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(54) Title: METHOD OF TREATING TRIPLE-NEGATIVE BREAST CANCER USING THIENOTRIAZOLODIAZEPINE COMPOUNDS

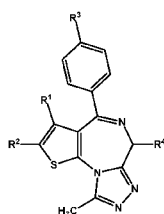
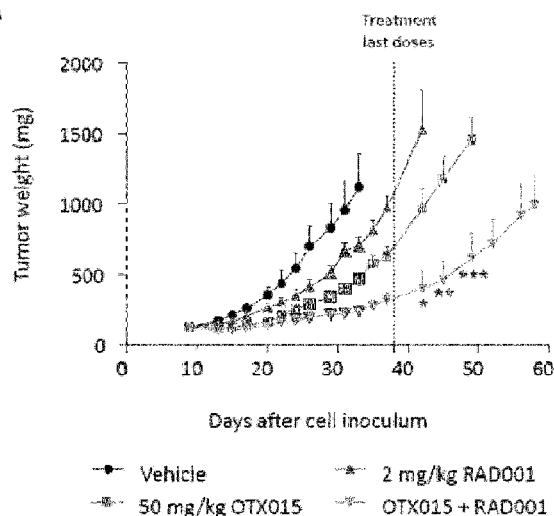


FIG. 18A



(57) Abstract: A method of treating triple-negative breast cancer in a mammal comprising the step of: administering to a patient a pharmaceutical acceptable amount of a compound being a thienotriazolodiazepine compound of the Formula (1) wherein R¹ is alkyl having a carbon number of 1-4, R² is a hydrogen atom; a halogen atom; or alkyl having a carbon number of 1-4 optionally substituted by a halogen atom or a hydroxyl group, R³ is a halogen atom; phenyl optionally substituted by a halogen atom, alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4 or cyano; —NR⁵—(CH₂)_m—R⁶ wherein R⁵ is a hydrogen atom or alkyl having a carbon number of 1-4, m is an integer of 0-4, and R⁶ is phenyl or pyridyl optionally substituted by a halogen atom; or —NR⁷—CO—(CH₂)_n—R⁸ wherein R⁷ is a hydrogen atom or alkyl having a carbon number of 1-4, n is an integer of 0-2, and R⁸ is phenyl or pyridyl optionally substituted by a halogen atom, and R⁴ is —(CH₂)_a—CO—NH—R⁹ wherein a is an integer of 1-4, and R⁹ is alkyl having a carbon number of 1-4; hydroxyalkyl having a carbon number of 1-4; alkoxy having a carbon number of 1-4; or phenyl or pyridyl optionally substituted by alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4, amino or a hydroxyl group or —(CH₂)_b—COOR¹⁰ wherein b is an integer of 1-4, and R¹⁰ is alkyl having a carbon number of 1-4, or a pharmaceutically acceptable salt thereof or a hydrate or solvate thereof, in combination with one or more chemotherapy drugs selected from the group consisting of m-TOR inhibitors and mitotic inhibitors.



GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, 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).

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TITLE OF THE INVENTION

METHOD OF TREATING TRIPLE-NEGATIVE BREAST CANCER USING
THIENOTRIAZOLODIAZEPINE COMPOUNDS

FIELD OF INVENTION

5 [0001] The present disclosure describes methods of treating triple-negative breast cancer using thienotriazolodiazepine compounds which have improved solubility and bioavailability and may be provided in the form of solid dispersions.

BACKGROUND OF THE INVENTION

[0002] The compound of Formula (1), described herein below, has been shown to inhibit the
10 binding of acetylated histone H4 to the tandem bromodomain (BRD)-containing family of transcriptional regulators known as the BET (bromodomains and extraterminal) proteins, which include BRD2, BRD3, and BRD4. *See* U.S. Patent Application Publication No. 2010/0286127 A1, which is incorporated herein by reference in its entirety. The BET proteins have emerged as major epigenetic regulators of proliferation and differentiation and also have been associated with
15 predisposition to dyslipidemia or improper regulation of adipogenesis, elevated inflammatory profile and risk for cardiovascular disease and type 2 diabetes, and increased susceptibility to autoimmune diseases such as rheumatoid arthritis and systemic lupus erythematosus as reported by Denis, G.V. "Bromodomain coactivators in cancer, obesity, type 2 diabetes, and inflammation," *Discov Med* 2010; 10:489-499, which is incorporated herein by reference in its entirety. Accordingly, the
20 compound of formula (1) may be useful for treatment of various cancers, cardiovascular disease, type 2 diabetes, and autoimmune disorders such as rheumatoid arthritis and systemic lupus erythematosus.

[0003] Triple-negative breast cancer (TNBC) is an aggressive and heterogeneous subtype group of breast cancers clinically defined by the lack of estrogen and progesterone receptors, as well as the
25 human epidermal growth factor receptor 2 (HER2). Few therapeutic options have shown clinical benefit beyond cytotoxic chemotherapy. Clinical studies have demonstrated that more than 50% of human breast cancers present a much lower median O₂ partial pressure than normal breast tissue, correlating with chemo- and radio-resistance. Here, the antitumor activity of Compound (1-1) (also referred to herein as OTX015) in normoxic and hypoxic environments, as well as in combination
30 with antitumor agents, was investigated.

BRIEF SUMMARY OF THE INVENTION

[0004] In some embodiments, the present disclosure provides for methods of treating triple-negative breast cancer using the compositions described herein.

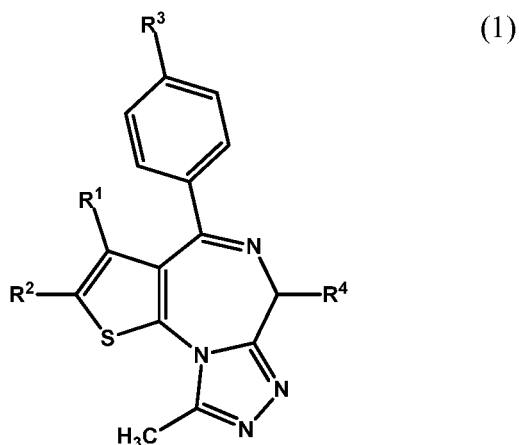
[0005] In some embodiments, the present disclosure provides for methods of treating triple-

5 negative breast cancer in a mammal comprising: administering to a patient in need a pharmaceutical acceptable amount of a composition comprising a solid dispersion according to any of the compositions described in Sections III, IV, V and VI described herein.

[0006] In some embodiments, the present disclosure provides for a compound of Formula (1), in particular of Formula (1A) for use in treating triple-negative breast cancer.

10 [0007] In some embodiments, the present disclosure provides for a solid dispersion according to any of the compositions described in Sections III, IV, V and VI described herein for use in treating triple-negative breast cancer.

[0008] In some embodiments, the present disclosure provides for methods of treating triple-negative breast cancer using thienotriazolodiazepine compound of the Formula (1)



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wherein

R¹ is alkyl having a carbon number of 1-4,

R² is a hydrogen atom; a halogen atom; or alkyl having a carbon number of 1-4 optionally substituted by a halogen atom or a hydroxyl group,

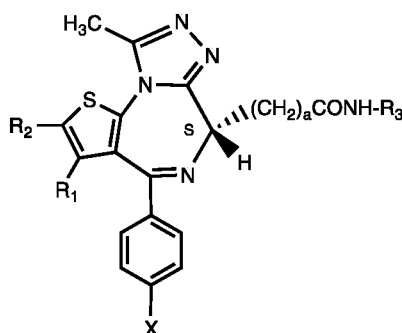
20 R³ is a halogen atom; phenyl optionally substituted by a halogen atom, alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4 or cyano; —NR⁵—(CH₂)_m—R⁶ wherein R⁵ is a hydrogen atom or alkyl having a carbon number of 1-4, m is an integer of 0-4, and R⁶ is phenyl or pyridyl optionally substituted by a halogen atom; or —NR⁷—CO—(CH₂)_n—R⁸ wherein R⁷ is a hydrogen atom or alkyl having a carbon number of 1-4, n is an integer of 0-2, and R⁸ is phenyl or

pyridyl optionally substituted by a halogen atom, and

R^4 is $-(CH_2)_a-CO-NH-R^9$ wherein a is an integer of 1-4, and R^9 is alkyl having a carbon number of 1-4; hydroxyalkyl having a carbon number of 1-4; alkoxy having a carbon number of 1-4; or phenyl or pyridyl optionally substituted by alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4, amino or a hydroxyl group or $-(CH_2)_b-COOR^{10}$ wherein b is an integer of 1-4, and R^{10} is alkyl having a carbon number of 1-4,

or a pharmaceutically acceptable salt thereof or a hydrate or solvate thereof, in combination with one or more chemotherapy drugs selected from the group consisting of m-TOR inhibitors and mitotic inhibitors.

[0009] In some embodiments, Formula (1) is selected from Formula (1A):



wherein X is a halogen, R^1 is C_1 - C_4 alkyl, R^2 is C_1 - C_4 alkyl, a is an integer of 1-4, R^3 is C_1 - C_4 alkyl, C_1 - C_4 hydroxyalkyl, C_1 - C_4 alkoxy, phenyl optionally having substituent(s) as defined for R^9 in Formula (1), or heteroaryl optionally having substituent(s) as defined for R^9 in Formula (1), a pharmaceutically acceptable salt thereof or a hydrate thereof.

[0010] In one such embodiment, the thienotriazolodiazepine compound is formulated as a solid dispersion comprising an amorphous thienotriazolodiazepine compound and a pharmaceutically acceptable polymer.

[0011] In one embodiment, Formula (1) is selected from the group consisting of: (i) (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide or a dihydrate thereof; (ii) methyl (S)-{4-(3'-cyanobiphenyl-4-yl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate, (iii) methyl (S)-{2,3,9-trimethyl-4-(4-phenylaminophenyl)-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate; and (iv) methyl (S)-{2,3,9-trimethyl-4-[4-(3-phenylpropionylamino)phenyl]-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate.

[0012] In one embodiment, the thienotriazolodiazepine compound represented by Formula (1) is (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide dihydrate.

[0013] In one embodiment, the thienotriazolodiazepine compound represented by Formula (1) is (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide.

[0014] In one embodiment, the thienotriazolodiazepine compound of the Formula (1) and the chemotherapy drug are administered concomitant.

[0015] In one embodiment, the thienotriazolodiazepine compound of the Formula (1) and the chemotherapy drug are administered sequentially.

[0016] In one embodiment, the m-TOR inhibitor is everolimus and the mitotic inhibitor is docetaxel.

[0017] In one embodiment, the thienotriazolodiazepine compound of the Formula (1) is formed as a solid dispersion. In one embodiment, the solid dispersion comprises an amorphous

thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt thereof or a hydrate thereof; and a pharmaceutically acceptable polymer. In one embodiment, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). In one embodiment, the pharmaceutically acceptable polymer is hydroxypropylmethylcellulose acetate succinate having a thienotriazolodiazepine compound to hydroxypropylmethylcellulose acetate succinate (HPMCAS) weight ratio of 1:3 to 1:1. In one embodiment, the solid dispersion exhibits a single glass transition temperature (T_g) inflection point ranging from about 130°C to about 140°C.

[0018] In one embodiment, a solid dispersion comprises an amorphous thienotriazolodiazepine compound of (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-

a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide dihydrate or a pharmaceutically acceptable salt thereof or a hydrate thereof; and a pharmaceutically acceptable polymer. In one embodiment, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-

hydroxyphenyl)acetamide dihydrate. In one embodiment, the pharmaceutically acceptable polymer is hydroxypropylmethylcellulose acetate succinate having a thienotriazolodiazepine compound to hydroxypropylmethylcellulose acetate succinate (HPMCAS) weight ratio of 1:3 to 1:1. In one

embodiment, the solid dispersion exhibits a single glass transition temperature (T_g) inflection point ranging from about 130°C to about 140°C.

[0019] It should be understood that any embodiment of the compounds according to Formula (1) described herein may be used in any embodiment of a pharmaceutical composition described herein, unless indicated otherwise. Moreover, any compound or pharmaceutical composition described herein as embodiment of the invention may be used as a medicament, in particular for treating triple-negative breast cancer as described in embodiments herein, unless indicated otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The foregoing summary, as well as the following detailed description of embodiments of the pharmaceutical compositions including thienotriazolodiazepine formulations and methods of the present invention, will be better understood when read in conjunction with the appended drawings of exemplary embodiments. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown.

[0021] In the drawings:

[0022] Figure 1A illustrates dissolution profile of a comparator formulation comprising a solid dispersion comprising 25% compound (1-1) and Eudragit L100-55;

[0023] Figure 1B illustrates dissolution profile of a comparator formulation comprising a solid dispersion comprising 50% compound (1-1) and Eudragit L100-55;

[0024] Figure 1C illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 25% compound (1-1) and polyvinylpyrrolidone (PVP);

[0025] Figure 1D illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 50% compound (1-1) and PVP;

[0026] Figure 1E illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 25% compound (1-1) and PVP-vinyl acetate (PVP-VA);

[0027] Figure 1F illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 50% compound (1-1) and PVP-VA;

[0028] Figure 1G illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 25% compound (1-1) and hypromellose acetate succinate (HPMCAS-M);

[0029] Figure 1H illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 50% compound (1-1) and HPMCAS-M;

[0030] Figure 1I illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 25% compound (1-1) and hypromellose phthalate (HPMCP-HP55);

[0031] Figure 1J illustrates dissolution profile of an exemplary formulation comprising a solid dispersion comprising 50% compound (1-1) and HPMCP-HP55;

5 [0032] Figure 2A illustrates results of *in vivo* screening of an exemplary formulation comprising a solid dispersion of 25% compound (1-1) and PVP;

[0033] Figure 2B illustrates results of an *in vivo* screening of an exemplary formulation comprising a solid dispersion of 25% compound (1-1) and HMPCAS-M;

[0034] Figure 2C illustrates results of an *in vivo* screening of an exemplary formulation
10 comprising a solid dispersion of 50% compound (1-1) and HMPCAS-M;

[0035] Figure 3 illustrates powder X-ray diffraction profiles of solid dispersions of compound (1-1);

[0036] Figure 4A illustrates modified differential scanning calorimetry trace for a solid dispersion of 25% compound (1-1) and PVP equilibrated under ambient conditions;

15 [0037] Figure 4B illustrates modified differential scanning calorimetry trace for a solid dispersion of 25% compound (1-1) and HMPCAS-M equilibrated under ambient conditions;

[0038] Figure 4C illustrates modified differential scanning calorimetry trace for a solid dispersion of 50% compound (1-1) and HMPCAS-M equilibrated under ambient conditions;

[0039] Figure 5 illustrates plot of glass transition temperature (T_g) versus relative humidity (RH)
20 for solid dispersions of 25% compound (1-1) and PVP or HMPCAS-M and 50% compound (1-1) and HMPCAS-MG;

[0040] Figure 6 illustrates modified differential scanning calorimetry trace for a solid dispersion of 25% compound (1-1) and PVP equilibrated under 75% relative humidity;

[0041] Figure 7B illustrates plasma concentration versus time curves for Compound (1-1) after 1
25 mg/kg intravenous dosing (solid rectangles) and 3 mg/kg oral dosing as 25% Compound (1-1):PVP (open circles), 25% Compound (1-1):HPMCAS-MG (open triangles), and 50% Compound (1-1):HPMCAS-MG (open inverted triangles). Figure 7A depicts the same data plotted on a semilogarithmic scale;

[0042] Figure 8B illustrates plasma concentration versus time curves for Compound (1-1) after 3
30 mg/kg oral dosing as 25% Compound (1-1): PVP (open circles), 25% Compound (1-1):HPMCAS-MG (open triangles), and 50% Compound (1-1):HPMCAS-MG (open inverted triangles). Figure 8A depicts the same data plotted on a semi-logarithmic scale;

- [0043] Figure 9 illustrates a powder X-ray diffraction profile of solid dispersions of compound (1-1) in HPMCAS-MG at time zero of a stability test;
- [0044] Figure 10 illustrates a powder X-ray diffraction profile of solid dispersions of compound (1-1) in HPMCAS-MG after 1 month at 40 °C and 75 % relative humidity;
- 5 [0045] Figure 11 illustrates a powder X-ray diffraction profile of solid dispersions of compound (1-1) in HPMCAS-MG after 2 months at 40 °C and 75 % relative humidity; and
- [0046] Figure 12 illustrates a powder X-ray diffraction profile of solid dispersions of compound (1-1) in HPMCAS-MG after 3 months at 40 °C and 75 % relative humidity.
- [0047] Figure 13 illustrates the GI50 and E_{max} values for HCC1937, MDA-MB- 231 and MDA-
- 10 MB-468 cell lines treated with compound (1-1);
- [0048] Figure 14A illustrates the % cell cycle phase, G1, S, G2/M over time for drug free medium and compound (1-1) for HCC1937 cell line;
- [0049] Figure 14B illustrates the % cell cycle phase, G1, S, G2/M over time for drug free medium and compound (1-1) for MDA-MB-231 cell line;
- 15 [0050] Figure 14C illustrates the % cell cycle phase, G1, S, G2/M over time for drug free medium and compound (1-1) for MDA-MB-468 cell line;
- [0051] Figure 15A illustrates the basal Western blot profile for C-MYC, BRD2, BRD3, BRD4 and β-tubulin for HCC1937, MDA-MB- 231 and MDA-MB-468 cell lines;
- [0052] Figure 15B illustrated the fluorescence intensive for basal level of C-MYC for HCC1937,
- 20 MDA-MB- 231 and MDA-MB-468 cell lines;
- [0053] Figure 15C illustrates the fluorescence intensive for basal level of BRD2 for HCC1937, MDA-MB- 231 and MDA-MB-468 cell lines;
- [0054] Figure 15D illustrates the fluorescence intensive for basal level of BRD3 for HCC1937, MDA-MB- 231 and MDA-MB-468 cell lines;
- 25 [0055] Figure 15E illustrates the fluorescence intensive for basal level of BRD4 for HCC1937, MDA-MB- 231 and MDA-MB-468 cell lines;
- [0056] Figure 16A illustrates the Western blot profiles C-MYC, BRD2, BRD3, BRD4 and β-tubulin for HCC1937 line treated with 650 nM compound (1-1);
- [0057] Figure 16B illustrates the illustrates the Western blot profile for C-MYC, BRD2, BRD3,
- 30 BRD4 and β-tubulin for MDA-MB- 231 cell line treated with 75 nM of compound (1-1);
- [0058] Figure 16C illustrates the illustrates the Western blot profile for C-MYC, BRD2, BRD3, BRD4 and β-tubulin for MDA-MB-468 cell line treated with 650 nM compound (1-1);

[0059] Figure 16D illustrates the fluorescence intensive for C-MYC when HCC1937, MDA-MB-231 and MDA-MB-468 cell lines treated with 650 nM, 75 nM, 650 nM, compound (1-1), respectively for 24, 48 and 72 hours;

[0060] Figure 16E illustrates the fluorescence intensive for BRD2 when HCC1937, MDA-MB-231 and MDA-MB-468 cell lines treated with 650 nM, 75 nM, 650 nM, compound (1-1), respectively for 24, 48 and 72 hours;

[0061] Figure 16F illustrates the fluorescence intensive for BRD3 when HCC1937, MDA-MB-231 and MDA-MB-468 cell lines treated with 650 nM, 75 nM, 650 nM, compound (1-1), respectively for 24, 48 and 72 hours;

[0062] Figure 16G illustrates the fluorescence intensive for BRD4 when HCC1937, MDA-MB-231 and MDA-MB-468 cell lines treated with 650 nM, 75 nM, 650 nM, compound (1-1), respectively for 24, 48 and 72 hours;

[0063] Figures 17A and B illustrate the combination of index values for HCC1937, MDA-MB-231 and MDA-MB-468 cell lines for compound (1-1) in combination with verolimus.

[0064] Figure 18A illustrates the tumor weight versus days after cell inoculum for control, compound (1-1), verolimus and compound (1-1) in combination with verolimus; and

[0065] Figure 18B illustrates the body weight versus days after cell inoculum for control, compound (1-1), verolimus and compound (1-1) in combination with verolimus.

[0066] Figure 19 illustrates the effect of Compound (1-1) on cell cycle over time in triple negative breast cancer cell lines;

[0067] Figures 20A and 20B illustrate the effect of Compound (1-1) on BRD2/3/4 and c-Myc expression; and

[0068] Figure 21 illustrates the effect of Compound (1-1) in combination with everolimus (A) or docetaxel (B) after 48 and 72 h in TNBC cells lines under normoxic and hypoxic conditions.

DETAILED DESCRIPTION OF THE INVENTION

[0069] The present subject matter will now be described more fully hereinafter with reference to the accompanying Figures and Examples, in which representative embodiments are shown. The present subject matter can, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided to describe and enable one of skill in the art. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which

the subject matter pertains. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entireties.

I. Definitions:

[0070] The term “alkyl group” as used herein refers to a saturated straight or branched hydrocarbon.

[0071] The term “substituted alkyl group” refers to an alkyl moiety having one or more substituents replacing a hydrogen or one or more carbons of the hydrocarbon backbone.

[0072] The term “alkenyl group” whether used alone or as part of a substituent group, for example, “C₁₋₄alkenyl(aryl),” refers to a partially unsaturated branched or straight chain monovalent hydrocarbon radical having at least one carbon—carbon double bond, whereby the double bond is derived by the removal of one hydrogen atom from each of two adjacent carbon atoms of a parent alkyl molecule and the radical is derived by the removal of one hydrogen atom from a single carbon atom. Atoms may be oriented about the double bond in either the cis (Z) or trans (E) conformation. Typical alkenyl radicals include, but are not limited to, ethenyl, propenyl, allyl(2-propenyl), butenyl and the like. Examples include C₂₋₈alkenyl or C₂₋₄alkenyl groups.

[0073] The term “C_(j-k)” (where *j* and *k* are integers referring to a designated number of carbon atoms) refers to an alkyl, alkenyl, alkynyl, alkoxy or cycloalkyl radical or to the alkyl portion of a radical in which alkyl appears as the prefix root containing from *j* to *k* carbon atoms inclusive. For example, C₍₁₋₄₎ denotes a radical containing 1, 2, 3 or 4 carbon atoms.

[0074] The terms “halo” or “halogen” as used herein refer to F, Cl, Br, or I.

[0075] The term “pharmaceutically acceptable salts” is art-recognized and refers to the relatively non-toxic, inorganic and organic acid addition salts, or inorganic or organic base addition salts of compounds, including, for example, those contained in compositions of the present invention.

[0076] The term “solid dispersion” as used herein refers to a group of solid products consisting of at least two different components, generally a hydrophilic carrier and a hydrophobic drug (active ingredient).

[0077] The term “chiral” is art-recognized and refers to molecules That have the property of non-superimposability of the mirror image partner, while the term “achiral” refers to molecules which are superimposable on their mirror image partner. A “prochiral molecule” is a molecule that has the potential to be converted to a chiral molecule in a particular process.

[0078] The symbol “=====” is used to denote a bond that may be a single, a double or a triple bond.

[0079] The term “enantiomer” as it used herein, and structural formulas depicting an enantiomer are meant to include the “pure” enantiomer free from its optical isomer as well as mixtures of the enantiomer and its optical isomer in which the enantiomer is present in an enantiomeric excess, e.g., at least 10%, 25%, 50%, 75%, 90%, 95%, 98%, or 99% enantiomeric excess.

[0080] The term “stereoisomers” when used herein consist of all geometric isomers, enantiomers or diastereomers. The present invention encompasses various stereoisomers of these compounds and mixtures thereof. Conformational isomers and rotamers of disclosed compounds are also contemplated.

[0081] The term “stereoselective synthesis” as it is used herein denotes a chemical or enzymatic reaction in which a single reactant forms an unequal mixture of stereoisomers during the creation of a new stereocenter or during the transformation of a pre-existing one, and are well known in the art. Stereoselective syntheses encompass both enantioselective and diastereoselective transformations.

For examples, see Carreira, E. M. and Kvaerno, L., *Classics in Stereoselective Synthesis*, Wiley-VCH: Weinheim, 2009.

[0082] The term “spray drying” refers to processes which involve the atomization of the feed suspension or solution into small droplets and rapidly removing solvent from the mixture in a processor chamber where there is a strong driving force for the evaporation (e.g., hot dry gas or partial vacuum or combinations thereof).

[0083] The term “therapeutically effective amount” as used herein refers to any amount of a thienotriazolodiazepine of the present invention or any other pharmaceutically active agent which, as compared to a corresponding a patient who has not received such an amount of the thienotriazolodiazepine or the other pharmaceutically active agent, results in improved treatment, healing, prevention, or amelioration of a disease, disorder, or side effect, or a decrease in the rate of advancement of a disease or disorder.

[0084] The term “about” means +/- 10%. In one embodiment, it means +/- 5%.

[0085] Throughout this application and in the claims that follow, unless the context requires otherwise, the word “comprise”, or variations such as “comprises” or “comprising”, should be understood to imply the inclusion of a stated integer step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps. Moreover, the word “comprise” should be understood to imply “consist of”.

[0086] It has now been found that thienotriazolodiazepine compound of Formula (1), described herein below, can be formulated as a solid dispersion with a pharmaceutically acceptable polymers, to provide an oral formulation that provides high absorption of the pharmaceutical ingredient into the circulation from the gastrointestinal tract. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate (also called hydroxypropylmethylcellulose acetate succinate or HPMCAS). In one embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone (PVP).

[0087] In some embodiments, the hydroxypropylmethyl cellulose acetate succinates (HPMCAS), may include M grade having 9% acetyl/11% succinoyl (e.g., HPMCAS having a mean particle size of 5 μm (i.e., HPMCAS-MF, fine powder grade) or having a mean particle size of 1 mm (i.e., HPMCAS-MG, granular grade)), H grade having 12% acetyl/6% succinoyl (e.g., HPMCAS having a mean particle size of 5 μm (i.e., HPMCAS-HF, fine powder grade) or having a mean particle size of 1 mm (i.e., HPMCAS-HG, granular grade)), and L grade having 8% acetyl/15% succinoyl (e.g., HPMCAS having a mean particle size of 5 μm (i.e., HPMCAS-LF, fine powder grade) or having a mean particle size of 1 mm (i.e., HPMCAS-LG, granular grade)).

[0088] In some embodiments, the polyvinyl pyrrolidones may have molecular weights of about 2,500 (KOLLIDON® 12 PF, weight-average molecular weight between 2,000 to 3,000), about 9,000 (KOLLIDON® 17 PF, weight-average molecular weight between 7,000 to 11,000), about 25,000 (KOLLIDON® 25, weight-average molecular weight between 28,000 to 34,000), about 50,000 (KOLLIDON® 30, weight-average molecular weight between 44,000 to 54,000), or about 1,250,000 (KOLLIDON® 90 or KOLLIDON® 90F, weight-average molecular weight between 1,000,000 to 1,500,000).

II. Methods of Treatment

[0089] In some embodiments, the present disclosure provides for methods of treating triple-negative breast cancer using the compositions described herein.

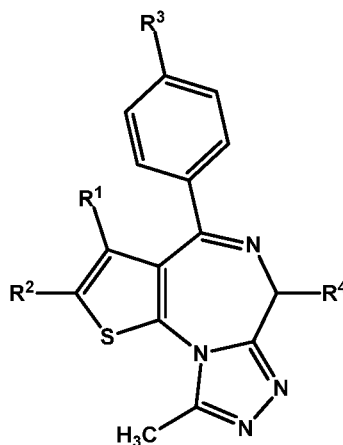
[0090] In some embodiments, the present disclosure provides for methods of treating triple-negative breast cancer in a mammal comprising: administering to a patient in need a pharmaceutically acceptable amount of a composition comprising a solid dispersion according to any of the compositions described in Sections III, IV, V and VI described herein.

[0091] In some embodiments, the present disclosure provides for methods of treating triple-negative breast cancer in a mammal comprising: administering to a patient in need a pharmaceutically acceptable amount of a composition comprising a pharmaceutical formulation according to any of the compositions described in Sections III, IV, V and VI described herein.

[0092] In some embodiments, the present disclosure provides for a compound of Formula (1), in particular of Formula (1A) for use in treating triple-negative breast cancer.

[0093] In some embodiments, the present disclosure provides for a solid dispersion according to any of the compositions described in Sections III, IV, V and VI described herein for use in treating triple-negative breast cancer.

[0094] In some embodiments, methods of treating triple-negative breast cancer use thienotriazolodiazepine compound of the Formula (1)



wherein

R¹ is alkyl having a carbon number of 1-4,

R² is a hydrogen atom; a halogen atom; or alkyl having a carbon number of 1-4 optionally substituted by a halogen atom or a hydroxyl group,

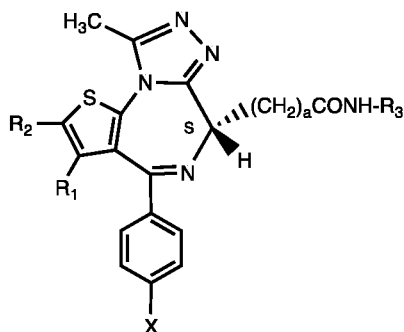
R³ is a halogen atom; phenyl optionally substituted by a halogen atom, alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4 or cyano; —NR⁵—(CH₂)_m—R⁶ wherein R⁵ is a hydrogen atom or alkyl having a carbon number of 1-4, m is an integer of 0-4, and R⁶ is phenyl or pyridyl optionally substituted by a halogen atom; or —NR⁷—CO—(CH₂)_n—R⁸ wherein R⁷ is a hydrogen atom or alkyl having a carbon number of 1-4, n is an integer of 0-2, and R⁸ is phenyl or pyridyl optionally substituted by a halogen atom, and

R⁴ is —(CH₂)_a—CO—NH—R⁹ wherein a is an integer of 1-4, and R⁹ is alkyl having a carbon number of 1-4; hydroxyalkyl having a carbon number of 1-4; alkoxy having a carbon number of 1-4; or phenyl or pyridyl optionally substituted by alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4, amino or a hydroxyl group or —(CH₂)_b—COOR¹⁰ wherein b is an integer of 1-4, and R¹⁰ is alkyl having a carbon number of 1-4,

including any salts, isomers, enantiomers, racemates, hydrates, solvates, metabolites, and

polymorphs thereof.

[0095] In some embodiments, Formula (1) is selected from Formula (1A):



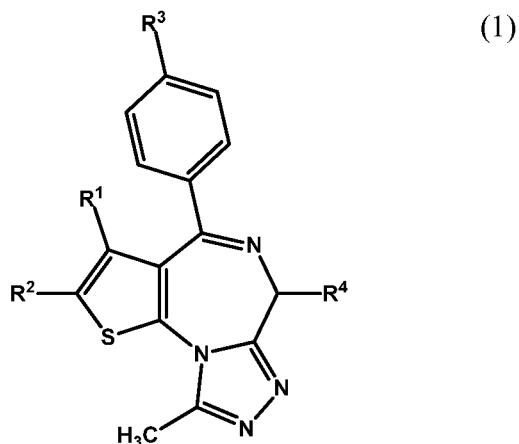
wherein X is a halogen, R¹ is C₁-C₄ alkyl, R² is C₁-C₄ alkyl, a is an integer of 1-4, R³ is C₁-C₄ alkyl, C₁-C₄ hydroxyalkyl, C₁-C₄ alkoxy, phenyl optionally having substituent(s) as defined for R⁹ in
 5 Formula (1), or heteroaryl optionally having substituent(s) as defined for R⁹ in Formula (1), a pharmaceutically acceptable salt thereof or a hydrate thereof.

[0096] In one such embodiment, the thienotriazolodiazepine compound is formulated as a solid dispersion comprising an amorphous thienotriazolodiazepine compound and a pharmaceutically acceptable polymer.

10 [0097] In the present invention, “treatment” or “treat” refers to an act or the action of administration of the active ingredient of the present invention to a person diagnosed by a doctor to have triple-negative breast cancer or be at risk of developing triple-negative breast cancer (patient), which aims, for example, to alleviate the triple-negative breast cancer or symptom, prevent the onset of the
 15 triple-negative breast cancer or symptom, or restore the state before onset of the triple-negative breast cancer.

III. Thienotriazolodiazepine Compounds:

[0098] In one embodiment, the thienotriazolodiazepine compounds, used in the formulations of the present invention, are represented by Formula (1):



wherein

R^1 is alkyl having a carbon number of 1-4,

R^2 is a hydrogen atom; a halogen atom; or alkyl having a carbon number of 1-4 optionally substituted by a halogen atom or a hydroxyl group,

- 5 R^3 is a halogen atom; phenyl optionally substituted by a halogen atom, alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4 or cyano; $-NR^5-(CH_2)_m-R^6$ wherein R^5 is a hydrogen atom or alkyl having a carbon number of 1-4, m is an integer of 0-4, and R^6 is phenyl or pyridyl optionally substituted by a halogen atom; or $-NR^7-CO-(CH_2)_n-R^8$ wherein R^7 is a hydrogen atom or alkyl having a carbon number of 1-4, n is an integer of 0-2, and R^8 is phenyl or
- 10 pyridyl optionally substituted by a halogen atom, and
- R^4 is $-(CH_2)_a-CO-NH-R^9$ wherein a is an integer of 1-4, and R^9 is alkyl having a carbon number of 1-4; hydroxyalkyl having a carbon number of 1-4; alkoxy having a carbon number of 1-4; or phenyl or pyridyl optionally substituted by alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4, amino or a hydroxyl group or $-(CH_2)_b-COOR^{10}$ wherein b is an integer of 1-
- 15 4, and R^{10} is alkyl having a carbon number of 1-4,

including any salts, isomers, enantiomers, racemates, hydrates, solvates, metabolites, and polymorphs thereof.

- [0099] In one embodiment, a suitable alkyl group includes linear or branched alkyl radicals including from 1 carbon atom up to 4 carbon atoms. In one embodiment, a suitable alkyl group
- 20 includes linear or branched alkyl radicals including from 1 carbon atom up to 3 carbon atoms. In one embodiment, a suitable alkyl group includes linear or branched alkyl radicals include from 1 carbon atom up to 2 carbon atoms. In one embodiment, exemplary alkyl radicals include, but are not limited to, methyl, ethyl, propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl. In one

embodiment, exemplary alkyl groups include, but are not limited to, methyl, ethyl, propyl, isopropyl, 2-methyl-1-propyl, and 2-methyl-2-propyl.

[00100] In some embodiments, the present invention provides pharmaceutically acceptable salts, solvates, including hydrates, and isotopically-labeled forms of the thienotriazolodiazepine

5 compounds described herein. In one embodiment, pharmaceutically acceptable salts of the thienotriazolodiazepine compounds include acid addition salts formed with inorganic acids. In one embodiment, pharmaceutically acceptable inorganic acid addition salts of the thienotriazolodiazepine include salts of hydrochloric, hydrobromic, hydroiodic, phosphoric, metaphosphoric, nitric and sulfuric acids. In one embodiment, pharmaceutically acceptable salts of
10 the thienotriazolodiazepine compounds include acid addition salts formed with organic acids. In one embodiment, pharmaceutically acceptable organic acid addition salts of the thienotriazolodiazepine include salts of tartaric, acetic, trifluoroacetic, citric, malic, lactic, fumaric, benzoic, formic, propionic, glycolic, gluconic, maleic, succinic, camphorsulfuric, isothionic, mucic, gentisic, isonicotinic, saccharic, glucuronic, furoic, glutamic, ascorbic, anthranilic, salicylic, phenylacetic,
15 mandelic, embonic (pamoic), methanesulfonic, ethanesulfonic, pantothenic, stearic, sulfinilic, alginic, galacturonic and arylsulfonic, for example benzenesulfonic and 4-methyl benzenesulfonic acids.

