to human cancers. Conjugates of tumor-associated MAbs and suitable toxic agents have been developed, but have had mixed success in the therapy of cancer in humans, and virtually no application in other diseases, such as autoimmune diseases. The toxic agent is most commonly a chemotherapeutic drug, although particle-emitting radionuclides, or bacterial or plant toxins, have also been conjugated to MAbs, especially for the therapy of cancer (Sharkey and Goldenberg, *CA Cancer J Clin.* 2006 Jul-Aug;56(4):226-243) and, more recently, with radioimmunoconjugates for the preclinical therapy of certain infectious diseases (Dadachova and Casadevall, *Q J Nucl Med Mol Imaging* 2006;50(3):193-204).

[05] The advantages of using MAb-chemotherapeutic drug conjugates are that (a) the chemotherapeutic drug itself is structurally well defined; (b) the chemotherapeutic drug is linked to the MAb protein using very well-defined conjugation chemistries, often at specific sites remote from the MAbs' antigen binding regions; (c) MAb-chemotherapeutic drug conjugates can be made more reproducibly and usually with less immunogenicity than chemical conjugates involving MAbs and bacterial or plant toxins, and as such are more amenable to commercial development and regulatory approval; and (d) the MAb-chemotherapeutic drug conjugates are orders of magnitude less toxic systemically than radionuclide MAb conjugates, particularly to the radiation-sensitive bone marrow.

**[06]** Camptothecin (CPT) and its derivatives are a class of potent antitumor agents. Irinotecan (also referred to as CPT-11) and topotecan are CPT analogs that are approved cancer therapeutics (Iyer and Ratain, *Cancer Chemother. Pharmacol.* 42: S31-S43 (1998)). CPTs act by inhibiting topoisomerase I enzyme by stabilizing topoisomerase I-DNA complex (Liu, *et al.* in *The Camptothecins: Unfolding Their Anticancer Potential*, Liehr J.G., Giovanella, B.C. and Verschraegen (eds), NY Acad Sci., NY 922:1-10 (2000)). CPTs present specific issues in the preparation of conjugates. One issue is the insolubility of most CPT derivatives in aqueous buffers. Second, CPTs provide specific challenges for structural modification for conjugating to macromolecules. For instance, CPT itself contains only a tertiary hydroxyl group in ring-E. The hydroxyl functional group in the case of CPT must be coupled to a linker suitable for subsequent protein conjugation; and in potent CPT derivatives, such as SN-38, the active metabolite of the chemotherapeutic CPT-11, and other C-10-hydroxyl-containing derivatives such as topotecan and 10-hydroxy-CPT, the presence of a phenolic hydroxyl at the C-10 position complicates the necessary C-20-hydroxyl derivatization. Third, the lability under physiological conditions of the  $\delta$ -lactone moiety of the E-ring of camptothecins results in greatly reduced antitumor potency. Therefore, the conjugation protocol is performed such that it is carried out at a pH of 7 or lower to avoid the lactone ring opening. However, conjugation of a bifunctional CPT possessing an amine-reactive group such as an active ester would typically require a pH of 8 or greater. Fourth, an intracellularly-cleavable moiety preferably is incorporated in the linker/spacer connecting the CPTs and the antibodies or other binding moieties.

**[07]** The human leukocyte antigen-DR (HLA-DR) is one of three isotypes of the major histocompatibility complex (MHC) class II antigens. HLA-DR is highly expressed on a variety of hematologic malignancies and has been actively pursued for antibody-based lymphoma therapy (Brown et al., 2001, *Clin Lymphoma* 2:188-90; DeNardo et al., 2005, *Clin Cancer Res* 11:7075s-9s; Stein et al., 2006, *Blood* 108:2736-44). The human HLA-DR antigen is expressed in non-Hodgkin lymphoma (NHL), chronic lymphocytic leukemia (CLL), and other B-cell malignancies at significantly higher levels than typical B-cell markers, including CD20. Preliminary studies indicate that anti-HLA-DR mAbs are markedly more potent than other naked mAbs of current clinical interest in *in vitro* and *in vivo* experiments in lymphomas, leukemias, and multiple myeloma (Stein et al., unpublished results).

**[08]** HLA-DR is also expressed on a subset of normal immune cells, including B cells, monocytes/macrophages, Langerhans cells, dendritic cells, and activated T cells (Dechant et

al., 2003, *Semin Oncol* 30:465-75). Thus, it is perhaps not surprising that prior attempts to develop anti-HLA-DR antibodies have been hampered by toxicity, notably infusion-related toxicities that are likely related to complement activation (Lin et al, 2009, *Leuk Lymphoma* 50:1958-63; Shi et al., 2002, *Leuk Lymphoma* 43:1303-12).

**[09]** The L243 antibody (hereafter mL243) is a murine IgG2a anti-HLA-DR antibody. This antibody may be of potential use in the treatment of diseases such as autoimmune disease or cancer, particularly leukemias or lymphomas, by targeting the D region of HLA. mL243 demonstrates potent suppression of *in vitro* immune function and is monomorphic for all HLA-DR proteins. However, problems exist with the administration of mouse antibodies to human patients, such as the induction of a human anti-mouse antibody (HAMA) response. A need exists for more effective compositions and methods of use of anti-HLA-DR antibodies, with improved efficacy and decreased toxicity. A further need exists for more effective methods of preparing and administering antibody-CPT conjugates, such as anti-HLA-DR-SN-38 conjugates. Preferably, the methods comprise optimized dosing and administration schedules that maximize efficacy and minimize toxicity of the antibody-CPT conjugates for therapeutic use in human patients.

#### SUMMARY OF THE INVENTION

**[010]** As used herein, the abbreviation "CPT" may refer to camptothecin or any of its derivatives, such as SN-38, unless expressly stated otherwise. The present invention resolves an unfulfilled need in the art by providing improved methods and compositions for preparing and administering CPT-antibody immunoconjugates. Preferably, the camptothecin is SN-38. The disclosed methods and compositions are of use for the treatment of a variety of diseases and conditions which are refractory or less responsive to other forms of therapy, and can include diseases against which suitable antibodies or antigen-binding antibody fragments for selective targeting can be developed, or are available or known, such as cancer.

**[011]** Preferably, the targeting moiety is an antibody, antibody fragment, bispecific or other multivalent antibody, or other antibody-based molecule or compound. More preferably, the antibody or fragment is an anti-HLA-DR antibody or fragment. The antibody can be of various isotypes, preferably human IgG1, IgG2, IgG3 or IgG4, more preferably comprising human IgG1 hinge and constant region sequences. Most preferably, the antibody is a human IgG4. The antibody or fragment thereof can be a chimeric human-mouse, a chimeric human-primate, a humanized (human framework and murine hypervariable (CDR) regions), or fully human antibody, as well as variations thereof, such as half-IgG4 antibodies (referred to as

“unibodies”), as described by van der Neut Kolfshoten et al. (*Science* 2007; 317:1554-1557). More preferably, the antibody or fragment thereof may be designed or selected to comprise human constant region sequences that belong to specific allotypes, which may result in reduced immunogenicity when the immunoconjugate is administered to a human subject. Preferred allotypes for administration include a non-G1m1 allotype (nG1m1), such as G1m3, G1m3,1, G1m3,2 or G1m3,1,2. More preferably, the allotype is selected from the group consisting of the nG1m1, G1m3, nG1m1,2 and Km3 allotypes.

**[012]** Where the disease state is cancer, many antigens expressed by or otherwise associated with tumor cells are known in the art, including but not limited to, carbonic anhydrase IX, alpha-fetoprotein (AFP),  $\alpha$ -actinin-4, A3, antigen specific for A33 antibody, ART-4, B7, Ba 733, BAGE, BrE3-antigen, CA125, CAMEL, CAP-1, CASP-8/m, , CCL19, CCL21, CD1, CD1a, CD2, CD3, CD4, CD5, CD8, CD11A, CD14, CD15, CD16, CD18, CD19, CD20, CD21, CD22, CD23, CD25, CD29, CD30, CD32b, CD33, CD37, CD38, CD40, CD40L, CD44, CD45, CD46, CD52, CD54, CD55, CD59, CD64, CD66a-e, CD67, CD70, CD70L, CD74, CD79a, CD80, CD83, CD95, CD126, CD132, CD133, CD138, CD147, CD154, CDC27, CDK-4/m, CDKN2A, CTLA-4, CXCR4, CXCR7, CXCL12, HIF-1 $\alpha$ , colon-specific antigen-p (CSAp), CEA (CEACAM5), CEACAM6, c-Met, DAM, DLL3, DLL4, EGFR, EGFRvIII, EGP-1 (TROP-2), EGP-2, ELF2-M, Ep-CAM, fibroblast growth factor (FGF), Flt-1, Flt-3, folate receptor, G250 antigen, GAGE, gp100, GRO- $\beta$ , HLA-DR, HM1.24, human chorionic gonadotropin (HCG) and its subunits, HER2/neu, HMGB-1, hypoxia inducible factor (HIF-1), HSP70-2M, HST-2, Ia, IGF-1R, IFN- $\gamma$ , IFN- $\alpha$ , IFN- $\beta$ , IFN- $\lambda$ , IL-4R, IL-6R, IL-13R, IL-15R, IL-17R, IL-18R, IL-2, IL-6, IL-8, IL-12, IL-15, IL-17, IL-18, IL-23, IL-25, insulin-like growth factor-1 (IGF-1), KC4-antigen, KS-1-antigen, KS1-4, Le-Y, LDR/FUT, macrophage migration inhibitory factor (MIF), MAGE, MAGE-3, MART-1, MART-2, mesothelin, NY-ESO-1, TRAG-3, mCRP, MCP-1, MIP-1A, MIP-1B, MIF, MUC1, MUC2, MUC3, MUC4, MUC5ac, MUC13, MUC16, MUM-1/2, MUM-3, NCA66, NCA95, NCA90, PAM4 antigen, pancreatic cancer mucin, PD-1 receptor, placental growth factor, p53, PLAGL2, prostatic acid phosphatase, PSA, PRAME, PSMA, PIGF, ILGF, ILGF-1R, IL-6, IL-25, RS5, RANTES, T101, SAGE, S100, survivin, survivin-2B, TAC, TAG-72, tenascin, TRAIL receptors, TNF- $\alpha$ , Tn antigen, Thomson-Friedenreich antigens, tumor necrosis antigens, VEGFR, ED-B fibronectin, WT-1, 17-1A-antigen, complement factors C3, C3a, C3b, C5a, C5, an angiogenesis marker, bcl-2, bcl-6, Kras, an oncogene marker and an oncogene product (see, e.g., Sensi et al., *Clin Cancer Res* 2006, 12:5023-32; Parmiani et al., *J Immunol* 2007, 178:1975-79; Novellino et al. *Cancer Immunol Immunother* 2005, 54:187-

207). Preferably, the antibody binds to CEACAM5, CEACAM6, EGP-1 (TROP-2), MUC-16, AFP, MUC5ac, CD74, CD19, CD20, CD22 or HLA-DR. The preferred anti-HLA-DR antibody may be utilized alone, or in combination with another anti-TAA (tumor-associated antigen) antibody.

**[013]** Exemplary antibodies that may be utilized include, but are not limited to, hR1 (anti-IGF-1R, U.S. Patent No. 9,441,043), hPAM4 (anti-mucin, U.S. Patent No. 7,282,567), hA20 (anti-CD20, U.S. Patent No. 7,151,164), hA19 (anti-CD19, U.S. Patent No. 7,109,304), hIMMU31 (anti-AFP, U.S. Patent No. 7,300,655), hLL1 (anti-CD74, U.S. Patent No. 7,312,318), hLL2 (anti-CD22, U.S. Patent No. 5,789,554), hMu-9 (anti-CSAp, U.S. Patent No. 7,387,772), hL243 (anti-HLA-DR, U.S. Patent No. 7,612,180), hMN-14 (anti-CEACAM5, U.S. Patent No. 6,676,924), hMN-15 (anti-CEACAM6, U.S. Patent No. 8,287,865), hRS7 (anti-EGP-1, U.S. Patent No. 7,238,785), hMN-3 (anti-CEACAM6, U.S. Patent No. 7,541,440), Ab124 and Ab125 (anti-CXCR4, U.S. Patent No. 7,138,496), the Examples section of each cited patent or application incorporated herein by reference. More preferably, the antibody is IMMU-31 (anti-AFP), hRS7 (anti-TROP-2), hMN-14 (anti-CEACAM5), hMN-3 (anti-CEACAM6), hMN-15 (anti-CEACAM6), hLL1 (anti-CD74), hLL2 (anti-CD22), hL243 or IMMU-114 (anti-HLA-DR), hA19 (anti-CD19) or hA20 (anti-CD20). Most preferably, the antibody is hL243. As used herein, the terms epratuzumab and hLL2 are interchangeable, as are the terms veltuzumab and hA20 and the terms hL243g4P, hL243gamma4P and IMMU-114.

**[014]** Alternative antibodies of use include, but are not limited to, abciximab (anti-glycoprotein IIb/IIIa), alemtuzumab (anti-CD52), bevacizumab (anti-VEGF), cetuximab (anti-EGFR), gemtuzumab (anti-CD33), ibritumomab (anti-CD20), panitumumab (anti-EGFR), rituximab (anti-CD20), tositumomab (anti-CD20), trastuzumab (anti-ErbB2), pembrolizumab (anti-PD-1 receptor), nivolumab (anti-PD-1 receptor), ipilimumab (anti-CTLA-4), abagovomab (anti-CA-125), adecatumumab (anti-EpCAM), atlizumab (anti-IL-6 receptor), benralizumab (anti-CD125), obinutuzumab (GA101, anti-CD20), CC49 (anti-TAG-72), AB-PG1-XG1-026 (anti-PSMA, U.S. Patent Application 11/983,372, deposited as ATCC PTA-4405 and PTA-4406), D2/B (anti-PSMA, WO 2009/130575), tocilizumab (anti-IL-6 receptor), basiliximab (anti-CD25), daclizumab (anti-CD25), efalizumab (anti-CD11a), GA101 (anti-CD20; Glycart Roche), muromonab-CD3 (anti-CD3 receptor), natalizumab (anti- $\alpha$ 4 integrin), omalizumab (anti-IgE); anti-TNF- $\alpha$  antibodies such as CDP571 (Ofei et al., 2011, Diabetes 45:881-85), MTNFAl, M2TNFAl, M3TNFAl, M3TNFABI, M302B, M303 (Thermo Scientific, Rockford, IL), infliximab (Centocor, Malvern, PA), certolizumab

pegol (UCB, Brussels, Belgium), anti-CD40L (UCB, Brussels, Belgium), adalimumab (Abbott, Abbott Park, IL), and Benlysta (Human Genome Sciences).

**[015]** In a preferred embodiment, the chemotherapeutic moiety is selected from camptothecin (CPT) and its analogs and derivatives and is more preferably SN-38. However, other chemotherapeutic moieties that may be utilized include taxanes (e.g, baccatin III, taxol), epothilones, anthracyclines (e.g., doxorubicin (DOX), epirubicin, morpholinodoxorubicin (morpholino-DOX), cyanomorpholino-doxorubicin (cyanomorpholino-DOX), 2-pyrrolinodoxorubicin (2-PDOX) or a prodrug form of 2-PDOX (pro-2-PDOX); *see, e.g.*, Priebe W (ed.), ACS symposium series 574, published by American Chemical Society, Washington D.C., 1995 (332pp) and Nagy *et al.*, *Proc. Natl. Acad. Sci. USA* 93:2464-2469, 1996), benzoquinoid ansamycins exemplified by geldanamycin (DeBoer *et al.*, *Journal of Antibiotics* 23:442-447, 1970; Neckers *et al.*, *Invest. New Drugs* 17:361-373, 1999), and the like. Preferably, the antibody or fragment thereof links to at least one chemotherapeutic moiety; preferably 1 to about 5 chemotherapeutic moieties; more preferably 6 or more chemotherapeutic moieties, more preferably 7 to 8, most preferably about 6 to about 12 chemotherapeutic moieties.

**[016]** An example of a water soluble CPT derivative is CPT-11. Extensive clinical data are available concerning CPT-11's pharmacology and its *in vivo* conversion to the active SN-38 (Iyer and Ratain, *Cancer Chemother Pharmacol.* 42:S31-43 (1998); Mathijssen *et al.*, *Clin Cancer Res.* 7:2182-2194 (2002); Rivory, *Ann NY Acad Sci.* 922:205-215, 2000)). The active form SN-38 is about 2 to 3 orders of magnitude more potent than CPT-11. In specific preferred embodiments, the immunoconjugate may be an hMN-14-SN-38, hMN-3-SN-38, hMN-15-SN-38, IMM-31-SN-38, hRS7-SN-38, hA20-SN-38, hL243-SN-38, hLL1-SN-38 or hLL2-SN-38 conjugate.

**[017]** Various embodiments may concern use of the subject methods and compositions to treat a cancer, including but not limited to non-Hodgkin's lymphomas, B-cell acute and chronic lymphatic leukemias, Burkitt lymphoma, Hodgkin's lymphoma, acute large B-cell lymphoma, hairy cell leukemia, acute myeloid leukemia, chronic myeloid leukemia, T-cell lymphomas and leukemias, multiple myeloma, Waldenstrom's macroglobulinemia, carcinomas, melanomas, sarcomas, gliomas, bone, and skin cancers. The carcinomas may include carcinomas of the oral cavity, esophagus, gastrointestinal tract, pulmonary tract, lung, stomach, colon, breast, ovary, prostate, uterus, endometrium, cervix, urinary bladder, pancreas, bone, brain, connective tissue, liver, gall bladder, urinary bladder, kidney, skin, central nervous system and testes.

[018] In certain embodiments involving treatment of cancer, the drug conjugates may be used in combination with surgery, radiation therapy, chemotherapy, immunotherapy with naked antibodies, radioimmunotherapy, immunomodulators, vaccines, and the like. These combination therapies can allow lower doses of each therapeutic to be given in such combinations, thus reducing certain severe side effects, and potentially reducing the courses of therapy required. When there is no or minimal overlapping toxicity, full doses of each can also be given.

[019] Preferred optimal dosing of immunoconjugates may include a dosage of between 3 mg/kg and 18 mg/kg, more preferably between 4 and 16 mg/kg, more preferably between 6 and 12 mg/kg, most preferably between 8 and 10 mg/kg, preferably given either weekly, twice weekly or every other week. The optimal dosing schedule may include treatment cycles of two consecutive weeks of therapy followed by one, two, three or four weeks of rest, or alternating weeks of therapy and rest, or one week of therapy followed by two, three or four weeks of rest, or three weeks of therapy followed by one, two, three or four weeks of rest, or four weeks of therapy followed by one, two, three or four weeks of rest, or five weeks of therapy followed by one, two, three, four or five weeks of rest, or administration once every two weeks, once every three weeks or once a month. Treatment may be extended for any number of cycles, preferably at least 2, at least 4, at least 6, at least 8, at least 10, at least 12, at least 14, or at least 16 cycles. Exemplary dosages of use may include 1 mg/kg, 2 mg/kg, 3 mg/kg, 4 mg/kg, 5 mg/kg, 6 mg/kg, 7 mg/kg, 8 mg/kg, 9 mg/kg, 10 mg/kg, 11 mg/kg, 12 mg/kg, 13 mg/kg, 14 mg/kg, 15 mg/kg, 16 mg/kg, 17 mg/kg, and 18 mg/kg. The person of ordinary skill will realize that a variety of factors, such as age, general health, specific organ function or weight, as well as effects of prior therapy on specific organ systems (e.g., bone marrow) may be considered in selecting an optimal dosage of immunoconjugate, and that the dosage and/or frequency of administration may be increased or decreased during the course of therapy. The dosage may be repeated as needed, with evidence of tumor shrinkage observed after as few as 4 to 8 doses. The optimized dosages and schedules of administration disclosed herein show unexpected superior efficacy and reduced toxicity in human subjects, which could not have been predicted from animal model studies. Surprisingly, the superior efficacy allows treatment of tumors that were previously found to be resistant to one or more standard anti-cancer therapies, including the parental compound, CPT-11, from which SN-38 is derived *in vivo*.

[020] A surprising result with the instant claimed compositions and methods is the unexpected tolerability of high doses of antibody-drug conjugate, even with repeated

infusions, with only relatively low-grade toxicities of nausea and vomiting observed, or manageable neutropenia. A further surprising result is the lack of accumulation of the antibody-drug conjugate, unlike other products that have conjugated SN-38 to albumin, PEG or other carriers. The lack of accumulation is associated with improved tolerability and lack of serious toxicity even after repeated or increased dosing. These surprising results allow optimization of dosage and delivery schedule, with unexpectedly high efficacies and low toxicities. The claimed methods provide for shrinkage of solid tumors, in individuals with previously resistant cancers, of 15% or more, preferably 20% or more, preferably 30% or more, more preferably 40% or more in size (as measured by longest diameter). The person of ordinary skill will realize that tumor size may be measured by a variety of different techniques, such as total tumor volume, maximal tumor size in any dimension or a combination of size measurements in several dimensions. This may be with standard radiological procedures, such as computed tomography, ultrasonography, and/or positron-emission tomography. The means of measuring size is less important than observing a trend of decreasing tumor size with immunoconjugate treatment, preferably resulting in elimination of the tumor.

**[021]** While the immunoconjugate may be administered as a periodic bolus injection, in alternative embodiments the immunoconjugate may be administered by continuous infusion of antibody-drug conjugates. In order to increase the C<sub>max</sub> and extend the PK of the immunoconjugate in the blood, a continuous infusion may be administered for example by indwelling catheter. Such devices are known in the art, such as HICKMAN®, BROVIAC® or PORT-A-CATH® catheters (see, e.g., Skolnik et al., *Ther Drug Monit* 32:741-48, 2010) and any such known indwelling catheter may be used. A variety of continuous infusion pumps are also known in the art and any such known infusion pump may be used. More preferably, these immunoconjugates can be administered by intravenous infusions over relatively short periods of 2 to 5 hours, more preferably 2-3 hours.

**[022]** In particularly preferred embodiments, the immunoconjugates and dosing schedules may be efficacious in patients resistant to standard therapies. For example, an hL243-SN-38 immunoconjugate may be administered to a patient who has not responded to prior therapy with irinotecan, the parent agent of SN-38. Surprisingly, the irinotecan-resistant patient may show a partial or even a complete response to hL243-SN-38. The ability of the immunoconjugate to specifically target the tumor tissue may overcome tumor resistance by improved targeting and enhanced delivery of the therapeutic agent. Combinations of different SN-38 immunoconjugates, or SN-38-antibody conjugates in combination with an antibody

conjugated to a radionuclide, toxin or other drug, may provide even more improved efficacy and/or reduced toxicity.

### BRIEF DESCRIPTION OF THE DRAWINGS

[023] The following drawings form part of the present specification and are included to further demonstrate certain embodiments of the present invention. The embodiments may be better understood by reference to one or more of these drawings in combination with the detailed description of specific embodiments presented herein.

[024] **FIG. 1. Structure of IMMU-140 (hL243-CL2A-SN-38).**

[025] **FIG. 2. Comparative binding of IMMU-114 and IMMU-140.** Binding curves were obtained for the SN-38 conjugated (IMMU-140) and naked (IMMU-114) forms of hL243. A control non-specific antibody (h679) showed no binding to HLA-DR+ cells.

[026] **FIG. 3. *In vivo* efficacy of IMMU-140 vs. IMMU-114 in MOLM-14 AML xenografts.**

[027] **FIG. 4. *In vivo* efficacy of IMMU-140 vs. IMMU-114 in MN-60 ALL xenografts.**

[028] **FIG. 5. *In vivo* efficacy of IMMU-140 vs. IMMU-114 in CAG MM xenografts.**

[029] **FIG. 6. *In vivo* efficacy of IMMU-140 vs. IMMU-114 in JVM-3 CLL xenografts.**

[030] **FIG. 7. Binding of hL243- $\gamma$ 4P to human melanoma cells *in vitro*.**

[031] **FIG. 8. Efficacy of IMMU-140 in human melanoma xenografts *in vivo*.**

### DETAILED DESCRIPTION OF THE INVENTION

#### **Definitions**

[032] In the description that follows, a number of terms are used and the following definitions are provided to facilitate understanding of the claimed subject matter. Terms that are not expressly defined herein are used in accordance with their plain and ordinary meanings.

[033] Unless otherwise specified, a or an means “one or more.”

[034] The term about is used herein to mean plus or minus ten percent (10%) of a value. For example, “about 100” refers to any number between 90 and 110.

[035] An antibody, as used herein, refers to a full-length (i.e., naturally occurring or formed by normal immunoglobulin gene fragment recombinatorial processes) immunoglobulin molecule (e.g., an IgG antibody) or an antigen-binding portion of an immunoglobulin molecule, such as an antibody fragment. An antibody or antibody fragment may be conjugated or otherwise derivatized within the scope of the claimed subject matter. Such

antibodies include but are not limited to IgG1, IgG2, IgG3, IgG4 (and IgG4 subforms), as well as IgA isotypes. As used below, the abbreviation "MAb" may be used interchangeably to refer to an antibody, antibody fragment, monoclonal antibody or multispecific antibody.

**[036]** An antibody fragment is a portion of an antibody such as F(ab')<sub>2</sub>, F(ab)<sub>2</sub>, Fab', Fab, Fv, scFv (single chain Fv), single domain antibodies (DABs or VHHs) and the like, including the half-molecules of IgG4 cited above (van der Neut Kolfshoten et al. (Science 2007; 317(14 Sept):1554-1557). Regardless of structure, an antibody fragment of use binds with the same antigen that is recognized by the intact antibody. The term "antibody fragment" also includes synthetic or genetically engineered proteins that act like an antibody by binding to a specific antigen to form a complex. For example, antibody fragments include isolated fragments consisting of the variable regions, such as the "Fv" fragments consisting of the variable regions of the heavy and light chains and recombinant single chain polypeptide molecules in which light and heavy variable regions are connected by a peptide linker ("scFv proteins"). The fragments may be constructed in different ways to yield multivalent and/or multispecific binding forms.

**[037]** A naked antibody is generally an entire antibody that is not conjugated to a therapeutic agent. A naked antibody may exhibit therapeutic and/or cytotoxic effects, for example by Fc-dependent functions, such as complement fixation (CDC) and ADCC (antibody-dependent cell cytotoxicity). However, other mechanisms, such as apoptosis, anti-angiogenesis, anti-metastatic activity, anti-adhesion activity, inhibition of heterotypic or homotypic adhesion, and interference in signaling pathways, may also provide a therapeutic effect. Naked antibodies include polyclonal and monoclonal antibodies, naturally occurring or recombinant antibodies, such as chimeric, humanized or human antibodies and fragments thereof. In some cases a "naked antibody" may also refer to a "naked" antibody fragment. As defined herein, "naked" is synonymous with "unconjugated," and means not linked or conjugated to a therapeutic agent.

**[038]** A chimeric antibody is a recombinant protein that contains the variable domains of both the heavy and light antibody chains, including the complementarity determining regions (CDRs) of an antibody derived from one species, preferably a rodent antibody, more preferably a murine antibody, while the constant domains of the antibody molecule are derived from those of a human antibody.

**[039]** A humanized antibody is a recombinant protein in which the CDRs from an antibody from one species; e.g., a murine antibody, are transferred from the heavy and light variable

chains of the murine antibody into human heavy and light variable domains (framework regions). The constant domains of the antibody molecule are derived from those of a human antibody. In some cases, specific residues of the framework region of the humanized antibody, particularly those that are touching or close to the CDR sequences, may be modified, for example replaced with the corresponding residues from the original murine, rodent, subhuman primate, or other antibody.

**[040]** A human antibody is an antibody obtained, for example, from transgenic mice that have been “engineered” to produce human antibodies in response to antigenic challenge. In this technique, elements of the human heavy and light chain loci are introduced into strains of mice derived from embryonic stem cell lines that contain targeted disruptions of the endogenous heavy chain and light chain loci. The transgenic mice can synthesize human antibodies specific for various antigens, and the mice can be used to produce human antibody-secreting hybridomas. Methods for obtaining human antibodies from transgenic mice are described by Green *et al.*, *Nature Genet.* 7:13 (1994), Lonberg *et al.*, *Nature* 368:856 (1994), and Taylor *et al.*, *Int. Immun.* 6:579 (1994). A fully human antibody also can be constructed by genetic or chromosomal transfection methods, as well as phage display technology, all of which are known in the art. See for example, McCafferty *et al.*, *Nature* 348:552-553 (1990) for the production of human antibodies and fragments thereof *in vitro*, from immunoglobulin variable domain gene repertoires from unimmunized donors. In this technique, human antibody variable domain genes are cloned in-frame into either a major or minor coat protein gene of a filamentous bacteriophage, and displayed as functional antibody fragments on the surface of the phage particle. Because the filamentous particle contains a single-stranded DNA copy of the phage genome, selections based on the functional properties of the antibody also result in selection of the gene encoding the antibody exhibiting those properties. In this way, the phage mimics some of the properties of the B cell. Phage display can be performed in a variety of formats, for their review, see e.g. Johnson and Chiswell, *Current Opinion in Structural Biology* 3:5564-571 (1993). Human antibodies may also be generated by *in vitro* activated B cells. See U.S. Patent Nos. 5,567,610 and 5,229,275, the Examples section of each of which is incorporated herein by reference.

**[041]** A therapeutic agent is an atom, molecule, or compound that is useful in the treatment of a disease. Examples of therapeutic agents include, but are not limited to, antibodies, antibody fragments, immunoconjugates, drugs, cytotoxic agents, pro-apoptotic agents, toxins, nucleases (including DNAses and RNAses), hormones, immunomodulators, chelators, boron compounds, photoactive agents or dyes, radionuclides, oligonucleotides, interference

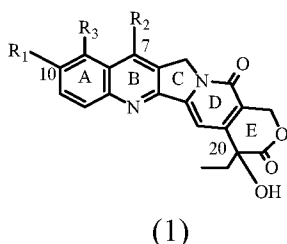
RNA, siRNA, RNAi, anti-angiogenic agents, chemotherapeutic agents, cytokines, chemokines, prodrugs, enzymes, binding proteins or peptides or combinations thereof.

**[042]** An immunoconjugate is an antibody, antigen-binding antibody fragment, antibody complex or antibody fusion protein that is conjugated to a therapeutic agent. Conjugation may be covalent or non-covalent. Preferably, conjugation is covalent.

