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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 April 2015 (02.04.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/047510 A1

(51) International Patent Classification:
C07K 16/30 (2006.01)

(21) International Application Number:
PCT/US2014/045074

(22) International Filing Date:
1 July 2014 (01.07.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
14/040,024 27 September 2013 (27.09.2013) US
14/258,228 22 April 2014 (22.04.2014) US
14/259,469 23 April 2014 (23.04.2014) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

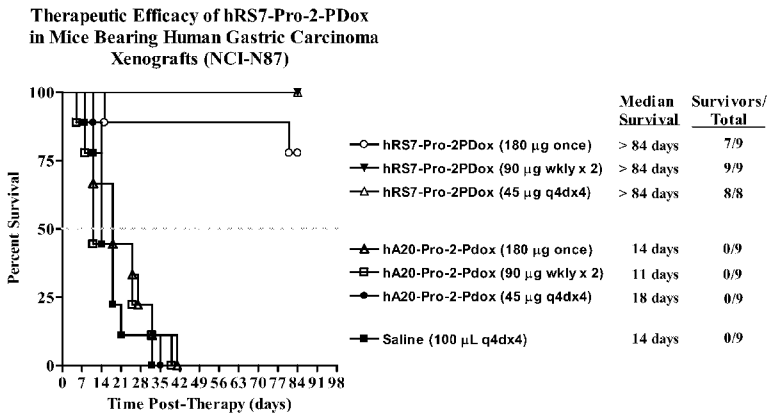
Published:

— *with international search report (Art. 21(3))*

— *with sequence listing part of description (Rule 5.2(a))*

(54) Title: ANTI-TROP-2 ANTIBODY-DRUG CONJUGATES AND USES THEREOF

FIG. 7



(57) Abstract: Described herein are compositions and methods of use of antibody-drug conjugates (ADCs) comprising an anti-Trop-2 antibody or antigen-binding fragment thereof, conjugated to one or more cytotoxic drugs. Preferably, the antibody is an RS7, 162-46.2 or MAB650 antibody. More preferably, the antibody is humanized. Preferably the drug is SN-38, pro-2-pyrrolinodoxorubicin, paclitaxel, calichemicin, DM1, DM3, DM4, MMAE, MMAD or MMAF. The compositions and methods are of use to treat Trop-2 expressing cancers, such as breast, ovarian, cervical, endometrial, lung, prostate, colon, stomach, esophageal, bladder, renal, pancreatic, thyroid, epithelial or head-and-neck cancer. Preferably, the cancer is one that is resistant to one or more standard cancer therapies. More preferably, the anti-Trop-2 antibody binds to Trop-2 expressed on normal cells, but administration of the anti-Trop-2 ADC to human cancer patients at a therapeutically effective dosage produces only limited toxicity.

WO 2015/047510 A1

ANTI-TROP-2 ANTIBODY-DRUG CONJUGATES AND USES THEREOF

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RELATED APPLICATIONS

[001] This application claims priority to U.S. Patent Applications 14/259,469, filed April 23, 2014; 14/040,024, filed September 27, 2013; and 14/258,228, filed April 22, 2014. The text of each priority application is incorporated herein by reference in its entirety.

SEQUENCE LISTING

[002] 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 June 24, 2014, is named IMM184WO8_SL.txt and is 44,899 bytes in size.

BACKGROUND OF THE INVENTION

Field of the Invention

[003] This invention relates to antibody-drug conjugates (ADCs) comprising one or more cytotoxic drug moieties conjugated to an antibody or antigen-binding antibody fragment that binds to Trop-2 antigen (also known as EGP-1, TACSTD2, M1S1, GP50, or GA733-1). In preferred embodiments, the antibody may be a humanized RS7 antibody and the drug may be SN-38 or pro-2PDox. However, the embodiments are not limiting and any other known anti-Trop-2 antibody or cytotoxic drug may be utilized. More preferably, a linker such as CL2A may be used to attach the drug to the antibody or antibody fragment. However, other linkers and other known methods of conjugating drugs to antibodies may be utilized. The antibody or fragment may be attached to 1-12, 1-6, 1-5 or about six copies of drug moiety or drug-linker moiety per antibody or fragment. More preferably, the drug to antibody ratio may vary between 1.5:1 to 8:1. The anti-Trop-2 ADCs are of use for therapy of Trop-2 expressing cancers, such as breast, ovarian, cervical, endometrial, lung, prostate, colorectal, stomach, esophageal, bladder, renal, pancreatic, thyroid, and head-and-neck cancer. The ADC may be of particular use for treatment of cancers that are resistant to one or more standard anti-cancer therapies, such as colorectal cancer, pancreatic ductal cancer, triple-negative breast cancer or

small-cell lung cancer. The anti-Trop-2 ADCs may be used alone or as a combination therapy, along with one or more therapeutic modalities selected from the group consisting of surgery, radiation therapy, chemotherapy, immunomodulators, cytokines, chemotherapeutic agents, pro-apoptotic agents, anti-angiogenic agents, cytotoxic agents, drugs, toxins, radionuclides, RNAi, siRNA, a second antibody or antibody fragment, and an immunoconjugate. In preferred embodiments, the combination of ADC and other therapeutic modalities exhibits a synergistic effect or an additive effect without increased host toxicities, and is more effective to induce cancer cell death than either ADC or other therapeutic modality alone, or the sum of the effects of ADC and other therapeutic modality administered individually. The combination may include one or more therapies directed against Trop-2, such as PROXINIUM® (VB4-845, Viventia), IGN-101 (Aphton), adecatumumab (MT201, Micromet), ING-1 (Xoma) or EMD 273 066 (Lexigen). The combination may also include administering an immunotherapy subsequent to tumor reduction with the ADC, such as subsequent administration of check point inhibiting agents (including antibodies) or T-cell (or NK-cell) redirecting bispecific antibodies. Alternatively, the combination may be directed to different target antigens expressed on the same cancer, such as the combination of anti-Trop-2 ADC and a radiolabeled anti-MUC5ac antibody, for example ^{90}Y-hPAM4.

[004] In contrast to earlier reports that anti-Trop-2 antibodies did not bind to normal epithelial cells and were tumor specific (see, e.g., U.S. Patent No. 5,840,854), we have observed at least limited Trop-2 expression in numerous types of normal tissues, including breast, eye, gastrointestinal tract, kidney, lung, ovary, fallopian tube, pancreas, parathyroid, prostate, salivary gland, skin, thymus, tonsil, ureter, urinary bladder and uterus (see, e.g., Example 4 below). It was therefore surprising and unexpected that, as discussed in the Examples below, administration of therapeutically effective dosages of anti-Trop-2 ADCs to human cancer patients resulted in only limited toxicity, with no formation of antibodies against the anti-Trop-2 ADC and no fatal toxicities observed. In preferred embodiments, the anti-Trop-2 ADC can be administered to human cancer patients at therapeutically effective dosages with only limited toxicity, more preferably $\leq$ Grade 3 neutropenia, nausea, diarrhea, alopecia and vomiting and no more serious side effects. Most preferably, the anti-Trop-2 ADC can be administered to human cancer patients with tumors that were previously resistant to one or more standard anti-cancer therapies, with only limited toxicity and without inducing a fatal immune response to the ADC. Surprisingly, the anti-Trop-2 ADC can also be effective against tumors that are refractory to topoisomerase-1 or topoisomerase-2 inhibitors, such as irinotecan, the parent compound of SN-38. In other preferred embodiments,

administration of the anti-Trop-2 ADC to human cancer patients is capable of inducing partial response or stable disease of such tumors.

Related Art

[005] Trop-2 (human trophoblast-cell-surface marker) is a cell surface glycoprotein that was originally identified in normal and malignant trophoblast cells (Lipinski et al., 1981, Proc Natl. Acad Sci USA 78:5147-50). Trop-2 is highly expressed in most human carcinomas, particularly in epithelial carcinomas and adenocarcinomas, with reported low to restricted expression in normal tissues (see, e.g., Cubas et al., 2010, Molec Cancer 9:253; Stepan et al., 2011, J Histochem Cytochem 59:701-10; Varughese et al., 2011, Am J Obst Gyn 205:567e-e7). Expression of Trop-2 is associated with metastasis, increased tumor aggressiveness and decreased patient survival (Cubas et al., 2010; Varughese et al., 2011). Pathogenic effects of Trop-2 have been reported to be mediated, at least in part, by the ERK 1/2 MAPK pathway (Cubas et al., 2010).

[006] Overexpression of Trop-2 in many different types of human carcinomas and adenocarcinomas, squamous cell carcinomas, as well as its transmembrane location, render it a potential target for anti-cancer immunotherapy. A need exists for effective ADCs against Trop-2 as therapeutic agents for Trop-2 expressing cancers.

SUMMARY

[007] In various embodiments, the present invention concerns treatment of Trop-2 expressing cancers with anti-Trop-2 antibody-drug conjugates (ADCs). It has been discovered that various anti-Trop-2 antibodies can be conjugated to a variety of drugs, all having selective efficacy against Trop-2-expressing cancers. The anti-Trop-2 ADC may be used alone or as a combination therapy with one or more other therapeutic modalities, such as surgery, radiation therapy, chemotherapy, immunomodulators, cytokines, chemotherapeutic agents, pro-apoptotic agents, anti-angiogenic agents, cytotoxic agents, drugs, toxins, radionuclides, RNAi, siRNA, a second antibody or antibody fragment, or an immunoconjugate. In preferred embodiments, the anti-Trop-2 ADC may be of use for treatment of cancers for which standard therapies are not effective or to which the cancers have become refractive, such as colorectal cancer, small-cell lung cancer, pancreatic ductal and non-ductal (e.g., neuroendocrine), cancers or triple-negative breast cancer, but including also non-small cell lung cancers and endocrine- and Her2- responsive breast cancers. More preferably, the combination of ADC and other therapeutic modality is more efficacious than

either alone, or the sum of the effects of individual treatments, especially without a concomitant increase in toxic side effects.

[008] In a specific embodiment, the anti-Trop-2 antibody may be a humanized RS7 antibody (see, e.g., U.S. Patent No. 7,238,785, the Figures and Examples section of which are incorporated herein by reference), comprising the light chain CDR sequences CDR1 (KASQDVSIAVA, SEQ ID NO:1); CDR2 (SASYRYT, SEQ ID NO:2); and CDR3 (QQHYITPLT, SEQ ID NO:3) and the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:4); CDR2 (WINTYTGEPTYTDDFKG, SEQ ID NO:5) and CDR3 (GGFGSSYWYFDV, SEQ ID NO:6). However, as discussed below other anti-Trop-2 antibodies are known and may be used in the subject ADCs. A number of cytotoxic drugs of use for cancer treatment are well-known in the art and any such known drug may be conjugated to the antibody of interest, so long as the conjugation method does not compromise the anti-Trop-2 antibody binding property by more than 65%, preferably not more than 50%, more preferably not more than 33%. In a more preferred embodiment, the drug conjugated to the antibody is a camptothecin or anthracycline, most preferably SN-38 or a pro-drug form of 2-pyrrolinodoxorubicin (2-PDox) (see, e.g., U.S. Patent Application Serial Nos. 14/175,089 and 14/204,698, the Figures and Examples section of each incorporated herein by reference).

[009] The anti-Trop-2 antibody moiety may be a monoclonal antibody, an antigen-binding antibody fragment, a bispecific or other multivalent antibody, or other antibody-based molecule. The antibody can be of various isotypes, preferably human IgG1, IgG2, IgG3 or IgG4, more preferably comprising human IgG1 hinge and constant region sequences. The antibody or fragment thereof can be a chimeric, a humanized, or a human antibody, as well as variations thereof, such as half-IgG4 antibodies (referred to as "unibodies"), as described by van der Neut Kolfschoten 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 ADC 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.

[010] The drug to be conjugated to the anti-Trop-2 antibody or antibody fragment may be selected from the group consisting of an anthracycline, a camptothecin, a tubulin inhibitor, a maytansinoid, a calicheamycin, an auristatin, a nitrogen mustard, an ethylenimine derivative,

an alkyl sulfonate, a nitrosourea, a triazene, a folic acid analog, a taxane, a COX-2 inhibitor, a pyrimidine analog, a purine analog, an antibiotic, an enzyme inhibitor, an epipodophyllotoxin, a platinum coordination complex, a vinca alkaloid, a substituted urea, a methyl hydrazine derivative, an adrenocortical suppressant, a hormone antagonist, an antimetabolite, an alkylating agent, an antimitotic, an anti-angiogenic agent, a tyrosine kinase inhibitor, an mTOR inhibitor, a heat shock protein (HSP90) inhibitor, a proteosome inhibitor, an HDAC inhibitor, a pro-apoptotic agent, and a combination thereof. As used herein, the term "drug" does not include protein or peptide toxins, such as ricin, abrin, ribonuclease (RNase), DNase I, Staphylococcal enterotoxin-A, pokeweed antiviral protein, onconase, gelonin, diphtheria toxin, *Pseudomonas* exotoxin or *Pseudomonas* endotoxin.

[011] Specific drugs of use may be 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, crizotinib, cyclophosphamide, cytarabine, dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, DM1, DM3, DM4, doxorubicin, 2-pyrrolinodoxorubicine (2-PDox), a pro-drug form of 2-PDox (pro-2-PDox), cyano-morpholino doxorubicin, doxorubicin glucuronide, endostatin, epirubicin glucuronide, erlotinib, estramustine, epidophyllotoxin, 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, lapatinib, lenolidamide, leucovorin, LFM-A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, monomethylauristatin F (MMAF), monomethylauristatin D (MMAD), monomethylauristatin E (MMAE), navelbine, neratinib, nilotinib, nitrosurea, olaparib, plicomycin, procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, SN-38, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide, transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839.

[012] Preferred optimal dosing of the subject ADCs may include a dosage of between 1 mg/kg and 20 mg/kg, preferably given either weekly, twice weekly, every other week, or

every third 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. This depends on tolerability of the dose as well as status of the patient's disease; the less toxic the therapy and the better the control of the disease, the longer the therapy can be given in repeated cycles.The dosage may be up to 24 mg/kg. 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, 18 mg/kg, 19 mg/kg, 20 mg/kg, 22 mg/kg and 24 mg/kg. Preferred dosages are 1, 2, 4, 6, 8, 9, 10, or 12 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 ADC, 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 3 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, especially in murine xenograft models where a toxic dose of the ADC is not readily established. Surprisingly, the superior efficacy allows treatment of tumors that were previously found to be resistant to one or more standard anti-cancer therapies.

[013] The anti-Trop-2 ADCs are of use for therapy of Trop-2 expressing cancers, such as breast, ovarian, cervical, endometrial, lung, prostate, colorectal, stomach, esophageal, urinary bladder, renal, pancreatic, thyroid, or head-and-neck cancer. The ADC may be of particular use for treatment of cancers that are resistant to one or more standard anti-cancer therapies, such as a metastatic colorectal cancer, triple-negative breast cancer, a HER+, ER+, progesterone+ breast cancer, metastatic non-small-cell lung cancer (NSCLC), metastatic pancreatic cancer, metastatic renal cell carcinoma, metastatic gastric cancer, metastatic prostate cancer, or metastatic small-cell lung cancer.

[014] In contrast to earlier reports that anti-Trop-2 antibodies did not bind to normal epithelial cells and were tumor specific (see, e.g., U.S. Patent No. 5,840,854), we have observed at least limited Trop-2 expression in numerous types of normal tissues, including breast, eye, gastrointestinal tract, kidney, lung, ovary, fallopian tube, pancreas, parathyroid, prostate, salivary gland, skin, thymus, tonsil, ureter, urinary bladder and uterus (see, e.g., Example 4 below). It was therefore surprising and unexpected that, as discussed in the Examples below, administration of therapeutically effective dosages of anti-Trop-2 ADCs to human cancer patients resulted in only limited toxicity, with no formation of antibodies against the anti-Trop-2 ADC and no fatal toxicities observed. In preferred embodiments, the anti-Trop-2 ADC can be administered to human cancer patients at therapeutically effective dosages with only limited toxicity, more preferably $\leq$ Grade 3 neutropenia, nausea, diarrhea, alopecia and vomiting and no more serious side effects. Most preferably, the anti-Trop-2 ADC can be administered to human cancer patients with tumors that were previously resistant to one or more standard anti-cancer therapies, with only limited toxicity and without inducing a fatal immune response to the ADC. In other preferred embodiments, administration of the anti-Trop-2 ADC to human cancer patients is capable of inducing partial response or stable disease of such tumors.

BRIEF DESCRIPTION OF THE DRAWINGS

[015] **FIG. 1.** Preclinical *in vivo* therapy of athymic nude mice, bearing Capan 1 human pancreatic carcinoma, with SN-38 conjugates of hRS7 (anti-Trop-2), hPAM4 (anti-MUC5ac), hMN-14 (anti-CEACAM5) or non-specific control hA20 (anti-CD20).

[016] **FIG. 2.** Preclinical *in vivo* therapy of athymic nude mice, bearing BxPC3 human pancreatic carcinoma, with anti-TROP2-CL2A-SN-38 conjugates compared to controls.

[017] **FIG. 3A.** Structure of doxorubicin. "Me" is a methyl group.

[018] **FIG. 3B.** Structure of 2-pyrrolinodoxorubicin,(2-PDox). "Me" is a methyl group.

[019] **FIG. 3C.** Structure of a prodrug form of 2-pyrrolinodoxorubicin,(pro-2-PDox). "Me" is a methyl group and "Ac" is an acetyl group.

[020] **FIG. 3D.** Structure of a maleimide-activated form of pro-2-PDox, for antibody coupling. "Me" is a methyl group and "Ac" is an acetyl group.

[021] **FIG. 4.** Therapy in nude mice bearing s.c. human tumor xenografts using 2.25 mg/kg protein dose (0.064 mg/kg of drug dose) of MAb-pro-2-PDox conjugates twice weekly x 2 weeks in nude mice with Capan-1 human pancreatic adenocarcinoma xenografts (n = 5).

[022] FIG. 5A. Therapy in nude mice bearing s.c. human tumor xenografts using 2.25 mg/kg protein dose (0.064 mg/kg of drug dose) of MAb-pro-2-PDox conjugates twice weekly x 2 weeks in nude mice (n = 7) with NCI-N87 human gastric carcinoma xenografts.

[023] FIG. 5B. Therapy in nude mice bearing s.c. human tumor xenografts using 2.25 mg/kg protein dose (0.064 mg/kg of drug dose) of MAb-pro-2-PDox conjugates twice weekly x 2 weeks in nude mice (n = 7) with MDA-MB-468 human breast carcinoma xenografts.

[024] FIG. 5C. Therapy in nude mice bearing s.c. human tumor xenografts using 2.25 mg/kg protein dose (0.064 mg/kg of drug dose) of MAb-pro-2-PDox conjugates twice weekly x 2 weeks in nude mice (n = 7) with BxPC3 human pancreatic carcinoma xenografts.

[025] FIG. 6A. *In vivo* efficacy of pro-2-PDox conjugates in nude mice with NCI-N87 human gastric cancer xenografts. Mice were administered a saline control.

[026] FIG. 6B. *In vivo* efficacy of pro-2-PDox conjugates in nude mice with NCI-N87 human gastric cancer xenografts. Mice were administered 45 μg of hA20-pro-2-PDox as indicated by arrows.

[027] FIG. 6C. *In vivo* efficacy of pro-2-PDox conjugates in nude mice with NCI-N87 human gastric cancer xenografts. Mice were administered 45 μg of hMN-15-pro-2-PDox as indicated by arrows.

[028] FIG. 6D. *In vivo* efficacy of pro-2-PDox conjugates in nude mice with NCI-N87 human gastric cancer xenografts. Mice were administered 45 μg of hRS7-pro-2-PDox as indicated by arrows.

[029] FIG. 6E. *In vivo* efficacy of pro-2-PDox conjugates in nude mice with NCI-N87 human gastric cancer xenografts. Mice were administered 45 μg of hLL1-pro-2-PDox as indicated by arrows.

[030] FIG. 6F. *In vivo* efficacy of pro-2-PDox conjugates in nude mice with NCI-N87 human gastric cancer xenografts. Mice were administered 45 μg of hMN-14-pro-2-PDox as indicated by arrows.

[031] FIG. 7. Effect of different dosing schedules of hRS7-pro-2-PDox on survival in nude mice with NCI-N87 human gastric carcinoma xenografts.

[032] FIG. 8A. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered a saline control.

[033] FIG. 8B. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered 45 μg q4dx4 of hRS7-pro-2-PDox.

[034] FIG. 8C. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered 90 μg weekly x 2 of hRS7-pro-2-PDox.

[035] FIG. 8D. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered a single dose of 180 μg hRS7-pro-2-PDox.

[036] FIG. 8E. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered 45 μg q4dx4 of hA20-pro-2-PDox.

[037] FIG. 8F. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered 90 μg weekly x 2 of hA20-pro-2-PDox.

[038] FIG. 8G. Dosing schedule study in mice injected with NCI-N87 human gastric cancer. Mice were administered a single dose of 180 μg hA20-pro-2-PDox.

[039] FIG. 9. Effect of different single doses of hRS7-pro-2-PDox on growth of human gastric carcinoma xenografts.

[040] FIG. 10. Effect of different single doses of hRS7-pro-2-PDox on survival of mice bearing human gastric carcinoma xenografts.

[041] FIG. 11. ADCC of various hRS7-ADCs vs. hRS7 IgG.

[042] FIG. 12A. Structures of CL2-SN-38 and CL2A-SN-38.

[043] FIG. 12B. Comparative efficacy of anti-Trop-2 ADC linked to CL2 vs. CL2A linkers versus hA20 ADC and saline control, using COLO 205 colonic adenocarcinoma. Animals were treated twice weekly for 4 weeks as indicated by the arrows. COLO 205 mice ($N = 6$) were treated with 0.4 mg/kg ADC and tumors measured twice a week.

[044] FIG. 12C. Comparative efficacy of anti-Trop-2 ADC linked to CL2 vs. CL2A linkers versus hA20 ADC and saline control, using Capan-1 pancreatic adenocarcinoma. Animals were treated twice weekly for 4 weeks as indicated by the arrows. Capan-1 mice ($N = 10$) were treated with 0.2 mg/kg ADC and tumors measured weekly.

[045] FIG. 13A. Therapeutic efficacy of hRS7-SN-38 ADC in several solid tumor-xenograft disease models. Efficacy of hRS7-CL2-SN-38 and hRS7-CL2A-SN-38 ADC treatment was studied in mice bearing human non–small cell lung, colorectal, pancreatic, or squamous cell lung tumor xenografts. All the ADCs and controls were administered in the amounts indicated (expressed as amount of SN-38 per dose; long arrows = conjugate injections, short arrows = irinotecan injections). Mice bearing Calu-3 tumors ($N = 5–7$) were injected with hRS7-CL2-SN-38 every 4 days for a total of 4 injections (q4dx4).

[046] FIG. 13B. Therapeutic efficacy of hRS7-SN-38 ADC in several solid tumor-xenograft disease models. Efficacy of hRS7-CL2-SN-38 and hRS7-CL2A-SN-38 ADC treatment was studied in mice bearing human non–small cell lung, colorectal, pancreatic, or squamous cell lung tumor xenografts. All the ADCs and controls were administered in the amounts indicated (expressed as amount of SN-38 per dose; long arrows = conjugate

injections, short arrows = irinotecan injections). COLO 205 tumor-bearing mice ($N = 5$) were injected 8 times (q4dx8) with the ADC or every 2 days for a total of 5 injections (q2dx5) with the MTD of irinotecan.

[047] FIG. 13C. Therapeutic efficacy of hRS7-SN-38 ADC in several solid tumor-xenograft disease models. Efficacy of hRS7-CL2-SN-38 and hRS7-CL2A-SN-38 ADC treatment was studied in mice bearing human non–small cell lung, colorectal, pancreatic, or squamous cell lung tumor xenografts. All the ADCs and controls were administered in the amounts indicated (expressed as amount of SN-38 per dose; long arrows = conjugate injections, short arrows = irinotecan injections). Capan-1 ($N = 10$) were treated twice weekly for 4 weeks with the agents indicated.

[048] FIG. 13D. Therapeutic efficacy of hRS7-SN-38 ADC in several solid tumor-xenograft disease models. Efficacy of hRS7-CL2-SN-38 and hRS7-CL2A-SN-38 ADC treatment was studied in mice bearing human non–small cell lung, colorectal, pancreatic, or squamous cell lung tumor xenografts. All the ADCs and controls were administered in the amounts indicated (expressed as amount of SN-38 per dose; long arrows = conjugate injections, short arrows = irinotecan injections). BxPC-3 tumor-bearing mice ($N = 10$) were treated twice weekly for 4 weeks with the agents indicated.

[049] FIG. 13E. Therapeutic efficacy of hRS7-SN-38 ADC in several solid tumor-xenograft disease models. Efficacy of hRS7-CL2-SN-38 and hRS7-CL2A-SN-38 ADC treatment was studied in mice bearing human non–small cell lung, colorectal, pancreatic, or squamous cell lung tumor xenografts. All the ADCs and controls were administered in the amounts indicated (expressed as amount of SN-38 per dose; long arrows = conjugate injections, short arrows = irinotecan injections). In addition to ADC given twice weekly for 4 week, SK-MES-1 tumor-bearing ($N = 8$) mice received the MTD of CPT-11 (q2dx5).

[050] FIG. 14A. Tolerability of hRS7-CL2A-SN-38 in Swiss-Webster mice. Fifty-six Swiss-Webster mice were administered 2 i.p. doses of buffer or the hRS7-CL2A-SN-38 3 days apart (4, 8, or 12 mg/kg of SN-38 per dose; 250, 500, or 750 mg conjugate protein/kg per dose). Seven and 15 days after the last injection, 7 mice from each group were euthanized, with blood counts and serum chemistries performed. Graphs show the percent of animals in each group that had elevated levels of AST.

[051] FIG. 14B. Tolerability of hRS7-CL2A-SN-38 in Swiss-Webster mice. Fifty-six Swiss-Webster mice were administered 2 i.p. doses of buffer or the hRS7-CL2A-SN-38 3 days apart (4, 8, or 12 mg/kg of SN-38 per dose; 250, 500, or 750 mg conjugate protein/kg per dose). Seven and 15 days after the last injection, 7 mice from each group were

euthanized, with blood counts and serum chemistries performed. Graphs show the percent of animals in each group that had elevated levels of ALT.

[052] FIG. 14C. Tolerability of hRS7-CL2A-SN-38 in Cynomolgus monkeys. Six monkeys per group were injected twice 3 days apart with buffer (control) or hRS7-CL2A-SN-38 at 0.96 mg/kg or 1.92 mg/kg of SN-38 equivalents per dose (60 and 120 mg/kg conjugate protein). All animals were bled on day −1, 3, and 6. Four monkeys were bled on day 11 in the 0.96 mg/kg group, 3 in the 1.92 mg/kg group. Changes in neutrophil counts in Cynomolgus monkeys.

[053] FIG. 14D. Tolerability of hRS7-CL2A-SN-38 in Cynomolgus monkeys. Six monkeys per group were injected twice 3 days apart with buffer (control) or hRS7-CL2A-SN-38 at 0.96 mg/kg or 1.92 mg/kg of SN-38 equivalents per dose (60 and 120 mg/kg conjugate protein). All animals were bled on day −1, 3, and 6. Four monkeys were bled on day 11 in the 0.96 mg/kg group, 3 in the 1.92 mg/kg group. Changes in platelet counts in Cynomolgus monkeys.

[054] FIG. 15. *In vitro* efficacy of anti-Trop-2-paclitaxel ADC against MDA-MB-468 human breast adenocarcinoma.

[055] FIG. 16. *In vitro* efficacy of anti-Trop-2-paclitaxel ADC against BxPC-3 human pancreatic adenocarcinoma.

[056] FIG. 17A. Comparison of *in vitro* efficacy of anti-Trop-2 ADCs (hRS7-SN-38 versus MAB650-SN-38) in Capan-1 human pancreatic adenocarcinoma.

[057] FIG. 17B. Comparison of *in vitro* efficacy of anti-Trop-2 ADCs (hRS7-SN-38 versus MAB650-SN-38) in BxPC-3 human pancreatic adenocarcinoma.

[058] FIG. 17C. Comparison of *in vitro* efficacy of anti-Trop-2 ADCs (hRS7-SN-38 versus MAB650-SN-38) in NCI-N87 human gastric adenocarcinoma.

[059] FIG. 19. IMMU-132 phase I/II data for best response by RECIST criteria.

[060] FIG. 20. IMMU-132 phase I/II data for time to progression and best response (RECIST).

[061] FIG. 21. Therapeutic efficacy of murine anti-Trop-2-SN-38 ADC (162-46.2-SN-38) compared to hRS7-SN-38 in mice bearing NCI-N87 human gastric carcinoma xenografts.

[062] FIG. 22. Therapeutic efficacy of murine anti-Trop-2-pro-2-PDox ADC (162-46.2-pro-2-PDox) compared to hRS7-pro-2-PDox in mice bearing NCI-N87 human gastric carcinoma xenografts.

[063] FIG. 23. Accumulation of SN-38 in tumors of nude mice with Capan-1 human pancreatic cancer xenografts, when administered as free irinotecan vs. IMMU-132 ADC.

[064] **FIG. 24.** Individual patient demographics and prior treatment for phase I/II IMMU-132 anti-Trop-2 ADC in pancreatic cancer patients.

[065] **FIG. 25.** Response assessment to IMMU-132 anti-Trop-2 ADC in pancreatic cancer patients.

[066] **FIG. 26.** Summary of time to progression (TTP) results in human pancreatic cancer patients administered IMMU-132 anti-Trop-2 ADC.

DETAILED DESCRIPTION

Definitions

[067] Unless otherwise specified, "a" or "an" means one or more.

[068] As used herein, “about” means plus or minus 10%. For example, “about 100” would include any number between 90 and 110.

[069] An antibody, as described 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 immunologically active (i.e., specifically binding) portion of an immunoglobulin molecule, like an antibody fragment.

[070] An antibody fragment is a portion of an antibody such as $F(ab')_2$, Fab', Fab, Fv, sFv and the like. Antibody fragments may also include single domain antibodies and IgG4 half-molecules, as discussed below. Regardless of structure, an antibody fragment binds with the same antigen that is recognized by the full-length antibody. The term "antibody fragment" also includes isolated fragments consisting of the variable regions of antibodies, 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").

[071] A chimeric antibody is a recombinant protein that contains the variable domains including the complementarity determining regions (CDRs) of an antibody derived from one species, preferably a rodent antibody, while the constant domains of the antibody molecule are derived from those of a human antibody. For veterinary applications, the constant domains of the chimeric antibody may be derived from that of other species, such as a cat or dog.

[072] A humanized antibody is a recombinant protein in which the CDRs from an antibody from one species; e.g., a rodent antibody, are transferred from the heavy and light variable chains of the rodent antibody into human heavy and light variable domains (e.g., framework region sequences). The constant domains of the antibody molecule are derived from those of

a human antibody. In certain embodiments, a limited number of framework region amino acid residues from the parent (rodent) antibody may be substituted into the human antibody framework region sequences.

[073] A human antibody is, e.g., an antibody obtained from transgenic mice that have been "engineered" to produce specific 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 murine heavy chain and light chain loci. The transgenic mice can synthesize human antibodies specific for particular 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, 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 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. Pat. Nos. 5,567,610 and 5,229,275, the Examples section of which is incorporated herein by reference.

[074] A therapeutic agent is a compound, molecule or atom which is administered separately, concurrently or sequentially with an antibody moiety or conjugated to an antibody moiety, i.e., antibody or antibody fragment, or a subfragment, and is useful in the treatment of a disease. Examples of therapeutic agents include antibodies, antibody fragments, drugs, toxins, nucleases, hormones, immunomodulators, pro-apoptotic agents, anti-angiogenic agents, boron compounds, photoactive agents or dyes and radioisotopes. Therapeutic agents of use are described in more detail below.

[075] An immunoconjugate is an antibody, antibody fragment or fusion protein conjugated to at least one therapeutic and/or diagnostic agent.

[076] A multispecific antibody is an antibody that can bind simultaneously to at least two targets that are of different structure, e.g., two different antigens, two different epitopes on the same antigen, or a hapten and/or an antigen or epitope. Multispecific, multivalent antibodies are constructs that have more than one binding site, and the binding sites are of different specificity.

[077] A bispecific antibody is an antibody that can bind simultaneously to two different targets. Bispecific antibodies (bsAb) and bispecific antibody fragments (bsFab) may have at least one arm that specifically binds to, for example, a tumor-associated antigen and at least one other arm that specifically binds to a targetable conjugate that bears a therapeutic or diagnostic agent. A variety of bispecific fusion proteins can be produced using molecular engineering.

Anti-Trop-2 Antibodies

[078] The subject ADCs include at least one antibody or fragment thereof that binds to Trop-2. In a specific preferred embodiment, the anti-Trop-2 antibody may be a humanized RS7 antibody (see, e.g., U.S. Patent No. 7,238,785, incorporated herein by reference in its entirety), comprising the light chain CDR sequences CDR1 (KASQDVSIAVA, SEQ ID NO:1); CDR2 (SASYRYT, SEQ ID NO:2); and CDR3 (QQHYITPLT, SEQ ID NO:3) and the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:4); CDR2 (WINTYTGEPTYTDDFKG, SEQ ID NO:5) and CDR3 (GGFGSSYWYFDV, SEQ ID NO:6).

[079] The RS7 antibody was a murine IgG_1 raised against a crude membrane preparation of a human primary squamous cell lung carcinoma. (Stein et al., Cancer Res. 50: 1330, 1990) The RS7 antibody recognizes a 46-48 kDa glycoprotein, characterized as cluster 13. (Stein et al., Int. J. Cancer Supp. 8:98-102, 1994) The antigen was designated as EGP-1 (epithelial glycoprotein-1), but is also referred to as Trop-2.

[080] Trop-2 is a type-I transmembrane protein and has been cloned from both human (Fornaro et al., Int J Cancer 1995; 62:610-8) and mouse cells (Sewedy et al., Int J Cancer 1998; 75:324-30). In addition to its role as a tumor-associated calcium signal transducer (Ripani et al., Int J Cancer 1998;76:671-6), the expression of human Trop-2 was shown to be necessary for tumorigenesis and invasiveness of colon cancer cells, which could be effectively reduced with a polyclonal antibody against the extracellular domain of Trop-2 (Wang et al., Mol Cancer Ther 2008;7:280-5).

[081] The growing interest in Trop-2 as a therapeutic target for solid cancers (Cubas et al., Biochim Biophys Acta 2009;1796:309-14) is attested by further reports that documented the clinical significance of overexpressed Trop-2 in breast (Huang et al., Clin Cancer Res 2005;11:4357-64), colorectal (Ohmachi et al., Clin Cancer Res 2006;12:3057-63; Fang et al., Int J Colorectal Dis 2009;24:875-84), and oral squamous cell (Fong et al., Modern Pathol 2008;21:186-91) carcinomas. The latest evidence that prostate basal cells expressing high levels of Trop-2 are enriched for *in vitro* and *in vivo* stem-like activity is particularly noteworthy (Goldstein et al., Proc Natl Acad Sci USA 2008;105:20882-7).

[082] Flow cytometry and immunohistochemical staining studies have shown that the RS7 MAb detects antigen on a variety of tumor types, with limited binding to normal human tissue (Stein et al., 1990). Trop-2 is expressed primarily by carcinomas such as carcinomas of the lung, stomach, urinary bladder, breast, ovary, uterus, and prostate. Localization and therapy studies using radiolabeled murine RS7 MAb in animal models have demonstrated tumor targeting and therapeutic efficacy (Stein et al., 1990; Stein et al., 1991).

[083] Strong RS7 staining has been demonstrated in tumors from the lung, breast, bladder, ovary, uterus, stomach, and prostate. (Stein et al., Int. J. Cancer 55:938, 1993) The lung cancer cases comprised both squamous cell carcinomas and adenocarcinomas. (Stein et al., Int. J. Cancer 55:938, 1993) Both cell types stained strongly, indicating that the RS7 antibody does not distinguish between histologic classes of non-small-cell carcinoma of the lung.

[084] The RS7 MAb is rapidly internalized into target cells (Stein et al., 1993). The internalization rate constant for RS7 MAb is intermediate between the internalization rate constants of two other rapidly internalizing MAbs, which have been demonstrated to be useful for immunoconjugate production. (*Id.*) It is well documented that internalization of immunoconjugates is a requirement for anti-tumor activity. (Pastan et al., Cell 47:641, 1986) Internalization of drug immunoconjugates has been described as a major factor in anti-tumor efficacy. (Yang et al., Proc. Nat'l Acad. Sci. USA 85: 1189, 1988) Thus, the RS7 antibody exhibits several important properties for therapeutic applications.

[085] While the hRS7 antibody is preferred, other anti-Trop-2 antibodies are known and/or publicly available and in alternative embodiments may be utilized in the subject ADCs. While humanized or human antibodies are preferred for reduced immunogenicity, in alternative embodiments a chimeric antibody may be of use. As discussed below, methods of antibody humanization are well known in the art and may be utilized to convert an available murine or chimeric antibody into a humanized form.

[086] Anti-Trop-2 antibodies are commercially available from a number of sources and include LS-C126418, LS-C178765, LS-C126416, LS-C126417 (LifeSpan BioSciences, Inc., Seattle, WA); 10428-MM01, 10428-MM02, 10428-R001, 10428-R030 (Sino Biological Inc., Beijing, China); MR54 (eBioscience, San Diego, CA); sc-376181, sc-376746, Santa Cruz Biotechnology (Santa Cruz, CA); MM0588-49D6, (Novus Biologicals, Littleton, CO); ab79976, and ab89928 (ABCAM®, Cambridge, MA).

[087] Other anti-Trop-2 antibodies have been disclosed in the patent literature. For example, U.S. Publ. No. 2013/0089872 discloses anti-Trop-2 antibodies K5-70 (Accession No. FERM BP-11251), K5-107 (Accession No. FERM BP-11252), K5-116-2-1 (Accession No. FERM BP-11253), T6-16 (Accession No. FERM BP-11346), and T5-86 (Accession No. FERM BP-11254), deposited with the International Patent Organism Depositary, Tsukuba, Japan. U.S. Patent No. 5,840,854 disclosed the anti-Trop-2 monoclonal antibody BR110 (ATCC No. HB11698). U.S. Patent No. 7,420,040 disclosed an anti-Trop-2 antibody produced by hybridoma cell line AR47A6.4.2, deposited with the IDAC (International Depository Authority of Canada, Winnipeg, Canada) as accession number 141205-05. U.S. Patent No. 7,420,041 disclosed an anti-Trop-2 antibody produced by hybridoma cell line AR52A301.5, deposited with the IDAC as accession number 141205-03. U.S. Publ. No. 2013/0122020 disclosed anti-Trop-2 antibodies 3E9, 6G11, 7E6, 15E2, 18B1. Hybridomas encoding a representative antibody were deposited with the American Type Culture Collection (ATCC), Accession Nos. PTA-12871 and PTA-12872. U.S. Patent No. 8,715,662 discloses anti-Trop-2 antibodies produced by hybridomas deposited at the AID-ICLC (Genoa, Italy) with deposit numbers PD 08019, PD 08020 and PD 08021. U.S. Patent Application Publ. No. 20120237518 discloses anti-Trop-2 antibodies 77220, KM4097 and KM4590. U.S. Patent No. 8,309,094 (Wyeth) discloses antibodies A1 and A3, identified by sequence listing. The Examples section of each patent or patent application cited above in this paragraph is incorporated herein by reference. Non-patent publication Lipinski et al. (1981, Proc Natl. Acad Sci USA, 78:5147-50) disclosed anti-Trop-2 antibodies 162-25.3 and 162-46.2.

[088] Numerous anti-Trop-2 antibodies are known in the art and/or publicly available. As discussed below, methods for preparing antibodies against known antigens were routine in the art. The sequence of the human Trop-2 protein was also known in the art (see, e.g., GenBank Accession No. CAA54801.1). Methods for producing humanized, human or chimeric antibodies were also known. The person of ordinary skill, reading the instant disclosure in light of general knowledge in the art, would have been able to make and use the genus of anti-Trop-2 antibodies in the subject ADCs.

[089] The drug to be conjugated to the anti-Trop-2 antibody or antibody fragment may be selected from the group consisting of an anthracycline, a camptothecin, a tubulin inhibitor, a maytansinoid, a calicheamycin, an auristatin, a nitrogen mustard, an ethylenimine derivative, an alkyl sulfonate, a nitrosourea, a triazene, a folic acid analog, a taxane, a COX-2 inhibitor, a pyrimidine analog, a purine analog, an antibiotic, an enzyme inhibitor, an epipodophyllotoxin, a platinum coordination complex, a vinca alkaloid, a substituted urea, a methyl hydrazine derivative, an adrenocortical suppressant, a hormone antagonist, an antimetabolite, an alkylating agent, an antimitotic, an anti-angiogenic agent, a tyrosine kinase inhibitor, an mTOR inhibitor, a heat shock protein (HSP90) inhibitor, a proteosome inhibitor, an HDAC inhibitor, a pro-apoptotic agent, and a combination thereof.

[090] Specific drugs of use may be 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, crizotinib, cyclophosphamide, cytarabine, dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, DM1, DM3, DM4, doxorubicin, 2-pyrrolinodoxorubicine (2-PDox), a pro-drug form of 2-PDox (pro-2-PDox), cyano-morpholino doxorubicin, doxorubicin glucuronide, endostatin, epirubicin glucuronide, erlotinib, estramustine, epidophyllotoxin, 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, lapatinib, lenolidamide, leucovorin, LFM-A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, monomethylauristatin F (MMAF), monomethylauristatin D (MMAD), monomethylauristatin E (MMAE), navelbine, neratinib, nilotinib, nitrosurea, olaparib, plicomycin, procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, SN-38, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide, transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839. In particularly preferred embodiments, the drug to be conjugated to the anti-Trop-2 antibody may be SN-38, pro-2-PDox or paclitaxel.

[091] Use of antibodies against targets related to Trop-2 has been disclosed for immunotherapeutics other than ADCs. The murine anti-Trop-1 IgG2a antibody edrecolomab (PANOREX®) has been used for treatment of colorectal cancer, although the murine antibody is not well suited for human clinical use (Baeuerle & Gires, 2007, Br. J Cancer 96:417-423). Low-dose subcutaneous administration of ecrecolomab was reported to induce humoral immune responses against the vaccine antigen (Baeuerle & Gires, 2007). Adecatumumab (MT201), a fully human anti-Trop-1 antibody, has been used in metastatic breast cancer and early-stage prostate cancer and is reported to act through ADCC and CDC activity (Baeuerle & Gires, 2007). MT110, a single-chain anti-Trop-1/anti-CD3 bispecific antibody construct has reported efficacy against ovarian cancer (Baeuerle & Gires, 2007). Proxinium, an immunotoxin comprising anti-Trop-1 single-chain antibody fused to Pseudomonas exotoxin, has been tested in head-and-neck and bladder cancer (Baeuerle & Gires, 2007). None of these studies contained any disclosure of the use of anti-Trop-2 immunoconjugates or of drug-conjugated antibodies.