[00101] The present invention provides pharmaceutically acceptable isotopically-labeled forms of the thienotriazolodiazepine compounds, described herein, wherein one or more atoms are replaced
20 by atoms having the same atomic number, but an atomic mass or mass number different from the atomic mass or mass number usually found in nature. Examples of isotopes suitable for inclusion in the thienotriazolodiazepine compounds include isotopes of hydrogen, e.g., ^2H and ^3H , carbon, e.g., ^{11}C , ^{13}C and ^{14}C , chlorine, e.g., ^{36}Cl , fluorine, e.g., ^{18}F , iodine, e.g., ^{123}I and ^{125}I , nitrogen, e.g., ^{13}N and ^{15}N , oxygen, e.g., ^{15}O , ^{17}O and ^{18}O , and sulfur, e.g., ^{35}S . Isotopically-labeled forms of the
25 thienotriazolodiazepine compounds generally can be prepared by conventional techniques known to those skilled in the art.

[00102] Certain isotopically-labeled forms of the compound of Formula (1), for example those incorporating a radioactive isotope, are useful in drug and/or substrate tissue distribution studies. The radioactive isotopes tritium (^3H) and carbon-14 (^{14}C) are particularly useful for this purpose in
30 view of their ease of incorporation and ready means of detection. Substitution with heavier isotopes such as deuterium (^2H) may afford certain therapeutic advantages that result from greater metabolic stability, for example increased in vivo half-life or reduced dosage requirements, and hence may be preferred in some circumstances. Substitution with positron emitting isotopes, such as ^{11}C , ^{18}F , ^{15}O ,

and ^{13}N can be used in Positron Emission Tomography (PET) studies for examining substrate receptor occupancy.

[00103] In some embodiments, the thienotriazolodiazepine compounds disclosed herein can exist in solvated as well as unsolvated forms with pharmaceutically acceptable solvents. It will be understood by those skilled-in the art that a solvate is a complex of variable stoichiometry formed by a solute (in this case, the thienotriazolodiazepine compounds described herein) and a solvent. It is preferred that such solvents not interfere with the biological activity of the solute (the thienotriazolodiazepine compounds). Examples of suitable solvents for solvate formation include, but are not limited to, water, methanol, dimethyl sulfoxide, ethanol and acetic acid. Suitably the solvent used is a pharmaceutically acceptable solvent. Suitably the solvent used is water. In one embodiment, pharmaceutically acceptable solvates of the thienotriazolodiazepine compounds, described herein, include ethanol solvate, a isopropanol solvate, a dioxolane solvate, a tetrahydrofuran solvate, a dimethyl sulfoxide solvate, tert-butanol solvate, 2-butanol solvate, dioxolane solvate, 1,3-Dimethyl-3,4,5,6-tetrahydro-2(1H)-pyrimidinone ("DMPU") solvate, 1,3-dimethylimidazolidinone ("DMI") solvate, and 1,3-dimethylimidazolidinone ("DMP") solvate, or mixtures thereof.

[00104] In some embodiments, the thienotriazolodiazepine compounds, described herein, may contain one or more chiral centers and/or double bonds and, therefore, may exist as geometric isomers, enantiomers or diastereomers. The enantiomer and diastereomers of the thienotriazolodiazepine compounds may be designated in accordance with the Cahn–Ingold–Prelog convention, which assigns an "*R*" or "*S*" descriptor to each stereocenter (also sometimes referred to as a chiral center) and an *E* or *Z* descriptor to each carbon-carbon double bond (to designate geometric isomers) so that the configuration of the entire molecule can be specified uniquely by including the descriptors in its systematic name.

[00105] In some embodiments, the thienotriazolodiazepine compounds, described herein, may exist as a racemic mixture, or racemate, which includes equal amounts of left- and right-handed enantiomers of a chiral molecule. Such a racemic mixture may be denoted by the prefix (\pm)- or dl-, indicating an equal (1:1) mixture of dextro and levo isomers. Also, the prefix *rac*- (or *racem*-) or the symbols *RS* and *SR* may be used to designate the racemic mixture.

[00106] Geometric isomers, resulting from the arrangement of substituents around a carbon-carbon double bond or arrangement of substituents around a cycloalkyl or heterocyclic ring, can also exist in the compounds of the present invention. In some embodiments, the symbol ===== may be used to denote a bond that may be a single, double or triple bond. Substituents around a carbon-carbon

double bond are designated as being in the “*Z*” or “*E*” configuration wherein the terms “*Z*” and “*E*” are used in accordance with IUPAC standards. Unless otherwise specified, structures depicting double bonds encompass both the “*E*” and “*Z*” isomers. Substituents around a carbon-carbon double bond alternatively can be referred to as “*cis*” or “*trans*,” where “*cis*” represents substituents on the same side of the double bond and “*trans*” represents substituents on opposite sides of the double bond. The arrangement of substituents around a carbocyclic ring can also be designated as “*cis*” or “*trans*.” The term “*cis*” represents substituents on the same side of the plane of the ring and the term “*trans*” represents substituents on opposite sides of the plane of the ring. Mixtures of compounds wherein the substituents are disposed on both the same and opposite sides of a plane of a ring are designated “*cis/trans*” or “*Z/E*.”

[00107] In some embodiments, thienotriazolodiazepine compounds disclosed herein may exist in single or multiple crystalline forms or polymorphs. In one embodiment, a thienotriazolodiazepine compound disclosed herein comprises an amorphous form thereof. In one embodiment, a thienotriazolodiazepine compound disclosed herein comprises a single polymorph thereof. In another embodiment, a thienotriazolodiazepine compound disclosed herein comprises a mixture of polymorphs thereof. In another embodiment, the compound is in a crystalline form.

[00108] In some embodiments, thienotriazolodiazepine compounds disclosed herein may exist as a single enantiomers or in enantiomerically enriched forms. In one embodiment, a thienotriazolodiazepine compound disclosed herein exists in an enantiomeric excess of more than 80%. In one embodiment, a thienotriazolodiazepine compound disclosed herein exists in an enantiomeric excess of more than 90%. In one embodiment, a thienotriazolodiazepine compound disclosed herein exists in an enantiomeric excess of more than 98%. In one embodiment, a thienotriazolodiazepine compound disclosed herein exists in an enantiomeric excess of more than 99%. In some embodiments, a thienotriazolodiazepine compound disclosed herein exists in an enantiomeric excess selected from the group consisting of at least 10%, at least 25%, at least 50%, at least 75%, at least 90%, at least 95%, at least 98%, at least and at least 99% enantiomeric excess.

[00109] For a pair of enantiomers, enantiomeric excess (ee) of enantiomer *E1* in relation to enantiomer *E2* can be calculated using the following equation eq. (1):

$$\% \text{ enantiomeric excess of } E1 = \frac{(E1 - E2) \times 100\%}{(E1 + E2)} \quad \text{eq. (1)}$$

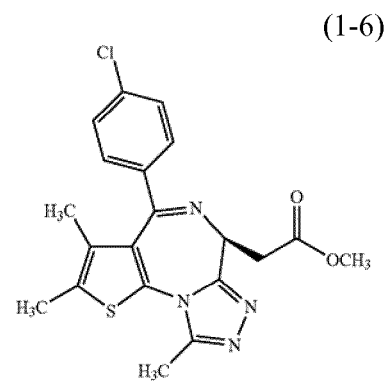
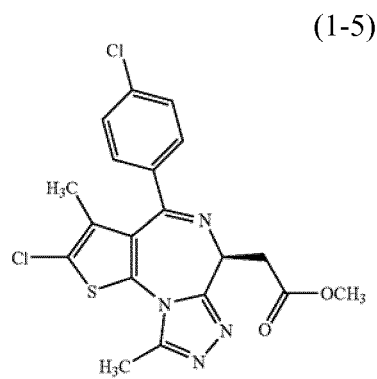
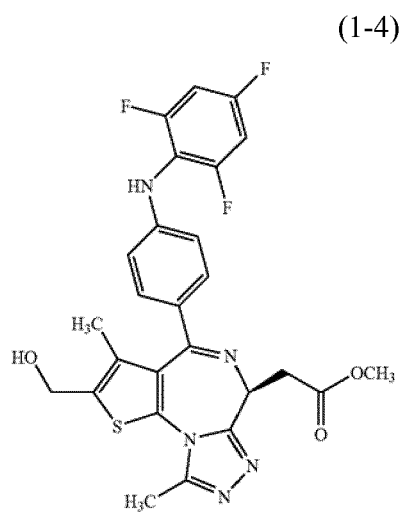
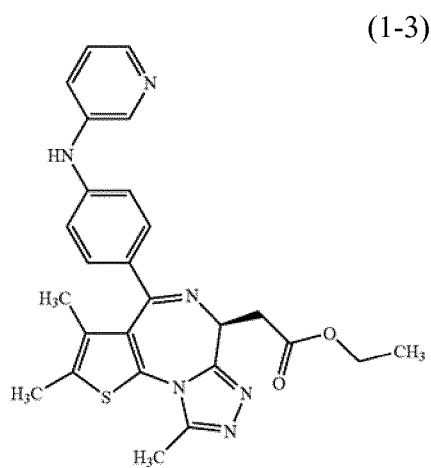
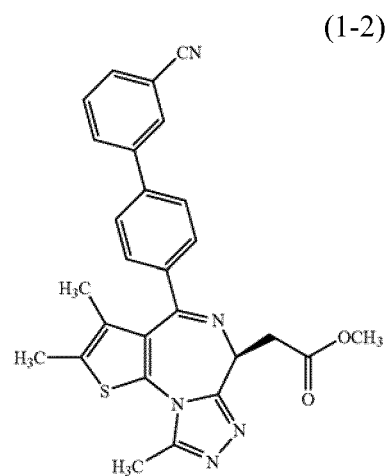
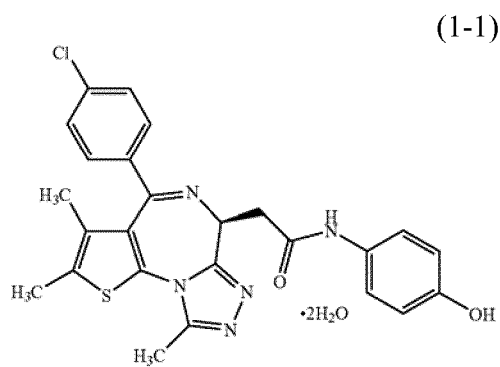
Relative amounts of *E1* and *E2* can be determined by chiral high performance liquid chromatography (HPLC), nuclear magnetic resonance (NMR) or any other suitable methods. In some embodiments, purity of an enantiomeric compound may refer to the amount of the enantiomers

E1 and *E2*, relative to the amount of other materials, which may notably include by-products and/or unreacted reactants or reagents.

[00110] In some embodiments, thienotriazolodiazepine compounds of Formula (1) include, but are not limited to, the thienotriazolodiazepine compounds (1-1) to (1-18), which are listed in the

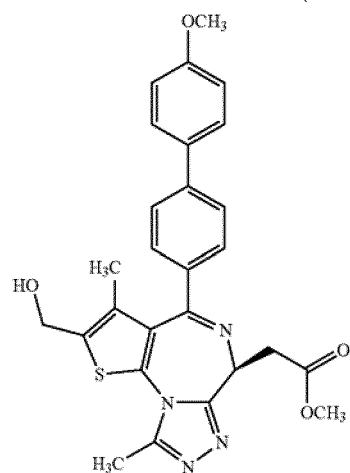
5 following Table A.

[00111] Table A: Exemplary compounds which may be used in the formulations described herein:

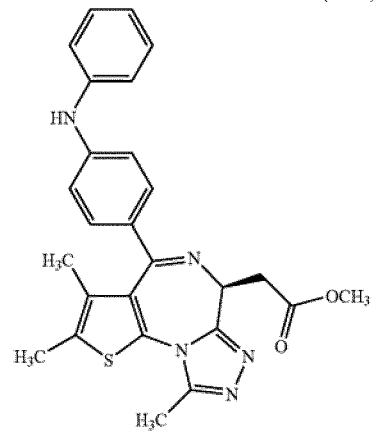


[00112] Table A (continued):

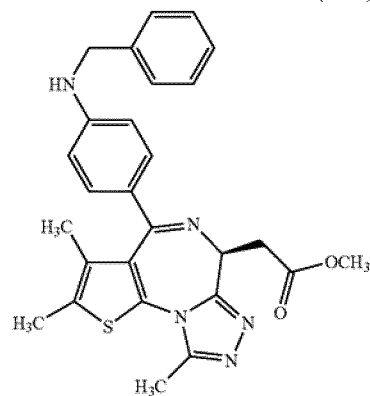
(1-7)



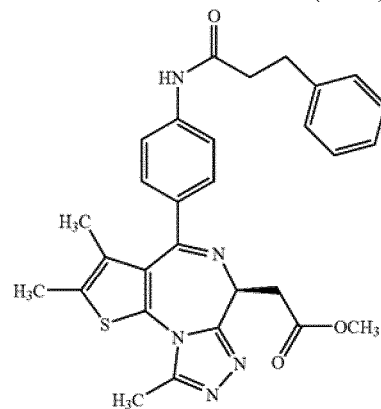
(1-8)



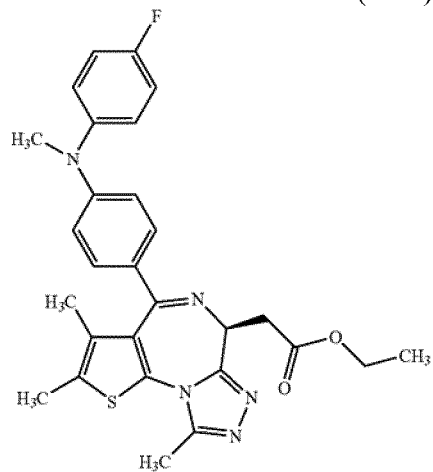
(1-9)



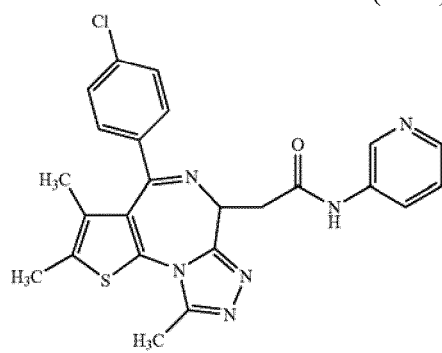
(1-10)



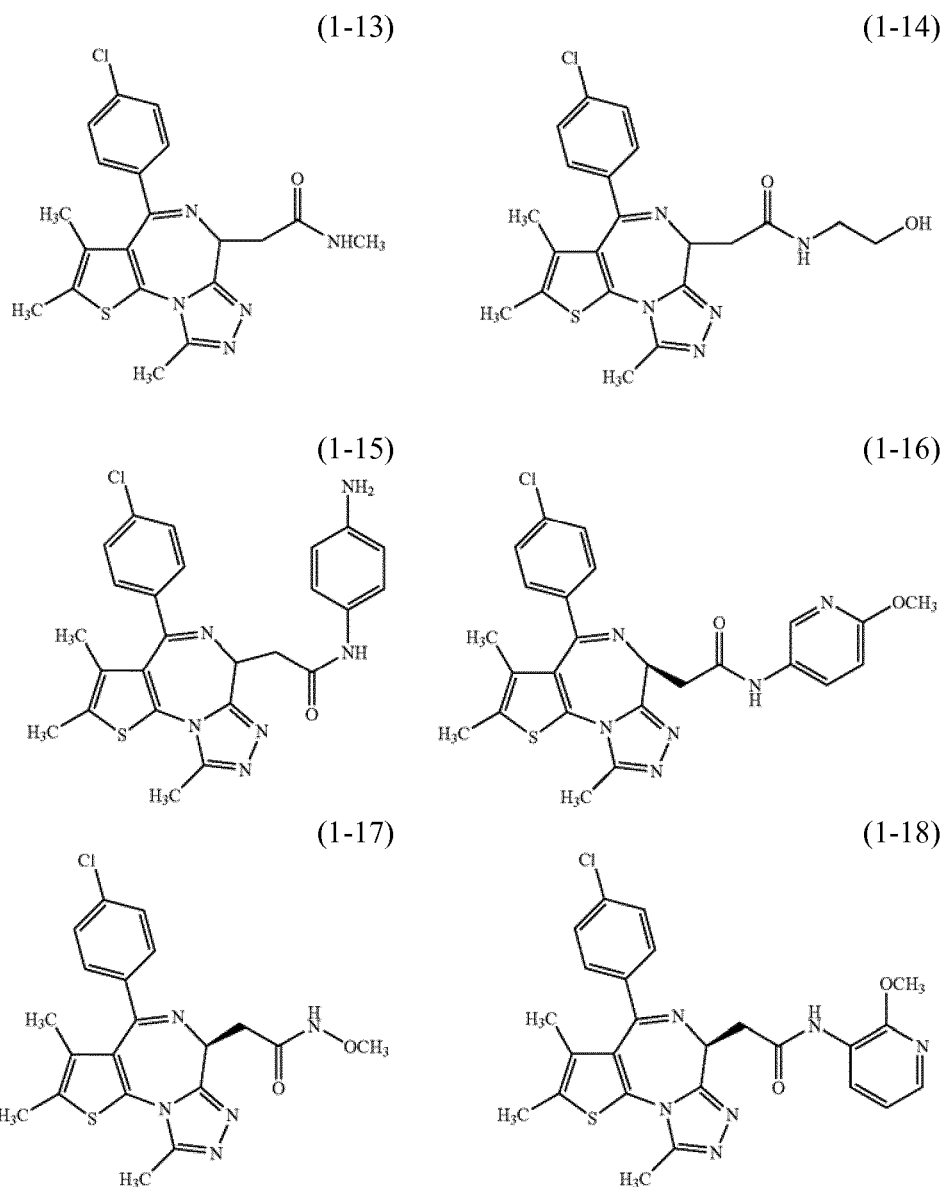
(1-11)



(1-12)



[00113] Table A (continued):

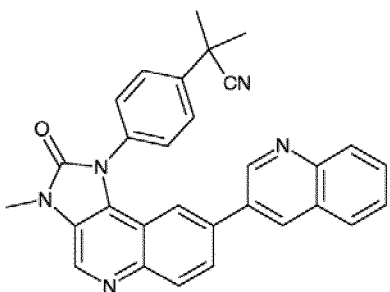
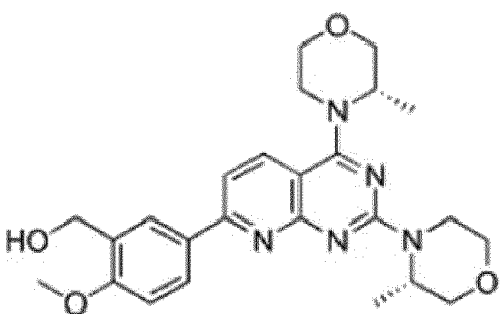


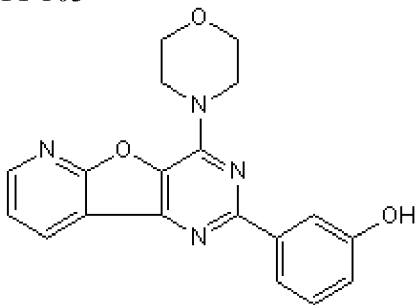
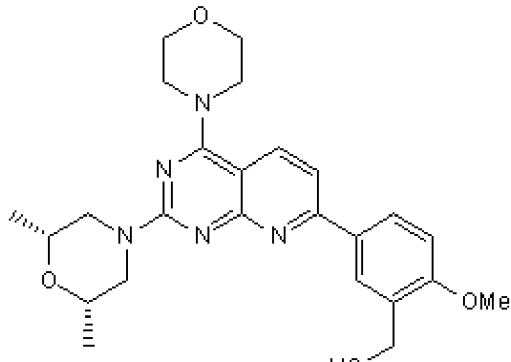
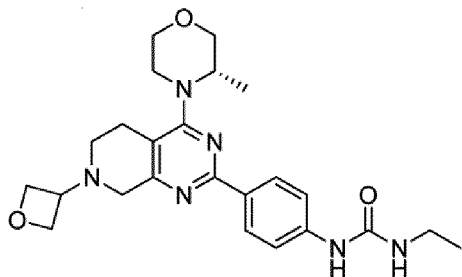
[00114] In some embodiments, thienotriazolodiazepine compounds of Formula (1) include (i) (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide or a dihydrate thereof, (ii) methyl (S)-{4-(3'-cyanobiphenyl-4-yl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate, (iii) methyl (S)-{2,3,9-trimethyl-4-(4-phenylaminophenyl)-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate; and (iv) methyl (S)-{2,3,9-trimethyl-4-[4-(3-phenylpropionylamino)phenyl]-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate.

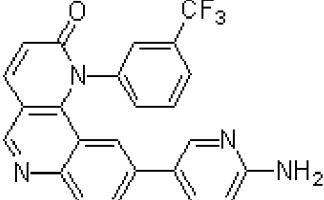
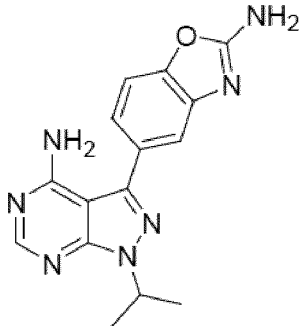
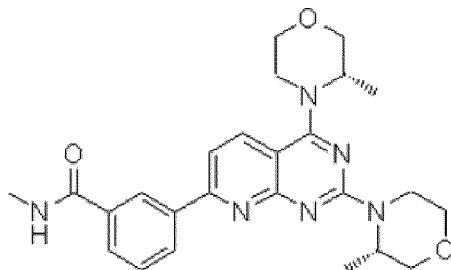
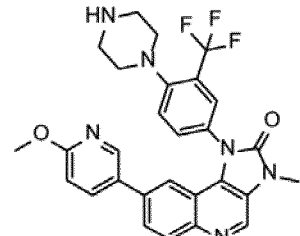
[00115] In some embodiments, thienotriazolodiazepine compounds of Formula (1) include (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide.

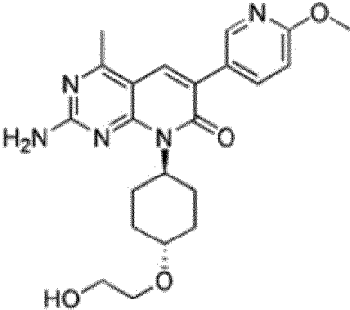
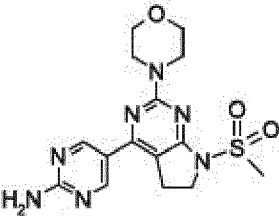
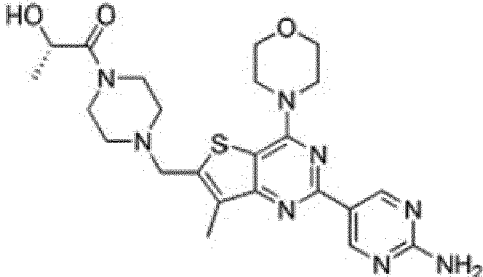
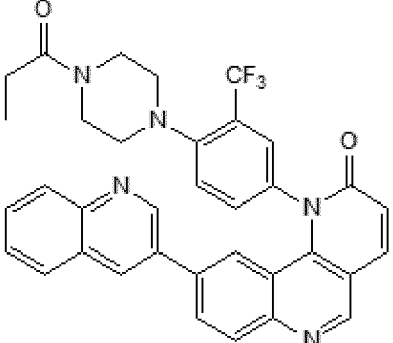
[00116] Example mammalian target of rapamycin (mTOR) inhibitors for use in combination with the thienotriazolodiazepine of Formula (1) in the methods of the present invention include, but are not limited to, the mTOR inhibitors listed in the below Table B.

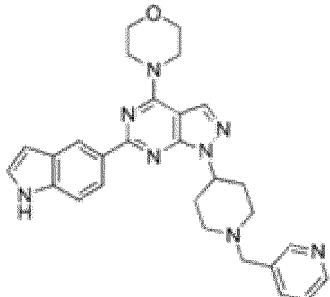
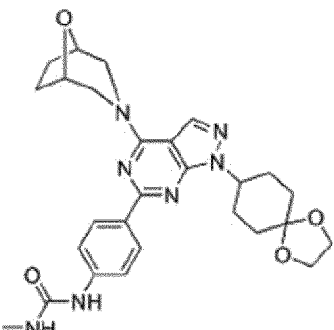
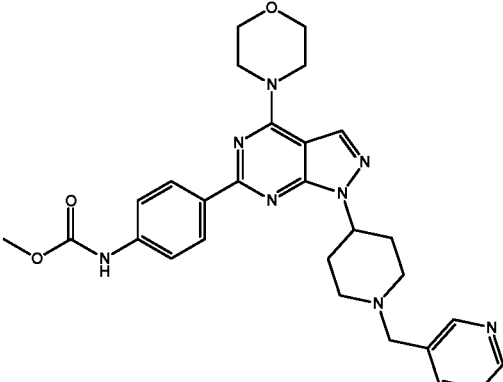
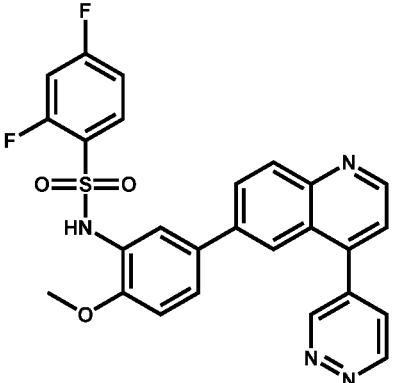
[00117] Table B: Exemplary mTOR inhibitor compounds which may be used in combination with thienotriazolodiazepine of Formula (1):

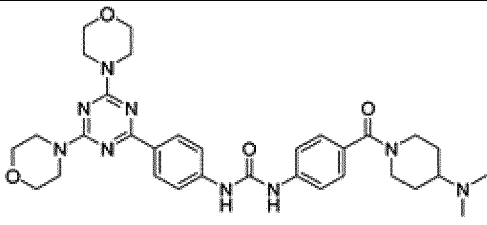
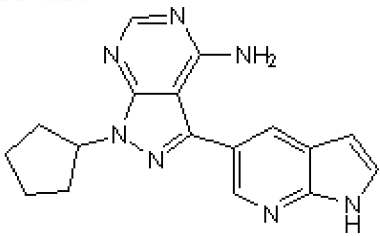
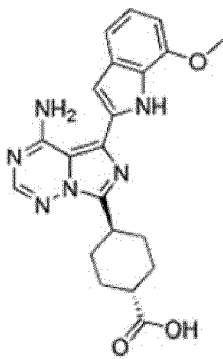
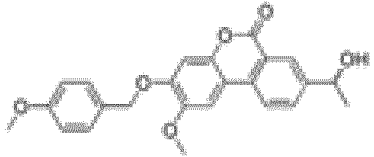
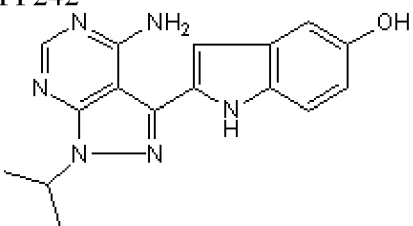
No.	Inhibitor Name	Description	Literature Citations
1	BEZ235 (NVP-BEZ235) 	BEZ235 (NVP-BEZ235) is a dual ATP-competitive PI3K and mTOR inhibitor of p110 α , p110 γ , p110 δ and p110 β with IC ₅₀ of 4 nM, 5 nM, 7 nM and 75 nM, respectively, and also inhibits ATR with IC ₅₀ of 21 nM.	Nature, 2012, 487(7408):505-9; Blood, 2011, 118(14), 3911-3921; Cancer Res, 2011, 71(15), 5067-5074.
2	Everolimus (RAD001)	Everolimus (RAD001) is an mTOR inhibitor of FKBP12 with IC ₅₀ of 1.6-2.4 nM.	Cell, 2012, 149(3):656-70; Cancer Cell, 2012, 21(2), 155-167; Clin Cancer Res, 2013, 19(3):598-609.
3	Rapamycin (Sirolimus, AY22989, NSC226080)	Rapamycin (Sirolimus, AY-22989, WY-090217) is a specific mTOR inhibitor with IC ₅₀ of ~0.1 nM.	Cancer Cell, 2011, 19(6), 792-804; Cancer Res, 2013, ; Cell Res, 2012, 22(6):1003-21.
4	AZD8055 	AZD8055 is a novel ATP-competitive inhibitor of mTOR with IC ₅₀ of 0.8 nM.	Autophagy, 2012, Am J Transplant, 2013, ; Biochem Pharmacol, 2012, 83(9), 1183-1194

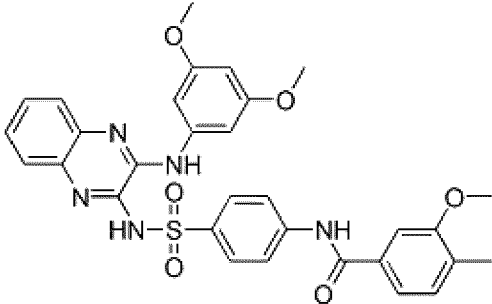
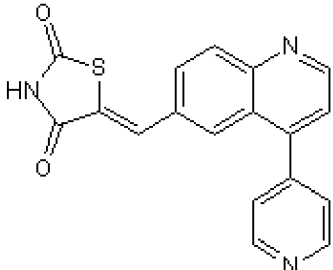
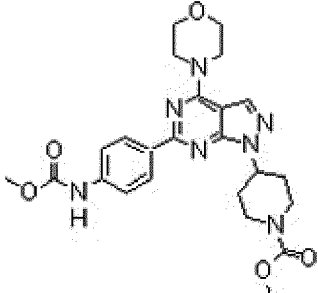
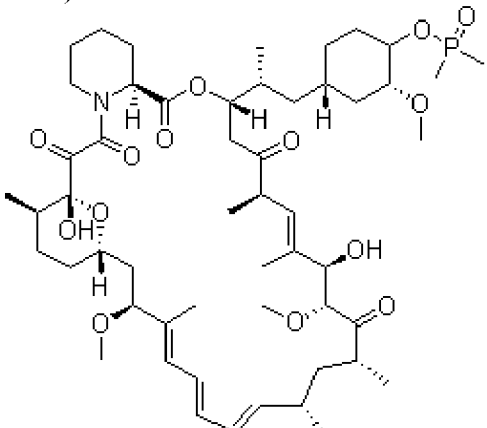
No.	Inhibitor Name	Description	Literature Citations
5	PI-103  3-[4-(4-Morpholinyl)pyrido [3',2':4,5]f-uro[3,2-d]pyrimidin-2-yl] phenol	PI-103 is a potent, ATP-competitive PI3K inhibitor of DNA-PK, p110 α , mTORC1, PI3KC2 β , p110 δ , mTORC2, p110 β , and p110 γ with IC ₅₀ of 2 nM, 8 nM, 20 nM, 26 nM, 48 nM, 83 nM, 88 nM and 150 nM, respectively.	Leukemia, 2013, 27(3):650-60; Leukemia, 2012, 26(5):927-33; Biochem Pharmacol, 2012, 83(9), 1183-1194.
6	Temsirolimus (CCI-779, NSC-683864)	Temsirolimus (CCI-779, Torisel) is a specific mTOR inhibitor with IC ₅₀ of 1.76 μ M.	Autophagy, 2011, 7(2), 176-187; Tuberc Respir Dis (Seoul), 2012, 72(4), 343-351; PLoS One, 2013, 8(5):e62104.
7	Ku-0063794  rel-5-[2-[(2R,6S)-2,6-dimethyl-4- mo-rpholinyl]-4-(4- morpholinyl)pyrido[2,3-d]pyrimidin-- 7-yl]-2-methoxybenzenemethanol	KU-0063794 is a potent and highly specific mTOR inhibitor for both mTORC1 and mTORC2 with IC ₅₀ ~10 nM.	Cell Stem Cell, 2012, 10(2):210-7; Circ Res, 2010, 107(10), 1265-1274; J Immunol, 2013, 190(7), 3246-55.
8	GDC-0349 	GDC-0349, is a potent and selective ATP-competitive inhibitor of mTOR with K _i of 3.8 nM.	
9	Torin 2	Torin 2 is a highly potent and selective mTOR inhibitor with	

No.	Inhibitor Name	Description	Literature Citations
	 <p>9-(6-Amino-3-pyridinyl)-1-[3-(trifluoromethyl)phenyl]-benzo[h]-1,6-naphthyridin-2(1H)-one</p>	IC ₅₀ of 0.25 nM, and also exhibits potent cellular activity against ATM/ATR/DNA-PK with EC ₅₀ of 28 nM, 35 nM and 118 nM, respectively.	
10	INK 128 (MLN-0128) 	INK 128 is a potent and selective mTOR inhibitor with IC ₅₀ of 1 nM.	
11	AZD2014 	AZD2014 is a novel dual mTORC1 and mTORC2 inhibitor with potential antineoplastic activity.	
12	NVP-BGT226(BGT226) 	NVP-BGT226 is a novel dual PI3K/mTOR inhibitor with IC ₅₀ of 1 nM.	
13	PF-04691502	PF-04691502 is an ATP-competitive, selective inhibitor of PI3K($\alpha/\beta/\delta/\gamma$)/mTOR with K _i of 1.8 nM/2.1 nM/1.6 nM/1.9 nM and 16 nM, also inhibits Akt phosphorylation on T308/S473 with IC ₅₀ of 7.5 nM/3.8 nM.	