**[043]** As used herein, the term antibody fusion protein is a recombinantly-produced antigen-binding molecule in which one or more natural antibodies, single-chain antibodies or antibody fragments are linked to another moiety, such as a protein or peptide, a toxin, a cytokine, a hormone, etc. In certain preferred embodiments, the fusion protein may comprise two or more of the same or different antibodies, antibody fragments or single-chain antibodies fused together, which may bind to the same epitope, different epitopes on the same antigen, or different antigens.

**[044]** An immunomodulator is a therapeutic agent that when present, alters, suppresses or stimulates the body's immune system. Typically, an immunomodulator of use stimulates immune cells to proliferate or become activated in an immune response cascade, such as macrophages, dendritic cells, B-cells, and/or T-cells. However, in some cases an immunomodulator may suppress proliferation or activation of immune cells. An example of an immunomodulator as described herein is a cytokine, which is a soluble small protein of approximately 5-20 kDa that is released by one cell population (e.g., primed T-lymphocytes) on contact with specific antigens, and which acts as an intercellular mediator between cells. As the skilled artisan will understand, examples of cytokines include lymphokines, monokines, interleukins, and several related signaling molecules, such as tumor necrosis factor (TNF) and interferons. Chemokines are a subset of cytokines. Certain interleukins and interferons are examples of cytokines that stimulate T cell or other immune cell proliferation. Exemplary interferons include interferon- $\alpha$ , interferon- $\beta$ , interferon- $\gamma$  and interferon- $\lambda$ .

**[045]** CPT is an abbreviation for camptothecin, and as used in the present application CPT represents camptothecin itself or an analog or derivative of camptothecin, such as SN-38. The structures of camptothecin and some of its analogs, with the numbering indicated and the rings labeled with letters A-E, are given in formula 1 in Chart 1 below.

**[046]** Chart 1CPT:  $R_1 = R_2 = R_3 = H$ 10-Hydroxy-CPT:  $R_1 = OH; R_2 = R_3 = H$ CPT-11:  $R_1 = \text{O}-\text{C}(=\text{O})-\text{N}(\text{C}_6\text{H}_{10})_2$ ;  $R_2 = \text{ethyl}; R_3 = H$ SN-38:  $R_1 = OH; R_2 = \text{ethyl}; R_3 = H$ Topotecan:  $R_1 = OH; R_2 = H; R_3 = \text{CH}_2-\text{N}(\text{CH}_3)_2$ **Camptothecin Conjugates**

**[047]** Non-limiting methods and compositions for preparing immunoconjugates comprising a camptothecin therapeutic agent attached to an antibody or antigen-binding antibody fragment are described below. In preferred embodiments, the solubility of the drug is enhanced by placing a defined polyethyleneglycol (PEG) moiety (i.e., a PEG containing a defined number of monomeric units) between the drug and the antibody, wherein the defined PEG is a low molecular weight PEG, preferably containing 1-30 monomeric units, more preferably containing 1-12 monomeric units, most preferably 7-8 monomeric units.

**[048]** Preferably, a first linker connects the drug at one end and may terminate with an acetylene or an azide group at the other end. This first linker may comprise a defined PEG moiety with an azide or acetylene group at one end and a different reactive group, such as carboxylic acid or hydroxyl group, at the other end. Said bifunctional defined PEG may be attached to the amine group of an amino alcohol, and the hydroxyl group of the latter may be attached to the hydroxyl group on the drug in the form of a carbonate. Alternatively, the non-azide(or acetylene) moiety of said defined bifunctional PEG is optionally attached to the N-terminus of an L-amino acid or a polypeptide, with the C-terminus attached to the amino group of amino alcohol, and the hydroxy group of the latter is attached to the hydroxyl group of the drug in the form of carbonate or carbamate, respectively.

**[049]** A second linker, comprising an antibody-coupling group and a reactive group complementary to the azide (or acetylene) group of the first linker, namely acetylene (or azide), may react with the drug-(first linker) conjugate via acetylene-azide cycloaddition reaction to furnish a final bifunctional drug product that is useful for conjugating to disease-targeting antibodies. The antibody-coupling group is preferably either a thiol or a thiol-reactive group.

**[050]** Methods for selective regeneration of the 10-hydroxyl group in the presence of the C-20 carbonate in preparations of drug-linker precursor involving CPT analogs such as SN-38

are provided below. Other protecting groups for reactive hydroxyl groups in drugs such as the phenolic hydroxyl in SN-38, for example t-butyldimethylsilyl or t-butyldiphenylsilyl, may also be used, and these are deprotected by tetrabutylammonium fluoride prior to linking of the derivatized drug to an antibody-coupling moiety. The 10-hydroxyl group of CPT analogs is alternatively protected as an ester or carbonate, other than 'BOC', such that the bifunctional CPT is conjugated to an antibody without prior deprotection of this protecting group. The protecting group is readily deprotected under physiological pH conditions after the bioconjugate is administered.

**[051]** In the acetylene-azide coupling, referred to as 'click chemistry', the azide part may be on L2 with the acetylene part on L3. Alternatively, L2 may contain acetylene, with L3 containing azide. 'Click chemistry' refers to a copper (+1)-catalyzed cycloaddition reaction between an acetylene moiety and an azide moiety (Kolb HC and Sharpless KB, *Drug Discov Today* 2003; 8: 1128-37), although alternative forms of click chemistry are known and may be used. Click chemistry takes place in aqueous solution at near-neutral pH conditions, and is thus amenable for drug conjugation. The advantage of click chemistry is that it is chemoselective, and complements other well-known conjugation chemistries such as the thiol-maleimide reaction.

**[052]** While the present application focuses on use of antibodies or antibody fragments as targeting moieties, the skilled artisan will realize that where a conjugate comprises an antibody or antibody fragment, another type of targeting moiety, such as an aptamer, avimer, affibody or peptide ligand, may be substituted.

**[053]** An exemplary preferred embodiment is directed to a conjugate of a drug derivative and an antibody of the general formula 2,

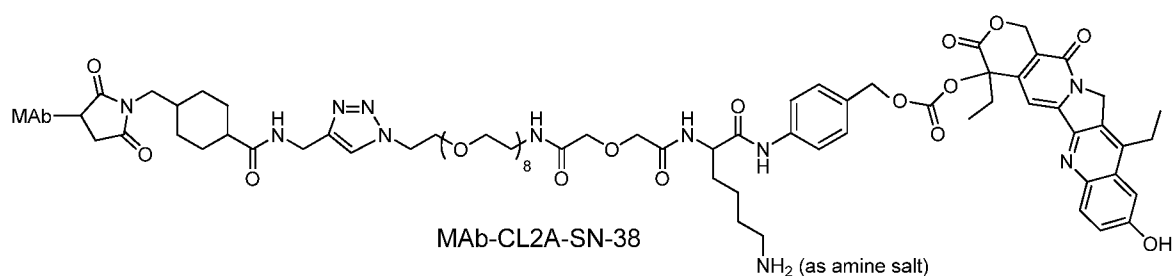


where MAb is a disease-targeting antibody; L2 is a component of the cross-linker comprising an antibody-coupling moiety and one or more of acetylene (or azide) groups; L1 comprises a defined PEG with azide (or acetylene) at one end, complementary to the acetylene (or azide) moiety in L2, and a reactive group such as carboxylic acid or hydroxyl group at the other end; AA is an L-amino acid; m is an integer with values of 0, 1, 2, 3, or 4; and A' is an additional spacer, selected from the group of ethanolamine, 4-hydroxybenzyl alcohol, 4-aminobenzyl alcohol, or substituted or unsubstituted ethylenediamine. The L amino acids of 'AA' are selected from alanine, arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine,

threonine, tryptophan, tyrosine, and valine. If the A' group contains hydroxyl, it is linked to the hydroxyl group or amino group of the drug in the form of a carbonate or carbamate, respectively.

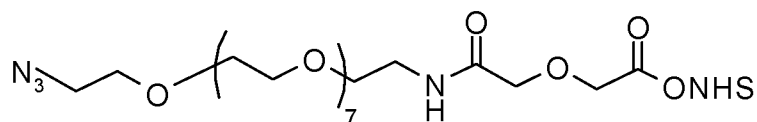
**[054]** In a preferred embodiment of formula 2, A' is a substituted ethanolamine derived from an L-amino acid, wherein the carboxylic acid group of the amino acid is replaced by a hydroxymethyl moiety. A' may be derived from any one of the following L-amino acids: alanine, arginine, asparagine, aspartic acid, cysteine, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, and valine.

**[055]** A preferred embodiment, referred to as MAb-CL2A-SN-38, is shown below.



**[056]** Other embodiments are possible within the context of 10-hydroxy-containing camptothecins, such as SN-38. In the example of SN-38 as the drug, the more reactive 10-hydroxy group of the drug is derivatized leaving the 20-hydroxyl group unaffected. Within the general formula 2, A' is a substituted ethylenediamine.

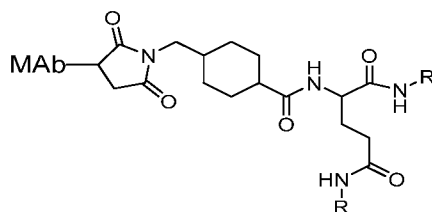
**[057]** In another preferred embodiment, the L1 component of the conjugate contains a defined polyethyleneglycol (PEG) spacer with 1–30 repeating monomeric units. In a further preferred embodiment, PEG is a defined PEG with 1–12 repeating monomeric units. The introduction of PEG may involve using heterobifunctionalized PEG derivatives which are available commercially. The heterobifunctional PEG may contain an azide or acetylene group. An example of a heterobifunctional defined PEG containing 8 repeating monomeric units, with 'NHS' being succinimidyl, is given below in formula 3:



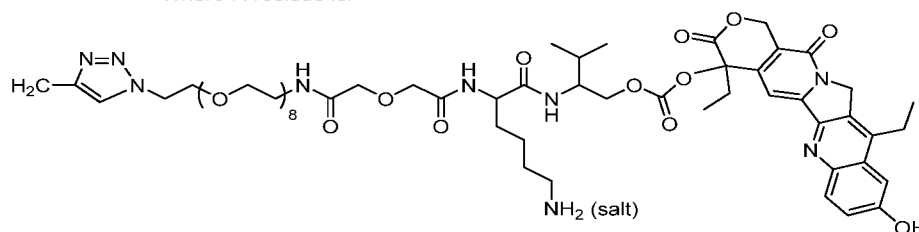
(3)

[058] In a preferred embodiment, L2 has a plurality of acetylene (or azide) groups, ranging from 2–40, but preferably 2–20, and more preferably 2–5, and a single antibody-binding moiety.

[059] A representative SN-38 conjugate of an antibody containing multiple drug molecules and a single antibody-binding moiety is shown below. The ‘L2’ component of this structure is appended to 2 acetylenic groups, resulting in the attachment of two azide-appended SN-38 molecules. The bonding to MAb is represented as a succinimide.



Where R residue is:



[060] In preferred embodiments, when the bifunctional drug contains a thiol-reactive moiety as the antibody-binding group, the thiols on the antibody are generated on the lysine groups of the antibody using a thiolating reagent. Methods for introducing thiol groups onto antibodies by modifications of MAb's lysine groups are well known in the art (Wong in *Chemistry of protein conjugation and cross-linking*, CRC Press, Inc., Boca Raton, FL (1991), pp 20-22). Alternatively, mild reduction of interchain disulfide bonds on the antibody (Willner et al., *Bioconjugate Chem.* 4:521-527 (1993)) using reducing agents such as dithiothreitol (DTT) can generate 7-to-10 thiols on the antibody; which has the advantage of incorporating multiple drug moieties in the interchain region of the MAb away from the antigen-binding region. In a more preferred embodiment, attachment of SN-38 to reduced disulfide sulfhydryl groups results in formation of an antibody-SN-38 immunoconjugate with 6 to 8 SN-38 moieties covalently attached per antibody molecule. Other methods of providing cysteine residues for attachment of drugs or other therapeutic agents are known, such as the use of cysteine engineered antibodies (see U.S. Patent No. 7,521,541, the Examples section of which is incorporated herein by reference.)

**[061]** In alternative preferred embodiments, the chemotherapeutic moiety is selected from the group consisting of doxorubicin (DOX), epirubicin, morpholinodoxorubicin (morpholino-DOX), cyanomorpholino-doxorubicin (cyanomorpholino-DOX), 2-pyrrolino-doxorubicin (2-PDOX), Pro-2PDOX, CPT, 10-hydroxy camptothecin, SN-38, topotecan, lurtotecan, 9-aminocamptothecin, 9-nitrocamptothecin, taxanes, geldanamycin, ansamycins, and epothilones. In a more preferred embodiment, the chemotherapeutic moiety is SN-38. Preferably, in the conjugates of the preferred embodiments, the antibody links to at least one chemotherapeutic moiety; preferably 1 to about 12 chemotherapeutic moieties; more preferably about 6 to about 12 chemotherapeutic moieties, most preferably about 6 to 8 chemotherapeutic moieties.

**[062]** Furthermore, in a preferred embodiment, the linker component 'L2' comprises a thiol group that reacts with a thiol-reactive residue introduced at one or more lysine side chain amino groups of said antibody. In such cases, the antibody is pre-derivatized with a thiol-reactive group such as a maleimide, vinylsulfone, bromoacetamide, or iodoacetamide by procedures well described in the art.

**[063]** In the context of this work, a process was surprisingly discovered by which CPT drug-linkers can be prepared wherein CPT additionally has a 10-hydroxyl group. This process involves, but is not limited to, the protection of the 10-hydroxyl group as a *t*-butyloxycarbonyl (BOC) derivative, followed by the preparation of the penultimate intermediate of the drug-linker conjugate. Usually, removal of BOC group requires treatment with strong acid such as trifluoroacetic acid (TFA). Under these conditions, the CPT 20-*O*-linker carbonate, containing protecting groups to be removed, is also susceptible to cleavage, thereby giving rise to unmodified CPT. In fact, the rationale for using a mildly removable methoxytrityl (MMT) protecting group for the lysine side chain of the linker molecule, as enunciated in the art, was precisely to avoid this possibility (Walker *et al.*, 2002). It was discovered that selective removal of phenolic BOC protecting group is possible by carrying out reactions for short durations, optimally 3-to-5 minutes. Under these conditions, the predominant product was that in which the 'BOC' at 10-hydroxyl position was removed, while the carbonate at '20' position was intact.

**[064]** An alternative approach involves protecting the CPT analog's 10-hydroxy position with a group other than 'BOC', such that the final product is ready for conjugation to antibodies without a need for deprotecting the 10-OH protecting group. The 10-hydroxy protecting group, which converts the 10-OH into a phenolic carbonate or a phenolic ester, is readily deprotected by physiological pH conditions or by esterases after *in vivo*

administration of the conjugate. The faster removal of a phenolic carbonate at the 10 position vs. a tertiary carbonate at the 20 position of 10-hydroxycamptothecin under physiological condition has been described by He et al. (He et al., *Bioorganic & Medicinal Chemistry* 12: 4003-4008 (2004)). A 10-hydroxy protecting group on SN-38 can be 'COR' where R can be a substituted alkyl such as "N(CH<sub>3</sub>)<sub>2</sub>-(CH<sub>2</sub>)<sub>n</sub>-" where n is 1-10 and wherein the terminal amino group is optionally in the form of a quaternary salt for enhanced aqueous solubility, or a simple alkyl residue such as "CH<sub>3</sub>-(CH<sub>2</sub>)<sub>n</sub>-" where n is 0-10, or it can be an alkoxy moiety such as "CH<sub>3</sub>-(CH<sub>2</sub>)<sub>n</sub>-O-" where n is 0-10, or "N(CH<sub>3</sub>)<sub>2</sub>-(CH<sub>2</sub>)<sub>n</sub>-O-" where n is 2-10, or "R<sub>1</sub>O-(CH<sub>2</sub>-CH<sub>2</sub>-O)<sub>n</sub>-CH<sub>2</sub>-CH<sub>2</sub>-O-" where R<sub>1</sub> is ethyl or methyl and n is an integer with values of 0-10. These 10-hydroxy derivatives are readily prepared by treatment with the chloroformate of the chosen reagent, if the final derivative is to be a carbonate. Typically, the 10-hydroxy-containing camptothecin such as SN-38 is treated with a molar equivalent of the chloroformate in dimethylformamide using triethylamine as the base. Under these conditions, the 20-OH position is unaffected. For forming 10-O-esters, the acid chloride of the chosen reagent is used.

**[065]** In a preferred process of the preparation of a conjugate of a drug derivative and an antibody of the general formula 2, wherein the descriptors L2, L1, AA and A-X are as described in earlier sections, the bifunctional drug moiety, [L2]-[L1]-[AA]<sub>m</sub>-[A-X]-Drug is first prepared, followed by the conjugation of the bifunctional drug moiety to the antibody (indicated herein as "MAb").

**[066]** In a preferred process of the preparation of a conjugate of a drug derivative and an antibody of the general formula 2, wherein the descriptors L2, L1, AA and A-OH are as described in earlier sections, the bifunctional drug moiety is prepared by first linking A-OH to the C-terminus of AA via an amide bond, followed by coupling the amine end of AA to a carboxylic acid group of L1. If AA is absent (i.e. m = 0), A-OH is directly attached to L1 via an amide bond. The cross-linker, [L1]-[AA]<sub>m</sub>-[A-OH], is attached to drug's hydroxyl or amino group, and this is followed by attachment to the L1 moiety, by taking recourse to the reaction between azide (or acetylene) and acetylene (or azide) groups in L1 and L2 via click chemistry.

**[067]** In one embodiment, the antibody is a monoclonal antibody (MAb). In other embodiments, the antibody may be a multivalent and/or multispecific MAb. The antibody may be a murine, chimeric, humanized, or human monoclonal antibody, and said antibody

may be in intact, fragment (Fab, Fab', F(ab)<sub>2</sub>, F(ab')<sub>2</sub>), or sub-fragment (single-chain constructs) form, or of an IgG1, IgG2a, IgG3, IgG4, IgA isotype, or submolecules therefrom.

**[068]** In a preferred embodiment, the antibody binds to an antigen or epitope of an antigen expressed on a cancer or malignant cell. The cancer cell is preferably a cell from a hematopoietic tumor, carcinoma, sarcoma, melanoma or a glial tumor. A preferred malignancy to be treated according to the present invention is a malignant solid tumor or hematopoietic neoplasm.

**[069]** In a preferred embodiment, the intracellularly-cleavable moiety may be cleaved after it is internalized into the cell upon binding by the MAb-drug conjugate to a receptor thereof, and particularly cleaved by esterases and peptidases.

#### **Anti-HLA-DR Antibodies**

**[070]** In preferred embodiments, the immunoconjugate comprises an anti-HLA-DR antibody, such as a humanized L243 antibody. Humanized L243 antibodies bind to the same epitope on HLA-DR as the parental murine L243 antibody, but have reduced immunogenicity. mL243 is a monoclonal antibody previously described by Lampson & Levy (J Immunol, 1980, 125:293), which has been deposited at the American Type Culture Collection, Rockville, MD, under Accession number ATCC HB55.

**[071]** The humanized L243 antibodies comprise the L243 heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:1), CDR2 (WINTYTREPTYADDFKG, SEQ ID NO:2) and CDR3 (DITAVVPTGFDY, SEQ ID NO:3) and the light chain CDR sequences CDR1 (RASENIYSNLA, SEQ ID NO:4), CDR2 (AASNLA, SEQ ID NO:5), and CDR3 (QHFWTTPWA, SEQ ID NO:6), attached to human antibody FR and constant region sequences. In more preferred embodiments, one or more murine FR amino acid residues are substituted for the corresponding human FR residues, particularly at locations adjacent to or nearby the CDR residues. Exemplary murine V<sub>H</sub> residues that may be substituted in the humanized design are at positions: F27, K38, K46, A68 and F91. Exemplary murine V<sub>L</sub> residues that may be substituted in the humanized design are at positions R37, K39, V48, F49, and G1.

**[072]** A particularly preferred form of hL243 antibody is illustrated in U.S. Patent No. 7,612,180, incorporated herein by reference, which incorporates FR sequences from the human RF-TS3, NEWM and REI antibodies. However, in other embodiments, the FR residues may be derived from any suitable human immunoglobulin, provided that the humanized antibody can fold such that it retains the ability to specifically bind HLA-DR. Preferably the type of human framework (FR) used is of the same/similar class/type as the

donor antibody. More preferably, the human FR sequences are selected to have a high degree of sequence homology with the corresponding murine FR sequences, particularly at positions spatially close or adjacent to the CDRs. In accordance with this embodiment, the frameworks (*ie*, FR1-4) of the humanized L243 V<sub>H</sub> or V<sub>L</sub> may be derived from a combination of human antibodies. Examples of human frameworks which may be used to construct CDR-grafted humanized antibodies are LAY, POM, TUR, TEI, KOL, NEWM, REI, RF and EU.

Preferably human RF-TS3 FR1-3 and NEWM FR4 are used for the heavy chain and REI FR1-4 are used for the light chain. The variable domain residue numbering system used herein is described in Kabat *et al*, (1991), Sequences of Proteins of Immunological Interest, 5th Edition, United States Department of Health and Human Services

**[073]** The light and heavy chain variable domains of the humanized antibody molecule may be fused to human light or heavy chain constant domains. The human constant domains may be selected with regard to the proposed function of the antibody. In one embodiment, the human constant domains may be selected based on a lack of effector functions. The heavy chain constant domains fused to the heavy chain variable region may be those of human IgA ( $\alpha$ 1 or  $\alpha$ 2 chain), IgG ( $\gamma$ 1,  $\gamma$ 2,  $\gamma$ 3 or  $\gamma$ 4 chain) or IgM ( $\mu$  chain). The light chain constant domains which may be fused to the light chain variable region include human lambda and kappa chains.

**[074]** In one particular embodiment of the present invention, a  $\gamma$ 1 chain is used. In yet another particular embodiment, a  $\gamma$ 4 chain is used. The use of the  $\gamma$ 4 chain may in some cases increase the tolerance to hL243 in subjects (decreased side effects and infusion reactions, *etc*).

**[075]** In one embodiment, analogues of human constant domains may be used. These include but are not limited to those constant domains containing one or more additional amino acids than the corresponding human domain or those constant domains wherein one or more existing amino acids of the corresponding human domain have been deleted or altered. Such domains may be obtained, for example, by oligonucleotide directed mutagenesis.

**[076]** In a particular embodiment, an anti-HLA-DR antibody or fragment thereof may be a fusion protein. The fusion protein may contain one or more anti-HLA-DR antibodies or fragments thereof. In various embodiments, the fusion protein may also comprise one or more additional antibodies against a different antigen, or may comprise a different effector protein or peptide, such as a cytokine. For example, the different antigen may be a tumor marker selected from a B cell lineage antigen, (eg, CD19, CD20, or CD22) for the treatment

of B cell malignancies. In another example, the different antigen may be expressed on other cells that cause other types of malignancies. Further, the cell marker may be a non-B cell lineage antigen, such as selected from the group consisting of HLA-DR, CD3, CD33, CD52, CD66, MUC1 and TAC.

[077] In one embodiment, an anti-HLA-DR antibody may be combined with other antibodies and used to treat a subject having or suspected of developing a disease. In accordance with this embodiment, an anti-HLA-DR antibody or fragment thereof may be combined with an anticancer monoclonal antibody such as a humanized monoclonal antibody (*eg* hA20, anti-CD20 Mab) and used to treat cancer. It is contemplated herein that an anti-HLA-DR antibody may be used as a separate antibody composition in combination with one or more other separate antibody compositions, or used as a bi-functional antibody containing, for example, one anti-HLA-DR and one other anti-tumor antibody, such as hA20. In another particular embodiment, the antibody may target a B cell malignancy. The B cell malignancy may consist of indolent forms of B cell lymphomas, aggressive forms of B cell lymphomas, chronic lymphatic leukemias, acute lymphatic leukemias, Waldenstrom's macroglobulinemia, and multiple myeloma. Other non-malignant B cell disorders and related diseases that may be treated with the subject antibodies include many autoimmune and immune dysregulatory diseases, such as septicemia and septic shock.

#### **General Antibody Techniques**

[078] Techniques for preparing monoclonal antibodies against virtually any target antigen are well known in the art. *See*, for example, Köhler and Milstein, *Nature* 256: 495 (1975), and Coligan *et al.* (eds.), *CURRENT PROTOCOLS IN IMMUNOLOGY*, VOL. 1, pages 2.5.1-2.6.7 (John Wiley & Sons 1991). Briefly, monoclonal antibodies can be obtained by injecting mice with a composition comprising a human antigen, such as human HLA-DR, removing the spleen to obtain B-lymphocytes, fusing the B-lymphocytes with myeloma cells to produce hybridomas, cloning the hybridomas, selecting positive clones which produce antibodies to the human antigen, culturing the clones that produce antibodies to the antigen, and isolating the antibodies from the hybridoma cultures.

[079] MAbs can be isolated and purified from hybridoma cultures by a variety of well-established techniques. Such isolation techniques include affinity chromatography with Protein-A or Protein-G Sepharose, size-exclusion chromatography, and ion-exchange chromatography. *See*, for example, Coligan at pages 2.7.1-2.7.12 and pages 2.9.1-2.9.3. Also, *see* Baines *et al.*, "Purification of Immunoglobulin G (IgG)," in *METHODS IN MOLECULAR BIOLOGY*, VOL. 10, pages 79-104 (The Humana Press, Inc. 1992).

**[080]** After the initial raising of antibodies to the immunogen, the antibodies can be sequenced and subsequently prepared by recombinant techniques. Humanization and chimerization of murine antibodies and antibody fragments are well known to those skilled in the art, as discussed below.

**[081]** The skilled artisan will realize that the claimed methods and compositions may utilize any of a wide variety of antibodies known in the art. Antibodies of use may be commercially obtained from a wide variety of known sources. For example, a variety of antibody secreting hybridoma lines are available from the American Type Culture Collection (ATCC, Manassas, VA). A large number of antibodies against various disease targets, including but not limited to tumor-associated antigens, have been deposited at the ATCC and/or have published variable region sequences and are available for use in the claimed methods and compositions. See, e.g., U.S. Patent Nos. 7,312,318; 7,282,567; 7,151,164; 7,074,403; 7,060,802; 7,056,509; 7,049,060; 7,045,132; 7,041,803; 7,041,802; 7,041,293; 7,038,018; 7,037,498; 7,012,133; 7,001,598; 6,998,468; 6,994,976; 6,994,852; 6,989,241; 6,974,863; 6,965,018; 6,964,854; 6,962,981; 6,962,813; 6,956,107; 6,951,924; 6,949,244; 6,946,129; 6,943,020; 6,939,547; 6,921,645; 6,921,645; 6,921,533; 6,919,433; 6,919,078; 6,916,475; 6,905,681; 6,899,879; 6,893,625; 6,887,468; 6,887,466; 6,884,594; 6,881,405; 6,878,812; 6,875,580; 6,872,568; 6,867,006; 6,864,062; 6,861,511; 6,861,227; 6,861,226; 6,838,282; 6,835,549; 6,835,370; 6,824,780; 6,824,778; 6,812,206; 6,793,924; 6,783,758; 6,770,450; 6,767,711; 6,764,688; 6,764,681; 6,764,679; 6,743,898; 6,733,981; 6,730,307; 6,720,155; 6,716,966; 6,709,653; 6,693,176; 6,692,908; 6,689,607; 6,689,362; 6,689,355; 6,682,737; 6,682,736; 6,682,734; 6,673,344; 6,653,104; 6,652,852; 6,635,482; 6,630,144; 6,610,833; 6,610,294; 6,605,441; 6,605,279; 6,596,852; 6,592,868; 6,576,745; 6,572,856; 6,566,076; 6,562,618; 6,545,130; 6,544,749; 6,534,058; 6,528,625; 6,528,269; 6,521,227; 6,518,404; 6,511,665; 6,491,915; 6,488,930; 6,482,598; 6,482,408; 6,479,247; 6,468,531; 6,468,529; 6,465,173; 6,461,823; 6,458,356; 6,455,044; 6,455,040; 6,451,310; 6,444,206; 6,441,143; 6,432,404; 6,432,402; 6,419,928; 6,413,726; 6,406,694; 6,403,770; 6,403,091; 6,395,276; 6,395,274; 6,387,350; 6,383,759; 6,383,484; 6,376,654; 6,372,215; 6,359,126; 6,355,481; 6,355,444; 6,355,245; 6,355,244; 6,346,246; 6,344,198; 6,340,571; 6,340,459; 6,331,175; 6,306,393; 6,254,868; 6,187,287; 6,183,744; 6,129,914; 6,120,767; 6,096,289; 6,077,499; 5,922,302; 5,874,540; 5,814,440; 5,798,229; 5,789,554; 5,776,456; 5,736,119; 5,716,595; 5,677,136; 5,587,459; 5,443,953; 5,525,338, the Examples section of each of which is incorporated herein by reference. These are exemplary only and a wide variety of other antibodies and their hybridomas are known in the art. The skilled artisan will realize that antibody

sequences or antibody-secreting hybridomas against almost any disease-associated antigen may be obtained by a simple search of the ATCC, NCBI and/or USPTO databases for antibodies against a selected disease-associated target of interest. The antigen binding domains of the cloned antibodies may be amplified, excised, ligated into an expression vector, transfected into an adapted host cell and used for protein production, using standard techniques well known in the art. Isolated antibodies may be conjugated to therapeutic agents, such as camptothecins, using the techniques disclosed herein.

#### *Chimeric and Humanized Antibodies*

**[082]** A chimeric antibody is a recombinant protein in which the variable regions of a human antibody have been replaced by the variable regions of, for example, a mouse antibody, including the complementarity-determining regions (CDRs) of the mouse antibody. Chimeric antibodies exhibit decreased immunogenicity and increased stability when administered to a subject. Methods for constructing chimeric antibodies are well known in the art (*e.g.*, Leung et al., 1994, *Hybridoma* 13:469).