Antibody Preparation

[092] Techniques for preparing monoclonal antibodies against virtually any target antigen, such as Trop-2, 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 an antigen, 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 antigen, culturing the clones that produce antibodies to the antigen, and isolating the antibodies from the hybridoma cultures.

[093] 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).

[094] 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.

Chimeric Antibodies

[095] 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. General techniques for cloning murine immunoglobulin variable domains are disclosed, for example, in Orlandi *et al., Proc. Nat'l Acad. Sci. USA 6*: 3833 (1989). Techniques for constructing chimeric antibodies are well known to those of skill in the art. As an example, Leung *et al., Hybridoma 13:*469 (1994), produced an LL2 chimera by combining DNA sequences encoding the V_κ and V_H domains of murine LL2, an anti-CD22 monoclonal antibody, with respective human κ and IgG_1 constant region domains.

Humanized Antibodies

[096] Techniques for producing humanized MAbs are well known in the art (see, e.g., Jones *et al., Nature 321*: 522 (1986), Riechmann *et al., Nature 332*: 323 (1988), Verhoeyen *et al., Science 239*: 1534 (1988), Carter *et al., Proc. Nat'l Acad. Sci. USA 89*: 4285 (1992), Sandhu, *Crit. Rev. Biotech. 12*: 437 (1992), and Singer *et al., J. Immun. 150*: 2844 (1993)). A chimeric or murine 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. As simply transferring mouse CDRs into human FRs often results in a reduction or even loss of antibody affinity, additional modification might be required in order to restore the original affinity of the murine antibody. This can be accomplished by the replacement of one or more human residues in the FR regions with their murine counterparts to obtain an antibody that possesses good binding affinity to its epitope. See, for example, Tempest *et al.*, *Biotechnology* 9:266 (1991) and Verhoeyen *et al.*, *Science* 239: 1534 (1988). Preferred residues for substitution include FR residues that are located within 1, 2, or 3 Angstroms of a CDR residue side chain, that are located adjacent to a CDR sequence, or that are predicted to interact with a CDR residue.

Human Antibodies

[097] 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). 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). 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.

[098] 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). 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.

[099] 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 μ, γ and κ 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). Library construction was performed according to Andris-Widhopf et al. (2000, In: *Phage Display Laboratory Manual*, Barbas et al. (eds), 1st edition, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY pp. 9.1 to 9.22). 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, as known in the art. 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).

[0100] Human antibodies may also be generated by *in vitro* activated B-cells. See U.S. Patent Nos. 5,567,610 and 5,229,275, incorporated herein by reference in their entirety. The skilled artisan will realize that these techniques are exemplary and any known method for making and screening human antibodies or antibody fragments may be utilized.

[0101] 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. Methods for obtaining human antibodies from transgenic mice are disclosed 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.

[0102] The XenoMouse® was transformed with germline-configured YACs (yeast artificial chromosomes) that contained portions of the human IgH and Igkappa loci, including the majority of the variable region sequences, along with 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.

Known Antibodies and Target Antigens

[0103] As discussed above, in preferred embodiments the ADCs are of use for treatment of Trop-2-expressing cancer. In certain embodiments, the target cancer may express one or more additional tumor-associated antigens (TAAs). Particular antibodies that may be of use for therapy of cancer within the scope of the claimed methods and compositions include, but are not limited to, LL1 (anti-CD74), LL2 or RFB4 (anti-CD22), veltuzumab (hA20, anti-CD20), rituxumab (anti-CD20), obinutuzumab (GA101, anti-CD20), lambrolizumab (anti-PD-1 receptor), nivolumab (anti-PD-1 receptor), ipilimumab (anti-CTLA-4), RS7 (anti-epithelial glycoprotein-1 (EGP-1, also known as Trop-2)), PAM4 or KC4 (both anti-mucin), MN-14 (anti-carcinoembryonic antigen (CEA, also known as CD66e or CEACAM5), MN-15 or MN-3 (anti-CEACAM6), Mu-9 (anti-colon-specific antigen-p), Immu 31 (an anti-alpha-fetoprotein), R1 (anti-IGF-1R), A19 (anti-CD19), TAG-72 (e.g., CC49), Tn, J591 or HuJ591 (anti-PSMA (prostate-specific membrane antigen)), AB-PG1-XG1-026 (anti-PSMA dimer),

D2/B (anti-PSMA), G250 (an anti-carbonic anhydrase IX MAb), L243 (anti-HLA-DR) alemtuzumab (anti-CD52), bevacizumab (anti-VEGF), cetuximab (anti-EGFR), gemtuzumab (anti-CD33), ibritumomab tiuxetan (anti-CD20); panitumumab (anti-EGFR); tositumomab (anti-CD20); PAM4 (aka clivatuzumab, anti-mucin) and trastuzumab (anti-ErbB2). Such antibodies are known in the art (e.g., U.S. Patent Nos. 5,686,072; 5,874,540; 6,107,090; 6,183,744; 6,306,393; 6,653,104; 6,730.300; 6,899,864; 6,926,893; 6,962,702; 7,074,403; 7,230,084; 7,238,785; 7,238,786; 7,256,004; 7,282,567; 7,300,655; 7,312,318; 7,585,491; 7,612,180; 7,642,239; and U.S. Patent Application Publ. No. 20050271671; 20060193865; 20060210475; 20070087001; the Examples section of each incorporated herein by reference.) Specific known antibodies of use include hPAM4 (U.S. Patent No. 7,282,567), hA20 (U.S. Patent No. 7,251,164), hA19 (U.S. Patent No. 7,109,304), hIMMU-31 (U.S. Patent No. 7,300,655), hLL1 (U.S. Patent No. 7,312,318), hLL2 (U.S. Patent No. 7,074,403), hMu-9 (U.S. Patent No. 7,387,773), hL243 (U.S. Patent No. 7,612,180), hMN-14 (U.S. Patent No. 6,676,924), hMN-15 (U.S. Patent No. 7,541,440), hR1 (U.S. Patent Application 12/772,645), hRS7 (U.S. Patent No. 7,238,785), hMN-3 (U.S. Patent No. 7,541,440), AB-PG1-XG1-026 (U.S. Patent Application 11/983,372, deposited as ATCC PTA-4405 and PTA-4406) and D2/B (WO 2009/130575) the text of each recited patent or application is incorporated herein by reference with respect to the Figures and Examples sections.

[0104] Other useful tumor-associated antigens that may be targeted include carbonic anhydrase IX, B7, CCL19, CCL21, CSAp, HER-2/*neu*, BrE3, CD1, CD1a, CD2, CD3, CD4, CD5, CD8, CD11A, CD14, CD15, CD16, CD18, CD19, CD20 (e.g., C2B8, hA20, 1F5 MAbs), CD21, CD22, CD23, CD25, CD29, CD30, CD32b, CD33, CD37, CD38, CD40, CD40L, CD44, CD45, CD46, CD47, CD52, CD54, CD55, CD59, CD64, CD67, CD70, CD74, CD79a, CD80, CD83, CD95, CD126, CD133, CD138, CD147, CD154, CEACAM5, CEACAM6, CTLA-4, alpha-fetoprotein (AFP), VEGF (e.g., AVASTIN®, fibronectin splice variant), ED-B fibronectin (e.g., L19), EGP-1 (Trop-2), EGP-2 (e.g., 17-1A), EGF receptor (ErbB1) (e.g., ERBITUX®), ErbB2, ErbB3, Factor H, FHL-1, Flt-3, folate receptor, Ga 733,GRO-β, HMGB-1, hypoxia inducible factor (HIF), HM1.24, HER-2/*neu,* histone H2B, histone H3, histone H4, insulin-like growth factor (ILGF), IFN-γ, IFN-α, IFN-β, IFN-λ, IL-2R, 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-25, IP-10, IGF-1R, Ia, HM1.24, gangliosides, HCG, the HLA-DR antigen to which L243 binds, CD66 antigens, i.e., CD66a-d or a combination thereof, MAGE, mCRP, MCP-1, MIP-1A, MIP-1B, macrophage migration-inhibitory factor (MIF), matrix metalloproteinase-2, matrix metalloproteinase-9, matrix metalloproteinase-12, MUC1, MUC2, MUC3, MUC4,

MUC5ac, placental growth factor (PlGF), PSA (prostate-specific antigen), PSMA, PAM4 antigen, PD-1 receptor, PD-L1, NCA-95, NCA-90, A3, A33, RNA, DNA, Ep-CAM, KS-1, Le(y), mesothelin, S100, tenascin, TAC, Tn antigen, Thomas-Friedenreich antigens, tumor necrosis antigens, tumor angiogenesis antigens, TNF-α, TRAIL receptor (R1 and R2), Trop-2, VEGFR, RANTES, T101, as well as cancer stem cell antigens, complement factors C3, C3a, C3b, C5a, C5, and an oncogene product.

[0105] Cancer stem cells, which are ascribed to be more therapy-resistant precursor malignant cell populations (Hill and Perris, *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 er 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). Another useful target for breast cancer therapy is the LIV-1 antigen described by Taylor et al. (*Biochem. J.* 2003; 375:51-9). The CD47 antigen is a further useful target for cancer stem cells (see, e.g., Naujokat et al., 2014, Immunotherapy 6:290-308; Goto et al., 2014, Eur J Cancer 50:1836-46; Unanue, 2013, Proc Natl Acad Sci USA 110:10886-7).

[0106] Checkpoint inhibitor antibodies have been used in cancer therapy. Immune checkpoints refer to inhibitory pathways in the immune system that are responsible for maintaining self-tolerance and modulating the degree of immune system response to minimize peripheral tissue damage. However, tumor cells can also activate immune system checkpoints to decrease the effectiveness of immune response against tumor tissues. Exemplary checkpoint inhibitor antibodies against cytotoxic T-lymphocyte antigen 4 (CTLA4, also known as CD152), programmed cell death protein 1 (PD1, also known as CD279) and programmed cell death 1 ligand 1 (PD-L1, also known as CD274), may be used in combination with one or more other agents to enhance the effectiveness of immune response against disease cells, tissues or pathogens. Exemplary anti-PD1 antibodies include lambrolizumab (MK-3475, MERCK), nivolumab (BMS-936558, BRISTOL-MYERS SQUIBB), AMP-224 (MERCK), 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). Exemplary anti-PD-L1 antibodies include MDX-1105 (MEDAREX), MEDI4736

(MEDIMMUNE) MPDL3280A (GENENTECH) and BMS-936559 (BRISTOL-MYERS SQUIBB). Anti-PD-L1 antibodies are also commercially available, for example from AFFYMETRIX EBIOSCIENCE (MIH1). Exemplary anti-CTLA4 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).

[0107] 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, and colon (e.g., Meyer-Siegler et al., 2004, *BMC Cancer* 12:34; Shachar & Haran, 2011, *Leuk Lymphoma* 52:1446-54). Milatuzumab (hLL1) is an exemplary anti-CD74 antibody of therapeutic use for treatment of MIF-mediated diseases.

[0108] Various other antibodies of use are known in the art (e.g., U.S. Patent Nos. 5,686,072; 5,874,540; 6,107,090; 6,183,744; 6,306,393; 6,653,104; 6,730.300; 6,899,864; 6,926,893; 6,962,702; 7,074,403; 7,230,084; 7,238,785; 7,238,786; 7,256,004; 7,282,567; 7,300,655; 7,312,318; 7,585,491; 7,612,180; 7,642,239 and U.S. Patent Application Publ. No. 20060193865; each incorporated herein by reference.)

[0109] 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 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.

Antibody Allotypes

[0110] 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 γ-type constant region are designated as Gm allotypes (1976, J Immunol 117:1056-59).

[0111] 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 (Stickler et al., 2011). 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 (Stickler et al., 2011).

Non-G1m1 allotype antibodies are not as immunogenic when administered to G1m1 patients (Stickler et al., 2011).

[0112] The human G1m1 allotype comprises the amino acids aspartic acid at Kabat position 356 and leucine at Kabat position 358 in the CH3 sequence of the heavy chain IgG1. The nG1m1 allotype comprises the amino acids glutamic acid at Kabat position 356 and methionine at Kabat position 358. Both G1ml and nG1ml allotypes comprise a glutamic acid residue at Kabat position 357 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 below for the exemplary antibodies rituximab (SEQ ID NO:7) and veltuzumab (SEQ ID NO:8).

Rituximab heavy chain variable region sequence (SEQ ID NO:7)

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFP
AVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDK**KA**EPKSCDKTH
TCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWY
VDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALP
APIEKTISKAKGQPREPQVYTLPPSR**DEL**TKNQVSLTCLVKGFYPSDIAVEWES
NGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNH
YTQKSLSLSPGK

Veltuzumab heavy chain variable region (SEQ ID NO:8)

ASTKGPSVFPLAPSSKSTSGGTAALGCLVKDYFPEPVTVSWNSGALTSGVHTFP
AVLQSSGLYSLSSVVTVPSSSLGTQTYICNVNHKPSNTKVDK**RV**EPKSCDKTH
TCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWY
VDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALP
APIEKTISKAKGQPREPQVYTLPPSR**EEM**TKNQVSLTCLVKGFYPSDIAVEWES
NGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFSCSVMHEALHNH
YTQKSLSLSPGK

[0113] Jefferis and Lefranc (2009, mAbs 1:1-7) reviewed sequence variations characteristic of IgG allotypes and their effect on immunogenicity. They reported that the G1m3 allotype is characterized by an arginine residue at Kabat position 214, compared to a lysine residue at Kabat 214 in the G1m17 allotype. The nG1m1,2 allotype was characterized by glutamic acid at Kabat position 356, methionine at Kabat position 358 and alanine at Kabat position 431. The G1m1,2 allotype was characterized by aspartic acid at Kabat position 356, leucine at Kabat position 358 and glycine at Kabat position 431. In addition to heavy chain constant region sequence variants, Jefferis and Lefranc (2009) reported allotypic variants in the kappa

light chain constant region, with the Km1 allotype characterized by valine at Kabat position 153 and leucine at Kabat position 191, the Km1,2 allotype by alanine at Kabat position 153 and leucine at Kabat position 191, and the Km3 allotype characterized by alanine at Kabat position 153 and valine at Kabat position 191.

[0114] 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

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

[0115] 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 G1m3 allotype, characterized by arginine at Kabat 214, and the nG1m1,2 null-allotype, characterized by glutamic acid at Kabat position 356, methionine at Kabat position 358 and alanine at Kabat position 431. 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. In alternative embodiments, the human IgG4 heavy chain in common with the G1m3 allotype has arginine at Kabat 214, glutamic acid at Kabat 356, methionine at Kabat 359 and alanine at Kabat 431. Since immunogenicity appears to relate at least in part to the residues at those locations, use of the human IgG4 heavy chain constant region sequence for therapeutic antibodies is also a preferred embodiment. Combinations of G1m3 IgG1 antibodies with IgG4 antibodies may also be of use for therapeutic administration.

Nanobodies

[0116] Nanobodies are single-domain antibodies of about 12-15 kDa in size (about 110 amino acids in length). Nanobodies can selectively bind to target antigens, like full-size antibodies, and have similar affinities for antigens. However, because of their much smaller size, they may be capable of better penetration into solid tumors. The smaller size also contributes to the stability of the nanobody, which is more resistant to pH and temperature extremes than full size antibodies (Van Der Linden et al., 1999, Biochim Biophys Act 1431:37-46). Single-domain antibodies were originally developed following the discovery that camelids (camels, alpacas, llamas) possess fully functional antibodies without light chains (e.g., Hamsen et al., 2007, Appl Microbiol Biotechnol 77:13-22). The heavy-chain antibodies consist of a single variable domain (V_{HH}) and two constant domains (C_H2 and C_H3). Like antibodies, nanobodies may be developed and used as multivalent and/or bispecific constructs. Humanized forms of nanobodies are in commercial development that are targeted to a variety of target antigens, such as IL-6R, vWF, TNF, RSV, RANKL, IL-17A & F and IgE (e.g., ABLYNX®, Ghent, Belgium), with potential clinical use in cancer and other disorders (e.g., Saerens et al., 2008, Curr Opin Pharmacol 8:600-8; Muyldermans, 2013, Ann Rev Biochem 82:775-97; Ibanez et al., 2011, J Infect Dis 203:1063-72).

[0117] The plasma half-life of nanobodies is shorter than that of full-size antibodies, with elimination primarily by the renal route. Because they lack an Fc region, they do not exhibit complement dependent cytotoxicity.

[0118] Nanobodies may be produced by immunization of camels, llamas, alpacas or sharks with target antigen, following by isolation of mRNA, cloning into libraries and screening for antigen binding. Nanobody sequences may be humanized by standard techniques (e.g., Jones et al., 1986, Nature 321: 522, Riechmann et al., 1988, Nature 332: 323, Verhoeyen et al., 1988, Science 239: 1534, Carter et al., 1992, Proc. Nat'l Acad. Sci. USA 89: 4285, Sandhu, 1992, Crit. Rev. Biotech. 12: 437, Singer et al., 1993, J. Immun. 150: 2844). Humanization is relatively straight-forward because of the high homology between camelid and human FR sequences.

[0119] In various embodiments, the subject ADCs may comprise nanobodies for targeted delivery of conjugated drug to targeted cancer cells. Nanobodies of use are disclosed, for example, in U.S. Patent Nos. 7,807,162; 7,939,277; 8,188,223; 8,217,140; 8,372,398; 8,557,965; 8,623,361 and 8,629,244, the Examples section of each incorporated herein by reference.)

Antibody Fragments

[0120] Antibody fragments are antigen binding portions of an antibody, such as $F(ab')_2$, Fab', $F(ab)_2$, Fab, Fv, sFv, scFv and the like. Antibody fragments which recognize specific epitopes can be generated by known techniques. $F(ab')_2$ fragments, for example, can be produced by pepsin digestion of the antibody molecule. These and other methods are described, for example, by Goldenberg, U.S. Pat. Nos. 4,036,945 and 4,331,647 and references contained therein. Also, see Nisonoff et al., Arch Biochem. Biophys. 89: 230 (1960); Porter, Biochem. J. 73: 119 (1959), Edelman et al., in METHODS IN ENZYMOLOGY VOL. 1, page 422 (Academic Press 1967), and Coligan at pages 2.8.1-2.8.10 and 2.10.-2.10.4. Alternatively, Fab' expression libraries can be constructed (Huse et al., 1989, Science, 246:1274-1281) to allow rapid and easy identification of monoclonal Fab' fragments with the desired specificity.

[0121] A single chain Fv molecule (scFv) comprises a VL domain and a VH domain. The VL and VH domains associate to form a target binding site. These two domains are further covalently linked by a peptide linker (L). A scFv molecule is denoted as either VL-L-VH if the VL domain is the N-terminal part of the scFv molecule, or as VH-L-VL if the VH domain is the N-terminal part of the scFv molecule. Methods for making scFv molecules and designing suitable peptide linkers are described in U.S. Pat. No. 4,704,692, U.S. Pat. No. 4,946,778, R. Raag and M. Whitlow, "Single Chain Fvs." FASEB Vol 9:73-80 (1995) and R. E. Bird and B. W. Walker, Single Chain Antibody Variable Regions, TIBTECH, Vol 9: 132-137 (1991).

[0122] Other antibody fragments, for example single domain antibody fragments, are known in the art and may be used in the claimed constructs. Single domain antibodies (VHH) may be obtained, for example, from camels, alpacas or llamas by standard immunization techniques. (See, e.g., Muyldermans et al., TIBS 26:230-235, 2001; Yau et al., J Immunol Methods 281:161-75, 2003; Maass et al., J Immunol Methods 324:13-25, 2007). The VHH may have potent antigen-binding capacity and can interact with novel epitopes that are inaccessible to conventional VH-VL pairs. (Muyldermans et al., 2001). Alpaca serum IgG contains about 50% camelid heavy chain only IgG antibodies (HCAbs) (Maass et al., 2007). Alpacas may be immunized with known antigens, such as TNF-α, and VHHs can be isolated that bind to and neutralize the target antigen (Maass et al., 2007). PCR primers that amplify virtually all alpaca VHH coding sequences have been identified and may be used to construct alpaca VHH phage display libraries, which can be used for antibody fragment isolation by standard biopanning techniques well known in the art (Maass et al., 2007).

[0123] An antibody fragment can also be prepared by proteolytic hydrolysis of a full-length antibody or by expression in E. coli or another host of the DNA coding for the fragment. An antibody fragment can be obtained by pepsin or papain digestion of full-length antibodies by conventional methods. For example, an antibody fragment can be produced by enzymatic cleavage of antibodies with pepsin to provide an approximate 100 kD fragment denoted $F(ab')_2$. This fragment can 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 an approximate 50 Kd Fab' monovalent fragment. Alternatively, an enzymatic cleavage using papain produces two monovalent Fab fragments and an Fc fragment directly.

[0124] 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 may also be used, so long as the fragments bind to the antigen that is recognized by the intact antibody.

General techniques for antibody cloning and production

[0125] Various techniques, such as production of chimeric or humanized antibodies, may involve procedures of antibody cloning and construction. The antigen-binding Vκ (variable light chain) and V_H (variable heavy chain) sequences for an antibody of interest may be obtained by a variety of molecular cloning procedures, such as RT-PCR, 5'-RACE, and cDNA library screening. The V genes of a MAb from a cell that expresses a murine MAb can be cloned by PCR amplification and sequenced. To confirm their authenticity, the cloned V_L and V_H genes can be expressed in cell culture as a chimeric Ab as described by Orlandi *et al.*, (*Proc. Natl. Acad. Sci.*, USA, 86: 3833 (1989)). Based on the V gene sequences, a humanized MAb can then be designed and constructed as described by Leung et al. (*Mol. Immunol.*, 32: 1413 (1995)).

[0126] cDNA can be prepared from any known hybridoma line or transfected cell line producing a murine MAb by general molecular cloning techniques (Sambrook et al., Molecular Cloning, A laboratory manual, 2nd Ed (1989)). The Vκ sequence for the MAb may be amplified using the primers VK1BACK and VK1FOR (Orlandi *et al.*, 1989) or the extended primer set described by Leung et al. (*BioTechniques*, 15: 286 (1993)). The V_H sequences can be amplified using the primer pair VH1BACK/VH1FOR (Orlandi *et al.*, 1989) or the primers annealing to the constant region of murine IgG described by Leung et al. (Hybridoma, 13:469 (1994)). Humanized V genes can be constructed by a combination of

long oligonucleotide template syntheses and PCR amplification as described by Leung et al. (*Mol. Immunol.*, 32: 1413 (1995)).

[0127] PCR products for Vκ can be subcloned into a staging vector, such as a pBR327-based staging vector, VKpBR, that contains an Ig promoter, a signal peptide sequence and convenient restriction sites. PCR products for V_H can be subcloned into a similar staging vector, such as the pBluescript-based VHpBS. Expression cassettes containing the Vκ and V_H sequences together with the promoter and signal peptide sequences can be excised from VKpBR and VHpBS and ligated into appropriate expression vectors, such as pKh and pG1g, respectively (Leung et al., Hybridoma, 13:469 (1994)). The expression vectors can be co-transfected into an appropriate cell and supernatant fluids monitored for production of a chimeric, humanized or human MAb. Alternatively, the Vκ and V_H expression cassettes can be excised and subcloned into a single expression vector, such as pdHL2, as described by Gillies *et al.* (*J. Immunol. Methods* 125:191 (1989) and also shown in Losman et al., *Cancer*, 80:2660 (1997)).

[0128] In an alternative embodiment, expression vectors may be transfected into host cells that have been pre-adapted for transfection, growth and expression in serum-free medium. Exemplary cell lines that may be used include the Sp/EEE, Sp/ESF and Sp/ESF-X cell lines (see, e.g., U.S. Patent Nos. 7,531,327; 7,537,930 and 7,608,425; the Examples section of each of which is incorporated herein by reference). These exemplary cell lines are based on the Sp2/0 myeloma cell line, transfected with a mutant Bcl-EEE gene, exposed to methotrexate to amplify transfected gene sequences and pre-adapted to serum-free cell line for protein expression.

Bispecific and Multispecific Antibodies

[0129] In certain embodiments the anti-Trop-2 ADC and one or more other therapeutic antibodies may be administered as separate antibodies, either sequentially or concurrently. In alternative embodiments, antibodies or antibody fragments may be administered as a single bispecific or multispecific antibody. 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).

[0130] 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). 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.

[0131] Cognate V_H and V_L 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), as discussed above. Reduction of the peptide linker length to less than 12 amino acid residues prevents pairing of V_H and V_L domains on the same chain and forces pairing of V_H and V_L domains with complementary domains on other chains, resulting in the formation of functional multimers. Polypeptide chains of V_H and V_L 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_H-linker-V_L or V_L-linker-V_H), in addition to the linker length.

[0132] 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™), discussed in more detail below, has been utilized to produce combinations of virtually any desired antibodies, antibody fragments and other effector molecules. 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.

DOCK-AND-LOCK™ (DNL™)

[0133] Bispecific or multispecific antibodies or other constructs may be produced using the DOCK-AND-LOCK™ technology (see, e.g., U.S. Patent Nos. 7,550,143; 7,521,056; 7,534,866; 7,527,787 and 7,666,400, the Examples section of each incorporated herein by

reference). Generally, the technique takes advantage of the specific and high-affinity binding interactions that occur between a dimerization and docking domain (DDD) sequence of the regulatory (R) subunits of cAMP-dependent protein kinase (PKA) and an anchor domain (AD) sequence derived from any of a variety of AKAP proteins (Baillie *et al.*, FEBS Letters. 2005; 579: 3264. Wong and Scott, Nat. Rev. Mol. Cell Biol. 2004; 5: 959). The DDD and AD peptides may be attached to any protein, peptide or other molecule. Because the DDD sequences spontaneously dimerize and bind to the AD sequence, the technique allows the formation of complexes between any selected molecules that may be attached to DDD or AD sequences.

[0134] Although the standard DNL™ complex comprises a trimer with two DDD-linked molecules attached to one AD-linked molecule, variations in complex structure allow the formation of dimers, trimers, tetramers, pentamers, hexamers and other multimers. In some embodiments, the DNL™ complex may comprise two or more antibodies, antibody fragments or fusion proteins which bind to the same antigenic determinant or to two or more different antigens. The DNL™ complex may also comprise one or more other effectors, such as proteins, peptides, immunomodulators, cytokines, interleukins, interferons, binding proteins, peptide ligands, carrier proteins, toxins, ribonucleases such as onconase, inhibitory oligonucleotides such as siRNA, antigens or xenoantigens, polymers such as PEG, enzymes, therapeutic agents, hormones, cytotoxic agents, anti-angiogenic agents, pro-apoptotic agents or any other molecule or aggregate.

[0135] 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 α and β isoforms (Scott, Pharmacol. Ther. 1991;50:123). Thus, the four isoforms of PKA regulatory subunits are RIα, RIβ, RIIα and RIIβ. 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 of RIIα (Newlon *et al.*, Nat. Struct. Biol. 1999; 6:222). As discussed below, similar portions of the amino acid sequences of other regulatory subunits are involved in dimerization and docking, each located near the N-terminal end of the regulatory subunit. 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)

[0136] 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 sub-cellular 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). The amino acid sequences of the AD are quite varied among individual AKAPs, with the binding affinities reported for RII dimers ranging from 2 to 90 nM (Alto *et al.*, Proc. Natl. Acad. Sci. USA. 2003;100:4445). AKAPs will only bind to dimeric R subunits. For human RIIα, 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 RIIα 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.

[0137] We have developed a platform technology to utilize the DDD of human PKA regulatory subunits and the AD of AKAP 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 DNL™ complex 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 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 $\mathbf{a}_2$. 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 $\mathbf{a}_2$ will create a docking site for binding to the AD sequence contained in **b,** thus facilitating a ready association of $\mathbf{a}_2$ and **b** to form a binary, trimeric complex composed of $\mathbf{a}_2\mathbf{b}$. 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 (Chmura *et al.*, Proc. Natl. Acad. Sci. USA. 2001;98:8480) to ligate site-specifically. Using various combinations of

linkers, adaptor modules and precursors, a wide variety of DNL™ constructs of different stoichiometry may be produced and used (see, e.g., U.S. Nos. 7,550,143; 7,521,056; 7,534,866; 7,527,787 and 7,666,400.)

[0138] 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, including peptides, proteins, antibodies, antibody fragments, and other effector moieties with a wide range of activities. Utilizing the fusion protein method of constructing AD and DDD conjugated effectors described below, virtually any protein or peptide may be incorporated into a DNL™ construct. However, the technique is not limiting and other methods of conjugation may be utilized.

[0139] 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, 2nd 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.

Structure-Function Relationships in AD and DDD Moieties

[0140] For different types of DNL™ constructs, different AD or DDD sequences may be utilized. Exemplary DDD and AD sequences are provided below.

DDD1

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:9)

DDD2

CGHIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:10)

AD1

QIEYLAKQIVDNAIQQA (SEQ ID NO:11)

AD2

CGQIEYLAKQIVDNAIQQAGC (SEQ ID NO:12)

[0141] The skilled artisan will realize that DDD1 and DDD2 are based on the DDD sequence of the human RIIα isoform of protein kinase A. However, in alternative embodiments, the DDD and AD moieties may be based on the DDD sequence of the human RIα form of protein kinase A and a corresponding AKAP sequence, as exemplified in DDD3, DDD3C and AD3 below.

DDD3

SLRECELYVQKHNIQALLKDSIVQLCTARPERPMAFLREYFERLEKEEAK (SEQ ID NO:13)

DDD3C

MSCGGSLRECELYVQKHNIQALLKDSIVQLCTARPERPMAFLREYFERLEKEEAK (SEQ ID NO:14)

AD3

CGFEELAWKIAKMIWSDVFQQGC (SEQ ID NO:15)

[0142] In other alternative embodiments, other sequence variants of AD and/or DDD moieties may be utilized in construction of the DNL™ complexes. For example, there are only four variants of human PKA DDD sequences, corresponding to the DDD moieties of PKA RIα, RIIα, RIβ and RIIβ. The RIIα DDD sequence is the basis of DDD1 and DDD2 disclosed above. The four human PKA DDD sequences are shown below. The DDD sequence represents residues 1-44 of RIIα, 1-44 of RIIβ, 12-61 of RIα and 13-66 of RIβ. (Note that the sequence of DDD1 is modified slightly from the human PKA RIIα DDD moiety.)

PKA RIα

SLRECELYVQKHNIQALLKDVSIVQLCTARPERPMAFLREYFEKLEKEEAK (SEQ ID NO:16)

PKA RIβ

SLKGCELYVQLHGIQQVLKDCIVHLCISKPERPMKFLREHFEKLEKEENRQILA (SEQ ID NO:17)

PKA RIIα

SHIQIPPGLTELLQGYTVEVGQQPPDLVDFAVEYFTRLREARRQ (SEQ ID NO:18)

PKA RIIβ

SIEIPAGLTELLQGFTVEVLRHQPADLLEFALQHFTRLQQENER (SEQ ID NO:19)

[0143] 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.)

[0144] For example, Kinderman et al. (2006, Mol Cell 24:397-408) 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 in SEQ ID NO:9 below. (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.

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:9)

[0145] As discussed in more detail below, conservative amino acid substitutions have been characterized for each of the twenty common L-amino acids. Thus, based on the data of Kinderman (2006) and conservative amino acid substitutions, potential alternative DDD sequences based on SEQ ID NO:9 are shown in **Table 2**. In devising **Table 2**, only highly conservative amino acid substitutions were considered. For example, charged residues were only substituted for residues of the same charge, residues with small side chains were substituted with residues of similar size, hydroxyl side chains were only substituted with other hydroxyls, etc. Because of the unique effect of proline on amino acid secondary

structure, no other residues were substituted for proline. A limited number of such potential alternative DDD moiety sequences are shown in SEQ ID NO:20 to SEQ ID NO:39 below. The skilled artisan will realize that an almost unlimited number of alternative species within the genus of DDD moieties can be constructed by standard techniques, for example using a commercial peptide synthesizer or well known site-directed mutagenesis techniques. The effect of the amino acid substitutions on AD moiety binding may also be readily determined by standard binding assays, for example as disclosed in Alto et al. (2003, Proc Natl Acad Sci USA 100:4445-50).

Table 2. Conservative Amino Acid Substitutions in DDD1 (SEQ ID NO:9). Consensus sequence disclosed as SEQ ID NO: 94.

S	**H**	**I**	**Q**	**I**	**P**	**P**	**G**	**L**	**T**	**E**	**L**	**L**	**Q**	**G**	**Y**	**T**	**V**	**E**	**V**	**L**	**R**
T	K R		N				A		S	D			N	A		S		D			K

Q	**Q**	**P**	**P**	**D**	**L**	**V**	**E**	**F**	**A**	**V**	**E**	**Y**	**F**	**T**	**R**	**L**	**R**	**E**	**A**	**R**	**A**
N	N			E			D		L I V		D			S	K		K	D	L I V	K	L I V

THIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:20)

SKIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:21)

SRIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:22)

SHINIPPGLTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:23)

SHIQIPPALTELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:24)

SHIQIPPGLSELLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:25)

SHIQIPPGLTDLLQGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:26)

SHIQIPPGLTELLNGYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:27)

SHIQIPPGLTELLQAYTVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:28)

SHIQIPPGLTELLQGYSVEVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:29)

SHIQIPPGLTELLQGYTVDVLRQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:30)

SHIQIPPGLTELLQGYTVEVLKQQPPDLVEFAVEYFTRLREARA (SEQ ID NO:31)

SHIQIPPGLTELLQGYTVEVLRNQPPDLVEFAVEYFTRLREARA (SEQ ID NO:32)

SHIQIPPGLTELLQGYTVEVLRQNPPDLVEFAVEYFTRLREARA (SEQ ID NO:33)

SHIQIPPGLTELLQGYTVEVLRQQPPELVEFAVEYFTRLREARA (SEQ ID NO:34)

SHIQIPPGLTELLQGYTVEVLRQQPPDLVDFAVEYFTRLREARA (SEQ ID NO:35)

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFLVEYFTRLREARA (SEQ ID NO:36)

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFIVEYFTRLREARA (SEQ ID NO:37)

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFVVEYFTRLREARA (SEQ ID NO:38)

SHIQIPPGLTELLQGYTVEVLRQQPPDLVEFAVDYFTRLREARA (SEQ ID NO:39)

[0146] Alto et al. (2003, Proc Natl Acad Sci USA 100:4445-50) 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:11), 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:11 below. The skilled artisan will realize that in designing sequence variants of the AD 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 DDD binding. **Table 3** shows potential conservative amino acid substitutions in the sequence of AKAP-IS (AD1, SEQ ID NO:19), similar to that shown for DDD1 (SEQ ID NO:16) in **Table 2** above.

[0147] A limited number of such potential alternative AD moiety sequences are shown in SEQ ID NO:40 to SEQ ID NO:57 below. Again, a very large number of species within the genus of possible AD moiety sequences could be made, tested and used by the skilled artisan, based on the data of Alto et al. (2003). It is noted that Figure 2 of Alto (2003) shows an even large number of potential amino acid substitutions that may be made, while retaining binding activity to DDD moieties, based on actual binding experiments.

AKAP-IS

QIEYLAKQIVDNAIQQA (SEQ ID NO:11)

Table 3. Conservative Amino Acid Substitutions in AD1 (SEQ ID NO:11). Consensus sequence disclosed as SEQ ID NO: 95.

Q	**I**	**E**	**Y**	**L**	**A**	**K**	**Q**	**I**	**V**	**D**	**N**	**A**	**I**	**Q**	**Q**	**A**

N	L V	D	F T S	I V		R	N			E	Q			N	N	L I V

NIEYLAKQIVDNAIQQA (SEQ ID NO:40)
QLEYLAKQIVDNAIQQA (SEQ ID NO:41)
QVEYLAKQIVDNAIQQA (SEQ ID NO:42)
QIDYLAKQIVDNAIQQA (SEQ ID NO:43)
QIEFLAKQIVDNAIQQA (SEQ ID NO:44)
QIETLAKQIVDNAIQQA (SEQ ID NO:45)
QIESLAKQIVDNAIQQA (SEQ ID NO:46)
QIEYIAKQIVDNAIQQA (SEQ ID NO:47)
QIEYVAKQIVDNAIQQA (SEQ ID NO:48)
QIEYLARQIVDNAIQQA (SEQ ID NO:49)
QIEYLAKNIVDNAIQQA (SEQ ID NO:50)
QIEYLAKQIVENAIQQA (SEQ ID NO:51)
QIEYLAKQIVDQAIQQA (SEQ ID NO:52)
QIEYLAKQIVDNAINQA (SEQ ID NO:53)
QIEYLAKQIVDNAIQNA (SEQ ID NO:54)
QIEYLAKQIVDNAIQQL (SEQ ID NO:55)
QIEYLAKQIVDNAIQQI (SEQ ID NO:56)
QIEYLAKQIVDNAIQQV (SEQ ID NO:57)

[0148] Gold et al. (2006, Mol Cell 24:383-95) utilized crystallography and peptide screening to develop a SuperAKAP-IS sequence (SEQ ID NO:58), 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, which increased binding to the DDD moiety of RIIα. 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 RIIα 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 DNL™ constructs. Other alternative sequences that might be substituted for the AKAP-IS AD sequence are shown in SEQ ID NO:59-61. Substitutions relative to the AKAP-IS sequence are underlined. It is anticipated that, as with the AD2 sequence shown in

SEQ ID NO:12, the AD moiety may also include the additional N-terminal residues cysteine and glycine and C-terminal residues glycine and cysteine.

SuperAKAP-IS

QIEYVAKQIVDYAIHQA (SEQ ID NO:58)

Alternative AKAP sequences

QIEYKAKQIVDHAIHQA (SEQ ID NO:59)

QIEYHAKQIVDHAIHQA (SEQ ID NO:60)

QIEYVAKQIVDHAIHQA (SEQ ID NO:61)

[0149] Figure 2 of Gold et al. disclosed additional DDD-binding sequences from a variety of AKAP proteins, shown below.

RII-Specific AKAPs

AKAP-KL

PLEYQAGLLVQNAIQQAI (SEQ ID NO:62)

AKAP79

LLIETASSLVKNAIQLSI (SEQ ID NO:63)

AKAP-Lbc

LIEEAASRIVDAVIEQVK (SEQ ID NO:64)

RI-Specific AKAPs

AKAPce

ALYQFADRFSELVISEAL (SEQ ID NO:65)

RIAD

LEQVANQLADQIIKEAT (SEQ ID NO:66)

PV38

FEELAWKIAKMIWSDVF (SEQ ID NO:67)

Dual-Specificity AKAPs

AKAP7

ELVRLSKRLVENAVLKAV (SEQ ID NO:68)

MAP2D

TAEEVSARIVQVVTAEAV (SEQ ID NO:69)

DAKAP1

QIKQAAFQLISQVILEAT (SEQ ID NO:70)

DAKAP2

LAWKIAKMIVSDVMQQ (SEQ ID NO:71)

[0150] Stokka et al. (2006, Biochem J 400:493-99) also developed peptide competitors of AKAP binding to PKA, shown in SEQ ID NO:72-74. The peptide antagonists were designated as Ht31 (SEQ ID NO:72), RIAD (SEQ ID NO:73) and PV-38 (SEQ ID NO:74). The Ht-31 peptide exhibited a greater affinity for the RII isoform of PKA, while the RIAD and PV-38 showed higher affinity for RI.

Ht31

DLIEEAASRIVDAVIEQVKAAGAY (SEQ ID NO:72)

RIAD

LEQYANQLADQIIKEATE (SEQ ID NO:73)

PV-38

FEELAWKIAKMIWSDVFQQC (SEQ ID NO:74)

[0151] Hundsrucker et al. (2006, Biochem J 396:297-306) 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 are provided in Table 1 of Hundsrucker et al., reproduced in **Table 4** below. AKAPIS represents a synthetic RII subunit-binding peptide. All other peptides are derived from the RII-binding domains of the indicated AKAPs.

Table 4. AKAP Peptide sequences

	Peptide Sequence
AKAPIS	QIEYLAKQIVDNAIQQA (SEQ ID NO:11)
AKAPIS-P	QIEYLAKQIPDNAIQQA (SEQ ID NO:75)
Ht31	KGADLIEEAASRIVDAVIEQVKAAG (SEQ ID NO:76)
Ht31-P	KGADLIEEAASRIPDAPIEQVKAAG (SEQ ID NO:77)
AKAP7δ-wt-pep	PEDAELVRLSKRLVENAVLKAVQQY (SEQ ID NO:78)
AKAP7δ-L304T-pep	PEDAELVRTSKRLVENAVLKAVQQY (SEQ ID NO:79)
AKAP7δ-L308D-pep	PEDAELVRLSKRDVENAVLKAVQQY (SEQ ID NO:80)
AKAP7δ-P-pep	PEDAELVRLSKRLPENAVLKAVQQY (SEQ ID NO:81)
AKAP7δ-PP-pep	PEDAELVRLSKRLPENAPLKAVQQY (SEQ ID NO:82)
AKAP7δ-L314E-pep	PEDAELVRLSKRLVENAVEKAVQQY (SEQ ID NO:83)
AKAP1-pep	EEGLDRNEEIKRAAFQIISQVISEA (SEQ ID NO:84)
AKAP2-pep	LVDDPLEYQAGLLVQNAIQQAIAEQ (SEQ ID NO:85)
AKAP5-pep	QYETLLIETASSLVKNAIQLSIEQL (SEQ ID NO:86)

AKAP9-pep	LEKQYQEQLEEEVAKVIVSMSIAFA (SEQ ID NO:87)
AKAP10-pep	NTDEAQEELAWKIAKMIVSDIMQQA (SEQ ID NO:88)
AKAP11-pep	VNLDKKAVLAEKIVAEAIEKAEREL (SEQ ID NO:89)
AKAP12-pep	NGILELETKSSKLVQNIIQTAVDQF (SEQ ID NO:90)
AKAP14-pep	TQDKNYEDELTQVALALVEDVINYA (SEQ ID NO:91)
Rab32-pep	ETSAKDNINIEEAARFLVEKILVNH (SEQ ID NO:92)

[0152] 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:11). 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.) The sequences of peptide antagonists with particularly high affinities for the RII DDD sequence were those of AKAP-IS, AKAP7δ-wt-pep, AKAP7δ-L304T-pep and AKAP7δ-L308D-pep.