No.	Inhibitor Name	Description	Literature Citations
			
14	CH5132799 	CH5132799 exhibits a strong inhibitory activity especially against PI3K α with IC ₅₀ of 14 nM and also inhibits mTOR with IC ₅₀ of 1.6 μ M.	
15	GDC-0980 (RG7422) 	GDC-0980 (RG7422) is a potent, selective inhibitor of PI3K α , PI3K β , PI3K δ and PI3K γ with IC ₅₀ of 5 nM, 27 nM, 7 nM, and 14 nM, and also a mTOR inhibitor with K _i of 17 nM.	
16	Torin 1  1-[4-[4-(1-Oxopropyl)-1-piperazinyl]-3-(trifluoromethyl)phenyl]-9-(3-quinolinyl)-benz-o[h]-1,6-naphthyridin-2(1H)-one	Torin1 is a potent inhibitor of mTOR with IC ₅₀ of 2-10 nM.	
17	WAY-600	WAY-600 is a potent, ATP-competitive and selective inhibitor of mTOR with IC ₅₀ of 9	

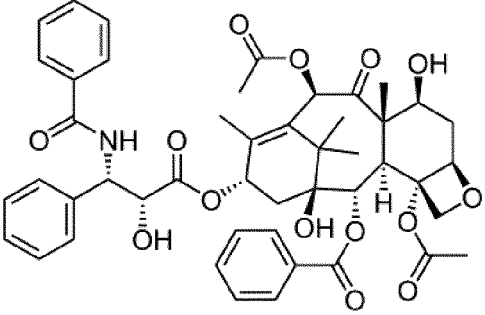
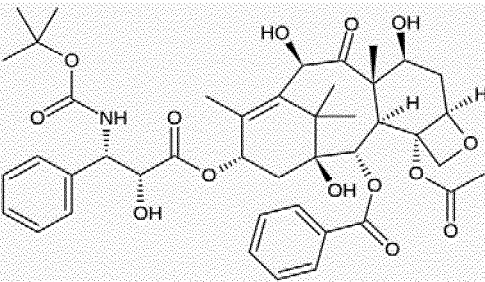
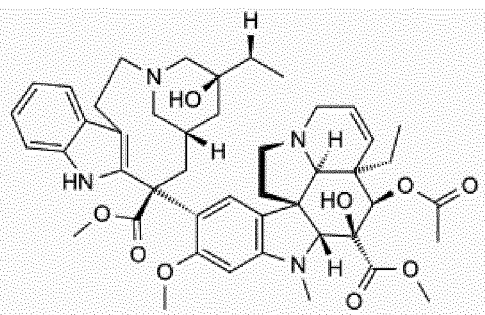
No.	Inhibitor Name	Description	Literature Citations
		nM.	
18	WYE-125132(WYE-132) 	WYE-125132 is a highly potent, ATP-competitive and specific mTOR inhibitor with IC ₅₀ of 0.19 nM.	
19	WYE-687 	WYE-687 is an ATP-competitive and selective inhibitor of mTOR with IC ₅₀ of 7 nM.	
20	GSK2126458(GSK458) 	GSK2126458 is a highly selective and potent inhibitor of p110 α , p110 β , p110 γ , p110 δ , mTORC1 and mTORC2 with K _i of 0.019 nM, 0.13 nM, 0.024 nM, 0.06 nM, 0.18 nM and 0.3 nM, respectively.	
21	PF-05212384 (PKI-587)	PKI-587 is a highly potent dual inhibitor of PI3K α , PI3K γ and mTOR with IC ₅₀ of 0.4	

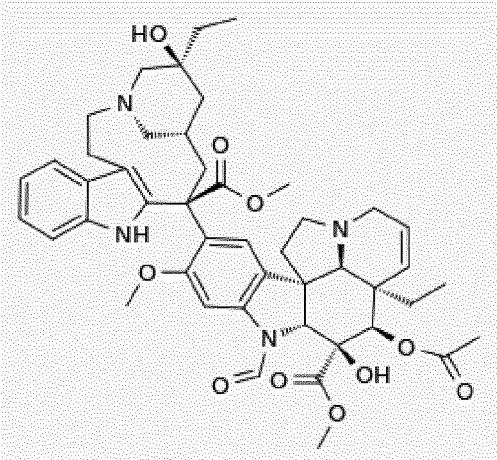
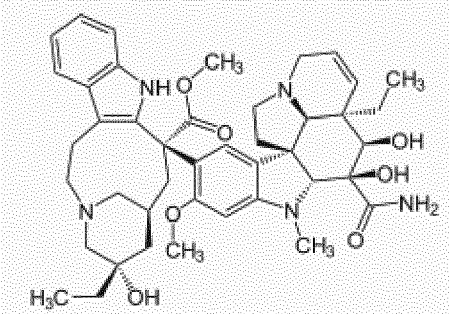
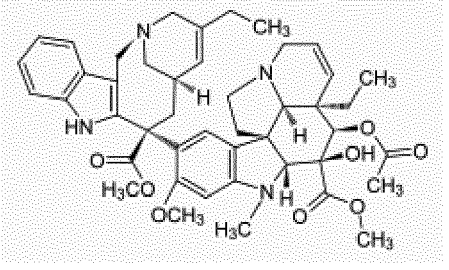
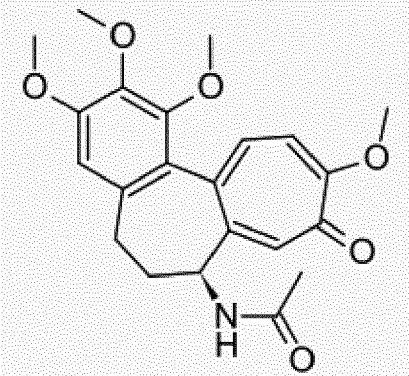
No.	Inhibitor Name	Description	Literature Citations
		nM, 5.4 nM and 1.6 nM, respectively.	
22	<p>PP-121</p>  <p>1-Cyclopentyl-3-(1H-pyrrolo[2,3-b]pyridin-5-yl)-1H-pyrazolo[3,4-d]pyrimidin-4-amine</p>	PP-121 is a multi-target inhibitor of PDGFR, Hck, mTOR, VEGFR2, Src and Abl with IC50 of 2 nM, 8 nM, 10 nM, 12 nM, 14 nM and 18 nM, respectively, and also inhibits DNA-PK with IC50 of 60 nM.	
23	<p>OSI-027(ASP4786)</p> 	OSI-027 is a selective and potent dual inhibitor of mTORC1 and mTORC2 with IC50 of 22 nM and 65 nM, respectively.	Exp Eye Res, 2013, 113C, 9-18
24	<p>Palomid 529(P529)</p> 	Palomid 529 inhibits both the mTORC1 and mTORC2 complexes, reduces phosphorylation of pAktS473, pGSK3βS9, and pS6 but neither pMAPK nor pAktT308. Phase 1.	
25	<p>PP242</p>  <p>2-[4-Amino-1-(1-methylethyl)-1H-pyrazolo[3,4-d]pyrimidin-3-yl]-1H-indol-5-ol</p>	PP242 is a selective mTOR inhibitor with IC50 of 8 nM.	Autophagy, 2012, 8(6), 903-914

No.	Inhibitor Name	Description	Literature Citations
26	XL765(SAR245409) 	XL765 is a dual inhibitor of mTOR/PI3k for mTOR, p110 α , p110 β , p110 γ and p110 δ with IC ₅₀ of 157 nM, 39 nM, 113 nM, 9 nM and 43 nM, respectively.	Endocrinology, 2013, 154(3):1247-59
27	GSK1059615  5-[[4-(4-Pyridinyl)-6-quinolinyl]methylene]-2,4-thiazolidenedione	GSK1059615 is a novel and dual inhibitor of PI3K α , PI3K β , PI3K δ , PI3K γ and mTOR with IC ₅₀ of 0.4 nM, 0.6 nM, 2 nM, 5 nM and 12 nM, respectively.	Nature, 2012, 486(7404), 532-536
28	WYE-354 	WYE-354 is a potent, specific and ATP-competitive inhibitor of mTOR with IC ₅₀ of 5 nM.	Mol Cancer Res, 2012, 10(6), 821-833.
29	Deforolimus (Ridaforolimus, MK-8669) 	Deforolimus (Ridaforolimus; AP23573; MK-8669; 42-(Dimethylphosphinate) rapamycin; Ridaforolimus) is a selective mTOR inhibitor with IC ₅₀ of 0.2 nM.	Mol Genet Meta, 2010, 100(4), 309-315.

[00118] Example mitotic inhibitors for use in combination with the thienotriazolodiazepine of Formula (1) in the methods of the present invention include, but are not limited to, the mitotic inhibitors listed in the below Table C.

[00119] Table C: Exemplary mitotic inhibitor compounds which may be used in combination with
5 thienotriazolodiazepine of Formula (1):

No.	Inhibitor Name	Description	Literature Citations
1	Paclitaxel 	Cytotoxic studies of paclitaxel in human tumor cell lines with IC ₅₀ of ~2.5 and 7.5 nM	Br J Cancer. 1993 Dec; 68(6):1104-9.
2	Docetaxel 	Docetaxel in: HCC1937 having IC ₅₀ of 7.2 ± 2.5 nM; MDA-MB-231 having IC ₅₀ of 3.0 ± 0.5 nM.	Annals of Oncology 20: 862–867, 2009
3	Vinblastine 		

No.	Inhibitor Name	Description	Literature Citations
4	Vincristine 		
5	Vindesine 		
6	Vinorelbine 		
7	Colchicine 		

IV. Formulations:

[00120] The compound of Formula (1) presents highly specific difficulties in relation to administration generally and the preparation of galenic compositions in particular, including the particular problems of drug bioavailability and variability in inter- and intra-patient dose response, necessitating development of a non-conventional dosage form with respect to the practically water-insoluble properties of the compound.

[00121] Previously, it had been found that the compound of Formula (1) could be formulated as a solid dispersion with the carrier ethyl acrylate-methyl methacrylate-trimethylammonioethyl methacrylate chloride copolymer (Eudragit RS, manufactured by Rohm) to provide an oral formulation that preferentially released the pharmaceutical ingredient in the lower intestine for treatment of inflammatory bowel diseases such as ulcerative colitis and Crohn's disease (US Patent Application 20090012064 A1, published Jan 8, 2009). It was found, through various experiments, including animal tests, that in inflammatory bowel diseases drug release in a lesion and a direct action thereof on the inflammatory lesion were more important than the absorption of the drug into circulation from the gastrointestinal tract.

[00122] It has now been unexpectedly found that thienotriazolodiazepine compounds, according to Formula (1), pharmaceutically acceptable salts, solvates, including hydrates, racemates, enantiomers isomers, and isotopically-labeled forms thereof, can be formulated as a solid dispersion with pharmaceutically acceptable polymers to provide an oral formulation that provides high absorption of the pharmaceutical ingredient into the circulation from the gastrointestinal tract for treatment of diseases other than inflammatory bowel diseases. Studies in both dogs and humans have confirmed high oral bioavailability of these solid dispersions compared with the Eudragit solid dispersion formulation previously developed for the treatment of inflammatory bowel disease.

[00123] Solid dispersions are a strategy to improve the oral bioavailability of poorly water soluble drugs.

[00124] The term "solid dispersion" as used herein refers to a group of solid products including at least two different components, generally a hydrophilic carrier and a hydrophobic drug, the thienotriazolodiazepine compounds, according to Formula (1). Based on the drug's molecular arrangement within the dispersion, six different types of solid dispersions can be distinguished. Commonly, solid dispersions are classified as simple eutectic mixtures, solid solutions, glass solution and suspension, and amorphous precipitations in a crystalline carrier. Moreover, certain

combinations can be encountered, for example, in the same sample some molecules may be present in clusters while some are molecularly dispersed.

[00125] In one embodiment, the thienotriazolodiazepine compounds, according to Formula (1) can be dispersed molecularly, in amorphous particles (clusters). In another embodiment, the
5 thienotriazolodiazepine compounds, according to Formula (1) can be dispersed as crystalline particles. In one embodiment, the carrier can be crystalline. In another embodiment, the carrier can be amorphous.

[00126] In one embodiment, the present invention provides a pharmaceutical composition comprising a solid dispersion of a thienotriazolodiazepine compound, in accordance with Formula
10 (1), or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof; and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate (also called hydroxypropylmethylcellulose acetate succinate or HPMCAS). In one embodiment, the dispersion has a thienotriazolodiazepine compound to hydroxypropylmethylcellulose acetate
15 succinate (HPMCAS) weight ratio of 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 130 °C to
20 140 °C. In other such embodiments, the single T_g occurs at about 135 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a
25 diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

[00127] In one embodiment, the present invention provides a pharmaceutical composition comprising a solid dispersion of a thienotriazolodiazepine compound of Formula (1) or a
30 pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof in a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone (also called povidone or PVP). In one embodiment, the dispersion has a thienotriazolodiazepine compound to PVP weight ratio of 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine

compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 175 °C to about 185 °C. In other such embodiments, the single T_g occurs at about 179 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

[00128] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of an amorphous form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to hypromellose acetate succinate ranges from 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 130 °C to 140 °C. In other such embodiments, the single T_g occurs at about 135 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

[00129] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of an amorphous form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one

embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to polyvinylpyrrolidone ranges from 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 175 °C to about 185 °C. In other such embodiments, the single T_g occurs at about 179 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

[00130] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of a crystalline form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to hypromellose acetate succinate ranges from 1:3 to 1:1.

[00131] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of a crystalline form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to polyvinylpyrrolidone ranges from 1:3 to 1:1.

[00132] In some embodiments, a pharmaceutical composition comprising a solid dispersion is prepared by spray drying.

[00133] In one embodiment, a pharmaceutical composition of the present invention comprises a spray dried solid dispersion of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an

isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate. In one embodiment, the weight ratio of compound (1) to hypromellose acetate succinate ranges from 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is
5 homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 130 °C to 140 °C. In other such embodiments, the single T_g occurs at about 135 °C. In some such embodiments, the solid
10 dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine
15 compound of Formula (1).

[00134] In one embodiment, a pharmaceutical composition of the present invention comprises a spray dried solid dispersion of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one
20 embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone. In one embodiment, the weight ratio of compound (1) to polyvinylpyrrolidone ranges from 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the
25 solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 175 °C to 185 °C. In other such embodiments, the single T_g occurs at about 179 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines
30 associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

[00135] In one embodiment, a pharmaceutical composition of the present invention comprises a spray dried solid dispersion of an amorphous form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to hypromellose acetate succinate ranges from 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 130 °C to 140 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In other such embodiments, the single T_g occurs at about 135 °C. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

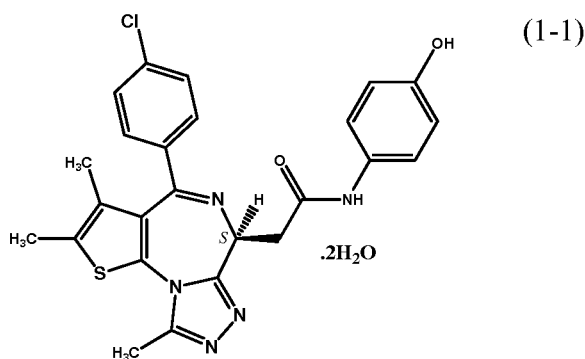
[00136] In one embodiment, a pharmaceutical composition of the present invention comprises a spray dried solid dispersion of an amorphous form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to polyvinylpyrrolidone ranges from 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 175 °C to 185 °C. In other such embodiments, the single T_g occurs at about 179 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound

of Formula (1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound of Formula (1).

[00137] In one embodiment, a pharmaceutical composition of the present invention comprises a spray dried solid dispersion of a crystalline form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is hypromellose acetate succinate. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to hypromellose acetate succinate ranges from 1:3 to 1:1.

[00138] In one embodiment, a pharmaceutical composition of the present invention comprises a spray dried solid dispersion of a crystalline form of a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is polyvinylpyrrolidone. In one embodiment, the weight ratio of thienotriazolodiazepine compound of Formula (1) to polyvinylpyrrolidone ranges from 1:3 to 1:1.

[00139] In one preferred embodiment, the present invention provides a pharmaceutical composition comprising a solid dispersion of 2-[(6S)-4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thienol[3,2-f]-[1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide dihydrate, compound (1-1):



or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is HPMCAS. In one embodiment, the dispersion has compound (1-1) and HPMCAS in a weight ratio of 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout

the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In one embodiment, the solid dispersion is spray dried. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 130 °C to 140 °C.

5 In other such embodiments, the single T_g occurs at about 135 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound (1-1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above
10 the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound (1-1).

[00140] In another embodiment, the pharmaceutical composition comprises a solid dispersion compound (1-1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form; and a pharmaceutically acceptable polymer.

15 In one embodiment, the pharmaceutically acceptable polymer is PVP. In one embodiment, the dispersion has compound (1-1) and PVP in weight ratio 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In one embodiment, the solid dispersion is spray dried.

20 In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 175 °C to 185 °C. In other such embodiments, the single T_g occurs at about 179 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of
25 diffraction lines associated with crystalline thienotriazolodiazepine compound (1-1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound (1-1).

[00141] In one embodiment, a pharmaceutical composition of the present invention comprises a
30 solid dispersion of an amorphous form of a thienotriazolodiazepine compound (1-1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof; and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is HPMCAS. In one embodiment, the

dispersion has compound (1-1) and HPMCAS in a weight ratio of 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In one embodiment, the solid dispersion is spray dried. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 130 °C to 140 °C. In other such embodiments, the single T_g occurs at about 135 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound (1-1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound (1-1).

[00142] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of an amorphous form of a thienotriazolodiazepine compound (1-1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof; and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is PVP. In one embodiment, the dispersion has compound (1-1) and PVP in weight ratio 1:3 to 1:1. In one embodiment, at least some portion of the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In another embodiment, the thienotriazolodiazepine compound is homogeneously dispersed throughout the solid dispersion. In one embodiment, the solid dispersion is spray dried. In some embodiments, the solid dispersion exhibits a single inflection for the glass transition temperature (T_g). In some embodiments, the single T_g occurs between 175 °C to 185 °C. In other such embodiments, the single T_g occurs at about 189 °C. In some such embodiments, the solid dispersion was exposed to a relative humidity of 75 % at 40 °C for at least one month. In some embodiments, the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound (1-1). For the purpose of this application “substantially free” shall mean the absence of a diffraction line, above the amorphous halo, at about 21° 2-theta associated with crystalline thienotriazolodiazepine compound (1-1).

[00143] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of a crystalline form of a thienotriazolodiazepine compound (1-1) or a

pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof; and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is HPMCAS. In one embodiment, the dispersion has compound (1-1) and HPMCAS in a weight ratio of 1:3 to 1:1. In one embodiment, the solid dispersion is spray dried.

[00144] In one embodiment, a pharmaceutical composition of the present invention comprises a solid dispersion of a crystalline form of a thienotriazolodiazepine compound (1-1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof; and a pharmaceutically acceptable polymer. In one embodiment, the pharmaceutically acceptable polymer is PVP. In one embodiment, the dispersion has compound (1-1) and PVP in weight ratio 1:3 to 1:1. In one embodiment, the solid dispersion is spray dried.

[00145] The solid dispersions of the invention, described herein, exhibit especially advantageous properties when administered orally. Examples of advantageous properties of the solid dispersions include, but are not limited to, consistent and high level of bioavailability when administered in standard bioavailability trials in animals or humans. The solid dispersions of the invention can include a solid dispersion comprising thienotriazolodiazepine compound of Formula (1) and a polymer and additives. In some embodiments, the solid dispersions can achieve absorption of the thienotriazolodiazepine compound of Formula (1) into the bloodstream that cannot be obtained by merely admixing the thienotriazolodiazepine compound of Formula (1) with additives since the thienotriazolodiazepine compound of Formula (1) drug has negligible solubility in water and most aqueous media. The bioavailability, of thienotriazolodiazepine compound of Formula (1) or of thienotriazolodiazepine compound (1-1) may be measured using a variety of in vitro and/or in vivo studies. The in vivo studies may be performed, for example, using rats, dogs or humans.

[00146] The bioavailability may be measured by the area under the curve (AUC) value obtained by plotting a serum or plasma concentration, of the thienotriazolodiazepine compound of Formula (1) or thienotriazolodiazepine compound (1-1), along the ordinate (Y-axis) against time along the abscissa (X-axis). The AUC value of the thienotriazolodiazepine compound of Formula (1) or thienotriazolodiazepine compound (1-1) from the solid dispersion, is then compared to the AUC value of an equivalent concentration of crystalline thienotriazolodiazepine compound of Formula (1) or crystalline thienotriazolodiazepine compound (1-1) without polymer. In some embodiments, the solid dispersion provides an area under the curve (AUC) value, when administered orally to a dog, that is selected from: at least 0.4 times, 0.5 times, 0.6 times, 0.8 times, 1.0 times, a corresponding

AUC value provided by a control composition administered intravenously to a dog, wherein the control composition comprises an equivalent quantity of a crystalline thienotriazolodiazepine compound of Formula (1).

[00147] The bioavailability may be measured by in vitro tests simulating the pH values of a gastric environment and an intestine environment. The measurements may be made by suspending a solid dispersion of the thienotriazolodiazepine compound of Formula (1) or thienotriazolodiazepine compound (1-1), in an aqueous in vitro test medium having a pH between 1.0 to 2.0, and the pH is then adjusted to a pH between 5.0 and 7.0, in a control in vitro test medium. The concentration of the amorphous thienotriazolodiazepine compound of Formula (1) or amorphous thienotriazolodiazepine compound (1-1) may be measured at any time during the first two hours following the pH adjustment. In some embodiments, the solid dispersion provides a concentration, of the amorphous thienotriazolodiazepine compound of Formula (1) or amorphous thienotriazolodiazepine compound (1-1), in an aqueous in vitro test medium at pH between 5.0 to 7.0 that is selected from: at least 5-fold greater, at least 6 fold greater, at least 7 fold greater, at least 8 fold greater, at least 9 fold greater or at least 10 fold greater, compared to a concentration of a crystalline thienotriazolodiazepine compound of Formula (1) or crystalline thienotriazolodiazepine compound (1-1), without polymer.

[00148] In other embodiments, the concentration of the amorphous thienotriazolodiazepine compound of Formula (1) or amorphous thienotriazolodiazepine compound (1-1), from the solid dispersion placed in an aqueous in vitro test medium having a pH of 1.0 to 2.0, is: at least 40%, at least 50%, at least 60 %, at least 70 %; at least 80 %, higher than a concentration of a crystalline thienotriazolodiazepine compound of Formula (1) without polymer. In some such embodiments, the polymer of the solid dispersion is HPMCAS. In some such embodiments, the polymer of the solid dispersion is PVP.

[00149] In other embodiments, a concentration of the amorphous thienotriazolodiazepine compound of Formula (1) or amorphous thienotriazolodiazepine compound (1-1), from the solid dispersion, is: at least 40%, at least 50%, at least 60 %, at least 70 %; at least 80 %, higher compared to a concentration of thienotriazolodiazepine compound of Formula (1), from a solid dispersion of thienotriazolodiazepine compound of the Formula (1) and a pharmaceutically acceptable polymer selected from the group consisting of: hypromellose phthalate and ethyl acrylate-methyl methacrylate-trimethylammonioethyl methacrylate chloride copolymer, wherein each solid dispersion was placed in an aqueous in vitro test medium having a pH of 1.0 to 2.0. In some such

embodiments, the polymer of the solid dispersion is HPMCAS. In some such embodiments, the polymer of the solid dispersion is PVP.

[00150] In some embodiments, the solid dispersions, described herein, exhibit stability against recrystallization of the thienotriazolodiazepine compound of the Formula (1) or the

thienotriazolodiazepine compound (1-1) when exposed to humidity and temperature over time. In one embodiment, the concentration of the amorphous thienotriazolodiazepine compound of the Formula (1) or the thienotriazolodiazepine compound (1-1) which remains amorphous is selected from: at least 90 %, at least 91%, at least 92%, at least 93%, at least 94%, at least 95%, at least 96%, at least 97%, at least 98% and at least 99%.

V. Dosage Forms:

[00151] Suitable dosage forms that can be used with the solid dispersions of the present invention include, but are not limited to, capsules, tablets, mini-tablets, beads, beadlets, pellets, granules, granulates, and powder. Suitable dosage forms may be coated, for example using an enteric coating. Suitable coatings may comprise but are not limited to cellulose acetate phthalate,

hydroxypropylmethylcellulose (HPMC), hydroxypropylmethylcellulose phthalate, a polymethylacrylic acid copolymer, or hydroxylpropylmethylcellulose acetate succinate (HPMCAS). In some embodiments, certain combinations can be encountered, for example, in the same sample some molecules of the thienotriazolodiazepine of the present invention may be present in clusters while some are molecularly dispersed with a carrier.

[00152] In some embodiments, the solid dispersions of the invention may be formulated as tablets, caplets, or capsules. In one some embodiments, the solid dispersions of the invention may be formulated as mini-tablets or pour-into-mouth granules, or oral powders for constitution. In some embodiments, the solid dispersions of the invention are dispersed in a suitable diluent in combination with other excipients (e.g., re-crystallization/precipitation inhibiting polymers, taste-masking components, etc.) to give a ready-to-use suspension formulation. In some embodiments, the solid dispersions of the invention may be formulated for pediatric treatment.

[00153] In one embodiment, the pharmaceutical composition of the present invention is formulated for oral administration. In one embodiment, the pharmaceutical composition comprises a solid dispersion, according to the various embodiments described herein, comprising a thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof;

and a polymer carrier. In one embodiment, the pharmaceutical composition further includes one or more additives such as disintegrants, lubricants, glidants, binders, and fillers.

[00154] Examples of suitable pharmaceutically acceptable lubricants and pharmaceutically acceptable glidants for use with the pharmaceutical composition include, but are not limited to, colloidal silica, magnesium trisilicate, starches, talc, tribasic calcium phosphate, magnesium stearate, aluminum stearate, calcium stearate, magnesium carbonate, magnesium oxide, polyethylene glycol, powdered cellulose, glyceryl behenate, stearic acid, hydrogenated castor oil, glyceryl monostearate, and sodium stearyl fumarate.

[00155] Examples of suitable pharmaceutically acceptable binders for use with the pharmaceutical composition include, but are not limited to starches; celluloses and derivatives thereof, e.g., microcrystalline cellulose (e.g., AVICEL PH from FMC), hydroxypropyl cellulose, hydroxyethyl cellulose, and hydroxypropylmethylcellulose (HPMC, e.g., METHOCEL from Dow Chemical); sucrose, dextrose, corn syrup; polysaccharides; and gelatin.

[00156] Examples of suitable pharmaceutically acceptable fillers and pharmaceutically acceptable diluents for use with the pharmaceutical composition include, but are not limited to, confectioner's sugar, compressible sugar, dextrates, dextrin, dextrose, lactose, mannitol, microcrystalline cellulose (MCC), powdered cellulose, sorbitol, sucrose, and talc.

[00157] In some embodiments, excipients may serve more than one function in the pharmaceutical composition. For example, fillers or binders may also be disintegrants, glidants, anti-adherents, lubricants, sweeteners and the like.

[00158] In some embodiments, the pharmaceutical compositions of the present invention may further include additives or ingredients, such as antioxidants (e.g., ascorbyl palmitate, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), α -tocopherols, propyl gallate, and fumaric acid), antimicrobial agents, enzyme inhibitors, stabilizers (e.g., malonic acid), and/or preserving agents.

[00159] Generally, the pharmaceutical compositions of the present invention may be formulated into any suitable solid dosage form. In some embodiments, the solid dispersions of the invention are compounded in unit dosage form, e.g., as a capsule, or tablet, or a multi-particulate system such as granules or granulates or a powder, for administration.

[00160] In one embodiment, a pharmaceutical compositions includes a solid dispersion of a thienotriazolodiazepine compound of Formula (1), according to the various embodiments of solid dispersions described herein, and hydroxypropylmethylcellulose acetate succinate (HPMCAS), wherein the thienotriazolodiazepine compound is amorphous in the solid dispersion and has a

thienotriazolodiazepine compound to hydroxypropylmethylcellulose acetate succinate (HPMCAS), weight ratio of 1:3 to 1:1; 45 -50 wt. % of lactose monohydrate; 35-40 wt. % of microcrystalline cellulose; 4-6 wt. % of croscarmellose sodium; 0.8-1.5 wt. % of colloidal silicon dioxide; and 0.8-1.5 wt. % of magnesium stearate.

5 VI. Dosage:

[00161] In one embodiment, the present invention provides a pharmaceutical composition that maybe formulated into any suitable solid dosage form. In one embodiment, a pharmaceutical composition in accordance with the present invention comprises one or more of the various
10 embodiments of the thienotriazolodiazepine of Formula (1) as described herein in a dosage amount ranging from about 10 mg to about 100 mg. In one embodiment, the pharmaceutical composition of the present invention includes one or more of the various embodiments of the thienotriazolodiazepine of Formula (1) as described herein in a dosage amount selected from the group consisting of from about 10 mg to about 100 mg, about 10 mg to about 90 mg, about 10 mg to about 80 mg, about 10 mg to about 70 mg, about 10 mg to about 60 mg, about 10 mg to about 50
15 mg, about 10 mg to about 40 mg, about 10 mg to about 30 mg, and about 10 mg to about 20 mg. In one embodiment, the pharmaceutical composition of the present invention includes one or more of the various embodiments of the thienotriazolodiazepine of Formula (1) as described herein in a dosage amount selected from the group consisting of about 10 mg, about 50 mg, about 75 mg, about 100 mg.

20 [00162] In one embodiment, the pharmaceutical composition of the present invention includes administering to a subject in need thereof one or more of the various embodiments of the thienotriazolodiazepine of Formula (I) as described herein in a dosage amount selected from the group consisting of about 1 mg, about 2 mg, about 2.5 mg, about 3 mg, about 4 mg, about 5 mg, about 7.5 mg, about 10 mg, about 15 mg, about 20 mg, about 25 mg, about 30 mg, about 35 mg,
25 about 40 mg, about 45 mg, about 50 mg, about 55 mg, about 60 mg, about 65 mg, about 70 mg, about 75 mg, about 80 mg, about 85 mg, about 90 mg, about 95 mg, about 100 mg, about 110 mg, about 120 mg, about 130 mg, about 140 mg, and about 150 mg, and in a dosage form selected from the group consisting of once weekly, once daily every sixth day, once daily every fifth day, once daily every fourth day, once daily every third day, once daily every other day, once daily, twice
30 daily, three times daily, four times daily, and five times daily. In another embodiment, any of the foregoing dosage amounts or dosage forms is decreased periodically or increased periodically. In

one embodiment, the pharmaceutical composition of the present invention includes administering to a subject in need thereof a thienotriazolodiazepine selected from the group consisting of compounds (1-1), (1-2), (1-3), (1-4), (1-5), (1-6), (1-7), (1-8), (1-9), (1-10), (1-11), (1-12), (1-13), (1-14), (1-15), (1-16), (1-17), and (1-18), in a dosage amount selected from the group consisting of about 1 mg, about 2 mg, about 2.5 mg, about 3 mg, about 4 mg, about 5 mg, about 7.5 mg, about 10 mg, about 15 mg, about 20 mg, about 25 mg, about 30 mg, about 35 mg, about 40 mg, about 45 mg, about 50 mg, about 55 mg, about 60 mg, about 65 mg, about 70 mg, about 75 mg, about 80 mg, about 85 mg, about 90 mg, about 95 mg, about 100 mg, about 110 mg, about 120 mg, about 130 mg, about 140 mg, and about 150 mg, and in a dosage form selected from the group consisting of once weekly, once daily every sixth day, once daily every fifth day, once daily every fourth day, once daily every third day, once daily every other day, once daily, twice daily, three times daily, four times daily, and five times daily. In another embodiment, any of the foregoing dosage amounts or dosage forms is decreased periodically or increased periodically.

[00163] Such unit dosage forms are suitable for administration 1 to 5 times daily depending on the particular purpose of therapy, the phase of therapy, and the like. In one embodiment, the dosage form may be administered to a subject in need thereof at least once daily for at least two successive days. In one embodiment, the dosage form may be administered to a subject in need thereof at least once daily on alternative days. In one embodiment, the dosage form may be administered to a subject in need thereof at least weekly and divided into equal and/or unequal doses. In one embodiment, the dosage form may be administered to a subject in need thereof weekly, given either on three alternate days and/or 6 times per week. In one embodiment, the dosage form may be administered to a subject in need thereof in divided doses on alternate days, every third day, every fourth day, every fifth day, every sixth day and/or weekly. In one embodiment, the dosage form may be administered to a subject in need thereof two or more equally or unequally divided doses per month.

[00164] The dosage form used, e.g., in a capsule, tablet, mini-tablet, beads, beadlets, pellets, granules, granulates, or powder may be coated, for example using an enteric coating. Suitable coatings may comprise but are not limited to cellulose acetate phthalate, hydroxypropylmethylcellulose (HPMC), hydroxypropylmethylcellulose phthalate, a polymethylacrylic acid copolymer, or hydroxylpropylmethylcellulose acetate succinate (HPMCAS).

VII. Process:

[00165] The thienotriazolodiazepine compounds disclosed herein can exist as free base or as acid addition salt. They can be obtained according to the procedures described in US Patent Application Publication No. 2010/0286127, incorporated by reference in its entirety herein, or in the present application. Individual enantiomers and diastereomers of the thienotriazolodiazepine compounds of the present invention can be prepared synthetically from commercially available starting materials that contain asymmetric or stereogenic centers, or by preparation of racemic mixtures followed by resolution methods well known to those of ordinary skill in the art. These methods of resolution are exemplified by (1) attachment of a mixture of enantiomers to a chiral auxiliary, separation of the resulting mixture of diastereomers by recrystallization or chromatography and liberation of the optically pure product from the auxiliary, (2) salt formation employing an optically active resolving agent, (3) direct separation of the mixture of optical enantiomers on chiral liquid chromatographic columns or (4) kinetic resolution using stereoselective chemical or enzymatic reagents. Racemic mixtures can also be resolved into their component enantiomers by well-known methods, such as chiral-phase gas chromatography or crystallizing the compound in a chiral solvent.

[00166] If desired, a particular enantiomer of the thienotriazolodiazepine compounds disclosed herein may be prepared by asymmetric synthesis, or by derivation with a chiral auxiliary, where the resulting diastereomeric mixture is separated and the auxiliary group cleaved to provide the pure desired enantiomers. Alternatively, where the molecule contains a basic functional group, such as amino, or an acidic functional group, such as carboxyl, diastereomeric salts are formed with an appropriate optically-active acid or base, followed by resolution of the diastereomers, thus formed by fractional crystallization or chromatographic means well known in the art, and subsequent recovery of the pure enantiomers. Various methods well known in the art may be used to to prepare the thienotriazolodiazepine compounds of Formula (1) with an enantiomeric excess of generally more than about 80%. Advantageously, preferred enantiomeric excess is of more than 80%, preferably of more than 90%, more preferably of more than 95%, and most preferably of 99% and more.

[00167] The solid dispersions of the present invention can be prepared by a number of methods, including by melting and solvent evaporation. The solid dispersions of the present invention can also be prepared according to the procedures described in: Chiou WL, Riegelman S:

“Pharmaceutical applications of solid dispersion systems”, *J. Pharm. Sci.* 1971; 60:1281-1302; Serajuddin ATM: “Solid dispersion of poorly water-soluble drugs: early promises, subsequent problems, and recent breakthroughs”, *J. Pharm. Sci.* 1999; 88:1058-1066; Leuner C, Dressman J: “Improving drug solubility for oral delivery using solid dispersions”, *Eur. J. Pharm. Biopharm.*

2000; 50:47-60; and Vasconcelos T, Sarmiento B, Costa P: "Solid dispersions as strategy to improve oral bioavailability of poor water soluble drugs", *Drug Discovery Today* 2007; 12:1068-1075, all of which are incorporated herein by reference in their entireties.

5 [00168] In one embodiment, solid dispersions of the present invention are prepared by a melting process. In one embodiment, the melting process comprises melting one or more of the various embodiments of the thienotriazolodiazepine of Formula (1) within a carrier. In one embodiment, the melting process includes cooling a melted compound of the present invention and a carrier. In one embodiment, the melting process comprises pulverization of the melted compound and the carrier. In one embodiment, a melted compound of the present invention and a carrier are pulverized
10 following the cooling step.

[00169] In some embodiments in which the thienotriazolodiazepine of Formula (1) or a pharmaceutically acceptable salt, a solvate, including a hydrate, a racemate, an enantiomer, an isomer, or an isotopically-labeled form thereof and the carrier are incompatible, a surfactant may be added during the melting step to prevent formation of two liquid phases or a suspension in the
15 heated mixture. In some embodiments, one or more of the various embodiments of the thienotriazolodiazepine of Formula (1) is suspended in a previously melted carrier, instead of using both drug and carrier in the melted state, thereby reducing the process temperature. In one embodiment, melted drug and carrier mixture is cooled in an ice bath with agitation. In one embodiment, melted drug and carrier mixture is cooled and solidified by spray cooling (alternatively spray
20 congealing).

[00170] In one embodiment, melted drug and carrier mixture is cooled and solidified by forming the melt into particles by spraying the melt into a cooling chamber through which ambient or cooled, low temperature air is passing. In one embodiment, melted drug and carrier mixture is cooled and solidified by atomization and re-solidification of the molten dispersion in a suitable fluid bed
25 processor. In one embodiment, melted drug and carrier mixture is cooled and solidified by melt-granulation in a heatable high-shear mixer.

[00171] In some embodiments, hot-stage extrusion or melt agglomeration may be used to avoid melting limitations of the drug. Hot-stage extrusion consists of the extrusion, at high rotational speed, of the drug and carrier, previously mixed, at melting temperature for a short period of time;
30 the resulting product is collected after cooling at room temperature and milled.