**[083]** A chimeric monoclonal antibody may be humanized by transferring the mouse CDRs from the heavy and light variable chains of the mouse immunoglobulin into the corresponding variable domains of a human antibody. The mouse framework regions (FR) in the chimeric monoclonal antibody are also replaced with human FR sequences. To preserve the stability and antigen specificity of the humanized monoclonal, one or more human FR residues may be replaced by the mouse counterpart residues. Humanized monoclonal antibodies may be used for therapeutic treatment of subjects. Techniques for production of humanized monoclonal antibodies are well known in the art. (See, *e.g.*, Jones et al., 1986, *Nature*, 321:522; Riechmann et al., *Nature*, 1988, 332:323; Verhoeyen et al., 1988, *Science*, 239:1534; Carter et al., 1992, *Proc. Nat'l Acad. Sci. USA*, 89:4285; Sandhu, *Crit. Rev. Biotech.*, 1992, 12:437; Tempest et al., 1991, *Biotechnology* 9:266; Singer et al., *J. Immun.*, 1993, 150:2844.)

**[084]** Other embodiments may concern non-human primate antibodies. General techniques for raising therapeutically useful antibodies in baboons may be found, for example, in Goldenberg et al., WO 91/11465 (1991), and in Losman et al., *Int. J. Cancer* 46: 310 (1990). In another embodiment, an antibody may be a human monoclonal antibody. Such antibodies may be obtained from transgenic mice that have been engineered to produce specific human antibodies in response to antigenic challenge, as discussed below.

#### *Human Antibodies*

**[085]** Methods for producing fully human antibodies using either combinatorial approaches or transgenic animals transformed with human immunoglobulin loci are known in the art (e.g., Mancini et al., 2004, *New Microbiol.* 27:315-28; Conrad and Scheller, 2005, *Comb. Chem. High Throughput Screen.* 8:117-26; Brekke and Loset, 2003, *Curr. Opin. Pharmacol.* 3:544-50; each incorporated herein by reference). Such fully human antibodies are expected to exhibit even fewer side effects than chimeric or humanized antibodies and to function *in vivo* as essentially endogenous human antibodies. In certain embodiments, the claimed methods and procedures may utilize human antibodies produced by such techniques.

**[086]** In one alternative, the phage display technique may be used to generate human antibodies (e.g., Dantas-Barbosa et al., 2005, *Genet. Mol. Res.* 4:126-40, incorporated herein by reference). Human antibodies may be generated from normal humans or from humans that exhibit a particular disease state, such as cancer (Dantas-Barbosa et al., 2005). The advantage to constructing human antibodies from a diseased individual is that the circulating antibody repertoire may be biased towards antibodies against disease-associated antigens.

**[087]** In one non-limiting example of this methodology, Dantas-Barbosa et al. (2005) constructed a phage display library of human Fab antibody fragments from osteosarcoma patients. Generally, total RNA was obtained from circulating blood lymphocytes (*Id.*) Recombinant Fab were cloned from the  $\mu$ ,  $\gamma$  and  $\kappa$  chain antibody repertoires and inserted into a phage display library (*Id.*) RNAs were converted to cDNAs and used to make Fab cDNA libraries using specific primers against the heavy and light chain immunoglobulin sequences (Marks et al., 1991, *J. Mol. Biol.* 222:581-97, incorporated herein by reference). Library construction was performed according to Andris-Widhopf et al. (2000, In: *Phage Display Laboratory Manual*, Barbas et al. (eds), 1<sup>st</sup> edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY pp. 9.1 to 9.22, incorporated herein by reference). The final Fab fragments were digested with restriction endonucleases and inserted into the bacteriophage genome to make the phage display library. Such libraries may be screened by standard phage display methods. The skilled artisan will realize that this technique is exemplary only and any known method for making and screening human antibodies or antibody fragments by phage display may be utilized.

**[088]** In another alternative, transgenic animals that have been genetically engineered to produce human antibodies may be used to generate antibodies against essentially any immunogenic target, using standard immunization protocols as discussed above. Methods for obtaining human antibodies from transgenic mice are described by Green et al., *Nature Genet.* 7:13 (1994), Lonberg et al., *Nature* 368:856 (1994), and Taylor et al., *Int. Immun.*

6:579 (1994). A non-limiting example of such a system is the XENOMOUSE® (*e.g.*, Green et al., 1999, *J. Immunol. Methods* 231:11-23, incorporated herein by reference) from Abgenix (Fremont, CA). In the XENOMOUSE® and similar animals, the mouse antibody genes have been inactivated and replaced by functional human antibody genes, while the remainder of the mouse immune system remains intact.

**[089]** The XENOMOUSE® was transformed with germline-configured YACs (yeast artificial chromosomes) that contained portions of the human IgH and Ig kappa loci, including the majority of the variable region sequences, along accessory genes and regulatory sequences. The human variable region repertoire may be used to generate antibody producing B cells, which may be processed into hybridomas by known techniques. A XENOMOUSE® immunized with a target antigen will produce human antibodies by the normal immune response, which may be harvested and/or produced by standard techniques discussed above. A variety of strains of XENOMOUSE® are available, each of which is capable of producing a different class of antibody. Transgenically produced human antibodies have been shown to have therapeutic potential, while retaining the pharmacokinetic properties of normal human antibodies (Green et al., 1999). The skilled artisan will realize that the claimed compositions and methods are not limited to use of the XENOMOUSE® system but may utilize any transgenic animal that has been genetically engineered to produce human antibodies.

#### *Production of Antibody Fragments*

**[090]** Some embodiments of the claimed methods and/or compositions may concern antibody fragments. Such antibody fragments may be obtained, for example, by pepsin or papain digestion of whole antibodies by conventional methods. For example, antibody fragments may be produced by enzymatic cleavage of antibodies with pepsin to provide a 5S fragment denoted F(ab')<sub>2</sub>. This fragment may be further cleaved using a thiol reducing agent and, optionally, a blocking group for the sulfhydryl groups resulting from cleavage of disulfide linkages, to produce 3.5S Fab' monovalent fragments. Alternatively, an enzymatic cleavage using pepsin produces two monovalent Fab fragments and an Fc fragment. Exemplary methods for producing antibody fragments are disclosed in U.S. Pat. No. 4,036,945; U.S. Pat. No. 4,331,647; Nisonoff et al., 1960, *Arch. Biochem. Biophys.*, 89:230; Porter, 1959, *Biochem. J.*, 73:119; Edelman et al., 1967, *METHODS IN ENZYMOLOGY*, page 422 (Academic Press), and Coligan et al. (eds.), 1991, *CURRENT PROTOCOLS IN IMMUNOLOGY*, (John Wiley & Sons).

**[091]** Other methods of cleaving antibodies, such as separation of heavy chains to form monovalent light-heavy chain fragments, further cleavage of fragments or other enzymatic,

chemical or genetic techniques also may be used, so long as the fragments bind to the antigen that is recognized by the intact antibody. For example, Fv fragments comprise an association of V<sub>H</sub> and V<sub>L</sub> chains. This association can be noncovalent, as described in Inbar et al., 1972, *Proc. Nat'l. Acad. Sci. USA*, 69:2659. Alternatively, the variable chains may be linked by an intermolecular disulfide bond or cross-linked by chemicals such as glutaraldehyde. See Sandhu, 1992, *Crit. Rev. Biotech.*, 12:437.

**[092]** Preferably, the Fv fragments comprise V<sub>H</sub> and V<sub>L</sub> chains connected by a peptide linker. These single-chain antigen binding proteins (scFv) are prepared by constructing a structural gene comprising DNA sequences encoding the V<sub>H</sub> and V<sub>L</sub> domains, connected by an oligonucleotides linker sequence. The structural gene is inserted into an expression vector that is subsequently introduced into a host cell, such as *E. coli*. The recombinant host cells synthesize a single polypeptide chain with a linker peptide bridging the two V domains. Methods for producing scFvs are well-known in the art. See Whitlow et al., 1991, *Methods: A Companion to Methods in Enzymology* 2:97; Bird et al., 1988, *Science*, 242:423; U.S. Pat. No. 4,946,778; Pack et al., 1993, *Bio/Technology*, 11:1271, and Sandhu, 1992, *Crit. Rev. Biotech.*, 12:437.

**[093]** Another form of an antibody fragment is a single-domain antibody (dAb), sometimes referred to as a single chain antibody. Techniques for producing single-domain antibodies are well known in the art (see, e.g., Cossins et al., *Protein Expression and Purification*, 2007, 51:253-59; Shuntao et al., *Molec Immunol* 2006, 43:1912-19; Tanha et al., *J. Biol. Chem.* 2001, 276:24774-780). Other types of antibody fragments may comprise one or more complementarity-determining regions (CDRs). CDR peptides ("minimal recognition units") can be obtained by constructing genes encoding the CDR of an antibody of interest. Such genes are prepared, for example, by using the polymerase chain reaction to synthesize the variable region from RNA of antibody-producing cells. See Larrick et al., 1991, *Methods: A Companion to Methods in Enzymology* 2:106; Ritter et al. (eds.), 1995, MONOCLONAL ANTIBODIES: PRODUCTION, ENGINEERING AND CLINICAL APPLICATION, pages 166-179 (Cambridge University Press); Birch et al., (eds.), 1995, MONOCLONAL ANTIBODIES: PRINCIPLES AND APPLICATIONS, pages 137-185 (Wiley-Liss, Inc.)

#### *Antibody Variations*

**[094]** In certain embodiments, the sequences of antibodies, such as the Fc portions of antibodies, may be varied to optimize the physiological characteristics of the conjugates, such as the half-life in serum. Methods of substituting amino acid sequences in proteins are widely known in the art, such as by site-directed mutagenesis (e.g. Sambrook et al., *Molecular*

*Cloning, A laboratory manual, 2<sup>nd</sup> Ed*, 1989). In preferred embodiments, the variation may involve the addition or removal of one or more glycosylation sites in the Fc sequence (e.g., U.S. Patent No. 6,254,868, the Examples section of which is incorporated herein by reference). In other preferred embodiments, specific amino acid substitutions in the Fc sequence may be made (e.g., Hornick et al., 2000, *J Nucl Med* 41:355-62; Hinton et al., 2006, *J Immunol* 176:346-56; Petkova et al. 2006, *Int Immunol* 18:1759-69; U.S. Patent No. 7,217,797; each incorporated herein by reference).

#### *Known Antibodies*

**[095]** Antibodies of use may be commercially obtained from a wide variety of known sources. For example, a variety of antibody secreting hybridoma lines are available from the American Type Culture Collection (ATCC, Manassas, VA). A large number of antibodies against various disease targets, including but not limited to tumor-associated antigens, have been deposited at the ATCC and/or have published variable region sequences and are available for use in the claimed methods and compositions. See, e.g., U.S. Patent Nos. 7,312,318; 7,282,567; 7,151,164; 7,074,403; 7,060,802; 7,056,509; 7,049,060; 7,045,132; 7,041,803; 7,041,802; 7,041,293; 7,038,018; 7,037,498; 7,012,133; 7,001,598; 6,998,468; 6,994,976; 6,994,852; 6,989,241; 6,974,863; 6,965,018; 6,964,854; 6,962,981; 6,962,813; 6,956,107; 6,951,924; 6,949,244; 6,946,129; 6,943,020; 6,939,547; 6,921,645; 6,921,645; 6,921,533; 6,919,433; 6,919,078; 6,916,475; 6,905,681; 6,899,879; 6,893,625; 6,887,468; 6,887,466; 6,884,594; 6,881,405; 6,878,812; 6,875,580; 6,872,568; 6,867,006; 6,864,062; 6,861,511; 6,861,227; 6,861,226; 6,838,282; 6,835,549; 6,835,370; 6,824,780; 6,824,778; 6,812,206; 6,793,924; 6,783,758; 6,770,450; 6,767,711; 6,764,688; 6,764,681; 6,764,679; 6,743,898; 6,733,981; 6,730,307; 6,720,155; 6,716,966; 6,709,653; 6,693,176; 6,692,908; 6,689,607; 6,689,362; 6,689,355; 6,682,737; 6,682,736; 6,682,734; 6,673,344; 6,653,104; 6,652,852; 6,635,482; 6,630,144; 6,610,833; 6,610,294; 6,605,441; 6,605,279; 6,596,852; 6,592,868; 6,576,745; 6,572,856; 6,566,076; 6,562,618; 6,545,130; 6,544,749; 6,534,058; 6,528,625; 6,528,269; 6,521,227; 6,518,404; 6,511,665; 6,491,915; 6,488,930; 6,482,598; 6,482,408; 6,479,247; 6,468,531; 6,468,529; 6,465,173; 6,461,823; 6,458,356; 6,455,044; 6,455,040; 6,451,310; 6,444,206; 6,441,143; 6,432,404; 6,432,402; 6,419,928; 6,413,726; 6,406,694; 6,403,770; 6,403,091; 6,395,276; 6,395,274; 6,387,350; 6,383,759; 6,383,484; 6,376,654; 6,372,215; 6,359,126; 6,355,481; 6,355,444; 6,355,245; 6,355,244; 6,346,246; 6,344,198; 6,340,571; 6,340,459; 6,331,175; 6,306,393; 6,254,868; 6,187,287; 6,183,744; 6,129,914; 6,120,767; 6,096,289; 6,077,499; 5,922,302; 5,874,540; 5,814,440; 5,798,229; 5,789,554; 5,776,456; 5,736,119; 5,716,595; 5,677,136; 5,587,459; 5,443,953; 5,525,338. These are

exemplary only and a wide variety of other antibodies and their hybridomas are known in the art. The skilled artisan will realize that antibody sequences or antibody-secreting hybridomas against almost any disease-associated antigen may be obtained by a simple search of the ATCC, NCBI and/or USPTO databases for antibodies against a selected disease-associated target of interest. The antigen binding domains of the cloned antibodies may be amplified, excised, ligated into an expression vector, transfected into an adapted host cell and used for protein production, using standard techniques well known in the art.

**[096]** Exemplary antibodies that may be utilized include, but are not limited to, hR1 (anti-IGF-1R, U.S. Patent No. 9,441,043), hPAM4 (anti-mucin, U.S. Pat. No. 7,282,567), hA20 (anti-CD20, U.S. Pat. No. 7,151,164), hA19 (anti-CD19, U.S. Pat. No. 7,109,304), hIMMU31 (anti-AFP, U.S. Pat. No. 7,300,655), hLL1 (anti-CD74, U.S. Pat. No. 7,312,318), hLL2 (anti-CD22, U.S. Pat. No. 5,789,554), hMu-9 (anti-CSAp, U.S. Pat. No. 7,387,772), hL243 (anti-HLA-DR, U.S. Pat. No. 7,612,180), hMN-14 (anti-CEACAM5, U.S. Pat. No. 6,676,924), hMN-15 (anti-CEACAM6, U.S. Pat. No. 8,287,865), hRS7 (anti-EGP-1, U.S. Pat. No. 7,238,785), hMN-3 (anti-CEACAM6, U.S. Pat. No. 7,541,440), Ab124 and Ab125 (anti-CXCR4, U.S. Pat. No. 7,138,496), the Examples section of each cited patent or application incorporated herein by reference. More preferably, the antibody is IMMU-31 (anti-AFP), hRS7 (anti-TROP-2), hMN-14 (anti-CEACAM5), hMN-3 (anti-CEACAM6), hMN-15 (anti-CEACAM6), hLL1 (anti-CD74), hLL2 (anti-CD22), hL243 or IMMU-114 (anti-HLA-DR), hA19 (anti-CD19) or hA20 (anti-CD20). As used herein, the terms epratuzumab and hLL2 are interchangeable, as are the terms veltuzumab and hA20, and the terms hL243g4P, hL243gamma4P and IMMU-114.

**[097]** Alternative antibodies of use include, but are not limited to, abciximab (anti-glycoprotein IIb/IIIa), alemtuzumab (anti-CD52), bevacizumab (anti-VEGF), cetuximab (anti-EGFR), gemtuzumab (anti-CD33), ibritumomab (anti-CD20), panitumumab (anti-EGFR), rituximab (anti-CD20), tositumomab (anti-CD20), trastuzumab (anti-ErbB2), pembrolizumab (anti-PD-1 receptor), nivolumab (anti-PD-1 receptor), ipilimumab (anti-CTLA-4), abagovomab (anti-CA-125), adecatumumab (anti-EpCAM), atlizumab (anti-IL-6 receptor), benralizumab (anti-CD125), obinutuzumab (GA101, anti-CD20), CC49 (anti-TAG-72), AB-PG1-XG1-026 (anti-PSMA, U.S. patent application Ser. No. 11/983,372, deposited as ATCC PTA-4405 and PTA-4406), D2/B (anti-PSMA, WO 2009/130575), tocilizumab (anti-IL-6 receptor), basiliximab (anti-CD25), daclizumab (anti-CD25), efalizumab (anti-CD11a), GA101 (anti-CD20; Glycart Roche), natalizumab (anti- $\alpha$ 4 integrin), omalizumab (anti-IgE); anti-TNF- $\alpha$  antibodies such as CDP571 (Ofei et al., 2011,

Diabetes 45:881-85), MTNFAI, M2TNFAI, M3TNFAI, M3TNFABI, M302B, M303 (Thermo Scientific, Rockford, Ill.), infliximab (Centocor, Malvern, Pa.), certolizumab pegol (UCB, Brussels, Belgium), anti-CD40L (UCB, Brussels, Belgium), adalimumab (Abbott, Abbott Park, Ill.), or Benlysta (Human Genome Sciences).

**[098]** A comprehensive analysis of suitable antigen (Cluster Designation, or CD) targets on hematopoietic malignant cells, as shown by flow cytometry and which can be a guide to selecting suitable antibodies for drug-conjugated immunotherapy, is Craig and Foon, *Blood* prepublished online Jan. 15, 2008; DOL 10.1182/blood-2007-11-120535.

**[099]** The CD66 antigens consist of five different glycoproteins with similar structures, CD66a-e, encoded by the carcinoembryonic antigen (CEA) gene family members, BCG, CGM6, NCA, CGM1 and CEA, respectively. These CD66 antigens (e.g., CEACAM6) are expressed mainly in granulocytes, normal epithelial cells of the digestive tract and tumor cells of various tissues. Also included as suitable targets for cancers are cancer testis antigens, such as NY-ESO-1 (Theurillat et al., *Int. J. Cancer* 2007; 120(11):2411-7), as well as CD79a in myeloid leukemia (Kozlov et al., *Cancer Genet. Cytogenet.* 2005; 163(1):62-7) and also B-cell diseases, and CD79b for non-Hodgkin's lymphoma (Poison et al., *Blood* 110(2):616-623). A number of the aforementioned antigens are disclosed in U.S. Provisional Application Ser. No. 60/426,379, entitled "Use of Multi-specific, Non-covalent Complexes for Targeted Delivery of Therapeutics," filed Nov. 15, 2002. Cancer stem cells, which are ascribed to be more therapy-resistant precursor malignant cell populations (Hill and Penis, *J. Natl. Cancer Inst.* 2007; 99:1435-40), have antigens that can be targeted in certain cancer types, such as CD133 in prostate cancer (Maitland et al., *Ernst Schering Found. Sympos. Proc.* 2006; 5:155-79), non-small-cell lung cancer (Donnenberg et al., *J. Control Release* 2007; 122(3):385-91), and glioblastoma (Beier et al., *Cancer Res.* 2007; 67(9):4010-5), and CD44 in colorectal cancer (Dalerba et al., *Proc. Natl. Acad. Sci. USA* 2007; 104(24):10158-63), pancreatic cancer (Li et al., *Cancer Res.* 2007; 67(3):1030-7), and in head and neck squamous cell carcinoma (Prince et al., *Proc. Natl. Acad. Sci. USA* 2007; 104(3):973-8).

**[0100]** For multiple myeloma therapy, suitable targeting antibodies have been described against, for example, CD38 and CD138 (Stevenson, *Mol Med* 2006; 12(11-12):345-346; Tassone et al., *Blood* 2004; 104(12):3688-96), CD74 (Stein et al., *ibid.*), CS1 (Tai et al., *Blood* 2008; 112(4):1329-37, and CD40 (Tai et al., 2005; *Cancer Res.* 65(13):5898-5906).

**[0101]** Macrophage migration inhibitory factor (MIF) is an important regulator of innate and adaptive immunity and apoptosis. It has been reported that CD74 is the endogenous receptor for MIF (Leng et al., 2003, *J Exp Med* 197:1467-76). The therapeutic effect of antagonistic

anti-CD74 antibodies on MIF-mediated intracellular pathways may be of use for treatment of a broad range of disease states, such as cancers of the bladder, prostate, breast, lung, colon and chronic lymphocytic leukemia (e.g., Meyer-Siegler et al., 2004, *BMC Cancer* 12:34; Shachar & Haran, 2011, *Leuk Lymphoma* 52:1446-54); autoimmune diseases such as rheumatoid arthritis and systemic lupus erythematosus (Morand & Leech, 2005, *Front Biosci* 10:12-22; Shachar & Haran, 2011, *Leuk Lymphoma* 52:1446-54); kidney diseases such as renal allograft rejection (Lan, 2008, *Nephron Exp Nephrol.* 109:e79-83); and numerous inflammatory diseases (Meyer-Siegler et al., 2009, *Mediators Inflamm* epub Mar. 22, 2009; Takahashi et al., 2009, *Respir Res* 10:33; Milatuzumab (hLL1) is an exemplary anti-CD74 antibody of therapeutic use for treatment of MIF-mediated diseases.

**[0102]** Anti-TNF- $\alpha$  antibodies are known in the art and may be of use to treat immune diseases, such as autoimmune disease, immune dysfunction (e.g., graft-versus-host disease, organ transplant rejection) or diabetes. Known antibodies against TNF- $\alpha$  include the human antibody CDP571 (Ofei et al., 2011, *Diabetes* 45:881-85); murine antibodies MTNFAl, M2TNFAl, M3TNFAl, M3TNFABI, M302B and M303 (Thermo Scientific, Rockford, Ill.); infliximab (Centocor, Malvern, Pa.); certolizumab pegol (UCB, Brussels, Belgium); and adalimumab (Abbott, Abbott Park, Ill.). These and many other known anti-TNF- $\alpha$  antibodies may be used in the claimed methods and compositions. Other antibodies of use for therapy of immune dysregulatory or autoimmune disease include, but are not limited to, anti-B-cell antibodies such as veltuzumab, epratuzumab, milatuzumab or hL243; tocilizumab (anti-IL-6 receptor); basiliximab (anti-CD25); daclizumab (anti-CD25); efalizumab (anti-CD11a); muromonab-CD3 (anti-CD3 receptor); anti-CD40L (UCB, Brussels, Belgium); natalizumab (anti- $\alpha$ 4 integrin) and omalizumab (anti-IgE).

**[0103]** Studies with checkpoint inhibitor antibodies for cancer therapy have generated unprecedented response rates in cancers previously thought to be resistant to cancer treatment (see, e.g., Ott & Bhardwaj, 2013, *Frontiers in Immunology* 4:346; Menzies & Long, 2013, *Ther Adv Med Oncol* 5:278-85; Pardoll, 2012, *Nature Reviews* 12:252-264; Mavilio & Lugli, ). Therapy with antagonistic checkpoint blocking antibodies against CTLA-4, PD-1 and PD-L1 are one of the most promising new avenues of immunotherapy for cancer and other diseases. In contrast to the majority of anti-cancer agents, checkpoint inhibitor do not target tumor cells directly, but rather target lymphocyte receptors or their ligands in order to enhance the endogenous antitumor activity of the immune system (Pardoll, 2012, *Nature Reviews* 12:252-264). Because such antibodies act primarily by regulating the immune

response to diseased cells, they may be used in combination with other therapeutic modalities, such as the subject anti-HLA-DR antibodies, to enhance their anti-tumor effect.

**[0104]** Programmed cell death protein 1 (PD-1, also known as CD279) encodes a cell surface membrane protein of the immunoglobulin superfamily, which is expressed in B cells and NK cells (Shinohara et al., 1995, *Genomics* 23:704-6; Blank et al., 2007, *Cancer Immunol Immunother* 56:739-45; Finger et al., 1997, *Gene* 197:177-87; Pardoll, 2012, *Nature Reviews* 12:252-264). Anti-PD1 antibodies have been used for treatment of melanoma, non-small-cell lung cancer, bladder cancer, prostate cancer, colorectal cancer, head and neck cancer, triple-negative breast cancer, leukemia, lymphoma and renal cell cancer (Topalian et al., 2012, *N Engl J Med* 366:2443-54; Lipson et al., 2013, *Clin Cancer Res* 19:462-8; Berger et al., 2008, *Clin Cancer Res* 14:3044-51; Gildener-Leapman et al., 2013, *Oral Oncol* 49:1089-96; Menzies & Long, 2013, *Ther Adv Med Oncol* 5:278-85).

**[0105]** Exemplary anti-PD1 antibodies include pembrolizumab (MK-3475, MERCK), nivolumab (BMS-936558, BRISTOL-MYERS SQUIBB), and pidilizumab (CT-011, CURETECH LTD.). Anti-PD1 antibodies are commercially available, for example from ABCAM® (AB137132), BIOLEGEND® (EH12.2H7, RMP1-14) and AFFYMETRIX EBIOSCIENCE (J105, J116, MIH4).

**[0106]** Programmed cell death 1 ligand 1 (PD-L1, also known as CD274) is a ligand for PD-1, found on activated T cells, B cells, myeloid cells and macrophages. The complex of PD-1 and PD-L1 inhibits proliferation of CD8+ T cells and reduces the immune response (Topalian et al., 2012, *N Engl J Med* 366:2443-54; Brahmer et al., 2012, *N Eng J Med* 366:2455-65). Anti-PDL1 antibodies have been used for treatment of non-small cell lung cancer, melanoma, colorectal cancer, renal-cell cancer, pancreatic cancer, gastric cancer, ovarian cancer, breast cancer, and hematologic malignancies (Brahmer et al., *N Eng J Med* 366:2455-65; Ott et al., 2013, *Clin Cancer Res* 19:5300-9; Radvanyi et al., 2013, *Clin Cancer Res* 19:5541; Menzies & Long, 2013, *Ther Adv Med Oncol* 5:278-85; Berger et al., 2008, *Clin Cancer Res* 14:13044-51).

**[0107]** Exemplary anti-PDL1 antibodies include MDX-1105 (MEDAREX), MEDI4736 (MEDIMMUNE) MPDL3280A (GENENTECH) and BMS-936559 (BRISTOL-MYERS SQUIBB). Anti-PDL1 antibodies are also commercially available, for example from AFFYMETRIX EBIOSCIENCE (MIH1).

**[0108]** Cytotoxic T-lymphocyte antigen 4 (CTLA-4, also known as CD152) is also a member of the immunoglobulin superfamily that is expressed exclusively on T-cells. CTLA-4 acts to inhibit T cell activation and is reported to inhibit helper T cell activity and enhance regulatory

T cell immunosuppressive activity (Pardoll, 2012, Nature Reviews 12:252-264). Anti-CTLA4 antibodies have been used in clinical trials for treatment of melanoma, prostate cancer, small cell lung cancer, non-small cell lung cancer (Robert & Ghiringhelli, 2009, Oncologist 14:848-61; Ott et al., 2013, Clin Cancer Res 19:5300; Weber, 2007, Oncologist 12:864-72; Wada et al., 2013, J Transl Med 11:89).

**[0109]** Exemplary anti-CTLA-4 antibodies include ipilimumab (Bristol-Myers Squibb) and tremelimumab (PFIZER). Anti-PD1 antibodies are commercially available, for example from ABCAM® (AB134090), SINO BIOLOGICAL INC. (11159-H03H, 11159-H08H), and THERMO SCIENTIFIC PIERCE (PA5-29572, PA5-23967, PA5-26465, MA1-12205, MA1-35914). Ipilimumab has recently received FDA approval for treatment of metastatic melanoma (Wada et al., 2013, J Transl Med 11:89).

**[0110]** These and other known checkpoint inhibitor antibodies may be used in combination with anti-HLA-DR antibodies alone or in further combination with an interferon, such as interferon- $\alpha$ , for improved cancer therapy.

**[0111]** The person of ordinary skill will be aware that it is possible to generate any number of antibodies against a known and well characterized target antigen, such as human HLA-DR. The human HLA-DR antigen has been well characterized in the art, for example by its amino acid sequence (see, e.g., GenBank Accession No. ADM15723.1).

#### **Bispecific and Multispecific Antibodies**

**[0112]** Bispecific antibodies are useful in a number of biomedical applications. For instance, a bispecific antibody with binding sites for a tumor cell surface antigen and for a T-cell surface receptor can direct the lysis of specific tumor cells by T cells. Bispecific antibodies recognizing gliomas and the CD3 epitope on T cells have been successfully used in treating brain tumors in human patients (Nitta, et al. *Lancet*. 1990; 355:368-371). A preferred bispecific antibody is an anti-CD3 X anti-CD19 antibody. In alternative embodiments, an anti-CD3 antibody or fragment thereof may be attached to an antibody or fragment against another B-cell associated antigen, such as anti-CD3 X anti-HLA-DR. In certain embodiments, the techniques and compositions for therapeutic agent conjugation disclosed herein may be used with bispecific or multispecific antibodies as the targeting moieties.

**[0113]** Numerous methods to produce bispecific or multispecific antibodies are known, as disclosed, for example, in U.S. Patent No. 7,405,320, the Examples section of which is incorporated herein by reference. Bispecific antibodies can be produced by the quadroma method, which involves the fusion of two different hybridomas, each producing a monoclonal

antibody recognizing a different antigenic site (Milstein and Cuello, *Nature*, 1983; 305:537-540).

**[0114]** Another method for producing bispecific antibodies uses heterobifunctional cross-linkers to chemically tether two different monoclonal antibodies (Staerz, et al. *Nature*, 1985; 314:628-631; Perez, et al. *Nature*, 1985; 316:354-356). Bispecific antibodies can also be produced by reduction of each of two parental monoclonal antibodies to the respective half molecules, which are then mixed and allowed to reoxidize to obtain the hybrid structure (Staerz and Bevan. *Proc Natl Acad Sci U S A*. 1986; 83:1453-1457). Another alternative involves chemically cross-linking two or three separately purified Fab' fragments using appropriate linkers. (See, e.g., European Patent Application 0453082).

**[0115]** Other methods include improving the efficiency of generating hybrid hybridomas by gene transfer of distinct selectable markers via retrovirus-derived shuttle vectors into respective parental hybridomas, which are fused subsequently (DeMonte, et al. *Proc Natl Acad Sci U S A*. 1990, 87:2941-2945); or transfection of a hybridoma cell line with expression plasmids containing the heavy and light chain genes of a different antibody.