AKAP-IS

QIEYLAKQIVDNAIQQA (SEQ ID NO:11)

[0153] Carr et al. (2001, J Biol Chem 276:17332-38) 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 RIIα DDD sequence of SEQ ID NO:9. 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. The skilled artisan will realize that in designing sequence variants of DDD, it would be most preferred to avoid changing the most conserved residues (italicized), and it would be preferred to also avoid changing the conserved residues (underlined), while conservative amino acid substitutions may be considered for residues that are neither underlined nor italicized..

SHIQ*IP*P*GL*T*ELLQGYT*V*EVLR*Q*QP*P*D*LVEFA*VE*YF*TR*L*REA*R*A (SEQ ID NO:9)

[0154] A modified set of conservative amino acid substitutions for the DDD1 (SEQ ID NO:9) sequence, based on the data of Carr et al. (2001) is shown in **Table 5**. Even with this reduced set of substituted sequences, there are over 65,000 possible alternative DDD moiety sequences that may be produced, tested and used by the skilled artisan without undue

experimentation. The skilled artisan could readily derive such alternative DDD amino acid sequences as disclosed above for **Table 2** and **Table 3.**

Table 5. Conservative Amino Acid Substitutions in DDD1 (SEQ ID NO:9). Consensus sequence disclosed as SEQ ID NO: 96.

S	**H**	**I**	**Q**	***I***	***P***	**P**	***G***	***L***	**T**	**E**	***L***	***L***	**Q**	***G***	***Y***	***T***	**V**	***E***	***V***	***L***	***R***
T			N						S								I L A				

Q	***Q***	***P***	**P**	***D***	***L***	**V**	**E**	***F***	***A***	**V**	**E**	***Y***	***F***	**T**	**R**	***L***	**R**	**E**	**A**	***R***	**A**
N										I L A	D			S	K		K		L I V		L I V

[0155] The skilled artisan will realize that these and other amino acid substitutions in the DDD or AD amino acid sequences may be utilized to produce alternative species within the genus of AD or DDD moieties, using techniques that are standard in the field and only routine experimentation.

Alternative DNL™ Structures

[0156] In certain alternative embodiments, DNL™ constructs may be formed using alternatively constructed antibodies or antibody fragments, in which an AD moiety may be attached at the C-terminal end of the kappa light chain (C_k), instead of the C-terminal end of the Fc on the heavy chain. The alternatively formed DNL™ constructs may be prepared as disclosed in Provisional U.S. Patent Application Serial Nos. 61/654,310, filed June 1, 2012, 61/662,086, filed June 20, 2012, 61/673,553, filed July 19, 2012, and 61/682,531, filed August 13, 2012, the entire text of each incorporated herein by reference. The light chain conjugated DNL™ constructs exhibit enhanced Fc-effector function activity *in vitro* and improved pharmacokinetics, stability and anti-lymphoma activity *in vivo* (Rossi et al., 2013, Bioconjug Chem 24:63-71).

[0157] C_k-conjugated DNL™ constructs may be prepared as disclosed in Provisional U.S. Patent Application Serial Nos. 61/654,310, 61/662,086, 61/673,553, and 61/682,531. Briefly, C_k-AD2-IgG, was generated by recombinant engineering, whereby the AD2 peptide was fused to the C-terminal end of the kappa light chain. Because the natural C-terminus of C_K is a cysteine residue, which forms a disulfide bridge to C_H1, a 16-amino acid residue "hinge"

linker was used to space the AD2 from the C_K-V_H1 disulfide bridge. The mammalian expression vectors for C_k-AD2-IgG-veltuzumab and C_k-AD2-IgG-epratuzumab were constructed using the pdHL2 vector, which was used previously for expression of the homologous C_H3-AD2-IgG modules. A 2208-bp nucleotide sequence was synthesized comprising the pdHL2 vector sequence ranging from the *Bam HI* restriction site within the V_K/C_K intron to the *Xho I* restriction site 3' of the C_k intron, with the insertion of the coding sequence for the hinge linker (EFPKPSTPPGSSGGAP, SEQ ID NO:93) and AD2, in frame at the 3'end of the coding sequence for C_K. This synthetic sequence was inserted into the IgG-pdHL2 expression vectors for veltuzumab and epratuzumab via *Bam HI* and *Xho I* restriction sites. Generation of production clones with SpESFX-10 were performed as described for the C_H3-AD2-IgG modules. C_k-AD2-IgG-veltuzumab and C_k-AD2-IgG-epratuzumab were produced by stably-transfected production clones in batch roller bottle culture, and purified from the supernatant fluid in a single step using MabSelect (GE Healthcare) Protein A affinity chromatography.

[0158] Following the same DNL™ process described previously for 22-(20)-(20) (Rossi et al., 2009, *Blood* 113:6161-71), C_k-AD2-IgG-epratuzumab was conjugated with C_H1-DDD2-Fab-veltuzumab, a Fab-based module derived from veltuzumab, to generate the bsHexAb 22*-(20)-(20), where the 22* indicates the C_k-AD2 module of epratuzumab and each (20) symbolizes a stabilized dimer of veltuzumab Fab. The properties of 22*-(20)-(20) were compared with those of 22-(20)-(20), the homologous Fc-bsHexAb comprising C_H3-AD2-IgG-epratuzumab, which has similar composition and molecular size, but a different architecture.

[0159] Following the same DNL™ process described previously for 20-2b (Rossi et al., 2009, *Blood* 114:3864-71), C_k-AD2-IgG-veltuzumab, was conjugated with IFNα2b-DDD2, a module of IFNα2b with a DDD2 peptide fused at its C-terminal end, to generate 20*-2b, which comprises veltuzumab with a dimeric IFNα2b fused to each light chain. The properties of 20*-2b were compared with those of 20-2b, which is the homologous Fc-IgG-IFNα.

[0160] Each of the bsHexAbs and IgG-IFNα were isolated from the DNL™ reaction mixture by MabSelect affinity chromatography. The two C_k-derived prototypes, an anti-CD22/CD20 bispecific hexavalent antibody, comprising epratuzumab (anti-CD22) and four Fabs of veltuzumab (anti-CD20), and a CD20-targeting immunocytokine, comprising veltuzumab and four molecules of interferon-α2b, displayed enhanced Fc-effector functions *in vitro*, as well

as improved pharmacokinetics, stability and anti-lymphoma activity *in vivo*, compared to their Fc-derived counterparts.

Amino Acid Substitutions

[0161] 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™ constructs may be modified as discussed above.

[0162] 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.

[0163] 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 ± 2 is preferred, within ± 1 are more preferred, and within ± 0.5 are even more preferred.

[0164] 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 .+-.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.

[0165] 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).

[0166] 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.

[0167] 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.*)

[0168] 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.

[0169] 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.

Pre-Targeting

[0170] Bispecific or multispecific antibodies may be of use in pretargeting techniques. In this case, one or more therapeutic agent may be conjugated to a targetable construct that comprises one or more haptens. The hapten is recognized by at least one arm of a bispecific or multispecific antibody that also binds to a tumor-associated antigen or other disease-associated antigen. In this case, the therapeutic agent binds indirectly to the antibodies, via the binding of the targetable construct. This process is referred to as pretargeting.

[0171] Pre-targeting is a multistep process originally developed to resolve the slow blood clearance of directly targeting antibodies, which contributes to undesirable toxicity to normal tissues such as bone marrow. With pre-targeting, a therapeutic agent is attached to a small delivery molecule (targetable construct) that is cleared within minutes from the blood. A pre-targeting bispecific or multispecific antibody, which has binding sites for the targetable construct as well as a target antigen, is administered first, free antibody is allowed to clear from circulation and then the targetable construct is administered.

[0172] Pre-targeting methods are disclosed, for example, in Goodwin et al., U.S. Pat. No. 4,863,713; Goodwin et al., J. Nucl. Med. 29:226, 1988; Hnatowich et al., J. Nucl. Med. 28:1294, 1987; Oehr et al., J. Nucl. Med. 29:728, 1988; Klibanov et al., J. Nucl. Med. 29:1951, 1988; Sinitsyn et al., J. Nucl. Med. 30:66, 1989; Kalofonos et al., J. Nucl. Med. 31:1791, 1990; Schechter et al., Int. J. Cancer 48:167, 1991; Paganelli et al., Cancer Res. 51:5960, 1991; Paganelli et al., Nucl. Med. Commun. 12:211, 1991; U.S. Pat. No. 5,256,395; Stickney et al., Cancer Res. 51:6650, 1991; Yuan et al., Cancer Res. 51:3119, 1991; U.S. Pat. Nos. 6,077,499; 7,011,812; 7,300,644; 7,074,405; 6,962,702; 7,387,772; 7,052,872; 7,138,103; 6,090,381; 6,472,511; 6,962,702; and 6,962,702, each incorporated herein by reference.

[0173] A pre-targeting method of treating or diagnosing a disease or disorder in a subject may be provided by: (1) administering to the subject a bispecific antibody or antibody fragment; (2) optionally administering to the subject a clearing composition, and allowing the composition to clear the antibody from circulation; and (3) administering to the subject the targetable construct, containing one or more chelated or chemically bound therapeutic or diagnostic agents.

Targetable Constructs

[0174] In certain embodiments, targetable construct peptides labeled with one or more therapeutic or diagnostic agents for use in pre-targeting may be selected to bind to a bispecific antibody with one or more binding sites for a targetable construct peptide and one or more binding sites for a target antigen associated with a disease or condition. Bispecific antibodies may be used in a pretargeting technique wherein the antibody may be administered first to a subject. Sufficient time may be allowed for the bispecific antibody to bind to a target antigen and for unbound antibody to clear from circulation. Then a targetable construct, such as a labeled peptide, may be administered to the subject and allowed to bind to the bispecific antibody and localize at the diseased cell or tissue.

[0175] Such targetable constructs can be of diverse structure and are selected not only for the availability of an antibody or fragment that binds with high affinity to the targetable construct, but also for rapid *in vivo* clearance when used within the pre-targeting method and bispecific antibodies (bsAb) or multispecific antibodies. Hydrophobic agents are best at eliciting strong immune responses, whereas hydrophilic agents are preferred for rapid *in vivo* clearance. Thus, a balance between hydrophobic and hydrophilic character is established. This may be accomplished, in part, by using hydrophilic chelating agents to offset the inherent hydrophobicity of many organic moieties. Also, sub-units of the targetable construct may be chosen which have opposite solution properties, for example, peptides, which contain amino acids, some of which are hydrophobic and some of which are hydrophilic.

[0176] Peptides having as few as two amino acid residues, preferably two to ten residues, may be used and may also be coupled to other moieties, such as chelating agents. The linker should be a low molecular weight conjugate, preferably having a molecular weight of less than 50,000 daltons, and advantageously less than about 20,000 daltons, 10,000 daltons or 5,000 daltons. More usually, the targetable construct peptide will have four or more residues and one or more haptens for binding, e.g., to a bispecific antibody. Exemplary haptens may include In-DTPA (indium-diethylene triamine pentaacetic acid) or HSG (histamine succinyl glycine). The targetable construct may also comprise one or more chelating moieties, such as DOTA (1,4,7,10-tetraazacyclododecane1,4,7,10-tetraacetic acid), NOTA (1,4,7-triaza-cyclononane-1,4,7-triacetic acid), TETA (*p*-bromoacetamido-benzyl-tetraethylaminetetraacetic acid), NETA ([2-(4,7-biscarboxymethyl[1,4,7]triazacyclononan-1-yl-ethyl]-2-carbonylmethyl-amino]acetic acid) or other known chelating moieties. Chelating moieties may be used, for example, to bind to a therapeutic and or diagnostic radionuclide, paramagnetic ion or contrast agent.

[0177] The targetable construct may also comprise unnatural amino acids, e.g., D-amino acids, in the backbone structure to increase the stability of the peptide *in vivo*. In alternative embodiments, other backbone structures such as those constructed from non-natural amino acids or peptoids may be used.

[0178] The peptides used as targetable constructs are conveniently synthesized on an automated peptide synthesizer using a solid-phase support and standard techniques of repetitive orthogonal deprotection and coupling. Free amino groups in the peptide, that are to be used later for conjugation of chelating moieties or other agents, are advantageously blocked with standard protecting groups such as a Boc group, while N-terminal residues may be acetylated to increase serum stability. Such protecting groups are well known to the skilled artisan. See Greene and Wuts Protective Groups in Organic Synthesis, 1999 (John Wiley and Sons, N.Y.). When the peptides are prepared for later use within the bispecific antibody system, they are advantageously cleaved from the resins to generate the corresponding C-terminal amides, in order to inhibit *in vivo* carboxypeptidase activity.

[0179] Where pretargeting with bispecific antibodies is used, the antibody will contain a first binding site for an antigen produced by or associated with a target tissue and a second binding site for a hapten on the targetable construct. Exemplary haptens include, but are not limited to, HSG and In-DTPA. Antibodies raised to the HSG hapten are known (e.g. 679 antibody) and can be easily incorporated into the appropriate bispecific antibody (see, e.g., U.S. Patent Nos. 6,962,702; 7,138,103 and 7,300,644, incorporated herein by reference with respect to the Examples sections). However, other haptens and antibodies that bind to them are known in the art and may be used, such as In-DTPA and the 734 antibody (e.g., U.S. Patent No.7,534,431, the Examples section incorporated herein by reference).

Immunoconjugates

[0180] In certain embodiments, a cytotoxic drug or other therapeutic or diagnostic agent may be covalently attached to an antibody or antibody fragment to form an immunoconjugate. In some embodiments, a drug or other agent may be attached to an antibody or fragment thereof via a carrier moiety. Carrier moieties may be attached, for example to reduced SH groups and/or to carbohydrate side chains. A carrier moiety 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); Upeslacis *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 carrier moiety can be conjugated via a carbohydrate moiety in the Fc region of the antibody.

[0181] Methods for conjugating functional groups to antibodies 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, the Examples section of which is incorporated herein by reference. The general method involves reacting an antibody 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.

[0182] The Fc region may be absent if the antibody component of the ADC 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); U.S. Patent Nos. 5,443,953 and 6,254,868, the Examples section of which is incorporated herein by reference. The engineered carbohydrate moiety is used to attach the therapeutic or diagnostic agent.

[0183] An alternative method for attaching carrier moieties to a targeting molecule involves use of click chemistry reactions. The click chemistry approach was originally conceived as a method to rapidly generate complex substances by joining small subunits together in a modular fashion. (See, e.g., Kolb et al., 2004, Angew Chem Int Ed 40:3004-31; Evans, 2007, Aust J Chem 60:384-95.) Various forms of click chemistry reaction are known in the art, such as the Huisgen 1,3-dipolar cycloaddition copper catalyzed reaction (Tornoe et al., 2002, J Organic Chem 67:3057-64), which is often referred to as the "click reaction." Other alternatives include cycloaddition reactions such as the Diels-Alder, nucleophilic substitution reactions (especially to small strained rings like epoxy and aziridine compounds), carbonyl chemistry formation of urea compounds and reactions involving carbon-carbon double bonds, such as alkynes in thiol-yne reactions.

[0184] The azide alkyne Huisgen cycloaddition reaction uses a copper catalyst in the presence of a reducing agent to catalyze the reaction of a terminal alkyne group attached to a

first molecule. In the presence of a second molecule comprising an azide moiety, the azide reacts with the activated alkyne to form a 1,4-disubstituted 1,2,3-triazole. The copper catalyzed reaction occurs at room temperature and is sufficiently specific that purification of the reaction product is often not required. (Rostovstev et al., 2002, Angew Chem Int Ed 41:2596; Tornoe et al., 2002, J Org Chem 67:3057.) The azide and alkyne functional groups are largely inert towards biomolecules in aqueous medium, allowing the reaction to occur in complex solutions. The triazole formed is chemically stable and is not subject to enzymatic cleavage, making the click chemistry product highly stable in biological systems. Although the copper catalyst is toxic to living cells, the copper-based click chemistry reaction may be used *in vitro* for immunoconjugate formation.

[0185] A copper-free click reaction has been proposed for covalent modification of biomolecules. (See, e.g., Agard et al., 2004, J Am Chem Soc 126:15046-47.) The copper-free reaction uses ring strain in place of the copper catalyst to promote a [3 + 2] azide-alkyne cycloaddition reaction (*Id.*) For example, cyclooctyne is an 8-carbon ring structure comprising an internal alkyne bond. The closed ring structure induces a substantial bond angle deformation of the acetylene, which is highly reactive with azide groups to form a triazole. Thus, cyclooctyne derivatives may be used for copper-free click reactions (*Id.*)

[0186] Another type of copper-free click reaction was reported by Ning et al. (2010, Angew Chem Int Ed 49:3065-68), involving strain-promoted alkyne-nitrone cycloaddition. To address the slow rate of the original cyclooctyne reaction, electron-withdrawing groups are attached adjacent to the triple bond (*Id.*) Examples of such substituted cyclooctynes include difluorinated cyclooctynes, 4-dibenzocyclooctynol and azacyclooctyne (*Id.*) An alternative copper-free reaction involved strain-promoted alkyne-nitrone cycloaddition to give N-alkylated isoxazolines (*Id.*) The reaction was reported to have exceptionally fast reaction kinetics and was used in a one-pot three-step protocol for site-specific modification of peptides and proteins (*Id.*) Nitrones were prepared by the condensation of appropriate aldehydes with *N*-methylhydroxylamine and the cycloaddition reaction took place in a mixture of acetonitrile and water (*Id.*) These and other known click chemistry reactions may be used to attach carrier moieties to antibodies *in vitro*.

[0187] Agard et al. (2004, J Am Chem Soc 126:15046-47) demonstrated that a recombinant glycoprotein expressed in CHO cells in the presence of peracetylated *N*-azidoacetylmannosamine resulted in the bioincorporation of the corresponding *N*-azidoacetyl sialic acid in the carbohydrates of the glycoprotein. The azido-derivatized glycoprotein reacted specifically with a biotinylated cyclooctyne to form a biotinylated glycoprotein, while

control glycoprotein without the azido moiety remained unlabeled (*Id.*) Laughlin et al. (2008, Science 320:664-667) used a similar technique to metabolically label cell-surface glycans in zebrafish embryos incubated with peracetylated *N*-azidoacetylgalactosamine. The azido-derivatized glycans reacted with difluorinated cyclooctyne (DIFO) reagents to allow visualization of glycans *in vivo*.

[0188] The Diels-Alder reaction has also been used for *in vivo* labeling of molecules. Rossin et al. (2010, Angew Chem Int Ed 49:3375-78) reported a 52% yield *in vivo* between a tumor-localized anti-TAG72 (CC49) antibody carrying a *trans*-cyclooctene (TCO) reactive moiety and an ^{111}In-labeled tetrazine DOTA derivative. The TCO-labeled CC49 antibody was administered to mice bearing colon cancer xenografts, followed 1 day later by injection of ^{111}In-labeled tetrazine probe (*Id.*) The reaction of radiolabeled probe with tumor localized antibody resulted in pronounced radioactivity localization in the tumor, as demonstrated by SPECT imaging of live mice three hours after injection of radiolabeled probe, with a tumor-to-muscle ratio of 13:1 (*Id.*) The results confirmed the *in vivo* chemical reaction of the TCO and tetrazine-labeled molecules.

[0189] Antibody labeling techniques using biological incorporation of labeling moieties are further disclosed in U.S. Patent No. 6,953,675 (the Examples section of which is incorporated herein by reference). Such "landscaped" antibodies were prepared to have reactive ketone groups on glycosylated sites. The method involved expressing cells transfected with an expression vector encoding an antibody with one or more N-glycosylation sites in the CH1 or Vκ domain in culture medium comprising a ketone derivative of a saccharide or saccharide precursor. Ketone-derivatized saccharides or precursors included N-levulinoyl mannosamine and N-levulinoyl fucose. The landscaped antibodies were subsequently reacted with agents comprising a ketone-reactive moiety, such as hydrazide, hydrazine, hydroxylamino or thiosemicarbazide groups, to form a labeled targeting molecule. Exemplary agents attached to the landscaped antibodies included chelating agents like DTPA, large drug molecules such as doxorubicin-dextran, and acyl-hydrazide containing peptides. The landscaping technique is not limited to producing antibodies comprising ketone moieties, but may be used instead to introduce a click chemistry reactive group, such as a nitrone, an azide or a cyclooctyne, onto an antibody or other biological molecule.

[0190] Modifications of click chemistry reactions are suitable for use *in vitro* or *in vivo*. Reactive targeting molecule may be formed either by either chemical conjugation or by biological incorporation. The targeting molecule, such as an antibody or antibody fragment, may be activated with an azido moiety, a substituted cyclooctyne or alkyne group, or a

nitrone moiety. Where the targeting molecule comprises an azido or nitrone group, the corresponding targetable construct will comprise a substituted cyclooctyne or alkyne group, and vice versa. Such activated molecules may be made by metabolic incorporation in living cells, as discussed above.

[0191] Alternatively, methods of chemical conjugation of such moieties to biomolecules are well known in the art, and any such known method may be utilized. General methods of immunoconjugate formation are disclosed, for example, in U.S. Patent Nos. 4,699,784; 4,824,659; 5,525,338; 5,677,427; 5,697,902; 5,716,595; 6,071,490; 6,187,284; 6,306,393; 6,548,275; 6,653,104; 6,962,702; 7,033,572; 7,147,856; and 7,259,240, the Examples section of each incorporated herein by reference.

Other Therapeutic Agents

[0192] A wide variety of therapeutic reagents can be administered concurrently or sequentially with the subject ADCs. Alternatively, such agents may be conjugated to the antibodies of the invention, for example, drugs, toxins, oligonucleotides, immunomodulators, hormones, hormone antagonists, enzymes, enzyme inhibitors, radionuclides, angiogenesis inhibitors, etc. The therapeutic agents recited here are those agents that also are useful for administration separately with an ADC as described above. Therapeutic agents include, for example, cytotoxic drugs such as vinca alkaloids, anthracyclines such as doxorubicin, 2-PDox or pro-2-PDox, gemcitabine, epipodophyllotoxins, taxanes, antimetabolites, alkylating agents, antibiotics, SN-38, COX-2 inhibitors, antimitotics, anti-angiogenic and pro-apoptotic agents, particularly doxorubicin, methotrexate, taxol, CPT-11, camptothecans, proteosome inhibitors, mTOR inhibitors, HDAC inhibitors, tyrosine kinase inhibitors, and others. Other useful anti-cancer cytotoxic drugs for administering concurrently or sequentially, or for the preparation of ADCs include nitrogen mustards, alkyl sulfonates, nitrosoureas, triazenes, folic acid analogs, COX-2 inhibitors, antimetabolites, pyrimidine analogs, purine analogs, platinum coordination complexes, mTOR inhibitors, tyrosine kinase inhibitors, proteosome inhibitors, HDAC inhibitors, camptothecins, hormones, and the like. Suitable cytotoxic 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 cytotoxic agents, such as experimental drugs, are known to those of skill in the art. In a preferred embodiment, conjugates of camptothecins and related compounds, such as SN-38, may be conjugated to hRS7 or other anti-Trop-2

antibodies. In another preferred embodiment, gemcitabine is administered to the subject in conjunction with SN-38-hRS7 and/or ^{90}Y-hPAM4.

[0193] A toxin can be of animal, plant or microbial origin. Toxins of use include ricin, abrin, ribonuclease (RNase), DNase I, Staphylococcal enterotoxin-A, pokeweed antiviral protein, onconase, gelonin, diphtheria toxin, *Pseudomonas* exotoxin, and *Pseudomonas* endotoxin. See, for example, Pastan et al., Cell 47:641 (1986), Goldenberg, CA--A Cancer Journal for Clinicians 44:43 (1994), Sharkey and Goldenberg, CA--A Cancer Journal for Clinicians 56:226 (2006). Additional toxins suitable for use are known to those of skill in the art and are disclosed in U.S. Pat. No. 6,077,499, the Examples section of which is incorporated herein by reference.

[0194] As used herein, the term "immunomodulator" includes a cytokine, a lymphokine, a monokine, a stem cell growth factor, a lymphotoxin, a hematopoietic factor, a colony stimulating factor (CSF), an interferon (IFN), parathyroid hormone, thyroxine, insulin, proinsulin, relaxin, prorelaxin, follicle stimulating hormone (FSH), thyroid stimulating hormone (TSH), luteinizing hormone (LH), hepatic growth factor, prostaglandin, fibroblast growth factor, prolactin, placental lactogen, OB protein, a transforming growth factor (TGF), TGF-α, TGF-β, insulin-like growth factor (ILGF), erythropoietin, thrombopoietin, tumor necrosis factor (TNF), TNF- α, TNF-β, a mullerian-inhibiting substance, mouse gonadotropin-associated peptide, inhibin, activin, vascular endothelial growth factor, integrin, interleukin (IL), granulocyte-colony stimulating factor (G-CSF), granulocyte macrophage-colony stimulating factor (GM-CSF), interferon- α, interferon- β, interferon-γ, interferon-λ, S1 factor, IL-1, IL-1cc, 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 and IL-25, LIF, kit-ligand, FLT-3, angiostatin, thrombospondin, endostatin, lymphotoxin, and the like.

[0195] Particularly useful therapeutic radionuclides include, but are not limited to ^{111}In, ^{177}Lu, ^{212}Bi, ^{213}Bi, ^{211}At, ^{62}Cu, ^{64}Cu, ^{67}Cu, ^{90}Y, ^{125}I, ^{131}I, ^{32}P, ^{33}P, ^{47}Sc, ^{111}Ag, ^{67}Ga, ^{142}Pr, ^{153}Sm, ^{161}Tb, ^{166}Dy, ^{166}Ho, ^{186}Re, ^{188}Re, ^{189}Re, ^{212}Pb, ^{223}Ra, ^{225}Ac, ^{59}Fe, ^{75}Se, ^{77}As, ^{89}Sr, ^{99}Mo, ^{105}Rh, ^{109}Pd, ^{143}Pr, ^{149}Pm, ^{169}Er, ^{194}Ir, ^{198}Au, ^{199}Au, ^{227}Th, and ^{211}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, Fm-255 and Th-227. 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.

[0196] For example, ^{90}Y, which emits an energetic beta particle, can be coupled to an antibody, antibody fragment or fusion protein, using diethylenetriaminepentaacetic acid (DTPA), or more preferably using DOTA. Methods of conjugating ^{90}Y to antibodies or targetable constructs are known in the art and any such known methods may be used. (See, e.g., U.S. Patent No. 7,259,249, the Examples section of which is incorporated herein by reference. See also Lindén et al., Clin Cancer Res. 11:5215-22, 2005; Sharkey et al., J Nucl Med. 46:620-33, 2005; Sharkey et al., J Nucl Med. 44:2000-18, 2003.)

[0197] Additional potential therapeutic radioisotopes include ^{11}C, ^{13}N, ^{15}O, ^{75}Br, ^{198}Au, ^{224}Ac, ^{126}I, ^{133}I, ^{77}Br, ^{113m}In, ^{95}Ru, ^{97}Ru, ^{103}Ru, ^{105}Ru, ^{107}Hg, ^{203}Hg, ^{121m}Te, ^{122m}Te, ^{125m}Te, ^{165}Tm, ^{167}Tm, ^{168}Tm, ^{197}Pt, ^{109}Pd, ^{105}Rh, ^{142}Pr, ^{143}Pr, ^{161}Tb, ^{166}Ho, ^{199}Au, ^{57}Co, ^{58}Co, ^{51}Cr, ^{59}Fe, ^{75}Se, ^{201}Tl, ^{225}Ac, ^{76}Br, ^{169}Yb, and the like.

[0198] In another embodiment, a radiosensitizer can be used in combination with a naked or conjugated antibody or antibody fragment. For example, the radiosensitizer can be used in combination with a radiolabeled antibody or antibody fragment. The addition of the radiosensitizer can result in enhanced efficacy when compared to treatment with the radiolabeled antibody or antibody fragment alone. Radiosensitizers are described in D. M. Goldenberg (ed.), CANCER THERAPY WITH RADIOLABELED ANTIBODIES, CRC Press (1995). Other typical radionsensitizers of interest for use with this technology include gemcitabine, 5-fluorouracil, and cisplatin, and have been used in combination with external irradiation in the therapy of diverse cancers.

[0199] Antibodies or fragments thereof that have a boron addend-loaded carrier for thermal neutron activation therapy will normally be affected in similar ways. However, it will be advantageous to wait until non-targeted immunoconjugate clears before neutron irradiation is performed. Clearance can be accelerated using an anti-idiotypic antibody that binds to the anti-cancer antibody. See U.S. Pat. No. 4,624,846 for a description of this general principle. For example, boron addends such as carboranes, can be attached to antibodies. Carboranes can be prepared with carboxyl functions on pendant side chains, as is well-known in the art.

Attachment of carboranes to a carrier, such as aminodextran, can be achieved by activation of the carboxyl groups of the carboranes and condensation with amines on the carrier. The intermediate conjugate is then conjugated to the antibody. After administration of the antibody conjugate, a boron addend is activated by thermal neutron irradiation and converted to radioactive atoms which decay by alpha-emission to produce highly toxic, short-range effects.

Formulation and Administration

[0200] Suitable routes of administration of ADCs include, without limitation, oral, parenteral, rectal, transmucosal, intestinal administration, intramedullary, intrathecal, direct intraventricular, intravenous, intravitreal, intracavitary, intraperitoneal, or intratumoral injections. The preferred routes of administration are parenteral, more preferably intravenous. Alternatively, one may administer the compound in a local rather than systemic manner, for example, via injection of the compound directly into a solid or hematological tumor.

[0201] ADCs can be formulated according to known methods to prepare pharmaceutically useful compositions, whereby the ADC 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.

[0202] In a preferred embodiment, the ADC 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.

[0203] The ADC 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.

[0204] 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 ADC. 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 ADC from such a matrix depends upon the molecular weight of the ADC, the amount of ADC 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.

[0205] Generally, the dosage of an administered ADC for humans will vary depending upon such factors as the patient's age, weight, height, sex, general medical condition and previous medical history. It may be desirable to provide the recipient with a dosage of ADC that is in the range of from about 0.3 mg/kg to 5 mg/kg as a single intravenous infusion, although a lower or higher dosage also may be administered as circumstances dictate. A dosage of 0.3-5 mg/kg for a 70 kg patient, for example, is 21-350 mg, or 12-206 mg/m^2 for a 1.7-m patient. The dosage may be repeated as needed, for example, once per week for 2-10 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, 0.3 mg/kg, 0.5 mg/kg, 0.7 mg/kg, 1.0 mg/kg, 1.2 mg/kg, 1.5 mg/kg, 2.0 mg/kg, 2.5 mg/kg, 3.0 mg/kg, 3.5 mg/kg, 4.0 mg/kg, 4.5 mg/kg, and 5.0 mg/kg. More preferred dosages are 0.6 mg/kg for weekly administration and 1.2 mg/kg for less frequent dosing. Any amount in the range of 0.3 to 5 mg/kg may be used. The dosage is preferably administered multiple times, once a week. A minimum dosage schedule of 4 weeks, more preferably 8 weeks, more preferably 16 weeks or longer may be used, with the dose frequency dependent on toxic side-effects and recovery therefrom, mostly related to hematological toxicities. 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 2, 4, 6, 8, 10, or 12 times or more.

[0206] Alternatively, an ADC 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. The dosage may be administered once every other week or even less frequently, so the patient can recover from any drug-related toxicities. Alternatively, the dosage schedule may be decreased, namely every 2 or 3 weeks for 2-3 months. 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.

[0207] 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)).

[0208] 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. In preferred embodiments, the method

of the invention is used to inhibit growth, progression, and/or metastasis of cancers, in particular those listed above.

Kits

[0209] Various embodiments may concern kits containing components suitable for treating cancer tissue in a patient. Exemplary kits may contain at least one anti-Trop-2 ADC 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. In certain embodiments, an anti-Trop-2 antibody or antigen binding fragment thereof may be provided in the form of a prefilled syringe or autoinjection pen containing a sterile, liquid formulation or lyophilized preparation of antibody (e.g., Kivitz et al., Clin. Ther. 2006, 28:1619-29).

[0210] 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 for use of the kit.

EXAMPLES

[0211] The examples below are illustrative of embodiments of the current invention and are not limiting to the scope of the claims.

Example 1. Production and Use of anti-Trop-2-SN-38 Antibody-Drug Conjugate

[0212] The humanized RS7 (hRS7) anti-Trop-2 antibody was produced as described in U.S. Patent No. 7,238,785, the Figures and Examples section of which are incorporated herein by reference. SN-38 attached to a CL2A linker was produced and conjugated to hRS7 (anti-Trop-2), hPAM4 (anti-MUC5ac), hA20 (anti-CD20) or hMN-14 (anti-CEACAM5) antibodies according to U.S. Patent 7,999,083 (Example 10 and 12 of which are incorporated herein by reference). The conjugation protocol resulted in a ratio of about 6 SN-38 molecules attached per antibody molecule.

[0213] Immune-compromised athymic nude mice (female), bearing subcutaneous human pancreatic or colon tumor xenografts were treated with either specific CL2A-SN-38

conjugate or control conjugate or were left untreated. The therapeutic efficacies of the specific conjugates were observed. **FIG. 1** shows a Capan 1 pancreatic tumor model, wherein specific CL2A-SN-38 conjugates of hRS7 (anti-Trop-2), hPAM4 (anti-MUC-5ac), and hMN-14 (anti-CEACAM5) antibodies showed better efficacies than control hA20-CL2A-SN-38 conjugate (anti-CD20) and untreated control. Similarly in a BXPC3 model of human pancreatic cancer, the specific hRS7-CL2A-SN-38 showed better therapeutic efficacy than control treatments (**FIG. 2**).

Example 2. Efficacy of Anti-Trop-2 Antibody Conjugated to a Prodrug Form of 2-Pyrrolinodoxorubicin (2-PDox)

[0214] A prodrug form of 2-PDox (referred to as pro-2-PDox) was prepared and conjugated to antibodies as disclosed in U.S. Patent Application 14/175,089 (Example 1 of which is incorporated herein by reference). The structures of doxorubicin, 2-PDox, pro-2-PDox and a maleimide activated form of pro-2-PDox that is suitable for conjugation to sulfhydryl groups on antibodies or other proteins are shown in **FIG. 3**. Unless otherwise stated below, the number of drug moieties per antibody molecule was in the range of about 6.5 to about 7.5.

[0215] *In vitro* cell-binding studies – Retention of antibody binding was confirmed by cell binding assays comparing binding of the conjugated to the unconjugated antibody (Chari, 2008, Acc Chem Res 41:98-107). The potency of the conjugate was tested in a 4-day MTS assay using appropriate target cells. The anti-Trop-2 ADC (hRS7-pro-2-PDox) exhibited IC_{50} values of 0.35–1.09 nM in gastric (NCI-N87), pancreatic (Capan-1), and breast (MDA-MB-468) human cancer cell lines, with free drug exhibiting 0.02–0.07 nM potency in the same cell lines. In additional studies, hRS7-pro-2-PDox was observed to be cytotoxic to MDA-MB-468, AG S, NCI-N87 and Capan-1 solid tumor cell lines (not shown).

[0216] No significant difference in binding of the antibody moiety to NCI-N87 gastric carcinoma cells was observed between unconjugated hRS7 and pro-2-PDox-hRS7 conjugated to 6 molecules of pro-2-PDox per antibody (not shown). It is concluded that conjugation of pro-2-PDox to antibodies does not affect antibody-antigen binding activity.

[0217] Serum stability – Serum stability of anti-Trop-2 ADC (hRS7-pro-2-PDox) was determined by incubation in human serum at a concentration of 0.2 mg/mL at 37°C. The incubate was analyzed by HPLC using butyl hydrophobic interaction chromatography (HIC). The analysis showed that there was no release of free drug from the conjugate, suggesting high serum stability of the conjugate. When the same experiment was repeated with hRS7-doxorubicin conjugate, containing the same cleavable linker as hRS7-pro-2-PDox, and where

the free drug was independently verified to be released with a half-life of 96 h, clear formation of a peak corresponding to free doxorubicin was seen on HIC HPLC.

[0218] Surprisingly, it was determined that the pro-2-PDox conjugate was held tightly to the antibody because it cross-linked the peptide chains of the antibody together. The cross-linking stabilizes the attachment of the drug to the antibody so that the drug is only released intracellularly after the antibody is metabolized. The cross-linking assists in minimizing toxicity, for example cardiotoxicity, that would result from release of free drug in circulation. Previous use of 2-PDox peptide conjugates failed because the drug cross-linked the peptide to other proteins or peptides *in vivo*. With the present anti-Trop-2 ADC, the pro-2-PDox is attached to interchain disulfide thiol groups while in the prodrug form. The prodrug protection is rapidly removed *in vivo* soon after injection and the resulting 2-PDox portion of the conjugate cross-links the peptide chains of the antibody, forming intramolecular cross-linking within the antibody molecule. This both stabilizes the ADC and prevents cross-linking to other molecules in circulation.

[0219] *In vivo* preclinical studies - Tumor size was determined by caliper measurements of length (L) and width (W) with tumor volume calculated as $(LxW^2)/2$. Tumors were measured and mice weighed twice a week. Mice were euthanized if their tumors reached >1 cm^3 in size, lost greater than 15% of their starting body weight, or otherwise became moribund. Statistical analysis for the tumor growth data was based on area under the curve (AUC) and survival time. 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 non-specific controls. For the saline control analysis a one-tailed *t*-test was used to assess significance. Survival studies were analyzed using Kaplan-Meier plots (log-rank analysis), using the Prism GraphPad Software (v4.03) software package (Advanced Graphics Software, Inc.; Encinitas, CA). All doses in preclinical experiments are expressed in antibody amounts. In terms of drug, 100 μg of antibody (5 mg/kg) in a 20-g mouse, for example, carries 1.4 μg–2.8 μg (0.14–0.17 mg/kg) of pro-2-PDox equivalent dose when using an ADC with 3–6 drugs/IgG.

[0220] A single i.v. dose of ≥ 300 μg [~ 10 μg of pro-2-PDox] of the anti-Trop-2 ADC was lethal, but 4 doses of 45 μg given in 2 weeks were tolerated by all animals. Using this dosing regimen, we examined the therapeutic effect of anti-Trop-2 hRS7-pro-2-PDox in 2 human tumor xenograft models, Capan-1 (pancreatic cancer) and NCI-N87 (gastric cancer). Therapy

began 7 days after tumor transplantation in nude mice. In the established, 7-day-old, Capan-1 model, 100% of established tumors quickly regressed, with no evidence of re-growth (**FIG. 4**). This result was reproduced in a repeat experiment (not shown). The anti-Trop-2 conjugate of pro-2-PDox was much more effective than the same drug conjugated to an antibody (hMN-14) against CEACAM5, which is also expressed in pancreatic cancer, or an antibody against CD20 (hA20), which is not. All treatments were superior to the saline control.

[0221] Similar results were observed in the established NCI-N87 model (**FIG. 5A**), where a 2nd course of therapy, administered after day 70, was safely tolerated and led to further regressions of residual tumor (**FIG. 5A**). The internalizing hRS7-SN-38 conjugate, targeting Trop-2, provided better therapeutic responses than a conjugate of a poorly internalizing anti-CEACAM5 antibody, hMN-14 (**FIG. 4**, **FIG. 5**). A non-targeted anti-CD20 ADC, hA20-pro-2-PDox, was ineffective, indicating selective therapeutic efficacy (**FIG. 4**, **FIG. 5**). Data from a breast cancer xenograft (MDA-MB-468) and a second pancreatic cancer xenograft (**FIG. 5B** and **FIG. 5C**, respectively) showed the same pattern, with the anti-Trop-2 ADC significantly more efficacious compared to non-targeting ADC or saline control. In both cases, administration of anti-Trop-2 ADC produced a clear inhibition of tumor growth to the end of the study.

[0222] PK and toxicity of hRS7-pro-2-PDox with substitutions of 6.8 or 3.7 drug/IgG – Antibody-drug conjugates (ADCs) carrying as much as 8 ultratoxic drugs/MAb are known to clear faster than unmodified MAb and to increase off-target toxicity, a finding that has led to the current trends to use drug substitutions of ≤ 4 (Hamblett et al., 2004, Clin Cancer Res 10:7063-70). ADCs were prepared and evaluated with mean drug/MAb substitution ratios (MSRs) of ~6:1 and ~3:1. Groups of normal mice (n = 5) were administered, i.v., single doses of unmodified hRS7 or hRS7-pro-2-PDox with drug substitution of 6.8 or 3.7 (same protein dose), and serum samples were collected at 30 min, 4 h, 24 h, 72 h, and 168 h post-injection. These were analyzed by ELISA for antibody concentration. There were no significant differences in serum concentrations at various times, indicating that these showed similar clearance from the blood. The PK parameters (Cmax, AUC, etc.) were also similar. ADCs with either higher or lower drug substitution had similar tolerability in nude mice, when the administered at the same dose of conjugated drug.

[0223] Therapeutic Efficacy at Minimum Effective Dose (MED) – Anti-Trop-2 ADC (hRS7-pro-2-PDox), was evaluated in nude mice bearing NCI-N87 human gastric cancer xenografts by administering a single bolus protein dose of 9 mg/kg, 6.75 mg/kg, 4.5 mg/kg, 2.25 mg/kg,

or 1 mg/kg. The therapy was started when the mean tumor volume (mTV) was 0.256 cm^3. On day 21, mTV in the saline control group (non-treatment group) was 0.801 ± 0.181 cm^3 which was significantly larger than that in mice treated with 9, 6.75, 4.5, or 2.25 mg/kg dose with mTV of 0.211 ± 0.042 cm^3, 0.239 ± 0.0.054 cm^3, 0.264 ± 0.087 cm^3, and 0.567 ± 0.179 cm^3, respectively (P<0.0047, one tailed t-test). From these, the minimum effective dose was estimated to be 2.25 mg/kg, while 9 mg/kg represented MTD.

Example 3. Additional Studies With Anti-Trop-2 pro-2-PDox ADC

[0224] Further *in vivo* efficacy studies were performed in nude mice implanted with NCI-N87 human gastric cancer xenografts (**FIG. 6A-F**). One treatment cycle with 4 x 45 µg of hRS7-pro-2-PDox rapidly regressed all tumors (**FIG. 6D**). A second treatment cycle was initiated about 2 months after the end of the first cycle, resulting in complete regression of all but one of the hRS7-pro-2-PDox treated animals. The hA20 (anti-CD20), hLL1 (anti-CD22) and hMN-14 (anti-CEACAM5) conjugates had little effect on tumor progression (**FIG. 6B, 6E** and **6F**) compared to saline control (**FIG. 6A**). Administration of pro-2-PDox-hMN-15 (anti-CEACAM6) resulted in a delayed regression of gastric cancer (**FIG. 6C**), which was less effective than the hRS7 conjugate (**FIG. 6D**).