[00172] In one embodiment, one or more of the various embodiments of the thienotriazolodiazepine of Formula (1) is processed at a reduced processing temperature to avoid degradation of any thermally labile compound. In one embodiment, the reduced processing temperature is achieved by associating a hot-stage extrusion with a temporary plasticizer such as carbon dioxide. In one embodiment, melt agglomeration is used in the preparation of solid dispersions in accordance with the present invention in conventional high shear mixers or in a rotary processors. In one embodiment, the solid dispersion in accordance with the present invention is prepared by adding a molten carrier containing a thienotriazolodiazepine compound in accordance with the present invention to a heated excipient. In one embodiment, the solid dispersion in accordance with the present invention is prepared by adding by adding a molten carrier to a heated mixture of the thienotriazolodiazepine in accordance with the present invention and one or more excipients. In one embodiment, the solid dispersion in accordance with the present invention is prepared by heating a mixture of a thienotriazolodiazepine compound in accordance with the present invention, a carrier and one or more excipients to a temperature within or above the melting range of the carrier.

[00173] In some embodiments, a one or more of the various embodiments for the formulation of the thienotriazolodiazepine, according to Formula (1), is prepared by a solvent evaporation method. In one embodiment, the solvent evaporation method comprises solubilization of a thienotriazolodiazepine compound, according to Formula (1), and carrier in a volatile solvent that is subsequently evaporated. In one embodiment, the volatile solvent may one or more excipients. In one embodiment, the one or more excipients include, but are not limited to anti-sticking agents, inert fillers, surfactants wetting agents, pH modifiers and additives. In one embodiment, the excipients may dissolved or in suspended or swollen state in the volatile solvent.

[00174] In one embodiment, preparation of solid dispersions in accordance with the present invention includes drying one or more excipients suspended in a volatile solvent. In one embodiment, the drying includes vacuum drying, slow evaporation of the volatile solvent at low temperature, use of a rotary evaporator, spray-drying, spray granulation, freeze-drying, or use of supercritical fluids.

[00175] In one embodiment, spray drying preparation of a formulation for the thienotriazolodiazepine composition, according to Formula (1), is used which involves atomization of a suspension or a solution of the composition into small droplets, followed by rapid removal

solvent from the formulation. In one embodiment, preparation of a formulation in accordance with the present invention involves spray granulation in which a solution or a suspension of the composition in a solvent is sprayed onto a suitable chemically and/or physically inert filler, such as lactose or mannitol. In one embodiment, spray granulation of the solution or the suspension of the composition is achieved via two-way or three-way nozzles.

[00176] In some embodiments, preparation of solid dispersions in accordance with the present invention includes use of supercritical fluids. The term “supercritical fluids” refers to substances existing as a single fluid phase above their critical temperature and critical pressure. In one embodiment, preparation of a formulation, in accordance with the present invention, includes use a supercritical carbon dioxide fluid. In one embodiment, preparation of a formulation, in accordance with the present invention, using the supercritical fluid technique comprises dissolving a thienotriazolodiazepine compound, according to Formula (1), and carrier in a common solvent that is introduced into a particle formation vessel through a nozzle, simultaneously with carbon dioxide; and spraying the solution to allow the solvent be rapidly extracted by the supercritical fluid, thereby resulting in the precipitation of solid dispersion particles on the walls of the vessel.

[00177] In some embodiments, preparation of solid dispersions in accordance with the present invention includes use of a co-precipitation method. In one embodiment, a non-solvent is added dropwise to a thienotriazolodiazepine composition, according to Formula (1), and a carrier solution, under constant stirring. In one embodiment, the thienotriazolodiazepine composition, according to Formula (1), and the carrier are co-precipitated to form microparticles during the addition of the non-solvent. In one embodiment, the resulting microparticles are filtered and dried to provide the desired solid dispersion.

[00178] The proportion of compound of Formula (1) and polymeric carrier(s) to be mixed is not particularly limited, as long as it can improve the bioavailability of the compound of Formula (1) and varies depending on the kind of polymer.

[00179] The invention is illustrated in the following non-limiting examples.

VIII. Examples:

Example 1: In vitro screening of solid dispersions of compound (1-1)

[00180] Ten solid dispersions were prepared using compound (1-1) and one of five polymers, including hypromellose acetate succinate (HPMCAS-M), hypromellose phthalate (HPMCP-HP55),

polyvinylpyrrolidone (PVP), PVP-vinyl acetate (PVP-VA), and Euragit L100-55, at both 25% and 50% of compound (1-1) loading, for each polymer. Solid dispersions were prepared by a solvent evaporation method, using spray-drying followed by secondary drying in a low-temperature convection oven. The performance of each solid dispersion was assessed via a non-sink dissolution performance test which measured both the total amount of drug and the amount of free drug present in solution over time. Non-sink dissolution was chosen because it best represents the *in vivo* situation for low soluble compounds. This test included a “gastric transfer” of dispersion from gastric pH (0.1N NaCl, pH 1.0) to intestinal pH (FaSSSIF, pH 6.5) approximately 30 to 40 minutes after the introduction of dispersion to the test medium, simulating *in vivo* conditions. [FaSSSIF is Fasted State Simulated Intestinal Fluid, comprised of 3 mM sodium taurocholate, 0.75 mM lechithin, 0.174 g NaOH pellets, 1.977 g NaH₂PO₄•H₂O, 3.093 g NaCl, and purified water qs 500 mL.] The amount of dissolved drug was quantified using a high-performance liquid chromatography (HPLC) method and an Agilent 1100 series HPLC. The dissolution profiles of the formulations (Figures 1A-1J) showed large increases in drug solubility in all dispersion candidates relative to the unformulated compound in the same media. Of the solid dispersions, the 25% compound (1-1) in PVP, 25% compound (1-1) in HPMCAS-M, and 50% compound (1-1) in HPMCAS-M dispersions provided enhanced oral absorption as compared to the unformulated compound, based on finding higher levels of free drug released at intestinal pH.

Example 2: *In vivo* screening of solid dispersions of compound (1-1)

[00181] The solid dispersions of compound (1-1), namely the 25% compound (1-1) in PVP, 25% compound (1-1) in HPMCAS-MG, and 50% compound (1-1) in HPMCAS-M dispersions, were prepared at larger scale for *in vivo* studies. Each formulation was assessed in the *in vitro* dissolution test described in Example 1. To ensure that these dispersions were both amorphous and homogeneous, each dispersion was assessed by powder x-ray diffraction (PXRD) and modulated differential scanning calorimetry (mDSC). The x-ray diffractometer was a Bruker D-2 Phaser. Additionally, to understand the effect of water on the glass transition temperature (T_g) for each dispersion, mDSC was performed on samples first equilibrated at a set relative humidity (i.e., 25%, 50%, and 75% RH) for at least 18 hours. Water can act as a plasticizer for solid dispersions and the hygroscopicity of the system due to the active compound or polymer can affect the amount of water uptake by these systems.

[00182] The non-sink dissolution results (Figures 2A-2C) were comparable to those found for the dispersions in Example 1. PXRD results (Figure 3) showed no evidence of crystalline compound in

any of the dispersions and mDSC results (Figures 4A-4C) showed a single glass transition temperature (T_g) for each dispersion, indicating that each dispersion was homogeneous. An inverse relationship between T_g and relative humidity was observed for each (Figure 5). Notably, for the 25% compound (1-1) in PVP solid dispersion equilibrated at 75% RH, there appeared to be two T_g s, indicating that phase separation was occurring, and this dispersion also showed a melt event at 75% RH, suggesting that crystallization occurred during the RH equilibration (Figure 6). This finding suggests that the 25% compound (1-1) in PVP dispersion may be less stable than the HPMCAS-M dispersions.

[00183] To assess the bioavailability of the three dispersions, groups of male beagle dogs (three per group) were given a 3 mg/kg dose of an aqueous suspension of solid dispersion of compound (1-1) administered by oral gavage or a 1 mg/kg dose of compound (1-1) dissolved in water:ethanol:polyethylene glycol (PEG) 400 (60:20:20) and administered as an intravenous bolus into the cephalic vein. Blood samples were collected from the jugular vein of each animal at 0 (pre-dose), 5, 15, and 30 minutes and 1, 2, 4, 8, 12, and 24 hours following intravenous administration and at 0 (pre-dose), 15 and 30 minutes and 1, 2, 4, 8, 12, and 24 hours following oral gavage administration. The amount of compound (1-1) present in each sample was detected using a qualified LC-MS/MS method with a lower limit of quantification of 0.5 ng/mL. The area under the plasma concentration-time curve (AUC) was determined by use of the linear trapezoidal rule up to the last measurable concentration without extrapolation of the terminal elimination phase to infinity. The elimination half-life ($t_{1/2}$) was calculated by least-squares regression analysis of the terminal linear part of the log concentration-time curve. The maximum plasma concentration (C_{max}) and the time to C_{max} (t_{max}) were derived directly from the plasma concentration data. The oral bioavailability (F) was calculated by dividing the dose normalized AUC after oral administration by the dose normalized AUC after intravenous administration and reported as percentages (%). Results, summarized in Table 1 below, gave mean oral bioavailabilities of the 25% compound (1-1) in PVP, 25% compound (1-1) in HPMCAS-M, and 50% compound (1-1) in HPMCAS-M solid dispersions of 58%, 49%, and 74%, respectively.

Table 1: Pharmacokinetic parameters of compound (1-1) after oral (po) and intravenous (iv) administrations to dogs (the values are averages from three dogs)

Compound (1-1) formulation	Dose & Route	C_{max} (ng/L)	t_{max} (hr)	AUC (ng•min/mL)	$t_{1/2}$ (hr)	F (%)
Solution in water:ethanol: PEG400 (60:20:20)	1 mg/kg IV	769	0.083	53,312	1.5	----

Aqueous suspension of 25% compound (1-1)/PVP solid dispersion	3 mg/kg PO	487	1.0	93,271	1.6	58
Aqueous suspension of 25% compound (1-1)/HPMCAS-M solid dispersion	3 mg/kg PO	228	0.5	78,595	2.0	49
Aqueous suspension of 50% compound (1-1)/HPMCAS-M solid dispersion	3 mg/kg PO	371	1.0	118,174	1.5	74

AUC: area under the plasma concentration-time curve; C_{max}: maximum plasma concentration; F: bioavailability; HPMCAS: hypromellose acetate sodium; IV: intravenous; PEG: polyethylene glycon; PO; *per os*, oral; PVP: polyvinylpyrrolidone; t_{max}: time of C_{max}; t_{1/2}: plasma elimination half-life

Example 3: Preparation and clinical use of capsules containing a solid dispersion of compound (1-1)

[00184] A gelatin capsule of 10 mg strength was prepared for initial clinical studies in patients with hematologic malignancies. Based on results of *in vitro* and *in vivo* testing of solid dispersions of compound (1-1), as described in Examples 1 and 2, a 50% compound (1-1) in HPMCAS-M solid dispersion was selected for capsule development. Capsule development was initiated targeting a fill weight of 190 mg in a size 3 hard gelatin capsule, as this configuration would potentially allow increasing the capsule strength by filling a larger size capsule while maintaining the pharmaceutical composition. Based on experience, four capsule formulations were designed with different amounts of disintegrant and with and without wetting agent. Since all four formulations showed similar disintegration test and dissolution test results, the simplest formulation (without wetting agent and minimum disintegrant) was selected for manufacturing. Manufacturing process development and scale-up studies were performed to confirm the spray drying process and post-drying times for the solid dispersion; blending parameters; roller compaction and milling of the blend to achieve target bulk density of approximately 0.60 g/cc; and capsule filling conditions.

[00185] Crystalline compound (1-1) and the polymer hypromellose acetate succinate (HPMCAS-M) were dissolved in acetone and spray-dried to produce solid dispersion intermediate (SDI) granules containing a 50% compound (1-1) loading. The SDI was shown by PXRD analysis to be amorphous and by mDSC analysis to be homogeneous (i.e., single Tg under ambient conditions). The 50% compound (1-1) in HPMCAS-M solid dispersion (1000 g) and excipients, including microcrystalline cellulose filler-binder (4428 g), croscarmellose sodium disintegrant (636 g), colloidal silicon dioxide dispersant/lubricant 156 g), magnesium stearate dispersant/lubricant (156 g), and lactose monohydrate filler (5364 g) were blended in stages in a V-blender. The blend was

them compacted and granulated to obtain a bulk density of approximately 0.6 g/mL. The blend was dispensed into size 3 hard gelatin capsules (target fill weight: 190 mg) using an automated filling machine and finished capsules were polished using a capsule polisher machine.

[00186] Pharmacokinetic assessments were performed following oral dosing of 10 mg capsules containing the 50% compound (1-1) in HPMCAS solid dispersion and results were compared with pharmacokinetic assessments performed following oral dosing of administration of 4 x 10 mg capsules containing the Eudragit solid dispersion of compound (1-1) to healthy volunteers

[00187] A comparison of the two pharmaceutical compositions is provided in Tables 2A and 2B below. The Eudragit formulation previously was described in Example 5 in US Patent Application

2009/0012064 A1, published January 8, 2009. That application noted that the Eudragit solid dispersion formulation was made by dissolving and/or dispersing the thienotriazolodiazepine of formula (A) and coating excipients, including ammonio methacrylate copolymer type B (Eudragit RS), methacrylic acid copolymer type C (Eudragit L100-55), talc, and magnesium aluminosilicate, in a mixture of water and ethanol. This heterogeneous mixture then was applied to microcrystalline cellulose spheres (Nonpareil 101, Freund) using a centrifugal fluidizing bed granulator to produce granules that were dispensed into size 2 hydroxypropyl methylcellulose capsules.

[00188] In both clinical studies, blood levels of compound (1-1) were determined using validated LC-MS/MS methods and pharmacokinetic analyses were performed based on plasma concentrations of compound (1-1) measured at various time points over 24 hours after capsule administration.

Results, summarized in Table 3 below, showed that the HPMCAS-M solid dispersion formulation had over 3-fold higher bioavailability in humans than the Eudragit solid dispersion formulation based on AUCs (924*4 / 1140, adjusting for difference in doses administered). Additionally, based on the observed T_{max} , the HPMCAS formulation is more rapidly absorbed than the Eudragit formulation (T_{max} of 1 h vs 4-6 h). The marked improvement in systemic exposure with the HPMCAS-M solid dispersion formulation is unexpected.

Table 2A: Solid dispersion capsules of compound (1-1) for clinical use

pharmaceutical composition containing 50% HPMCAS solid dispersion of compound (1-1):
10 mg strength, size 3 hard gelatin capsule

Ingredient	Function	Capsule Content	
		mg	Wt %
Compound of formula (II)	active agent	10.0*	5.56
Hypromellose acetate succinate (HPMCAS-M)	carrier for solid dispersion	10.0	5.56
Lactose monohydrate	filler	85.0	47.22
Microcrystalline cellulose	filler-binder	70.0	38.89

Croscarmellose sodium	disintegrant	10.0	5.56
Colloidal silicon dioxide	dispersant/lubricant	2.5	1.39
Magnesium stearate	dispersant/lubricant		
Total		190.0	100.0

Table 2B: Pharmaceutical composition containing Eudragit L100-55 solid dispersion of compound (1-1): 10 mg strength, size 2 hard gelatin capsule

Ingredient	Function	Capsule Content	
		mg	Wt %
Compound (1-1)	active agent	10.0*	3.8
Core:			
Microcrystalline cellulose spheres (Nonpareil 101, Freund, Inc)	vehicle	100.0	38.5
Compound/polymer layer:			
Ammonio methacrylate copolymer, type B (NF. PhEur) (Eudragit RS, Evonik)	coating agent	10.8	4.2
Methacrylic acid copolymer, type C (NF)/ Methacrylic acid-ethyl acrylate copolymer (1:1) type A (PhEur) (Eudragit L100-55, Evonik)	coating agent	25.2	9.7
Talc	coating agent	88.2	33.9
Magnesium aluminometasilicate (Neuslin, Fuji Chemical)	coating agent	20.0	7.7
Triethyl citrate	plasticizer	5.0	1.9
Silicon dioxide	fluidizing agent	0.8	0.3
		260.0	100.0

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* as anhydrate

Table 3: Pharmacokinetic parameters following oral administration of solid dispersions of compound (1-1) to humans

Compound (1-1) formulation	# Patients	Dose and Route	C _{max} (ng/mL)	T _{max} (hr)	AUC _{0-24h} (ng•h/mL)
Eudragit solid dispersion formulation	7	40 mg PO	83	4 to 6	1140
50% HPMCAS-M solid dispersion formulation	7	10 mg PO	286	1	925

10 AUC_{0-24h}: area under the compound (1-1) plasma concentration vs. time curve over 24 hours

C_{max}: maximum concentration in plasma

hr: hour

HPMCAS: hypromellose acetate succinate

mL: milliliter

15 ng: nanogram

PO: *per os*, oral

T_{max}: time of C_{max}

[00189] Example 4. Oral exposure in the rat

[00190] The oral bioavailability of three formulations of solid dispersions of compound (1-1) was determined in rats. The three dispersions chosen were the 25% dispersion of compound (1-1) in PVP, the 25% dispersion of compound (1-1) in HPMCAS-MG, and the 50% dispersion of compound (1-1) in HPMCAS-MG. The animals used in the study were Specific Pathogen Free (SPF) Hsd:Sprague Dawley rats obtained from the Central Animal Laboratory at the University of Turku, Finland. The rats were originally purchased from Harlan, The Netherlands. The rats were female and were ten weeks of age, and 12 rats were used in the study. The animals were housed in polycarbonate Makrolon II cages (three animals per cage), the animal room temperature was 21 +/- 3 °C, the animal room relative humidity was 55 +/- 15%, and the animal room lighting was artificial and was cycled for 12 hour light and dark periods (with the dark period between 18:00 and 06:00 hours). Aspen chips (Tapvei Oy, Estonia) were used for bedding, and bedding was changed at least once per week. Food and water was provided prior to dosing the animals but was removed during the first two hours after dosing.

[00191] The oral dosing solutions containing the 25% dispersion of compound (1-1) in PVP, the 25% dispersion of compound (1-1) in HPMCAS-MG, and the 50% dispersion of compound (1-1) in HPMCAS-MG were prepared by adding a pre-calculated amount of sterile water for injection to containers holding the dispersion using appropriate quantities to obtain a concentration of 0.75 mg/mL of compound (1-1). The oral dosing solutions were subjected to vortex mixing for 20 seconds prior to each dose. The dosing solution for intravenous administration contained 0.25 mg/mL of compound (1-1) and was prepared by dissolving 5 mg of compound (1-1) in a mixture containing 4 mL of polyethylene glycol with an average molecular weight of 400 Da (PEG400), 4 mL of ethanol (96% purity), and 12 mL of sterile water for injection. The dosing solution containing the 25% dispersion of compound (1-1) in PVP was used within 30 minutes after the addition of water. The dosing solutions containing the 25% dispersion of compound (1-1) in HPMCAS-MG and the 50% dispersion of compound (1-1) in HPMCAS-MG were used within 60 minutes of after the addition of water. A dosing volume of 4 mL/kg was used to give dose levels of compound (1-1) of 1 mg/kg for intravenous administration and 3 mg/kg for oral administration. The dosing scheme is given in Table 4.

[00192] Table 4. Dosing scheme for rat oral exposure study.

Rat	Weight	Dose (mL)	Test Item	Route
1	236.5	0.95	Compound (1-1)	intravenous
2	221	0.88	Compound (1-1)	intravenous

3	237.5	0.95	Compound (1-1)	intravenous
4	255.5	1.02	25% dispersion of compound (1-1) in PVP	oral
5	224.2	0.90	25% dispersion of compound (1-1) in PVP	oral
6	219.2	0.88	25% dispersion of compound (1-1) in PVP	oral
7	251.6	1.01	25% dispersion of compound (1-1) in HPMCAS-MG	oral
8	240.4	0.96	25% dispersion of compound (1-1) in HPMCAS-MG	oral
9	238	0.95	25% dispersion of compound (1-1) in HPMCAS-MG	oral
10	226.6	0.91	50% dispersion of compound (1-1) in HPMCAS-MG	oral
11	228.4	0.91	50% dispersion of compound (1-1) in HPMCAS-MG	oral
12	228.5	0.91	50% dispersion of compound (1-1) in HPMCAS-MG	oral

[00193] Blood samples of approximately 50 μL were collected into Eppendorf tubes containing 5 μL of ethylenediaminetetraacetic acid (EDTA) solution at time points of 0.25, 0.5, 1, 2, 4, 8, 12, and 24 hours after dosing, with each sample collected within a window of 5 minutes from the prescribed time point. From each sample, 20 μL of plasma was obtained and stored at dry ice temperatures for analysis. Analysis of each sample for the concentration of compound (1-1) was performed using a validated liquid chromatography tandem mass spectrometry (LC-MS/MS) method with a lower limit of quantitation of 0.5 ng/mL.

[00194] Pharmacokinetic parameters were calculated with the Phoenix WinNonlin software package (version 6.2.1, Pharsight Corp., CA, USA) with standard noncompartmental methods. The elimination phase half-life ($t_{1/2}$) was calculated by least-squares regression analysis of the terminal linear part of the log concentration-time curve. The area under the plasma concentration-time curve (AUC) was determined by use of the linear trapezoidal rule up to the last measurable concentration and thereafter by extrapolation of the terminal elimination phase to infinity. The mean residence time (MRT), representing the average amount of time a compound remains in a compartment or system, was calculated by extrapolating the drug concentration profile to infinity. The maximum

plasma concentration (C_{\max}) and the time to C_{\max} (t_{\max}) were derived directly from the plasma concentration data. The tentative oral bioavailability (F) was calculated by dividing the dose normalised AUC after oral administration by the dose normalised AUC after intravenous administration, i.e. $F = (AUC(\text{oral})/\text{Dose}(\text{oral})) / (AUC(\text{intravenous}) / \text{Dose}(\text{intravenous}))$ and is reported as percentage (%).

[00195] The pharmacokinetic parameters are given in Table 5, and the plasma concentration versus time plots are shown in Figures 7 and 8.

Table 5. Pharmacokinetic parameters of compound (1-1) after oral and intravenous administrations. The values are an average from three animals.

Compound	Parameter	1 mg/kg intravenous	3 mg/kg oral	F(%)
Compound (1-1) water:ethanol:PEG 400 (60:20:20)	AUC (min*ng/ml) C_{\max} (ng/ml) T_{\max} (hr) $t_{1/2}$ (hr) 8.5 CI/F (ml/min/kg) MRT (hr)	74698 730 0.25 8.5 13.4 7.4		
25% dispersion of compound (1-1) in PVP	AUC (min*ng/ml) C_{\max} (ng/ml) T_{\max} (hr) $t_{1/2}$ (hr) 8.5 CI/F (ml/min/kg) MRT (hr)		39920 77.9 1 13.8 75.2 18.0	18
25% dispersion of compound (1-1) in HPMCAS-MG	AUC (min*ng/ml) C_{\max} (ng/ml) T_{\max} (hr) $t_{1/2}$ (hr) 8.5 CI/F (ml/min/kg) MRT (hr)		35306 48.3 0.5 11.0 85.0 17.1	16
50% dispersion of compound (1-1) in HPMCAS-MG	AUC (min*ng/ml) C_{\max} (ng/ml) T_{\max} (hr) $t_{1/2}$ (hr) 8.5 CI/F (ml/min/kg) MRT (hr)		40238 67.0 2 9.5 74.6 12.8	18

[00196] Example 5. Preparation of spray dried dispersions.

[00197] Spray dried dispersions of compound (1-1) were prepared using five selected polymers: HPMCAS-MG (Shin Etsu Chemical Co., Ltd.), HPMCP-HP55 (Shin Etsu Chemical Co., Ltd.), PVP (ISP, a division of Ashland, Inc.), PVP-VA (BASF Corp.), and Eudragit L100-55 (Evonik Industries

AG). All spray dried solutions were prepared at 25% and 50% by weight with each polymer. All solutions were prepared in acetone, with the exception of the PVP solutions, which were prepared in ethanol. For each solution, 1.0 g of solids (polymer and compound (1-1)) were prepared in 10 g of solvent. The solutions were spray dried using a Büchi B-290, PE-024 spray dryer with a 1.5 mm
5 nozzle and a Büchi B-295, P-002 condenser. The spray dryer nozzle pressure was set to 80 psi, the target outlet temperature was set to 40 °C, the chiller temperature was set to -20 °C, the pump speed was set to 100%, and the aspirator setting was 100%. After spray drying, the solid dispersions were collected and dried overnight in a low temperature convection oven to remove residual solvents.

[00199] Example 6: Stability with humidity and temperature.

[00200] Table 6

Test	Procedure	Acceptance Criteria	T=0 (Initial)	T-1 month (storage at 40°C/75%RH)	T-2 month (storage at 40°C/75%RH)	T= 3 month (storage at 40°C/75%RH)
Appearance	AM-0002	White to off-white powder	Test Date/Ref: 06Aug2012/02-41-2 White Powder	Test Date/Ref: 24Sep2012/02-41-59 White Powder	Test Date/Ref: 24Oct2012/02-37-106 White Powder	Test Date/Ref: 17Dec2012/02-37-119 White Powder
Potency (HPLC)	AM-0028	45.0 • 55.0 wt%	Test Date/Ref: 25Jul2012/02-37-21 50.0	Test Date/Ref: 25Sep2012/02-41-0 49.4	Test Date/Ref: 24Oct2012/02-37-105 49.8	Test Date/Ref: 29Nov2012/02-34-107 49.2
Individual Related Substances (HPLC)	AM-0029	Report results	Test Date/Ref: 25Jul2012/02-34-49 RRT % Area No reportable related substances	Test Date/Ref: 26Sep2012/02-41-64 RRT % Area No reportable related substances	Test Date/Ref: 24Oct2012/02-37-105 RRT % Area 0.68 0.06 0.77 0.06	Test Date/Ref: 29Nov2012/02-34-107 RRT % Area 0.68 0.07 0.77 0.09
Total Related Substances (HPLC)	AM-0029	Report results	Test Date/Ref: 25Jul2012/02-34-49 No reportable related substances	Test Date/Ref: 26Sep2012/02-41-64 No reportable related substances	Test Date/Ref: 24Oct2012/02-37-105 0.12%	Test Date/Ref: 29Nov2012/02-34-107 0.16%
Water Content (KF)	AM-0030 USP <921>	Report results (wt%)	Test Date/Ref: 02Aug2012/02-41-1 1.52	Test Date/Ref: 27Sep2012/02-37-99 2.53	Test Date/Ref: 25Oct2012/02-37-110 2.70	Test Date/Ref: 29Nov2012/02-37-116 3.43
X-Ray Powder Diffraction (XRPD)	USP <941>	Consistent with an amorphous form	Test Date/Ref: 24Jul2012/02-24-131 Consistent with an amorphous form See Figure 9	Test Date/Ref: 01Oct2012/02-41-73 Consistent with an amorphous form See Figure 10	Test Date/Ref: 24Oct2012/02-37-107 Consistent with an amorphous form See Figure 11	Test Date/Ref: 17Dec2012/02-37-120 Consistent with an amorphous form See Figure 12
Modulated Differential Scanning Calorimetry (mDSC)	USP <891> (n = 2 replicates)	Report individual and average glass transition temperatures (T _g , °C)	Test Date/Ref: 24Jul2012/02-24-130 Replicate 1 = 134.30°C, Replicate 2 = 134.23°C, Replicate 3 = 135.28°C, Average = 134.60°C	Test Date/Ref: 26Sep2012/02-37-98 Replicate 1 = 134.65°C, Replicate 2 = 134.43°C, Average = 134.54°C	Test Date/Ref: 24Oct2012/02-37-108 Replicate 1 = 135.35°C, Replicate 2 = 134.93°C, Average = 135.14°C	Test Date/Ref: 17Dec2012/02-37-121 Replicate 1 = 134.36°C, Replicate 2 = 137.16°C, Average = 135.76°C

[00201] Spray dried dispersions of compound (1-1) in HPMCAS-MG were assessed for stability by exposure to moisture at elevated temperature. The glass transition temperature (T_g) as a function of relative humidity was determined at 75% relative humidity, 40 °C for 1, 2 and 3 months. The spray dried dispersion was stored in an LDPE bag inside a HDPE bottle to simulate bulk product packaging. The

- results are summarized in Table 6. At time zero, the T_g was 134 °C, at 1 month the T_g was 135 °C and at 3 months the T_g was 134 °C and only a single inflection point was observed for each measurement. X-ray diffraction patterns were also obtained for each sample. Figure 9 illustrates a powder X-ray diffraction profile of solid dispersions of compound (1-1) in HPMCAS-MG at time zero of a stability test. Figures 10, 11, and 12 illustrate a powder X-ray diffraction profile of solid dispersions of compound (1-1) in HPMCAS-MG after 1-, 2-, and 3-months, respectively, at 40 °C and 75 % relative humidity. The patterns did not show any diffraction lines associated with compound (1-1).
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[00202] Example 7: *In vitro* Treatment of Triple Negative Breast Cancer Cell Lines.

[00203] Compound (1-1) growth inhibition concentrations 50% (GI50) value was determined in HCC197, MDA-MB-231 and MDA-MB-468 human-derived TNBC cell lines. Cells were exposed to increasing doses of compound (1-1) for 72 h, and cell proliferation was evaluated with the MTT assay. The growth inhibitory 50% (GI50) concentrations and the maximum effect (Emax) values were calculated with the equation for sigmoidal dose response using Prism 5.00 for Windows. Compound (1-1) showed antiproliferative activity in the 3 cell lines after 72 hours, with GI50 values ranging from 81.7 to 448.3 nM as shown in Figure 13.

[00204] Results are expressed as the concentration that inhibits 50% of cell growth (GI50). Emax % indicates the maximum inhibitory effect induced by compound (1-1) on cell proliferation (percent with respect to control untreated cells). Both values are indicated as means with 95% confidence intervals. In all cases, $n \geq 4$.

[00205] The effect of compound (1-1) on the cell cycle was evaluated following exposure for 24, 48 and 72 h. Cells were staining with propidium iodide then analyzed using a FACScan flow cytometer. HCC1937, MDA-MB- 231 and MDA-MB-468 cell lines were simultaneously treated with compound (1-1) (75 nM for MDA-MB-231 cells and 650 nM for the two other cell lines) for 24, 48 and 72 h. After 72 h of treatment, control and treated cells were washed with PBS and re-incubated with compound (1-1) free medium (drug washout). As show in Figure 14A-14C, significant differences in the percentage of compound (1-1) –treated cells in the G1, S and G2/M phases with respect to untreated controls were determined by a one-way ANOVA test ($p < 0.001$) followed by an SNK a posteriori test. After washout, significant differences in the percentage of cells in a given cell cycle phase between control and pre-treated cells were determined with the Student t-test for independent samples with equal or different variance, as appropriate. *, × and # means significant difference between treated cells respect and controls in G1 phase (* $p < 0.05$, ** $p < 0.01$), G2/M phase (× $p < 0.05$, ×× $p < 0.01$) and S phase $p < 0.05$, ## $p < 0.01$), respectively. Each bar and vertical line represents the mean \pm SEM, respectively ($n \geq 3$). In the three TNBC cell lines, 24 hour-compound (1-1) exposure induced a significant ($p < 0.05$) increase in the percentage of cells in G1, with a reduction of cells in the S phase. In HCC1937 and MDA-MB-231 cells, however, this blockade was transient since they recovered the control cell cycle pattern after 48 h of drug washout. Interestingly, after drug washout MDA-MB-468 cell line showed a substantial ($p < 0.05$) accumulation of cells in G2/M phase in detriment of cells in G1 stage.

[00206] The expression levels of BRD2/3/4 as well as c-Myc were analyzed by both Western blotting with commercial antibodies and RT-PCR in the three TNBC cell lines, in untreated cells and after 24, 48 and 72 hours exposure of compound (1-1) (75 nM for MDA-MB231 cells and 650 nM for HCC1937 and MDA-MB-468 cell lines). RT-PCR was done with Fast SYBR Green Master Mix on a StepOnePlus Real-Time PCR System for 24, 48 and 72 h (B panel). As shown in Fig. 14, significant differences in the mRNA levels were determined by one-way ANOVA test ($p < 0.001$) followed by SNK a posteriori test ($*p < 0.05$, $**p < 0.01$). Logarithmic transformation of the variable was applied before the ANOVA test if required. Basal levels of C-MYC, BRD2, BRD3 and BRD4 for HCC1937, MDA-MB-231 and MDA-MB-468 cell are shown in Fig. 15A-15E. As shown in Fig. 16A-C, Western blots are representative of three independent experiments where each bar and vertical line represents the mean \pm SEM, respectively ($n = 3$). As shown in Fig. 15D-15G, C-MYC protein and mRNA levels were unchanged by Compound (1-1) treatment in all the three cell lines. Compound (1-1) down-regulated ($p < 0.05$) c-Myc expression (mRNA and proteins) in MDA-MB-468 cells. BRD2 levels were increased ($p < 0.05$) in MDA-MB231 and MDA-MB-468 cells. Compound (1-1) also reduced ($p < 0.05$) mRNA levels of BRD3 in HCC1937 and MDA-MB-468 cells.

[00207] Compound (1-1) was combined with everolimus and the combination index (CI) determined by the Chou-Talalay method ($CI < 1$, synergy; $CI \approx 1$, additivity; $CI > 1.1$, antagonism). The antiproliferative activity of concomitant compound (1-1) and everolimus was evaluated by the MTT assay after 72 hour in the indicated cells lines. Everolimus had an additive effect simultaneously combined with Compound (1-1) in HCC1937 and MDA-MB-231 cells ($CI = 1.02$ and 0.94 , respectively), and was antagonistic in the MDA-MB-468 cell line ($CI = 1.60$), Figs. 17A and 17B. Baseline expression of BRD2/3/4 and C-MYC protein and mRNA did not correlate with sensitivity to Compound (1-1), nor did the combination effect of both drugs.

[00208] Example 8: *In vivo* Treatment of mice.

[00209] *In vivo* assays were performed in 8-week-old female MDA-MB-231 nude mice-derived xenografts. 10×10^6 cells were injected, when tumor volume reached 100 mm^3 , mice were randomized to 4 groups ($n=9$): 1) vehicle; 2) 50 mg/kg Compound (1-1) (BID, po); 3) 2 mg/kg of everolimus (3 time a week, ip); 4) combination Compound (1-1) and everolimus; 4 weeks treatment.

[00210] As illustrated in Figure 18A, tumor weight was compared between the different drugs regimens at each time point using a two way ANOVA test ($p < 0.001$) followed by a Bonferroni a posteriori test during the treatment period and subsequently. Symbols with • indicate significant

differences between treatment vs. vehicle-treated mice ($p < 0.05$). * indicates a significant difference in the tumor mass between the combination treated animals and the two single agent groups (* $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$). Results represent the mean \pm SEM (during the treatment period, $n = 9$). Variation of animal body weight during treatment is illustrated in Fig. 18B.

5 In vivo, Compound 1-1-treated xenografts showed a significant ($p < 0.05$) reduction in tumor mass with respect to vehicle-treated mice (best T/C% = 40.7) after 19 days of treatment without body weight loss. Although everolimus alone was not active, combination with Compound (1-1) was the most effective treatment strategy (best T/C% = 20.7). The T/C ratio was 39% after 10 days of combination treatment, with an optimal value of 21% on day 23. Compound (1-1) can be used for
10 the treatment of TNBC, either alone or in combination with mTOR inhibitors.

[00211] Example 9

[00212] Compound (1-1) growth inhibition concentrations 50% (GI_{50}) values were determined in HCC197, MDA-MB-231 and MDA-M B-468 human-derived TNBC cell lines after 48 and 72 h in normoxia and hypoxia (0.1% atmospheric O_2), employing the MTT assay and cell counting. RT-
15 PCR was performed with Fast SYBR Green Master Mix on a StepOnePlus Real-Time PCR System at baseline, and after 24, 48 and 72 h of 500 nM compound (1-1). Compound (1-1) was combined with docetaxel or the mTOR inhibitor, everolimus, and the combination index (CI) determined by the Chou-Talalay method (CI<0.9, synergy; CI=0.9-1.1, additivity; CI>1.1, antagonism).