**[0116]** Cognate V<sub>H</sub> and V<sub>L</sub> domains can be joined with a peptide linker of appropriate composition and length (usually consisting of more than 12 amino acid residues) to form a single-chain Fv (scFv) with binding activity. Methods of manufacturing scFvs are disclosed in U.S. Pat. No. 4,946,778 and U.S. Pat. No. 5,132,405, the Examples section of each of which is incorporated herein by reference. Reduction of the peptide linker length to less than 12 amino acid residues prevents pairing of V<sub>H</sub> and V<sub>L</sub> domains on the same chain and forces pairing of V<sub>H</sub> and V<sub>L</sub> domains with complementary domains on other chains, resulting in the formation of functional multimers. Polypeptide chains of V<sub>H</sub> and V<sub>L</sub> domains that are joined with linkers between 3 and 12 amino acid residues form predominantly dimers (termed diabodies). With linkers between 0 and 2 amino acid residues, trimers (termed triabody) and tetramers (termed tetrabody) are favored, but the exact patterns of oligomerization appear to depend on the composition as well as the orientation of V-domains (V<sub>H</sub>-linker-V<sub>L</sub> or V<sub>L</sub>-linker-V<sub>H</sub>), in addition to the linker length.

**[0117]** These techniques for producing multispecific or bispecific antibodies exhibit various difficulties in terms of low yield, necessity for purification, low stability or the labor-intensiveness of the technique. More recently, a technique known as DOCK-AND-LOCK® (DNL®) has been utilized to produce combinations of virtually any desired antibodies, antibody fragments and other effector molecules (see, e.g., U.S. Patent Nos. 7,521,056; 7,527,787; 7,534,866; 7,550,143; 7,666,400; 7,858,070; 7,871,622; 7,906,121; 7,906,118;

8,163,291; 7,901,680; 7,981,398; 8,003,111 and 8,034,352, the Examples section of each of which incorporated herein by reference). The technique utilizes complementary protein binding domains, referred to as anchoring domains (AD) and dimerization and docking domains (DDD), which bind to each other and allow the assembly of complex structures, ranging from dimers, trimers, tetramers, pentamers and hexamers. These form stable complexes in high yield without requirement for extensive purification. The DNL technique allows the assembly of monospecific, bispecific or multispecific antibodies. Any of the techniques known in the art for making bispecific or multispecific antibodies may be utilized in the practice of the presently claimed methods.

**[0118]** In various embodiments, a conjugate as disclosed herein may be part of a composite, multispecific antibody. Such antibodies may contain two or more different antigen binding sites, with differing specificities. The multispecific composite may bind to different epitopes of the same antigen, or alternatively may bind to two different antigens.

**[0119]** Such antibodies need not only be used in combination, but can be combined as fusion proteins of various forms, such as IgG, Fab, scFv, and the like, as described in U.S. Patent Nos. 6,083,477; 6,183,744 and 6,962,702 and U.S. Patent Application Publication Nos. 20030124058; 20030219433; 20040001825; 20040202666; 20040219156; 20040219203; 20040235065; 20050002945; 20050014207; 20050025709; 20050079184; 20050169926; 20050175582; 20050249738; 20060014245 and 20060034759, the Examples section of each incorporated herein by reference.

#### **DOCK AND LOCK® (DNL®)**

**[0120]** In certain embodiments, the anti-HLA-DR antibodies or fragments may be incorporated into a multimeric complex, for example using a technique referred to as DOCK-AND-LOCK® (DNL®). The method exploits specific protein/protein interactions that occur between the regulatory (R) subunits of cAMP-dependent protein kinase (PKA) and the anchoring domain (AD) of A-kinase anchoring proteins (AKAPs) (Baillie *et al.*, FEBS Letters. 2005; **579**: 3264. Wong and Scott, Nat. Rev. Mol. Cell Biol. 2004; **5**: 959). PKA, which plays a central role in one of the best studied signal transduction pathways triggered by the binding of the second messenger cAMP to the R subunits, was first isolated from rabbit skeletal muscle in 1968 (Walsh *et al.*, J. Biol. Chem. 1968;243:3763). The structure of the holoenzyme consists of two catalytic subunits held in an inactive form by the R subunits (Taylor, J. Biol. Chem. 1989;264:8443). Isozymes of PKA are found with two types of R subunits (RI and RII), and each type has  $\alpha$  and  $\beta$  isoforms (Scott, Pharmacol. Ther.

1991;50:123). The R subunits have been isolated only as stable dimers and the dimerization domain has been shown to consist of the first 44 amino-terminal residues (Newlon *et al.*, Nat. Struct. Biol. 1999;6:222). Binding of cAMP to the R subunits leads to the release of active catalytic subunits for a broad spectrum of serine/threonine kinase activities, which are oriented toward selected substrates through the compartmentalization of PKA via its docking with AKAPs (Scott *et al.*, J. Biol. Chem. 1990;265:21561).

**[0121]** Since the first AKAP, microtubule-associated protein-2, was characterized in 1984 (Lohmann *et al.*, Proc. Natl. Acad. Sci USA. 1984;81:6723), more than 50 AKAPs that localize to various subcellular sites, including plasma membrane, actin cytoskeleton, nucleus, mitochondria, and endoplasmic reticulum, have been identified with diverse structures in species ranging from yeast to humans (Wong and Scott, Nat. Rev. Mol. Cell Biol. 2004;5:959). The AD of AKAPs for PKA is an amphipathic helix of 14-18 residues (Carr *et al.*, J. Biol. Chem. 1991;266:14188), with binding affinities reported for RII dimers ranging from 2 to 90 nM (Alto *et al.*, Proc. Natl. Acad. Sci. USA. 2003;100:4445).

Interestingly, AKAPs will only bind to dimeric R subunits. For human RII $\alpha$ , the AD binds to a hydrophobic surface formed by the 23 amino-terminal residues (Colledge and Scott, Trends Cell Biol. 1999; 6:216). Thus, the dimerization domain and AKAP binding domain of human RII $\alpha$  are both located within the same N-terminal 44 amino acid sequence (Newlon *et al.*, Nat. Struct. Biol. 1999;6:222; Newlon *et al.*, EMBO J. 2001;20:1651), which is termed the DDD herein.

#### *DDD of Human RII $\alpha$ and AD of AKAPs as Linker Modules*

**[0122]** We have developed a platform technology to utilize the DDD of human RII $\alpha$  and the AD of AKAP proteins as an excellent pair of linker modules for docking any two entities, referred to hereafter as **A** and **B**, into a noncovalent complex, which could be further locked into a stably tethered structure through the introduction of cysteine residues into both the DDD and AD at strategic positions to facilitate the formation of disulfide bonds. The general methodology of the “dock-and-lock” approach is as follows. Entity **A** is constructed by linking a DDD sequence to a precursor of **A**, resulting in a first component hereafter referred to as **a**. Because the DDD sequence would effect the spontaneous formation of a dimer, **A** would thus be composed of **a**<sub>2</sub>. Entity **B** is constructed by linking an AD sequence to a precursor of **B**, resulting in a second component hereafter referred to as **b**. The dimeric motif of DDD contained in **a**<sub>2</sub> will create a docking site for binding to the AD sequence contained in **b**, thus facilitating a ready association of **a**<sub>2</sub> and **b** to form a binary, trimeric complex

composed of **a<sub>2</sub>b**. This binding event is made irreversible with a subsequent reaction to covalently secure the two entities via disulfide bridges, which occurs very efficiently based on the principle of effective local concentration because the initial binding interactions should bring the reactive thiol groups placed onto both the DDD and AD into proximity (Chimura *et al.*, Proc. Natl. Acad. Sci. USA. 2001;98:8480) to ligate site-specifically.

**[0123]** In preferred embodiments, the anti-HLA-DR MAb DNL constructs may be based on a variation of the **a<sub>2</sub>b** structure, in which an IgG immunoglobulin molecule (e.g., hL243) is attached at its C-terminal end to two copies of an AD moiety. Preferably the AD moiety is attached to the C-terminal end of each light chain. Each AD moiety is capable of binding to two DDD moieties in the form of a dimer. By attaching a cytokine or other therapeutic protein or peptide to each DDD moiety, four copies of cytokine or other therapeutic moiety are conjugated to each IgG molecule.

**[0124]** By attaching the DDD and AD away from the functional groups of the two precursors, such site-specific ligations are also expected to preserve the original activities of the two precursors. This approach is modular in nature and potentially can be applied to link, site-specifically and covalently, a wide range of substances. The DNL method was disclosed in U.S. Patent Nos. 7,550,143; 7,521,056; 7,653,866; 7,527,787 and 7,666,400, the Examples section of each incorporated herein by reference.

**[0125]** In preferred embodiments, the effector moiety is a protein or peptide, more preferably an antibody, antibody fragment or cytokine, which can be linked to a DDD or AD unit to form a fusion protein or peptide. A variety of methods are known for making fusion proteins, including nucleic acid synthesis, hybridization and/or amplification to produce a synthetic double-stranded nucleic acid encoding a fusion protein of interest. Such double-stranded nucleic acids may be inserted into expression vectors for fusion protein production by standard molecular biology techniques (see, e.g. Sambrook et al., *Molecular Cloning, A laboratory manual*, 2<sup>nd</sup> Ed, 1989). In such preferred embodiments, the AD and/or DDD moiety may be attached to either the N-terminal or C-terminal end of an effector protein or peptide. However, the skilled artisan will realize that the site of attachment of an AD or DDD moiety to an effector moiety may vary, depending on the chemical nature of the effector moiety and the part(s) of the effector moiety involved in its physiological activity. Site-specific attachment of a variety of effector moieties may be performed using techniques known in the art, such as the use of bivalent cross-linking reagents and/or other chemical conjugation techniques.

#### *DDD and AD Sequence Variants*

[0126] In certain embodiments, the AD and DDD sequences incorporated into the anti-HLA-DR MAb DNL complex comprise the amino acid sequences of DDD1 (SEQ ID NO:7) and AD1 (SEQ ID NO:9) below. In more preferred embodiments, the AD and DDD sequences comprise the amino acid sequences of DDD2 (SEQ ID NO:8) and AD2 (SEQ ID NO:10), which are designed to promote disulfide bond formation between the DDD and AD moieties.

*DDD1*

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:7)

*DDD2*

CGHIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:8)

*AD1*

QIEYLAKQIVDNAIQQA (SEQ ID NO:9)

*AD2*

CGQIEYLAKQIVDNAIQQAGC (SEQ ID NO:10)

[0127] However, in alternative embodiments sequence variants AD and/or DDD moieties may be utilized in construction of the anti-HLA-DR MAb DNL complexes. The structure-function relationships of the AD and DDD domains have been the subject of investigation. (See, e.g., Burns-Hamuro et al., 2005, Protein Sci 14:2982-92; Carr et al., 2001, J Biol Chem 276:17332-38; Alto et al., 2003, Proc Natl Acad Sci USA 100:4445-50; Hundsrucker et al., 2006, Biochem J 396:297-306; Stokka et al., 2006, Biochem J 400:493-99; Gold et al., 2006, Mol Cell 24:383-95; Kinderman et al., 2006, Mol Cell 24:397-408, the entire text of each of which is incorporated herein by reference.)

[0128] For example, Kinderman et al. (2006) examined the crystal structure of the AD-DDD binding interaction and concluded that the human DDD sequence contained a number of conserved amino acid residues that were important in either dimer formation or AKAP binding, underlined below in SEQ ID NO:7. (See Figure 1 of Kinderman et al., 2006, incorporated herein by reference.) The skilled artisan will realize that in designing sequence variants of the DDD sequence, one would desirably avoid changing any of the underlined residues, while conservative amino acid substitutions might be made for residues that are less critical for dimerization and AKAP binding. Conservative amino acid substitutions are discussed in more detail below, but could involve for example substitution of an aspartate residue for a glutamate residue, or a leucine or valine residue for an isoleucine residue, etc. Such conservative amino acid substitutions are well known in the art.

*Human DDD sequence from protein kinase A*SHIQIPPGLTELLQGYTVEVLRQPPDLVEFAVEYFTRLREARA (SEQ ID NO:7)

[0129] Alto et al. (2003) performed a bioinformatic analysis of the AD sequence of various AKAP proteins to design an RII selective AD sequence called AKAP-IS (SEQ ID NO:9), with a binding constant for DDD of 0.4 nM. The AKAP-IS sequence was designed as a peptide antagonist of AKAP binding to PKA. Residues in the AKAP-IS sequence where substitutions tended to decrease binding to DDD are underlined in SEQ ID NO:9.

*AKAP-IS sequence*QIEYLAKQIVDNAIQQA (SEQ ID NO:9)

[0130] Similarly, Gold (2006) utilized crystallography and peptide screening to develop a SuperAKAP-IS sequence (SEQ ID NO:11), exhibiting a five order of magnitude higher selectivity for the RII isoform of PKA compared with the RI isoform. Underlined residues indicate the positions of amino acid substitutions, relative to the AKAP-IS sequence, that increased binding to the DDD moiety of RII $\alpha$ . In this sequence, the N-terminal Q residue is numbered as residue number 4 and the C-terminal A residue is residue number 20. Residues where substitutions could be made to affect the affinity for RII $\alpha$  were residues 8, 11, 15, 16, 18, 19 and 20 (Gold et al., 2006). It is contemplated that in certain alternative embodiments, the SuperAKAP-IS sequence may be substituted for the AKAP-IS AD moiety sequence to prepare anti-HLA-DR MAb DNL constructs. It is anticipated that, as with the AKAP-IS sequence shown in SEQ ID NO:9, the AD moiety may also include the additional N-terminal residues cysteine and glycine and C-terminal residues glycine and cysteine, as shown in SEQ ID NO:10.

*SuperAKAP-IS*QIEYVAKQIVDYAIHQQA (SEQ ID NO:11)

[0131] Hundsrucker et al. (2006) developed still other peptide competitors for AKAP binding to PKA, with a binding constant as low as 0.4 nM to the DDD of the RII form of PKA. The sequences of various AKAP antagonistic peptides is provided in Table 1 of Hundsrucker et al. (incorporated herein by reference). Residues that were highly conserved among the AD domains of different AKAP proteins are indicated below by underlining with reference to the AKAP IS sequence (SEQ ID NO:9). The residues are the same as observed by Alto et al.

(2003), with the addition of the C-terminal alanine residue. (See FIG. 4 of Hundsrucker et al. (2006), incorporated herein by reference.)

*AKAP-IS*

QIEYLAKQIVDNAIQQA (SEQ ID NO:9)

**[0132]** Carr et al. (2001) examined the degree of sequence homology between different AKAP-binding DDD sequences from human and non-human proteins and identified residues in the DDD sequences that appeared to be the most highly conserved among different DDD moieties. These are indicated below by underlining with reference to the human PKA RII $\alpha$  DDD sequence of SEQ ID NO:7. Residues that were particularly conserved are further indicated by italics. The residues overlap with, but are not identical to those suggested by Kinderman et al. (2006) to be important for binding to AKAP proteins.

SHIQIPPGLTELLQGYIVEVLRQOPDLVEFAVEYFTRLREARA (SEQ ID NO:7)

**[0133]** The skilled artisan will realize that in general, those amino acid residues that are highly conserved in the DDD and AD sequences from different proteins are ones that it may be preferred to remain constant in making amino acid substitutions, while residues that are less highly conserved may be more easily varied to produce sequence variants of the AD and/or DDD sequences described herein.

**Antibody Allotypes**

**[0134]** Immunogenicity of therapeutic antibodies is associated with increased risk of infusion reactions and decreased duration of therapeutic response (Baert et al., 2003, N Engl J Med 348:602-08). The extent to which therapeutic antibodies induce an immune response in the host may be determined in part by the allotype of the antibody (Stickler et al., 2011, Genes and Immunity 12:213-21). Antibody allotype is related to amino acid sequence variations at specific locations in the constant region sequences of the antibody. The allotypes of IgG antibodies containing a heavy chain  $\gamma$ -type constant region are designated as Gm allotypes (1976, J Immunol 117:1056-59).

**[0135]** For the common IgG1 human antibodies, the most prevalent allotype is G1m1 (Stickler et al., 2011, Genes and Immunity 12:213-21). However, the G1m3 allotype also occurs frequently in Caucasians (*Id.*). It has been reported that G1m1 antibodies contain allotypic sequences that tend to induce an immune response when administered to non-G1m1 (nG1m1) recipients, such as G1m3 patients (*Id.*). Non-G1m1 allotype antibodies are not as immunogenic when administered to G1m1 patients (*Id.*).

[0136] The human G1m1 allotype comprises the amino acids D12 (Kabat position 356) and L14 (Kabat position 358) in the CH3 sequence of the heavy chain IgG1. The nG1m1 allotype comprises the amino acids E12 and M14 at the same locations. Both G1m1 and nG1m1 allotypes comprise an E13 residue in between the two variable sites and the allotypes are sometimes referred to as DEL and EEM allotypes. A non-limiting example of the heavy chain constant region sequences for G1m1 and nG1m1 allotype antibodies is shown for the exemplary antibodies rituximab (SEQ ID NO:12) and veltuzumab (SEQ ID NO:13).

*Rituximab heavy chain variable region sequence (SEQ ID NO:12)*

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVL  
 QSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDK**K**AEPKSCDKTHTCPPCPAP  
 ELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAK  
 TKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPRE  
 PQVYTLPPSR**DEL**TKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDG  
 SFFLYSKLTVDKSRWQQGNVFSVMSMHEALHNHYTQKSLSLSPGK

*Veltuzumab heavy chain variable region (SEQ ID NO:13)*

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFPAVL  
 QSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDK**R**VEPKSCDKTHTCPPCPAP  
 ELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAK  
 TKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPRE  
 PQVYTLPPSR**EEM**TKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDG  
 SFFLYSKLTVDKSRWQQGNVFSVMSMHEALHNHYTQKSLSLSPGK

[0137] With regard to therapeutic antibodies, veltuzumab and rituximab are, respectively, humanized and chimeric IgG1 antibodies against CD20, of use for therapy of a wide variety of hematological malignancies and/or autoimmune diseases. **Table 1** compares the allotype sequences of rituximab vs. veltuzumab. As shown in **Table 1**, rituximab (G1m17,1) is a DEL allotype IgG1, with an additional sequence variation at Kabat position 214 (heavy chain CH1) of lysine in rituximab vs. arginine in veltuzumab. It has been reported that veltuzumab is less immunogenic in subjects than rituximab (*see, e.g.,* Morchhauser et al., 2009, J Clin Oncol 27:3346-53; Goldenberg et al., 2009, Blood 113:1062-70; Robak & Robak, 2011, BioDrugs 25:13-25), an effect that has been attributed to the difference between humanized and chimeric antibodies. However, the difference in allotypes between the EEM and DEL allotypes likely also accounts for the lower immunogenicity of veltuzumab.

**Table 1. Allotypes of Rituximab vs. Veltuzumab**

	Complete allotype	Heavy chain position and associated allotypes					
		214 (allotype)	356/358 (allotype)	431 (allotype)			
Rituximab	G1m17,1	K	17	D/L	1	A	-
Veltuzumab	G1m3	R	3	E/M	-	A	-

**[0138]** In order to reduce the immunogenicity of therapeutic antibodies in individuals of nG1m1 genotype, it is desirable to select the allotype of the antibody to correspond to the EEM allotype, with a glutamate residue at Kabat position 356, a methionine at Kabat position 358, and preferably an arginine residue at Kabat position 214. Surprisingly, it was found that repeated subcutaneous administration of G1m3 antibodies over a long period of time did not result in a significant immune response.

#### **Amino Acid Substitutions**

**[0139]** In alternative embodiments, the disclosed methods and compositions may involve production and use of proteins or peptides with one or more substituted amino acid residues. For example, the DDD and/or AD sequences used to make DNL<sup>®</sup> constructs may be modified as discussed above.

**[0140]** The skilled artisan will be aware that, in general, amino acid substitutions typically involve the replacement of an amino acid with another amino acid of relatively similar properties (i.e., conservative amino acid substitutions). The properties of the various amino acids and effect of amino acid substitution on protein structure and function have been the subject of extensive study and knowledge in the art.

**[0141]** For example, the hydropathic index of amino acids may be considered (Kyte & Doolittle, 1982, *J. Mol. Biol.*, 157:105-132). The relative hydropathic character of the amino acid contributes to the secondary structure of the resultant protein, which in turn defines the interaction of the protein with other molecules. Each amino acid has been assigned a hydropathic index on the basis of its hydrophobicity and charge characteristics (Kyte & Doolittle, 1982), these are: isoleucine (+4.5); valine (+4.2); leucine (+3.8); phenylalanine (+2.8); cysteine/cystine (+2.5); methionine (+1.9); alanine (+1.8); glycine (-0.4); threonine (-0.7); serine (-0.8); tryptophan (-0.9); tyrosine (-1.3); proline (-1.6); histidine (-3.2); glutamate (-3.5); glutamine (-3.5); aspartate (-3.5); asparagine (-3.5); lysine (-3.9); and arginine (-4.5). In making conservative substitutions, the use of amino acids whose hydropathic indices are within  $\pm 2$  is preferred, within  $\pm 1$  are more preferred, and within  $\pm 0.5$  are even more preferred.

**[0142]** Amino acid substitution may also take into account the hydrophilicity of the amino acid residue (e.g., U.S. Pat. No. 4,554,101). Hydrophilicity values have been assigned to amino acid residues: arginine (+3.0); lysine (+3.0); aspartate (+3.0); glutamate (+3.0); serine (+0.3); asparagine (+0.2); glutamine (+0.2); glycine (0); threonine (-0.4); proline (-0.5  $\pm$  0.1); alanine (-0.5); histidine (-0.5); cysteine (-1.0); methionine (-1.3); valine (-1.5); leucine (-1.8);

isoleucine (-1.8); tyrosine (-2.3); phenylalanine (-2.5); tryptophan (-3.4). Replacement of amino acids with others of similar hydrophilicity is preferred.

**[0143]** Other considerations include the size of the amino acid side chain. For example, it would generally not be preferred to replace an amino acid with a compact side chain, such as glycine or serine, with an amino acid with a bulky side chain, e.g., tryptophan or tyrosine. The effect of various amino acid residues on protein secondary structure is also a consideration. Through empirical study, the effect of different amino acid residues on the tendency of protein domains to adopt an alpha-helical, beta-sheet or reverse turn secondary structure has been determined and is known in the art (see, e.g., Chou & Fasman, 1974, *Biochemistry*, 13:222-245; 1978, *Ann. Rev. Biochem.*, 47: 251-276; 1979, *Biophys. J.*, 26:367-384).

**[0144]** Based on such considerations and extensive empirical study, tables of conservative amino acid substitutions have been constructed and are known in the art. For example: arginine and lysine; glutamate and aspartate; serine and threonine; glutamine and asparagine; and valine, leucine and isoleucine. Alternatively: Ala (A) leu, ile, val; Arg (R) gln, asn, lys; Asn (N) his, asp, lys, arg, gln; Asp (D) asn, glu; Cys (C) ala, ser; Gln (Q) glu, asn; Glu (E) gln, asp; Gly (G) ala; His (H) asn, gln, lys, arg; Ile (I) val, met, ala, phe, leu; Leu (L) val, met, ala, phe, ile; Lys (K) gln, asn, arg; Met (M) phe, ile, leu; Phe (F) leu, val, ile, ala, tyr; Pro (P) ala; Ser (S), thr; Thr (T) ser; Trp (W) phe, tyr; Tyr (Y) trp, phe, thr, ser; Val (V) ile, leu, met, phe, ala.

**[0145]** Other considerations for amino acid substitutions include whether or not the residue is located in the interior of a protein or is solvent exposed. For interior residues, conservative substitutions would include: Asp and Asn; Ser and Thr; Ser and Ala; Thr and Ala; Ala and Gly; Ile and Val; Val and Leu; Leu and Ile; Leu and Met; Phe and Tyr; Tyr and Trp (See, e.g., PROWL website at rockefeller.edu). For solvent exposed residues, conservative substitutions would include: Asp and Asn; Asp and Glu; Glu and Gln; Glu and Ala; Gly and Asn; Ala and Pro; Ala and Gly; Ala and Ser; Ala and Lys; Ser and Thr; Lys and Arg; Val and Leu; Leu and Ile; Ile and Val; Phe and Tyr. (Id.) Various matrices have been constructed to assist in selection of amino acid substitutions, such as the PAM250 scoring matrix, Dayhoff matrix, Grantham matrix, McLachlan matrix, Doolittle matrix, Henikoff matrix, Miyata matrix, Fitch matrix, Jones matrix, Rao matrix, Levin matrix and Risler matrix (*Idem.*)

**[0146]** In determining amino acid substitutions, one may also consider the existence of intermolecular or intramolecular bonds, such as formation of ionic bonds (salt bridges)

between positively charged residues (e.g., His, Arg, Lys) and negatively charged residues (e.g., Asp, Glu) or disulfide bonds between nearby cysteine residues.

[0147] Methods of substituting any amino acid for any other amino acid in an encoded protein sequence are well known and a matter of routine experimentation for the skilled artisan, for example by the technique of site-directed mutagenesis or by synthesis and assembly of oligonucleotides encoding an amino acid substitution and splicing into an expression vector construct.

### Conjugation Protocols

[0148] In certain embodiments, the anti-HLA-DR antibody or fragment may be conjugated to one or more therapeutic or diagnostic agents. The therapeutic agents do not need to be the same but can be different, e.g. a drug and a radioisotope. For example,  $^{131}\text{I}$  can be incorporated into a tyrosine of an antibody or fusion protein and a drug attached to an epsilon amino group of a lysine residue. Therapeutic and diagnostic agents also can be attached, for example to reduced SH groups and/or to carbohydrate side chains. Many methods for making covalent or non-covalent conjugates of therapeutic or diagnostic agents with antibodies or fusion proteins are known in the art and any such known method may be utilized.

[0149] A therapeutic or diagnostic agent can be attached at the hinge region of a reduced antibody component via disulfide bond formation. Alternatively, such agents can be attached using a heterobifunctional cross-linker, such as *N*-succinyl 3-(2-pyridyldithio)propionate (SPDP). Yu *et al.*, *Int. J. Cancer* 56: 244 (1994). General techniques for such conjugation are well-known in the art. See, for example, Wong, CHEMISTRY OF PROTEIN CONJUGATION AND CROSS-LINKING (CRC Press 1991); Upešlacis *et al.*, "Modification of Antibodies by Chemical Methods," in MONOCLONAL ANTIBODIES: PRINCIPLES AND APPLICATIONS, Birch *et al.* (eds.), pages 187-230 (Wiley-Liss, Inc. 1995); Price, "Production and Characterization of Synthetic Peptide-Derived Antibodies," in MONOCLONAL ANTIBODIES: PRODUCTION, ENGINEERING AND CLINICAL APPLICATION, Ritter *et al.* (eds.), pages 60-84 (Cambridge University Press 1995). Alternatively, the therapeutic or diagnostic agent can be conjugated via a carbohydrate moiety in the Fc region of the antibody. The carbohydrate group can be used to increase the loading of the same agent that is bound to a thiol group, or the carbohydrate moiety can be used to bind a different therapeutic or diagnostic agent.

[0150] Methods for conjugating peptides to antibody components via an antibody carbohydrate moiety are well-known to those of skill in the art. See, for example, Shih *et al.*, *Int. J. Cancer* 41: 832 (1988); Shih *et al.*, *Int. J. Cancer* 46: 1101 (1990); and Shih *et al.*, U.S.

Patent No. 5,057,313, incorporated herein in their entirety by reference. The general method involves reacting an antibody component having an oxidized carbohydrate portion with a carrier polymer that has at least one free amine function. This reaction results in an initial Schiff base (imine) linkage, which can be stabilized by reduction to a secondary amine to form the final conjugate.

**[0151]** The Fc region may be absent if the antibody used as the antibody component of the immunoconjugate is an antibody fragment. However, it is possible to introduce a carbohydrate moiety into the light chain variable region of a full length antibody or antibody fragment. See, for example, Leung *et al.*, *J. Immunol.* 154: 5919 (1995); Hansen *et al.*, U.S. Patent No. 5,443,953 (1995), Leung *et al.*, U.S. patent No. 6,254,868, incorporated herein by reference in their entirety. The engineered carbohydrate moiety is used to attach the therapeutic or diagnostic agent.

**[0152]** In some embodiments, a chelating agent may be attached to an antibody, antibody fragment or fusion protein and used to chelate a therapeutic or diagnostic agent, such as a radionuclide. Exemplary chelators include but are not limited to DTPA (such as Mx-DTPA), DOTA, TETA, NETA or NOTA. Methods of conjugation and use of chelating agents to attach metals or other ligands to proteins are well known in the art (see, e.g., U.S. Patent Application Serial No. 12/112,289, incorporated herein by reference in its entirety).

**[0153]** In certain embodiments, radioactive metals or paramagnetic ions may be attached to proteins or peptides by reaction with a reagent having a long tail, to which may be attached a multiplicity of chelating groups for binding ions. Such a tail can be a polymer such as a polylysine, polysaccharide, or other derivatized or derivatizable chains having pendant groups to which can be bound chelating groups such as, e.g., ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA), porphyrins, polyamines, crown ethers, bis-thiosemicarbazones, polyoximes, and like groups known to be useful for this purpose.

**[0154]** Chelates may be directly linked to antibodies or peptides, for example as disclosed in U.S. Patent 4,824,659, incorporated herein in its entirety by reference. Particularly useful metal-chelate combinations include 2-benzyl-DTPA and its monomethyl and cyclohexyl analogs, used with diagnostic isotopes in the general energy range of 60 to 4,000 keV, such as <sup>125</sup>I, <sup>131</sup>I, <sup>123</sup>I, <sup>124</sup>I, <sup>62</sup>Cu, <sup>64</sup>Cu, <sup>18</sup>F, <sup>111</sup>In, <sup>67</sup>Ga, <sup>68</sup>Ga, <sup>99m</sup>Tc, <sup>94m</sup>Tc, <sup>11</sup>C, <sup>13</sup>N, <sup>15</sup>O, <sup>76</sup>Br, for radioimaging. The same chelates, when complexed with non-radioactive metals, such as manganese, iron and gadolinium are useful for MRI. Macrocyclic chelates such as NOTA, DOTA, and TETA are of use with a variety of metals and radiometals, most particularly with radionuclides of gallium, yttrium and copper, respectively. Such metal-chelate complexes can

be made very stable by tailoring the ring size to the metal of interest. Other ring-type chelates such as macrocyclic polyethers, which are of interest for stably binding nuclides, such as  $^{223}\text{Ra}$  for RAIT are encompassed.