[0225] The effect of varying dosage schedule of anti-Trop-2 ADC on anti-tumor efficacy was examined (**FIG. 7, FIG. 8A-G**). The experiment began 9 days after tumor implantation when mean tumor volume for all groups was 0.383 cm^3, and ended on day 93 (84 days after initiation of therapy). In this study, administration of anti-Trop-2 ADC as a single dose of 180 µg, two weekly doses of 90 µg, and q4dx4 of 45 µg all resulted in significantly enhanced survival (**FIG. 7, FIG. 8B-D**). For the saline control, 0 of 9 mice survived (**FIG. 8A**). For mice receiving 45 µg q4dx4 of hRS7-pro-2-PDox, 8 of 9 mice were alive at day 94 (**FIG. 8B**). For mice receiving 90 µg weekly x 2 of hRS7-pro-2-PDox, 9 of 9 mice were alive at day 94 (**FIG. 8C**). For mice receiving a single dose of 180 µg of hRS7-pro-2-PDox, 7 of 9 mice were alive at day 94 (**FIG. 8D**).

[0226] At the same dosage schedule, the control hA20 (anti-CD20) conjugate had no effect on survival (**FIG. 7, FIG. 8E-F**). A toxicity study showed that the three dosage schedules of hRS7-pro-2-PDox resulted in similarly low levels of toxicity (not shown).

[0227] The hRS7-pro-2-PDox conjugate was also effective in Capan-1 pancreatic cancer (not shown) and was more effective at inhibiting tumor growth than a hRS7-SN-38 conjugate (not shown). The hPAM4-pro-2-PDox conjugate was also more effective at inhibiting growth of Capan-1 human pancreatic cancer than an hPAM4-SN-38 conjugate (not shown). At 63 days

after Capan-1 tumor injection (with therapy starting at 1 days post-innoculation), 0 of 10 mice were alive in the saline control, 10 of 10 mice were alive in mice treated twice weekly x 2 weeks with 45 μg of hPAM4-pro-2-PDox, 2 of 10 mice were alive in mice treated twice weekly x 2 weeks with 45 μg of hA20-pro-2-PDox, 0 of 10 mice were alive in mice treated twice weekly x 4 weeks with 250 μg of hPAM4-SN-38, and 0 of 10 mice were alive in mice treated twice weekly x 4 weeks with 250 μg of h20-SN-38.

[0228] hRS7-pro-2-PDox was substantially more effective than hRS7-SN-38 at inhibiting growth of PxPC-3 pancreatic cancer (not shown) and was slightly more effective than hRS7-SN-38 at inhibiting growth of MDA-MB-468 breast cancer (not shown).

[0229] The effect of different single doses of hRS7-pro-2-PDox on growth of NCI-N87 gastric carcinoma xenografts is shown in **FIG. 9**. Using a single dose, the maximum effect on tumor growth was observed at 90 μg or higher (**FIG. 9**).

[0230] Survival curves for mice bearing NCI-N87 human gastric carcinoma xenografts and administered a single dose of anti-Trop-2 ADC are shown in **FIG. 10**. A single dose of 45 μg was the minimum required to see a significant survival benefit compared to saline control (**FIG. 10**). Mice administered single doses of 90 μg or higher showed 100% survival to the termination of the experiment.

[0231] The ADCC activity of various hRS7-ADC conjugates was determined in comparison to hRS7 IgG (**FIG. 11**). PBMCs were purified from blood purchased from the Blood Center of New Jersey. A Trop-2-positive human pancreatic adenocarcinoma cell line (BxPC-3) was used as the target cell line with an effector to target ratio of 100:1. ADCC mediated by hRS7 IgG was compared to hRS7-Pro-2-PDox, hRS7-CL2A-SN-38, and the reduced and capped hRS7-NEM. All were used at 33.3 nM.

[0232] Results are shown in **FIG. 11**. Overall activity was low, but significant. There was 8.5% specific lysis for the hRS7 IgG which was not significantly different from hRS7-Pro-2-PDox. Both were significantly better than hLL2 control and hRS7-NEM and hRS7-SN-38 ($P<0.02$, two-tailed t-test). There was no difference between hRS7-NEM and hRS7-SN-38.

Example 4. Efficacy of anti-Trop-2-SN-38 ADC Against Diverse Epithelial Cancers *In Vivo*

Abstract

[0233] The purpose of this study was to evaluate the efficacy of an SN-38-anti-Trop-2 (hRS7) ADC against several human solid tumor types, and to assess its tolerability in mice and monkeys, the latter with tissue cross-reactivity to hRS7 similar to humans. Two SN-38 derivatives, CL2-SN-38 and CL2A-SN-38, were conjugated to the anti-Trop-2–humanized

antibody, hRS7. The immunoconjugates were characterized *in vitro* for stability, binding, and cytotoxicity. Efficacy was tested in five different human solid tumor-xenograft models that expressed Trop-2 antigen. Toxicity was assessed in mice and in Cynomolgus monkeys.

[0234] The hRS7 conjugates of the two SN-38 derivatives were equivalent in drug substitution (~6), cell binding (K_d ~ 1.2 nmol/L), cytotoxicity (IC_{50} ~ 2.2 nmol/L), and serum stability *in vitro* ($t_{1/2}$ ~ 20 hours). Exposure of cells to the ADC demonstrated signaling pathways leading to PARP cleavage, but differences *versus* free SN-38 in p53 and p21 upregulation were noted. Significant antitumor effects were produced by hRS7-SN-38 at nontoxic doses in mice bearing Calu-3 ($P \leq 0.05$), Capan-1 ($P < 0.018$), BxPC-3 ($P < 0.005$), and COLO 205 tumors ($P < 0.033$) when compared to nontargeting control ADCs. Mice tolerated a dose of 2 × 12 mg/kg (SN-38 equivalents) with only short-lived elevations in ALT and AST liver enzyme levels. Cynomolgus monkeys infused with 2 × 0.96 mg/kg exhibited only transient decreases in blood counts, although, importantly, the values did not fall below normal ranges.

[0235] In summary, the anti-Trop-2 hRS7-CL2A-SN-38 ADC provided significant and specific antitumor effects against a range of human solid tumor types. It was well tolerated in monkeys, with tissue Trop-2 expression similar to humans, at clinically relevant doses.

Introduction

[0236] Successful irinotecan treatment of patients with solid tumors has been limited, due in large part to the low conversion rate of the CPT-11 prodrug into the active SN-38 metabolite. Others have examined nontargeted forms of SN-38 as a means to bypass the need for this conversion and to deliver SN-38 passively to tumors. We conjugated SN-38 covalently to a humanized anti-Trop-2 antibody, hRS7. This antibody–drug conjugate has specific antitumor effects in a range of s.c. human cancer xenograft models, including non–small cell lung carcinoma, pancreatic, colorectal, and squamous cell lung carcinomas, all at nontoxic doses (e.g., ≤3.2 mg/kg cumulative SN-38 equivalent dose). Trop-2 is widely expressed in many epithelial cancers, but also some normal tissues, and therefore a dose escalation study in Cynomolgus monkeys was performed to assess the clinical safety of this conjugate. Monkeys tolerated 24 mg SN-38 equivalents/kg with only minor, reversible, toxicities. Given its tumor-targeting and safety profile, hRS7-SN-38 provides a significant improvement in the management of solid tumors responsive to irinotecan.

Material and Methods

[0237] Cell lines, antibodies, and chemotherapeutics - All human cancer cell lines used in this study were purchased from the American Type Culture Collection. These include Calu-3 (non–small cell lung carcinoma), SK-MES-1 (squamous cell lung carcinoma), COLO 205 (colonic adenocarcinoma), Capan-1 and BxPC-3 (pancreatic adenocarcinomas), and PC-3 (prostatic adenocarcinomas). Humanized RS7 IgG and control humanized anti-CD20 (hA20 IgG, veltuzumab) and anti-CD22 (hLL2 IgG, epratuzumab) antibodies were prepared at Immunomedics, Inc. Irinotecan (20 mg/mL) was obtained from Hospira, Inc.

[0238] SN-38 immunoconjugates and *in vitro* aspects - Synthesis of CL2-SN-38 has been described previously (Moon et al., 2008, J Med Chem 51:6916-26). Its conjugation to hRS7 IgG and serum stability were performed as described (Moon et al., 2008, J Med Chem 51:6916-26; Govindan et al., 2009, Clin Chem Res 15:6052-61). Preparations of CL2A-SN-38 (M.W. 1480) and its hRS7 conjugate, and stability, binding, and cytotoxicity studies, were conducted as described in the preceding Examples.

[0239] *In vivo* therapeutic studies - For all animal studies, the doses of SN-38 immunoconjugates and irinotecan are shown in SN-38 equivalents. Based on a mean SN-38/IgG substitution ratio of 6, a dose of 500 μg ADC to a 20-g mouse (25 mg/kg) contains 0.4 mg/kg of SN-38. Irinotecan doses are likewise shown as SN-38 equivalents (i.e., 40 mg irinotecan/kg is equivalent to 24 mg/kg of SN-38).

[0240] NCr female athymic nude (*nu/nu*) mice, 4 to 8 weeks old, and male Swiss-Webster mice, 10 weeks old, were purchased from Taconic Farms. Tolerability studies were performed in Cynomolgus monkeys (*Macaca fascicularis*; 2.5–4 kg male and female) by SNBL USA, Ltd.

[0241] Animals were implanted subcutaneously with different human cancer cell lines. Tumor volume (TV) was determined by measurements in 2 dimensions using calipers, with volumes defined as: $L \times w^2/2$, where L is the longest dimension of the tumor and w is the shortest. Tumors ranged in size between 0.10 and 0.47 cm^3 when therapy began. Treatment regimens, dosages, and number of animals in each experiment are described in the Results. The lyophilized hRS7-CL2A-SN-38 and control ADC were reconstituted and diluted as required in sterile saline. All reagents were administered intraperitoneally (0.1 mL), except irinotecan, which was administered intravenously. The dosing regimen was influenced by our prior investigations, where the ADC was given every 4 days or twice weekly for varying lengths of time (Moon et al., 2008, J Med Chem 51:6916-26; Govindan et al., 2009, Clin Chem Res 15:6052-61). This dosing frequency reflected a consideration of the conjugate's serum half-life *in vitro*, to allow a more continuous exposure to the ADC.

[0242] Statistics - Growth curves are shown as percent change in initial TV over time. Statistical analysis of tumor growth was based on area under the curve (AUC). Profiles of individual tumor growth were obtained through linear-curve modeling. An *f*-test was employed to determine equality of variance between groups before statistical analysis of growth curves. A 2-tailed *t*-test was used to assess statistical significance between the various treatment groups and controls, except for the saline control, where a 1-tailed *t*-test was used (significance at $P \leq 0.05$). Statistical comparisons of AUC were performed only up to the time that the first animal within a group was euthanized due to progression.

[0243] Pharmacokinetics and biodistribution - ^{111}In-radiolabeled hRS7-CL2A-SN-38 and hRS7 IgG were injected into nude mice bearing s.c. SK-MES-1 tumors (~0.3 cm^3). One group was injected intravenously with 20 μCi (250-μg protein) of ^{111}In-hRS7-CL2A-SN-38, whereas another group received 20 μCi (250-μg protein) of ^{111}In-hRS7 IgG. At various timepoints mice (5 per timepoint) were anesthetized, bled via intracardiac puncture, and then euthanized. Tumors and various tissues were removed, weighed, and counted by γ scintillation to determine the percentage injected dose per gram tissue (% ID/g). A third group was injected with 250 μg of unlabeled hRS7-CL2A-SN-38 3 days before the administration of ^{111}In-hRS7-CL2A-SN-38 and likewise necropsied. A 2-tailed *t*-test was used to compare hRS7-CL2A-SN-38 and hRS7 IgG uptake after determining equality of variance using the *f*-test. Pharmacokinetic analysis on blood clearance was performed using WinNonLin software (Parsight Corp.).

[0244] Tolerability in Swiss-Webster mice and Cynomolgus monkeys - Briefly, mice were sorted into 4 groups each to receive 2-mL i.p. injections of either a sodium acetate buffer control or 3 different doses of hRS7-CL2A-SN-38 (4, 8, or 12 mg/kg of SN-38) on days 0 and 3 followed by blood and serum collection, as described in Results. Cynomolgus monkeys (3 male and 3 female; 2.5–4.0 kg) were administered 2 different doses of hRS7-CL2A-SN-38. Dosages, times, and number of monkeys bled for evaluation of possible hematologic toxicities and serum chemistries are described in the Results.

Results

[0245] Stability and potency of hRS7-CL2A-SN-38 - Two different linkages were used to conjugate SN-38 to hRS7 IgG (**FIG. 12A**). The first is termed CL2-SN-38 and has been described previously (Moon et al., 2008, J Med Chem 51:6916-26; Govindan et al., 2009, Clin Chem Res 15:6052-61). A change in the synthesis of CL2 to remove the phenylalanine moiety within the linker was used to produce the CL2A linker. This change simplified the synthesis, but did not affect the conjugation outcome (e.g., both CL2-SN-38 and CL2A-SN-

38 incorporated ~6 SN-38 per IgG molecule). Side-by-side comparisons found no significant differences in serum stability, antigen binding, or *in vitro* cytotoxicity. This result was surprising, since the phenylalanine residue in CL2 is part of a designed cleavage site for cathepsin B, a lysosomal protease.

[0246] To confirm that the change in the SN-38 linker from CL2 to CL2A did not impact *in vivo* potency, hRS7-CL2A and hRS7-CL2-SN-38 were compared in mice bearing COLO 205 (**FIG. 12B**) or Capan-1 tumors (**FIG. 12C**), using 0.4 mg or 0.2 mg/kg SN-38 twice weekly × 4 weeks, respectively, and with starting tumors of 0.25 cm^3 size in both studies. Both the hRS7-CL2A and CL2-SN-38 conjugates significantly inhibited tumor growth compared to untreated (AUC_{14days} $P < 0.002$ vs. saline in COLO 205 model; AUC_{21days} $P < 0.001$ vs. saline in Capan-1 model), and a nontargeting anti-CD20 control ADC, hA20-CL2A-SN-38 (AUC_{14days} $P < 0.003$ in COLO-205 model; AUC_{35days}: $P < 0.002$ in Capan-1 model). At the end of the study (day 140) in the Capan-1 model, 50% of the mice treated with hRS7-CL2A-SN-38 and 40% of the hRS7-CL2-SN-38 mice were tumor-free, whereas only 20% of the hA20-ADC-treated animals had no visible sign of disease. As demonstrated in **FIG. 12**, the CL2A linker resulted in a somewhat higher efficacy compared to CL2.

[0247] Mechanism of action - *In vitro* cytotoxicity studies demonstrated that hRS7-CL2A-SN-38 had IC_{50} values in the nmol/L range against several different solid tumor lines (**Table 6**). The IC_{50} with free SN-38 was lower than the conjugate in all cell lines. Although there was no apparent correlation between Trop-2 expression and sensitivity to hRS7-CL2A-SN-38, the IC_{50} ratio of the ADC versus free SN-38 was lower in the higher Trop-2-expressing cells, most likely reflecting the enhanced ability to internalize the drug when more antigen is present.

[0248] SN-38 is known to activate several signaling pathways in cells, leading to apoptosis (e.g., Cusack et al., 2001, Cancer Res 61:3535-40; Liu et al. 2009, Cancer Lett 274:47-53; Lagadec et al., 2008, Br J Cancer 98:335-44). Our initial studies examined the expression of 2 proteins involved in early signaling events ($p21^{Waf1/Cip1}$ and p53) and 1 late apoptotic event [cleavage of poly-ADP-ribose polymerase (PARP)] *in vitro* (not shown). In BxPC-3, SN-38 led to a 20-fold increase in $p21^{Waf1/Cip1}$ expression (not shown), whereas hRS7-CL2A-SN-38 resulted in only a 10-fold increase (not shown), a finding consistent with the higher activity with free SN-38 in this cell line (**Table 6**). However, hRS7-CL2A-SN-38 increased $p21^{Waf1/Cip1}$ expression in Calu-3 more than 2-fold over free SN-38 (not shown).

[0249] A greater disparity between hRS7-CL2A-SN-38- and free SN-38-mediated signaling events was observed in p53 expression (not shown). In both BxPC-3 and Calu-3, upregulation of p53 with free SN-38 was not evident until 48 hours, whereas hRS7-CL2A-SN-38 upregulated p53 within 24 hours (not shown). In addition, p53 expression in cells exposed to the ADC was higher in both cell lines compared to SN-38 (not shown). Interestingly, although hRS7 IgG had no appreciable effect on $p21^{Waf1/Cip1}$ expression, it did induce the upregulation of p53 in both BxPC-3 and Calu-3, but only after a 48-hour exposure (not shown). In terms of later apoptotic events, cleavage of PARP was evident in both cell lines when incubated with either SN-38 or the conjugate (not shown). The presence of the cleaved PARP was higher at 24 hours in BxPC-3 (not shown), which correlates with high expression of p21 and its lower IC_{50}. The higher degree of cleavage with free SN-38 over the ADC was consistent with the cytotoxicity findings.

[0250] Efficacy of hRS7-SN-38 - Because Trop-2 is widely expressed in several human carcinomas, studies were performed in several different human cancer models, which started using the hRS7-CL2-SN-38 linkage, but later, conjugates with the CL2A-linkage were used. Calu-3–bearing nude mice given 0.04 mg SN-38/kg of the hRS7-CL2-SN-38 every 4 days × 4 had a significantly improved response compared to animals administered the equivalent amount of non-targeting hLL2-CL2-SN-38 (TV = 0.14 ± 0.22 cm^3 vs. 0.80 ± 0.91 cm^3, respectively; AUC_{42days} $P < 0.026$; **FIG. 13A**). A dose–response was observed when the dose was increased to 0.4 mg/kg SN-38 (**FIG. 13A**). At this higher dose level, all mice given the specific hRS7 conjugate were "cured" within 28 days, and remained tumor-free until the end of the study on day 147, whereas tumors regrew in animals treated with the irrelevant ADC (specific vs. irrelevant AUC_{98days}: $P = 0.05$). In mice receiving the mixture of hRS7 IgG and SN-38, tumors progressed >4.5-fold by day 56 (TV = 1.10 ± 0.88 cm^3; AUC_{56days} $P < 0.006$ vs. hRS7-CL2-SN-38) (**FIG. 13A**).

[0251] Efficacy also was examined in human colonic (COLO 205) and pancreatic (Capan-1) tumor xenografts. In COLO 205 tumor-bearing animals, (**FIG. 13B**), hRS7-CL2-SN-38 (0.4 mg/kg, q4dx8) prevented tumor growth over the 28-day treatment period with significantly smaller tumors compared to control anti-CD20 ADC (hA20-CL2-SN-38), or hRS7 IgG (TV = 0.16 ± 0.09 cm^3, 1.19 ± 0.59 cm^3, and 1.77 ± 0.93 cm^3, respectively; AUC_{28days} $P < 0.016$).

Table 6. Expression of Trop-2 *in vitro* cytotoxicity of SN-38 and hRS7-SN-38 in various solid tumor lines

Cell line	Trop-2 expression *via* FACS		Cytotoxicity results				
	Median fluorescence (background)	Percent positive	SN-38 IC_{50} (nmol/L)	95% CI IC_{50} (nmol/L)	hRS7-SN-38 IC_{50} (nmol/L)	95% CI IC_{50} (nmol/L)	ADC/free SN-38 ratio
Calu-3	282.2 (4.7)	99.6%	7.19	5.77–8.95	9.97	8.12–12.25	1.39
COLO 205	141.5 (4.5)	99.5%	1.02	0.66–1.57	1.95	1.26–3.01	1.91
Capan-1	100.0 (5.0)	94.2%	3.50	2.17–5.65	6.99	5.02–9.72	2.00
PC-3	46.2 (5.5)	73.6%	1.86	1.16–2.99	4.24	2.99–6.01	2.28
SK-MES-1	44.0 (3.5)	91.2%	8.61	6.30–11.76	23.14	17.98–29.78	2.69
BxPC-3	26.4 (3.1)	98.3%	1.44	1.04–2.00	4.03	3.25–4.98	2.80

[0252] The MTD of irinotecan (24 mg SN-38/kg, q2dx5) was as effective as hRS7-CL2-SN-38 in COLO 205 cells, because mouse serum can more efficiently convert irinotecan to SN-38 (Morton et al., 2000, Cancer Res 60:4206-10) than human serum, but the SN-38 dose in irinotecan (2,400 μg cumulative) was 37.5-fold greater than with the conjugate (64 μg total).

[0253] Animals bearing Capan-1 (**FIG. 13C**) showed no significant response to irinotecan alone when given at an SN-38-dose equivalent to the hRS7-CL2-SN-38 conjugate (e.g., on day 35, average tumor size was 0.04 ± 0.05 cm^3 in animals given 0.4 mg SN-38/kg hRS7-SN-38 vs. 1.78 ± 0.62 cm^3 in irinotecan-treated animals given 0.4 mg/kg SN-38; AUC_{day35} $P < 0.001$; **FIG. 13C**). When the irinotecan dose was increased 10-fold to 4 mg/kg SN-38, the response improved, but still was not as significant as the conjugate at the 0.4 mg/kg SN-38 dose level (TV = 0.17 ± 0.18 cm^3 vs. 1.69 ± 0.47 cm^3, AUC_{day49} $P < 0.001$) (**FIG. 13C**). An equal dose of nontargeting hA20-CL2-SN-38 also had a significant antitumor effect as compared to irinotecan-treated animals, but the specific hRS7 conjugate was significantly better than the irrelevant ADC (TV = 0.17 ± 0.18 cm^3 vs. 0.80 ± 0.68 cm^3, AUC_{day49} $P < 0.018$) (**FIG. 13C**).

[0254] Studies with the hRS7-CL2A-SN-38 ADC were then extended to 2 other models of human epithelial cancers. In mice bearing BxPC-3 human pancreatic tumors (**FIG. 13D**), hRS7-CL2A-SN-38 again significantly inhibited tumor growth in comparison to control mice treated with saline or an equivalent amount of nontargeting hA20-CL2A-SN-38 (TV = 0.24 ± 0.11 cm^3 vs. 1.17 ± 0.45 cm^3 and 1.05 ± 0.73 cm^3, respectively; AUC_{day21} $P < 0.001$), or irinotecan given at a 10-fold higher SN-38 equivalent dose (TV = 0.27 ± 0.18 cm^3 vs. 0.90 ±

0.62 cm^3, respectively; AUC_{day25} $P < 0.004$) (**FIG. 13D**). Interestingly, in mice bearing SK-MES-1 human squamous cell lung tumors treated with 0.4 mg/kg of the ADC (**FIG. 13E**), tumor growth inhibition was superior to saline or unconjugated hRS7 IgG (TV = 0.36 ± 0.25 cm^3 vs. 1.02 ± 0.70 cm^3 and 1.30 ± 1.08 cm^3, respectively; $AUC_{28\ days}$, $P < 0.043$), but nontargeting hA20-CL2A-SN-38 or the MTD of irinotecan provided the same antitumor effects as the specific hRS7-SN-38 conjugate (**FIG. 13E**).

[0255] In all murine studies, the hRS7-SN-38 ADC was well tolerated in terms of body weight loss (not shown).

[0256] Biodistribution of hRS7-CL2A-SN-38 - The biodistributions of hRS7-CL2A-SN-38 or unconjugated hRS7 IgG were compared in mice bearing SK-MES-1 human squamous cell lung carcinoma xenografts (not shown), using the respective ^{111}In-labeled substrates. A pharmacokinetic analysis was performed to determine the clearance of hRS7-CL2A-SN-38 relative to unconjugated hRS7 (not shown). The ADC cleared faster than the equivalent amount of unconjugated hRS7, with the ADC exhibiting ~40% shorter half-life and mean residence time. Nonetheless, this had a minimal impact on tumor uptake (not shown). Although there were significant differences at the 24- and 48-hour timepoints, by 72 hours (peak uptake) the amounts of both agents in the tumor were similar. Among the normal tissues, hepatic and splenic differences were the most striking (not shown). At 24 hours postinjection, there was >2-fold more hRS7-CL2A-SN-38 in the liver than hRS7 IgG (not shown). Conversely, in the spleen there was 3-fold more parental hRS7 IgG present at peak uptake (48-hour timepoint) than hRS7-CL2A-SN-38 (not shown). Uptake and clearance in the rest of the tissues generally reflected differences in the blood concentration (not shown).

[0257] Because twice-weekly doses were given for therapy, tumor uptake in a group of animals that first received a predose of 0.2 mg/kg (250 μg protein) of the hRS7 ADC 3 days before the injection of the ^{111}In-labeled antibody was examined. Tumor uptake of ^{111}In-hRS7-CL2A-SN-38 in predosed mice was substantially reduced at every timepoint in comparison to animals that did not receive the predose (e.g., at 72 hours, predosed tumor uptake was 12.5% ± 3.8% ID/g vs. 25.4% ± 8.1% ID/g in animals not given the predose; $P = 0.0123$; not shown). Predosing had no appreciable impact on blood clearance or tissue uptake (not shown). These studies suggest that in some tumor models, tumor accretion of the specific antibody can be reduced by the preceding dose(s), which likely explains why the specificity of a therapeutic response could be diminished with increasing ADC doses and why further dose escalation is not indicated.

[0258] Tolerability of hRS7-CL2A-SN-38 in Swiss-Webster mice and Cynomolgus monkeys
Swiss-Webster mice tolerated 2 doses over 3 days, each of 4, 8, and 12 mg SN-38/kg of the hRS7-CL2A-SN-38, with minimal transient weight loss (not shown). No hematopoietic toxicity occurred and serum chemistries only revealed elevated aspartate transaminase (AST, **FIG. 14A**) and alanine transaminase (ALT, **FIG. 14B**). Seven days after treatment, AST rose above normal levels (>298 U/L) in all 3 treatment groups (**FIG. 14A**), with the largest proportion of mice being in the 2 × 8 mg/kg group. However, by 15 days posttreatment, most animals were within the normal range. ALT levels were also above the normal range (>77 U/L) within 7 days of treatment (**FIG. 14B**) and with evidence of normalization by Day 15. Livers from all these mice did not show histologic evidence of tissue damage (not shown). In terms of renal function, only glucose and chloride levels were somewhat elevated in the treated groups. At 2 × 8 mg/kg, 5 of 7 mice had slightly elevated glucose levels (range of 273–320 mg/dL, upper end of normal 263 mg/dL) that returned to normal by 15 days postinjection. Similarly, chloride levels were slightly elevated, ranging from 116 to 127 mmol/L (upper end of normal range 115 mmol/L) in the 2 highest dosage groups (57% in the 2 × 8 mg/kg group and 100% of the mice in the 2 × 12 mg/kg group), and remained elevated out to 15 days postinjection. This also could be indicative of gastrointestinal toxicity, because most chloride is obtained through absorption by the gut; however, at termination, there was no histologic evidence of tissue damage in any organ system examined (not shown).

[0259] Because mice do not express Trop-2 identified by hRS7, a more suitable model was required to determine the potential of the hRS7 conjugate for clinical use. Immunohistology studies revealed binding in multiple tissues in both humans and Cynomolgus monkeys (breast, eye, gastrointestinal tract, kidney, lung, ovary, fallopian tube, pancreas, parathyroid, prostate, salivary gland, skin, thymus, thyroid, tonsil, ureter, urinary bladder, and uterus; not shown). Based on this cross-reactivity, a tolerability study was performed in monkeys.

[0260] The group receiving 2 × 0.96 mg SN-38/kg of hRS7-CL2A-SN-38 had no significant clinical events following the infusion and through the termination of the study. Weight loss did not exceed 7.3% and returned to acclimation weights by day 15. Transient decreases were noted in most of the blood count data (neutrophil and platelet data shown in **FIG 14C** and **FIG. 14D**), but values did not fall below normal ranges. No abnormal values were found in the serum chemistries. Histopathology of the animals necropsied on day 11 (8 days after last injection) showed microscopic changes in hematopoietic organs (thymus, mandibular and mesenteric lymph nodes, spleen, and bone marrow), gastrointestinal organs (stomach, duodenum, jejunum, ileum, cecum, colon, and rectum), female reproductive organs (ovary,

uterus, and vagina), and at the injection site. These changes ranged from minimal to moderate and were fully reversed at the end of the recovery period (day 32) in all tissues, except in the thymus and gastrointestinal tract, which were trending towards full recovery at this later timepoint (not shown).

[0261] At the 2 × 1.92 mg SN-38/kg dose level of the conjugate, there was 1 death arising from gastrointestinal complications and bone marrow suppression, and other animals within this group showed similar, but more severe adverse events than the 2 × 0.96 mg/kg group (not shown). These data indicate that dose-limiting toxicities were identical to that of irinotecan; namely, intestinal and hematologic. Thus, the MTD for hRS7-CL2A-SN-38 lies between 2 × 0.96 and 1.92 mg SN-38/kg, which represents a human equivalent dose of 2 × 0.3 to 0.6 mg/kg SN-38.

Discussion

[0262] Trop-2 is a protein expressed on many epithelial tumors, including lung, breast, colorectal, pancreas, prostate, and ovarian cancers, making it a potentially important target for delivering cytotoxic agents (Ohmachi et al., 2006, Clin Cancer Res 12:3057-63; Fong et al., 2008, Br J Cancer 99:1290-95; Cubas et al., 2009, Biochim Biophys Acta 1796:309-14). The RS7 antibody internalizes when bound to Trop-2 (Shih et al., 1995, Cancer Res 55:5857s-63s), which enables direct intracellular delivery of cytotoxics.

[0263] SN-38 is a potent topoisomerase-I inhibitor, with IC_{50} values in the nanomolar range in several cell lines. It is the active form of the prodrug, irinotecan, that is used for the treatment of colorectal cancer, and which also has activity in lung, breast, and brain cancers. We reasoned that a directly targeted SN-38, in the form of an ADC, would be a significantly improved therapeutic over CPT-11, by overcoming the latter's low and patient-variable bioconversion to active SN-38 (Mathijssen et al., 2001, Clin Cancer Res 7:2182-94).

[0264] The Phe-Lys peptide inserted in the original CL2 derivative allowed for possible cleavage via cathepsin B. To simplify the synthetic process, in CL2A the phenylalanine was eliminated, and thus the cathepsin B cleavage site was removed. Interestingly, this product had a better-defined chromatographic profile compared to the broad profile obtained with CL2 (not shown), but more importantly, this change had no impact on the conjugate's binding, stability, or potency in side-by-side testing. These data suggest that SN-38 in CL2 was released from the conjugate primarily by the cleavage at the pH-sensitive benzyl carbonate bond to SN-38's lactone ring and not the cathepsin B cleavage site.

[0265] *In vitro* cytotoxicity of hRS7 ADC against a range of solid tumor cell lines consistently had IC_{50} values in the nmol/L range. However, cells exposed to free SN-38 demonstrated a lower IC_{50} value compared to the ADC. This disparity between free and conjugated SN-38 was also reported for ENZ-2208 (Sapra et al., 2008, Clin Cancer Res 14:1888-96, Zhao et al., 2008, Bioconjug Chem 19:849-59) and NK012 (Koizumi et al., 2006, Cancer Res 66:10048-56). ENZ-2208 utilizes a branched PEG to link about 3.5 to 4 molecules of SN-38 per PEG, whereas NK012 is a micelle nanoparticle containing 20% SN-38 by weight. With our ADC, this disparity (i.e., ratio of potency with free vs. conjugated SN-38) decreased as the Trop-2 expression levels increased in the tumor cells, suggesting an advantage to targeted delivery of the drug. In terms of *in vitro* serum stability, both the CL2- and CL2A-SN-38 forms of hRS7-SN-38 yielded a $t_{1/2}$ of ~20 hours, which is in contrast to the short $t_{1/2}$ of 12.3 minutes reported for ENZ-2208 (Zhao et al., 2008, Bioconjug Chem 19:849-59), but similar to the 57% release of SN-38 from NK012 under physiological conditions after 24 hours (Koizumi et al., 2006, Cancer Res 66:10048-56).

[0266] Treatment of tumor-bearing mice with hRS7-SN-38 (either with CL2-SN-38 or CL2A-SN-38) significantly inhibited tumor growth in 5 different tumor models. In 4 of them, tumor regressions were observed, and in the case of Calu-3, all mice receiving the highest dose of hRS7-SN-38 were tumor-free at the conclusion of study. Unlike in humans, irinotecan is very efficiently converted to SN-38 by a plasma esterase in mice, with a greater than 50% conversion rate, and yielding higher efficacy in mice than in humans (Morton et al., 2000, Cancer Res 60:4206-10; Furman et al., 1999, J Clin Oncol 17:1815-24). When irinotecan was administered at 10-fold higher or equivalent SN-38 levels, hRS7-SN-38 was significantly better in controlling tumor growth. Only when irinotecan was administered at its MTD of 24 mg/kg q2dx5 (37.5-fold more SN-38) did it equal the effectiveness of hRS7-SN-38. In patients, we would expect this advantage to favor hRS7-CL2A-SN-38 even more, because the bioconversion of irinotecan would be substantially lower.

[0267] We also showed in some antigen-expressing cell lines, such as SK-MES-1, that using an antigen-binding ADC does not guarantee better therapeutic responses than a nonbinding, irrelevant conjugate. This is not an unusual or unexpected finding. Indeed, the nonbinding SN-38 conjugates mentioned earlier enhance therapeutic activity when compared to irinotecan, and so an irrelevant IgG-SN-38 conjugate is expected to have some activity. This is related to the fact that tumors have immature, leaky vessels that allow the passage of macromolecules better than normal tissues (Jain, 1994, Sci Am 271:58-61). With our

conjugate, 50% of the SN-38 will be released in ~13 hours when the pH is lowered to a level mimicking lysosomal levels (e.g., pH 5.3 at 37°C; data not shown), whereas at the neutral pH of serum, the release rate is reduced nearly 2-fold. If an irrelevant conjugate enters an acidic tumor microenvironment, it is expected to release some SN-38 locally. Other factors, such as tumor physiology and innate sensitivities to the drug, will also play a role in defining this "baseline" activity. However, a specific conjugate with a longer residence time should have enhanced potency over this baseline response as long as there is ample antigen to capture the specific antibody. Biodistribution studies in the SK-MES-1 model also showed that if tumor antigen becomes saturated as a consequence of successive dosing, tumor uptake of the specific conjugate is reduced, which yields therapeutic results similar to that found with an irrelevant conjugate.

[0268] Although it is challenging to make direct comparisons between our ADC and the published reports of other SN-38 delivery agents, some general observations can be made. In our therapy studies, the highest individual dose was 0.4 mg/kg of SN-38. In the Calu-3 model, only 4 injections were given for a total cumulative dose of 1.6 mg/kg SN-38 or 32 μg SN-38 in a 20 g mouse. Multiple studies with ENZ-2208 were done using its MTD of 10 mg/kg × 5 (Sapra et al., 2008, Clin Cancer Res 14:1888-96; Pastorini et al., 2010, Clin Cancer Res 16:4809-21), and preclinical studies with NK012 involved its MTD of 30 mg/kg × 3 (Koizumi et al., 2006, Cancer Res 66:10048-56). Thus, significant antitumor effects were obtained with hRS7-SN-38 at 30-fold and 55-fold less SN-38 equivalents than the reported doses in ENZ-2208 and NK012, respectively. Even with 10-fold less hRS7 ADC (0.04 mg/kg), significant antitumor effects were observed, whereas lower doses of ENZ-2208 were not presented, and when the NK012 dose was lowered 4-fold to 7.5 mg/kg, efficacy was lost (Koizumi et al., 2006, Cancer Res 66:10048-56). Normal mice showed no acute toxicity with a cumulative dose over 1 week of 24 mg/kg SN-38 (1,500 mg/kg of the conjugate), indicating that the MTD was higher. Thus, tumor-bearing animals were effectively treated with 7.5- to 15-fold lower amounts of SN-38 equivalents.

[0269] Biodistribution studies revealed the hRS7-CL2A-SN-38 had similar tumor uptake as the parental hRS7 IgG, but cleared substantially faster with 2-fold higher hepatic uptake, which may be due to the hydrophobicity of SN-38. With the ADC being cleared through the liver, hepatic and gastrointestinal toxicities were expected to be dose limiting. Although mice had evidence of increased hepatic transaminases, gastrointestinal toxicity was mild at best, with only transient loss in weight and no abnormalities noted upon histopathologic examination. Interestingly, no hematological toxicity was noted. However, monkeys showed

an identical toxicity profile as expected for irinotecan, with gastrointestinal and hematological toxicity being dose-limiting.

[0270] Because Trop-2 recognized by hRS7 is not expressed in mice, it was important to perform toxicity studies in monkeys that have a similar tissue expression of Trop-2 as humans. Monkeys tolerated 0.96 mg/kg/dose (~12 mg/m^2) with mild and reversible toxicity, which extrapolates to a human dose of ~0.3 mg/kg/dose (~11 mg/m^2). In a Phase I clinical trial of NK012, patients with solid tumors tolerated 28 mg/m^2 of SN-38 every 3 weeks with Grade 4 neutropenia as dose-limiting toxicity (DLT; Hamaguchi et al., 2010, Clin Cancer Res 16:5058-66). Similarly, Phase I clinical trials with ENZ-2208 revealed dose-limiting febrile neutropenia, with a recommendation to administer 10 mg/m^2 every 3 weeks or 16 mg/m^2 if patients were administered G-CSF (Kurzrock et al., *AACR-NCI-EORTC International Conference on Molecular Targets and Cancer Therapeutics;* 2009 *Nov 15–19;* Boston, MA; Poster No C216*;* Patnaik et al., *AACR-NCI-EORTC International Conference on Molecular Targets and Cancer Therapeutics;* 2009 *Nov 15–19;* Boston, MA; Poster No C221). Because monkeys tolerated a cumulative human equivalent dose of 22 mg/m^2, it appears that even though hRS7 binds to a number of normal tissues, the MTD for a single treatment of the hRS7 ADC could be similar to that of the other nontargeting SN-38 agents. Indeed, the specificity of the anti–Trop-2 antibody did not appear to play a role in defining the DLT, because the toxicity profile was similar to that of irinotecan. More importantly, if antitumor activity can be achieved in humans as in mice that responded with human equivalent dose of just at 0.03 mg SN-38 equivalents/kg/dose, then significant antitumor responses may be realized clinically.

[0271] In conclusion, toxicology studies in monkeys, combined with *in vivo* human cancer xenograft models in mice, have indicated that this ADC targeting Trop-2 is an effective therapeutic in several tumors of different epithelial origin.

Example 5. Anti-Trop-2 ADC Comprising hRS7 and Paclitaxel

[0272] A new antibody-drug conjugate (ADC) was made by conjugating paclitaxel (TAXOL®) to the hRS7 anti-human Trop-2 antibody (hRS7-paclitaxel). The final product had a mean drug to antibody substitution ratio of 2.2. This ADC was tested *in vitro* using two different Trop-2-postive cell lines as targets: BxPC-3 (human pancreatic adenocarcinoma) and MDA-MB-468 (human triple negative breast carcinoma). One day prior to adding the ADC, cells were harvested from tissue culture and plated into 96-well plates at 2000 cells per well. The next day cells were exposed to free paclitaxel (6.1×10^{-11} to 4×10^{-6} M) or the

drug-equivalent of hRS7-paclitaxel. For comparison, hRS7-SN-38 and free SN-38 were also tested at a range of 3.84 x 10^{-12} to 2.5 x 10^{-7} M. Plates were incubated at 37°C for 96 h. After this incubation period, an MTS substrate was added to all of the plates and read for color development at half-hour intervals until untreated control wells had an OD_{492nm} reading of approximately 1.0. Growth inhibition was measured as a percent of growth relative to untreated cells using Microsoft Excel and Prism software (non-linear regression to generate sigmoidal dose response curves which yield IC_{50}-values).

[0273] The hRS7-paclitaxel ADC exhibited cytotoxic activity in the MDA-MB-468 breast cell line (**FIG. 15**), with an IC_{50}-value approximately 4.5-fold higher than hRS7-SN-38. The free paclitaxel was much more potent than the free SN-38 (**FIG. 15**). While the IC_{50} for free SN-38 was 1.54x10^{-9} M, the IC_{50} for free paclitaxel was less than 6.1x10^{-11} M. Similar results were obtained for the BxPC-3 pancreatic cell line (**FIG. 16**) in which the hRS7-paclitaxel ADC had an IC_{50}-value approximately 2.8-fold higher than the hRS7-SN-38 ADC. These results show the efficacy of anti-Trop-2 conjugated paclitaxel *in vitro,* with IC_{50}-values in the nanomolar range, similar to the hRS7-SN-38 ADC.

Example 6. Cell Binding Assay of Anti-Trop-2 Antibodies

[0274] Two different murine monoclonal antibodies against human Trop-2 were obtained for ADC conjugation. The first, 162-46.2, was purified from a hybridoma (ATCC, HB-187) grown up in roller-bottles. A second antibody, MAB650, was purchased from R&D Systems (Minneapolis, MN). For a comparison of binding, the Trop-2 positive human gastric carcinoma, NCI-N87, was used as the target. Cells (1.5x10^5/well) were plated into 96-well plates the day before the binding assay. The following morning, a dose/response curve was generated with 162-46.2, MAB650, and murine RS7 (0.03 to 66 nM). These primary antibodies were incubated with the cells for 1.5 h at 4°C. Wells were washed and an anti-mouse-HRP secondary antibody was added to all the wells for 1 h at 4°C. Wells are washed again followed by the addition of a luminescence substrate. Plates were read using Envision plate reader and values are reported as relative luminescent units.

[0275] All three antibodies had similar K_D-values of 0.57 nM for RS7, 0.52 nM for 162-46.2 and 0.49 nM for MAB650. However, when comparing the maximum binding (B_{max}) of 162-46.2 and MAB650 to RS7 they were reduced by 25% and 50%, respectively (B_{Max} 11,250 for RS7, 8,471 for 162-46.2 and 6,018 for MAB650) indicating different binding properties in comparison to RS7.

Example 7. Cytotoxicity of Anti-Trop-2 ADC (MAB650-SN-38)

[0276] A novel anti-Trop-2 ADC was made with SN-38 and MAB650, yielding a mean drug to antibody substitution ratio of 6.89. Cytotoxicity assays were performed to compare the MAB650-SN-38 and hRS7-SN-38 ADCs using two different human pancreatic adenocarcinoma cell lines (BxPC-3 and Capan-1) and a human triple negative breast carcinoma cell line (MDA-MB-468) as targets.

[0277] One day prior to adding the ADCs, cells were harvested from tissue culture and plated into 96-well plates. The next day cells were exposed to hRS7-SN-38, MAB650-SN-38, and free SN-38 at a drug range of $3.84x10^{-12}$ to $2.5x10^{-7}$ M. Unconjugated MAB650 was used as a control at protein equivalent doses as the MAB650-SN-38. Plates were incubated at 37°C for 96 h. After this incubation period, an MTS substrate was added to all of the plates and read for color development at half-hour intervals until an OD_{492nm} of approximately 1.0 was reached for the untreated cells. Growth inhibition was measured as a percent of growth relative to untreated cells using Microsoft Excel and Prism software (non-linear regression to generate sigmoidal dose response curves which yield IC_{50}-values.