[00213] Compound (1-1) showed antiproliferative activity in the 3 cell lines after 48- and 72-h
20 treatments in normoxia and hypoxia. MDA-MB-231 was the most sensitive in both conditions. Hypoxia significantly ($p < 0.05$) increased the antiproliferative activity of compound (1-1) in MDA-MB-468 cells. In addition, the antitumor effect of compound (1-1) was accompanied - in these cells only - with a marked ($p < 0.05$) reduction in the expression levels of c-MYC and n-MYC. The three cell lines presented a substantial increase in p21 expression following compound (1-1) exposure,
25 correlating with G1 cell cycle arrest. Everolimus had an additive effect when simultaneously combined with compound (1-1) in HCC1937 and MDA-MB-231 cells (CI=1.02 and 0.94, respectively), and was antagonistic in MDA-MB-468 cells (CI=1.60). Likewise, docetaxel also had an additive effect when simultaneously combined with compound (1-1) in HCC1937 and MDA-MB-231 cells (CI=1.03 and 0.95 respectively), and showed a slight synergism in MDA-MB-468
30 cells (CI=0.87).

[00214] These preclinical data support the further development of compound (1-1) in the clinical setting for TNBC, alone or in combination with mTOR inhibitors. A single agent Phase Ib study in solid tumor patients including TNBC is underway.

[00215] Example 10

5 [00216] The aim of this work was to evaluate *in vitro* antitumor activity of compound (1-1) both in normoxic and hypoxic environments, as well as in combination with the mTOR inhibitor everolimus and docetaxel.

[00217] Experimental Procedures: The antiproliferative activity of compound (1-1) was evaluated in three human-derived TNBC cell lines: HCC1937, MDA-MB-231 and MDA-MB-468. Cells were
10 exposed to increasing concentrations of compound (1-1) for 48 and 72 h in normoxia and hypoxia (0.1% atmospheric O₂). MTT assays and cell counting were employed for assessing proliferation. The concentration that inhibits 50% of cell growth (GI₅₀) and the maximum inhibitory effect induced by compound (1-1) at 6 μ M (E_{max} %) were calculated with the equation for sigmoidal dose response using Prism 5.00 for Windows. The effect of compound (1-1) on the cell cycle was
15 evaluated under normoxic conditions following exposure for 24, 48 and 72 h. Cells were stained with propidium iodide and then analyzed using a FACScan flow cytometer. As targets of compound (1-1), the basal expression levels of BRD2/3/4 as well as c-Myc were analyzed by both Western blotting and RT-PCR in TNBC cell lines under normoxia. mRNA and protein levels of BRD2/3/4, c-Myc, n-Myc and CDKN1A (p21) were also evaluated after 24, 48 and 72 h exposure to compound
20 (1-1) at the indicated concentrations in TNBC cell line models. Antiproliferative effects of compound (1-1) combined with RAD001 or docetaxel for 48 and 72 h under normoxia and hypoxia was evaluated in the three TNBC cell lines. Combination effects were evaluated using the combination index (CI) determined by the Chou-Talalay method (CI < 0.90, synergism; 0.90 \leq CI \leq 1.10, additive effect; CI > 1.10, antagonism).

25 [00218] As shown in Table 7, compound (1-1) antiproliferative effects were seen in the HCC1937 and MDA-MB-231 cell lines under both normoxic and hypoxic conditions. MDA-MB-468 cells were only sensitive to compound (1-1) under hypoxia.

[00219] Table 7. Compound (1-1) GI₅₀ and E_{max} values after 48 h treatment

		Compound (1-1) (48 h exposure)			
		Normoxia		Hypoxia	
Cell Line	Method	GI ₅₀ (nM)	E _{max} %	GI ₅₀ (nM)	E _{max} %
	Cell Count	>6000	31	>6000	27

HCC1937			(22-41)		(16-39)
	MTT	109.8	41	23.1	60
		(28.6-421.6)	(23-59)	(8.8-60.6)	(54-67)
	Cell Count	92.2	71	144.3	67
MDA-MB		(63.4-134.0)	(64-78)	(51.8-396.0)	(50-83)
	MTT	131.9	71	63.3	68
		(80.2-217.0)	(62-79)	(35.3-113.3)	(60-76)
	Cell Count	>6000	30	60.6*	50
MDA-MB-468			(21-40)	(31.3-117.3)	(44-56)
	MTT	>6000	<10	258.0*	53
				(80.2-830.1)	(31-74)

[00220] The results in Table 7 are expressed as the concentration that inhibits 50% of cell growth (GI_{50}). $E_{max}\%$ indicates the maximum inhibitory effect induced by compound (1-1) on cell proliferation at 6 μ M (percent with respect to control untreated cells). Both values are indicated as means with 95% confidence intervals. When $E_{max}\% \leq 60\%$, the IG_{50} values are considered apparent (*). In all cases, $n \geq 4$.

[00221] As shown in Fig. 19, in all cell lines, 24 h-compound (1-1) exposure induced a significant ($p < 0.05$) increase in the percentage of cells in G1, with a concomitant reduction of cells in the S phase. HCC1937, MDA-MB-231 and MDA-MB-468 cell lines were simultaneously treated with compound (1-1) (75 nM for MDA-MB-231 cells and 650 nM for the two other cell lines) for 24, 48 and 72 h. In all cases, cells were stained with propidium iodide and analyzed by flow cytometry. Significant differences in the percentage of compound 1-1-treated cells in the G1, S and G2/M phases with respect to untreated control cells were determined by a one-way ANOVA test ($p < 0.01$) followed by an SNK a posteriori test. *, \times , and # mean significant differences between treated cells and controls in G1 cell cycle phase (* $p < 0.05$, ** $p < 0.01$), G2/M phase ($\times p < 0.05$, $\times \times p < 0.01$) and S phase (# $p < 0.05$, ## $p < 0.01$), respectively. Each bar and vertical line represents the mean \pm SEM, respectively ($n \geq 3$).

[00222] As shown in Figs. 20A and 20B, compound (1-1) downregulated ($p < 0.01$) c-Myc expression (mRNA and protein) and mRNA levels of BRD4 and n-Myc ($p < 0.05$) in MDA-MB-468 cells. BRD2 levels were increased in MDA-MB-231 and MDA-MB-468 cells ($p < 0.05$ and $p <$

0.01, respectively). CDKN1A (p21) mRNA levels were increased in all three cell models ($p < 0.001$). The expression of BRD2/3/4, p21, n-Myc and c-Myc in terms of mRNA and proteins levels were evaluated in HCC1937, MDA-MB-231 and MDA-MB-468 cell lines by RT-PCR and Western blotting, respectively, both at basal levels (Fig. 19A) and after exposure to compound (1-1) (75 nM for MDA-MB-231 cells and 650 nM for the two other cell lines) for 24, 48 and 72 h (Fig. 19B). Significant differences in the mRNA levels were determined by one-way ANOVA test ($p < 0.01$) followed by SNK a posteriori test (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). Logarithmic transformation of the variable was applied before the ANOVA test if required. Each bar and vertical line represents the mean \pm SEM, respectively ($n = 3$). Western blots are representative of 3 independent experiments. (a) n-Myc mRNA were not detected in HCC1937 and MDA-MB-231 cells.

[00223] As shown in Table 8, compound (1-1) inhibited proliferation in all TNBC cell lines, with GI_{50} values < 500 nM after 72 h treatment. Similar effects on proliferation were seen under normoxic and hypoxic conditions.

[00224] Table 8: Compound (1-1) GI_{50} and E_{max} values after 72 h treatment.

		Compound (1-1) (72 h exposure)			
		Normoxia		Hypoxia	
Cell Line	Method	GI_{50} (nM)	E_{max} %	GI_{50} (nM)	E_{max} %
HCC1937	Cell Count	261.5	70	246.9	54
		(38.1-1796)	(17-100)	(58.1-1049)	(31-77)
	MTT	81.9*	51	29.0	74
		(47.0-140.5)	(44-58)	(2.7-308.6)	(54-86)
MDA-MB	Cell Count	55.9	89	49.09	82
		(45.3-69.0)	(84-93)	(24.8-96.9)	(72-92)
	MTT	81.7	83	48.2	83
		(67.2-99.4)	(79-87)	(17.1-135.9)	(72-95)
MDA-MB-468	Cell Count	303.8	80	251.1	71
		(91.5-1008)	(50-100)	(33.4-1886)	(28-100)
	MTT	448.3*	42	296.2	77
		(269.2-746.5)	(34-51)	(174.2-503.7)	(63-91)

[00225] The results in Table 8 are expressed as the concentration that inhibits 50% of cell growth (GI_{50}). E_{max} % indicates the maximum inhibitory effect induced by compound (1-1) on cell proliferation at 6 μ M (percent with respect to control untreated cells). Both values are indicated as means with 95% confidence intervals. When E_{max} % \leq 60%, the IG_{50} values are considered apparent (*). In all cases, $n \geq 4$.

[00226] Fig. 22 shows the results of *in vitro* evaluation of compound (1-1) combination effects with everolimus (A) or docetaxel (B) after 48 and 72 h in TNBC cells lines under normoxic and hypoxic conditions. Concomitant treatment of compound (1-1) and everolimus showed additive effects after 72 h in HCC1937 and MDA-MB-231 cell lines, but was antagonistic in MDA-MB-468 cells under hypoxic and normoxic conditions. Combination of compound (1-1) and docetaxel was additive or slightly synergistic in TNBC cell lines. Synergism is defined by $CI < 0.9$; a CI value between 0.9 and 1.10 indicates an additive effect of the drugs; $CI > 1.10$ reflects antagonism ($n = 3$).

[00227] Conclusions: Compound (1-1) displays antiproliferative effects in the three TNBC cell lines under normoxia and hypoxia with GI_{50} values < 500 nM. The growth inhibitory activity of compound (1-1) was accompanied by a significant accumulation of cells in the G1 phase, with a concomitant reduction of cells in the S phase and increased of CDKN1A (p21) mRNA levels. The mechanism of action of compound (1-1) appears to be Myc-independent since treatment resulted in downregulation only in the expression of c-Myc and n-Myc in the MDA-MB-468 cell line. When combined with everolimus, compound (1-1) showed additive antiproliferative effects in the HCC1937 and MDA-MB-231 cell lines but was antagonistic in MDA-MB-468 cells (under both normoxia and hypoxia). Compound (1-1) and docetaxel showed additive antiproliferative effects in the HCC1937 and MDA-MB-231 cell lines, and a synergistic effect in MDA-MB-468 cells, under both normoxia and hypoxia.

[00228] It will be appreciated by those skilled in the art that changes could be made to the exemplary embodiments shown and described above without departing from the broad inventive concept thereof. It is understood, therefore, that this invention is not limited to the exemplary embodiments shown and described, but it is intended to cover modifications within the spirit and scope of the present invention as defined by the claims. For example, specific features of the exemplary embodiments may or may not be part of the claimed invention and features of the disclosed embodiments may be combined. Unless specifically set forth herein, the terms “a”, “an” and “the” are not limited to one element but instead should be read as meaning “at least one”.

[00229] It is to be understood that at least some of the figures and descriptions of the invention have been simplified to focus on elements that are relevant for a clear understanding of the

invention, while eliminating, for purposes of clarity, other elements that those of ordinary skill in the art will appreciate may also comprise a portion of the invention. However, because such elements are well known in the art, and because they do not necessarily facilitate a better understanding of the invention, a description of such elements is not provided herein.

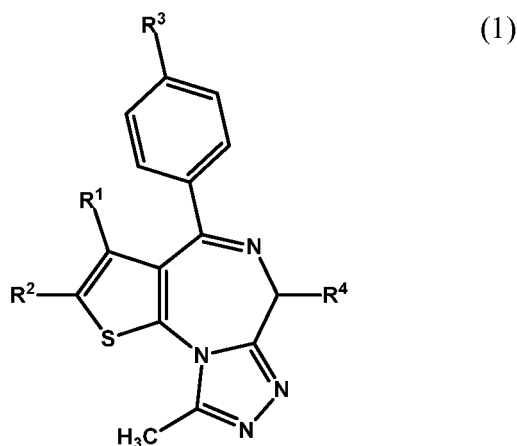
- 5 **[00230]** Further, to the extent that the method does not rely on the particular order of steps set forth herein, the particular order of the steps should not be construed as limitation on the claims. The claims directed to the method of the present invention should not be limited to the performance of their steps in the order written, and one skilled in the art can readily appreciate that the steps may be varied and still remain within the spirit and scope of the present invention.

10

CLAIMS

I/we claim:

1. A method of treating triple-negative breast cancer in a mammal comprising the step of:
administering to a patient a pharmaceutical acceptable amount of a compound being a
5 thienotriazolodiazepine compound of the Formula (1)



wherein

R^1 is alkyl having a carbon number of 1-4,

R^2 is a hydrogen atom; a halogen atom; or alkyl having a carbon number of 1-4 optionally substituted by a halogen atom or a hydroxyl group,

- 10 R^3 is a halogen atom; phenyl optionally substituted by a halogen atom, alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4 or cyano; $-NR^5-(CH_2)_m-R^6$ wherein R^5 is a hydrogen atom or alkyl having a carbon number of 1-4, m is an integer of 0-4, and R^6 is phenyl or pyridyl optionally substituted by a halogen atom; or $-NR^7-CO-(CH_2)_n-R^8$ wherein R^7 is a hydrogen atom or alkyl having a carbon number of 1-4, n is an integer of 0-2, and R^8 is phenyl or
15 pyridyl optionally substituted by a halogen atom, and

- R^4 is $-(CH_2)_a-CO-NH-R^9$ wherein a is an integer of 1-4, and R^9 is alkyl having a carbon number of 1-4; hydroxyalkyl having a carbon number of 1-4; alkoxy having a carbon number of 1-4; or phenyl or pyridyl optionally substituted by alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4, amino or a hydroxyl group or $-(CH_2)_b-COOR^{10}$ wherein b is an integer of
20 1-4, and R^{10} is alkyl having a carbon number of 1-4,
or a pharmaceutically acceptable salt thereof or a hydrate or solvate thereof.

2. The method according to claim 1, further comprising administering one or more chemotherapy drugs selected from the group consisting of m-TOR inhibitors and mitotic inhibitors.

3. The method according to claim 2, wherein the thienotriazolodiazepine compound of the Formula (1) and the chemotherapy drug are administered concomitantly.

4. The method according to claim 2, wherein the thienotriazolodiazepine compound of the Formula (1) and the chemotherapy drug are administered sequentially.

5. The method according to any one of claims 2 to 4, wherein the chemotherapy drug is an mTOR inhibitor.

6. The method according to claim 5, wherein the mTOR inhibitor is selected from the group consisting of rapamycin, temsirolimus, ridaforolimus and everolimus.

7. The method according to claim 6, wherein the mTOR inhibitor is everolimus.

8. The method according to any one of claims 2 to 4, wherein the chemotherapy drug is a mitotic inhibitor.

9. The method according to claim 8, wherein the mitotic inhibitor is docetaxel.

10. The method according to any one of claims 1 to 9, wherein the thienotriazolodiazepine compound of Formula (1) is selected from the group consisting of:

(i) (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide or a dihydrate thereof;

(ii) methyl (S)-{4-(3'-cyanobiphenyl-4-yl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate,

(iii) methyl (S)-{2,3,9-trimethyl-4-(4-phenylaminophenyl)-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate; and

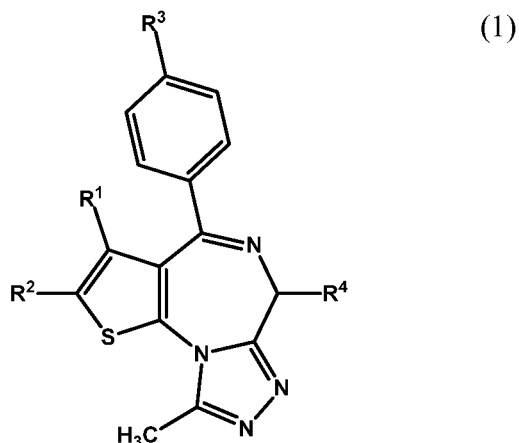
(iv) methyl (S)-{2,3,9-trimethyl-4-[4-(3-phenylpropionylamino)phenyl]-6H-thieno[3,2-f][1,2,4]triazolo[4,3-a][1,4]diazepin-6-yl} acetate.

11. The method according to claim 10, wherein the thienotriazolodiazepine compound represented by Formula (1) is (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide dihydrate.
- 5 12. The method according to claim 10, wherein the thienotriazolodiazepine compound represented by Formula (1) is (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide.
13. The method according to any one of claims 1 to 12, wherein the thienotriazolodiazepine
10 compound is formed as a solid dispersion.
14. The method according to claim 13, wherein the solid dispersion comprises an amorphous thienotriazolodiazepine compound of Formula (1) or a pharmaceutically acceptable salt thereof or a hydrate thereof; and a pharmaceutically acceptable polymer.
- 15 15. The method according to claim 14, wherein the pharmaceutically acceptable polymer is hydroxypropylmethylcellulose acetate succinate having a thienotriazolodiazepine compound to hydroxypropylmethylcellulose acetate succinate (HPMCAS) weight ratio of 1:3 to 1:1.
- 20 16. The method according to any one of claims 13 to 15, wherein the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of Formula (1).
17. The method according to any one of claims 13 to 16, wherein the solid dispersion exhibits a
25 single glass transition temperature (T_g) inflection point ranging from about 130°C to about 140°C.
18. The method according to any one of claims 13 to 17, wherein the solid dispersion comprises an amorphous thienotriazolodiazepine compound of (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide dihydrate or a
30 pharmaceutically acceptable salt thereof or a hydrate thereof; and a pharmaceutically acceptable polymer.

19. The method according to claim 18, wherein the solid dispersion exhibits an X-ray powder diffraction pattern substantially free of diffraction lines associated with crystalline thienotriazolodiazepine compound of (S)-2-[4-(4-chlorophenyl)-2,3,9-trimethyl-6H-thieno[3,2-f][1,2,4]triazolo-[4,3-a][1,4]diazepin-6-yl]-N-(4-hydroxyphenyl)acetamide dihydrate.

5

20. A compound of the Formula (1)



wherein

R^1 is alkyl having a carbon number of 1-4,

R^2 is a hydrogen atom; a halogen atom; or alkyl having a carbon number of 1-4 optionally substituted by a halogen atom or a hydroxyl group,

R^3 is a halogen atom; phenyl optionally substituted by a halogen atom, alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4 or cyano; $-NR^5-(CH_2)_m-R^6$ wherein R^5 is a hydrogen atom or alkyl having a carbon number of 1-4, m is an integer of 0-4, and R^6 is phenyl or pyridyl optionally substituted by a halogen atom; or $-NR^7-CO-(CH_2)_n-R^8$ wherein R^7 is a hydrogen atom or alkyl having a carbon number of 1-4, n is an integer of 0-2, and R^8 is phenyl or pyridyl optionally substituted by a halogen atom, and

R^4 is $-(CH_2)_a-CO-NH-R^9$ wherein a is an integer of 1-4, and R^9 is alkyl having a carbon number of 1-4; hydroxyalkyl having a carbon number of 1-4; alkoxy having a carbon number of 1-4; or phenyl or pyridyl optionally substituted by alkyl having a carbon number of 1-4, alkoxy having a carbon number of 1-4, amino or a hydroxyl group or $-(CH_2)_b-COOR_{10}$ wherein b is an integer of 1-4, and R^{10} is alkyl having a carbon number of 1-4, or a pharmaceutically acceptable salt thereof or a hydrate or solvate thereof, for use in treating triple-negative breast cancer.

21. A solid dispersion of the compound according to claim 20 and a pharmaceutically acceptable polymer for use in treating triple-negative breast cancer.

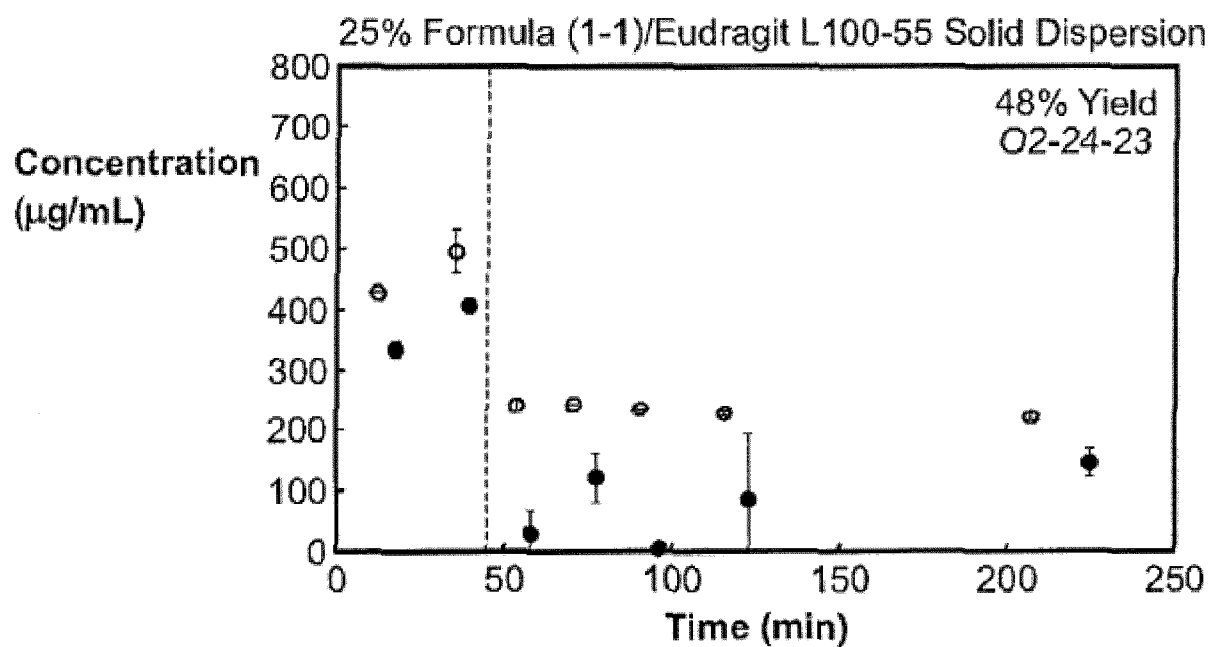


FIG. 1A

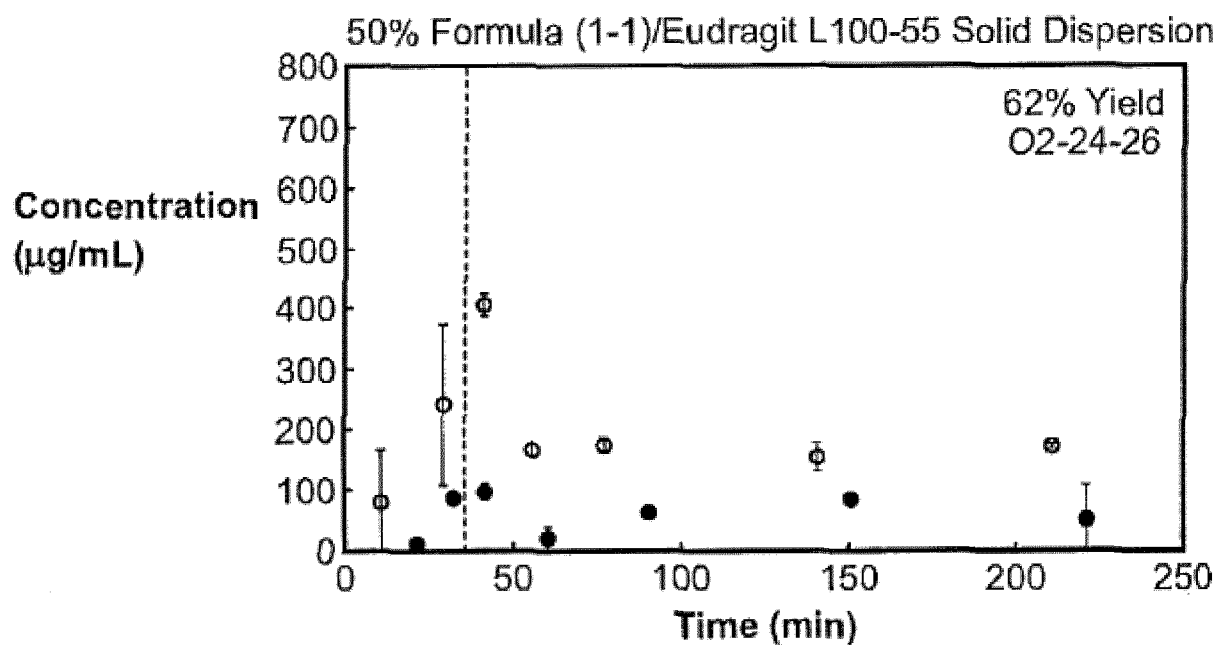
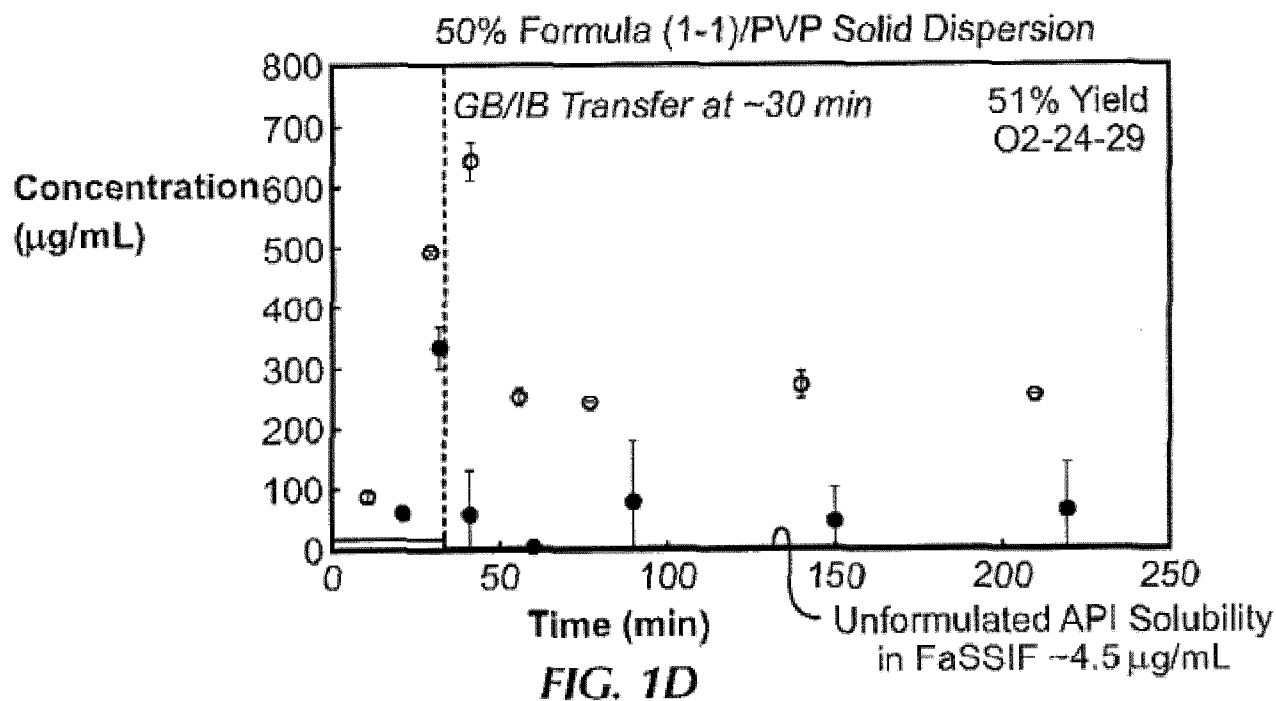
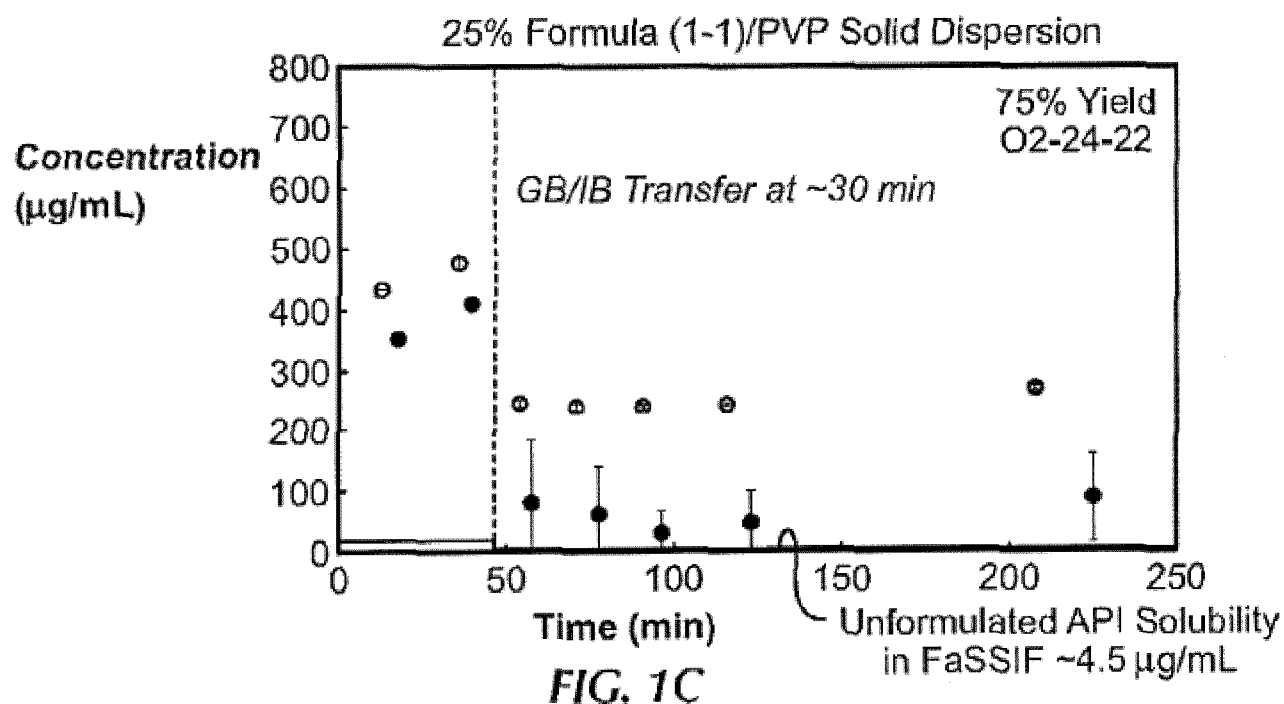