**[0155]** More recently, methods of  $^{18}\text{F}$ -labeling of use in PET scanning techniques have been disclosed, for example by reaction of F-18 with a metal or other atom, such as aluminum. The  $^{18}\text{F}$ -Al conjugate may be complexed with chelating groups, such as DOTA, NOTA or NETA that are attached directly to antibodies or used to label targetable constructs in pre-targeting methods. Such F-18 labeling techniques are disclosed in U.S. Patent Application Serial No. 12/112,289, filed 4/30/08, the entire text of which is incorporated herein by reference.

**[0156]** In preferred embodiments, the conjugation protocol is based on a thiol-maleimide, a thiol-vinylsulfone, a thiol-bromoacetamide, or a thiol-iodoacetamide reaction that is facile at neutral or acidic pH. This obviates the need for higher pH conditions for conjugations as, for instance, would be necessitated when using active esters. Further details of exemplary conjugation protocols are described below in the Examples section.

### **Therapeutic Treatment**

**[0157]** In another aspect, the invention relates to a method of treating a subject, comprising administering a therapeutically effective amount of a therapeutic conjugate as described herein to a subject. Diseases that may be treated with the therapeutic conjugates described herein include, but are not limited to B-cell malignancies (e.g., non-Hodgkin's lymphoma, mantle cell lymphoma, multiple myeloma, Hodgkin's lymphoma, diffuse large B cell lymphoma, Burkitt lymphoma, follicular lymphoma, acute lymphatic leukemia, chronic lymphatic leukemia, hairy cell leukemia) using an anti-HLA-DR immunoconjugate. More preferably, the cancer is AML (acute myelocytic leukemia), ALL (acute lymphocytic leukemia) or MM (multiple myeloma). However, any HLA-DR positive tumor may be treated with the subject immunoconjugates, such as skin, esophageal, stomach, colon, rectal, pancreatic, lung, breast, ovarian, bladder, endometrial, cervical, testicular, melanoma, kidney, or liver cancer. Such therapeutics can be given once or repeatedly, depending on the disease state and tolerability of the conjugate, and can also be used optionally in combination with other therapeutic modalities, such as surgery, external radiation, radioimmunotherapy, immunotherapy, chemotherapy, antisense therapy, interference RNA therapy, gene therapy, and the like. Each combination will be adapted to the tumor type, stage, patient condition and prior therapy, and other factors considered by the managing physician.

**[0158]** As used herein, the term “subject” refers to any animal (i.e., vertebrates and invertebrates) including, but not limited to mammals, including humans. It is not intended that the term be limited to a particular age or sex. Thus, adult and newborn subjects, as well as fetuses, whether male or female, are encompassed by the term. Doses given herein are for humans, but can be adjusted to the size of other mammals, as well as children, in accordance with weight or square meter size.

**[0159]** In an exemplary embodiment, an hL243 antibody is a humanized antibody comprising the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:1), CDR2 (WINTYTREPTYADDFKG, SEQ ID NO:2), and CDR3 (DITAVVPTGFDY, SEQ ID NO:3) and light chain CDR sequences CDR1 (RASENIYSNLA, SEQ ID NO:4), CDR2 (AASNLA, SEQ ID NO:5), and CDR3 (QHFWTTPWA, SEQ ID NO:6).

**[0160]** In a preferred embodiment, the antibodies that are used in the treatment of human disease are human or humanized (CDR-grafted) versions of antibodies; although murine and chimeric versions of antibodies can be used. Same species IgG molecules as delivery agents are mostly preferred to minimize immune responses. This is particularly important when considering repeat treatments. For humans, a human or humanized IgG antibody is less likely to generate an anti-IgG immune response from patients. Antibodies such as hLL1 and hLL2 rapidly internalize after binding to internalizing antigen on target cells, which means that the chemotherapeutic drug being carried is rapidly internalized into cells as well. However, antibodies that have slower rates of internalization can also be used to effect selective therapy.

**[0161]** In another preferred embodiment, the therapeutic conjugates can be used to treat autoimmune disease or immune system dysfunction (e.g., graft-versus-host disease, organ transplant rejection). Antibodies of use to treat autoimmune/immune dysfunction disease may bind to exemplary antigens including, but not limited to, BCL-1, BCL-2, BCL-6, CD1a, CD2, CD3, CD4, CD5, CD7, CD8, CD10, CD11b, CD11c, CD13, CD14, CD15, CD16, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD34, CD38, CD40, CD40L, CD41a, CD43, CD45, CD55, CD56, CCD57, CD59, CD64, CD71, CD74, CD79a, CD79b, CD117, CD138, FMC-7 and HLA-DR. Antibodies that bind to these and other target antigens, discussed above, may be used to treat autoimmune or immune dysfunction diseases. Autoimmune diseases that may be treated with immunoconjugates may include acute idiopathic thrombocytopenic purpura, chronic idiopathic thrombocytopenic purpura, dermatomyositis, Sydenham's chorea, myasthenia gravis, systemic lupus erythematosus, lupus nephritis, rheumatic fever, polyglandular syndromes, bullous pemphigoid, diabetes mellitus, Henoch-

Schonlein purpura, post-streptococcal nephritis, erythema nodosum, Takayasu's arteritis, ANCA-associated vasculitides, Addison's disease, rheumatoid arthritis, multiple sclerosis, sarcoidosis, ulcerative colitis, erythema multiforme, IgA nephropathy, polyarteritis nodosa, ankylosing spondylitis, Goodpasture's syndrome, thromboangitis obliterans, Sjogren's syndrome, primary biliary cirrhosis, Hashimoto's thyroiditis, thyrotoxicosis, scleroderma, chronic active hepatitis, polymyositis/dermatomyositis, polychondritis, bullous pemphigoid, pemphigus vulgaris, Wegener's granulomatosis, membranous nephropathy, amyotrophic lateral sclerosis, tabes dorsalis, giant cell arteritis/polymyalgia, pernicious anemia, rapidly progressive glomerulonephritis, psoriasis or fibrosing alveolitis.

**[0162]** In another preferred embodiment, a therapeutic agent used in combination with the camptothecin conjugate of this invention may comprise one or more isotopes. Radioactive isotopes useful for treating diseased tissue include, but are not limited to-  $^{111}\text{In}$ ,  $^{177}\text{Lu}$ ,  $^{212}\text{Bi}$ ,  $^{213}\text{Bi}$ ,  $^{211}\text{At}$ ,  $^{62}\text{Cu}$ ,  $^{67}\text{Cu}$ ,  $^{90}\text{Y}$ ,  $^{125}\text{I}$ ,  $^{131}\text{I}$ ,  $^{32}\text{P}$ ,  $^{33}\text{P}$ ,  $^{47}\text{Sc}$ ,  $^{111}\text{Ag}$ ,  $^{67}\text{Ga}$ ,  $^{142}\text{Pr}$ ,  $^{153}\text{Sm}$ ,  $^{161}\text{Tb}$ ,  $^{166}\text{Dy}$ ,  $^{166}\text{Ho}$ ,  $^{186}\text{Re}$ ,  $^{188}\text{Re}$ ,  $^{189}\text{Re}$ ,  $^{212}\text{Pb}$ ,  $^{223}\text{Ra}$ ,  $^{225}\text{Ac}$ ,  $^{59}\text{Fe}$ ,  $^{75}\text{Se}$ ,  $^{77}\text{As}$ ,  $^{89}\text{Sr}$ ,  $^{99}\text{Mo}$ ,  $^{105}\text{Rh}$ ,  $^{109}\text{Pd}$ ,  $^{143}\text{Pr}$ ,  $^{149}\text{Pm}$ ,  $^{169}\text{Er}$ ,  $^{194}\text{Ir}$ ,  $^{198}\text{Au}$ ,  $^{199}\text{Au}$ ,  $^{227}\text{Th}$  and  $^{211}\text{Pb}$ . The therapeutic radionuclide preferably has a decay-energy in the range of 20 to 6,000 keV, preferably in the ranges 60 to 200 keV for an Auger emitter, 100-2,500 keV for a beta emitter, and 4,000-6,000 keV for an alpha emitter. Maximum decay energies of useful beta-particle-emitting nuclides are preferably 20-5,000 keV, more preferably 100-4,000 keV, and most preferably 500-2,500 keV. Also preferred are radionuclides that substantially decay with Auger-emitting particles. For example, Co-58, Ga-67, Br-80m, Tc-99m, Rh-103m, Pt-109, In-111, Sb-119, I-125, Ho-161, Os-189m and Ir-192. Decay energies of useful beta-particle-emitting nuclides are preferably <1,000 keV, more preferably <100 keV, and most preferably <70 keV. Also preferred are radionuclides that substantially decay with generation of alpha-particles. Such radionuclides include, but are not limited to: Dy-152, At-211, Bi-212, Ra-223, Rn-219, Po-215, Bi-211, Ac-225, Fr-221, At-217, Bi-213, Th-227 and Fm-255. Decay energies of useful alpha-particle-emitting radionuclides are preferably 2,000-10,000 keV, more preferably 3,000-8,000 keV, and most preferably 4,000-7,000 keV. Additional potential radioisotopes of use include  $^{11}\text{C}$ ,  $^{13}\text{N}$ ,  $^{15}\text{O}$ ,  $^{75}\text{Br}$ ,  $^{198}\text{Au}$ ,  $^{224}\text{Ac}$ ,  $^{126}\text{I}$ ,  $^{133}\text{I}$ ,  $^{77}\text{Br}$ ,  $^{113\text{m}}\text{In}$ ,  $^{95}\text{Ru}$ ,  $^{97}\text{Ru}$ ,  $^{103}\text{Ru}$ ,  $^{105}\text{Ru}$ ,  $^{107}\text{Hg}$ ,  $^{203}\text{Hg}$ ,  $^{121\text{m}}\text{Te}$ ,  $^{122\text{m}}\text{Te}$ ,  $^{125\text{m}}\text{Te}$ ,  $^{165}\text{Tm}$ ,  $^{167}\text{Tm}$ ,  $^{168}\text{Tm}$ ,  $^{197}\text{Pt}$ ,  $^{109}\text{Pd}$ ,  $^{105}\text{Rh}$ ,  $^{142}\text{Pr}$ ,  $^{143}\text{Pr}$ ,  $^{161}\text{Tb}$ ,  $^{166}\text{Ho}$ ,  $^{199}\text{Au}$ ,  $^{57}\text{Co}$ ,  $^{58}\text{Co}$ ,  $^{51}\text{Cr}$ ,  $^{59}\text{Fe}$ ,  $^{75}\text{Se}$ ,  $^{201}\text{Tl}$ ,  $^{225}\text{Ac}$ ,  $^{76}\text{Br}$ ,  $^{169}\text{Yb}$ , and the like.

**[0163]** Radionuclides and other metals may be delivered, for example, using chelating groups attached to an antibody or conjugate. Macrocyclic chelates such as NOTA, DOTA, and

TETA are of use with a variety of metals and radiometals, most particularly with radionuclides of gallium, yttrium and copper, respectively. Such metal-chelate complexes can be made very stable by tailoring the ring size to the metal of interest. Other ring-type chelates, such as macrocyclic polyethers for complexing <sup>223</sup>Ra, may be used.

**[0164]** Therapeutic agents of use in combination with the camptothecin conjugates described herein also include, for example, chemotherapeutic drugs such as vinca alkaloids, anthracyclines, epipodophyllotoxins, taxanes, antimetabolites, tyrosine kinase inhibitors, alkylating agents, antibiotics, Cox-2 inhibitors, antimetabolites, antiangiogenic and proapoptotic agents, particularly doxorubicin, methotrexate, taxol, other camptothecins, and others from these and other classes of anticancer agents, and the like. Other cancer chemotherapeutic drugs include nitrogen mustards, alkyl sulfonates, nitrosoureas, triazines, folic acid analogs, pyrimidine analogs, purine analogs, platinum coordination complexes, hormones, and the like. Suitable chemotherapeutic agents are described in REMINGTON'S PHARMACEUTICAL SCIENCES, 19th Ed. (Mack Publishing Co. 1995), and in GOODMAN AND GILMAN'S THE PHARMACOLOGICAL BASIS OF THERAPEUTICS, 7th Ed. (MacMillan Publishing Co. 1985), as well as revised editions of these publications. Other suitable chemotherapeutic agents, such as experimental drugs, are known to those of skill in the art.

**[0165]** Exemplary drugs of use include, but are not limited to, 5-fluorouracil, afatinib, aplidin, azaribine, anastrozole, anthracyclines, axitinib, AVL-101, AVL-291, bendamustine, bleomycin, bortezomib, bosutinib, bryostatin-1, busulfan, calicheamycin, camptothecin, carboplatin, 10-hydroxycamptothecin, carmustine, celecoxib, chlorambucil, cisplatin (CDDP), Cox-2 inhibitors, irinotecan (CPT-11), SN-38, carboplatinum, cladribine, camptothecins, crizotinib, cyclophosphamide, cytarabine, dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, doxorubicin, 2-pyrrolinodoxorubicine (2P-DOX), cyano-morpholino doxorubicin, doxorubicin glucuronide, epirubicin glucuronide, erlotinib, estramustine, epipodophyllotoxin, erlotinib, entinostat, estrogen receptor binding agents, etoposide (VP16), etoposide glucuronide, etoposide phosphate, exemestane, fingolimod, floxuridine (FUdR), 3',5'-O-dioleoyl-FudR (FUdR-dO), fludarabine, flutamide, farnesyl-protein transferase inhibitors, flavopiridol, fostamatinib, ganetespib, GDC-0834, GS-1101, gefitinib, gemcitabine, hydroxyurea, ibrutinib, idarubicin, idelalisib, ifosfamide, imatinib, L-asparaginase, lapatinib, lenolidamide, leucovorin, LFM-A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, navelbine, neratinib, nilotinib, nitrosourea, olaparib, plicomycin,

procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide, transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839. Such agents may be part of the conjugates described herein or may alternatively be administered in combination with the described conjugates, either prior to, simultaneously with or after the conjugate.

Alternatively, one or more therapeutic naked antibodies as are known in the art may be used in combination with the described conjugates. Exemplary therapeutic naked antibodies are described above.

**[0166]** In preferred embodiments, a therapeutic agent to be used in combination with a DNA-breaking antibody conjugate (e.g., an SN-38-ADC) is a microtubule inhibitor, such as a vinca alkaloid, a taxanes, a maytansinoid or an auristatin. Exemplary known microtubule inhibitors include paclitaxel, vincristine, vinblastine, mertansine, epothilone, docetaxel, discodermolide, combrestatin, podophyllotoxin, CI-980, phenylahistins, steganacins, curacins, 2-methoxy estradiol, E7010, methoxy benzenesulfonamides, vinorelbine, vinflunine, vindesine, dolastatins, spongistatin, rhizoxin, tasidotin, halichondrins, hemiasterlins, cryptophycin 52, MMAE and eribulin mesylate.

**[0167]** In an alternative preferred embodiment, a therapeutic agent to be used in combination with a DNA-breaking ADC, such as an SN-38-antibody conjugate, is a PARP inhibitor, such as olaparib, talazoparib (BMN-673), rucaparib, veliparib, CEP 9722, MK 4827, BGB-290, ABT-888, AG014699, BSI-201, CEP-8983 or 3-aminobenzamide.

**[0168]** In another alternative, a therapeutic agent used in combination with an antibody or immunoconjugate is a Bruton kinase inhibitor, such as such as ibrutinib (PCI-32765), PCI-45292, CC-292 (AVL-292), ONO-4059, GDC-0834, LFM-A13 or RN486.

**[0169]** In yet another alternative, a therapeutic agent used in combination with an antibody or immunoconjugate is a PI3K inhibitor, such as idelalisib, Wortmannin, demethoxyviridin, perifosine, PX-866, IPI-145 (duvelisib), BAY 80-6946, BEZ235, RP6530, TGR1202, SF1126, INK1117, GDC-0941, BKM120, XL147, XL765, Palomid 529, GSK1059615, ZSTK474, PWT33597, IC87114, TG100-115, CAL263, PI-103, GNE477, CUDC-907, AEZS-136 or LY294002.

**[0170]** Therapeutic agents that may be used in concert with the camptothecin conjugates also may comprise toxins conjugated to targeting moieties. Toxins that may be used in this regard include ricin, abrin, ribonuclease (RNase), ranpirnase, DNase I, Staphylococcal enterotoxin-A, pokeweed antiviral protein, gelonin, diphtheria toxin, *Pseudomonas* exotoxin, and

*Pseudomonas* endotoxin. (See, e.g., Pastan. et al., *Cell* (1986), 47:641, and Sharkey and Goldenberg, *CA Cancer J Clin.* 2006 Jul-Aug;56(4):226-43.) Additional toxins suitable for use herein are known to those of skill in the art and are disclosed in U.S. 6,077,499.

**[0171]** Yet another class of therapeutic agent may comprise one or more immunomodulators. Immunomodulators of use may be selected from a cytokine, a stem cell growth factor, a lymphotoxin, an hematopoietic factor, a colony stimulating factor (CSF), an interferon (IFN), erythropoietin, thrombopoietin and a combination thereof. Specifically useful are lymphotoxins such as tumor necrosis factor (TNF), hematopoietic factors, such as interleukin (IL), colony stimulating factor, such as granulocyte-colony stimulating factor (G-CSF) or granulocyte macrophage-colony stimulating factor (GM-CSF), interferon, such as interferons- $\alpha$ , - $\beta$ , - $\gamma$  or - $\lambda$ , and stem cell growth factor, such as that designated "S1 factor". Included among the cytokines are growth hormones such as human growth hormone, N-methionyl human growth hormone, and bovine growth hormone; parathyroid hormone; thyroxine; insulin; proinsulin; relaxin; prorelaxin; glycoprotein hormones such as follicle stimulating hormone (FSH), thyroid stimulating hormone (TSH), and luteinizing hormone (LH); hepatic growth factor; prostaglandin, fibroblast growth factor; prolactin; placental lactogen, OB protein; tumor necrosis factor- $\alpha$  and - $\beta$ ; mullerian-inhibiting substance; mouse gonadotropin-associated peptide; inhibin; activin; vascular endothelial growth factor; integrin; thrombopoietin (TPO); nerve growth factors such as NGF- $\beta$ ; platelet-growth factor; transforming growth factors (TGFs) such as TGF- $\alpha$  and TGF- $\beta$ ; insulin-like growth factor-I and -II; erythropoietin (EPO); osteoinductive factors; interferons such as interferon- $\alpha$ , - $\beta$ , and - $\gamma$ ; colony stimulating factors (CSFs) such as macrophage-CSF (M-CSF); interleukins (ILs) such as IL-1, IL-1 $\alpha$ , IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-9, IL-10, IL-11, IL-12; IL-13, IL-14, IL-15, IL-16, IL-17, IL-18, IL-21, IL-25, LIF, kit-ligand or FLT-3, angiostatin, thrombospondin, endostatin, tumor necrosis factor and lymphotoxin (LT). As used herein, the term cytokine includes proteins from natural sources or from recombinant cell culture and biologically active equivalents of the native sequence cytokines.

**[0172]** Chemokines of use include RANTES, MCAF, MIP1-alpha, MIP1-Beta and IP-10.

**[0173]** The person of ordinary skill will realize that the subject immunoconjugates, comprising a camptothecin conjugated to an antibody or antibody fragment, may be used alone or in combination with one or more other therapeutic agents, such as a second antibody, second antibody fragment, second immunoconjugate, radionuclide, toxin, drug, chemotherapeutic agent, radiation therapy, chemokine, cytokine, immunomodulator, enzyme,

hormone, oligonucleotide, RNAi or siRNA. Such additional therapeutic agents may be administered separately, in combination with, or attached to the subject antibody-drug immunoconjugates.

### **Formulation and Administration**

**[0174]** Suitable routes of administration of the conjugates include, without limitation, oral, parenteral, subcutaneous, rectal, transmucosal, intestinal administration, intramuscular, intramedullary, intrathecal, direct intraventricular, intravenous, intravitreal, intraperitoneal, intranasal, or intraocular injections. The preferred routes of administration are parenteral. Alternatively, one may administer the compound in a local rather than systemic manner, for example, via injection of the compound directly into a solid tumor.

**[0175]** Immunoconjugates can be formulated according to known methods to prepare pharmaceutically useful compositions, whereby the immunoconjugate is combined in a mixture with a pharmaceutically suitable excipient. Sterile phosphate-buffered saline is one example of a pharmaceutically suitable excipient. Other suitable excipients are well-known to those in the art. See, for example, Ansel *et al.*, PHARMACEUTICAL DOSAGE FORMS AND DRUG DELIVERY SYSTEMS, 5th Edition (Lea & Febiger 1990), and Gennaro (ed.), REMINGTON'S PHARMACEUTICAL SCIENCES, 18th Edition (Mack Publishing Company 1990), and revised editions thereof.

**[0176]** In a preferred embodiment, the immunoconjugate is formulated in Good's biological buffer (pH 6-7), using a buffer selected from the group consisting of N-(2-acetamido)-2-aminoethanesulfonic acid (ACES); N-(2-acetamido)iminodiacetic acid (ADA); N,N-bis(2-hydroxyethyl)-2-aminoethanesulfonic acid (BES); 4-(2-hydroxyethyl)piperazine-1-ethanesulfonic acid (HEPES); 2-(N-morpholino)ethanesulfonic acid (MES); 3-(N-morpholino)propanesulfonic acid (MOPS); 3-(N-morpholinyl)-2-hydroxypropanesulfonic acid (MOPSO); and piperazine-N,N'-bis(2-ethanesulfonic acid) [Pipes]. More preferred buffers are MES or MOPS, preferably in the concentration range of 20 to 100 mM, more preferably about 25 mM. Most preferred is 25 mM MES, pH 6.5. The formulation may further comprise 25 mM trehalose and 0.01% v/v polysorbate 80 as excipients, with the final buffer concentration modified to 22.25 mM as a result of added excipients. The preferred method of storage is as a lyophilized formulation of the conjugates, stored in the temperature range of -20 °C to 2 °C, with the most preferred storage at 2 °C to 8 °C.

**[0177]** The immunoconjugate can be formulated for intravenous administration via, for example, bolus injection, slow infusion or continuous infusion. Preferably, the antibody of

the present invention is infused over a period of less than about 4 hours, and more preferably, over a period of less than about 3 hours. For example, the first 25-50 mg could be infused within 30 minutes, preferably even 15 min, and the remainder infused over the next 2-3 hrs. Formulations for injection can be presented in unit dosage form, e.g., in ampoules or in multi-dose containers, with an added preservative. The compositions can take such forms as suspensions, solutions or emulsions in oily or aqueous vehicles, and can contain formulatory agents such as suspending, stabilizing and/or dispersing agents. Alternatively, the active ingredient can be in powder form for constitution with a suitable vehicle, e.g., sterile pyrogen-free water, before use.

**[0178]** Additional pharmaceutical methods may be employed to control the duration of action of the therapeutic conjugate. Control release preparations can be prepared through the use of polymers to complex or adsorb the immunoconjugate. For example, biocompatible polymers include matrices of poly(ethylene-co-vinyl acetate) and matrices of a polyanhydride copolymer of a stearic acid dimer and sebacic acid. Sherwood *et al.*, *Bio/Technology* 10: 1446 (1992). The rate of release of an immunoconjugate from such a matrix depends upon the molecular weight of the immunoconjugate, the amount of immunoconjugate within the matrix, and the size of dispersed particles. Saltzman *et al.*, *Biophys. J.* 55: 163 (1989); Sherwood *et al.*, *supra*. Other solid dosage forms are described in Ansel *et al.*, PHARMACEUTICAL DOSAGE FORMS AND DRUG DELIVERY SYSTEMS, 5th Edition (Lea & Febiger 1990), and Gennaro (ed.), REMINGTON'S PHARMACEUTICAL SCIENCES, 18th Edition (Mack Publishing Company 1990), and revised editions thereof.

**[0179]** Generally, the dosage of an administered immunoconjugate for humans will vary depending upon such factors as the patient's age, weight, height, sex, general medical condition and previous medical history. A dosage of 1-20 mg/kg for a 70 kg patient, for example, is 70-1,400 mg, or 41-824 mg/m<sup>2</sup> for a 1.7-m patient. The dosage may be repeated as needed, for example, once per week for 4-10 weeks, once per week for 8 weeks, or once per week for 4 weeks. It may also be given less frequently, such as every other week for several months, or monthly or quarterly for many months, as needed in a maintenance therapy. Preferred dosages may include, but are not limited to, 1 mg/kg, 2 mg/kg, 3 mg/kg, 4 mg/kg, 5 mg/kg, 6 mg/kg, 7 mg/kg, 8 mg/kg, 9 mg/kg, 10 mg/kg, 11 mg/kg, 12 mg/kg, 13 mg/kg, 14 mg/kg, 15 mg/kg, 16 mg/kg, 17 mg/kg, and 18 mg/kg. The dosage is preferably administered multiple times, once or twice a week. A minimum dosage schedule of 4 weeks, more preferably 8 weeks, more preferably 16 weeks or longer may be used. The schedule of administration may comprise administration once or twice a week, on a cycle selected from

the group consisting of: (i) weekly; (ii) every other week; (iii) one week of therapy followed by two, three or four weeks off; (iv) two weeks of therapy followed by one, two, three or four weeks off; (v) three weeks of therapy followed by one, two, three, four or five week off; (vi) four weeks of therapy followed by one, two, three, four or five week off; (vii) five weeks of therapy followed by one, two, three, four or five week off; and (viii) monthly. The cycle may be repeated 4, 6, 8, 10, 12, 16 or 20 times or more.

**[0180]** Alternatively, an immunoconjugate may be administered as one dosage every 2 or 3 weeks, repeated for a total of at least 3 dosages. Or, twice per week for 4-6 weeks. If the dosage is lowered to approximately 200-300 mg/m<sup>2</sup> (340 mg per dosage for a 1.7-m patient), it may be administered once or even twice weekly for 4 to 10 weeks. Alternatively, the dosage schedule may be decreased, namely every 2 or 3 weeks for 2-3 months. It has been determined, however, that even higher doses, such as 12 mg/kg once weekly or once every 2-3 weeks can be administered by slow i.v. infusion, for repeated dosing cycles. The dosing schedule can optionally be repeated at other intervals and dosage may be given through various parenteral routes, with appropriate adjustment of the dose and schedule.

**[0181]** In certain preferred embodiments, the SN-38 conjugated anti-HLA-DR may be administered subcutaneously. For subcutaneous administration, dosages of ADCs such as IMMU-140 (hL243-CL2A-SN-38) may be limited by the ability to concentrate the ADC without precipitation or aggregation, as well as the volume of administration that may be given subcutaneously (preferably, 1, 2, or 3 ml or less). Consequently, for subcutaneous administration the ADC may be given at 2 to 4 mg/kg, given daily for 1 week, or 3 times weekly for 2 weeks, or twice weekly for two weeks, followed by rest. Maintenance doses of ADC may be administered i.v. or s.c. every two to three weeks or monthly after induction. Alternatively, induction may occur with two to four cycles of i.v. administration at 8-10 mg/kg (each cycle with ADC administration on Days 1 and 8 of two 21-day cycles with a one-week rest period in between), followed by s.c. administration as active dosing one or more times weekly or as maintenance therapy. Dosing may be adjusted based on interim tumor scans and/or by analysis of Trop-2 positive circulating tumor cells.

**[0182]** In preferred embodiments, the immunoconjugates are of use for therapy of cancer. Examples of cancers include, but are not limited to, carcinoma, lymphoma, glioblastoma, melanoma, sarcoma, and leukemia, myeloma, or lymphoid malignancies. More particular examples of such cancers are noted below and include: squamous cell cancer (e.g., epithelial squamous cell cancer), Ewing sarcoma, Wilms tumor, astrocytomas, lung cancer including small-cell lung cancer, non-small cell lung cancer, adenocarcinoma of the lung and squamous

carcinoma of the lung, cancer of the peritoneum, gastric or stomach cancer including gastrointestinal cancer, pancreatic cancer, glioblastoma multiforme, cervical cancer, ovarian cancer, liver cancer, bladder cancer, hepatoma, hepatocellular carcinoma, neuroendocrine tumors, medullary thyroid cancer, differentiated thyroid carcinoma, breast cancer, ovarian cancer, colon cancer, rectal cancer, endometrial cancer or uterine carcinoma, salivary gland carcinoma, kidney or renal cancer, prostate cancer, vulvar cancer, anal carcinoma, penile carcinoma, as well as head-and-neck cancer. The term "cancer" includes primary malignant cells or tumors (e.g., those whose cells have not migrated to sites in the subject's body other than the site of the original malignancy or tumor) and secondary malignant cells or tumors (e.g., those arising from metastasis, the migration of malignant cells or tumor cells to secondary sites that are different from the site of the original tumor).