[0278] As shown in **FIG. 17**, hRS7-SN-38 and MAB650-SN-38 had similar growth-inhibitory effects with IC_{50}-values in the low nM range which is typical for SN-38-ADCs in these cell lines. In the human Capan-1 pancreatic adenocarcinoma cell line (**FIG. 17A**), the hRS7-SN-38 ADC showed an IC_{50} of 3.5 nM, compared to 4.1 nM for the MAB650-SN-38 ADC and 1.0 nM for free SN-38. In the human BxPC-3 pancreatic adenocarcinoma cell line (**FIG. 17B**), the hRS7-SN-38 ADC showed an IC_{50} of 2.6 nM, compared to 3.0 nM for the MAB650-SN-38 ADC and 1.0 nM for free SN-38. In the human NCI-N87 gastric adenocarcinoma cell line (**FIG. 17C**), the hRS7-SN-38 ADC showed an IC_{50} of 3.6 nM, compared to 4.1 nM for the MAB650-SN-38 ADC and 4.3 nM for free SN-38.

[0279] In summary, in these *in vitro* assays, the SN-38 conjugates of two anti-Trop-2 antibodies, hRS7 and MAB650, showed equal efficacies against several tumor cell lines, which was similar to that of free SN-38. Because the targeting function of the anti-Trop-2 antibodies would be a much more significant factor *in vivo* than *in vitro*, the data support that anti-Trop-2-SN-38 ADCs as a class would be highly efficacious *in vivo,* as demonstrated in the Examples above for hRS7-SN-38.

Cytotoxicity of Anti-Trop-2 ADC (162-46.2-SN-38)

[0280] A novel anti-Trop-2 ADC was made with SN-38 and 162-46.2, yielding a drug to antibody substitution ratio of 6.14. Cytotoxicity assays were performed to compare the 162-46.2-SN-38 and hRS7-SN-38 ADCs using two different Trop-2-postive cell lines as targets,

the BxPC-3 human pancreatic adenocarcinoma and the MDA-MB-468 human triple negative breast carcinoma.

[0281] One day prior to adding the ADC, cells were harvested from tissue culture and plated into 96-well plates at 2000 cells per well. The next day cells were exposed to hRS7-SN-38, 162-46.2-SN-38, or free SN-38 at a drug range of 3.84 x 10^{-12} to 2.5 x 10^{-7} M. Unconjugated 162-46.2 and hRS7 were used as controls at the same protein equivalent doses as the 162-46.2-SN-38 and hRS7-SN-38, respectively. Plates were incubated at 37°C for 96 h. After this incubation period, an MTS substrate was added to all of the plates and read for color development at half-hour intervals until untreated control wells had an OD_{492nm} reading of approximately 1.0. Growth inhibition was measured as a percent of growth relative to untreated cells using Microsoft Excel and Prism software (non-linear regression to generate sigmoidal dose response curves which yield IC_{50}-values).

[0282] As shown in **FIG. 18A** and **FIG.18B**, the 162-46.2-SN-38 ADC had a similar IC_{50}-values when compared to hRS7-SN-38. When tested against the BxPC-3 human pancreatic adenocarcinoma cell line (**FIG. 18A**), hRS7-SN-38 had an IC_{50} of 5.8 nM, compared to 10.6 nM for 162-46.2-SN-38 and 1.6 nM for free SN-38. When tested against the MDA-MB-468 human breast adenocarcinoma cell line (**FIG. 18B**), hRS7-SN-38 had an IC_{50} of 3.9 nM, compared to 6.1 nM for 162-46.2-SN-38 and 0.8 nM for free SN-38. The free antibodies alone showed little cytotoxicity to either Trop-2 positive cancer cell line.

[0283] In summary, comparing the efficacies *in vitro* of three different anti-Trop-2 antibodies conjugated to the same cytotoxic drug, all three ADCs exhibited equivalent cytotoxic effects against a variety of Trop-2 positive cancer cell lines. These data support that the class of anti-Trop-2 antibodies, incorporated into drug-conjugated ADCs, are effective anti-cancer therapeutic agents for Trop-2 expressing solid tumors.

Example 9. Clinical Trials With IMMU-132 Anti-Trop-2 ADC Comprising hRS7 Antibody Conjugated to SN-38

Summary

[0284] The present Example reports results from a phase I clinical trial and ongoing phase II extension with IMMU-132, an ADC of the internalizing, humanized, hRS7 anti-Trop-2 antibody conjugated by a pH-sensitive linker to SN-38 (mean drug-antibody ratio = 7.6). Trop-2 is a type I transmembrane, calcium-transducing, protein expressed at high density (~1 x 10^5), frequency, and specificity by many human carcinomas, with limited normal tissue expression. Preclinical studies in nude mice bearing Capan-1 human pancreatic tumor

xenografts have revealed IMMU-132 is capable of delivering as much as 120-fold more SN-38 to tumor than derived from a maximally tolerated irinotecan therapy.

[0285] The present Example reports the initial Phase I trial of 25 patients who had failed multiple prior therapies (some including topoisomerase-I/II inhibiting drugs), and the ongoing Phase II extension now reporting on 69 patients, including in colorectal (CRC), small-cell and non-small cell lung (SCLC, NSCLC, respectively), triple-negative breast (TNBC), pancreatic (PDC), esophageal, and other cancers.

[0286] As discussed in detail below, Trop-2 was not detected in serum, but was strongly expressed ($\geq 2^+$ immunohistochemical staining) in most archived tumors. In a 3+3 trial design, IMMU-132 was given on days 1 and 8 in repeated 21-day cycles, starting at 8 mg/kg/dose, then 12 and 18 mg/kg before dose-limiting neutropenia. To optimize cumulative treatment with minimal delays, phase II is focusing on 8 and 10 mg/kg (n=30 and 14, respectively). In 49 patients reporting related AE at this time, neutropenia ≥Grade 3 occurred in 28% (4% Grade 4). Most common non-hematological toxicities initially in these patients have been fatigue (55%;≥G3 = 9%), nausea (53%;≥G3=0%), diarrhea (47%;≥G3 = 9%), alopecia (40%), and vomiting (32%;≥G3 = 2%); alopecia also occurred frequently. Homozygous UGT1A1 *28/*28 was found in 6 patients, 2 of whom had more severe hematological and GI toxicities. In the Phase I and the expansion phases, there are now 48 patients (excluding PDC) who are assessable by RECIST/CT for best response. Seven (15%) of the patients had a partial response (PR), including patients with CRC (N = 1), TNBC (N = 2), SCLC (N = 2), NSCLC (N = 1), and esophageal cancers (N = 1), and another 27 patients (56%) had stable disease (SD), for a total of 38 patients (79%) with disease response; 8 of 13 CT-assessable PDC patients (62%) had SD, with a median time to progression (TTP) of 12.7 wks compared to 8.0 weeks in their last prior therapy. The TTP for the remaining 48 patients is 12.6+ wks *(range 6.0 to 51.4 wks)*. Plasma CEA and CA19-9 correlated with responses who had elevated titers of these antigens in their blood. No anti-hRS7 or anti-SN-38 antibodies were detected despite dosing over months. The conjugate cleared from the serum within 3 days, consistent with *in vivo* animal studies where 50% of the SN-38 was released daily, with >95% of the SN-38 in the serum being bound to the IgG in a non-glucoronidated form, and at concentrations as much as 100-fold higher than SN-38 reported in patients given irinotecan. These results show that the hRS7-SN-38-containing ADC is therapeutically active in metastatic solid cancers, with manageable diarrhea and neutropenia.

Pharmacokinetics

[0287] Two ELISA methods were used to measure the clearance of the IgG (capture with anti-hRS7 idiotype antibody) and the intact conjugate (capture with anti-SN-38 IgG/probe with anti-hRS7 idiotype antibody). SN-38 was measured by HPLC. Total IMMU-132 fraction (intact conjugate) cleared more quickly than the IgG (not shown), reflecting known gradual release of SN-38 from the conjugate. HPLC determination of SN-38 (Unbound and TOTAL) showed >95% the SN-38 in the serum was bound to the IgG. Low concentrations of SN-38G suggest SN-38 bound to the IgG is protected from glucoronidation. Comparison of ELISA for conjugate and SN-38 HPLC revealed both overlap, suggesting the ELISA is a surrogate for monitoring SN-38 clearance.

[0288] A summary of the dosing regiment and patient pool is provided in **Table 7.**

Table 7. Clinical Trial Parameters

Dosing regimen	Once weekly for 2 weeks administered every 21 days for up to 8 cycles. In the initial enrollment, the planned dose was delayed and reduced if ≥ Grade 2 treatment-related toxicity; protocol was amended to dose delay and reduction only in the event of ≥ Grade 3 toxicity.
Dose level cohorts	8, 12, 18 mg/kg; later reduced to an intermediate dose level of 10 mg/kg.
Cohort size	Standard Phase I [3+3] design; expansion includes ~15 patients in select cancers.
DLT	Grade 4 ANC ≥ 7 d; ≥Grade 3 febrile neutropenia of any duration; G4 Plt ≥ 5 d; G4 Hgb; Grade 4 N/V/D any duration/G3 N/V/D for > 48 h; G3 infusion-related reactions; related ≥G3 non-hematological toxicity.
Maximum Acceptable Dose (MAD)	Maximum dose where ≥2/6 patients tolerate 1st 21-d cycle w/o delay or reduction or ≥ G3 toxicity.
Patients	Metastatic colorectal, pancreas, gastric, esophageal, lung (NSCLC, SCLC), triple-negative breast (TNBC), prostate, ovarian, renal, urinary bladder, head/neck, hepatocellular. Refractory/relapsed after standard treatment regimens for metastatic cancer. Prior irinotecan-containing therapy NOT required for enrollment. No bulky lesion > 5 cm. Must be 4 weeks beyond any major surgery, and 2 weeks beyond radiation or chemotherapy regimen. Gilbert's disease or known CNS

	metastatic disease are excluded.

Clinical Trial Status

[0289] A total of 69 patients (including 25 patients in Phase I) with diverse metastatic cancers having a median of 3 prior therapies were reported. Eight patients had clinical progression and withdrew before CT assessment. Thirteen CT-assessable pancreatic cancer patients were separately reported. The median TTP (time to progression) in PDC patients was 11.9 wks (range 2 to 21.4 wks) compared to median 8 wks TTP for the preceding last therapy.

[0290] A total of 48 patients with diverse cancers had at least 1 CT-assessment from which Best Response (**FIG. 19**) and Time to Progression (TTP; **FIG. 20**) were determined. To summarize the Best Response data, of 8 assessable patients with TNBC (triple-negative breast cancer), there were 2 PR (partial response), 4 SD (stable disease) and 2 PD (progressive disease) for a total response [PR + SD] of 6/8 (75%). For SCLC (small cell lung cancer), of 4 assessable patients there were 2 PR, 0 SD and 2 PD for a total response of 2/4 (50%). For CRC (colorectal cancer), of 18 assessable patients there were 1 PR, 11 SD and 6 PD for a total response of 12/18 (67%). For esophageal cancer, of 4 assessable patients there were 1 PR, 2 SD and 1 PD for a total response of 3/4 (75%). For NSCLC (non-small cell lung cancer), of 5 assessable patients there were 1 PR, 3 SD and 1 PD for a total response of 4/5 (80%). Over all patients treated, of 48 assessable patients there were 7 PR, 27 SD and 14 PD for a total response of 34/48 (71%). These results demonstrate that the anti-TROP-2 ADC (hRS7-SN-38) showed significant clinical efficacy against a wide range of solid tumors in human patients.

[0291] The reported side effects of therapy (adverse events) are summarized in **Table 8.** As apparent from the data of **Table 8**, the therapeutic efficacy of hRS7-SN-38 was achieved at dosages of ADC showing an acceptably low level of adverse side effects.

Table 8.

Related Adverse Events Listing for IMMU-132-01 **Criteria: Total ≥ 10% or ≥ Grade 3**

	N = 47 patients		
	TOTAL	Grade 3	Grade 4
Fatigue	55%	4 (9%)	0
Nausea	53%	0	0
Diarrhea	47%	4 (9%)	0
Neutropenia	43%	11 (24%)	2 (4%)
Alopecia	40%	--	--
Vomiting	32%	1 (2%)	0
Anemia	13%	2 (4%)	0
Dysgeusia	15%	0	0
Pyrexia	13%	0	0
Abdominal pain	11%	0	0
Hypokalemia	11%	1 (2%)	0
WBC Decrease	6%	1 (2%)	0
Febrile Neutropenia	6%	1 (2%)	2 (4%)
Deep vein thrombosis	2%	1 (2%)	0
Grading by CTCAE v 4.0			

[0292] Exemplary partial responses to the anti-Trop-2 ADC were confirmed by CT data (not shown). As an exemplary PR in CRC, a 62 year-old woman first diagnosed with CRC underwent a primary hemicolectomy. Four months later, she had a hepatic resection for liver metastases and received 7 mos of treatment with FOLFOX and 1 mo 5FU. She presented with multiple lesions primarily in the liver (3+ Trop-2 by immunohistology), entering the hRS7-SN-38 trial at a starting dose of 8 mg/kg about 1 year after initial diagnosis. On her first CT assessment, a PR was achieved, with a 37% reduction in target lesions (not shown). The patient continued treatment, achieving a maximum reduction of 65% decrease after 10 months of treatment (not shown) with decrease in CEA from 781 ng/mL to 26.5 ng/mL), before progressing 3 months later.

[0293] As an exemplary PR in NSCLC, a 65 year-old male was diagnosed with stage IIIB NSCLC (sq. cell). Initial treatment of caboplatin/etoposide (3 mo) in concert with 7000 cGy XRT resulted in a response lasting 10 mo. He was then started on Tarceva maintenance therapy, which he continued until he was considered for IMMU-132 trial, in addition to

undergoing a lumbar laminectomy. He received first dose of IMMU-132 after 5 months of Tarceva, presenting at the time with a 5.6 cm lesion in the right lung with abundant pleural effusion. He had just completed his 6th dose two months later when the first CT showed the primary target lesion reduced to 3.2 cm (not shown).

[0294] As an exemplary PR in SCLC, a 65 year-old woman was diagnosed with poorly differentiated SCLC. After receiving carboplatin/etoposide (Topoisomerase-II inhibitor) that ended after 2 months with no response, followed with topotecan (Topoisomerase-I inhibitor) that ended after 2 months, also with no response, she received local XRT (3000 cGy) that ended 1 month later. However, by the following month progression had continued. The patient started with IMMU-132 the next month (12 mg/kg; reduced to 6.8 mg/kg; Trop-2 expression 3+), and after two months of IMMU-132, a 38% reduction in target lesions, including a substantial reduction in the main lung lesion occurred (not shown). The patient progressed 3 months later after receiving 12 doses.

[0295] These results are significant in that they demonstrate that the anti-Trop-2 ADC was efficacious, even in patients who had failed or progressed after multiple previous therapies.

[0296] In conclusion, at the dosages used, the primary toxicity was a manageable neutropenia, with few Grade 3 toxicities. IMMU-132 showed evidence of activity (PR and durable SD) in relapsed/refractory patients with triple-negative breast cancer, small cell lung cancer, non-small cell lung cancer, colorectal cancer and esophageal cancer, including patients with a previous history of relapsing on topoisomerase-I inhibitor therapy. These results show efficacy of the anti-Trop-2 ADC in a wide range of cancers that are resistant to existing therapies.

Example 10. Comparative Efficacy of Different Anti-Trop-2 ADCs

[0297] The therapeutic efficacy of a murine anti-Trop-2 monoclonal antibody (162-46.2) conjugated with either SN-38 or Pro-2-PDox was compared to hRS7-SN-38 and hRS7-Pro-2-PDox antibody-drug conjugate (ADC) in mice bearing human gastric carcinoma xenografts (NCI-N87). NCI-N87 cells were expanded in tissue culture and harvested with trypsin/EDTA. Female athymic nude mice were injected s.c. with 200 µL of NCI-N87 cell suspension mixed 1:1 with matrigel such that $1x10^7$ cells was administered to each mouse. Once tumors reached approximately 0.25 cm^3 in size (6 days later), the animals were divided up into seven different treatment groups of nine mice each. For the SN-38 ADCs, mice received 500 µg i.v. injections once a week for two weeks. Control mice received the non-tumor targeting hA20-SN-38 ADC at the same dose/schedule. For the Pro-2-PDox-ADCs,

mice were administered 45 μg i.v. twice weekly for two weeks. Control mice received hA20-Pro-2-PDox ADC at the same dose/schedule. A final group of mice received only saline and served as the untreated control. Tumors were measured and mice weighed twice a week. Mice were euthanized for disease progression if their tumor volumes exceeded 1.0 cm^3 in size.

[0298] Mean tumor volumes for the SN-38-ADC treated mice are shown in **FIG. 21**. As determined by area under the curve (AUC), both hRS7-SN-38 and 162-46.2-SN-38 significantly inhibited tumor growth when compared to saline and hA20-SN-38 control mice ($P<0.001$). Treatment with hRS7-SN-38 achieved stable disease in 7 of 9 mice with mean time to tumor progression (TTP) of 18.4 ± 3.3 days. Mice treated with 162-46.2-SN-38 achieved a positive response in 6 of 9 mice with the remaining 3 achieving stable disease. Mean TTP was 24.2 ± 6.0 days, which is significantly longer than hRS7-SN-38 treated animals ($P=0.0382$).

[0299] For the Pro-2-PDox ADCs (**FIG. 22**), mice treated with hRS7-Pro-2-PDox experienced tumor regressions and an overall anti-tumor response that was significantly better than 162-46.2-Pro-2-PDox treatment ($P<0.0001$; AUC). While the tumors did not immediately respond to the 162-46.2-Pro-2-PDox therapy, they did eventually regress. This regression did not occur until approximate 11 days after the start of therapy. Within 39 days of the start of therapy (day 45 post-tumor cell implantation) there were no significant differences in tumor size between hRS7-Pro-2-PDox and 162-46.2-Pro-2-PDox treated mice (Mean Tumor Volume = 0.151 ± 0.025 cm^3 and 0.190 ± 0.53 cm^3, respectively). On this day, 9 of 9 mice treated with hRS7-Pro-2-PDox had tumors that were smaller than when therapy began. Likewise, 7 of 9 mice in the 162-46.2-Pro-2-PDox group had tumors that were smaller than when therapy began.

[0300] These results confirm the *in vivo* efficacy of four different anti-Trop-2 ADCs for treatment of human gastric carcinoma.

Example 11. Treatment of Patients with Advanced, Metastatic Pancreatic Cancer With Anti-Trop-2 ADC

Summary

[0301] IMMU-132 (hRS7-SN-38) is an anti-Trop-2 ADC comprising the cancer cell internalizing, humanized, anti-Trop-2 hRS7 antibody, conjugated by a pH-sensitive linker to SN-38, the active metabolite of irinotecan, at a mean drug-antibody ratio of 7.6. Trop-2 is a type-I transmembrane, calcium-transducing protein expressed at high density, frequency, and

specificity in many epithelial cancers, including pancreatic ductal adenocarcinoma, with limited normal tissue expression. All 29 pancreatic tumor microarray specimens tested were Trop-2-positive by immunohistochemistry, and human pancreatic cancer cell lines were found to express 115k-891k Trop-2 copies on the cell membrane. We reported in Example 9 above the results from the IMMU-132 Phase I study enrolling patients with 13 different tumor types using a 3+3 design. The Phase I dose-limiting toxicity was neutropenia. Over 80% of 24 assessable patients in this study had long-term stable disease, with partial responses (RECIST) observed in patients with colorectal (CRC), triple-negative breast (TNBC), small-cell and non-small cell lung (SCLC, NSCLC), and esophageal (EAC) cancers. The present Example reports the results from the IMMU-132 Phase I/II study cohort of patients with metastatic PDC. Patients with PDC who failed a median of 2 prior therapies (range 1-5) were given IMMU-132 on days 1 and 8 in repeated 21-day cycles.

[0302] In the subgroup of PDC patients (N=15), 14 received prior gemcitabine-containing regimens. Initial toxicity data from 9 patients found neutropenia [3 of 9 ≥G3, 33%; and 1 case of G4 febrile neutropenia), which resulted in dose delays or dose reductions. Two patients had Grade 3 diarrhea; no patient had Grade 3-4 nausea or vomiting. Alopecia (Grades 1-2) occurred in 5 of 9 patients. Best response was assessable in 13 of 14 patients, with 8 stable disease for 8 to 21.4 wks (median 12.7 wks; 11.9 wks all 14 patients). One patient who is continuing treatment has not yet had their first CT assessment. Five had progressive disease by RECIST; 1 withdrew after just 1 dose due to clinical progression and was not assessable. Serum CA19-9 titers decreased in 3 of the patients with stable disease by 23 to 72%. Despite multiple administrations, none of the patients developed an antibody response to IMMU-132 or SN-38. Peak and trough serum samples showed that IMMU-132 cleared more quickly than the IgG, which is expected based on the known local release of SN-38 within the tumor cell. Concentrations of SN-38-bound to IgG in peak samples from one patient given 12 mg/kg of IMMU-132 showed levels of ~4000 ng/mL, which is 40-times higher than the SN-38 titers reported in patients given irinotecan therapy.

[0303] We conclude that IMMU-132 is active (long-term stable disease) in 62% (8/13) of PDC patients who failed multiple prior therapies, with manageable neutropenia and little GI toxicity. Advanced PDC patients can be given repeated treatment cycles (>6) of 8-10 mg/kg IMMU-132 on days 1 and 8 of a 21-day cycle, with some dose adjustments or growth factor support for neutropenia in subsequent treatment cycles. These results agree with the findings in patients with advanced CRC, TNBC, SCLC, NSCLC, EAC who have shown partial responses and long-term stable disease with IMMU-132 administration. In summary,

monotherapy IMMU-132 is a novel, efficacious treatment regimen for patients with PDC, including those with tumors that were previously resistant to other therapeutic regimens for PDC.

Methods and Results

[0304] Trop-2 expression - The expression of Trop-2 on the surface of various cancer cell lines was determined by flow cytometry using QUANTBRITE® PE beads. The results for number of Trop-2 molecules detected in the different cell lines was: BxPC-3 pancreatic cancer (891,000); NCI-N87 gastric cancer (383,000); MDA-MB-468 breast cacner (341,000); SK-MES-1 squamous cell lung cancer (27,000); Capan-1 pancreatic cancer (115,000); AGS gastric cancer (78,000) COLO 205 colon cancer (52,000). Trop-2 expression was also observed in 29 of 29 (100%) tissue microarrays of pancreatic adenocarcinoma (not shown).

[0305] SN-38 accumulation – SN-38 accumulation was determined in nude mice bearing Capan-1 human pancreatic cancer xenografts (~0.06-0.27 g). Mice were injected IV with irinotecan 40 mg/kg (773 μg; Total SN-38 equivalents = 448 μg). This dose is MTD in mice. Human dose equivalent = 3.25 mg/kg or ~126 mg/m^2. Or mice were injected IV with IMMU-132 1.0 mg (SN-38:antibody ratio = 7.6; SN-38 equivalents = 20 μg). This dose is well below the MTD in mice. Human equivalent dose ~4 mg/kg IMMU-132 (~80 μg/kg SN-38 equivalents). Necropsies were performed on 3 animals per interval, in irinotecan injected mice at 5 min, 1, 2, 6 and 24 hours or in IMMU-132 injected mice at 1, 6, 24, 48 and 72 h. Tissues were extracted and analyzed by reversed-phase HPLC analysis for SN-38, SN-38G, and irinotecan. Extracts from IMMU-132-treated animals also were acid hydrolyzed to release SN-38 from the conjugate (i.e., SN-38 (TOTAL]). The results, shown in **FIG. 23**, demonstrate that the IMMU-132 ADC has the potential to deliver 120 times more SN-38 to the tumor compared to irinotecan, even though 22-fold less SN-38 equivalents were administered with the ADC.

[0306] IMMU-132 clinical protocol – The protocol used in the phase I/II study was as indicated in Table 9 below.

Table 9. Clinical Protocol Using IMMU-132: OVERVIEW

	Once weekly for 2 weeks administered every 21 days for up to 8 cycles. Patients with objective responses are allowed to continue beyond 8 cycles. In the initial enrollment, the planned dose was delayed and reduced if ≥ Grade 2 treatment-related toxicity; protocol was amended later in study to dose delay and reduction only in the event of ≥ Grade 3 toxicity. The development of severe toxicities due to treatment requires dose reduction by 25% of the assigned dose for 1st occurrence, 50% for 2nd occurrence, and treatment discontinued entirely in the event of a 3rd occurrence.
	8, 12, 18 mg/kg; later reduced to an intermediate dose level of 10 mg/kg.
	Standard Phase I [3+3] design; expansion includes 15 patients in select cancers.
	Grade 4 ANC ≥ 7 d; ≥Grade 3 febrile neutropenia of any duration; Grade 4 Platelets ≥ 5 d; Grade 4 Hgb; Grade 4 N/V/D of any duration or any Grade 3 N/V/D for > 48 h; Grade 3 infusion-related reactions; ≥ Grade 3 non-heme toxicity at least possibly due to study drug.
	Maximum dose where ≥2/6 patients tolerate the full 21-d treatment cycle without dose delay or reduction or ≥ Grade 3 toxicity.
	• Metastatic colorectal, **pancreas**, gastric, esophageal, lung (NSCLC, SCLC), triple-negative breast, prostate, ovarian, renal, urinary bladder, head and neck, hepatocellular. • Refractory/relapsed after standard treatment regimens for metastatic cancer. • Prior irinotecan-containing therapy NOT required for enrollment. • No bulky lesion > 5 cm. • Must be 4 weeks beyond any major surgery, and 2 weeks beyond radiation or chemotherapy regimen. • *Gilbert's* disease or known CNS metastatic disease are excluded.

[0307] Patients were administered IMMU-132 according to the protocol summarized above. The response assessment to last prior therapy before IMMU-132 treatment is summarized in **FIG 24**. The response assessment to IMMU-132 administration is shown in **FIG. 25**. A

summary of time to progression (TTP) results following administration of IMMU-132 is shown in **FIG. 26.**

[0308] An exemplary case study is as follows. A 34 y/o white male initially diagnosed with metastatic pancreatic cancer (liver) had progressed on multiple chemotherapy regimens, including gemcitabine/ Erlotinib/FG-3019, FOLFIRINOX and GTX prior to introduction of IMMU-132 (8 mg/kg dose given days 1 and 8 of a 21 day cycle). The patient received the drug for 4 mo with good symptomatic tolerance, an improvement in pain, a 72% maximum decline in CA19-9 (from 15885 U/mL to 4418 U/mL) and stable disease by CT RECIST criteria along with evidence of tumor necrosis. Therapy had to be suspended due to a liver abscess; the patient expired ~6 weeks later, 6 mo following therapy initiation.

Conclusions

[0309] Preclinical studies indicated that IMMU-132 delivers 120-times the amount of SN-38 to a human pancreatic tumor xenograft than when irinotecan is given. As part of a larger study enrolling patients with diverse metastatic solid cancers, the Phase 2 dose of IMMU-132 was determined to be 8 to 10 mg/kg, based on manageable neutropenia and diarrhea as the major side effects. No anti-antibody or anti-SN-38 antibodies have been detected to-date, even with repeated therapeutic cycles.

[0310] A study of 14 advanced PDC patients who relapsed after a median of 2 prior therapies showed CT-confirmed antitumor activity consisting of 8/13 (62%) with stable disease. Median duration of TTP for 13 CT assessable pts was 12.7 weeks compared to 8.0 weeks estimated from last prior therapy. This ADC, with a known drug of nanomolar toxicity, conjugated to an antibody targeting Trop-2 prevalent on many epithelial cancers, by a linker affording cleavage at the tumor site, represents a new efficacious strategy in pancreatic cancer therapy with ADCs. In comparison to the present standard of care for pancreatic cancer patients, the extension of time to progression in pancreatic cancer patients, particularly in those resistant to multiple prior therapies, was surprising and could not have been predicted.

Example 12. Treatment of Triple-Negative Breast Cancer With pro-2-PDox-hRS7 ADC

[0311] pro-2-PDox-hRS7 ADC is prepared as described in the Examples above. Patients with triple-negative breast cancer who had failed at least two standard therapies receive 3 cycles of 70 mg pro-2-PDox-hRS7 injected i.v. every 3 weeks. Objective responses are observed at this dose level of pro-2-PDox- hRS7, with an average decrease in tumor volume

of 35%, after two cycles of therapy. All serum samples evaluated for human anti-hRS7 antibody (HAHA) are negative.

Example 13. Treatment of Metastatic Colon Cancer With pro-2-PDox-hRS7 ADC

[0312] A 52-year old man with metastatic colon cancer (3-5 cm diameters) to his left and right liver lobes, as well as a 5 cm metastasis to his right lung, and an elevated blood CEA value of 130 ng/mL, is treated with a 100 mg dose of hRS7 anti-Trop-2 conjugated with pro-2-PDox at 4 drug molecules per IgG, administered by slow intravenous infusion every other week for 4 doses. Upon CT evaluation 8 weeks from treatment begin, a 25% reduction of the total mean diameters of the 3 target lesions is measured, thus constituting a good stable disease response by RECIST1.1 criteria. Repeated courses of therapy continue as his neutropenia normalizes.

Example 14. Treatment of Metastatic Pancreatic Cancer With pro-2-PDox-hRS7 ADC

[0313] A 62-year-old man with metastatic ductal adenocarcinoma of the pancreas, who has relapsed after prior therapies with FOLFIRINOX followed by Nab-taxol (Abraxane®) plus gemcitabine is given hRS7-pro-2-PDox ADC at a dose of 120 mg every third week for 4 courses, and after a 3-week delay, another course of 2 injections 2 weeks apart are given intravenously. The patient shows some nausea and transient diarrhea with the therapy, and also Grade 3 neutropenia after the first course, which recovers before the second course of therapy. CT measurements made at 8 weeks following start of therapy show an 18% shrinkage of the sum of the 3 target lesions in the liver, as compared to the pretreatment baseline measurements, constituting stable disease by RECIST 1.1 criteria. Also, the patient's CA19-9 blood titer is reduced by 55% from a baseline value of 12,400. His general symptoms of weakness, fatigue and abdominal discomfort also improve considerably, including regaining his appetite and a weight increase of 2 kg during the following 6 weeks.

Example 15. Combining Antibody-Targeted Radiation (Radioimmunotherapy) and Anti-Trop-2-SN-38 ADC Improves Pancreatic Cancer Therapy

[0314] We previously reported effective anti-tumor activity in nude mice bearing human pancreatic tumors with ^{90}Y-humanized PAM4 IgG (hPAM4; ^{90}Y-clivatuzumab tetraxetan) that was enhanced when combined with gemcitabine (GEM) (Gold et al., Int J. Cancer 109:618-26, 2004; Clin Cancer Res 9:3929S-37S, 2003). These studies led to clinical testing of fractionated ^{90}Y-hPAM4 IgG combined with GEM that is showing encouraging objective

responses. While GEM is known for its radiosensitizing ability, alone it is not a very effective therapeutic agent for pancreatic cancer and its dose is limited by hematologic toxicity, which is also limiting for ^{90}Y-hPAM4 IgG.

[0315] As discussed in the Examples above, an anti-Trop-2 ADC composed of hRS7 IgG linked to SN-38 shows anti-tumor activity in various solid tumors. This ADC is very well tolerated in mice (*e.g.*, $\geq$ 60 mg), yet just 4.0 mg (0.5 mg, twice-weekly x 4) is significantly therapeutic. Trop-2 is also expressed in most pancreatic cancers.

[0316] The present study examined combinations of ^{90}Y-hPAM4 IgG with RS7-SN-38 in nude mice bearing 0.35 cm^3 subcutaneous xenografts of the human pancreatic cancer cell line, Capan-1. Mice (n=10) were treated with a single dose of ^{90}Y-hPAM4 IgG alone (130 μCi, *i.e.*, the maximum tolerated dose (MTD) or 75 μCi), with RS7-SN-38 alone (as above), or combinations of the 2 agents at the two ^{90}Y-hPAM4 dose levels, with the first ADC injection given the same day as the ^{90}Y-hPAM4. All treatments were tolerated, with $\leq$ 15% loss in body weight. Objective responses occurred in most animals, but they were more robust in both of the combination groups as compared to each agent given alone. All animals in the 0.13-mCi ^{90}Y-hPAM4 IgG + hRS7-SN-38 group achieved a tumor-free state within 4 weeks, while other animals continued to have evidence of persistent disease. These studies provide the first evidence that combined radioimmunotherapy and ADC enhances efficacy at safe doses.

[0317] In the ongoing PAM4 clinical trials, a four week clinical treatment cycle is performed. In week 1, subjects are administered a dose of ^{111}In-hPAM4, followed at least 2 days later by gemcitabine dose. In weeks 2, 3 and 4, subjects are administered a ^{90}Y-hPAM4 dose, followed at least 2 days later by gemcitabine (200 mg/m^2). Escalation started at 3 x 6.5 mCi/m^2. The maximum tolerated dose in front-line pancreatic cancer patients was 3 x 15 mCi/m^2 (hematologic toxicity is dose-limiting). Of 22 CT-assessable patients, the disease control rate (CR+PR+SD) was 68%, with 5 (23%) partial responses and 10 (45%) having stabilization as best response by RECIST criteria.

Preparation of Antibody-Drug Conjugate (ADC)

[0318] The SN-38 conjugated hRS7 antibody was prepared as described above and according to previously described protocols (Moon et al. J Med Chem 2008, 51:6916-6926; Govindan et al., Clin Cancer Res 2009. 15:6052-6061). A reactive bifunctional derivative of SN-38 (CL2A-SN-38) was prepared. The formula of CL2A-SN-38 is (maleimido-[x]-Lys-PABOCO-20-*O*-SN-38, where PAB is *p*-aminobenzyl and 'x' contains a short PEG).

Following reduction of disulfide bonds in the antibody with TCEP, the CL2A-SN-38 was reacted with reduced antibody to generate the SN-38 conjugated RS7.

[0319] ^{90}Y-hPAM4 is prepared as previously described (Gold et al., Clin Cancer Res 2003, 9:3929S-37S; Gold et al., Int J Cancer 2004, 109:618-26).

Combination RAIT + ADC

[0320] The Trop-2 antigen is expressed in most epithelial cancers (lung, breast, prostate, ovarian, colorectal, pancreatic) and hRS7-SN-38 conjugates are being examined in various human cancer-mouse xenograft models. Initial clinical trials with ^{90}Y-hPAM4 IgG plus radiosensitizing amounts of GEM are encouraging, with evidence of tumor shrinkage or stable disease. However, therapy of pancreatic cancer is very challenging. Therefore, a combination therapy was examined to determine whether it would induce a better response. Specifically, administration of hRS7-SN-38 at effective, yet non-toxic doses was combined with RAIT with ^{90}Y-hPAM4 IgG.

[0321] The results demonstrated that the combination of hRS7-SN-38 with ^{90}Y-hPAM4 was more effective than either treatment alone, or the sum of the individual treatments (not shown). At a dosage of 75 μCi ^{90}Y-hPAM4, only 1 of 10 mice was tumor-free after 20 weeks of therapy (not shown), the same as observed with hRS7-SN-38 alone (not shown). However, the combination of hRS7-SN-38 with ^{90}Y-hPAM4 resulted in 4 of 10 mice that were tumor-free after 20 weeks (not shown), and the remaining subjects showed substantial decrease in tumor volume compared with either treatment alone (not shown). At 130 μCi ^{90}Y-hPAM4 the difference was even more striking, with 9 of 10 animals tumor-free in the combined therapy group compared to 5 of 10 in the RAIT alone group (not shown). These data demonstrate the synergistic effect of the combination of hRS7-SN-38 with ^{90}Y-hPAM4. RAIT + ADC significantly improved time to progression and increased the frequency of tumor-free treatment. The combination of ADC with hRS7-SN-38 added to the MTD of RAIT with ^{90}Y-hPAM4 had minimal additional toxicity, indicated by the % weight loss of the animal in response to treatment (not shown).

[0322] The effect of different sequential treatments on tumor survival indicated that the optimal effect is obtained when RAIT is administered first, followed by ADC (not shown). In contrast, when ADC is administered first followed by RAIT, there is a decrease in the incidence of tumor-free animals (not shown). Neither unconjugated hPAM4 nor hRS7 antibodies had anti-tumor activity when given alone (not shown).

* * *

[0323] It will be apparent to those skilled in the art that various modifications and variations can be made to the products, compositions, methods and processes of this invention. Thus, it is intended that the present invention cover such modifications and variations, provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of treating a Trop-2 expressing cancer comprising administering to a subject with a Trop-2 expressing cancer an antibody-drug conjugate (ADC) comprising (i) an anti-Trop-2 antibody or antigen-binding fragment thereof; and (ii) a cytotoxic drug conjugated to the anti-Trop-2 antibody or antibody fragment.
2. The method of claim 1, wherein the anti-Trop-2 antibody is a chimeric, humanized or human antibody.
3. The method of claim 1, wherein the anti-Trop-2 antibody is selected from the group consisting of hRS7, 162-46.2, MAB650, K5-70, K5-107, K5-116-2-1, T6-16, T5-86, BR110, 3E9, 6G11, 7E6, 15E2, 18B1, 77220, KM4097, KM4590, A1, A3, and 162-25.3; or wherein the antibody is produced by a hybridoma selected from the group consisting of AR47A6.4.2, AR52A301.5, PTA-12871, PTA-12872, PD 08019, PD 08020, and PD 08021.
4. The method of claim 1, wherein the anti-Trop-2 antibody is selected from the group consisting of hRS7, 162-46.2 and MAB650.
5. The method of claim 1, wherein the antibody is an IgG1, IgG2, IgG3 or IgG4 antibody.
6. The method of claim 1, wherein the antibody allotype is selected from the group consisting of nG1m1, G1m3, G1m3,1, G13,2, G1m3,1,2, and Km3.
7. The method of claim 1, wherein the drug is selected from the group consisting of an anthracycline, a camptothecin, a tubulin inhibitor, a maytansinoid, a calicheamycin, an auristatin, a nitrogen mustard, an ethylenimine derivative, an alkyl sulfonate, a nitrosourea, a triazene, a folic acid analog, a taxane, a COX-2 inhibitor, a pyrimidine analog, a purine analog, an antibiotic, an enzyme inhibitor, an epipodophyllotoxin, a platinum coordination complex, a vinca alkaloid, a substituted urea, a methyl hydrazine derivative, an adrenocortical suppressant, a hormone antagonist, an antimetabolite, an alkylating agent, an antimitotic, an anti-angiogenic agent, a tyrosine kinase inhibitor, an mTOR inhibitor, a heat shock protein (HSP90) inhibitor, a proteosome inhibitor, an HDAC inhibitor, and a pro-apoptotic agent.
8. The method of claim 1, wherein the drug is 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, crizotinib, cyclophosphamide, cytarabine,

dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, DM1, DM3, DM4, doxorubicin, 2-pyrrolinodoxorubicine (2-PDox), a pro-drug form of 2-PDox (pro-2-PDox), cyano-morpholino doxorubicin, doxorubicin glucuronide, endostatin, epirubicin glucuronide, erlotinib, estramustine, epidophyllotoxin, 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, lapatinib, lenolidamide, leucovorin, LFM-A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, monomethylauristatin F (MMAF), monomethylauristatin D (MMAD), monomethylauristatin E (MMAE), navelbine, neratinib, nilotinib, nitrosurea, olaparib, plicomycin, procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, SN-38, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide, transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839.

9. The method of claim 1, wherein the drug is selected from the group consisting of SN-38, pro-2-pyrrolinodoxorubicin (pro-2-PDox), paclitaxel, calichemicin, DM1, DM3, DM4, MMAE, MMAD and MMAF.
10. The method of claim 1, wherein the average ratio of drug to antibody is between 1 and 12.
11. The method of claim 1, wherein the average ratio of drug to antibody is between 1.5 and 8.
12. The method of claim 1, wherein the average ratio of drug to antibody is between 1 and 6.
13. The method of claim 1, wherein the average ratio of drug to antibody is less than 6.
14. The method of claim 1, wherein the average ratio of drug to antibody is about 6.
15. The method of claim 1, wherein the cancer is selected from the group consisting of breast, ovarian, cervical, endometrial, lung, prostate, colorectal, stomach, esophageal, bladder, renal, pancreatic, thyroid, and head-and-neck cancers.
16. The method of claim 1, wherein the cancer is resistant to treatment with at least one anti-cancer therapy.
17. The method of claim 1, wherein the cancer is resistant to treatment with a topoisomerase 1 or topoisomerase 2 inhibitor.

18. The method of claim 17, wherein the cancer is resistant to treatment with irinotecan or SN-38.
19. The method of claim 16, wherein the cancer is selected from the group consisting of pancreatic cancer, triple-negative breast cancer, metastatic colorectal cancer, a HER+, ER+, progesterone+ breast cancer, metastatic non-small-cell lung cancer (NSCLC), metastatic pancreatic cancer, metastatic renal cell carcinoma, metastatic gastric cancer, metastatic prostate cancer, metastataic esophageal cancer, metastatic urinary bladder cancer, and metastatic small-cell lung cancer.
20. The method of claim 1, further comprising treating the subject with one or more therapies selected from the group consisting of surgery, radiation therapy, chemotherapy, an immunomodulator, a cytokine, a chemotherapeutic agent, a pro-apoptotic agent, an anti-angiogenic agent, a cytotoxic agent, a drug, a toxin, a radionuclide, an RNAi, an siRNA, a second antibody, an antigen-binding fragment of a second antibody, an RNase, a DNase, and an immunoconjugate.
21. The method of claim 20, wherein the therapy comprises administration of an anti-Trop-2 agent selected from the group consisting of VB4-845, IGN-101, adecatumumab, ING-1 and EMD 273 066.
22. The method of claim 20, wherein the therapy comprises administration of an anti-MUC5ac antibody or antigen-binding antibody fragment.
23. The method of claim 20, wherein the therapy comprises administration of ^{90}Y-hPAM4.
24. The method of claim 23, wherein the cancer is pancreatic cancer.
25. The method of claim 20, wherein the drug is 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, crizotinib, cyclophosphamide, cytarabine, dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, DM1, DM3, DM4, doxorubicin, 2-pyrrolinodoxorubicine (2-PDox), a pro-drug form of 2-PDox (pro-2-PDox), cyano-morpholino doxorubicin, doxorubicin glucuronide, endostatin, epirubicin glucuronide, erlotinib, estramustine, epidophyllotoxin, 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, lapatinib, lenolidamide, leucovorin, LFM-A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, monomethylauristatin F (MMAF), monomethylauristatin D (MMAD), monomethylauristatin E (MMAE), navelbine, neratinib, nilotinib, nitrosurea, olaparib, plicomycin, procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, SN-38, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide, transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839.