FIG. 1B



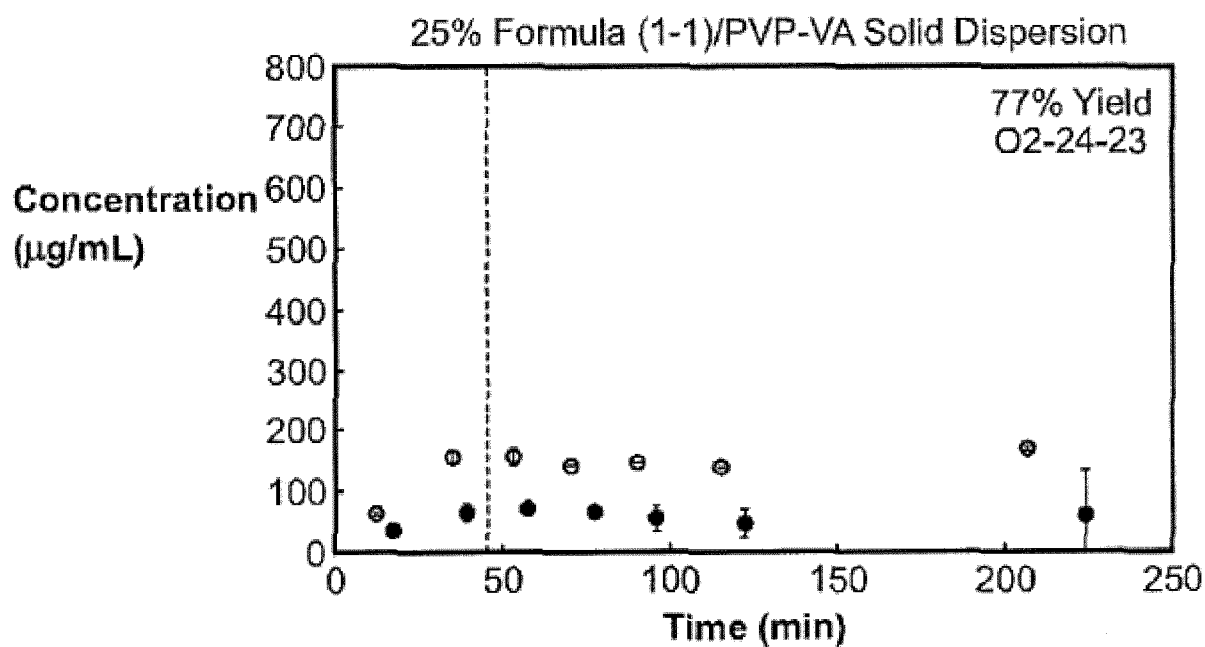


FIG. 1E

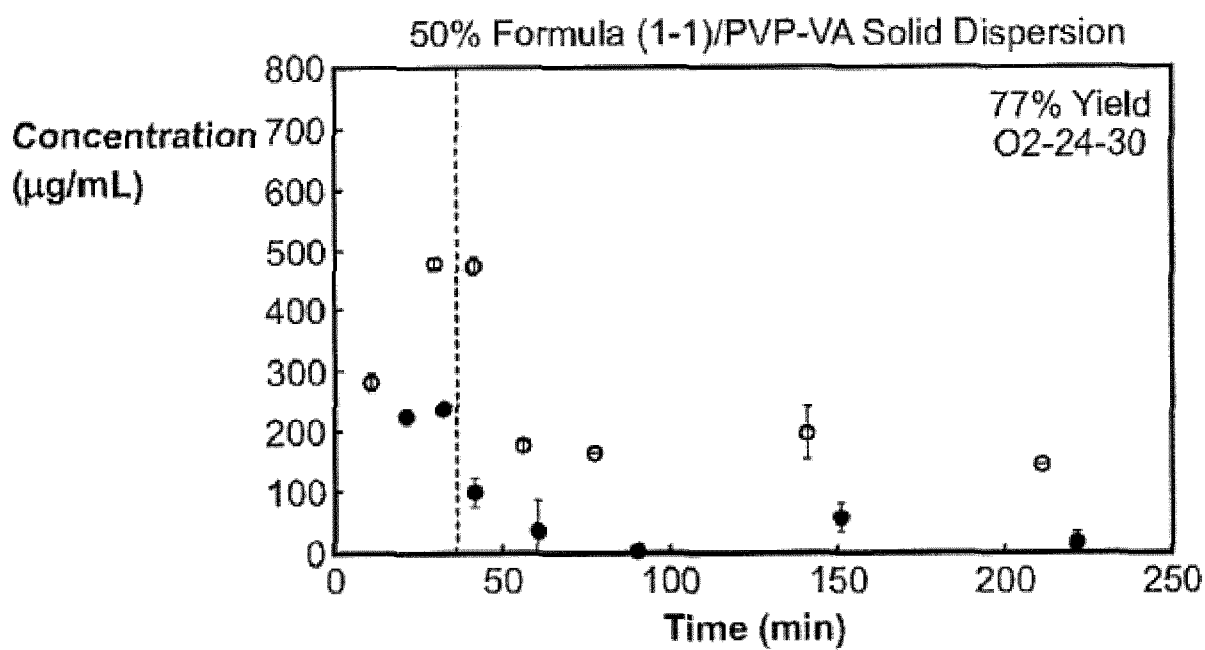


FIG. 1F

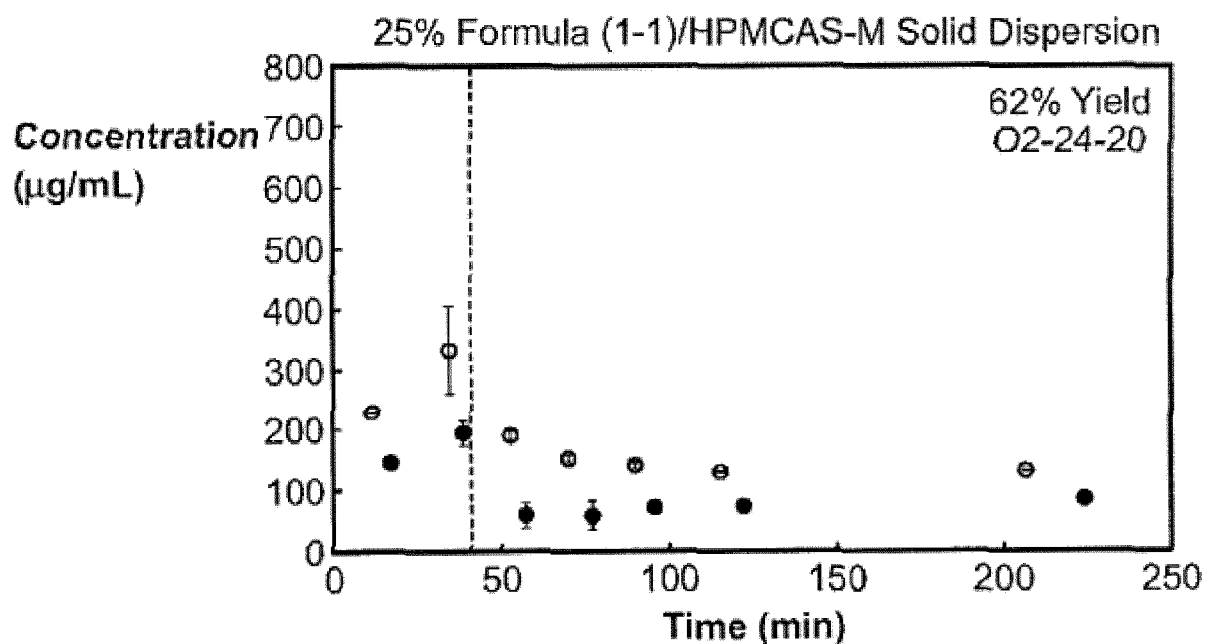


FIG. 1G

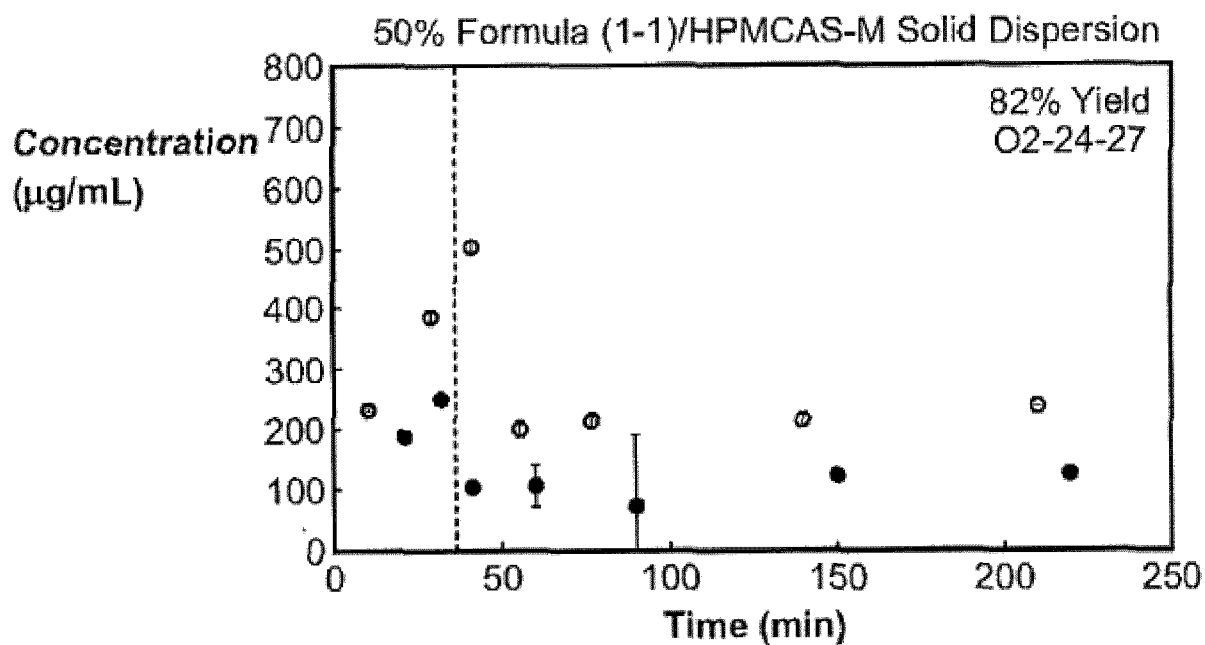


FIG. 1H

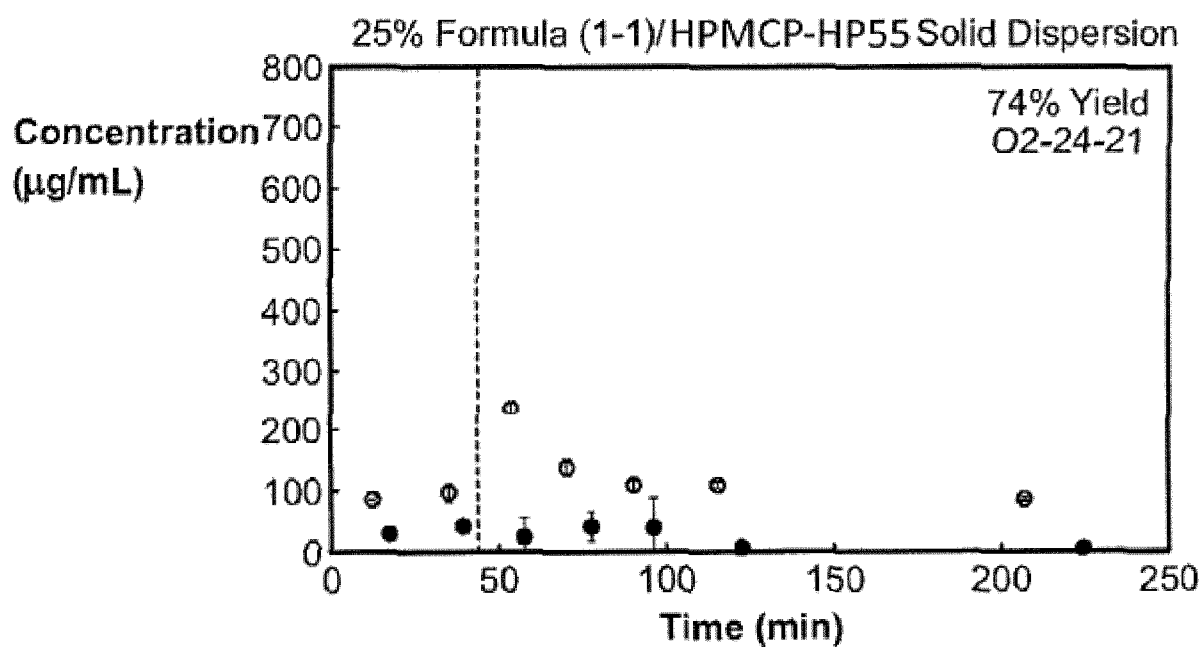


FIG. 1I

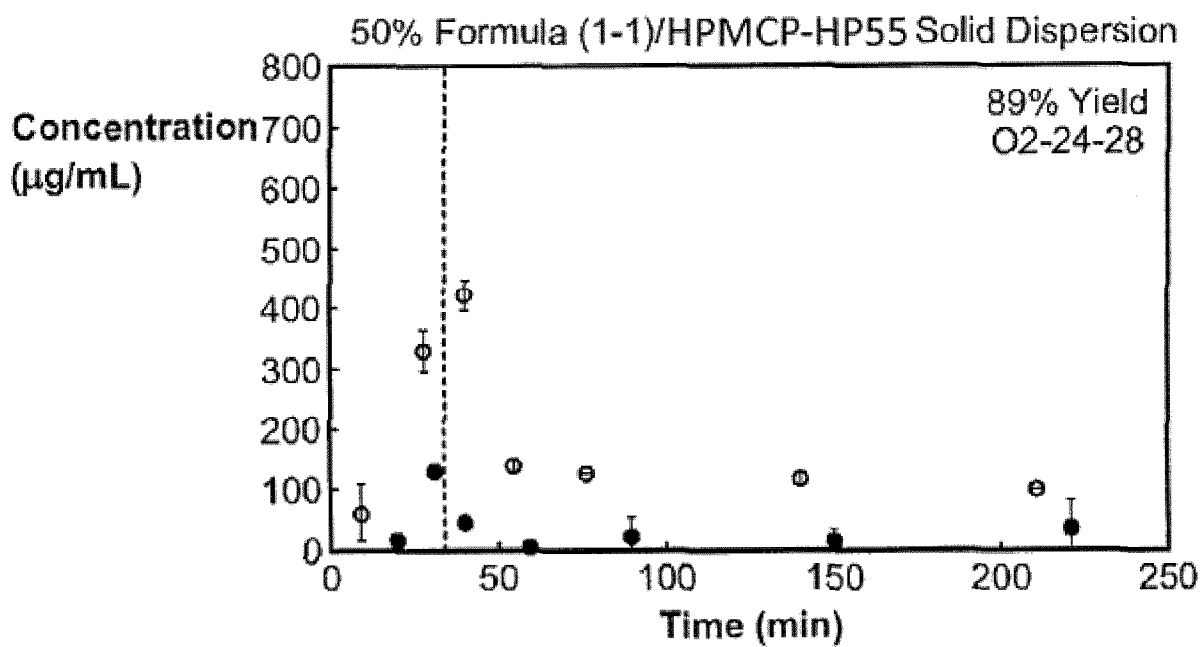


FIG. 1J

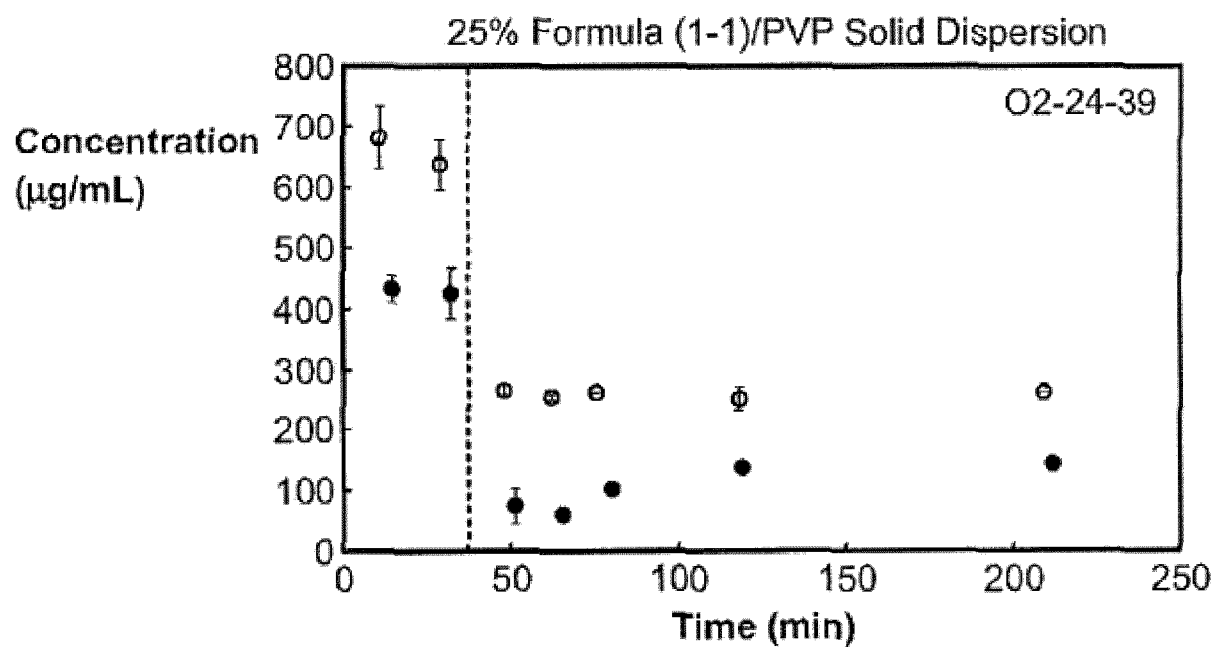


FIG. 2A

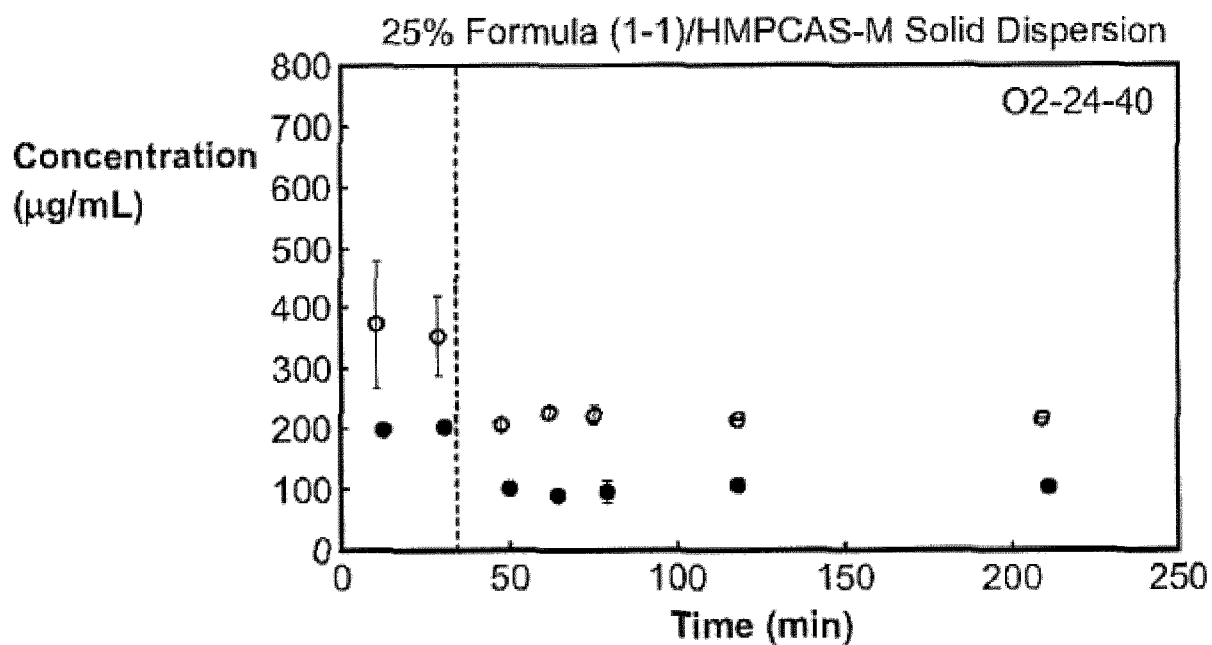


FIG. 2B

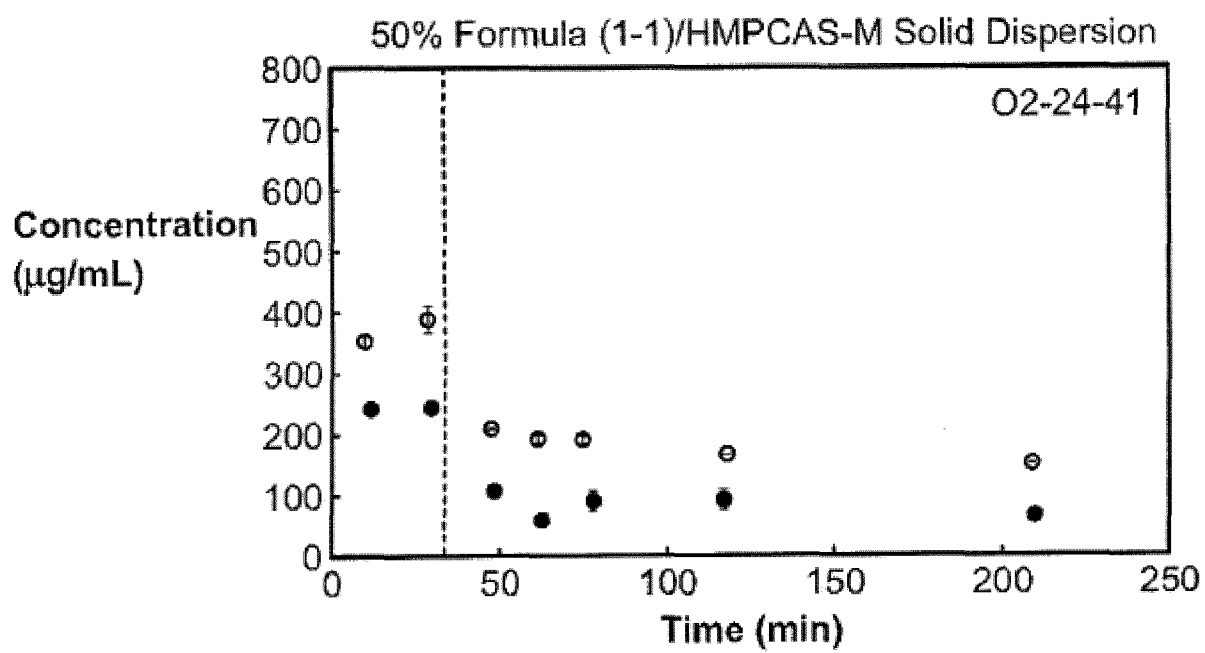


FIG. 2C

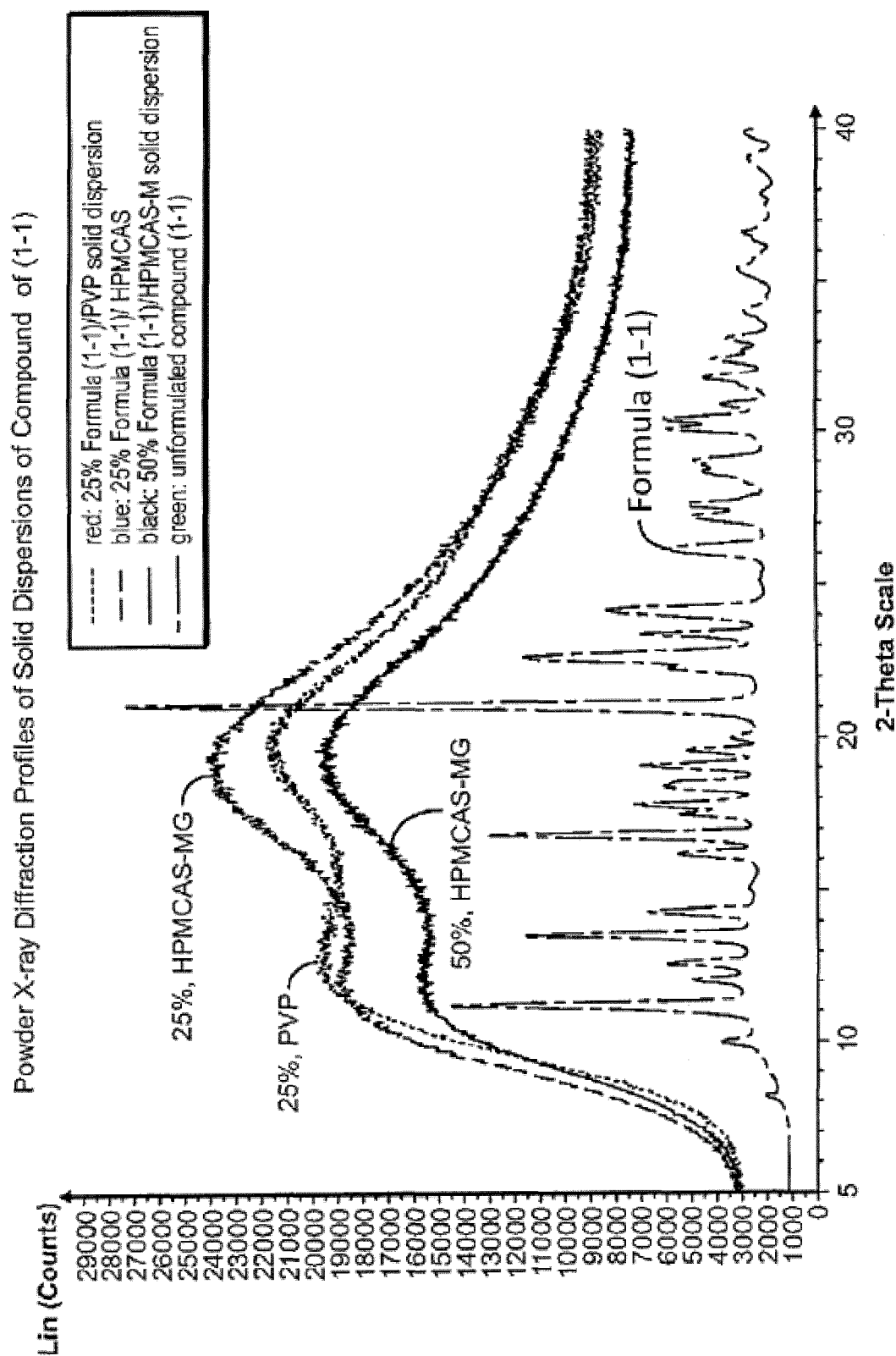
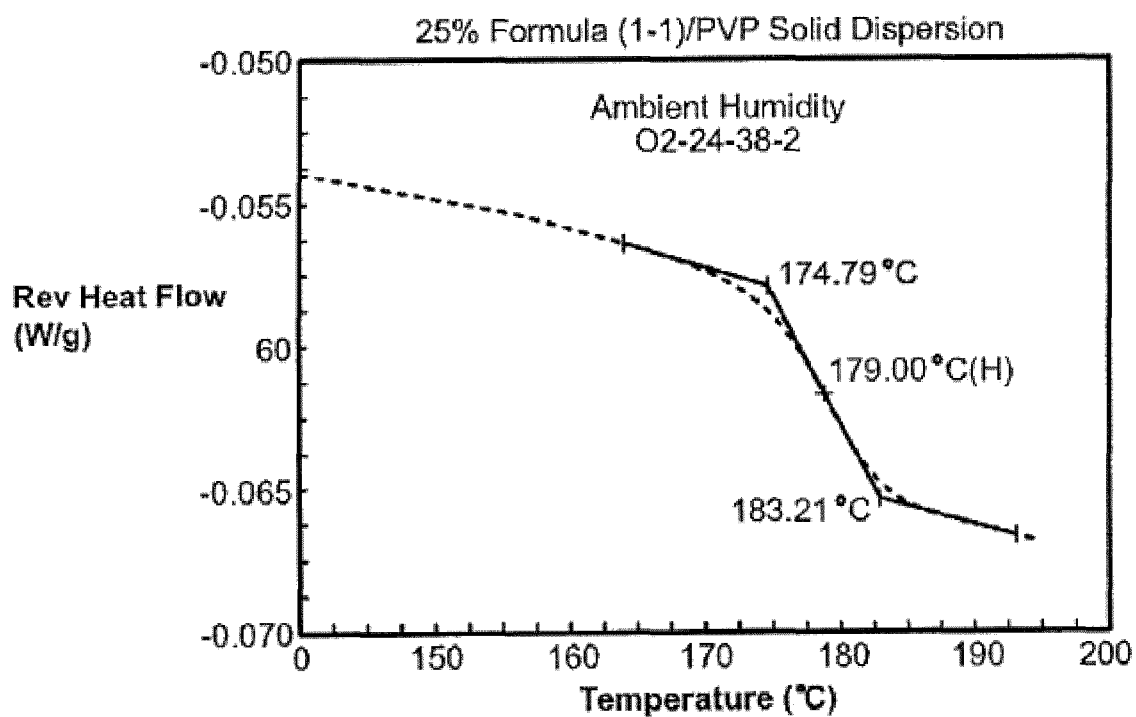
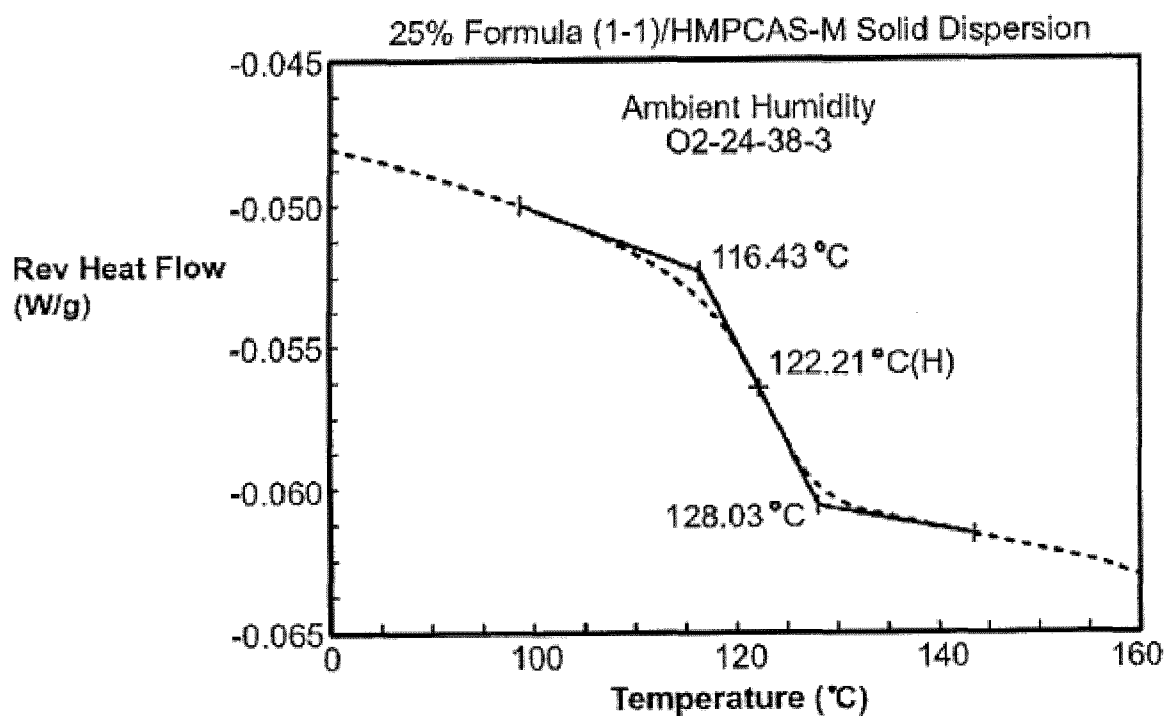