**[0183]** Other examples of cancers or malignancies include, but are not limited to: Acute Childhood Lymphoblastic Leukemia, Acute Lymphoblastic Leukemia, Acute Lymphocytic Leukemia, Acute Myeloid Leukemia, Adrenocortical Carcinoma, Adult (Primary) Hepatocellular Cancer, Adult (Primary) Liver Cancer, Adult Acute Lymphocytic Leukemia, Adult Acute Myeloid Leukemia, Adult Hodgkin's Lymphoma, Adult Lymphocytic Leukemia, Adult Non-Hodgkin's Lymphoma, Adult Primary Liver Cancer, Adult Soft Tissue Sarcoma, AIDS-Related Lymphoma, AIDS-Related Malignancies, Anal Cancer, Astrocytoma, Bile Duct Cancer, Bladder Cancer, Bone Cancer, Brain Stem Glioma, Brain Tumors, Breast Cancer, Cancer of the Renal Pelvis and Ureter, Central Nervous System (Primary) Lymphoma, Central Nervous System Lymphoma, Cerebellar Astrocytoma, Cerebral Astrocytoma, Cervical Cancer, Childhood (Primary) Hepatocellular Cancer, Childhood (Primary) Liver Cancer, Childhood Acute Lymphoblastic Leukemia, Childhood Acute Myeloid Leukemia, Childhood Brain Stem Glioma, Childhood Cerebellar Astrocytoma, Childhood Cerebral Astrocytoma, Childhood Extracranial Germ Cell Tumors, Childhood Hodgkin's Disease, Childhood Hodgkin's Lymphoma, Childhood Hypothalamic and Visual Pathway Glioma, Childhood Lymphoblastic Leukemia, Childhood Medulloblastoma, Childhood Non-Hodgkin's Lymphoma, Childhood Pineal and Supratentorial Primitive Neuroectodermal Tumors, Childhood Primary Liver Cancer, Childhood Rhabdomyosarcoma, Childhood Soft Tissue Sarcoma, Childhood Visual Pathway and Hypothalamic Glioma, Chronic Lymphocytic Leukemia, Chronic Myelogenous Leukemia, Colon Cancer, Cutaneous T-Cell Lymphoma, Endocrine Pancreas Islet Cell Carcinoma, Endometrial Cancer, Ependymoma, Epithelial Cancer, Esophageal Cancer, Ewing's Sarcoma and Related Tumors, Exocrine Pancreatic Cancer, Extracranial Germ Cell

Tumor, Extragonadal Germ Cell Tumor, Extrahepatic Bile Duct Cancer, Eye Cancer, Female Breast Cancer, Gaucher's Disease, Gallbladder Cancer, Gastric Cancer, Gastrointestinal Carcinoid Tumor, Gastrointestinal Tumors, Germ Cell Tumors, Gestational Trophoblastic Tumor, Hairy Cell Leukemia, Head and Neck Cancer, Hepatocellular Cancer, Hodgkin's Lymphoma, Hypergammaglobulinemia, Hypopharyngeal Cancer, Intestinal Cancers, Intraocular Melanoma, Islet Cell Carcinoma, Islet Cell Pancreatic Cancer, Kaposi's Sarcoma, Kidney Cancer, Laryngeal Cancer, Lip and Oral Cavity Cancer, Liver Cancer, Lung Cancer, Lymphoproliferative Disorders, Macroglobulinemia, Male Breast Cancer, Malignant Mesothelioma, Malignant Thymoma, Medulloblastoma, Melanoma, Mesothelioma, Metastatic Occult Primary Squamous Neck Cancer, Metastatic Primary Squamous Neck Cancer, Metastatic Squamous Neck Cancer, Multiple Myeloma, Multiple Myeloma/Plasma Cell Neoplasm, Myelodysplastic Syndrome, Myelogenous Leukemia, Myeloid Leukemia, Myeloproliferative Disorders, Nasal Cavity and Paranasal Sinus Cancer, Nasopharyngeal Cancer, Neuroblastoma, Non-Hodgkin's Lymphoma, Nonmelanoma Skin Cancer, Non-Small Cell Lung Cancer, Occult Primary Metastatic Squamous Neck Cancer, Oropharyngeal Cancer, Osteo-/Malignant Fibrous Sarcoma, Osteosarcoma/Malignant Fibrous Histiocytoma, Osteosarcoma/Malignant Fibrous Histiocytoma of Bone, Ovarian Epithelial Cancer, Ovarian Germ Cell Tumor, Ovarian Low Malignant Potential Tumor, Pancreatic Cancer, Paraproteinemias, Polycythemia vera, Parathyroid Cancer, Penile Cancer, Pheochromocytoma, Pituitary Tumor, Primary Central Nervous System Lymphoma, Primary Liver Cancer, Prostate Cancer, Rectal Cancer, Renal Cell Cancer, Renal Pelvis and Ureter Cancer, Retinoblastoma, Rhabdomyosarcoma, Salivary Gland Cancer, Sarcoidosis Sarcomas, Sezary Syndrome, Skin Cancer, Small Cell Lung Cancer, Small Intestine Cancer, Soft Tissue Sarcoma, Squamous Neck Cancer, Stomach Cancer, Supratentorial Primitive Neuroectodermal and Pineal Tumors, T-Cell Lymphoma, Testicular Cancer, Thymoma, Thyroid Cancer, Transitional Cell Cancer of the Renal Pelvis and Ureter, Transitional Renal Pelvis and Ureter Cancer, Trophoblastic Tumors, Ureter and Renal Pelvis Cell Cancer, Urethral Cancer, Uterine Cancer, Uterine Sarcoma, Vaginal Cancer, Visual Pathway and Hypothalamic Glioma, Vulvar Cancer, Waldenström's macroglobulinemia, Wilms' tumor, and any other hyperproliferative disease, besides neoplasia, located in an organ system listed above.

**[0184]** The methods and compositions described and claimed herein may be used to treat malignant or premalignant conditions and to prevent progression to a neoplastic or malignant state, including but not limited to those disorders described above. Such uses are indicated in

conditions known or suspected of preceding progression to neoplasia or cancer, in particular, where non-neoplastic cell growth consisting of hyperplasia, metaplasia, or most particularly, dysplasia has occurred (for review of such abnormal growth conditions, see Robbins and Angell, Basic Pathology, 2d Ed., W. B. Saunders Co., Philadelphia, pp. 68-79 (1976)).

**[0185]** Dysplasia is frequently a forerunner of cancer, and is found mainly in the epithelia. It is the most disorderly form of non-neoplastic cell growth, involving a loss in individual cell uniformity and in the architectural orientation of cells. Dysplasia characteristically occurs where there exists chronic irritation or inflammation. Dysplastic disorders which can be treated include, but are not limited to, anhidrotic ectodermal dysplasia, anterofacial dysplasia, asphyxiating thoracic dysplasia, atriadigital dysplasia, bronchopulmonary dysplasia, cerebral dysplasia, cervical dysplasia, chondroectodermal dysplasia, cleidocranial dysplasia, congenital ectodermal dysplasia, craniodiaphysial dysplasia, craniocarpotarsal dysplasia, craniometaphysial dysplasia, dentin dysplasia, diaphysial dysplasia, ectodermal dysplasia, enamel dysplasia, encephalo-ophthalmic dysplasia, dysplasia epiphysialis hemimelia, dysplasia epiphysialis multiplex, dysplasia epiphysialis punctata, epithelial dysplasia, faciocardigital dysplasia, familial fibrous dysplasia of jaws, familial white folded dysplasia, fibromuscular dysplasia, fibrous dysplasia of bone, florid osseous dysplasia, hereditary renal-retinal dysplasia, hidrotic ectodermal dysplasia, hypohidrotic ectodermal dysplasia, lymphopenic thymic dysplasia, mammary dysplasia, mandibulofacial dysplasia, metaphysial dysplasia, Mondini dysplasia, monostotic fibrous dysplasia, mucoepithelial dysplasia, multiple epiphysial dysplasia, oculoauriculovertebral dysplasia, oculodentodigital dysplasia, oculovertbral dysplasia, odontogenic dysplasia, ophthalmomandibulomelic dysplasia, periapical cemental dysplasia, polyostotic fibrous dysplasia, pseudoachondroplastic spondyloepiphysial dysplasia, retinal dysplasia, septo-optic dysplasia, spondyloepiphysial dysplasia, and ventriculoradial dysplasia.

**[0186]** Additional pre-neoplastic disorders which can be treated include, but are not limited to, benign dysproliferative disorders (e.g., benign tumors, fibrocystic conditions, tissue hypertrophy, intestinal polyps or adenomas, and esophageal dysplasia), leukoplakia, keratoses, Bowen's disease, Farmer's Skin, solar cheilitis, and solar keratosis.

**[0187]** In preferred embodiments, the method of the invention is used to inhibit growth, progression, and/or metastasis of cancers, in particular those listed above.

**[0188]** Additional hyperproliferative diseases, disorders, and/or conditions include, but are not limited to, progression, and/or metastases of malignancies and related disorders such as leukemia (including acute leukemias; e.g., acute lymphocytic leukemia, acute myelocytic

leukemia [including myeloblastic, promyelocytic, myelomonocytic, monocytic, and erythroleukemia]) and chronic leukemias (e.g., chronic myelocytic [granulocytic] leukemia and chronic lymphocytic leukemia), polycythemia vera, lymphomas (e.g., Hodgkin's disease and non-Hodgkin's disease), multiple myeloma, Waldenström's macroglobulinemia, heavy chain disease, and solid tumors including, but not limited to, sarcomas and carcinomas such as fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, osteogenic sarcoma, chordoma, angiosarcoma, endotheliosarcoma, lymphangiosarcoma, lymphangioendotheliosarcoma, synovioma, mesothelioma, Ewing's tumor, leiomyosarcoma, rhabdomyosarcoma, colon carcinoma, pancreatic cancer, breast cancer, ovarian cancer, prostate cancer, squamous cell carcinoma, basal cell carcinoma, adenocarcinoma, sweat gland carcinoma, sebaceous gland carcinoma, papillary carcinoma, papillary adenocarcinomas, cystadenocarcinoma, medullary carcinoma, bronchogenic carcinoma, renal cell carcinoma, hepatoma, bile duct carcinoma, choriocarcinoma, seminoma, embryonal carcinoma, Wilm's tumor, cervical cancer, testicular tumor, lung carcinoma, small cell lung carcinoma, bladder carcinoma, epithelial carcinoma, glioma, astrocytoma, medulloblastoma, craniopharyngioma, ependymoma, pinealoma, emangioblastoma, acoustic neuroma, oligodendroglioma, meningioma, melanoma, neuroblastoma, and retinoblastoma.

**[0189]** Autoimmune diseases that may be treated with immunoconjugates may include acute and chronic immune thrombocytopenias, dermatomyositis, Sydenham's chorea, myasthenia gravis, systemic lupus erythematosus, lupus nephritis, rheumatic fever, polyglandular syndromes, bullous pemphigoid, diabetes mellitus, Henoch-Schonlein purpura, post-streptococcal nephritis, erythema nodosum, Takayasu's arteritis, ANCA-associated vasculitides, Addison's disease, rheumatoid arthritis, multiple sclerosis, sarcoidosis, ulcerative colitis, erythema multiforme, IgA nephropathy, polyarteritis nodosa, ankylosing spondylitis, Goodpasture's syndrome, thromboangitis obliterans, Sjogren's syndrome, primary biliary cirrhosis, Hashimoto's thyroiditis, thyrotoxicosis, scleroderma, chronic active hepatitis, polymyositis/dermatomyositis, polychondritis, bullous pemphigoid, pemphigus vulgaris, Wegener's granulomatosis, membranous nephropathy, amyotrophic lateral sclerosis, tabes dorsalis, giant cell arteritis/polymyalgia, pernicious anemia, rapidly progressive glomerulonephritis, psoriasis or fibrosing alveolitis.

#### **Kits**

**[0190]** Various embodiments may concern kits containing components suitable for treating diseased tissue in a patient. Exemplary kits may contain at least one conjugated antibody or other targeting moiety as described herein. If the composition containing components for

administration is not formulated for delivery via the alimentary canal, such as by oral delivery, a device capable of delivering the kit components through some other route may be included. One type of device, for applications such as parenteral delivery, is a syringe that is used to inject the composition into the body of a subject. Inhalation devices may also be used.

**[0191]** The kit components may be packaged together or separated into two or more containers. In some embodiments, the containers may be vials that contain sterile, lyophilized formulations of a composition that are suitable for reconstitution. A kit may also contain one or more buffers suitable for reconstitution and/or dilution of other reagents. Other containers that may be used include, but are not limited to, a pouch, tray, box, tube, or the like. Kit components may be packaged and maintained sterilely within the containers. Another component that can be included is instructions to a person using a kit for its use.

### EXAMPLES

**[0192]** Various embodiments of the present invention are illustrated by the following examples, without limiting the scope thereof.

#### General

**[0193]** Abbreviations used below are: DCC, dicyclohexylcarbodiimide; NHS, N-hydroxysuccinimide, DMAP, 4-dimethylaminopyridine; EEDQ, 2-ethoxy-1-ethoxycarbonyl-1,2-dihydroquinoline; MMT, monomethoxytrityl; PABOH, *p*-aminobenzyl alcohol; PEG, polyethylene glycol; SMCC, succinimidyl 4-(*N*-maleimidomethyl)cyclohexane-1-carboxylate; TBAF, tetrabutylammonium fluoride; TBDMS, *tert*-butyldimethylsilyl chloride.

**[0194]** Chloroformates of hydroxy compounds in the following examples were prepared using triphosgene and DMAP according to the procedure described in Moon et al. (J. Medicinal Chem. 51:6916-6926, 2008). Extractive work-up refers to extraction with chloroform, dichloromethane or ethyl acetate, and washing optionally with saturated bicarbonate, water, and with saturated sodium chloride. Flash chromatography was done using 230-400 mesh silica gel and methanol-dichloromethane gradient, using up to 15% v/v methanol-dichloromethane, unless otherwise stated. Reverse phase HPLC was performed by Method A using a 7.8 × 300 mm C18 HPLC column, fitted with a precolumn filter, and using a solvent gradient of 100% solvent A to 100% solvent B in 10 minutes at a flow rate of 3 mL per minute and maintaining at 100% solvent B at a flow rate of 4.5 mL per minute for 5 or 10 minutes; or by Method B using a 4.6×30 mm Xbridge C18, 2.5 μm, column, fitted with a precolumn filter, using the solvent gradient of 100% solvent A to 100% of solvent B at a flow rate of 1.5 mL per minutes for 4 min and 100 % of solvent B at a flow rate of 2 mL per

minutes for 1 minutes. Solvent A was 0.3% aqueous ammonium acetate, pH 4.46 while solvent B was 9:1 acetonitrile-aqueous ammonium acetate (0.3%), pH 4.46. HPLC was monitored by a dual in-line absorbance detector set at 360 nm and 254 nm.

**Example 1. Efficacy of Anti-HLA-DR Antibody Drug Conjugate IMMU-140 (hL243-CL2A-SN-38) in HLA-DR<sup>+</sup> Cancers *In vitro* and *In vivo***

[0195] Relapsed AML (acute myelocytic leukemia), ALL (acute lymphocytic leukemia) and MM (multiple myeloma) continue to be a therapy challenge. IMMU-114 (hL243) is a humanized anti-HLA-DR IgG<sub>4</sub> monoclonal antibody engineered to lack effector-cell functions, but retains HLA-DR binding and a broad range of antitumor effects in diverse hematological neoplasms (Stein R *et al.*, *Blood*. 2010;115:5180-90). When given subcutaneously, it demonstrated efficacy in an initial Phase I clinical trial in relapsed or refractory NHL and CLL, with a good safety profile (ClinicalTrials.gov, NCT01728207).

[0196] *In vitro*, AML has proven to be resistant to the antitumor effects of IMMU-114, despite high expression levels of HLA-DR. Likewise, in several different human ALL, CLL, and MM cell lines, IMMU-114 demonstrated a range of antitumor effects from a low of 9% to a high of 69%.

[0197] In an effort to improve the antitumor activity of IMMU-114, an antibody-drug conjugate (ADC), termed IMMU-140, was made in which IMMU-114 was conjugated with the active metabolite of irinotecan, SN-38. Another ADC utilizing SN-38 (sacituzumab govitecan) being studied in solid tumors has been well tolerated, with clinically significant objective responses in patients given multiple cycles over >6 months, with manageable neutropenia being the major toxicity. Thus, our goal was to determine if SN-38, a drug not commonly used in hematopoietic cancers, would prove to be an effective and safe therapeutic when targeted with the IMMU-114 antibody.

[0198] In this current study, the *in vitro* and *in vivo* activity of hL243-SN-38 (IMMU-140) *versus* parental IMMU-114 was examined in human AML, ALL, MM, and CLL xenografts.

*Methods*

[0199] The method used for the conjugation of SN-38 to hL243 IgG<sub>4</sub> has been previously described and resulted in a drug-to-antibody-ratio range of 6.1 to 6.6 (Moon SJ *et al.* *J. Med. Chem.* 2008;51:6916–26). The SN-38 linker (below, on left) contains a short polyethylene glycol (PEG) moiety to confer aqueous solubility. A maleimide group was incorporated for fast thiol-maleimide conjugation to mildly reduced antibody. A benzylcarbonate site provided a pH-mediated cleavage site to release the drug from the linker. The cross-linker was attached

to SN-38's 20-hydroxy position, to keep the lactone ring of the drug from opening to the less active carboxylic acid form under physiological conditions. The structure of the ADC is shown in **FIG. 1**.

**[0200]** The conjugate was characterized by size-exclusion HPLC (not shown). Unmodified IMMU-114 and IMMU-140 conjugate with a drug/antibody molar substitution of 6.1 were compared (not shown). Unmodified IMMU-114 was detected at 280 nm, and the conjugate was detected at the absorbance wavelength of SN-38, namely 360 nm. The conjugate was > 98 % monomeric (not shown).

**[0201]** There was no evidence of any loss of binding specificity of the ADC, as demonstrated by comparable binding of IMMU-140 and IMMU-114 to an HLA-DR positive human melanoma cell line (A-374) *via* a cell-based ELISA (**FIG. 2**). Both recognize the a-chain when it associates with the b-chain.  $K_D$ -values are shown in the **Table 2** below. Antibody control (h679) is a humanized anti-histamine-succinyl-glycine (HSG) IgG.

**Table 2. Binding affinities of IMMU-140 vs. IMMU-114.**

	$K_D$ (nM)	95% C.I.	$R^2$
<b>IMMU-140</b>	<b>0.77</b>	<b>0.62 to 0.91</b>	<b>0.97</b>
<b>IMMU-114</b>	<b>0.65</b>	<b>0.53 to 0.77</b>	<b>0.97</b>

**[0202]** For *in vitro* cytotoxicity assays, cells were plated in 96-well plates ( $1 \times 10^4$  cells/well) followed by addition of each test agent: Free SN-38 ( $2.5 \times 10^{-7}$  to  $3.8 \times 10^{-12}$  M), IMMU-140 ( $2.5 \times 10^{-7}$  to  $3.8 \times 10^{-12}$  M, SN-38 equivalents), and IMMU-114 ( $4 \times 10^{-8}$  to  $6.2 \times 10^{-13}$  M). Plates were incubated for 96 h before cell viability determined by MTS. Inhibition determined as percent viable cells in treated wells compared to untreated controls.

**[0203]** Apoptosis signaling was determined in cells ( $2 \times 10^6$ ) treated with 10 nM protein concentration of either IMMU-114 or IMMU-140 before being lysed and proteins (25 mg) resolved *via* SDS-PAGE. Proteins were transferred to PVD membranes for Western blotting.

**[0204]** For AML and MM disease models, NSG/SCID and C.B.-17 SCID mice received 2 Gy irradiation 24 h prior to an i.v. injection of MOLM-14 ( $2 \times 10^6$ ) or CAG cells ( $1 \times 10^7$ ), respectively.

**[0205]** ALL (MN-60) and CLL (JVM-3) were established in C.B-17 SCID mice injected i.v. with  $1 \times 10^7$  cells.

[0206] All therapies began 5 days post-tumor-cell injection. Test agents, including non-targeting control SN-38-ADCs, were administered at doses indicated in the figures (100 to 500 mg), twice-weekly for 4 wks. Animals were sacrificed at disease progression, characterized by the onset of hind-limb paralysis or loss of more than 15% body weight.

### Results

[0207] HLA-DR expression was examined in various human cancer cell lines. Human ALL, MM, CLL, and AML cell lines were harvested from tissue culture and analyzed by FACS for HLA-DR (alpha chain) expression using AlexaFluor-647-labeled IMMU-114. Mean fluorescence intensity (MFI) of IMMU-114 and non-targeting control h679 antibody demonstrated high expression of HLA-DR in all four cell lines, with MFI values for IMMU-114 of  $6.58 \times 10^4$  (MN-60 ALL cell line),  $8.07 \times 10^4$  (CAG MM cell line),  $7.87 \times 10^4$  (JVM-3 CLL cell line) and  $5.75 \times 10^3$  (MOLM-14 AML cell line). By comparison, CAG, MN-60, and JVM-3 exhibit >10-fold higher expression compared to the AML cell line, MOLM-14.

[0208] *In vitro*, IMMU-140 achieved IC<sub>50</sub>-values at low nM concentrations (ranging from 0.8 to 7.1 nM) in all four hematopoietic tumor types (ALL, MM, CLL, and AML), as shown in **Table 3** below. *In vitro*, JVM-3 demonstrated the most sensitivity to both IMMU-140 and IMMU-114. The remaining three cell lines only exhibited 50% or greater growth-inhibition in the presence of SN-38 and IMMU-140. While 50% inhibition was not achieved in those cell lines with IMMU-114, the unconjugated antibody mediated significant growth inhibition in both CAG (MM) and MN-60 (ALL) at 40 nM when compared to a non-targeting control antibody. As was reported previously with two other AML cell lines (Stein R *et al.*, *Blood*. 2010;115:5180-90), MOLM-14 also was resistant to IMMU-114, but was sensitive to IMMU-140.

**Table 3. *In vitro* cytotoxicity of IMMU-140 vs. IMMU-114 in AML, ALL, CLL and MM cells.**

Cell Line	Disease	Free SN-38 IC <sub>50</sub> (nM)	IMMU-140 <sup>‡</sup> IC <sub>50</sub> (nM)	IMMU-114	
				IC <sub>50</sub> (nM)	Maximum % Inhibition at 40 nM

JVM-3	CLL	0.51 ± 0.18	0.77 ± 0.15	1.52 ± 0.84	†65 ± 11
CAG	MM	7.02 ± 1.77	7.05 ± 2.73	>40	†28 ± 6
MN-60	ALL	0.86 ± 0.09	1.29 ± 0.27	>40	†37 ± 10
MOLM-14	AML	*0.90 ± 0.13	1.21 ± 0.08	>40	11 ± 5

‡Concentration of IMMU-140 shown as SN-38 equivalents

\*IC<sub>50</sub> of free SN-38 is significantly different compared to IMMU-140 in MOLM-14 ( $P=0.0266$ )

†Significant inhibition compared to control antibody ( $P<0.0061$ )

**[0209]** IMMU-140 demonstrated dual-apoptosis signaling pathways mediated through its anti-HLA-DR binding of target cells and delivery of SN-38. IMMU-114 signals apoptosis *via* p-ERK-1/2 and apoptosis-inducing factor (AIF) in NHL, ALL, MM, and CLL, but not AML (Stein R et al. *Blood*. 2010;115(25):5180-5190 ). Here we demonstrated that both IMMU-114 and IMMU-140 are capable of mediating the phosphorylation of ERK1/2 and up-regulating AIF in three different hematopoietic cell lines (not shown), including the AML cell line MOLM-14 (not shown), suggesting defects in other signaling components of this pathway in AML since it is insensitive to IMMU-114 both *in vitro* and *in vivo*.

**[0210]** Importantly, IMMU-140, through its SN-38 payload, also mediated PARP cleavage in all three cell lines (not shown), including MOLM-14. The resulting double-stranded DNA (dsDNA) breaks, as evidenced by increased p-H2A.X levels, were most evident in the cells treated with IMMU-140 (not shown).

**[0211]** In experimental MOLM-14 AML, saline control and IMMU-114 treated mice succumbed to disease progression quickly, with a median survival time (MST) of only 14 and 15 days, respectively (**FIG. 3**). Conversely, mice treated with IMMU-140 had a greater than 1.5-fold increase in survival (MST=37 d,  $P=0.0031$ ) (**FIG. 3**). Further, a dose-reduction to 250 mg IMMU-140 still provided a statistically significant, greater than 80% improvement in survival compared to saline and control ADC (anti-CEA-SN-38 IMMU-130) administered at the same dose (MST=21 d,  $P=0.0031$ ) (**FIG. 3**).

**[0212]** In mice bearing MN-60 ALL xenografts (**FIG. 4**), IMMU-114 provided a >60% improvement in survival compared to saline control (MST = 37 d vs. 22.5 d, respectively;

$P < 0.0001$ ), whereas IMMU-140 increased this by another 80% (MST=66.5 d) which was significantly better than all other treatments, including IMMU-114 ( $P < 0.0001$ ) (FIG. 4). Therapy with IMMU-140 was well tolerated by the mice with no appreciable loss in body weight.

[0213] Mice with CAG MM xenografts (FIG. 5) had a greater than 151-d MST when treated with IMMU-140 compared to 32 d for saline control ( $P < 0.0001$ ). This survival benefit also was significantly higher than for mice treated with bortezomib (0.89 mg/kg) or control ADC + bortezomib (MST=32.5 d for both;  $P < 0.0001$ ) (FIG. 5). While not significant, IMMU-140 does provide a >60% improvement in survival when compared to IMMU-114 therapy (MST=94.5 d,  $P = 0.0612$ ) (FIG. 5). Bortezomib therapy combined with IMMU-114 or IMMU-140 did not improve survival above monotherapy (FIG. 5).

[0214] Mice bearing JVM-3 CLL xenografts (FIG. 6) demonstrated similar sensitivity to both IMMU-140 and IMMU-114. There was a significant survival benefit in mice treated with either the high (500 mg) or low (100 mg) dose of IMMU-140 vs. saline or control ADC treated mice ( $P < 0.0002$ ) (FIG. 6). Likewise, mice treated with either dose of IMMU-114 had >96-d MSTs ( $P < 0.0001$  vs. saline and  $P < 0.0003$  vs. control ADC) (FIG. 6). There are no significant differences between mice treated with IMMU-140 and IMMU-114 at the doses administered to the mice (FIG. 6). These results demonstrate that efficacy may be achieved at doses less than 100 mg which suggest a wide therapeutic window clinically for IMMU-140 in this disease.

[0215] In all experiments, therapy with IMMU-140 was well tolerated, as evidenced by no significant loss in body weight

### *Conclusions*

[0216] IMMU-114 is an IgG<sub>4</sub> Mab that lacks immune functions, eliminating known adverse events of prior HLA-DR Mabs. HLA-DR, as recognized by IMMU-114, is expressed on a wide range of human hematopoietic and solid cancer types. Conjugating 6-8 SN-38 molecules *via* a cleavable linker to IMMU-114 (hL243-SN-38) did not alter its binding to HLA-DR positive cells.

[0217] hL243-SN-38 (IMMU-140) provides an added benefit of a dual-therapeutic through the direct antitumor activity mediated by the IMMU-114 HLA-DR-binding moiety (p-ERK1/2 and AIF signaling) and the added cytotoxic effect of SN-38 delivery to the cells (caspase cascade and PARP cleavage). IMMU-140 antibody-drug conjugate showed higher potency than naked IMMU-114 pre-clinically in ALL and AML and an added, if not

significant, survival benefit in experimental MM and CLL. Overall, the dual-therapeutic potential of SN-38-conjugated IMM-114 (IMMU-140) allows for the ability to treat a range of HLA-DR-positive hematopoietic and solid cancers.

**[0218]** Therapy with the IMM-140 ADC proved to be superior to IMM-114 (which is active clinically in NHL and CLL) in both AML and ALL xenografts, and beneficial in MM and CLL. Most importantly, in IMM-114-refractive AML, IMM-140 demonstrated a significant antitumor effect without any undue toxicity. The data show that this new ADC is of use in these intractable malignancies.

### **Example 2. Efficacy of IMM-140 in HLA-DR<sup>+</sup> Human Melanoma**

**[0219]** Expression of the HLA-DR antigen is not limited to hematopoietic cancer, but rather is also found in skin, esophageal, stomach, colon, rectal, pancreatic, lung, breast, ovarian, bladder, endometrial, cervical, testicular, melanoma, kidney, and liver cancers. The present study was conducted to examine the efficacy of IMM-140 in non-hematopoietic HLA-DR<sup>+</sup> tumors.

#### *Cell Binding Studies*

**[0220]** LUMIGLO® chemiluminescent substrate system was used to detect antibody binding to cells. Briefly, A-375 human melanoma cells were plated into a 96 black-well, flat-clear-bottom plate overnight. The hL243-γ4P antibody was added to triplicate wells (2 μg/mL final concentration in the well). As a control for non-specific binding, a humanized anti-CD22 antibody was likewise added to another set of triplicate wells. Two plates were set up in which one was incubated at room temperature (RT) and one at 4° C. After incubating for 1 h the media was removed and the cells washed with fresh, cold media followed by the addition of a 1:20,000 dilution of goat-anti-human horseradish peroxidase-conjugated secondary antibody for 1 h at 4° C. The plates were again washed before the addition of the LUMIGLO® reagent.

**[0221]** Plates were read for luminescence using an ENVISION™ plate reader. Mean luminescent values were determined and graphed as shown in **FIG. 7**. Mean luminescence of hL243γ4 on A-375 cells, at both 4° C and RT, was greater than 48-fold higher than background and 25-fold higher than non-specific control, consistent with high expression of HLA-DR on this human melanoma cell line. In all, 4 of 4 human melanoma cell lines tested (A-375, SK-MEL-28, SK-MEL-5, and SK-MEL-2) were positive for hL243-γ4P binding (48-, 25-, 12-, and 2-fold above background, respectively).

#### *IN VIVO EFFICACY IN A-375 TUMOR XENOGRAFTS.*

[0222] Athymic NCr *nu/nu* nude mice were injected s.c. with  $5 \times 10^6$  A-375 cells per mouse. Once tumors reached approximately  $0.3 \text{ cm}^3$  in size, the animals were divided into six different treatment groups of 10 mice each. Mice received 250  $\mu\text{g}$  i.p. injections of IMMU-140 (hL243-SN-38) (DAR=5.05) twice a week for four weeks. An ADC control group consisted of mice receiving the same doses of non-tumor targeting anti-CD20 ADC (hA20-CL2A-SN-38; DAR=6.08) on the same schedule. Additionally, one group of mice received naked hL243- $\gamma$ 4P alone (250  $\mu\text{g}$ ) and one group hL243- $\gamma$ 4P plus irinotecan at doses equivalent to the ADC dose (250  $\mu\text{g}$  MAb + 7.5  $\mu\text{g}$  irinotecan). A final group received only irinotecan at 10-fold higher doses than the amount of SN-38 carried by hL243-SN-38 (i.e., 75  $\mu\text{g}$ ). All irinotecan injections were administered as i.v. injections. A final group of mice received only saline (100  $\mu\text{L}$  i.p.). Treatment groups are summarized in **Table 4** below.