26. The method of claim 20, wherein the radionuclide is selected from the group consisting of ^{11}C, ^{13}N, ^{15}O, ^{32}P, ^{33}P, ^{47}Sc, ^{51}Cr, ^{57}Co, ^{58}Co, ^{59}Fe, ^{62}Cu, ^{67}Cu, ^{67}Ga, ^{67}Ga, ^{75}Br, ^{75}Se, ^{75}Se, ^{76}Br, ^{77}As, ^{77}Br, ^{80m}Br, ^{89}Sr, ^{90}Y, ^{95}Ru, ^{97}Ru, ^{99}Mo, ^{99m}Tc, ^{103m}Rh, ^{103}Ru, ^{105}Rh, ^{105}Ru, ^{107}Hg, ^{109}Pd, ^{109}Pt, ^{111}Ag, ^{111}In, ^{113m}In, ^{119}Sb, ^{121m}Te, ^{122m}Te, ^{125}I, ^{125m}Te, ^{126}I, ^{131}I, ^{133}I, ^{142}Pr, ^{143}Pr, ^{149}Pm, ^{152}Dy, ^{153}Sm, ^{161}Ho, ^{161}Tb, ^{165}Tm, ^{166}Dy, ^{166}Ho, ^{167}Tm, ^{168}Tm, ^{169}Er, ^{169}Yb, ^{177}Lu, ^{186}Re, ^{188}Re, ^{189m}Os, ^{189}Re, ^{192}Ir, ^{194}Ir, ^{197}Pt, ^{198}Au, ^{199}Au, ^{199}Au, ^{201}Tl, ^{203}Hg, ^{211}At, ^{211}Bi, ^{211}Pb, ^{212}Bi, ^{212}Pb, ^{213}Bi, ^{215}Po, ^{217}At, ^{219}Rn, ^{221}Fr, ^{223}Ra, ^{224}Ac, ^{225}Ac, ^{255}Fm and ^{227}Th.

27. The method of claim 20, wherein the toxin is selected from the group consisting of ricin, abrin, alpha toxin, saporin, ribonuclease (RNase), DNase I, Staphylococcal enterotoxin-A, pokeweed antiviral protein, gelonin, diphtheria toxin, Pseudomonas exotoxin, and Pseudomonas endotoxin.

28. The method of claim 20, wherein the immunomodulator is selected from the group consisting of a cytokine, a stem cell growth factor, a lymphotoxin, a hematopoietic factor, a colony stimulating factor (CSF), an interferon (IFN), an interleukin, erythropoietin and thrombopoietin.

29. The method of claim 20, wherein the cytokine is selected from the group consisting of human growth hormone, N-methionyl human growth hormone, bovine growth hormone, parathyroid hormone, thyroxine, insulin, proinsulin, relaxin, prorelaxin, follicle stimulating hormone (FSH), thyroid stimulating hormone (TSH), luteinizing hormone (LH), hepatic growth factor, prostaglandin, fibroblast growth factor, prolactin, placental lactogen, OB protein, tumor necrosis factor-α, tumor necrosis factor-ß, mullerian-

inhibiting substance, mouse gonadotropin-associated peptide, inhibin, activin, vascular endothelial growth factor, integrin, thrombopoietin (TPO), NGF-ß, platelet-growth factor, TGF-α, TGF-ß, insulin-like growth factor-I, insulin-like growth factor-II, erythropoietin (EPO), osteoinductive factors, interferon-α, interferon-β, interferon-γ, macrophage-CSF (M-CSF), IL-1, IL-1α, 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, FLT-3, angiostatin, thrombospondin, endostatin, tumor necrosis factor and lymphotoxin.

30. The method of claim 20, wherein the second antibody, second antibody fragment or immunoconjugate binds to an antigen selected from the group consisting of carbonic anhydrase IX, B7, CCL19, CCL21, CSAp, HER-2/*neu*, BrE3, 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, CD47, CD52, CD54, CD55, CD59, CD64, CD67, CD70, CD74, CD79a, CD80, CD83, CD95, CD126, CD133, CD138, CD147, CD154, CEACAM5, CEACAM6, CTLA-4, alpha-fetoprotein (AFP), VEGF, ED-B fibronectin, EGP-1 (Trop-2), EGP-2, EGF receptor, ErbB2, ErbB3, Factor H, Flt-1, Flt-3, folate receptor, Ga 733,GRO-β, HMGB-1, hypoxia inducible factor, HM1.24, HER-2/*neu,* histone H2B, histone H3, histone H4, insulin-like growth factor, IFN-γ, IFN-α, IFN-β, IFN-λ, IL-2R, 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-25, IP-10, IGF-1R, Ia, HM1.24, gangliosides, HCG, HLA-DR, CD66a-d, MAGE, mCRP, MCP-1, MIP-1A, MIP-1B, macrophage migration-inhibitory factor (MIF), matrix metalloproteinase-2, matrix metalloproteinase-9, matrix metalloproteinase-12, MUC1, MUC2, MUC3, MUC4, MUC5ac, placental growth factor, PSA (prostate-specific antigen), PSMA, PD-1 receptor, PD-L1, NCA-95, NCA-90, A3, A33, Ep-CAM, KS-1, Le(y), mesothelin, S100, tenascin, TAC, Tn antigen, Thomas-Friedenreich antigens, tumor necrosis antigens, tumor angiogenesis antigens, TNF-α, TRAIL receptor R1, TRAIL receptor R2, VEGFR, RANTES, T101, complement factors C3, C3a, C3b, C5a, C5, and an oncogene product.

31. The method of claim 1, wherein the antibody fragment is selected from the group consisting of $F(ab')_2$, Fab', Fab, Fv, scFv, single-domain antibody and IgG4 half-molecule.

32. The method of claim 1, wherein the anti-Trop-2 antibody or fragment thereof comprises the light chain CDR sequences CDR1 (KASQDVSIAVA, SEQ ID NO:1); CDR2

(SASYRYT, SEQ ID NO:2); and CDR3 (QQHYITPLT, SEQ ID NO:3) and the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:4); CDR2 (WINTYTGEPTYTDDFKG, SEQ ID NO:5) and CDR3 (GGFGSSYWYFDV, SEQ ID NO:6).

33. The method of claim 1, wherein the anti-Trop-2 antibody or fragment thereof binds to the same epitope as an anti-Trop-2 antibody comprising the light chain CDR sequences CDR1 (KASQDVSIAVA, SEQ ID NO:1); CDR2 (SASYRYT, SEQ ID NO:2); and CDR3 (QQHYITPLT, SEQ ID NO:3) and the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:4); CDR2 (WINTYTGEPTYTDDFKG, SEQ ID NO:5) and CDR3 (GGFGSSYWYFDV, SEQ ID NO:6).
34. The method of claim 1, wherein the anti-Trop-2 antibody binds to Trop-2 expressed on normal cells and wherein adminstration of the anti-Trop-2 ADC to the subject does not induce a fatal immune response to the ADC.
35. The method of claim 34, wherein administration of the anti-Trop-2 ADC to the subject at a therapeutically effective dosage results in limited toxicity.
36. The method of claim 35, wherein administration of the anti-Trop-2 ADC to the subject results in ≤ Grade 3 neutropenia, nausea, diarrhea, alopecia or vomiting.
37. A method of killing a Trop-2 expressing cell comprising exposing the cell to an antibody-drug conjugate (ADC) comprising (i) an anti-Trop-2 antibody or antigen-binding fragment thereof; and (ii) a cytotoxic drug conjugated to the anti-Trop-2 antibody or antibody fragment.
38. A method of delivering a cytotoxic drug to a Trop-2 expressing cell comprising exposing the cell to an antibody-drug conjugate (ADC) comprising (i) an anti-Trop-2 antibody or antigen-binding fragment thereof; and (ii) a cytotoxic drug conjugated to the anti-Trop-2 antibody or antibody fragment.
39. A composition comprising an antibody-drug conjugate (ADC) comprising (i) an anti-Trop-2 antibody or antigen-binding fragment thereof; and (ii) a cytotoxic drug conjugated to the anti-Trop-2 antibody or antibody fragment.
40. The composition of claim 39, wherein the anti-Trop-2 antibody is a chimeric, humanized or human antibody.
41. The composition of claim 39, wherein the anti-Trop-2 antibody is selected from the group consisting of hRS7, 162-46.2, MAB650, K5-70, K5-107, K5-116-2-1, T6-16, T5-86, BR110, 3E9, 6G11, 7E6, 15E2, 18B1, 77220, KM4097, KM4590, A1, A3, and 162-

25.3; or wherein the antibody is produced by a hybridoma selected from the group consisting of AR47A6.4.2, AR52A301.5, PTA-12871, PTA-12872, PD 08019, PD 08020, and PD 08021.

42. The composition of claim 39, wherein the anti-Trop-2 antibody is selected from the group consisting of hRS7, 162-46.2 and MAB650.
43. The composition of claim 39, wherein the antibody is an IgG1, IgG2, IgG3 or IgG4 antibody.
44. The composition of claim 39, wherein the antibody allotype is selected from the group consisting of nG1m1, G1m3, G1m3,1, G13,2, G1m3,1,2, and Km3.
45. The composition of claim 39, wherein the drug is selected from the group consisting of an anthracycline, a camptothecin, a tubulin inhibitor, a maytansinoid, a calicheamycin, an auristatin, a nitrogen mustard, an ethylenimine derivative, an alkyl sulfonate, a nitrosourea, a triazene, a folic acid analog, a taxane, a COX-2 inhibitor, a pyrimidine analog, a purine analog, an antibiotic, an enzyme inhibitor, an epipodophyllotoxin, a platinum coordination complex, a vinca alkaloid, a substituted urea, a methyl hydrazine derivative, an adrenocortical suppressant, a hormone antagonist, an antimetabolite, an alkylating agent, an antimitotic, an anti-angiogenic agent, a tyrosine kinase inhibitor, an mTOR inhibitor, a heat shock protein (HSP90) inhibitor, a proteosome inhibitor, an HDAC inhibitor, and a pro-apoptotic agent.
46. The composition of claim 39, wherein the drug is 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, crizotinib, cyclophosphamide, cytarabine, dacarbazine, dasatinib, dinaciclib, docetaxel, dactinomycin, daunorubicin, DM1, DM3, DM4, doxorubicin, 2-pyrrolinodoxorubicine (2-PDox), a pro-drug form of 2-PDox (pro-2-PDox), cyano-morpholino doxorubicin, doxorubicin glucuronide, endostatin, epirubicin glucuronide, erlotinib, estramustine, epidophyllotoxin, 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, lapatinib, lenolidamide, leucovorin, LFM-

A13, lomustine, mechlorethamine, melphalan, mercaptopurine, 6-mercaptopurine, methotrexate, mitoxantrone, mithramycin, mitomycin, mitotane, monomethylauristatin F (MMAF), monomethylauristatin D (MMAD), monomethylauristatin E (MMAE), navelbine, neratinib, nilotinib, nitrosurea, olaparib, plicomycin, procarbazine, paclitaxel, PCI-32765, pentostatin, PSI-341, raloxifene, semustine, SN-38, sorafenib, streptozocin, SU11248, sunitinib, tamoxifen, temazolomide, transplatinum, thalidomide, thioguanine, thiotepa, teniposide, topotecan, uracil mustard, vatalanib, vinorelbine, vinblastine, vincristine, vinca alkaloids and ZD1839.

47. The composition of claim 39, wherein the drug is selected from the group consisting of SN-38, pro-2-pyrrolinodoxorubicin (pro-2-PDox), paclitaxel, calichemicin, DM1, DM3, DM4, MMAE, MMAD and MMAF.
48. The composition of claim 39, wherein the average ratio of drug to antibody is between 1 and 12.
49. The composition of claim 39, wherein the average ratio of drug to antibody is between 1.5 and 8.
50. The composition of claim 39, wherein the average ratio of drug to antibody is between 1 and 6.
51. The composition of claim 39, wherein the average ratio of drug to antibody is less than 6.
52. The composition of claim 39, wherein the average ratio of drug to antibody is about 6.
53. The composition of claim 39, wherein the antibody fragment is selected from the group consisting of $F(ab')_2$, Fab', Fab, Fv, scFv, single-domain antibody and IgG4 half-molecule.
54. The composition of claim 39, wherein the anti-Trop-2 antibody or fragment thereof comprises the light chain CDR sequences CDR1 (KASQDVSIAVA, SEQ ID NO:1); CDR2 (SASYRYT, SEQ ID NO:2); and CDR3 (QQHYITPLT, SEQ ID NO:3) and the heavy chain CDR sequences CDR1 (NYGMN, SEQ ID NO:4); CDR2 (WINTYTGEPTYTDDFKG, SEQ ID NO:5) and CDR3 (GGFGSSYWYFDV, SEQ ID NO:6).
55. The composition of claim 39, wherein the anti-Trop-2 antibody or fragment thereof binds to the same epitope as an anti-Trop-2 antibody comprising the light chain CDR sequences CDR1 (KASQDVSIAVA, SEQ ID NO:1); CDR2 (SASYRYT, SEQ ID NO:2); and CDR3 (QQHYITPLT, SEQ ID NO:3) and the heavy chain CDR sequences CDR1

(NYGMN, SEQ ID NO:4); CDR2 (WINTYTGEPTYTDDFKG, SEQ ID NO:5) and CDR3 (GGFGSSYWYFDV, SEQ ID NO:6).

56. The composition of claim 39, further comprising a therapeutic agent selected from the group consisting of an immunomodulator, a cytokine, a chemotherapeutic agent, a pro-apoptotic agent, an anti-angiogenic agent, a cytotoxic agent, a drug, a toxin, a radionuclide, an RNAi, an siRNA, a second antibody, an antigen-binding fragment of a second antibody, an RNase, a DNase, and an immunoconjugate.

FIG. 1

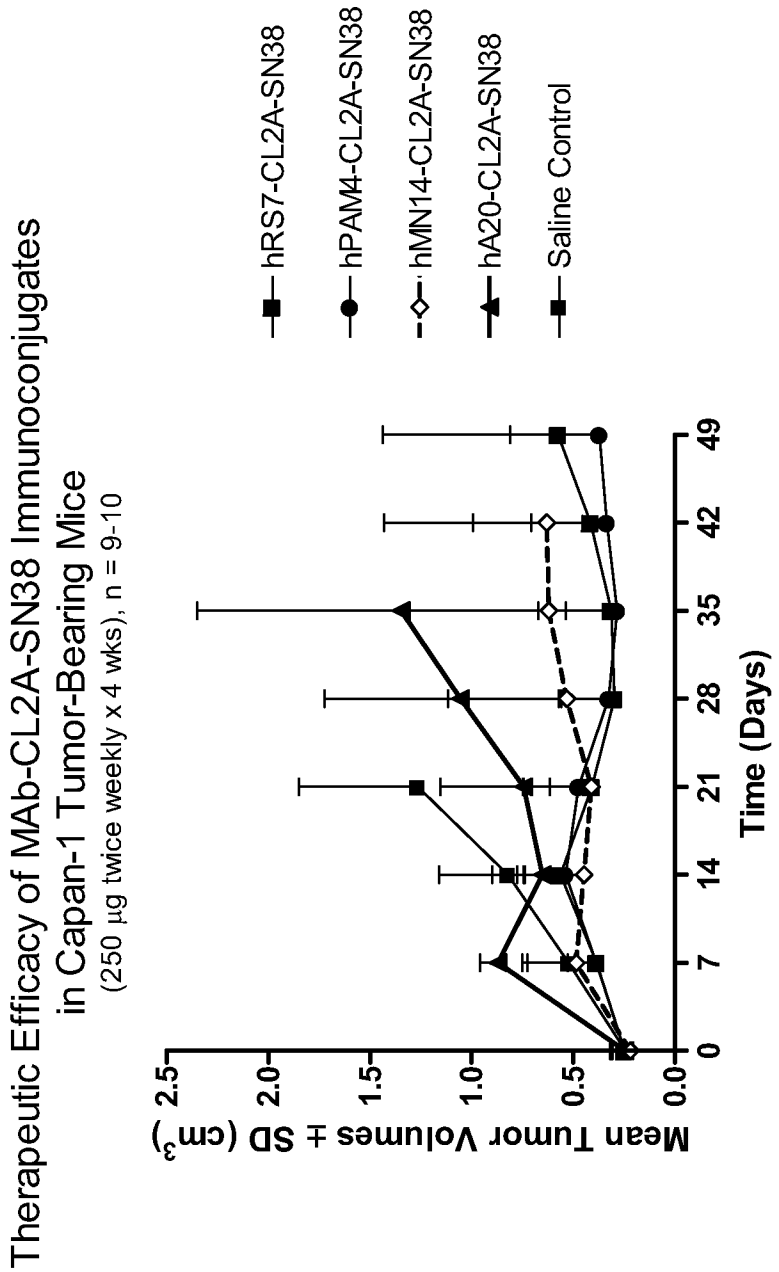

Therapeutic Efficacy of MAb-CL2A-SN38 Immunoconjugates
in Capan-1 Tumor-Bearing Mice
(250 μg twice weekly x 4 wks), n = 9-10
hRS7-CL2A-SN38
hPAM4-CL2A-SN38
hMN14-CL2A-SN38
hA20-CL2A-SN38
Saline Control
Mean Tumor Volumes ± SD (cm3)
2.5
2.0
1.5
1.0
0.5
0.0
0
7
14
21
28
35
42
49
Time (Days)

FIG. 2

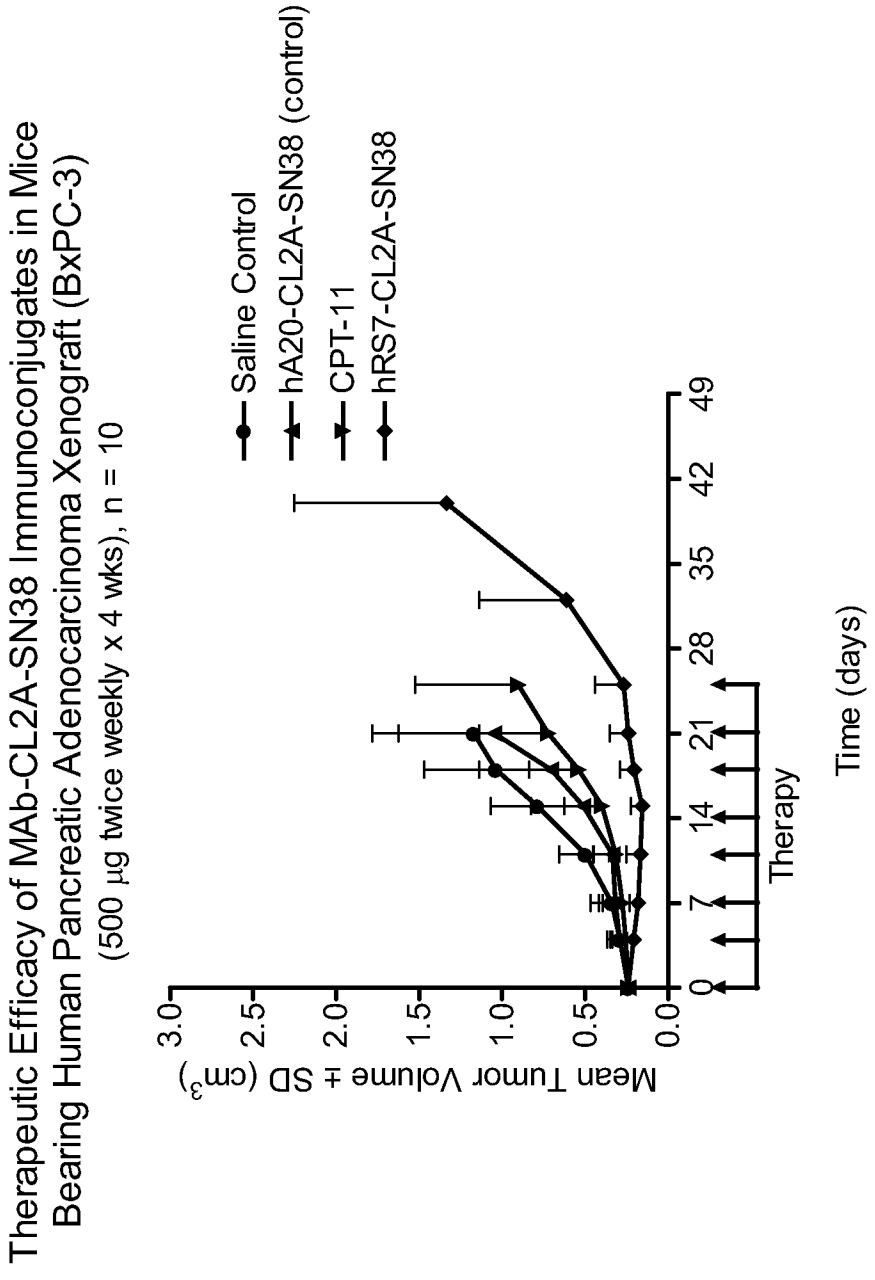

Therapeutic Efficacy of MAb-CL2A-SN38 Immunoconjugates in Mice Bearing Human Pancreatic Adenocarcinoma Xenograft (BxPC-3)
(500 μg twice weekly x 4 wks), n = 10
Saline Control
hA20-CL2A-SN38 (control)
CPT-11
hRS7-CL2A-SN38
Mean Tumor Volume ± SD (cm3)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
7
14
21
28
35
42
49
Therapy
Time (days)

FIG. 3

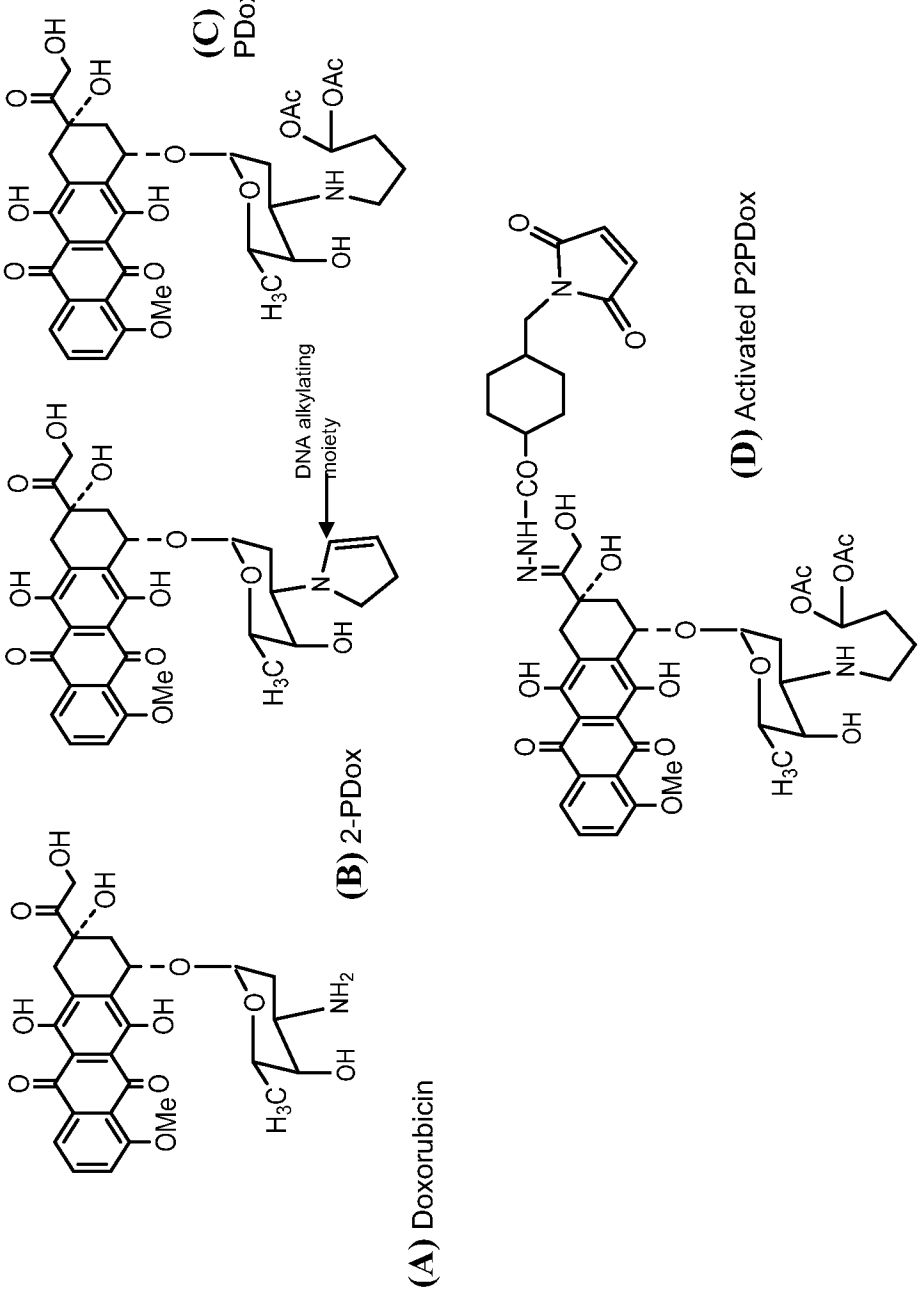

(A) Doxorubicin
(B) 2-PDox
DNA alkylating moiety
(C) A pro-drug form of 2-PDox (P2PDox)
(D) Activated P2PDox

FIG. 4

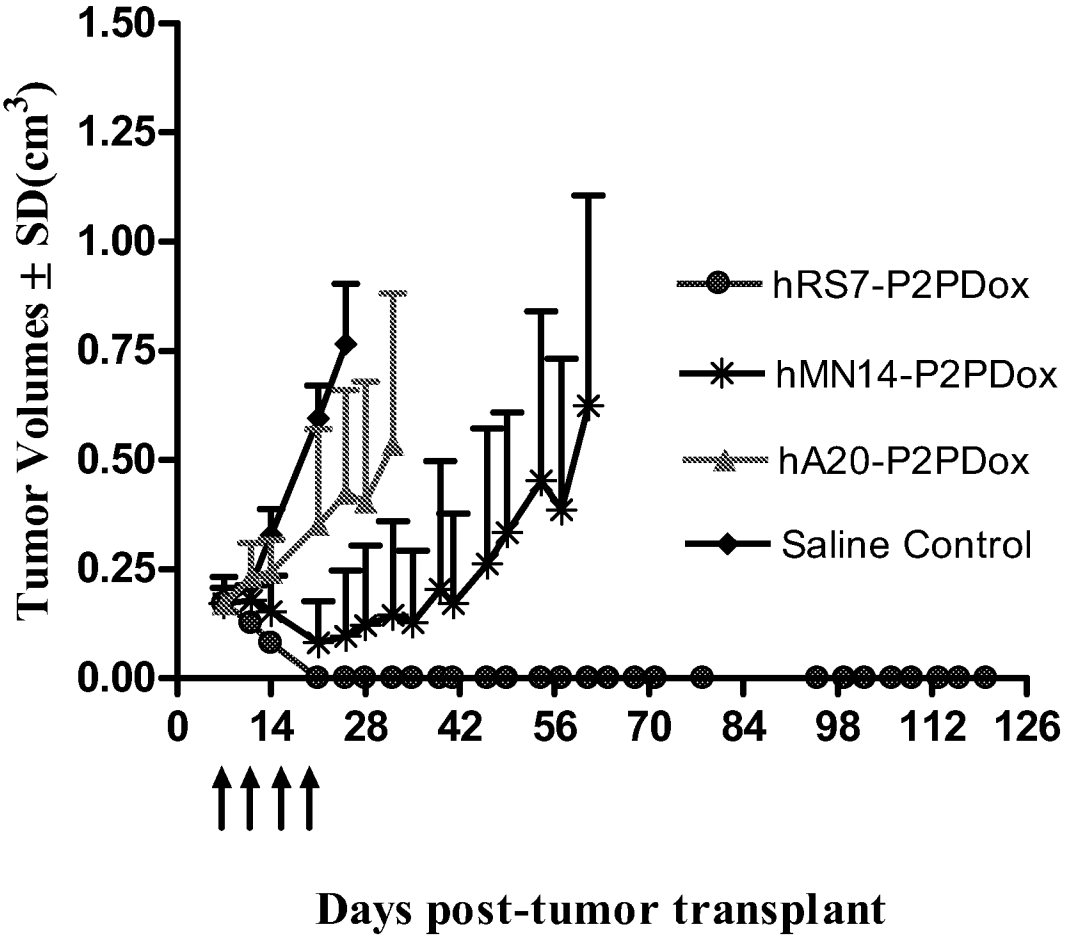

Tumor Volumes ± SD(cm3)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
14
28
42
56
70
84
98
112
126
hRS7-P2PDox
hMN14-P2PDox
hA20-P2PDox
Saline Control
Days post-tumor transplant

FIG. 5A

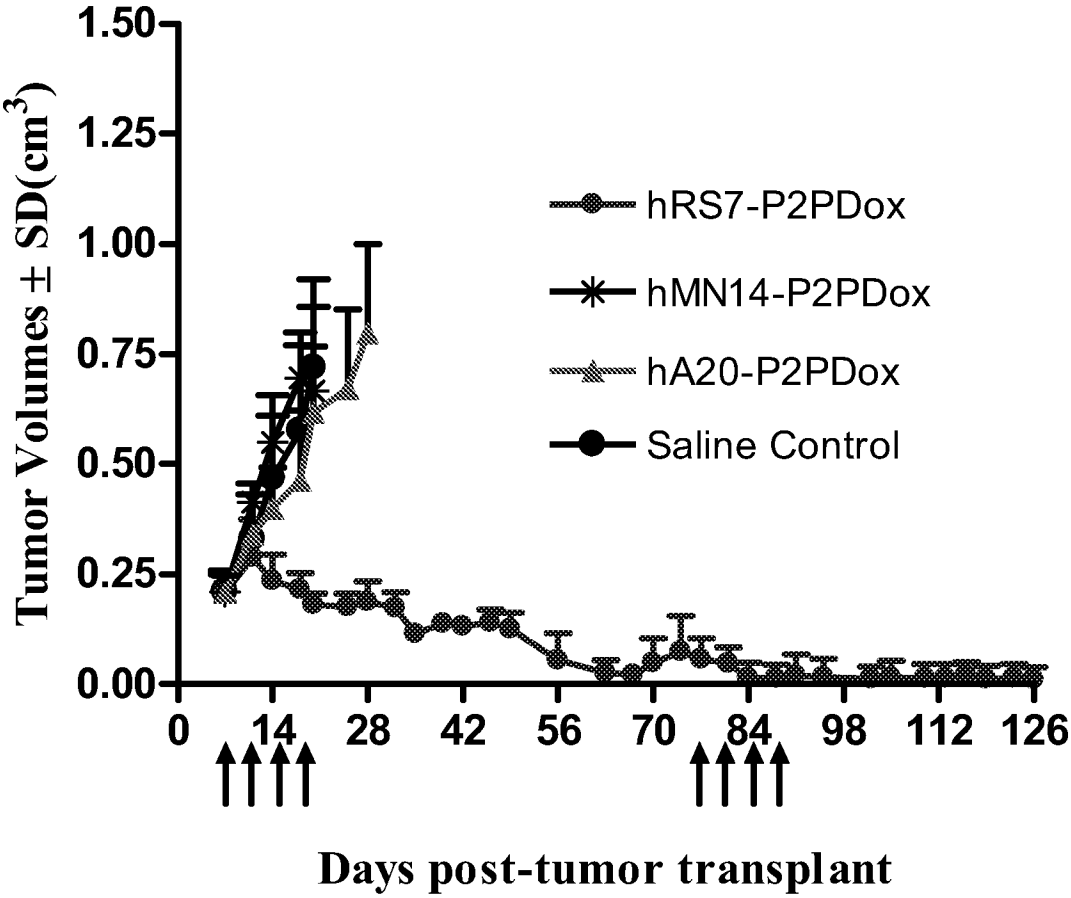

1.50
1.25
1.00
0.75
0.50
0.25
0.00
Tumor Volumes ± SD(cm3)
0
14
28
42
56
70
84
98
112
126
Days post-tumor transplant
hRS7-P2PDox
hMN14-P2PDox
hA20-P2PDox
Saline Control

FIG. 5B

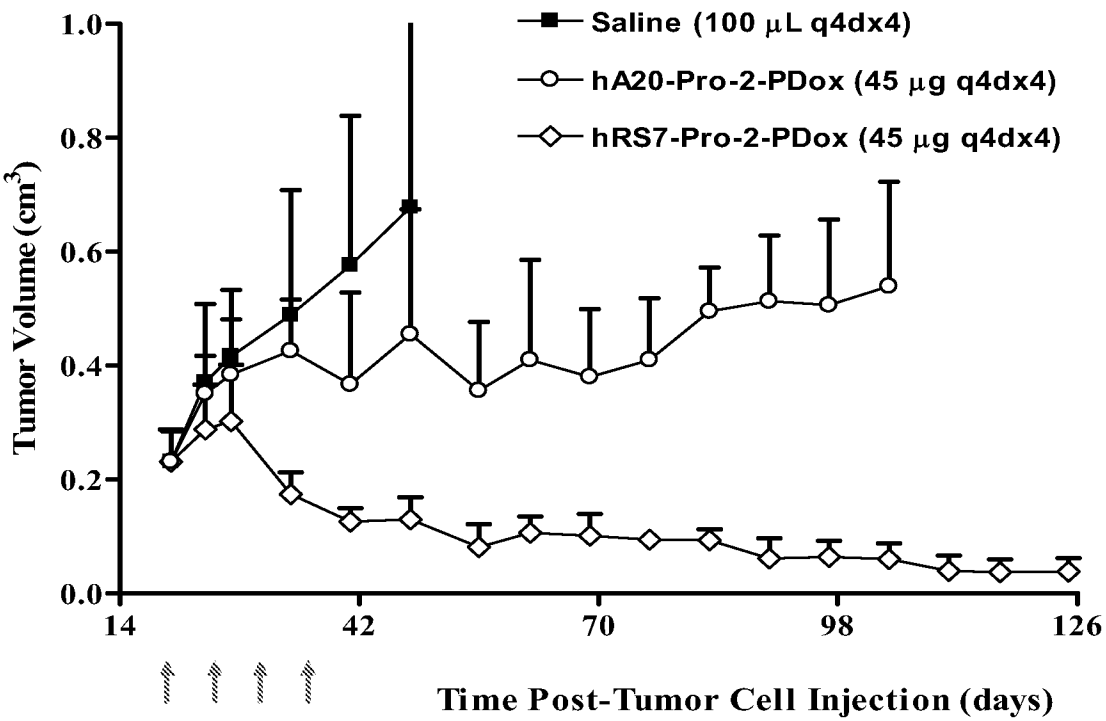

Saline (100 μL q4dx4)
hA20-Pro-2-PDox (45 μg q4dx4)
hRS7-Pro-2-PDox (45 μg q4dx4)
Tumor Volume (cm3)
1.0
0.8
0.6
0.4
0.2
0.0
14
42
70
98
126
Time Post-Tumor Cell Injection (days)

FIG. 5C

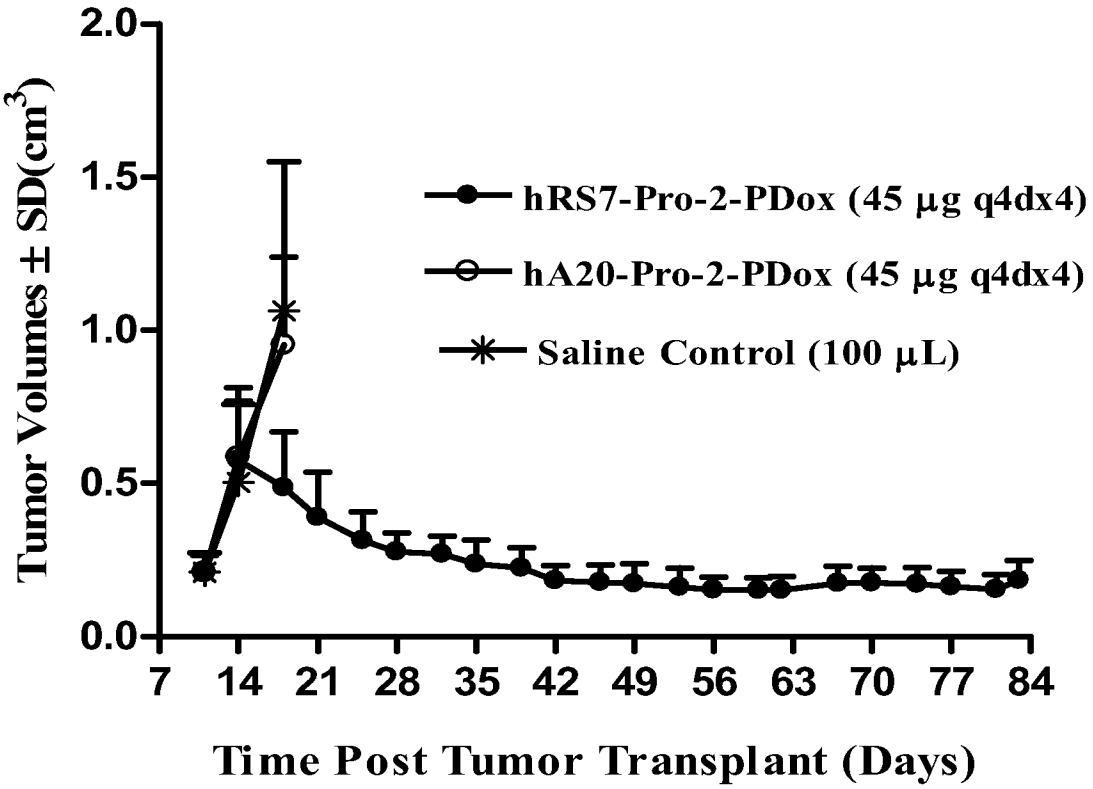

2.0
1.5
1.0
0.5
0.0
Tumor Volumes ± SD(cm3)
7
14
21
28
35
42
49
56
63
70
77
84
Time Post Tumor Transplant (Days)
hRS7-Pro-2-PDox (45 µg q4dx4)
hA20-Pro-2-PDox (45 µg q4dx4)
Saline Control (100 µL)

FIG. 6

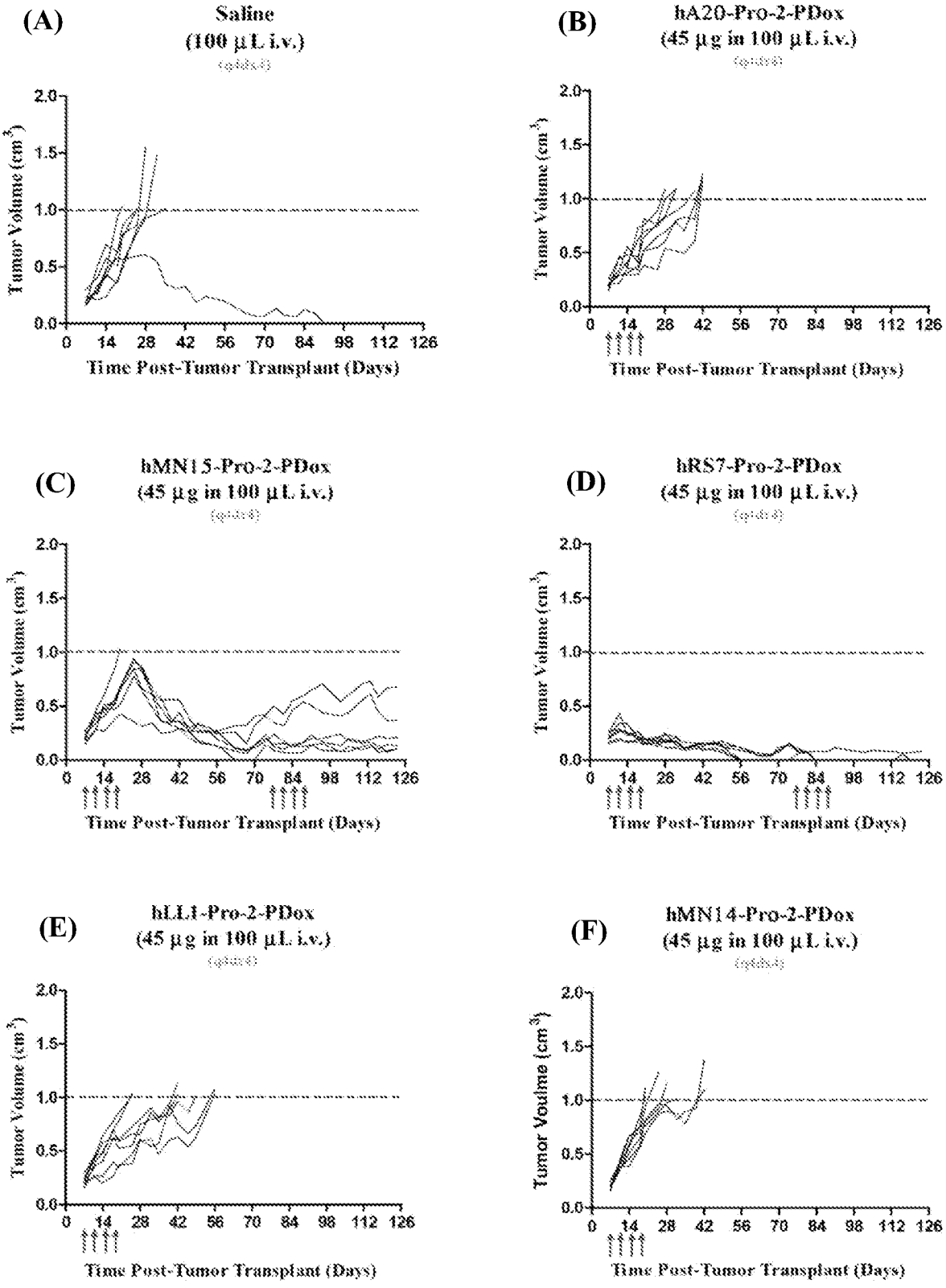
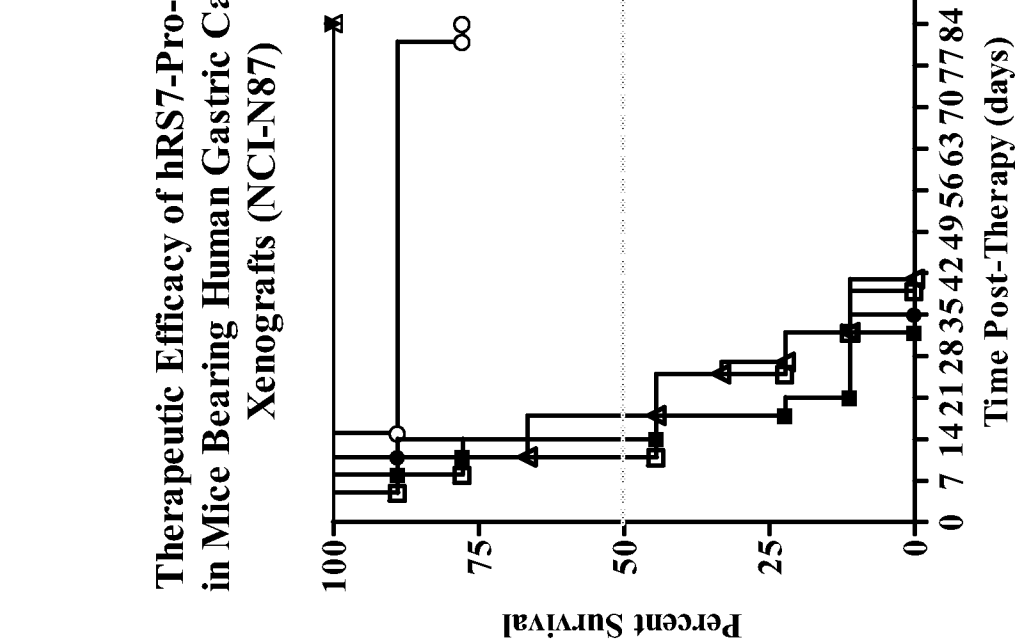