FIG. 3

**FIG. 4A****FIG. 4B**

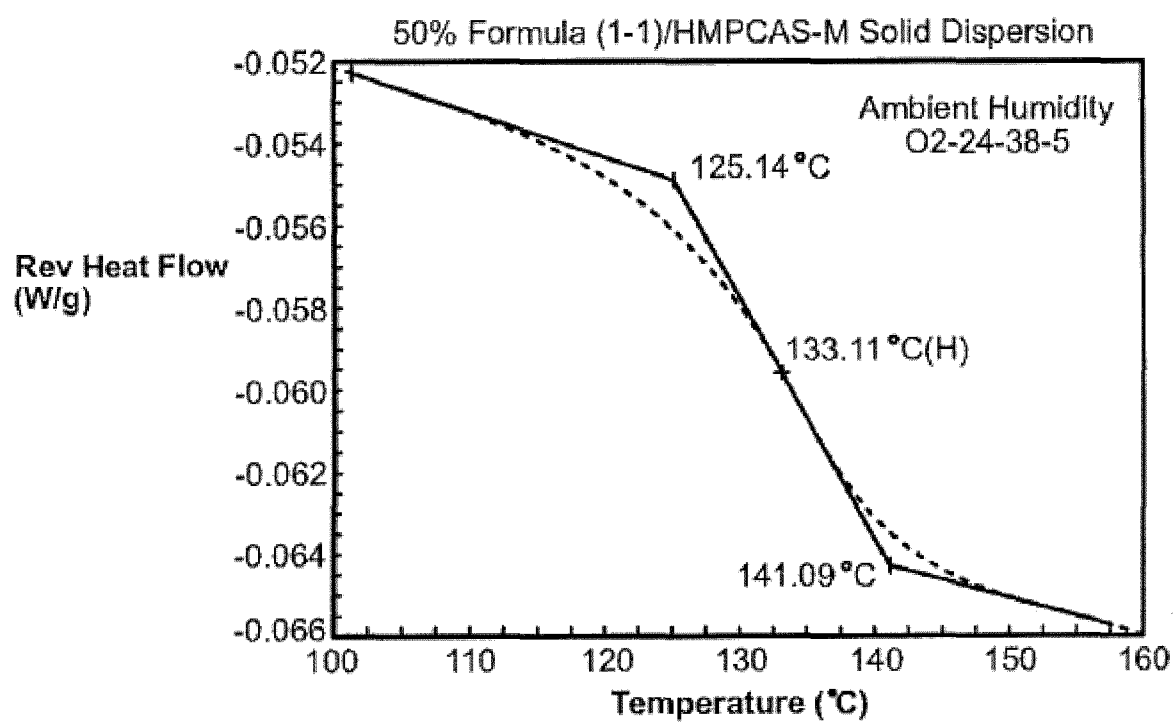


FIG. 4C

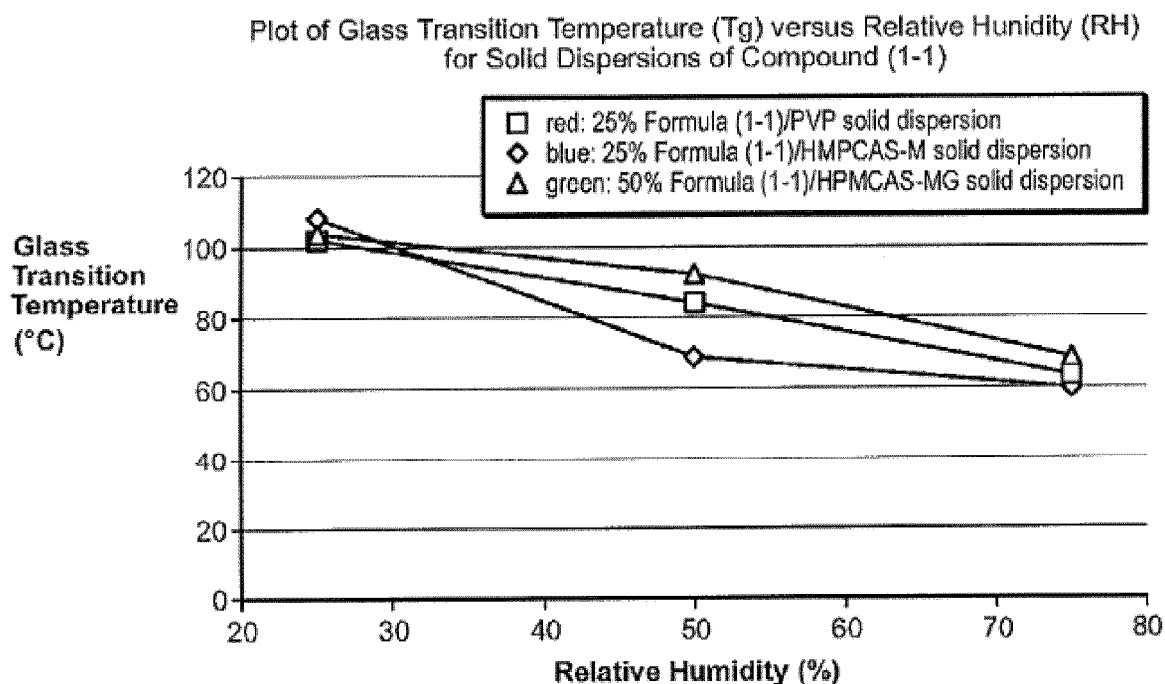


FIG. 5

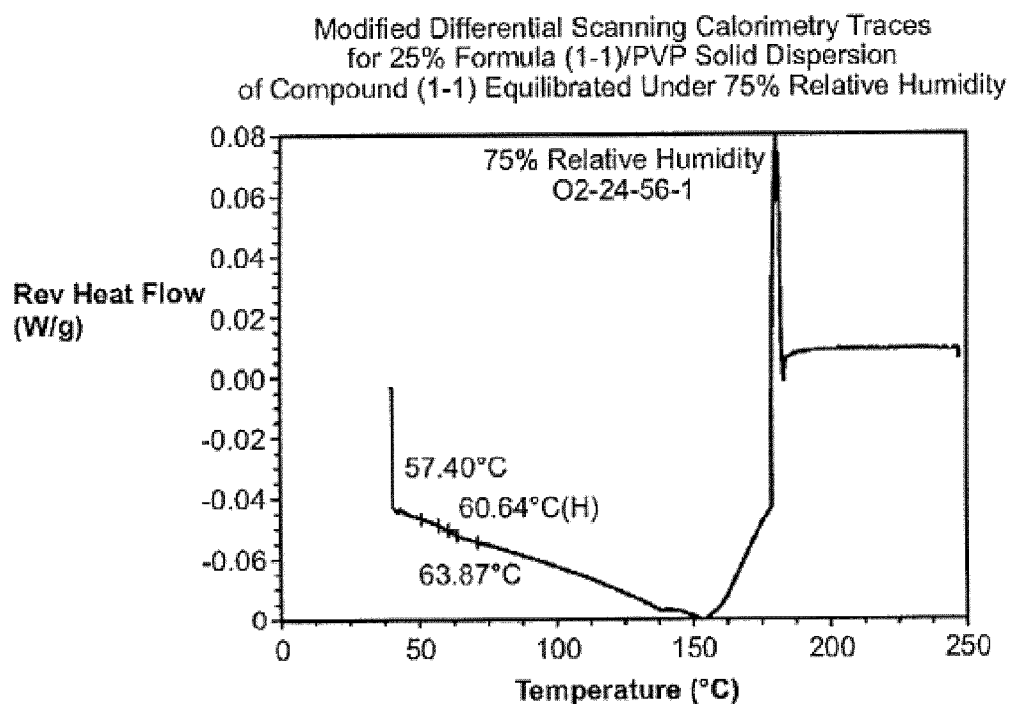
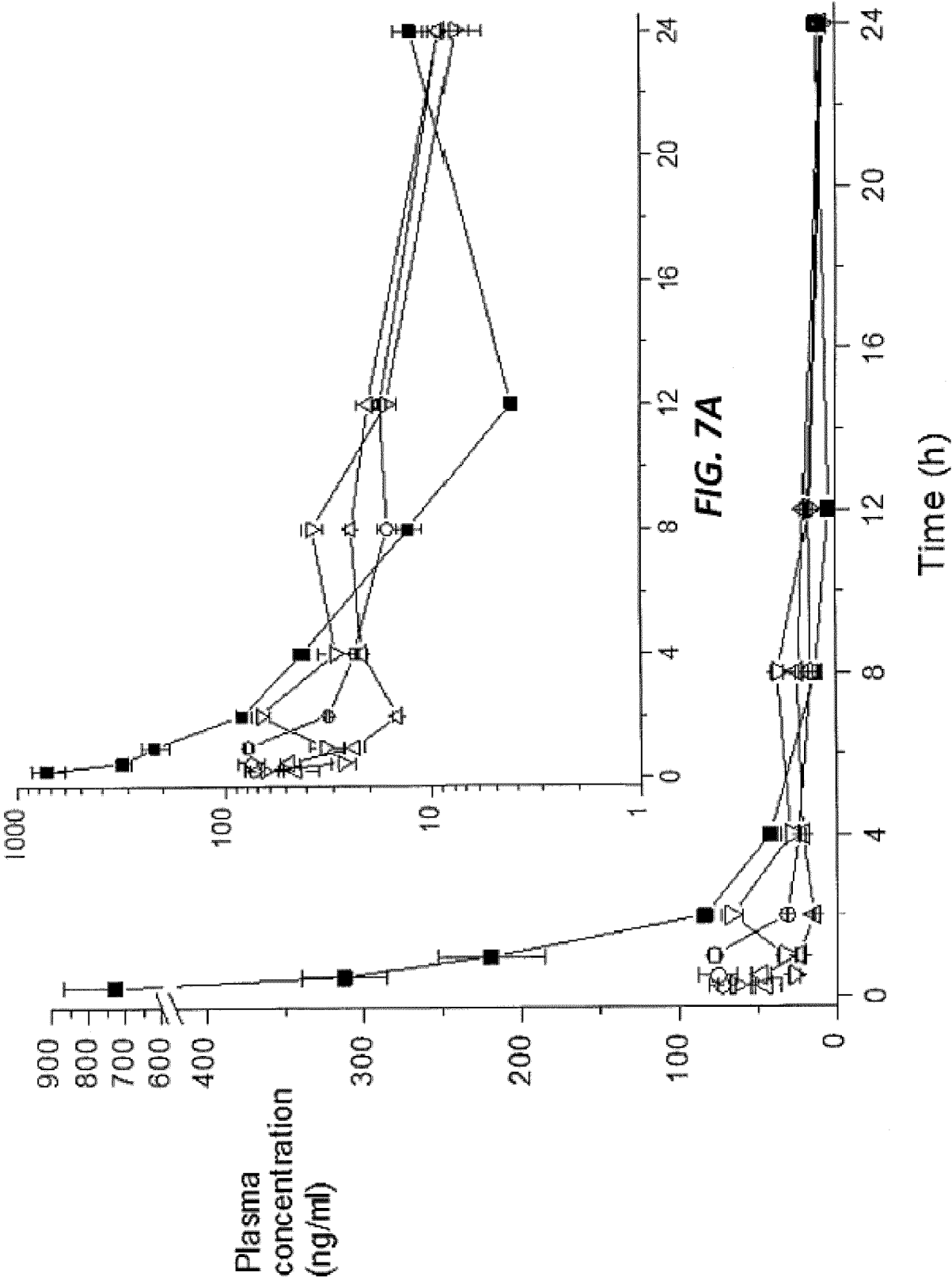
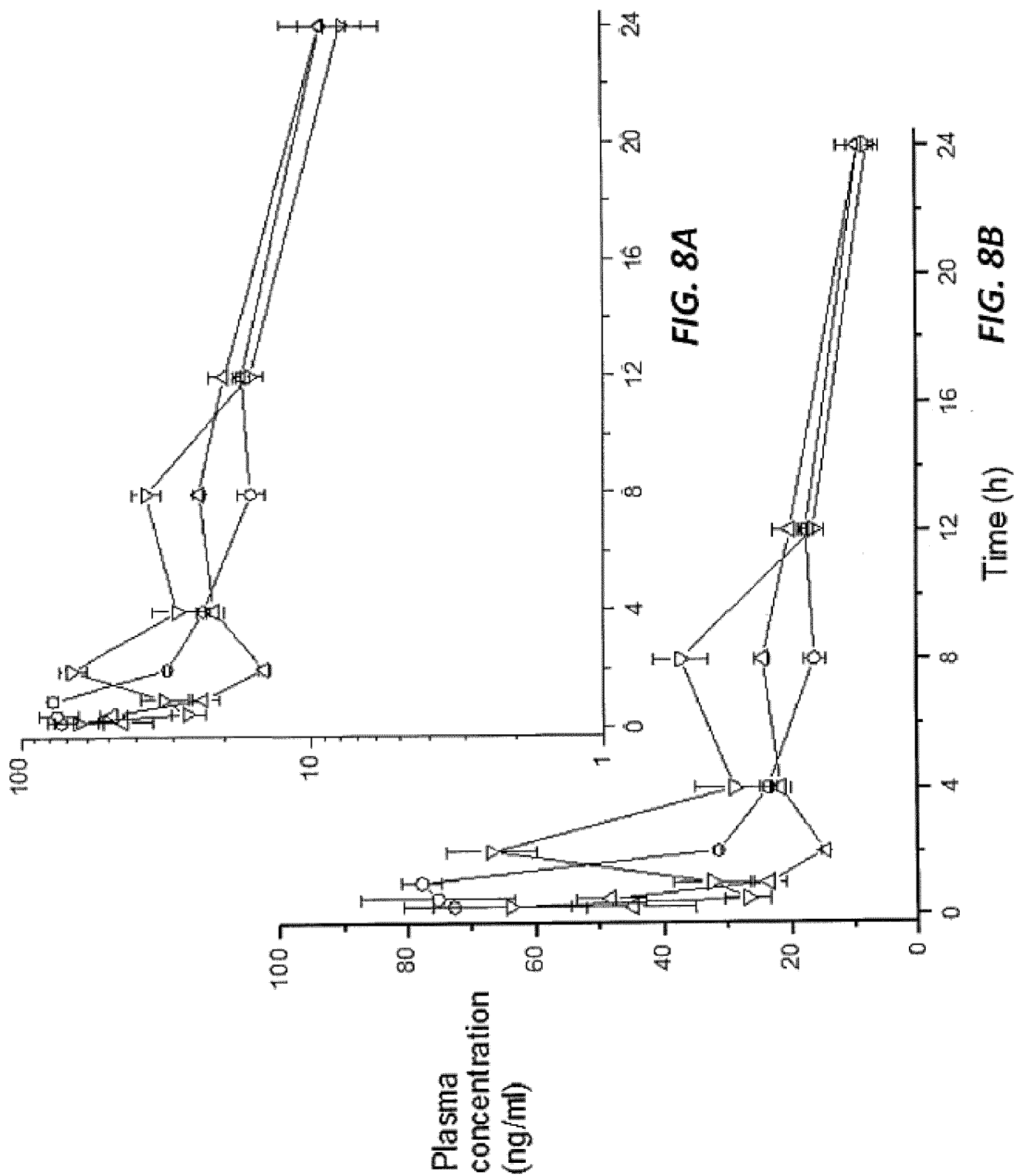
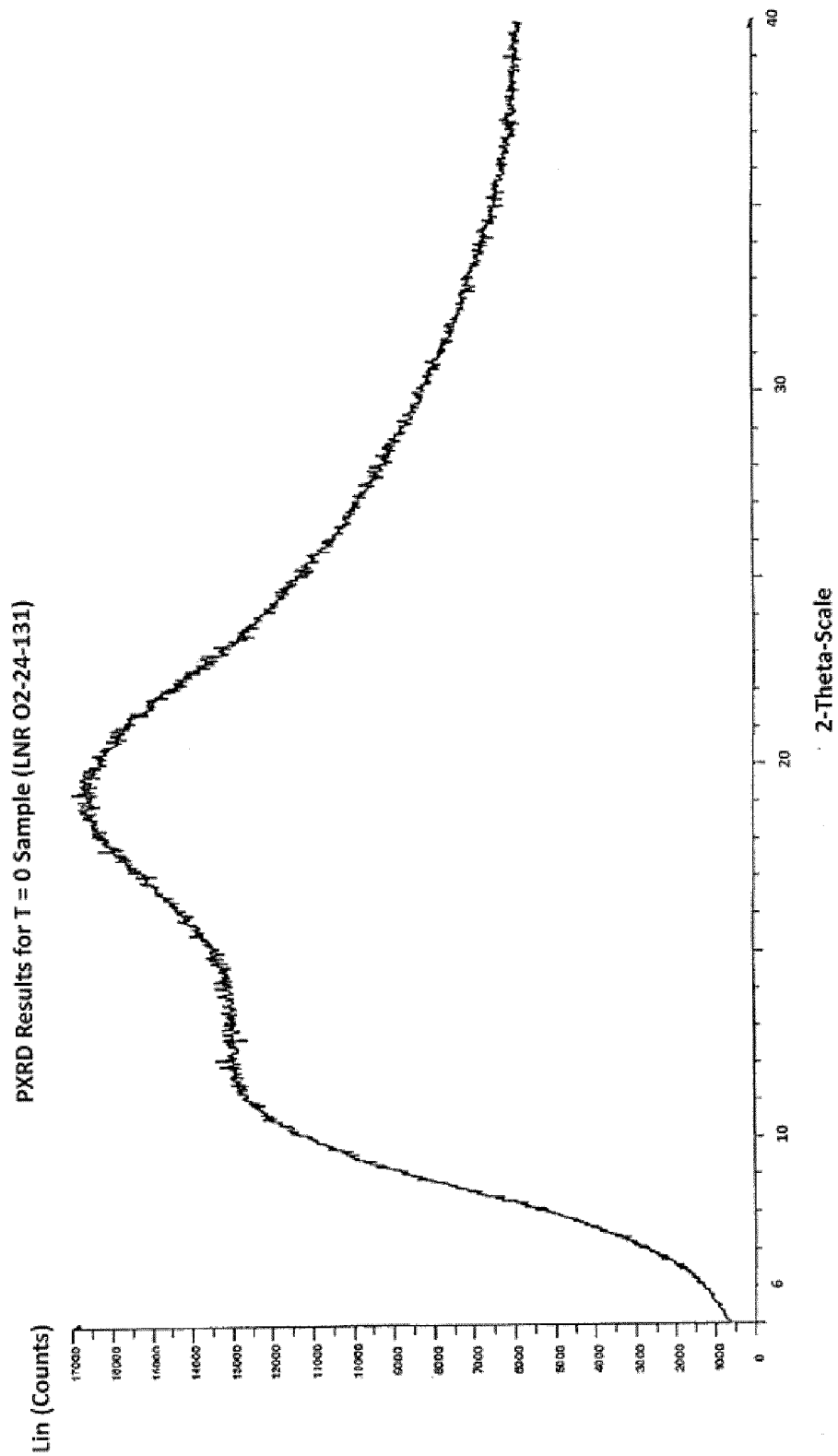


FIG. 6





**FIG. 9**

PXRD Results for 1 month Stability Sample (LNR O2-41-73)

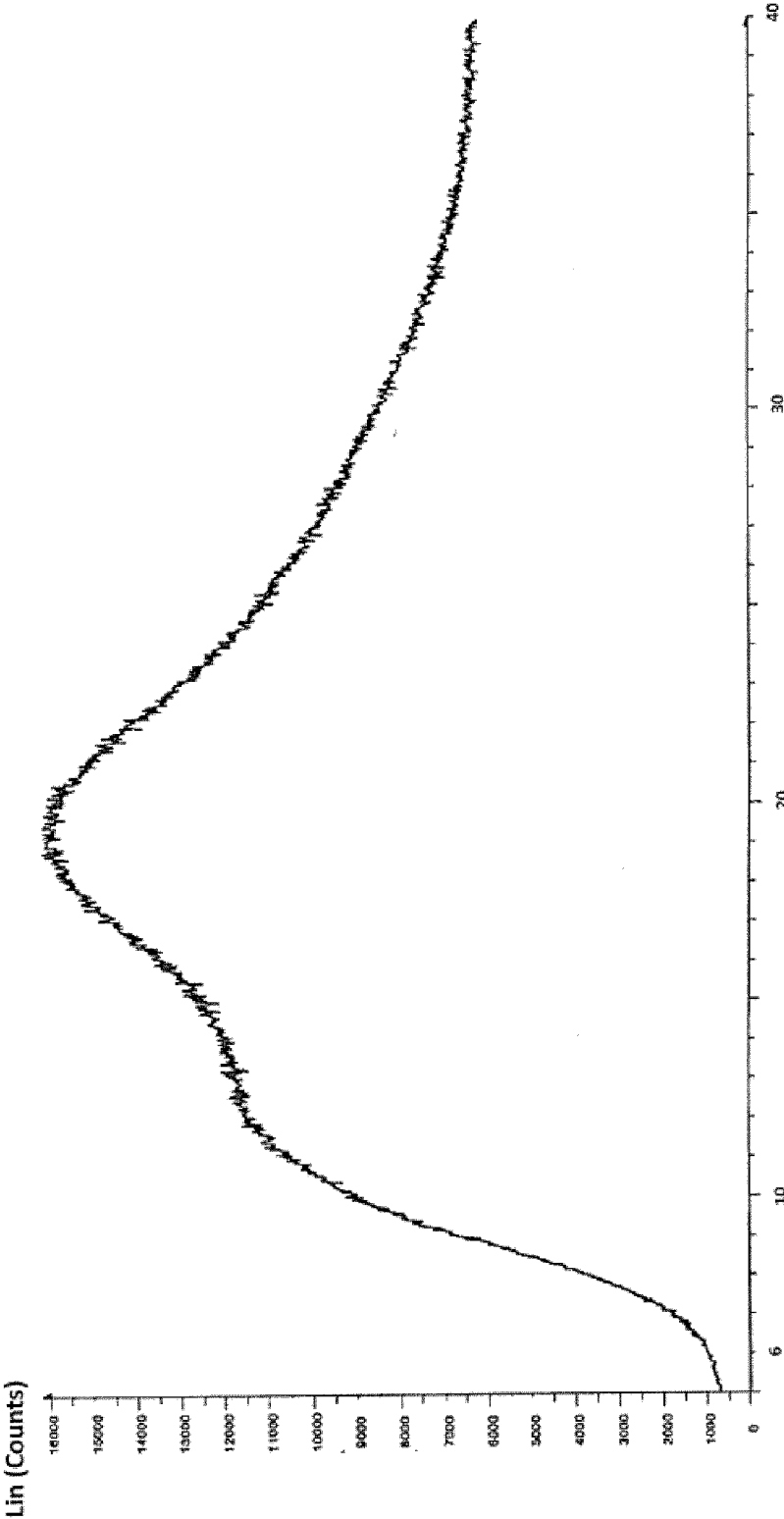


FIG. 10

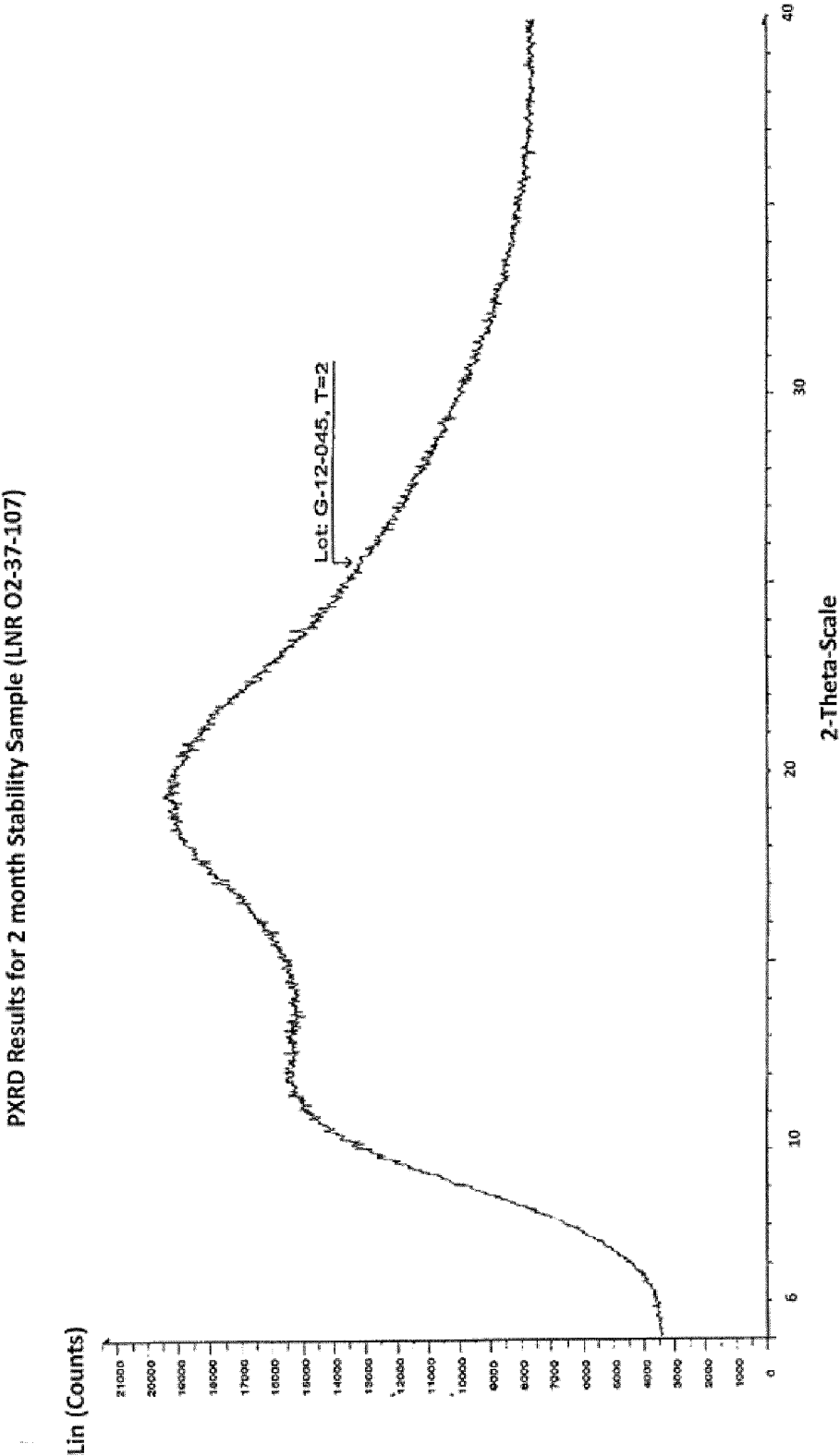


FIG. 11

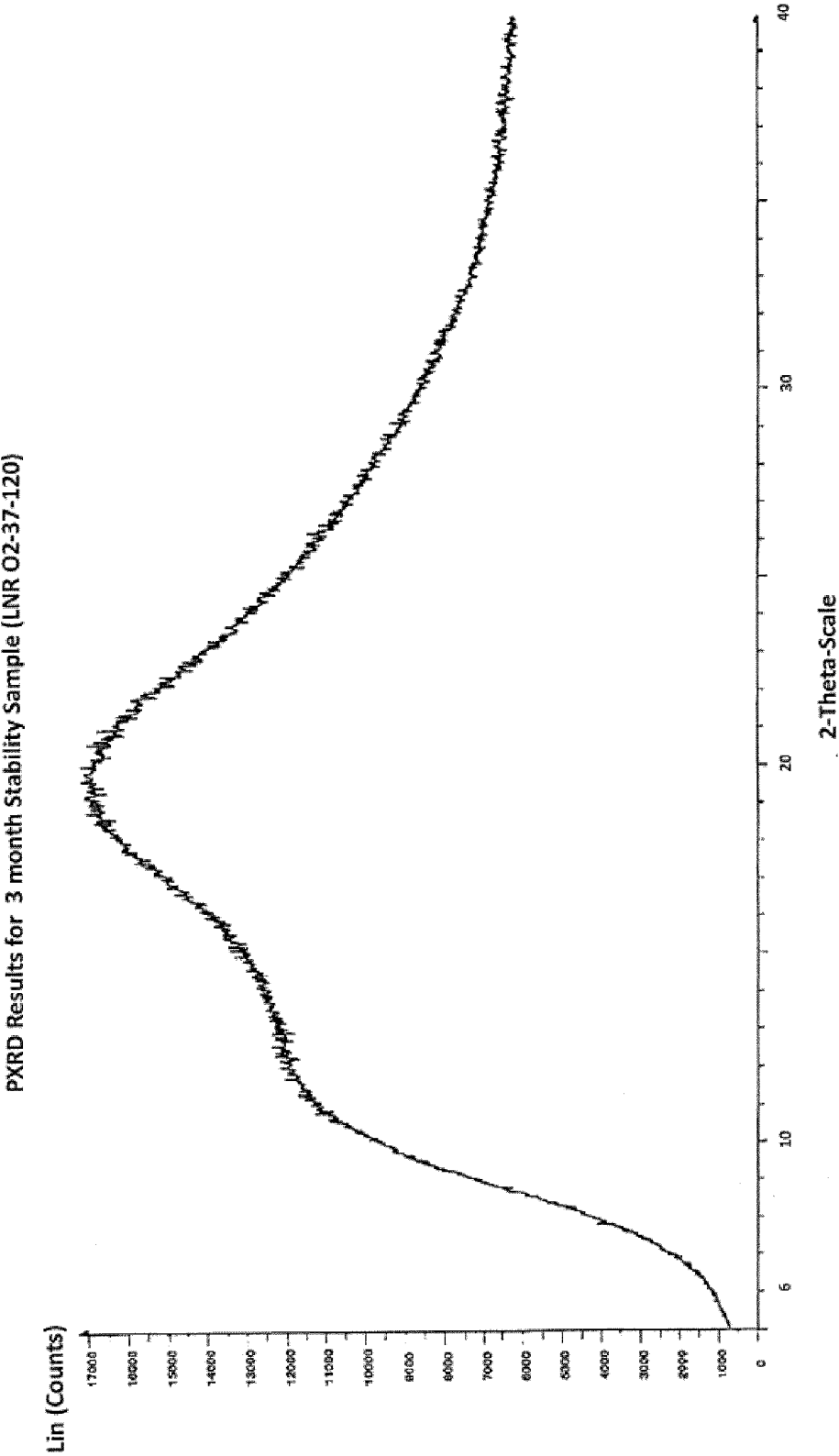


FIG. 12

FIG. 13

Cell line	OTX015		Characterization of the mutational status of key proteins in TNBC cell lines*		
	GI ₅₀ (nM) 95%CI	E _{max} (at 6 μ M)	TP53	BRCA1	PTEN
HCC1937	81.9 (47.0-140.5)	51	Mutated	Mutated	Deleted
MDA-MB-231	81.7 (67.2-99.4)	87	Mutated	WT	WT
MDA-MB-468	448.3 (269.2-746.5)	42	Mutated	WT	Deleted

FIG. 14A

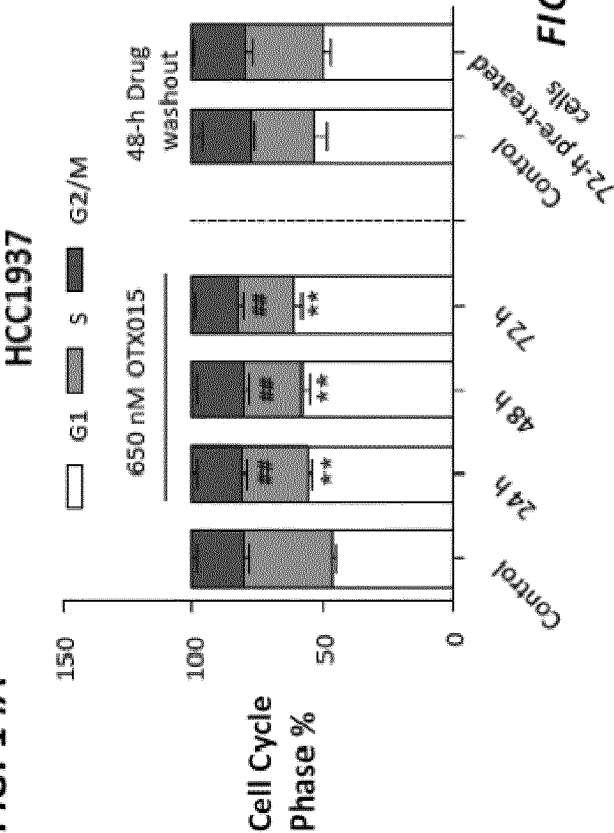
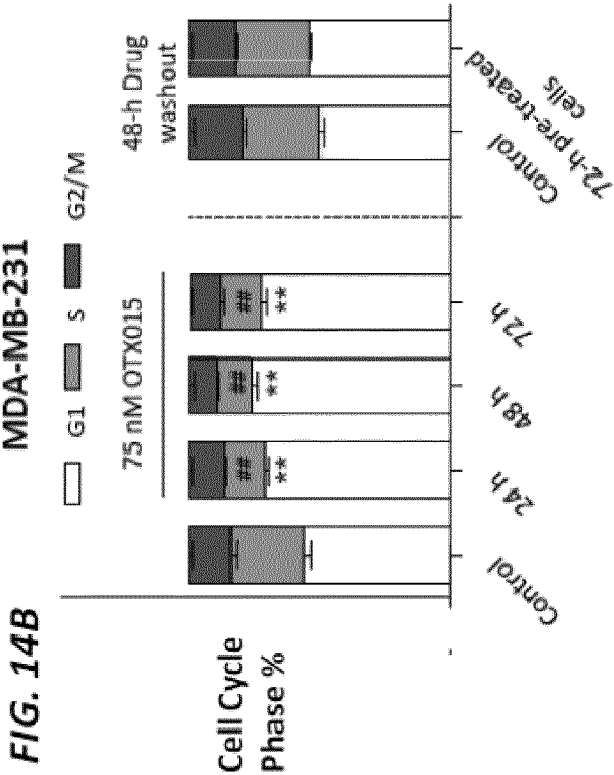
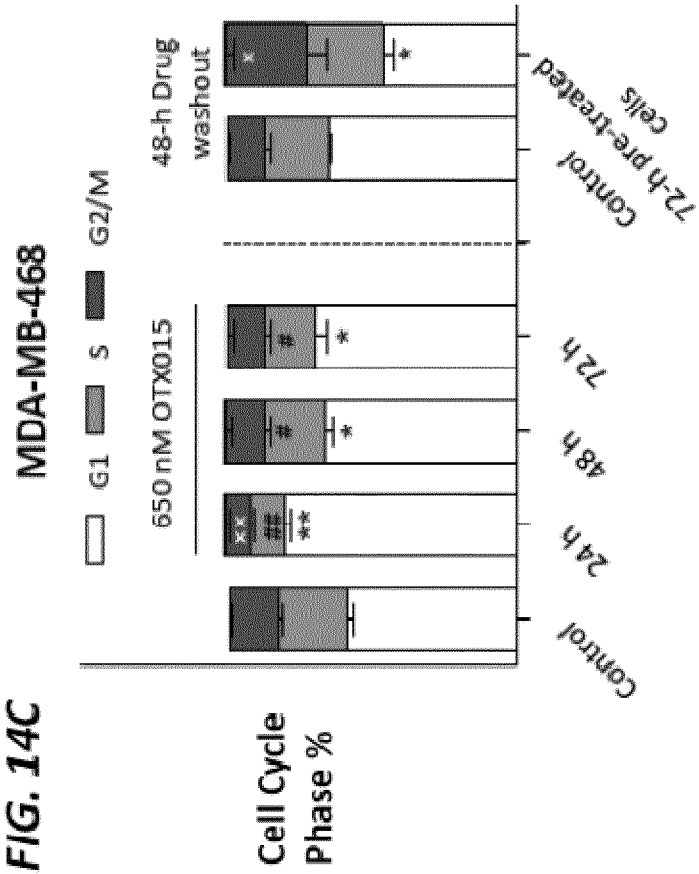


FIG. 14B





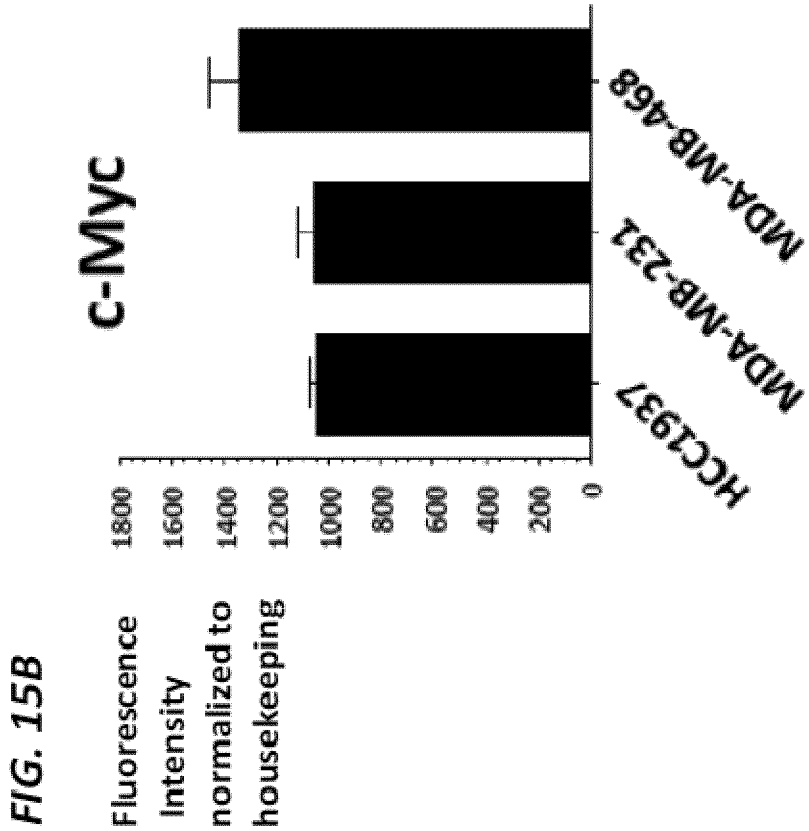
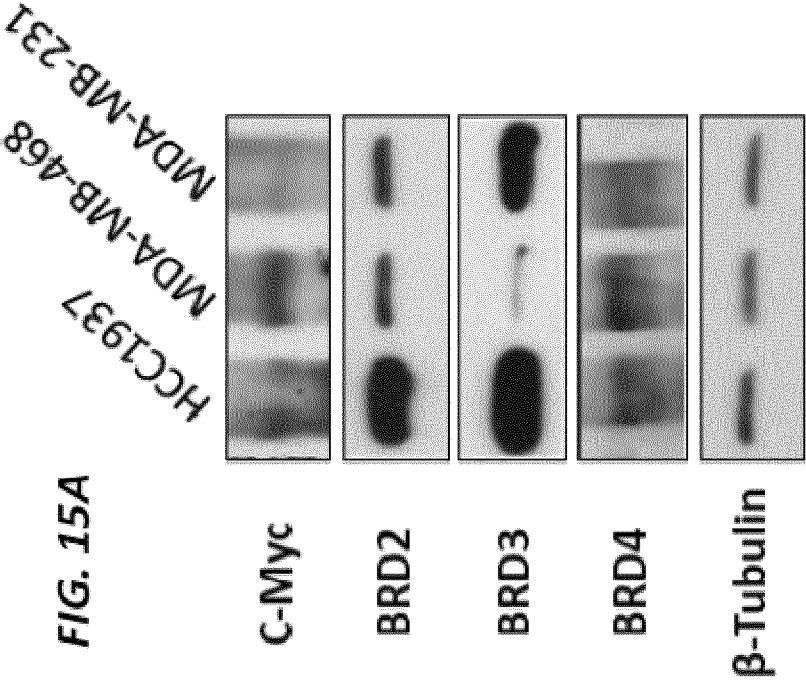


FIG. 15C

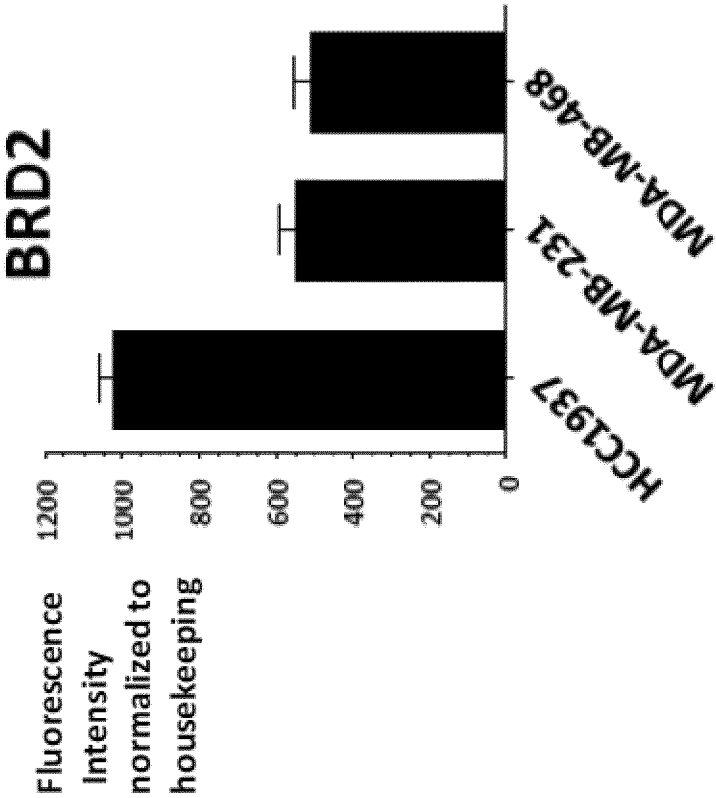
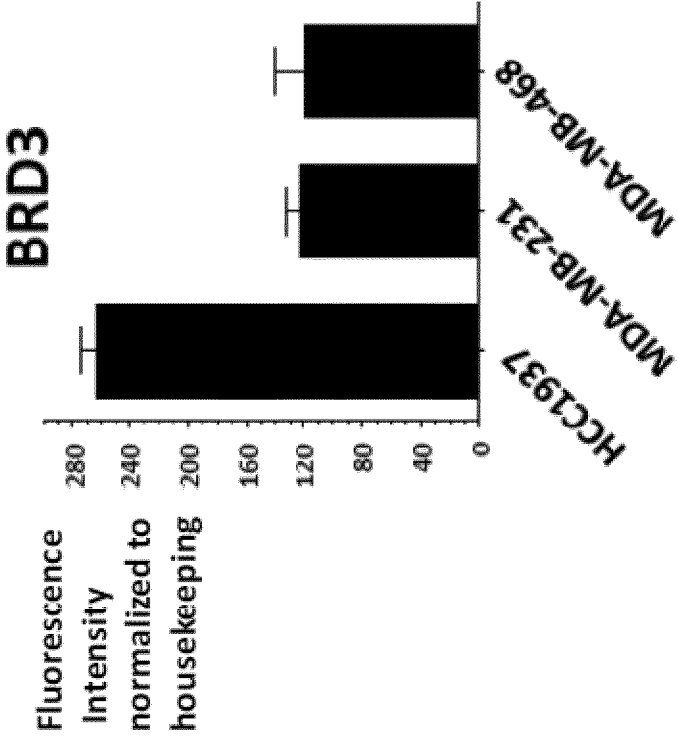