**Table 4. Treatment Groups for Melanoma-Bearing Nude Mice**

<b>hL243-CL2A-SN-38 Therapy of Mice Bearing Human Melanoma Tumors (A-375)</b>			
<b>Group</b>	<b>(N)</b>	<b>Amount Injected</b>	<b>Schedule</b>
<b>1</b>	<b>10</b>	<b>Saline</b> (100 $\mu\text{L}$ i.p.)	Twice weekly x 4 wks
<b>2</b>	<b>10</b>	<b>hL243-CL2A-SN-38</b> (250 $\mu\text{g}$ i.p.)	Twice weekly x 4 wks
<b>3</b>	<b>10</b>	<b>hA20-CL2A-SN-38</b> (250 $\mu\text{g}$ i.p.)	Twice weekly x 4 wks
<b>4</b>	<b>10</b>	<b>hL243-<math>\gamma</math>4P + Irinotecan</b> (250 $\mu\text{g}$ i.p. + 7.5 $\mu\text{g}$ i.v.)	Twice weekly x 4 wks
<b>5</b>	<b>10</b>	<b>hL243-<math>\gamma</math>4P Alone</b> (250 $\mu\text{g}$ i.p.)	Twice weekly x 4 wks
<b>6</b>	<b>10</b>	<b>Irinotecan Alone</b> 10-fold excess (75 $\mu\text{g}$ i.v.)	Twice weekly x 4 wks

[0223] Tumors were measured and mice weighed weekly. Animals were euthanized for disease progression if their tumor volume exceeded  $2.0 \text{ cm}^3$  in size. A partial response was defined as shrinking the tumor  $>30\%$  from initial size. Stable disease was when the tumor volume remains between 70% and 120% of initial size. Time-to-tumor progression (TTP) was determined as time when tumor grew more than 20% from its nadir.

[0224] Statistical analysis for the tumor growth data was based on area under the curve (AUC) and TTP. Profiles of individual tumor growth were obtained through linear curve modeling. An *F*-test was employed to determine equality of variance between groups prior to

statistical analysis of growth curves. A two-tailed *t*-test was used to assess statistical significance between all the various treatment groups and controls except for the saline control in which a one-tailed *t*-test was used in the analysis. As a consequence of incompleteness of some of the growth curves (due to deaths), statistical comparisons of AUC was only performed up to the time at which the first animal within a group was sacrificed. A two-tailed *t*-test was used to compare TTP values between groups.

[0225] Mean tumor volume for all the groups when therapy began was  $0.314 \pm 0.078 \text{ cm}^3$ . Mean tumor growth curves are shown in **FIG. 8**. This disease model proved to be very aggressive with saline control tumors progressing rapidly (TTP=7 days; **Table 5**). While tumors likewise progressed in the control groups, all treatments were able to slow tumor growth relative to saline control ( $P < 0.0142$ , AUC) (**FIG. 8** and **Table 5**). However, only mice treated with hL243-SN-38 demonstrated a significant antitumor effect when compared to all other groups ( $P < 0.0244$ ; AUC) (**FIG. 8** and **Table 5**). All the mice in this group were partial responders with two mice tumor-free when the experiment ended on therapy day 70. This resulted in a greater than 3-fold delay in tumor progression when compared to all the other non-ADC control groups ( $P < 0.0005$ ) (**FIG. 8** and **Table 5**). Even though this tumor was sensitive to the non-specific ADC, treatment with hL243-SN-38 imparted an 80% greater delay in TTP compared to mice treated with the control ADC ( $28 \pm 9.9$  days vs.  $15.6 \pm 7.7$  days, respectively;  $P = 0.012$ ) (**FIG. 8** and **Table 5**). These data demonstrate that even in a mouse disease-model of an aggressive human melanoma tumor, therapy with hL243-SN-38 resulted in significant tumor regressions and delay in disease progression (**FIG. 8** and **Table 5**).

**Table 5. Time-to-tumor progression for A-375 tumor-bearing mice treated with hL243-SN-38.**

Treatment	N	% PR (TF)	TTP (days)	hL243-SN-38 vs.
				Controls ( <i>P</i> -value)
hL243-SN-38	10	100 (2)	$28.0 \pm 9.9$	N.A.
Control ADC	10	30 (1)	$15.6 \pm 7.0$	0.0120
CTP-11	10	0 (0)	$8.4 \pm 4.4$	0.0005

<b>Naked hL243 + CPT-11</b>	10	0 (0)	7.0 ± 0.0	0.0005
<b>Naked hL243</b>	10	0 (0)	7.0 ± 0.0	0.0005
<b>Saline</b>	9*	0 (0)	7.0 ± 0.0	0.0003
<b>N = Number of mice per group</b> <b>*One mouse censored as an outlier (Critical-Z test).</b> <b>% PR = Percent of mice that exhibited a positive response to treatment</b> <b>TF = Number of mice tumor-free when experiment ended.</b> <b>TTP=Time to Tumor Progression for mice not tumor-free</b> <b>N.A. = Not Applicable</b>				

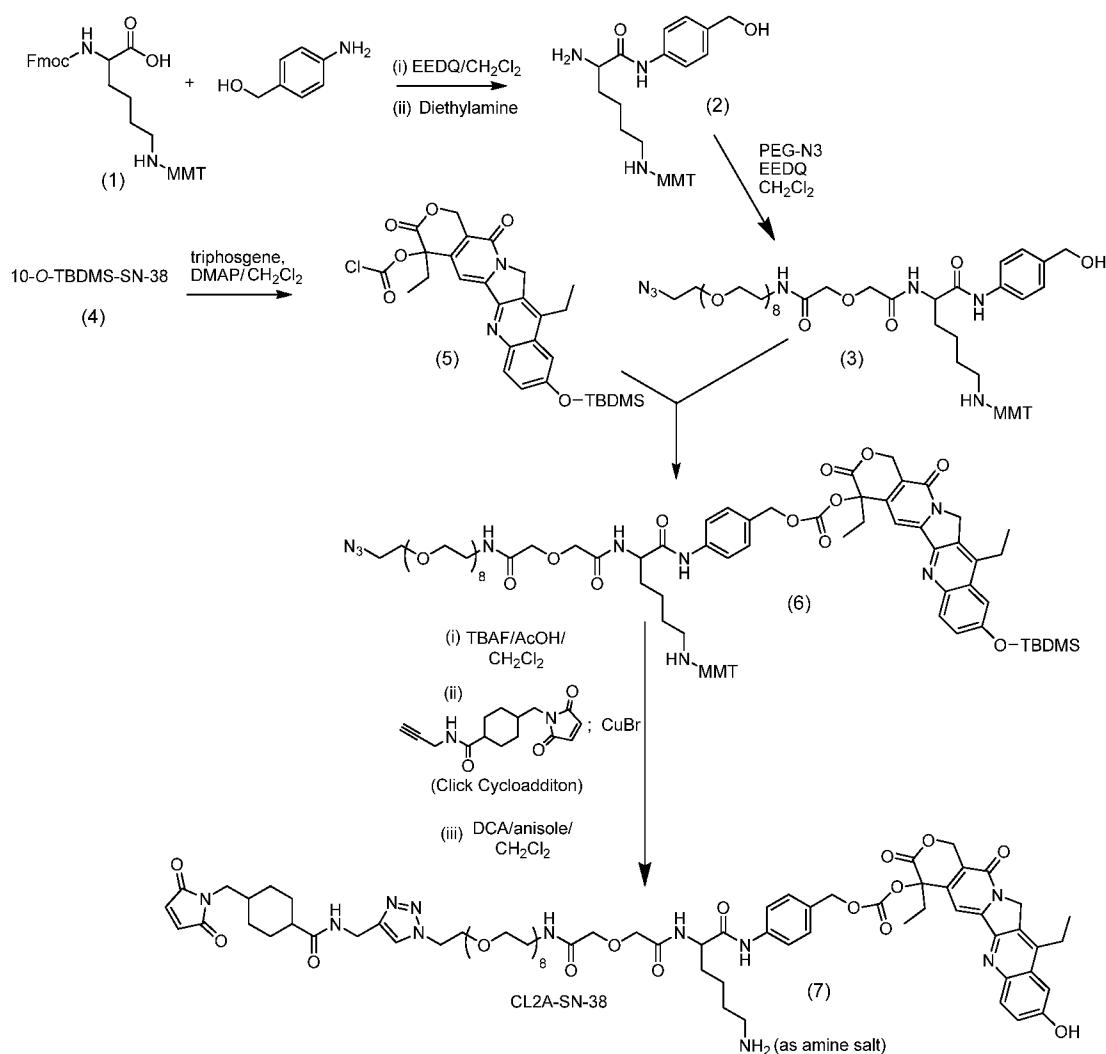
### Example 3. Preparation of CL2A-SN-38

[0226] To the mixture of commercially available Fmoc-Lys(MMT)-OH (0.943g), *p*-aminobenzyl alcohol (0.190g) in methylene chloride (10 mL) was added EEDQ (0.382g) at room temperature and stirred for 4 h. Extractive work up followed by flash chromatography yielded 1.051 g of material as white foam. All HPLC analyses were performed by Method B as stated in 'General' in section 0148. HPLC ret. time : 3.53 min., Electrospray mass spectrum showed peaks at m/e 745.8 (M+H) and m/e 780.3 (M+Cl<sup>-</sup>), consistent with structure. This intermediate (0.93 g) was dissolved in diethylamine (10 mL) and stirred for 2 h. After solvent removal, the residue was washed in hexane to obtain 0.6 g of the intermediate ((2) in Scheme-3) as colorless precipitate (91.6% pure by HPLC). HPLC ret. time : 2.06 min. Electrospray mass spectrum showed peaks at m/e 523.8 (M+H), m/e 546.2 (M+Na) and m/e 522.5 (M-H).

[0227] This crude intermediate (0.565g) was coupled with commercially available O-(2-azidoethyl)-O'-(N-diglycolyl-2-aminoethyl)heptaethyleneglycol ('PEG-N3', 0.627g) using EEDQ in methylene chloride (10 mL). Solvent removal and flash chromatography yielded 0.99 g of the product ((3) in Scheme-3; light yellow oil; 87% yield). HPLC ret. time : 2.45 min. Electrospray mass spectrum showed peaks at m/e 1061.3 (M+H), m/e 1082.7 (M+Na) and m/e 1058.8(M-H), consistent with structure. This intermediate (0.92 g) was reacted with 10-*O*-TBDMS-SN-38-20-*O*-chloroformate in methylene chloride (10 mL) for 10 min under argon. The mixture was purified by flash chromatography to obtain 0.944g as light yellow oil ((6) in Scheme-3; yield = 68%). HPLC ret. time : 4.18 min. To this intermediate (0.94 g) in methylene chloride (10 mL) was added the mixture of TBAF ( 1M in THF, 0.885 mL) and acetic acid (0.085 mL) in methylene chloride (3 mL), then stirred for 10 min. The mixture

was diluted with methylene chloride (100 mL), washed with 0.25 M sodium citrate and brine. The solvent removal yielded 0.835g of yellow oily product. HPLC ret. time : 2.80 min., (99% purity). Electrospray mass spectrum showed peaks at m/e 1478 (M+H), m/e 1500.6 (M+Na), m/e 1476.5 (M-H), m/e 1590.5 (M+TFA), consistent with structure.

Scheme-3: Preparation of CL2A-SN-38



**[0228]** This azido-derivatized SN-38 intermediate (0.803g) was reacted with 4-(N-maleimidomethyl)-N-(2-propynyl)cyclohexane-1-carboxamide (0.233 g) in methylene chloride (10 mL) in presence of CuBr (0.0083 g), DIEA (0.01 mL) and triphenylphosphine (0.015 g), for 18 h. Extractive work up, including washing with and 0.1M EDTA (10 mL), and flash chromatography yielded 0.891 g as yellow foam. (yield = 93%), HPLC ret. time : 2.60 min. Electrospray mass spectrum showed peaks at m/e 1753.3 (M+H), m/e 1751.6 (M-H), 1864.5 (M+TFA), consistent with structure. Finally, deprotection of the penultimate

intermediate ( 0.22g ) with a mixture of dichloroacetic acid ( 0.3 mL) and anisole (0.03 mL) in methylene chloride (3 mL), followed by precipitation with ether yielded 0.18 g (97% yield) of CL2A-SN-38; (7) in Scheme-3) as light yellow powder. HPLC ret. time : 1.88 min. Electrospray mass spectrum showed peaks at m/e 1480.7 (M+H), 1478.5 (M-H), consistent with structure.

**Example 4. Conjugation of bifunctional SN-38 products to mildly reduced antibodies**

[0229] Each antibody was reduced with dithiothreitol (DTT), used in a 50-to-70-fold molar excess, in 40 mM PBS, pH 7.4, containing 5.4 mM EDTA, at 37 °C (bath) for 45 min. The reduced product was purified by size-exclusion chromatography and/or diafiltration, and was buffer-exchanged into a suitable buffer at pH 6.5. The thiol content was determined by Ellman's assay, and was in the 6.5-to-8.5 SH/IgG range. Alternatively, the antibodies were reduced with Tris (2-carboxyethyl) phosphine (TCEP) in phosphate buffer at pH in the range of 5–7, followed by *in situ* conjugation. The reduced MAb was reacted with CL2A-SN-38 using DMSO at 7–15 % v/v as co-solvent, and incubating for 20 min at ambient temperature. The conjugate was purified by centrifuged SEC, passage through a hydrophobic column, and finally by ultrafiltration-diafiltration. The product was assayed for SN-38 by absorbance at 366 nm and correlating with standard values, while the protein concentration was deduced from absorbance at 280 nm, corrected for spillover of SN-38 absorbance at this wavelength. This way, the SN-38/MAb substitution ratios were determined. The purified conjugates were stored as lyophilized formulations in glass vials, capped under vacuum and stored in a –20 °C freezer. SN-38 molar substitution ratios (MSR) obtained for some of these conjugates, which were typically in the 5-to-7 range, are shown in **Table 6**.

**Table 6. SN-38/MAb Molar substitution ratios (MSR) in some conjugates**

MAb	Conjugate	MSR
hMN-14	hMN-14-[CL2A-SN-38]	6.1
hRS7	hRS7-CL2A-SN-38 using drug-linker of Example 10	5.8
hA20	hA20-CL2A-SN-38 using drug-linker of Example 10	5.8
hLL2	hLL2-CL2A-SN-38 using drug-linker of Example 10	5.7
hPAM4	hPAM4-CL2A-SN-38 using drug-linker of Example 10	5.9

**Example 5. Use of hL243-SN-38 to treat therapy-refractive metastatic colonic cancer (mCRC)**

[0230] The patient is a 67-year-old man who presents with metastatic colon cancer. Following transverse colectomy shortly after diagnosis, the patient then receives 4 cycles of FOLFOX chemotherapy in a neoadjuvant setting prior to partial hepatectomy for removal of metastatic lesions in the left lobe of the liver. This is followed by an adjuvant FOLFOX regimen for a total of 10 cycles of FOLFOX.

[0231] CT shows metastases to liver. His target lesion is a 3.0-cm tumor in the left lobe of the liver. Non-target lesions included several hypo-attenuated masses in the liver. Baseline CEA is 685 ng/mL.

[0232] After the patient signs the informed consent, hL243-SN-38 (10 mg/kg) is given every other week for 4 months. The patient experiences nausea (Grade 2) and fatigue (Grade 2) following the first treatment and continues the treatment without major adverse events. The first response assessment done (after 8 doses) shows shrinkage of the target lesion by 26% by computed tomography (CT) and his CEA level decreases to 245 ng/mL. In the second response assessment (after 12 doses), the target lesion has shrunk by 35%. His overall health and clinical symptoms are considerably improved.

**Example 6. Treatment of relapsed follicular lymphoma with IMMU-140 (anti-HLA-DR-SN-38)**

[0233] After receiving R-CHOP chemotherapy for follicular lymphoma presenting with extensive disease in various regional lymph nodes (cervical, axillary, mediastinal, inguinal, abdominal) and marrow involvement, this 68-year-old man is given the experimental agent, IMMU-114-SN-38 (anti-HLA-DR-SN-38) at a dose of 10 mg/kg weekly for 3 weeks, with a rest of 3 weeks, and then a second course for another 3 weeks. He is then evaluated for change in index tumor lesions by CT, and shows a 23% reduction according CHESON criteria. The therapy is repeated for another 2 courses, which then shows a 55% reduction of tumor by CT, which is a partial response.

**Example 7. Treatment of relapsed chronic lymphatic leukemia with IMMU-140**

[0234] A 67-year-old man with a history of CLL, as defined by the International Workshop on Chronic Lymphocytic Leukemia and World Health Organization classifications, presents with relapsed disease after prior therapies with fludarabine, dexamethasone, and rituximab, as well as a regimen of CVP. He now has fever and night sweats associated with generalized

lymph node enlargement, a reduced hemoglobin and platelet production, as well as a rapidly rising leukocyte count. His LDH is elevated and the beta-2-microglobulin is almost twice normal. The patient is given therapy with IMMU-114-SN-38 conjugate at a dosing scheme of 8 mg/kg weekly for 4 weeks, a rest of 2 weeks, and then the cycle repeated again. Evaluation shows that the patient's hematological parameters are improving and his circulating CLL cells appear to be decreasing in number. The therapy is then resumed for another 3 cycles, after which his hematological and lab values indicate that he has a partial response.

**Example 8. Immunoconjugate storage**

[0235] The conjugates described in above were purified and buffer-exchanged with 2-(N-morpholino)ethanesulfonic acid (MES), pH 6.5, and further formulated with trehalose (25 mM final concentration) and polysorbate 80 (0.01% v/v final concentration), with the final buffer concentration becoming 22.25 mM as a result of excipient addition. The formulated conjugates were lyophilized and stored in sealed vials, with storage at 2 °C – 8 °C. The lyophilized immunoconjugates were stable under the storage conditions and maintained their physiological activities.

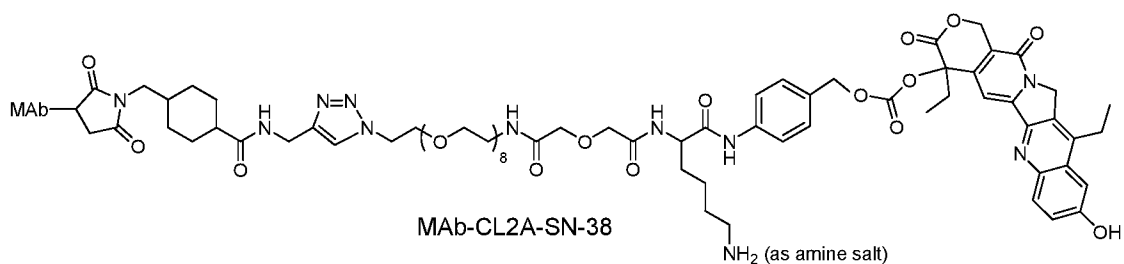
\* \* \*

[0236] From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usage and conditions without undue experimentation. All patents, patent applications and publications cited herein are incorporated by reference.

**We claim:**

1. A method of treating an HLA-DR<sup>+</sup> cancer comprising administering to a human patient with an HLA-DR<sup>+</sup> cancer an immunoconjugate comprising SN-38 conjugated to an anti-HLA-DR antibody or antigen-binding fragment thereof.
2. The method of claim 1, wherein the anti-HLA-DR antibody is an hL243 antibody, comprising the the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:1), CDR2 (WINTYTREPTYADDFKG, SEQ ID NO:2), and CDR3 (DITAVVPTGFDY, SEQ ID NO:3) and light chain CDR sequences CDR1 (RASENIYSNLA, SEQ ID NO:4), CDR2 (AASNLA, SEQ ID NO:5), and CDR3 (QHFWTTPWA, SEQ ID NO:6).
3. The method of claim 1, wherein the cancer is a hematopoietic cancer or solid tumor.
4. The method of claim 3, wherein the hematopoietic cancer is selected from the group consisting of lymphoma, leukemia, multiple myeloma, acute myeloid leukemia, acute lymphatic leukemia, non-Hodgkin's lymphoma, chronic lymphatic leukemia, chronic myeloid leukemia, DLBCL (diffuse large B-cell lymphoma), follicular lymphoma, SLL (small lymphocytic lymphoma), mantle cell lymphoma, Hodgkin's lymphoma, Burkitt lymphoma, hairy cell leukemia and marginal zone lymphoma.
5. The method of claim 3, wherein the solid tumor is selected from the group consisting of skin cancer, esophageal cancer, stomach cancer, colon cancer, rectal cancer, pancreatic cancer, lung cancer, breast cancer, ovarian cancer, bladder cancer, endometrial cancer, cervical cancer, testicular cancer, malignant melanoma, kidney cancer, and liver cancer.
6. The method of claim 1, wherein the HLA-DR<sup>+</sup> cancer is selected from the group consisting of AML (acute myelocytic leukemia), ALL (acute lymphocytic leukemia) and MM (multiple myeloma).
7. The method of claim 1, wherein the HLA-DR<sup>+</sup> cancer does not respond to treatment with unconjugated anti-HLA-DR antibody.
8. The method of claim 1, wherein the immunoconjugate is administered as a front-line therapy to patients who have not previously been treated for the cancer.
9. The method of claim 1, wherein the immunoconjugate is administered to a patient who has previously relapsed from or been resistant to at least one anti-cancer therapy.

10. The method of claim 1, wherein the immunoconjugate is administered to a patient who is not eligible for stem-cell or bone-marrow transplantation.
11. The method of claim 1, wherein the immunoconjugate is administered at a dosage of between 3 mg/kg and 18 mg/kg.
12. The method of claim 11, wherein the dosage is selected from the group consisting of 4 mg/kg, 6 mg/kg, 8 mg/kg, 9 mg/kg, 10 mg/kg, 12 mg/kg, 16 mg/kg and 18 mg/kg.
13. The method of claim 1, wherein the immunoconjugate is administered at a dosage of between 6 mg/kg and 12 mg/kg.
14. The method of claim 1, wherein the immunoconjugate is administered at a dosage of between 8 mg/kg and 10 mg/kg.
15. The method of claim 3, wherein the cancer is a solid tumor and the treatment results in a reduction in tumor size of at least 15%, at least 20%, at least 30%, or at least 40%.
16. The method of claim 1, wherein the cancer is metastatic.
17. The method of claim 16, further comprising reducing in size or eliminating the metastases.
18. The method of claim 9, wherein the patient has failed to respond to therapy with irinotecan, prior to treatment with the immunoconjugate.
19. The method of claim 1, wherein there is a linker between the SN-38 and the antibody.
20. The method of claim 19, wherein the linker is CL2A and the structure of the immunoconjugate is MAb-CL2A-SN-38



MAb-CL2A-SN-38.

21. The method of claim 20, wherein the 10-hydroxy position of SN-38 in MAb-CL2A-SN-38 is a 10-*O*-ester or 10-*O*-carbonate derivative using a 'COR' moiety, wherein "CO" is carbonyl and the "R" group is selected from (i) an N,N-disubstituted aminoalkyl group "N(CH<sub>3</sub>)<sub>2</sub>-(CH<sub>2</sub>)<sub>n</sub>-" wherein n is 1-10 and wherein the terminal amino group is optionally in the form of a quaternary salt; (ii) an alkyl residue "CH<sub>3</sub>-(CH<sub>2</sub>)<sub>n</sub>-" wherein n is 0-10; (iii) an alkoxy moiety "CH<sub>3</sub>-(CH<sub>2</sub>)<sub>n</sub>-O-" wherein n is 0-10; (iv) an "N(CH<sub>3</sub>)<sub>2</sub>-(CH<sub>2</sub>)<sub>n</sub>-O-" wherein n is 2-10; or (v) an "R<sub>1</sub>O-(CH<sub>2</sub>-CH<sub>2</sub>-O)<sub>n</sub>-CH<sub>2</sub>-CH<sub>2</sub>-O-" wherein R<sub>1</sub> is ethyl or methyl and n is an integer with values of 0-10.
22. The method of claim 1, wherein there are 6 or more SN-38 molecules attached to each antibody molecule.
23. The method of claim 1, wherein the immunoconjugate comprises 7 to 8 molecules of SN-38 conjugated to the antibody or antigen-binding fragment thereof.
24. The method of claim 1, wherein the antibody is an IgG1 or IgG4 antibody.
25. The method of claim 1, wherein the antibody is an IgG4 antibody.
26. The method of claim 1, wherein the antibody has an allotype selected from the group consisting of G1m3, G1m3,1, G1m3,2, G1m3,1,2, nG1m1, nG1m1,2 and Km3 allotypes.
27. The method of claim 1, wherein the immunoconjugate dosage is administered to the human patient once or twice a week on a schedule with a cycle selected from the group consisting of: (i) weekly; (ii) every other week; (iii) one week of therapy followed by two, three or four weeks off; (iv) two weeks of therapy followed by one, two, three or four weeks off; (v) three weeks of therapy followed by one, two, three, four or five weeks off; (vi) four weeks of therapy followed by one, two, three, four or five weeks off; (vii) five weeks of therapy followed by one, two, three, four or five weeks off; and (viii) monthly.
28. The method of claim 27, wherein the cycle is repeated 4, 6, 8, 10, 12, 16 or 20 times.
29. The method of claim 1, wherein the immunoconjugate is administered in combination with one or more therapeutic modalities selected from the group consisting of unconjugated antibodies, radiolabeled antibodies, drug-conjugated antibodies, toxin-conjugated antibodies, gene therapy, chemotherapy, therapeutic peptides, cytokine

therapy, oligonucleotides, localized radiation therapy, surgery and interference RNA therapy.

30. The method of claim 29, wherein the therapeutic modality comprises treatment with a therapeutic agent selected from the group consisting of 5-fluorouracil, afatinib, aplidin, azaribine, anastrozole, anthracyclines, axitinib, AVL-101, AVL-291, bendamustine, bleomycin, bortezomib, bosutinib, bryostatin-1, busulfan, calicheamycin, camptothecin, carboplatin, 10-hydroxycamptothecin, carmustine, celecoxib, chlorambucil, cisplatinum, Cox-2 inhibitors, irinotecan (CPT-11), SN-38, carboplatin, cladribine, camptothecans, cyclophosphamide, crizotinib, cytarabine, dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, doxorubicin, 2-pyrrolinodoxorubicine (2P-DOX), cyanomorpholino doxorubicin, doxorubicin glucuronide, epirubicin glucuronide, erlotinib, estramustine, epidophyllotoxin, entinostat, estrogen receptor binding agents, etoposide (VP16), etoposide glucuronide, etoposide phosphate, exemestane, fingolimod, flavopiridol, floxuridine (FUdR), 3',5'-O-dioleoyl-FudR (FUdR-dO), fludarabine, flutamide, farnesyl-protein transferase inhibitors, fostamatinib, ganetespib, GDC-0834, GS-1101, gefitinib, gemcitabine, hydroxyurea, ibrutinib, idarubicin, idelalisib, ifosfamide, imatinib, L-asparaginase, lapatinib, lenolidamide, leucovorin, LFM-A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, navelbine, neratinib, nilotinib, nitrosurea, olaparib, plicomycin, procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide (an aqueous form of DTIC), transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839.
31. The method of claim 29, wherein the immunoconjugate is administered in combination with a second antibody or antigen-binding fragment thereof that binds to a tumor-associated antigen (TAA) selected from the group consisting of carbonic anhydrase IX, alpha-fetoprotein (AFP),  $\alpha$ -actinin-4, ART-4, Ba 733, BAGE, BrE3-antigen, CA125, CAMEL, CAP-1, CASP-8/m, CCL19, CCL21, CD1, CD1a, CD2, CD3, CD4, CD5, CD8, CD11A, CD14, CD15, CD16, CD18, CD19, CD20, CD21, CD22, CD23, CD25, CD29, CD30, CD32b, CD33, CD37, CD38, CD40, CD40L, CD44, CD45, CD46, CD52, CD54, CD55, CD59, CD64, CD66a-e, CD67, CD70, CD70L, CD74, CD79a, CD80, CD83, CD95, CD126, CD132, CD133, CD138, CD147, CD154, CDC27, CDK-4/m,

CDKN2A, CTLA-4, CXCR4, CXCR7, CXCL12, HIF-1 $\alpha$ , colon-specific antigen-p (CSAp), CEA (CEACAM5), CEACAM6, c-Met, DAM, EGFR, EGFRvIII, EGP-1 (TROP-2), EGP-2, ELF2-M, Ep-CAM, fibroblast growth factor (FGF), Flt-1, Flt-3, folate receptor, G250 antigen, GAGE, gp100, GRO- $\beta$ , HLA-DR, HM1.24, human chorionic gonadotropin (HCG), HER2/neu, HMGB-1, hypoxia inducible factor (HIF-1), HSP70-2M, HST-2, Ia, IGF-1R, IFN- $\gamma$ , IFN- $\alpha$ , IFN- $\beta$ , IFN- $\lambda$ , IL-4R, IL-6R, IL-13R, IL-15R, IL-17R, IL-18R, IL-2, IL-6, IL-8, IL-12, IL-15, IL-17, IL-18, IL-23, IL-25, insulin-like growth factor-1 (IGF-1), KS1-4, Le-Y, LDR/FUT, macrophage migration inhibitory factor (MIF), MAGE, MAGE-3, MART-1, MART-2, NY-ESO-1, TRAG-3, CRP, MCP-1, MIP-1A, MIP-1B, MUC1, MUC2, MUC3, MUC4, MUC5ac, MUC13, MUC16, MUM-1/2, MUM-3, NCA66, NCA95, NCA90, pancreatic cancer mucin, PD-1 receptor, placental growth factor, p53, PLAGL2, prostatic acid phosphatase, PSA, PRAME, PSMA, PIGF, ILGF, ILGF-1R, IL-6, IL-25, RS5, RANTES, T101, SAGE, S100, survivin, survivin-2B, TAC, TAG-72, tenascin, TRAIL receptors, TNF- $\alpha$ , Tn antigen, Thomson-Friedenreich antigens, tumor necrosis antigens, VEGFR, ED-B fibronectin, WT-1, 17-1A-antigen, complement factor C3, C3a, C3b, C5a, C5, an angiogenesis marker, bcl-2, bcl-6, Kras, and an oncogene product.

32. The method of claim 31, wherein the TAA is selected from the group consisting of CD19, CD20, CD22 and CD74.
33. The method of claim 31, wherein the second antibody is selected from the group consisting of hA19, hA20, hLL1 and hLL2.
34. The method of claim 1, wherein the anti-HLA-DR antibody comprises a human heavy chain  $\gamma$ 4 constant region sequence with a Ser241Pro substitution.
35. The method of claim 1, wherein the anti-HLA-DR antibody is a chimeric, humanized or human antibody.
36. The method of claim 35, wherein the anti-HLA-DR antibody is a humanized antibody comprising light chain murine L243 FR residues R37, K39, V48, F49, and G100 and heavy chain murine L243 FR residues F27, K38, K46, A68, and F91.
37. The method of claim 1, wherein the anti-HLA-DR-SN-38 immunoconjugate is administered subcutaneously.
38. The method of claim 37, wherein the immunoconjugate is administered at a dosage of 2 to 4 mg/kg.