(A)
Saline
(100 µL i.v.)
(B)
hA20-Pro-2-PDox
(45 µg in 100 µL i.v.)
(C)
hMN15-Pro-2-PDox
(45 µg in 100 µL i.v.)
(D)
hRS7-Pro-2-PDox
(45 µg in 100 µL i.v.)
(E)
hLL1-Pro-2-PDox
(45 µg in 100 µL i.v.)
(F)
hMN14-Pro-2-PDox
(45 µg in 100 µL i.v.)
Tumor Volume (cm3)
Time Post-Tumor Transplant (Days)
0.0
0.5
1.0
1.5
2.0
0
14
28
42
56
70
84
98
112
126

FIG. 7

Therapeutic Efficacy of hRS7-Pro-2-PDox in Mice Bearing Human Gastric Carcinoma Xenografts (NCI-N87)



	Median Survival	Survivors/ Total
hRS7-Pro-2PDox (180 µg once)	> 84 days	7/9
hRS7-Pro-2PDox (90 µg wkly x 2)	> 84 days	9/9
hRS7-Pro-2PDox (45 µg q4dx4)	> 84 days	8/8
hA20-Pro-2-Pdox (180 µg once)	14 days	0/9
hA20-Pro-2-Pdox (90 µg wkly x 2)	11 days	0/9
hA20-Pro-2-Pdox (45 µg q4dx4)	18 days	0/9
Saline (100 µL q4dx4)	14 days	0/9

FIG. 8

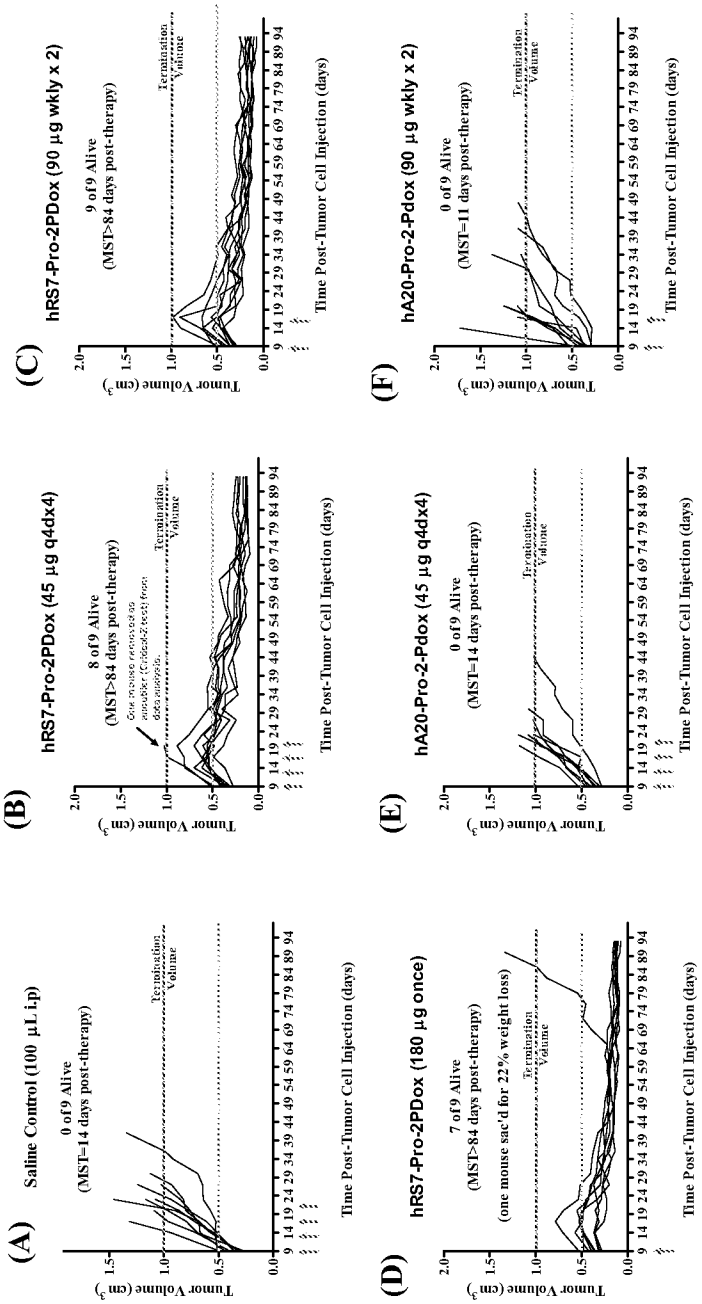

(A)
Saline Control (100 µL i.p)
0 of 9 Alive
(MST=14 days post-therapy)
(B)
hRS7-Pro-2PDox (45 µg q4dx4)
8 of 9 Alive
(MST>84 days post-therapy)
(C)
hRS7-Pro-2PDox (90 µg wkly x 2)
9 of 9 Alive
(MST>84 days post-therapy)
(D)
hRS7-Pro-2PDox (180 µg once)
7 of 9 Alive
(MST>84 days post-therapy)
(one mouse sac'd for 22% weight loss)
(E)
hA20-Pro-2-Pdox (45 µg q4dx4)
0 of 9 Alive
(MST=14 days post-therapy)
(F)
hA20-Pro-2-Pdox (90 µg wkly x 2)
0 of 9 Alive
(MST=11 days post-therapy)
(G)
hA20-Pro-2-Pdox (180 µg once)
0 of 9 Alive
(MST=18 days post-therapy)
Termination Volume
Tumor Volume (cm 3)
Time Post-Tumor Cell Injection (days)

FIG. 9

Minimum Effective Dose of a Single Injection of an Anti-Trop-2 Pro-2-PDox-Immunoconjugate(hRS7-Pro-2-PDox) in Mice Bearing Human Gastric Carcinoma Xenografts (NCI-N87)

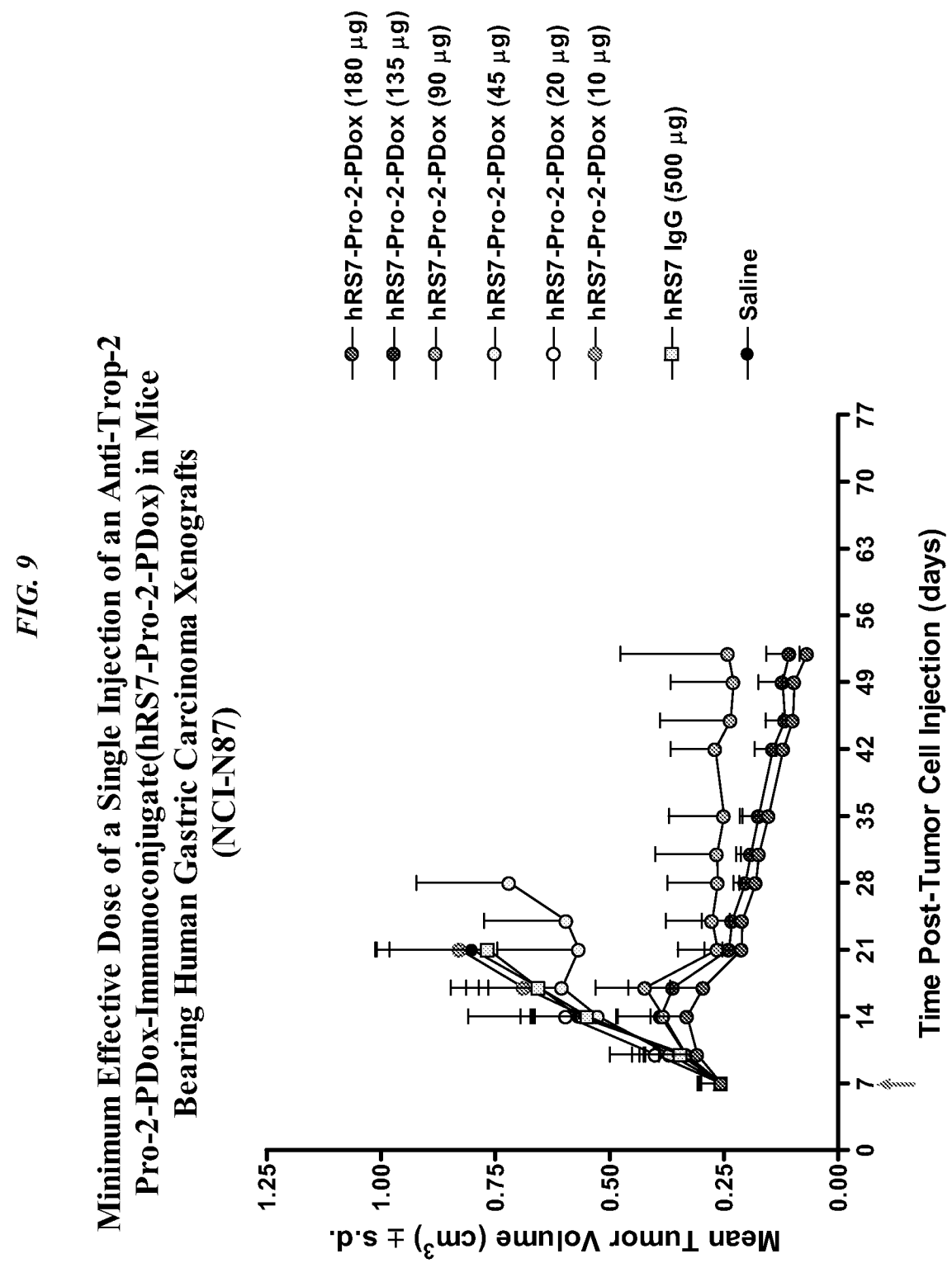


FIG. 10

Minimum Effective Dose of a Single Injection of an Anti-Trop-2 Pro-2-PDox-Immunoconjugate (hRS7-Pro-2-PDox) in Mice Bearing Human Gastric Carcinoma Xenografts (NCI-N87)

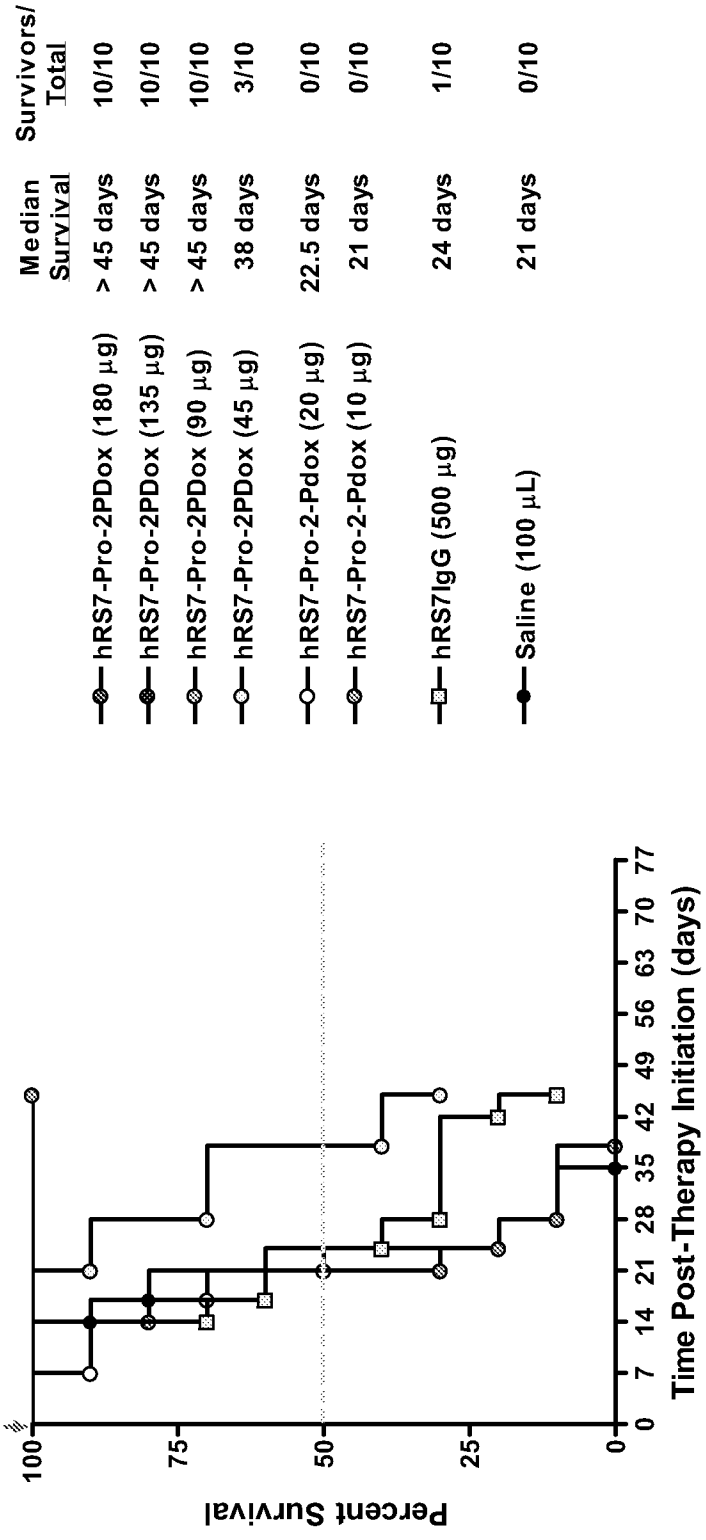


FIG. 11

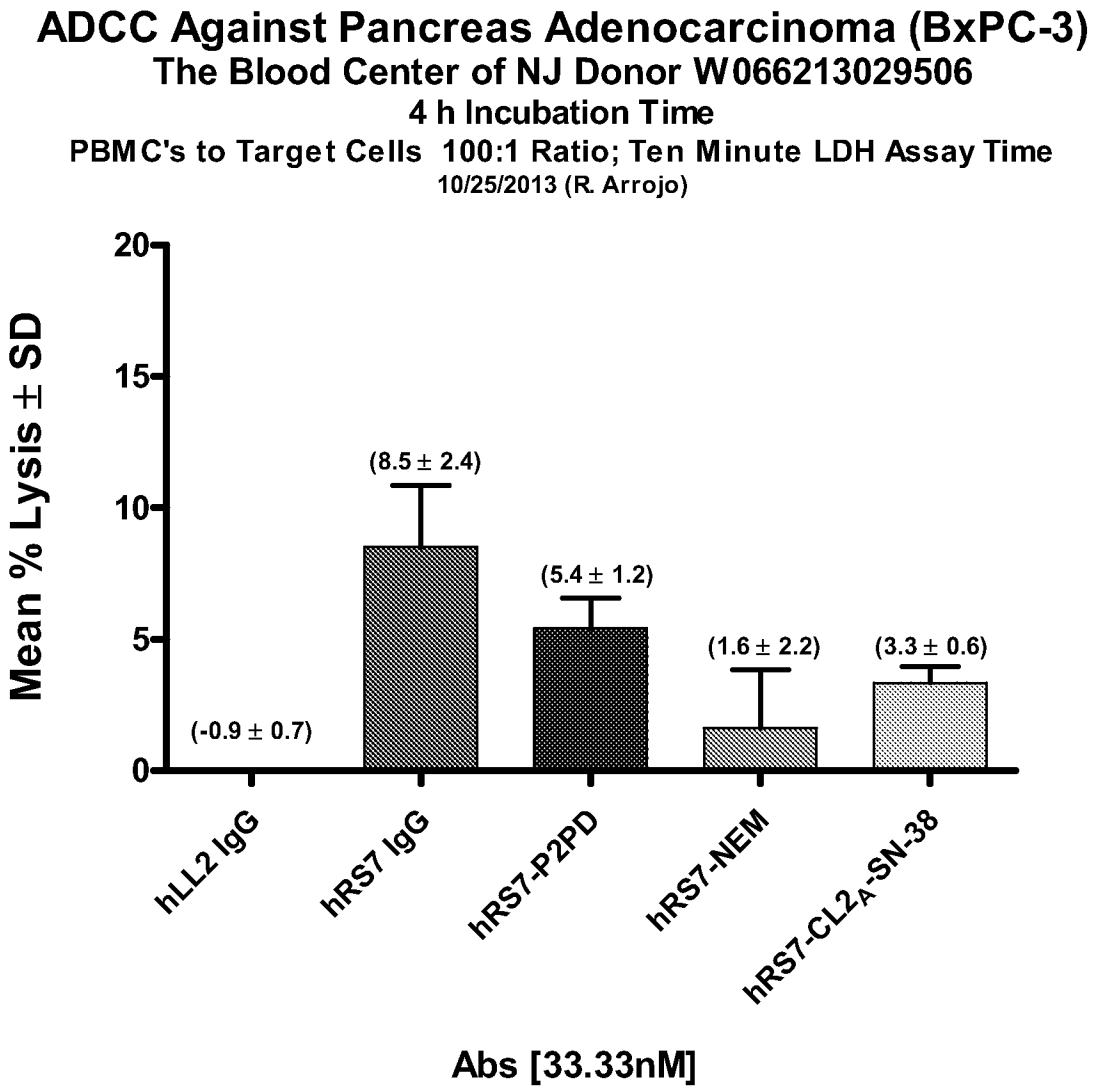
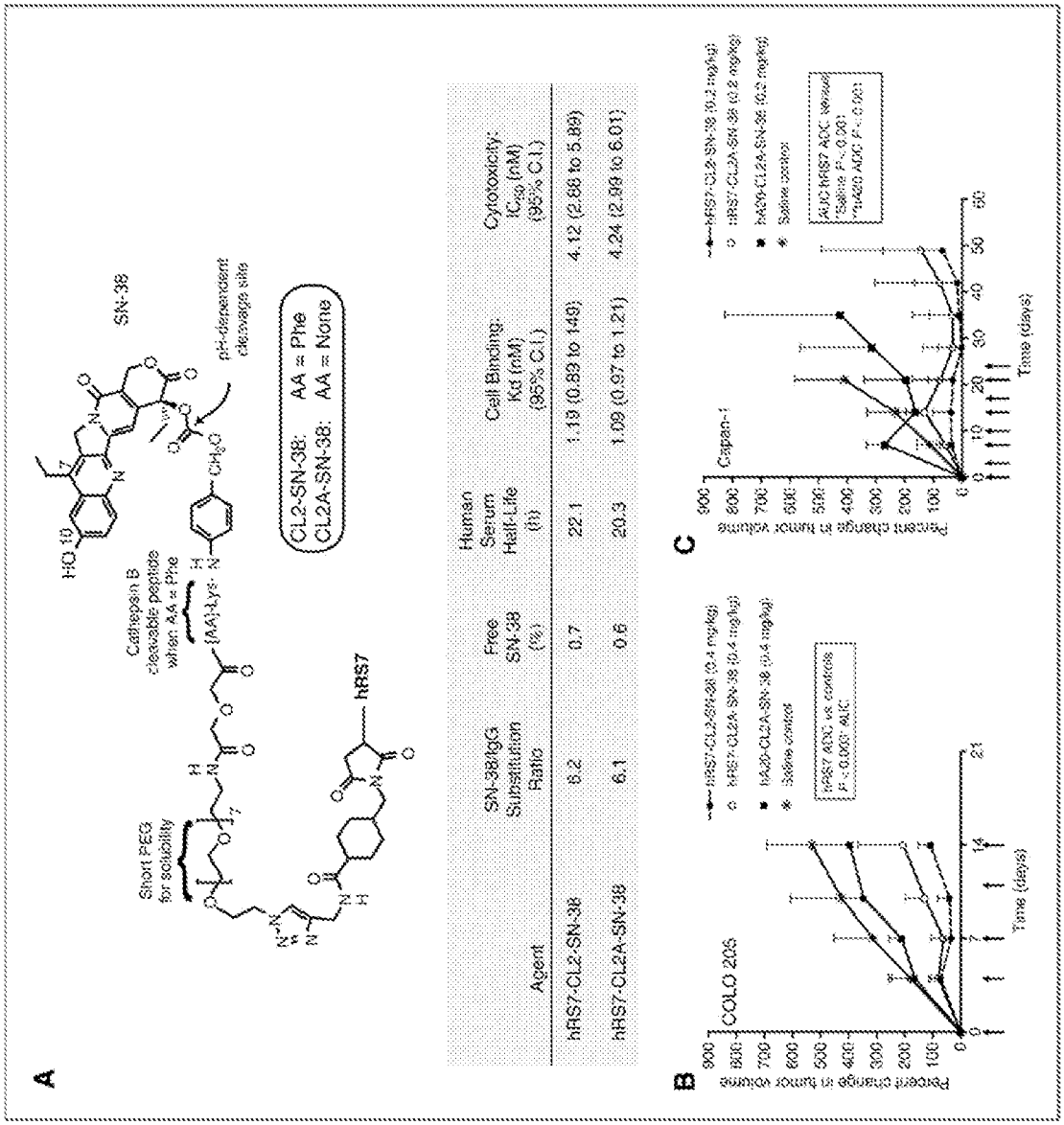

ADCC Against Pancreas Adenocarcinoma (BxPC-3)
The Blood Center of NJ Donor W066213029506
4 h Incubation Time
PBMC's to Target Cells 100:1 Ratio; Ten Minute LDH Assay Time
10/25/2013 (R. Arrojo)
Mean % Lysis ± SD
20
15
10
5
0
(-0.9 ± 0.7)
(8.5 ± 2.4)
(5.4 ± 1.2)
(1.6 ± 2.2)
(3.3 ± 0.6)
hLL2 IgG
hRS7 IgG
hRS7-P2PD
hRS7-NEM
hRS7-CL2A-SN-38
Abs [33.33nM]

FIG. 12



Agent	SN-38/IgG Substitution Ratio	Free SN-38 (%)	Human Serum Half-Life (h)	Cell Binding: Kd (nM) (95% CI.)	Cytotoxicity: IC_{50} (nM) (95% CI.)
hRS7-CL2-SN-38	8.2	0.7	22.1	1.19 (0.89 to 149)	4.12 (2.66 to 5.89)
hRS7-CL2A-SN-38	6.1	0.6	20.3	1.09 (0.97 to 1.21)	4.24 (2.99 to 6.01)

FIG. 13

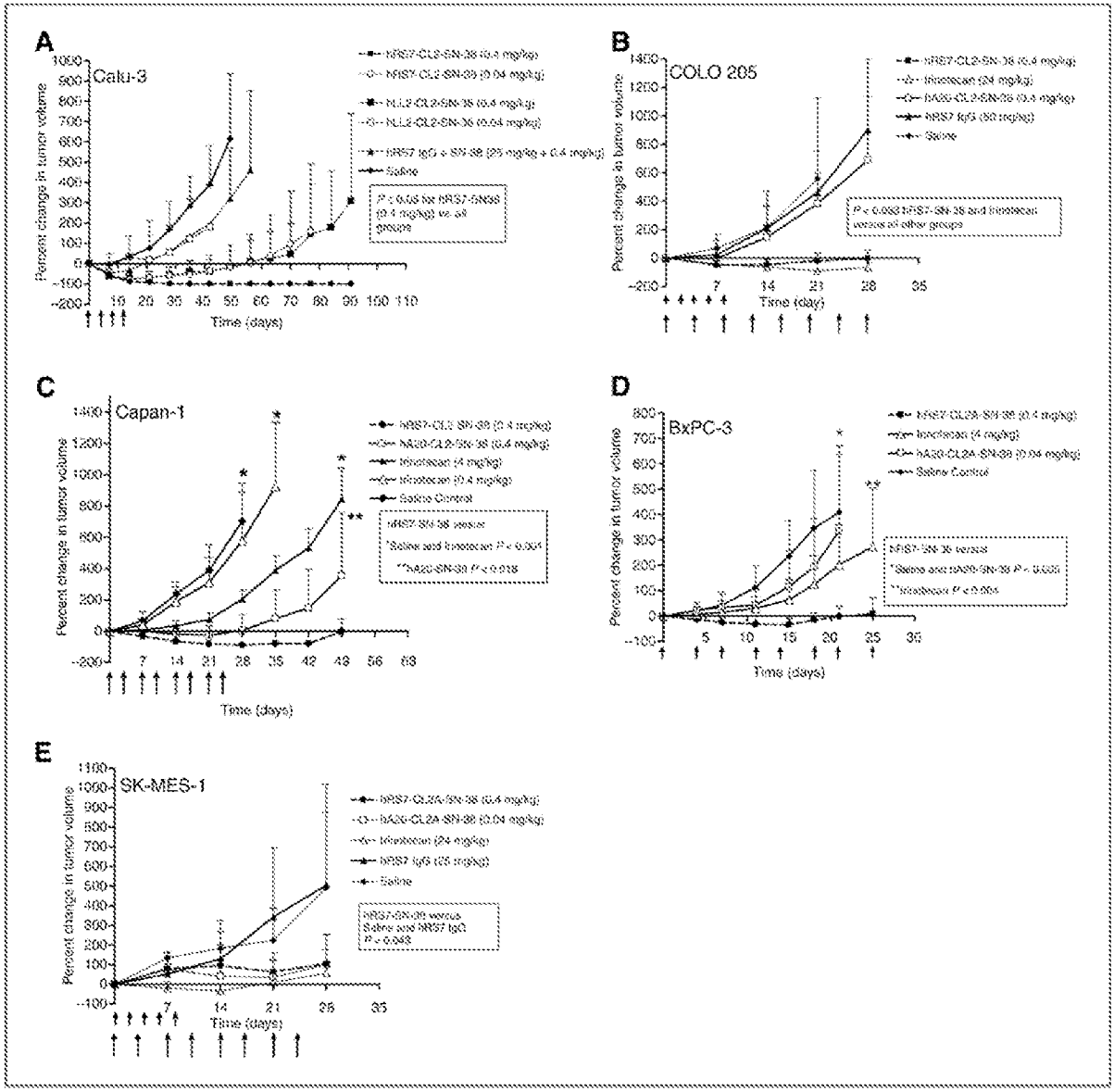

A
Caki-3
Percent change in tumor volume
Time (days)
Saline
B
COLO 205
Percent change in tumor volume
Time (day)
Saline
C
Capan-1
Percent change in tumor volume
Time (days)
Saline Control
D
BxPC-3
Percent change in tumor volume
Time (days)
Saline Control
E
SK-MES-1
Percent change in tumor volume
Time (days)
Saline

FIG. 14

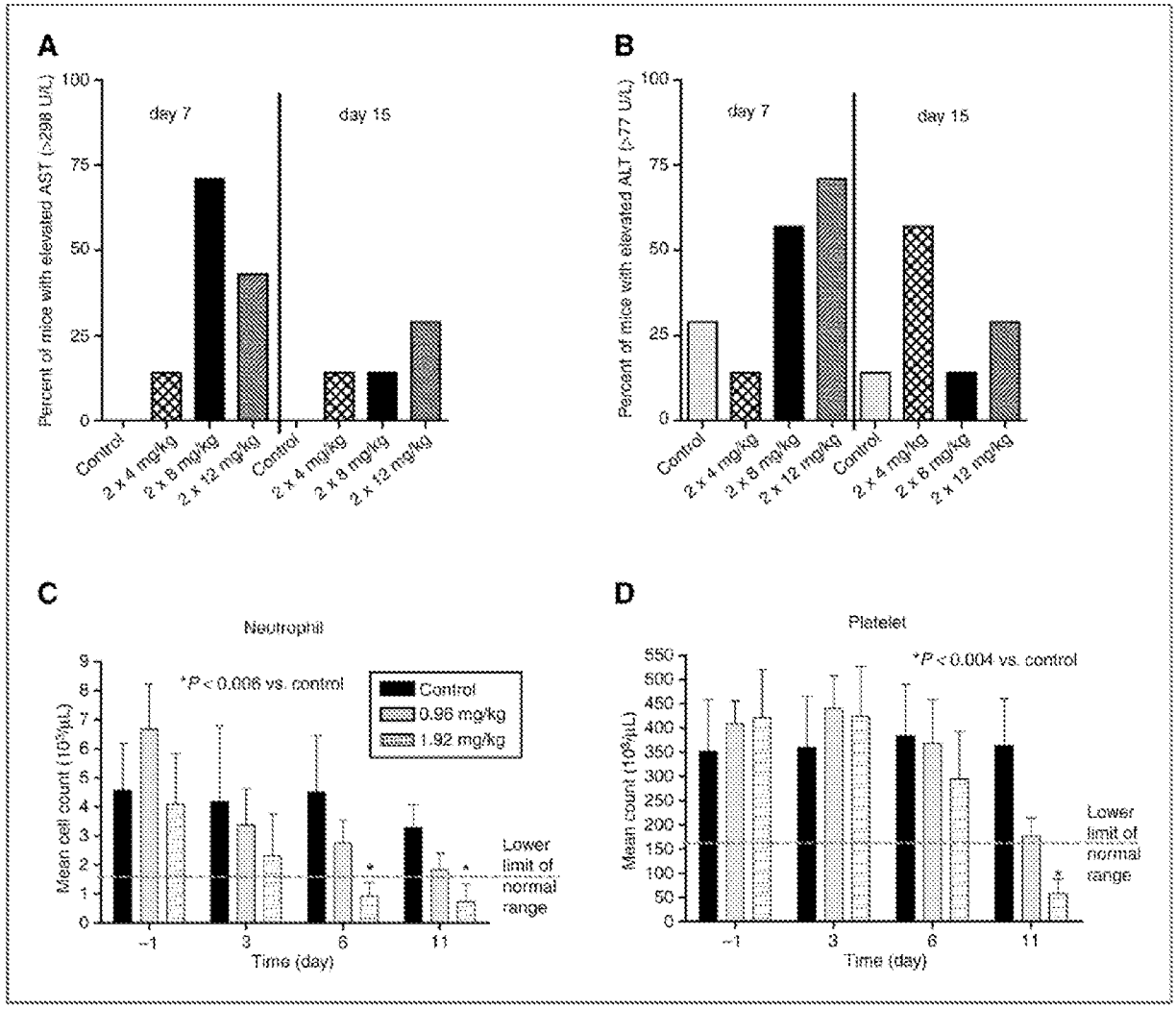
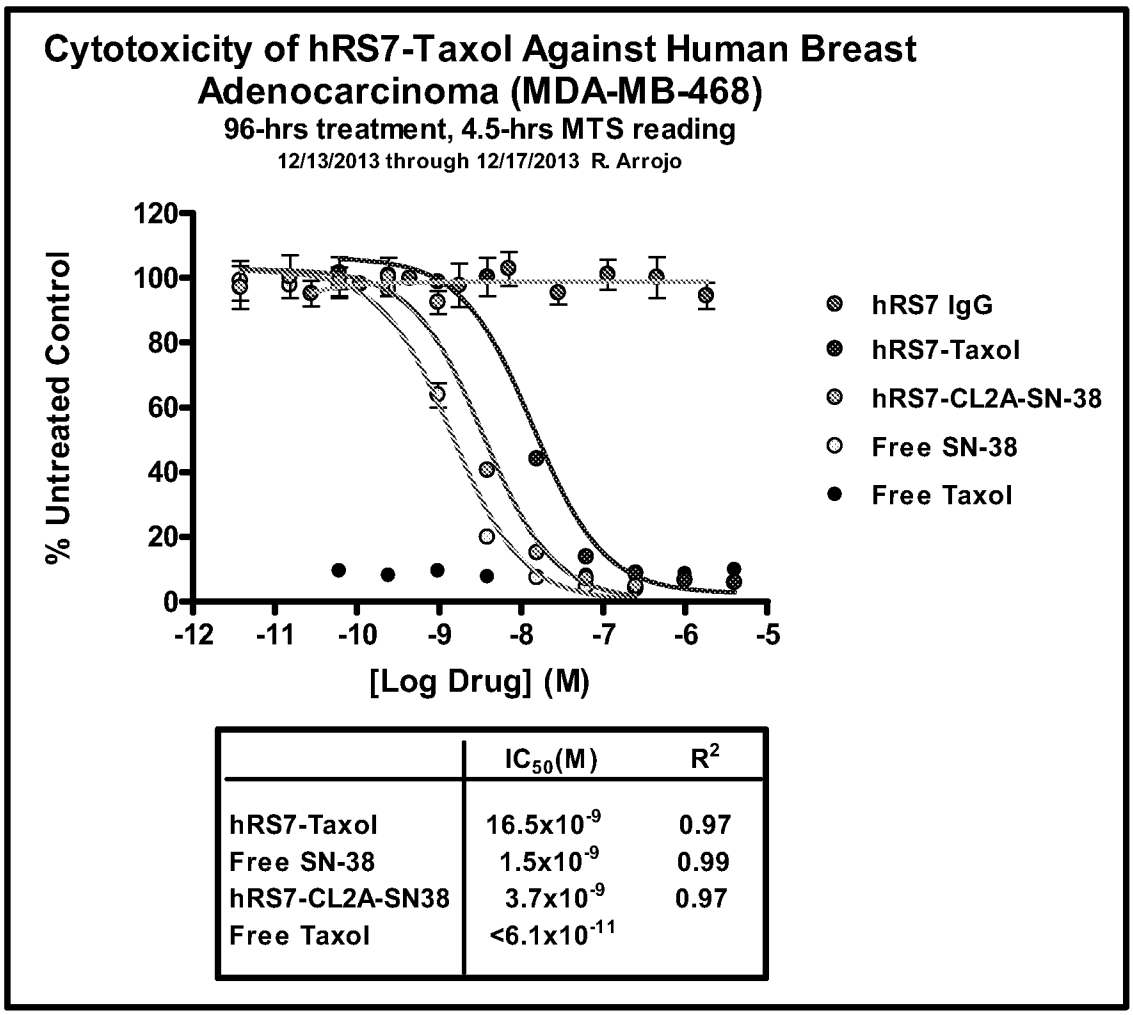
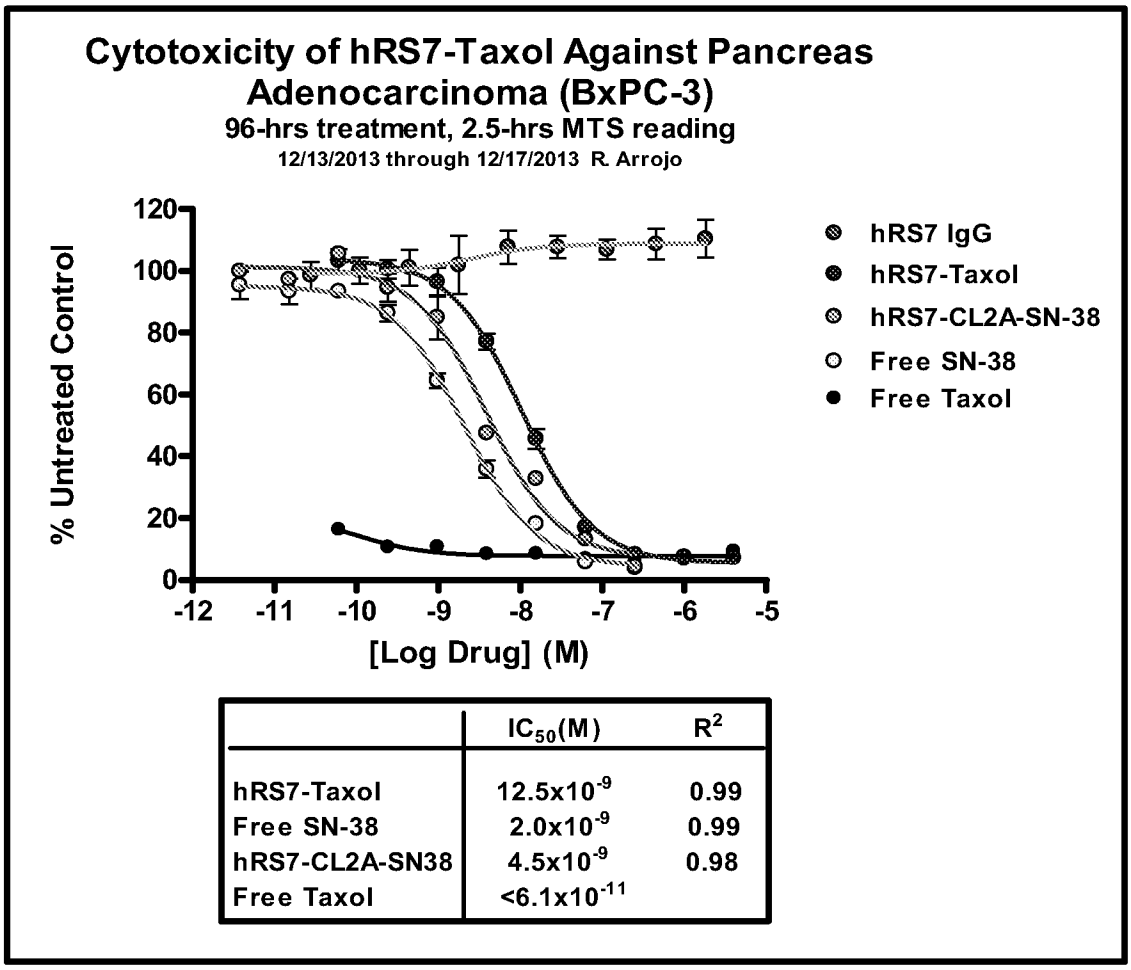

A
Percent of mice with elevated AST (>298 U/L)
day 7
day 15
Control
2 x 4 mg/kg
2 x 8 mg/kg
2 x 12 mg/kg
B
Percent of mice with elevated ALT (>77 U/L)
C
Neutrophil
*P < 0.006 vs. control
Control
0.96 mg/kg
1.92 mg/kg
Mean cell count (10³/μL)
Lower limit of normal range
Time (day)
D
Platelet
*P < 0.004 vs. control
Mean count (10³/μL)

FIG. 15



	IC_{50}(M)	R^2
hRS7-Taxol	16.5×10^{-9}	0.97
Free SN-38	1.5×10^{-9}	0.99
hRS7-CL2A-SN38	3.7×10^{-9}	0.97
Free Taxol	$<6.1 \times 10^{-11}$	

FIG. 16



	IC_{50}(M)	R^2
hRS7-Taxol	$12.5x10^{-9}$	0.99
Free SN-38	$2.0x10^{-9}$	0.99
hRS7-CL2A-SN38	$4.5x10^{-9}$	0.98
Free Taxol	$<6.1x10^{-11}$	

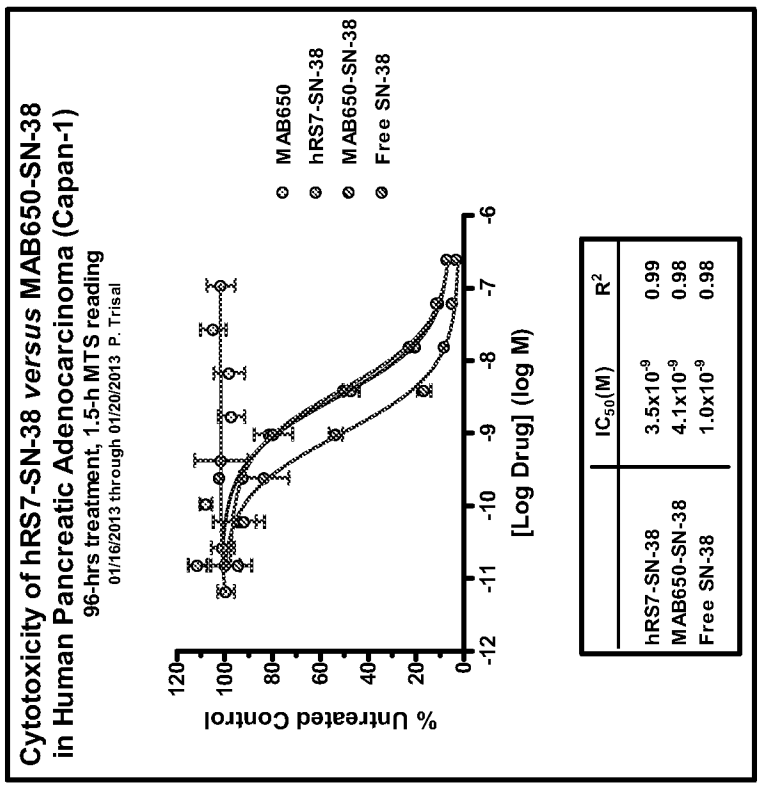


FIG. 17A

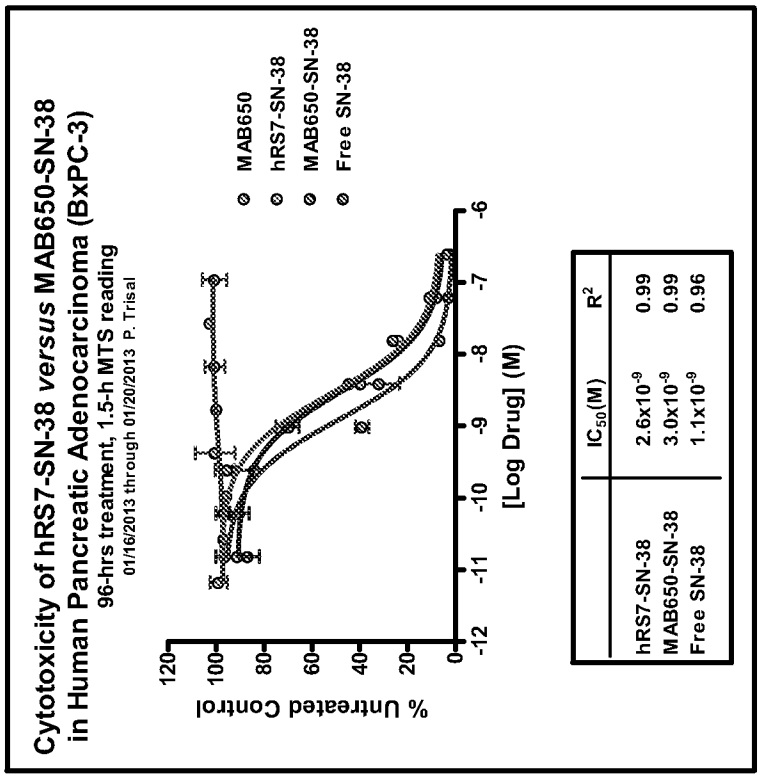
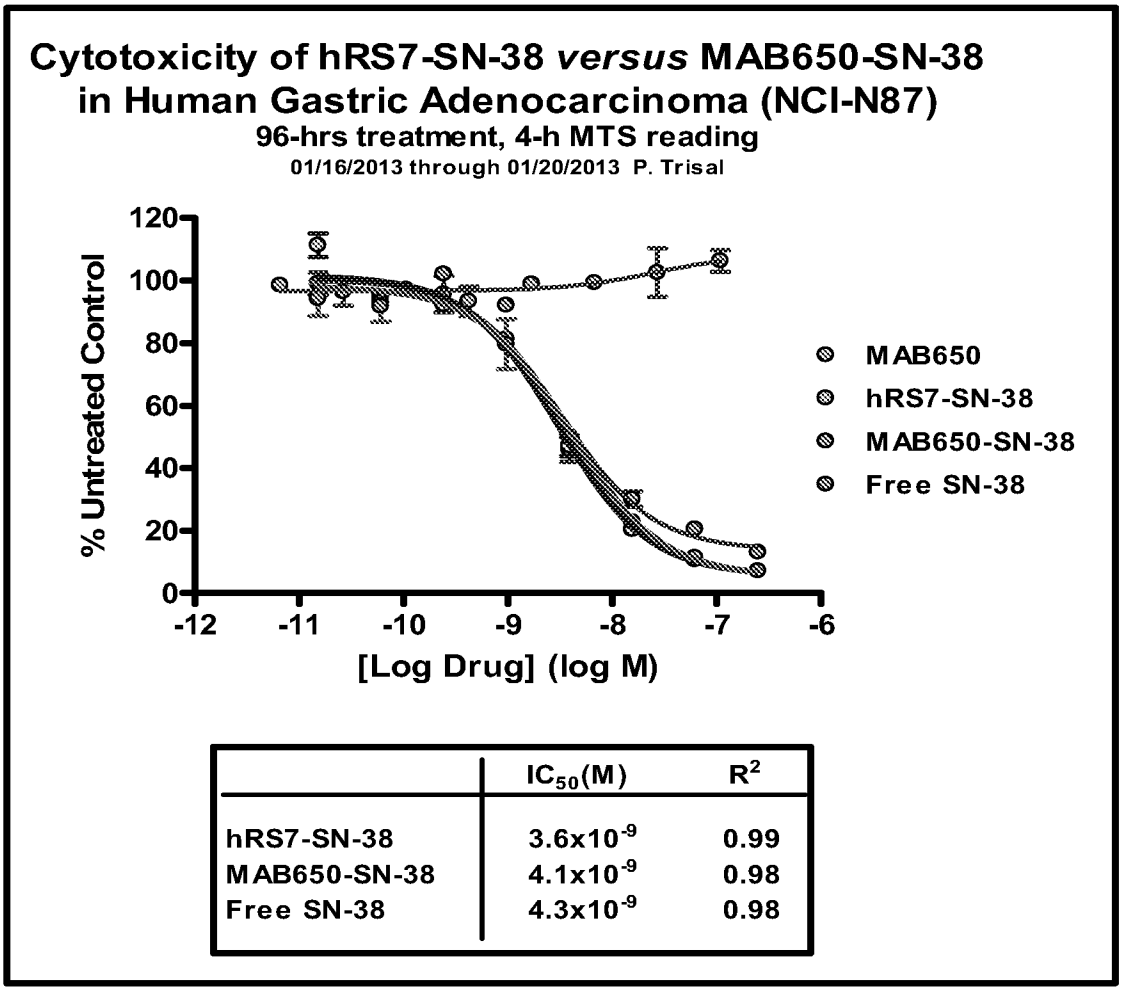


FIG. 17B

FIG. 17C



	IC_{50}(M)	R^2
hRS7-SN-38	$3.6x10^{-9}$	0.99
MAB650-SN-38	$4.1x10^{-9}$	0.98
Free SN-38	$4.3x10^{-9}$	0.98

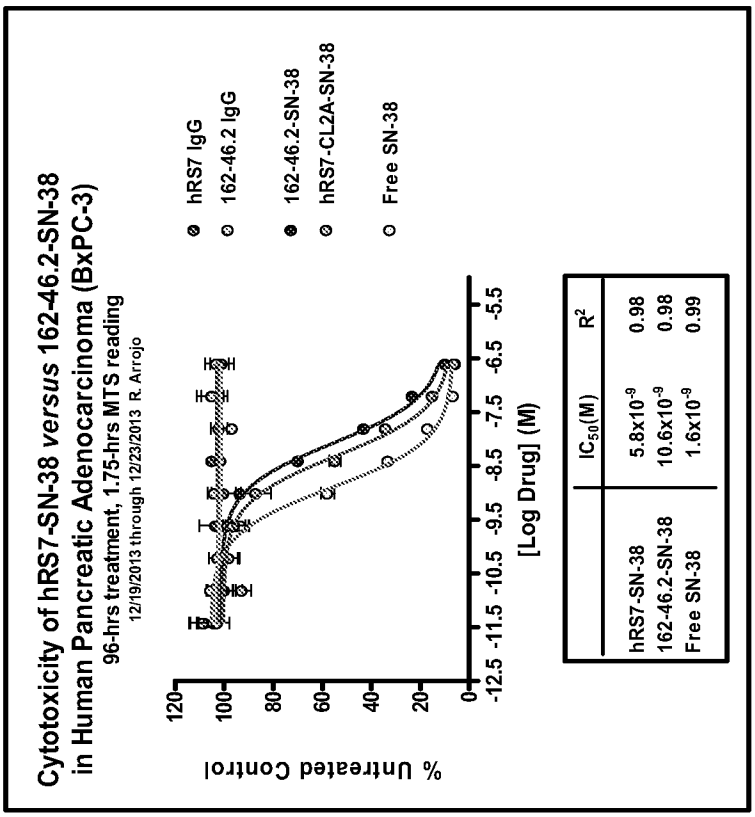


FIG. 18A

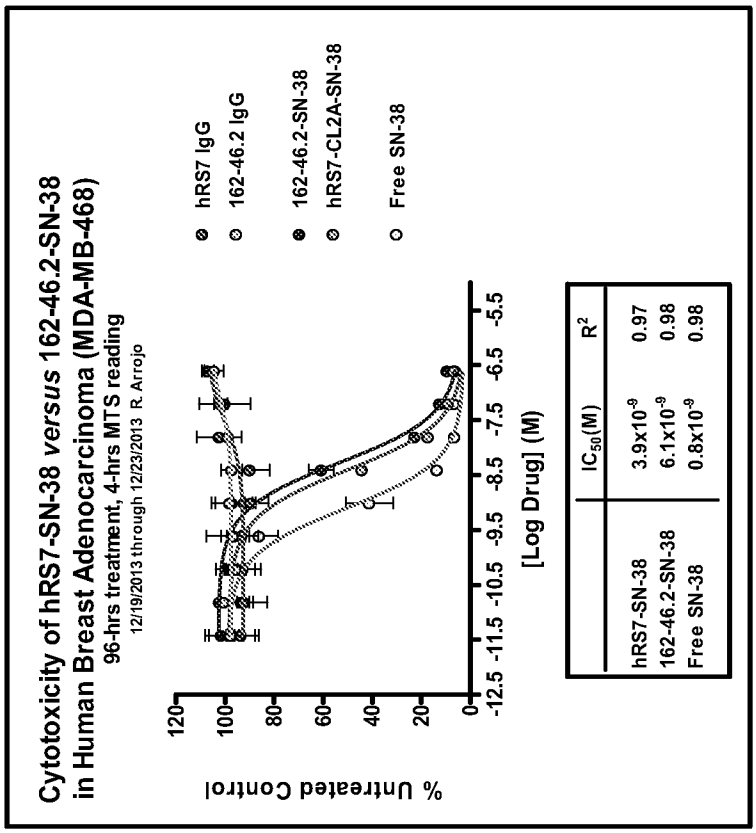


FIG. 18B

FIG. 19

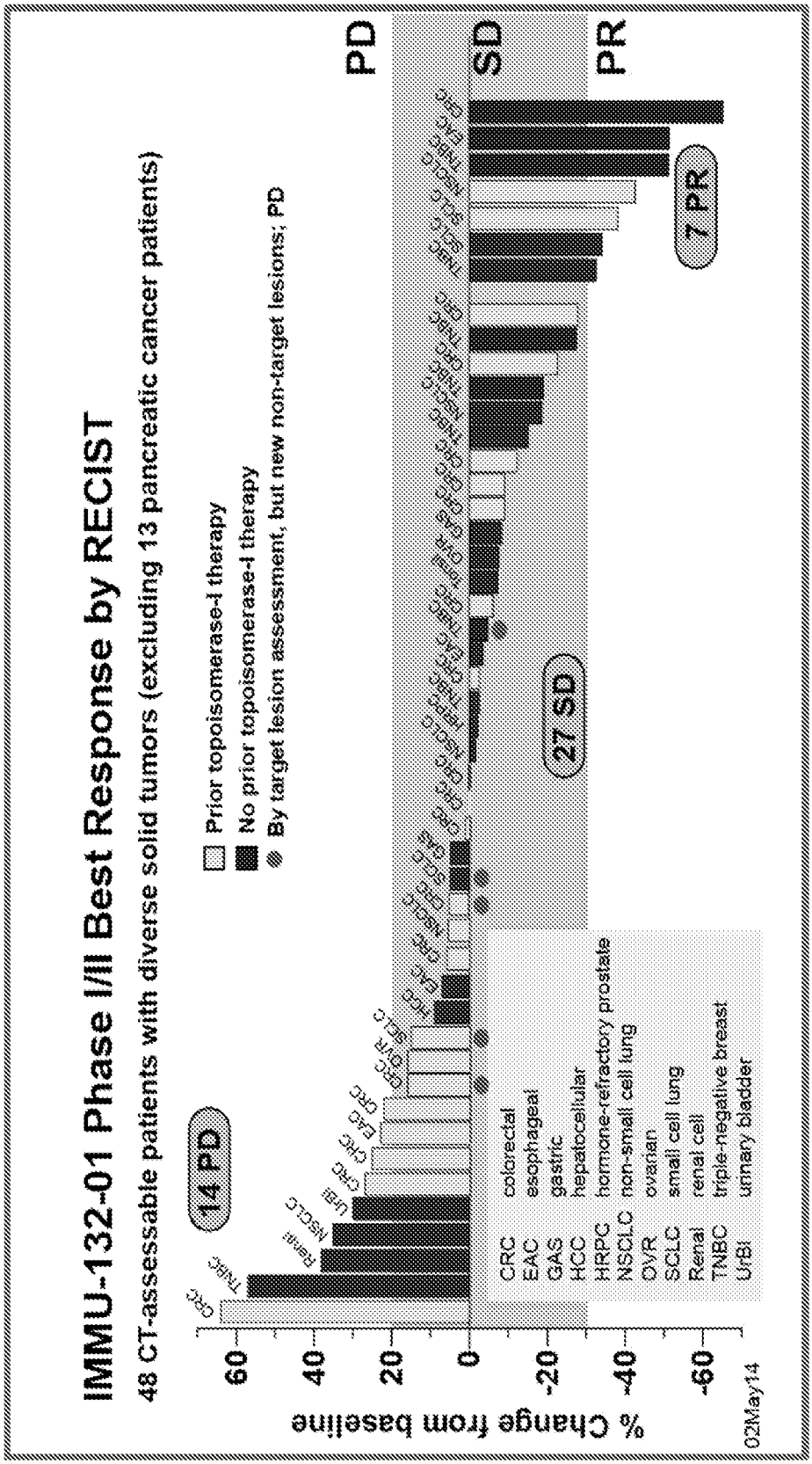

IMMU-132-01 Phase I/II Best Response by RECIST
48 CT-assessable patients with diverse solid tumors (excluding 13 pancreatic cancer patients)
Prior topoisomerase-I therapy
No prior topoisomerase-I therapy
By target lesion assessment, but new non-target lesions; PD
% change from baseline
60
40
20
0
-20
-40
-60
PD
SD
PR
14 PD
27 SD
7 PR
CRC colorectal
EAC esophageal
GAS gastric
HCC hepatocellular
HRPC hormone-refractory prostate
NSCLC non-small cell lung
OVR ovarian
SCLC small cell lung
Renal renal cell
TNBC triple-negative breast
UrBl urinary bladder
02May14

FIG. 20

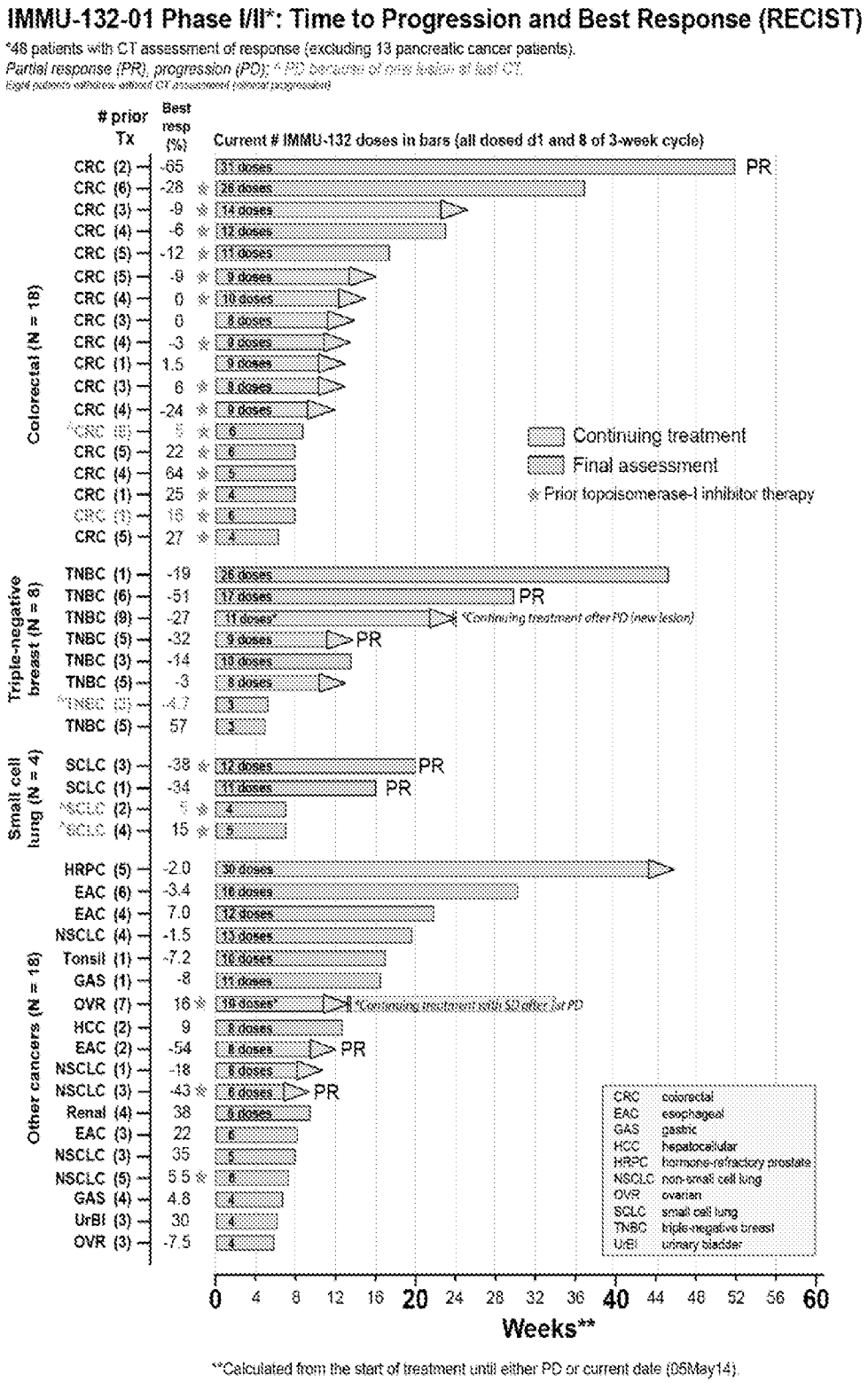

IMMU-132-01 Phase I/II*: Time to Progression and Best Response (RECIST)
*48 patients with CT assessment of response (excluding 13 pancreatic cancer patients).
Partial response (PR), progression (PD); ^ PD because of new lesion at last CT.
Eight patients withdrew without CT assessment (clinical progression)
prior Tx
Best resp (%)
Current # IMMU-132 doses in bars (all dosed d1 and 8 of 3-week cycle)
Colorectal (N = 18)
CRC (2) -65 31 doses PR
CRC (6) -28 ※ 26 doses
CRC (3) -9 ※ 14 doses
CRC (4) -6 ※ 12 doses
CRC (5) -12 ※ 11 doses
CRC (5) -9 ※ 9 doses
CRC (4) 0 ※ 10 doses
CRC (3) 0 8 doses
CRC (4) -3 ※ 9 doses
CRC (1) 1.5 9 doses
CRC (3) 6 ※ 8 doses
CRC (4) -24 ※ 9 doses
^CRC (6) 5 ※ 6
CRC (5) 22 ※ 6
CRC (4) 64 ※ 5
CRC (1) 25 ※ 4
CRC (1) 18 ※ 6
CRC (5) 27 ※ 4
Triple-negative breast (N = 8)
TNBC (1) -19 26 doses
TNBC (6) -51 17 doses PR
TNBC (8) -27 11 doses* *Continuing treatment after PD (new lesion)
TNBC (5) -32 9 doses PR
TNBC (3) -14 10 doses
TNBC (5) -3 8 doses
^TNBC (3) -4.7 3
TNBC (5) 57 3
Small cell lung (N = 4)
SCLC (3) -38 ※ 12 doses PR
SCLC (1) -34 11 doses PR
^SCLC (2) 5 ※ 4
^SCLC (4) 15 ※ 5
Other cancers (N = 18)
HRPC (5) -2.0 30 doses
EAC (6) -3.4 16 doses
EAC (4) 7.0 12 doses
NSCLC (4) -1.5 13 doses
Tonsil (1) -7.2 10 doses
GAS (1) -8 11 doses
OVR (7) 16 ※ 10 doses* *Continuing treatment with SD after 1st PD
HCC (2) 9 8 doses
EAC (2) -54 8 doses PR
NSCLC (1) -18 8 doses
NSCLC (3) -43 ※ 6 doses PR
Renal (4) 38 8 doses
EAC (3) 22 6
NSCLC (3) 35 5
NSCLC (5) 5.5 ※ 6
GAS (4) 4.8 4
UrBl (3) 30 4
OVR (3) -7.5 4
Continuing treatment
Final assessment
※ Prior topoisomerase-I inhibitor therapy
CRC colorectal
EAC esophageal
GAS gastric
HCC hepatocellular
HRPC hormone-refractory prostate
NSCLC non-small cell lung
OVR ovarian
SCLC small cell lung
TNBC triple-negative breast
UrBl urinary bladder
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60
Weeks**
**Calculated from the start of treatment until either PD or current date (05May14).

FIG. 21

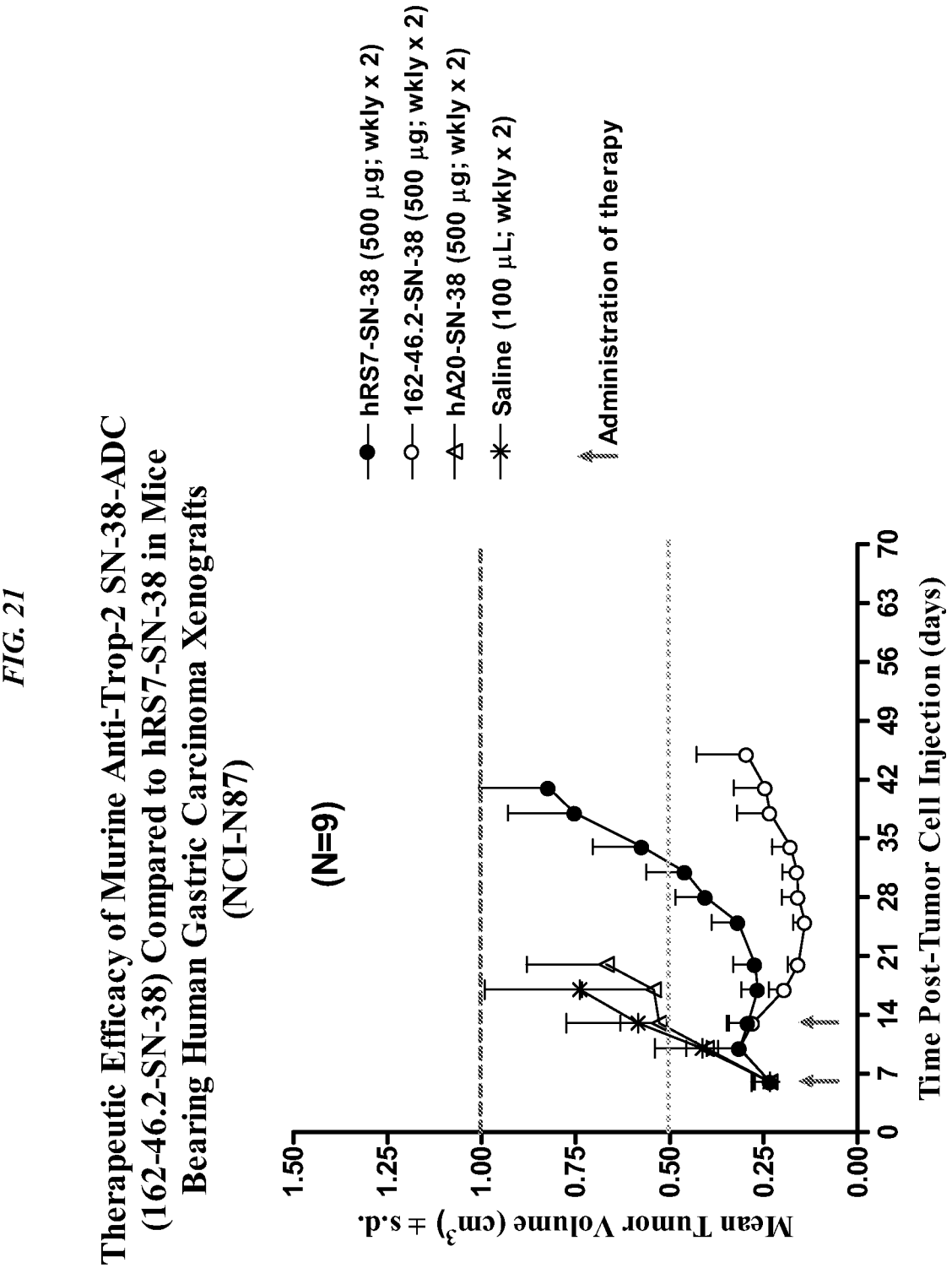

Therapeutic Efficacy of Murine Anti-Trop-2 SN-38-ADC
(162-46.2-SN-38) Compared to hRS7-SN-38 in Mice
Bearing Human Gastric Carcinoma Xenografts
(NCI-N87)
(N=9)
hRS7-SN-38 (500 μg; wkly x 2)
162-46.2-SN-38 (500 μg; wkly x 2)
hA20-SN-38 (500 μg; wkly x 2)
Saline (100 μL; wkly x 2)
Administration of therapy
Mean Tumor Volume (cm³) ± s.d.
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
7
14
21
28
35
42
49
56
63
70
Time Post-Tumor Cell Injection (days)

FIG. 22

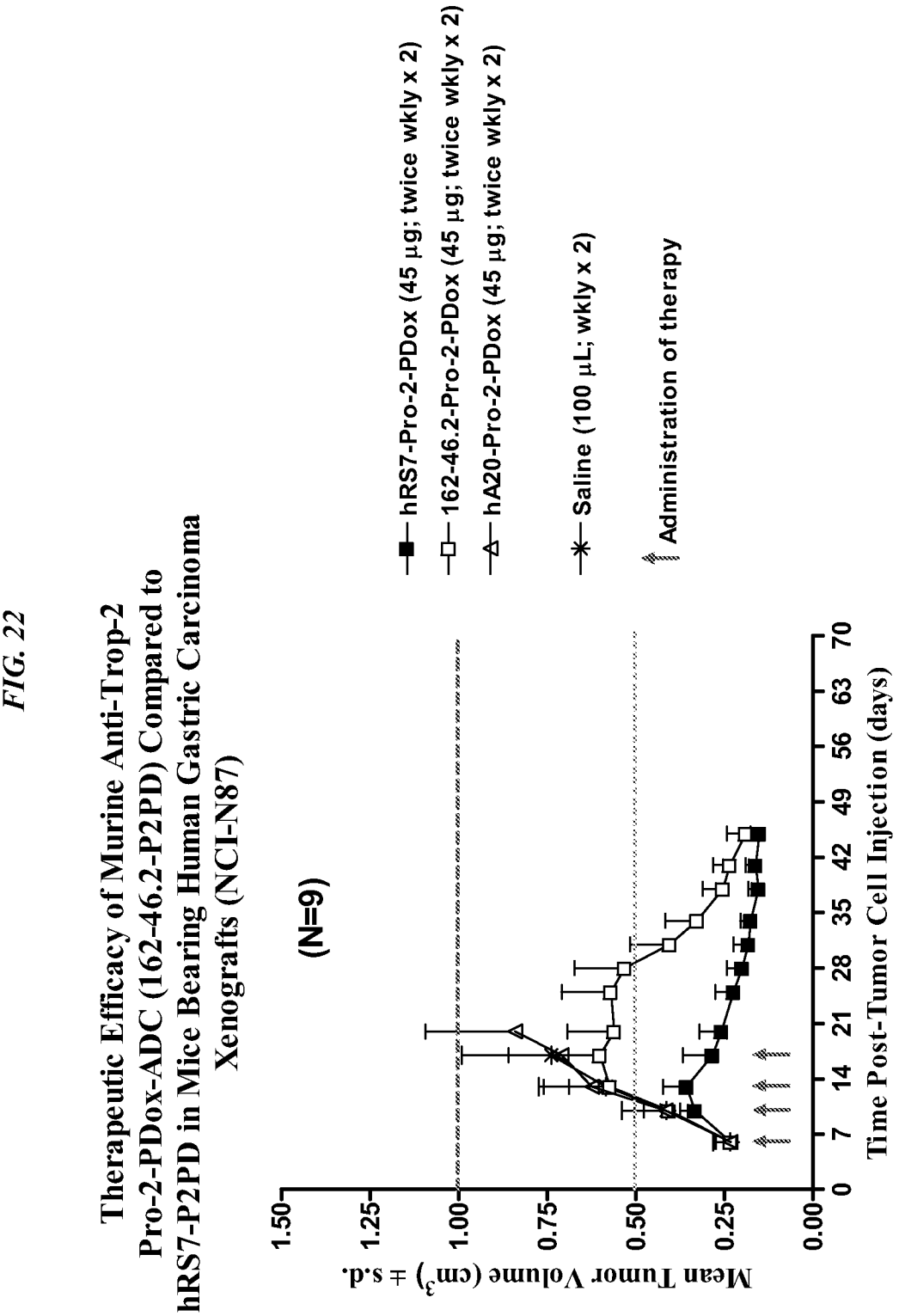

Therapeutic Efficacy of Murine Anti-Trop-2 Pro-2-PDox-ADC (162-46.2-P2PD) Compared to hRS7-P2PD in Mice Bearing Human Gastric Carcinoma Xenografts (NCI-N87)
(N=9)
hRS7-Pro-2-PDox (45 μg; twice wkly x 2)
162-46.2-Pro-2-PDox (45 μg; twice wkly x 2)
hA20-Pro-2-PDox (45 μg; twice wkly x 2)
Saline (100 μL; wkly x 2)
Administration of therapy
Mean Tumor Volume (cm3) ± s.d.
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
7
14
21
28
35
42
49
56
63
70
Time Post-Tumor Cell Injection (days)

FIG. 23

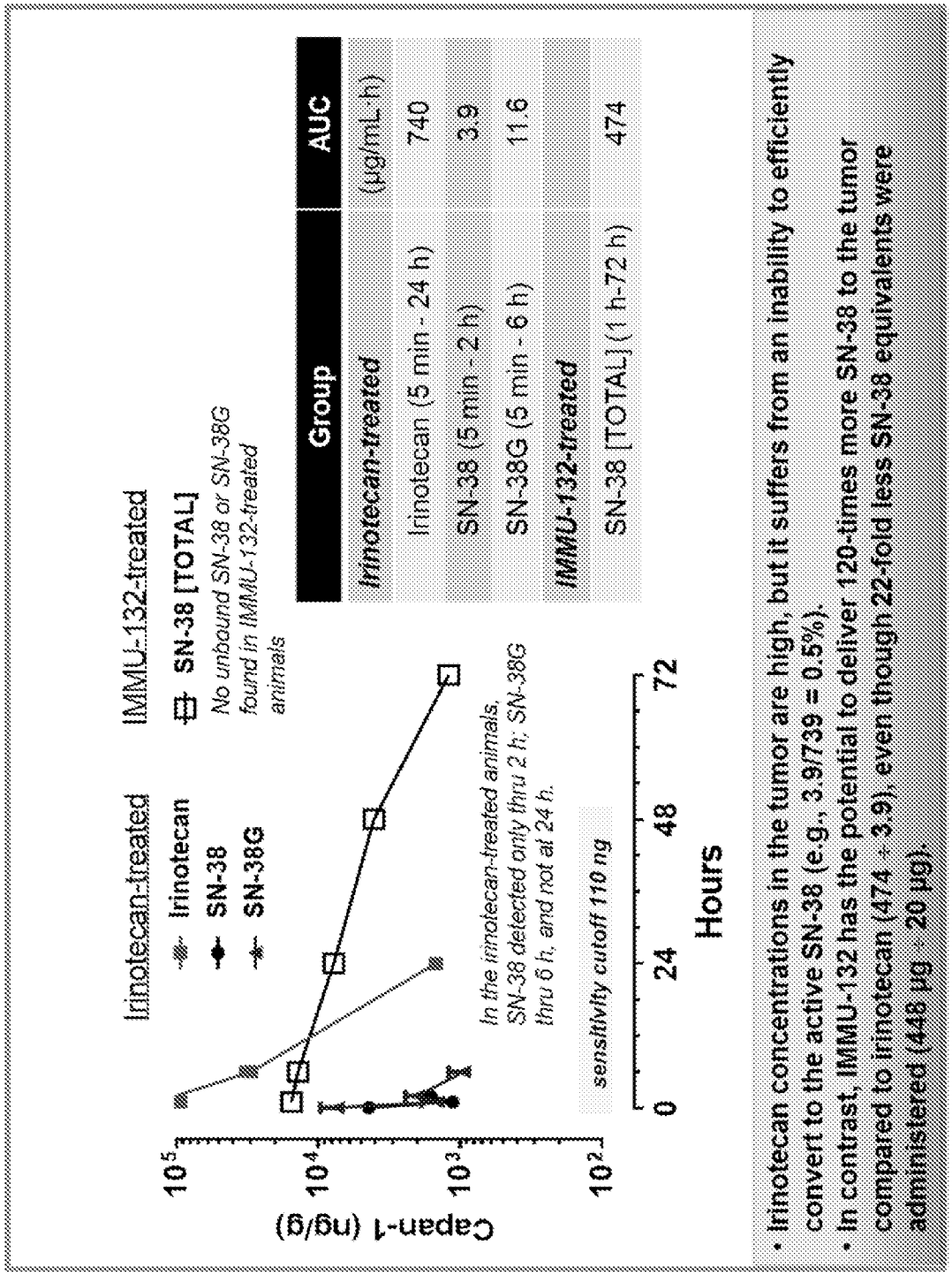

Irinotecan-treated
Irinotecan
SN-38
SN-38G
IMMU-132-treated
SN-38 [TOTAL]
No unbound SN-38 or SN-38G found in IMMU-132-treated animals
Capan-1 (ng/g)
10^5
10^4
10^3
10^2
In the irinotecan-treated animals, SN-38 detected only thru 2 h; SN-38G thru 6 h, and not at 24 h.
sensitivity cutoff 110 ng
0
24
48
72
Hours
Group
AUC
Irinotecan-treated
(μg/mL·h)
Irinotecan (5 min - 24 h)
740
SN-38 (5 min - 2 h)
3.9
SN-38G (5 min - 6 h)
11.6
IMMU-132-treated
SN-38 [TOTAL] (1 h-72 h)
474
• Irinotecan concentrations in the tumor are high, but it suffers from an inability to efficiently convert to the active SN-38 (e.g., 3.9/739 = 0.5%).
• In contrast, IMMU-132 has the potential to deliver 120-times more SN-38 to the tumor compared to irinotecan (474 ÷ 3.9), even though 22-fold less SN-38 equivalents were administered (448 μg ÷ 20 μg).

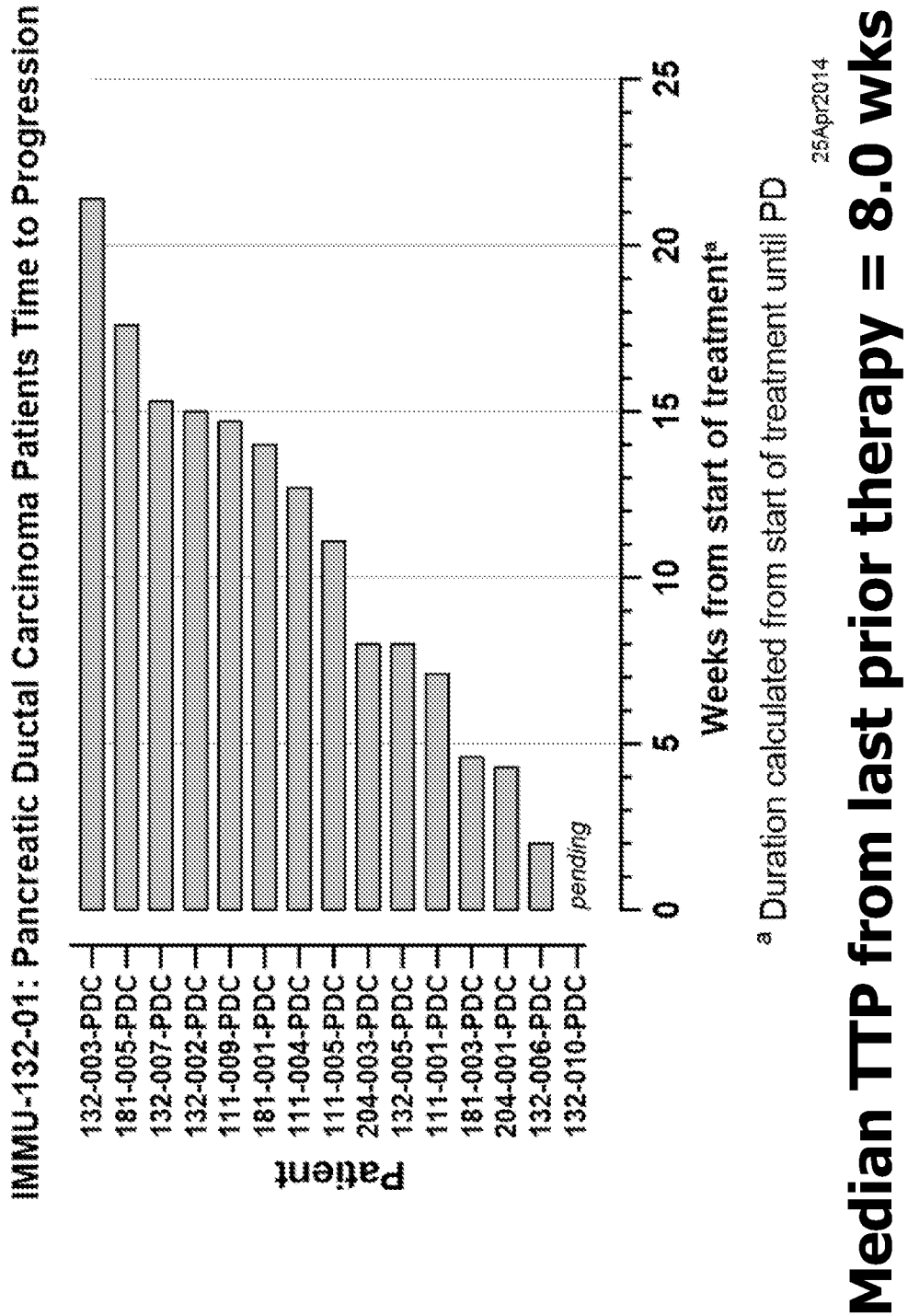
FIG. 24

Individual Patient Demographics and Prior Treatment							
Patient	Age/ Gender	Months from 1st diagnosis until end last prior treatment	Number Prior Tx	Last Prior Therapy	Last Therapy Duration (mo)	Response to last therapy?	Last Prior Therapy TTP[a] (weeks)
111-005	52/M	8.8	1	FOLFIRINOX	8	Yes	32
132-003	36/M	2.4	4	GTX	4	Yes	8
132-010[d]	49/F	12.8	2	GEM + Abraxane	1	No	4
181-001	66/F	20.3	5	GEM/Tarceva	4.7	Yes	4
204-001	52/F	7.5	1	GEM	6	No	36
132-002	60/F	10.3	2	5-fluorouracil	1	No	4
111-009	62/M	5.9	1	FOLFOX	4.5	Yes	16
132-005	88/F	15.7	2*	FOLFIRI	1.75	No	7
132-006	65/F	12.7	2	FOLFIRINOX	4	No	16
132-007	69/F	1.6	5*	GEM + Abraxane	1	No	4
181-013	55/F	2.2	1	GEM + Abraxane	2	No	8
204-003	58/F	23.7	5	GEM + Abraxane	1	Yes	4
111-001	65/F	19.6	2	GEM + Abraxane	3	No	12
111-004	53/F	16.6	4	GEM + Abraxane	1	No	4
181-005	75/F	18.9	2	Xeloda	6	No	36

FIG. 25

Patient	IMMU-132 TTP[b] (weeks)	Initial dose level (mg/kg)	# doses	RECIST Best [c] response in target lesions (% change)	Baseline CA19.9 (units/mL)	CA19.9 Best response (% change)
111-005	11.1	8	6	+16.4%	2	NA*
132-003	21.4	8	11	-13.0%	15,885	-72%
132-010[d]	TBD*	8	5+	TBD*	14.1	NA*
181-001	14.0	8	6	+11.0%	64	-5%
204-001	4.3	8	3	+3.6%	23,356	9%
132-002	15.0	10	14	-15.0%	3672	-23%
111-009	14.7	10	8	-6.5%	29	NA*
132-005	8.0	10	5	+11.0%[#]	78,629	+42%
132-006	2	10	1	CPD[c]	1083	ND*
132-007	15.3	10	6	+11.0%	204	-52%
181-013	4.6	10	3	+18.0%[#]	2775	55%
204-003	8.0	10	7	+59.0%	149	3%
111-001	7.1	12	3	+21.0%	10,610	69%
111-004	12.7	12	9	+11.7%	2069	+187%
181-005	17.6	12	9	-3.0%[#]	11,838	0

FIG. 26


IMMU-132-01: Pancreatic Ductal Carcinoma Patients Time to Progression
Patient
132-003-PDC
181-005-PDC
132-007-PDC
132-002-PDC
111-009-PDC
181-001-PDC
111-004-PDC
111-005-PDC
204-003-PDC
132-005-PDC
111-001-PDC
181-003-PDC
204-001-PDC
132-006-PDC
132-010-PDC
pending
0
5
10
15
20
25
Weeks from start of treatment[a]
[a] Duration calculated from start of treatment until PD
25Apr2014
Median TTP from last prior therapy = 8.0 wks
(range = 4 to 36 wks; N = 13 pts)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/045074

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C07K 16/30 (2014.01)
CPC - C07K 16/30 (2014.09)
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)
IPC(8) - A61K 39/395, 51/10; A61P 35/00; C07K 16/28, 16/30, 16/46, 19/00 (2014.01)
CPC - A61K 39/0011, 39/395, 39/39558; C07K 16/28, 16/30, 16/46, 19/00 (2014.09)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - A61K 39/0011, 39/395, 39/39558; C07K 16/28, 16/30, 16/46, 19/00 (2014.09) (keyword delimited)
USPC - 424/1.49, 85.4, 133.1, 134.1, 179.1; 435/194, 199; 530/387.3

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Orbit, Google Patents, Google Scholar, GenCore 6.4.1.
Search terms used: Trop-2 antibody pancreatic cancer conjugate hrs7 immunotoxin; SEQ ID NOs: 1-6

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/0274704 A1 (CHANG et al) 10 November 2011 (10.11.2011) entire document	1-16, 19, 20, 22-35, 37-56
--		----------
Y		17, 18, 21, 36
Y	CUNNINGHAM et al. "Cetuximab Monotherapy and Cetuximab plus Irinotecan in Irinotecan-Refractory Metastatic Colorectal Cancer" N Engl J Med 2004; 351:337-45 entire document	17, 18, 36
Y	US 2005/0220758 A1 (ZOBEL et al) 06 October 2005 (06.10.2005) entire document	21
A	EDELMAN et al. "The Covalent Structure of an Entire γG Immunoglobulin Molecule," Proc. Natl. Acad. Sci. 1 May 1969 (01.05.1969), Vol. 63, Pgs. 78-85. entire document	1-56
A	US 2011/0070156 A1 (GOVINDAN et al) 24 March 2011 (24.03.2011) entire document	1-56
A	CARDILLO et al. "Humanized Anti-Trop-2 IgG-SN-38 Conjugate for Effective Treatment of Diverse Epithelial Cancers: Preclinical Studies in Human Cancer Xenograft Models and Monkeys" Clin Cancer Res. 3 March 2011 (03.03.2011), Vol. 17, Pgs. 3157-3169. entire document	1-56
A	GOVINDAN et al. "New Antibody Conjugates in Cancer Therapy" The Scientific World Journal, 12 October 2010 (12.10.2010) Vol. 10, Pgs. 2070-2089. entire document	1-56

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 2014	06 NOV 2014

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/045074

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 filed or furnished:

   a. (means)

   ☐ on paper

   ☒ in electronic form

   b. (time)

   ☒ in the international application as filed

   ☐ together with the international application in electronic form

   ☐ subsequently to this Authority for the purposes of search

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 in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

3. Additional comments:

SEQ ID NOs:1-10 were searched.