39. The method of claim 37, wherein the immunoconjugate is administered in a volume of 1, 2 or 3 ml or less.
40. The method of claim 37, wherein a maintenance dose of immunoconjugate is administered subcutaneously after the immunoconjugate is administered intravenously to the same subject.

FIG. 1

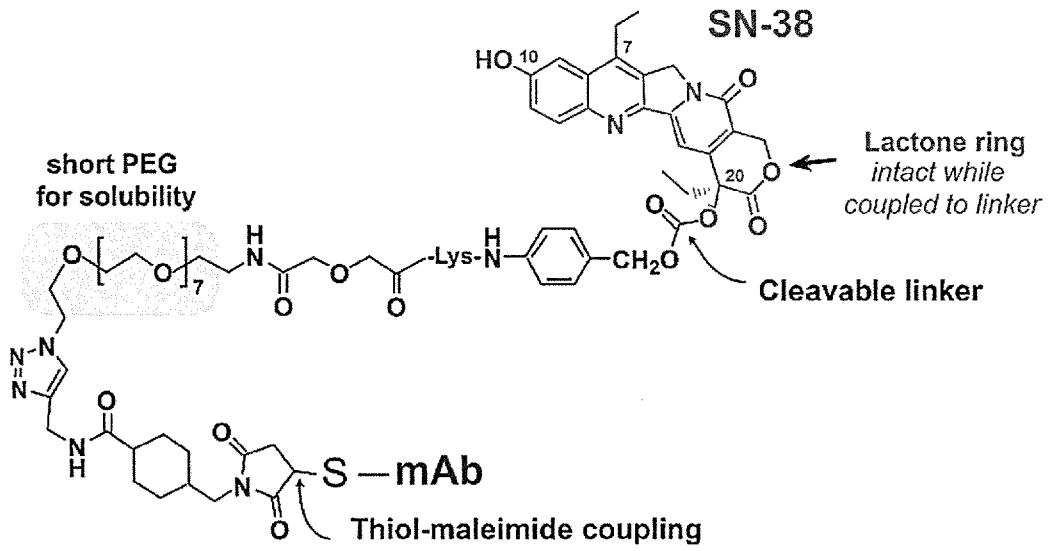


FIG. 2

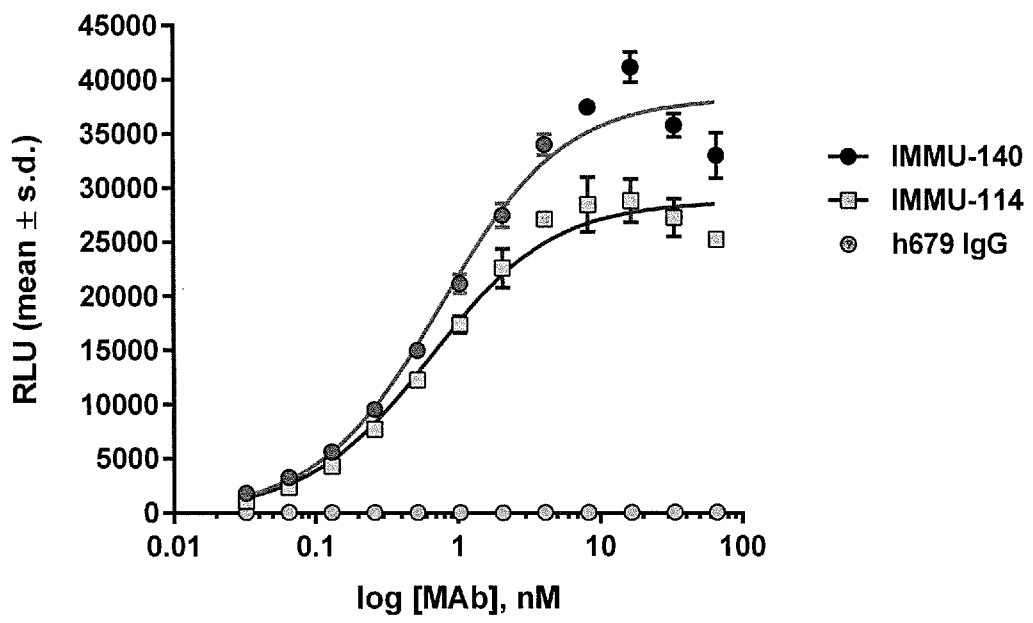


FIG. 3

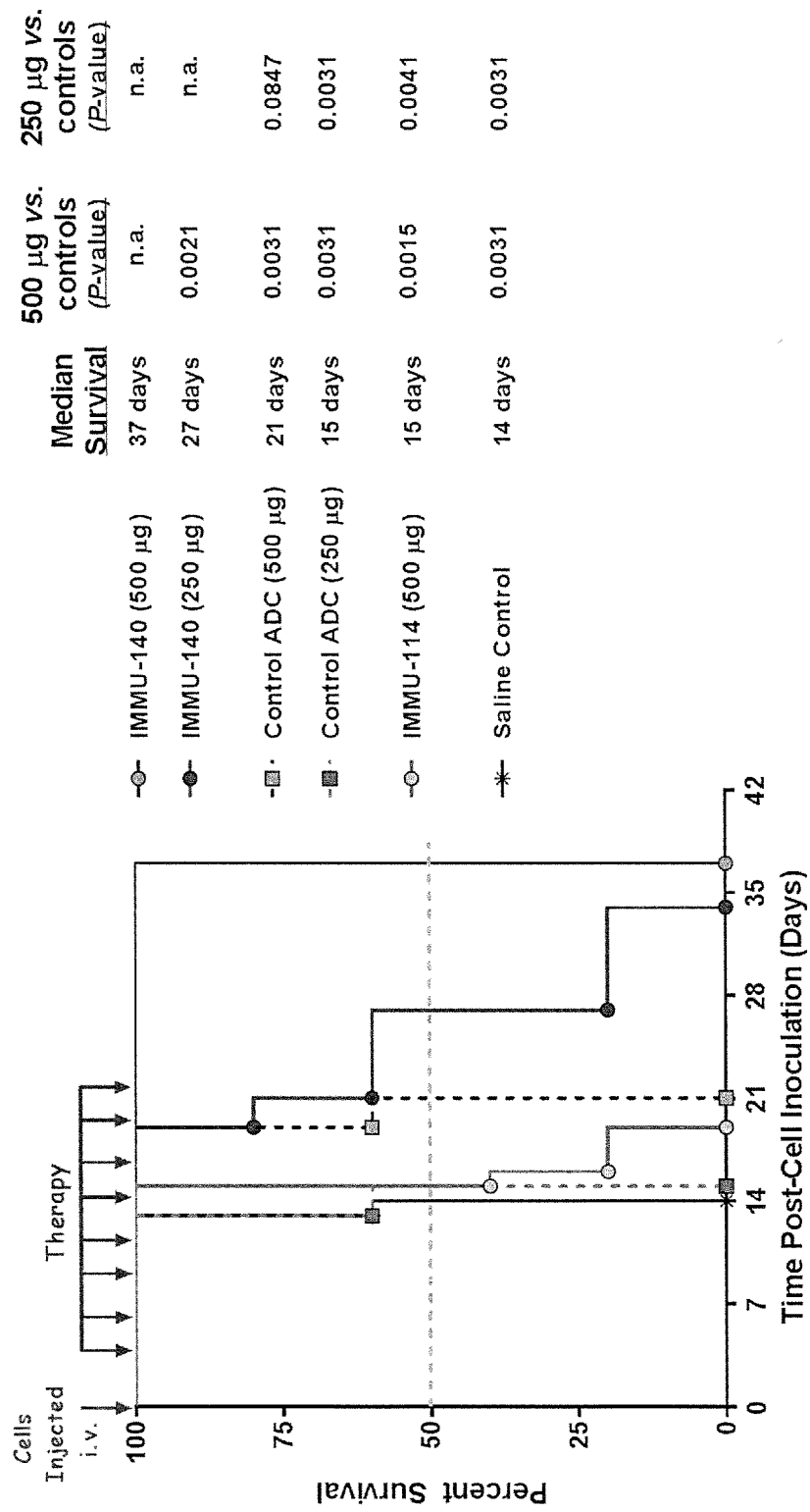


FIG. 4

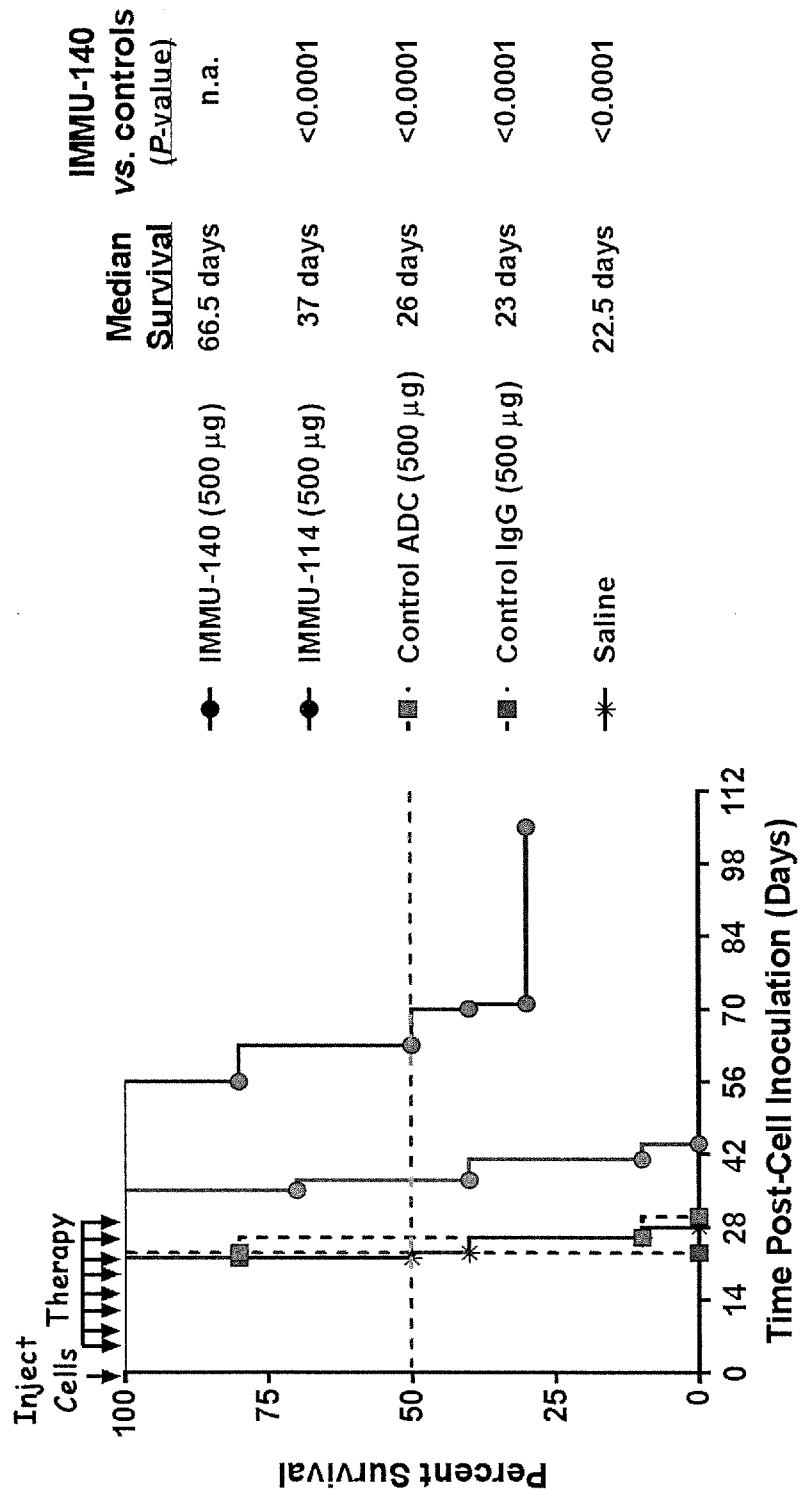


FIG. 5

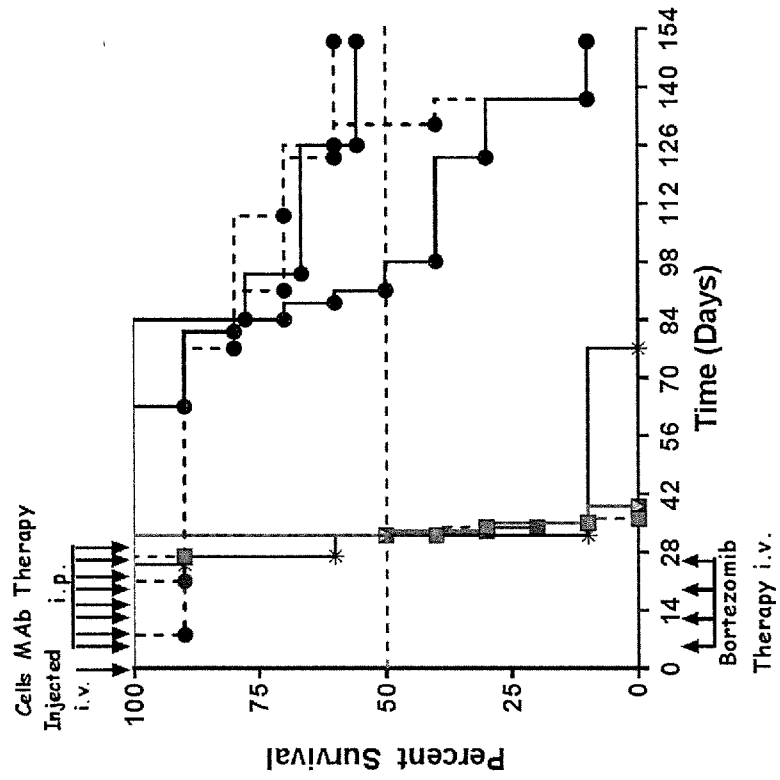


FIG. 6

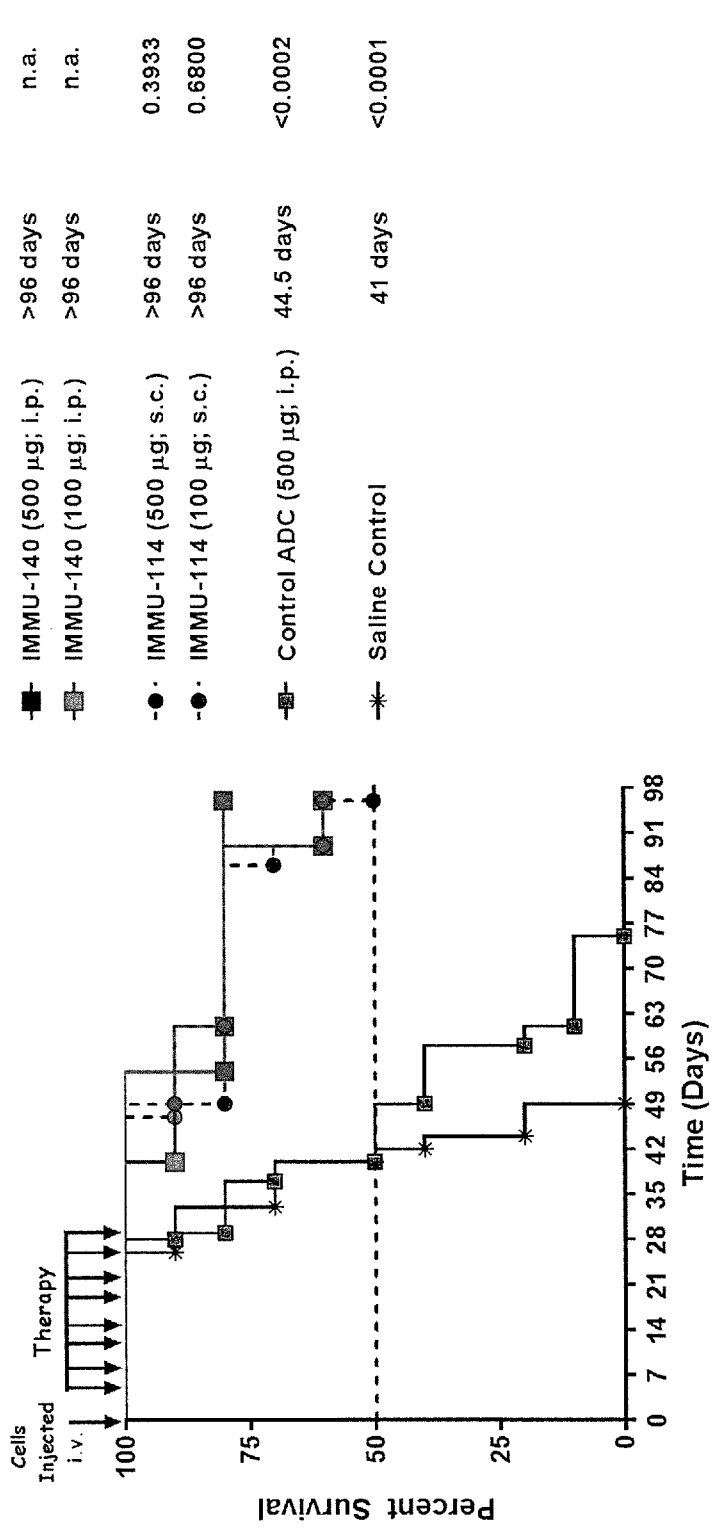


FIG. 7

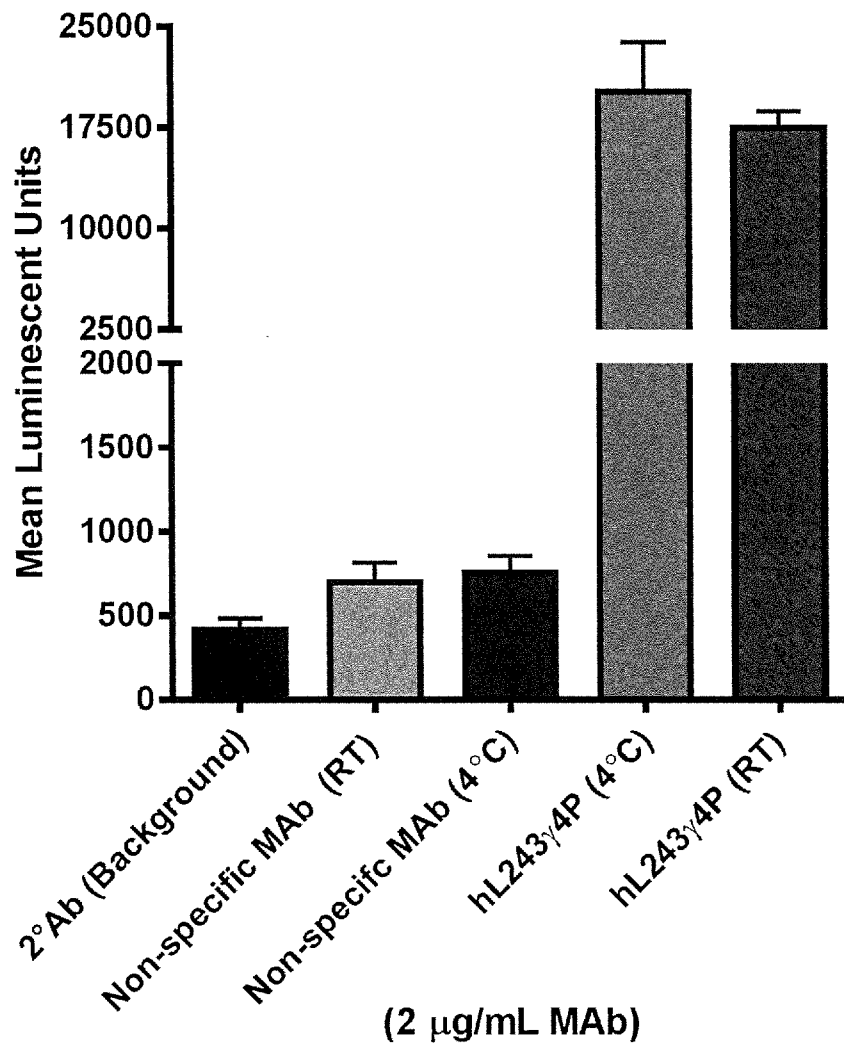
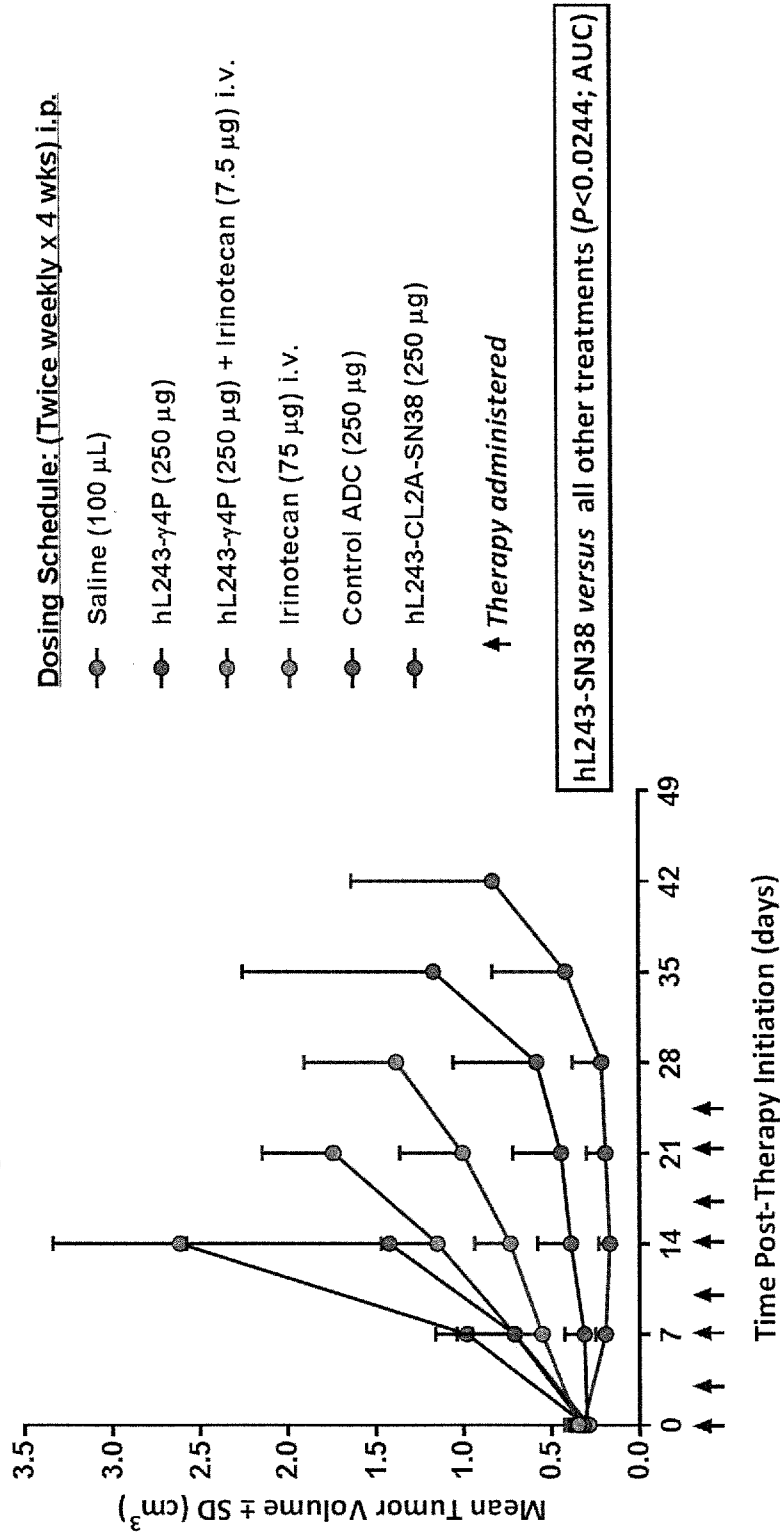
**hL243 $\gamma$ 4P Binding on the A-375 Human Melanoma Cell Line**

FIG. 8

Therapeutic Efficacy of an Anti-HLA-DR-SN-38 Immunoconjugate (hL243-CL2A-SN-38) in Mice Bearing Human Melanoma Xenografts (A-375)



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/45516

A. CLASSIFICATION OF SUBJECT MATTER		
IPC - A61K 39/395, 47/51; A61P 35/02, 35/04; C07K 16/30, 16/28 (2017.01)		
CPC - A61K 39/39558, 47/6803, 47/6849, 47/6851; C07K 16/2803, 16/2887, 16/30, 16/3007		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) See Search History document		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched See Search History document		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) See Search History document		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2015/196662 A1 (IMMUNOMEDICS, INC.) 16 July 2016; paragraphs [0008]-[0010], [0023], [0114], [0184], [0192], [0203], [0208]-[0209], [0214], [0222], [0410], [0412], [0423], [0440], [0443], [0447]; claims 1-3, 5, 9-19	1-9, 11-29, 31, 35, 37-38, 40 --- 10, 34, 36, 39
Y	WO 2013/017540 A1 (SANOFI) 7 February 2013; page 2, line 11; page 19, lines 17-23	10
Y	US 2014/0227178 A1 (IMMUNOMEDICS, INC.) 14 August 2014; paragraphs [0009], [0057]-[0058], [0182]	34, 36
Y	(YOUNES, A et al.) Phase I Mutidose-Escalation Study of the Anti-CD19 Maytansinoid Immunoconjugate SAR3419 Administered by Intravenous Infusion Every 3 Weeks to Patients With Relapsed/Refractory B-Cell Lymphoma. Journal of Clinical Oncology. 1 August 2012, Epub 2 July 2012, Vol. 30, No. 22; pages 2776-2782; abstract; page 2778, 2nd column, 2nd paragraph; DOI: 10.1200/JCO.2011.39.4403	39
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search	Date of mailing of the international search report	
29 November 2017 (29.11.2017)	22 DEC 2017	
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/45516

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing:
- a.  forming part of the international application as filed:
    - in the form of an Annex C/ST.25 text file.
    - on paper or in the form of an image file.
  - b.  furnished together with the international application under PCT Rule 13ter.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.
  - c.  furnished subsequent to the international filing date for the purposes of international search only:
    - in the form of an Annex C/ST.25 text file (Rule 13ter.1(a)).
    - on paper or in the form of an image file (Rule 13ter.1(b) and Administrative Instructions, Section 713).
2.  In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
3. Additional comments:

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/45516

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

.-\*\*\*-Please see supplemental page-\*\*\*-

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-20, 21 (in-part), 22-28, 29 (in-part), 31 (in-part) and 34-40; MAb-CL2A-SN-38 (immunoconjugate) and unconjugated antibodies that bind to carbonic anhydrase IX (combined therapeutic)

- Remark on Protest**
- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No.

PCT/US17/45516

.-\*\*\*-Continued from Box No. III: Observations where unity of invention is lacking-\*\*\*-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Groups I+, Claims 1-40, MAb-CL2A-SN-38, and unconjugated antibodies that bind to carbonic anhydrase IX are directed toward a method of treating an HLA-DR+ cancer comprising administering to a human patient an immunoconjugate comprising SN-38 conjugated to an anti-HLA-DR antibody.

The method will be searched to the extent that it encompasses an immunoconjugate encompassing MAb-CL2A-SN-38 (first exemplary immunoconjugate); and combinations encompassing unconjugated antibodies that bind to carbonic anhydrase IX (first exemplary combined therapeutic); Applicant is invited to elect additional immunoconjugate(s), with fully specified linker and/or SN-38 structure(s) or modification(s) thereto, such that the structure of the immunoconjugate is fully specified; and/or specific therapeutic compounds or antibodies which bind to specific targets for therapeutic combination(s), to be searched. Additional immunoconjugate(s) and/or therapeutic(s) for combination will be searched upon the payment of additional fees. It is believed that claims 1-20, 21 (in-part), 22-28, 29 (in-part), 31 (in-part) and 34-40 encompass this first named invention and thus these claims will be searched without fee to the extent that they encompass MAb-CL2A-SN-38 (immunoconjugate) and unconjugated antibodies that bind to carbonic anhydrase IX (combined therapeutic). Applicants must specify the claims that encompass any additionally elected immunoconjugate(s) and/or combined therapeutic(s). Applicants must further indicate, if applicable, the claims which encompass the first named invention, if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the "+" group(s) will result in only the first claimed invention to be searched/examined. An exemplary election would be a combined therapeutic encompassing 5-fluorouracil (first exemplary elected combined therapeutic).

Groups I+ share the technical features including: a method of treating an HLA-DR+ cancer comprising administering to a human patient with an HLA-DR+ cancer an immunoconjugate comprising SN-38 conjugated to an anti-HLA-DR antibody or antigen-binding fragment thereof.

However, these shared technical features are previously disclosed by US 2015/0196662 A1 to Immunomedics, Inc. (hereinafter 'Immunomedics').

Immunomedics discloses a method of treating a cancer (a method of treating a cancer; paragraph [0184]) comprising administering to a human patient with a cancer (paragraphs [0008], [0184], [0439], [0440]) an immunoconjugate comprising SN-38 conjugated to an anti-HLA-DR antibody or antigen-binding fragment thereof (an immunoconjugate comprising SN-38 conjugated to an anti-HLA-DR antibody or antigen-binding fragment thereof; paragraphs [0008], [0192], [0439], [0440]). Immunomedics further discloses wherein antigens expressed by the cancer cells include HLA-DR (wherein antigens expressed by the cancer cells include HLA-DR; paragraph [0010]). Immunomedics does not disclose an HLA-DR+ cancer. However, it would have been obvious to a person of ordinary skill in the art at the time of the invention was made to have determined whether a cancer, such as lymphoma or leukemia, expressed HLA-DR, as disclosed by Immunomedics, in order to identify the cancer as an HLA-DR+ cancer, in order to increase the likelihood that treatment with an anti-HLA-DR antibody, as disclosed by Immunomedics, would have been successful.

Since none of the special technical features of the Groups I+ inventions is found in more than one of the inventions, and since all of the shared technical features are previously disclosed by the Immunomedics reference, unity of invention is lacking.