FIG. 15D



650 nM
HCC1937

FIG. 16A

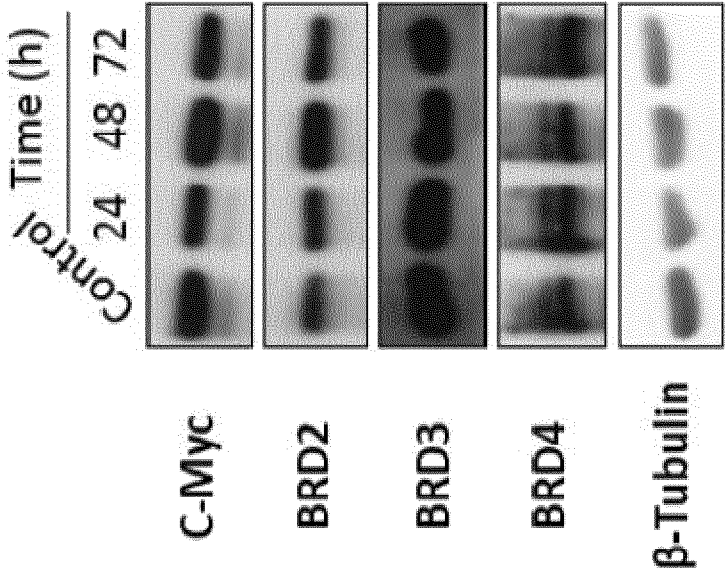


FIG. 15E

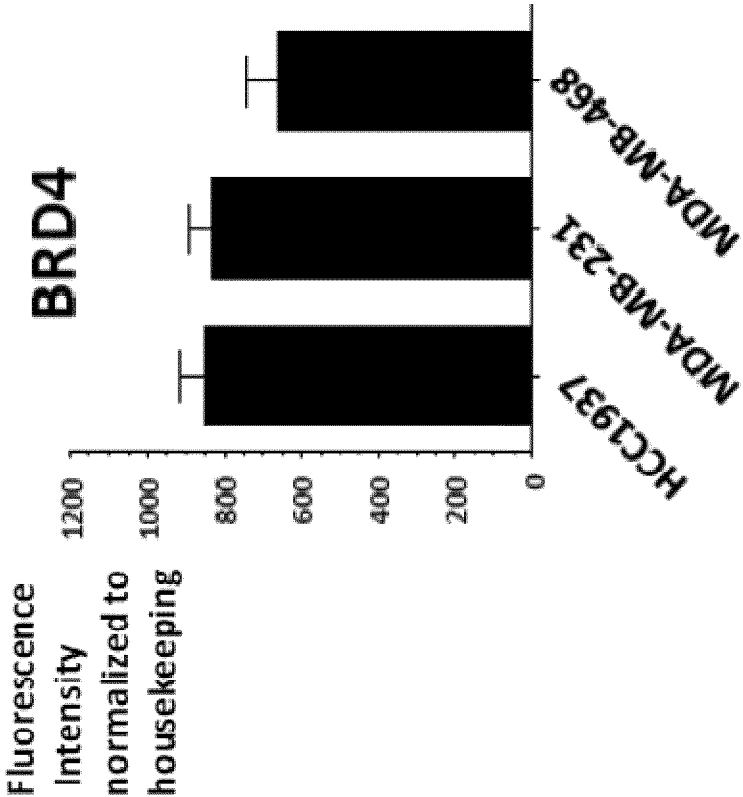


FIG. 16C

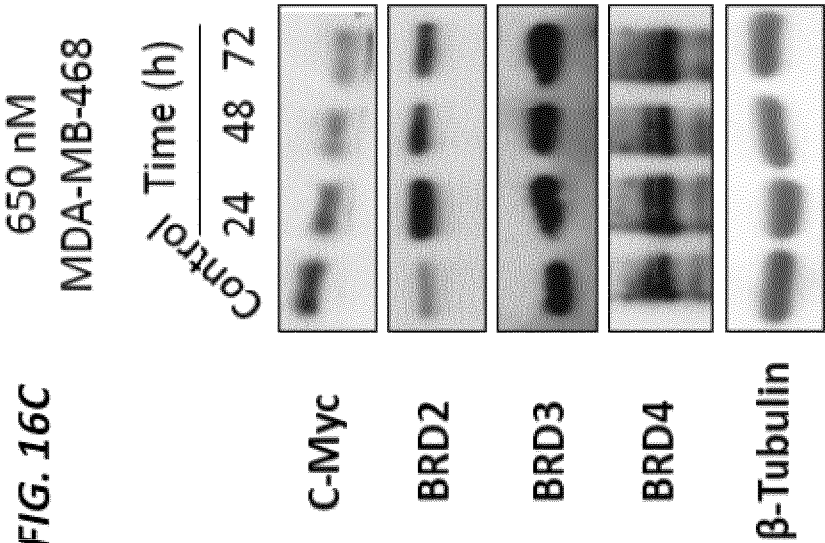


FIG. 16B

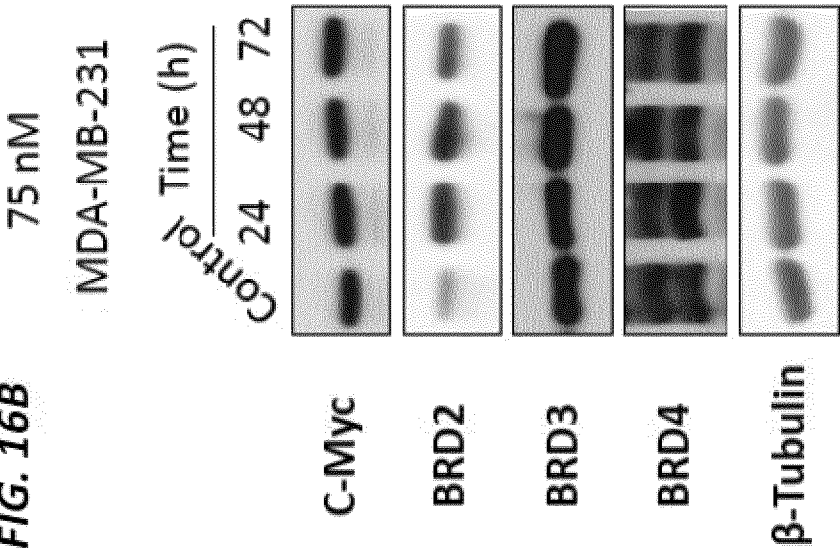


FIG. 16D

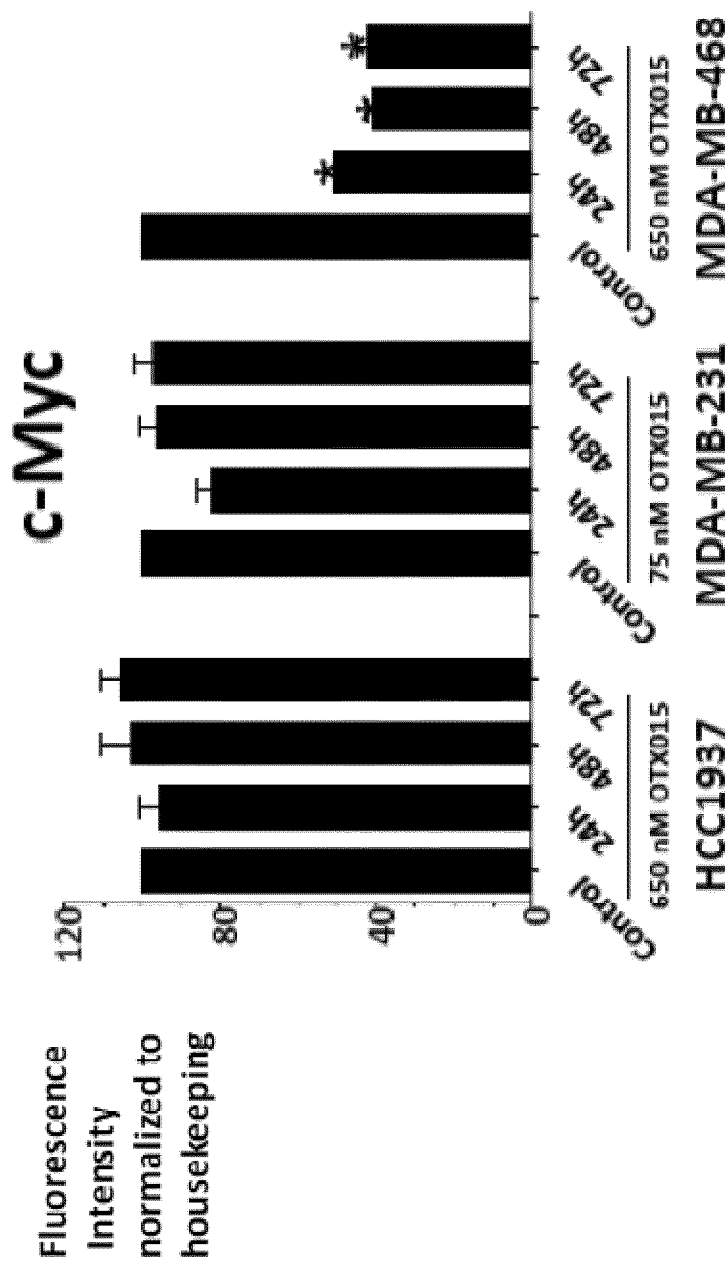


FIG. 16E

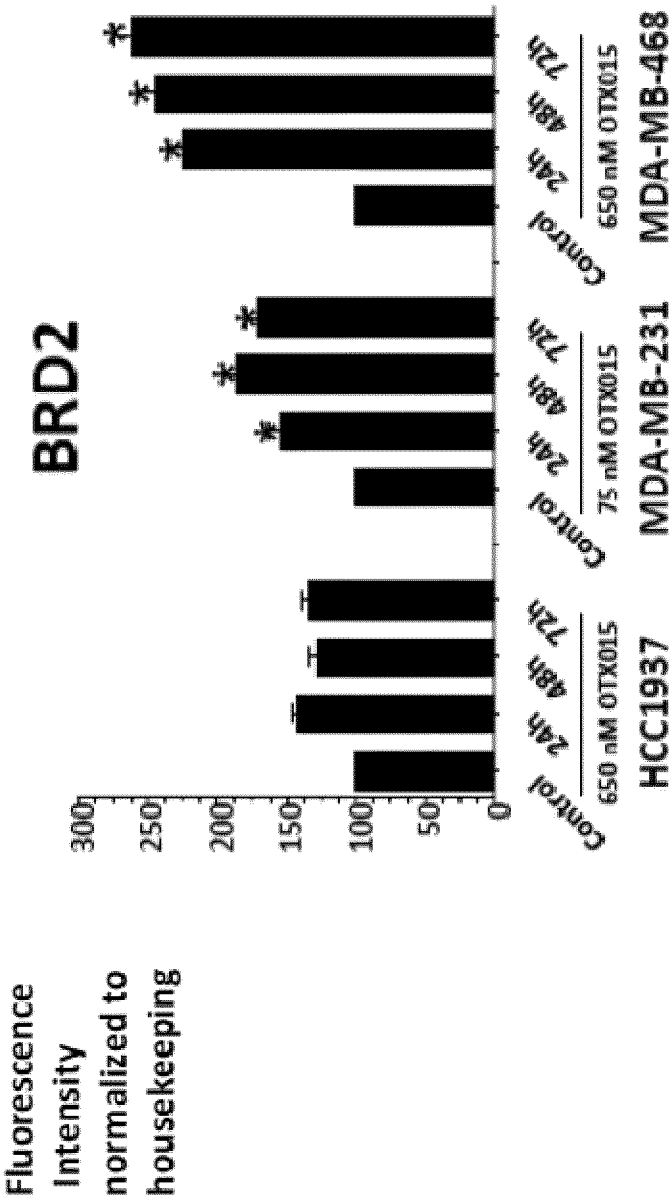


FIG. 16F

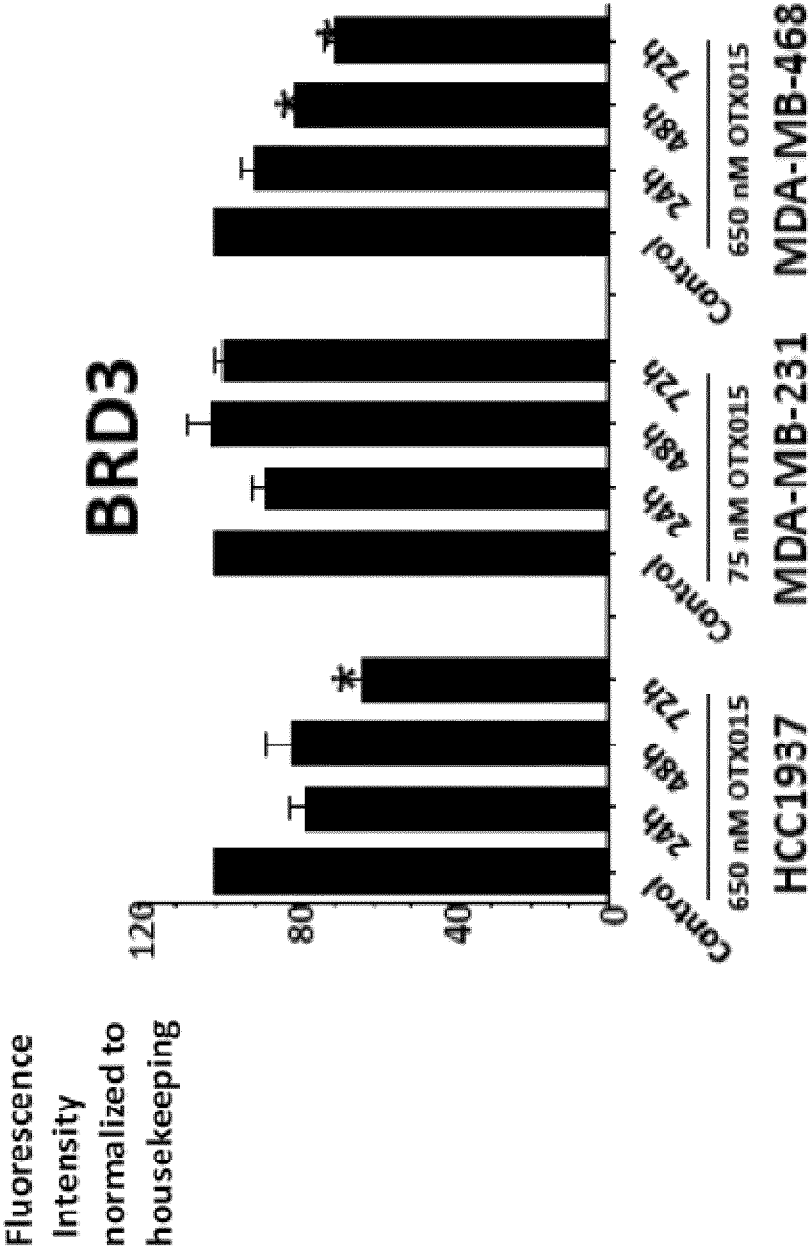
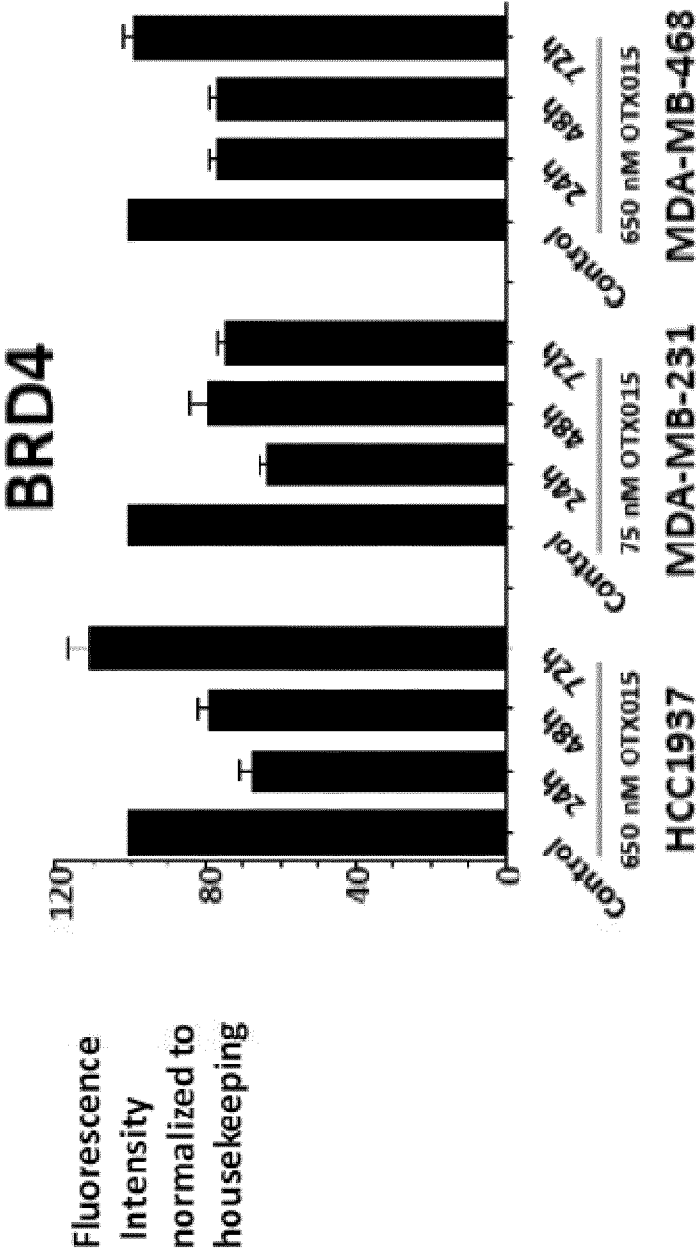


FIG. 16G



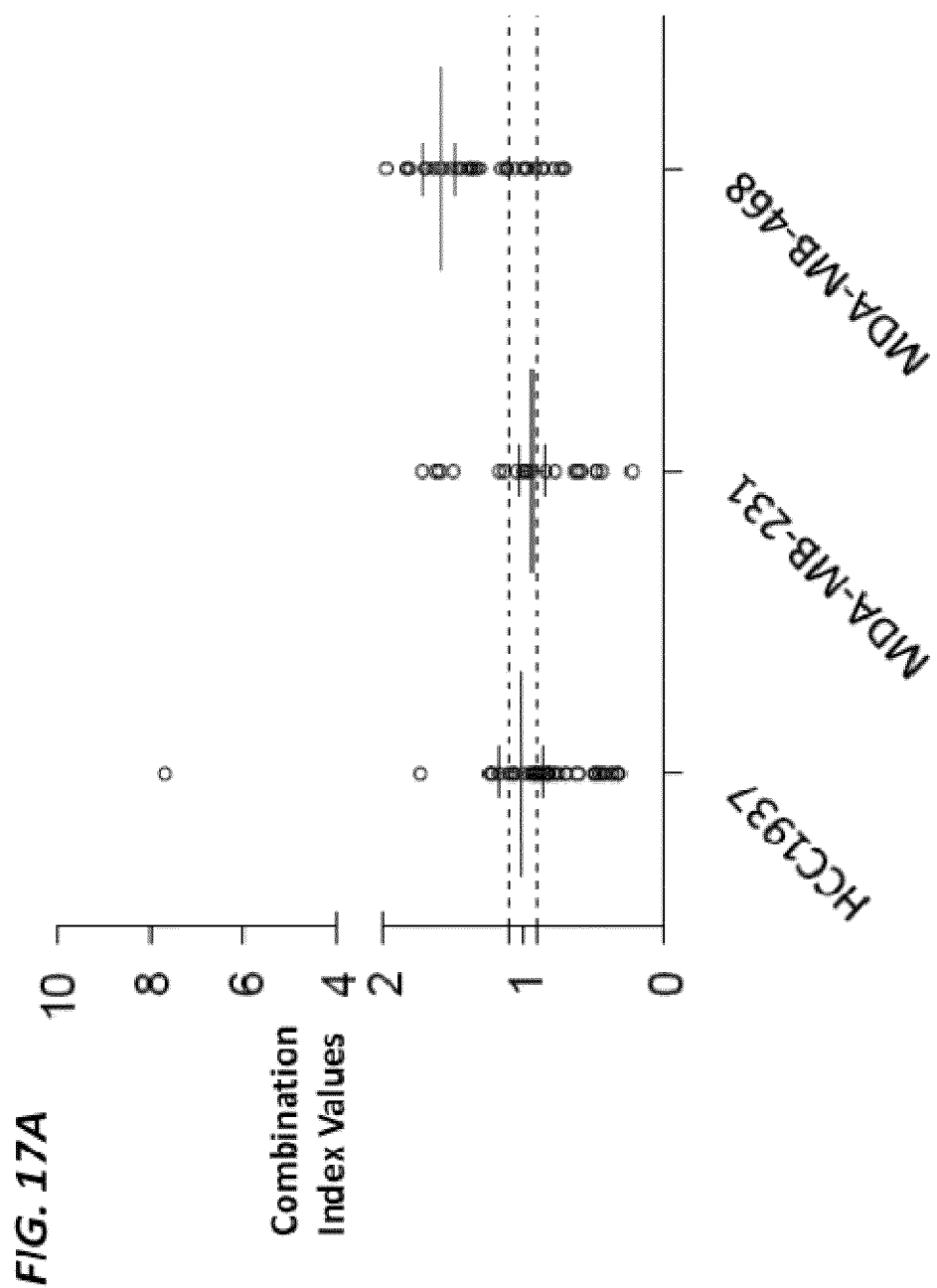


FIG. 17B

Cell line	CI value	Effect
HCC1937	1.02	Additive
MDA-MB-231	0.94	Additive
MDA-MB-468	1.60	Antagonistic

FIG. 18A

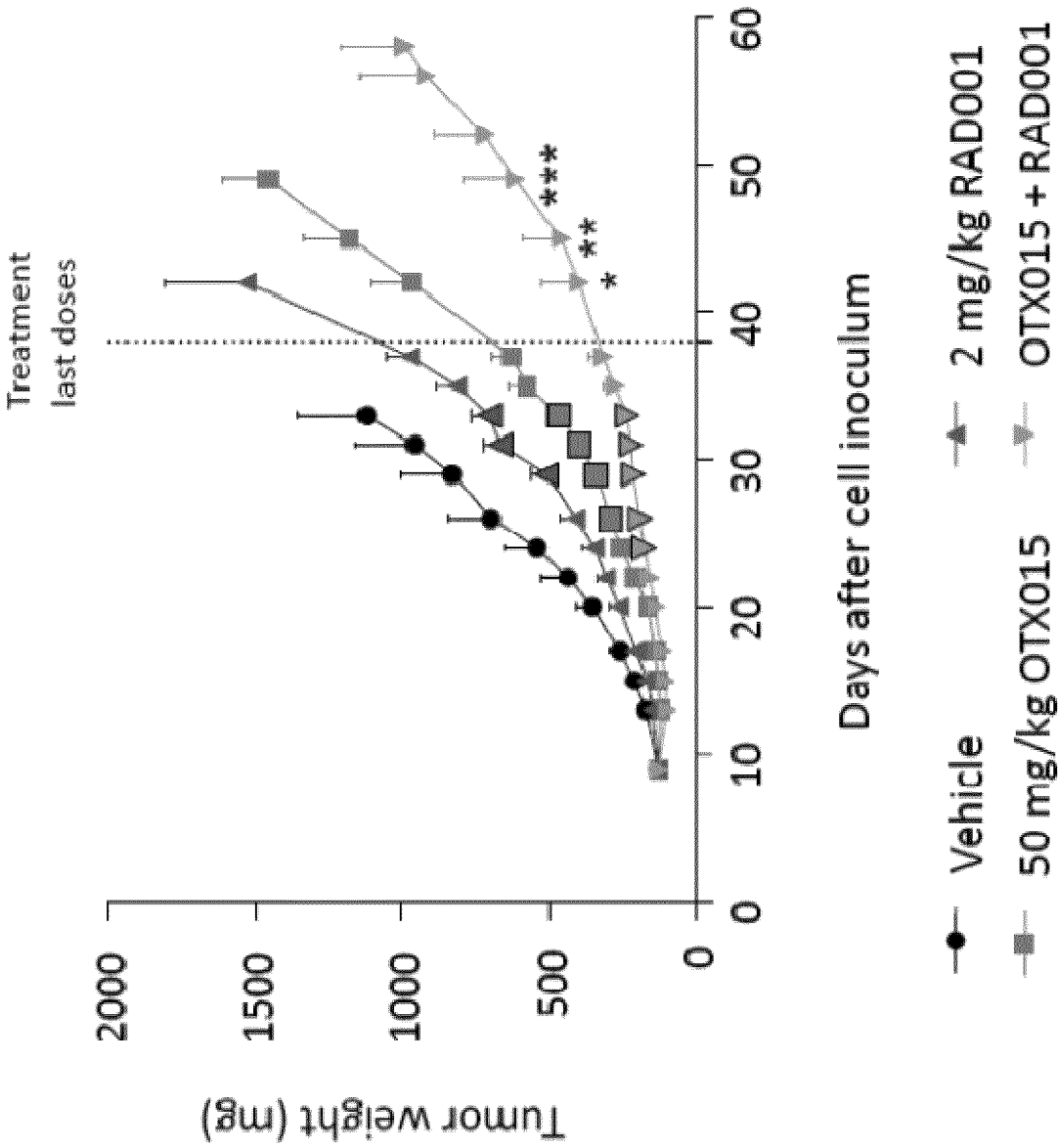
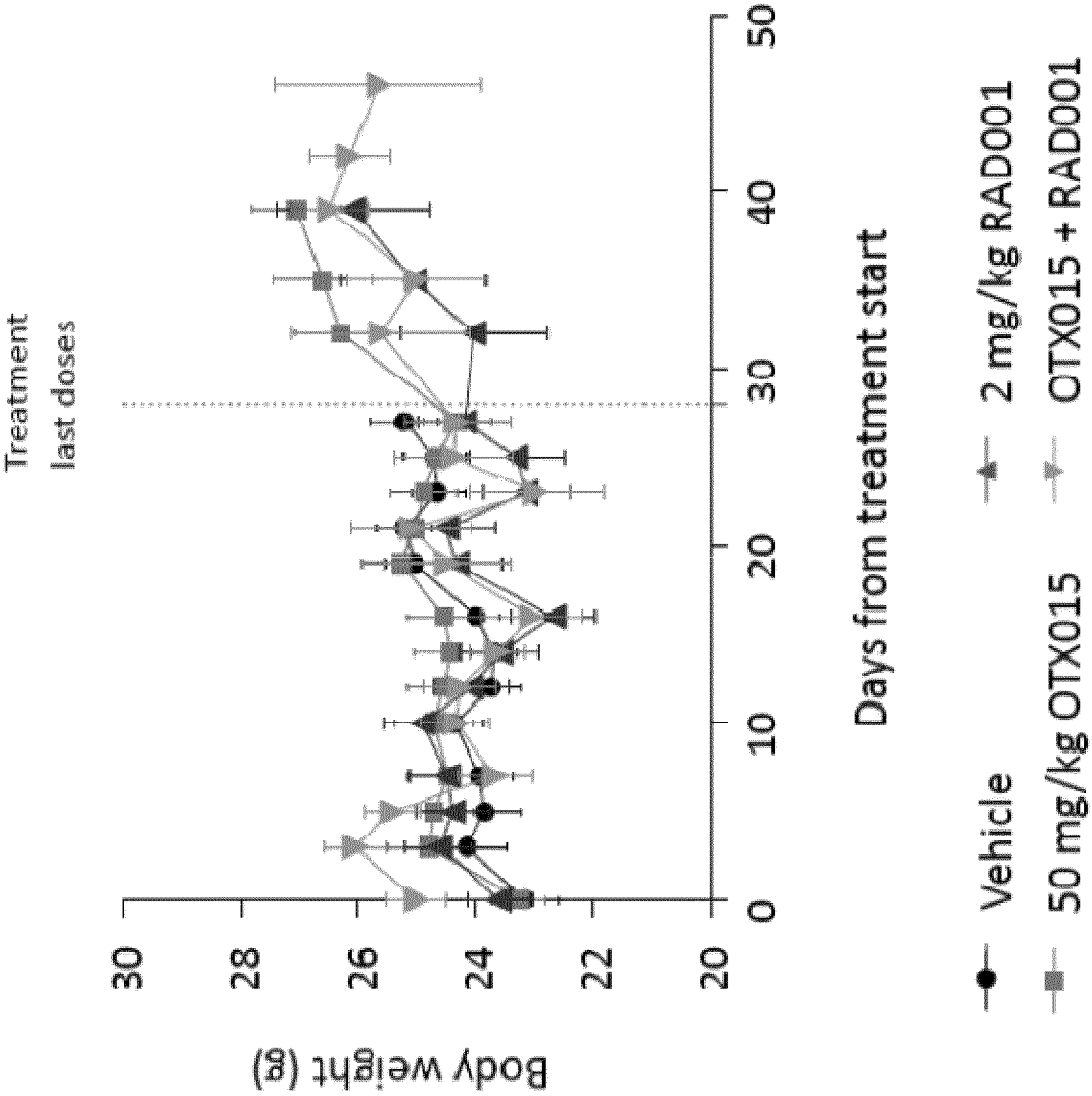


FIG. 18B



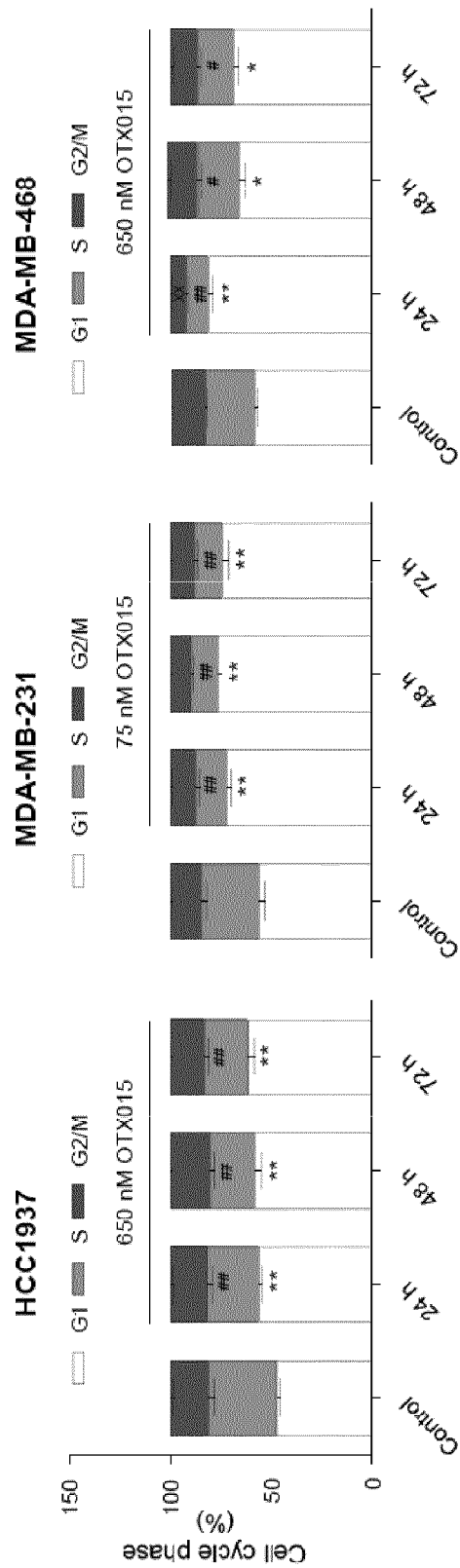
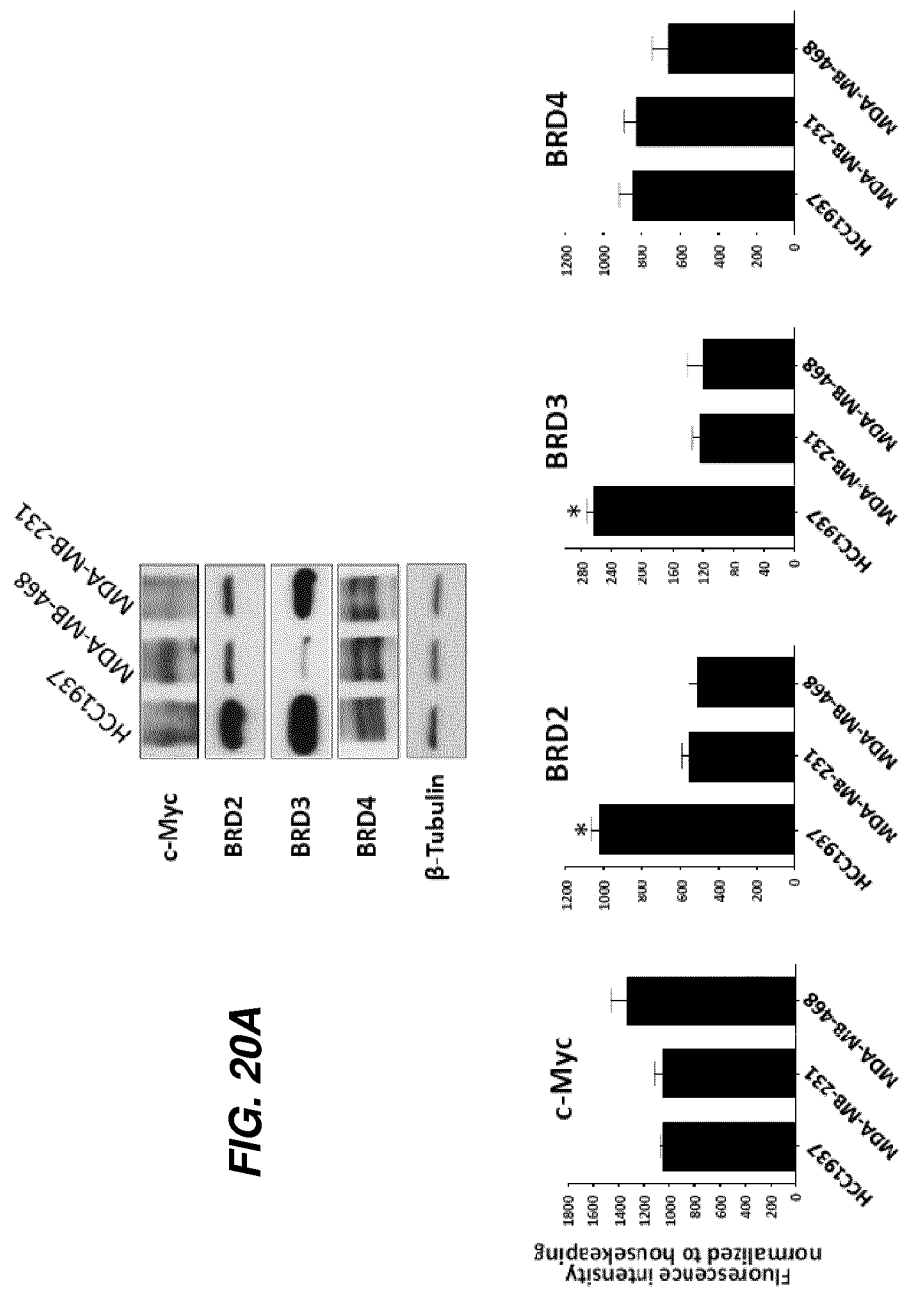


FIG. 19



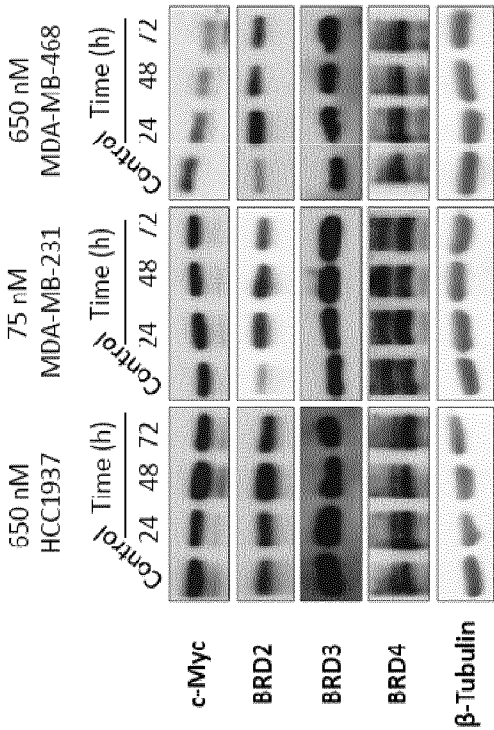
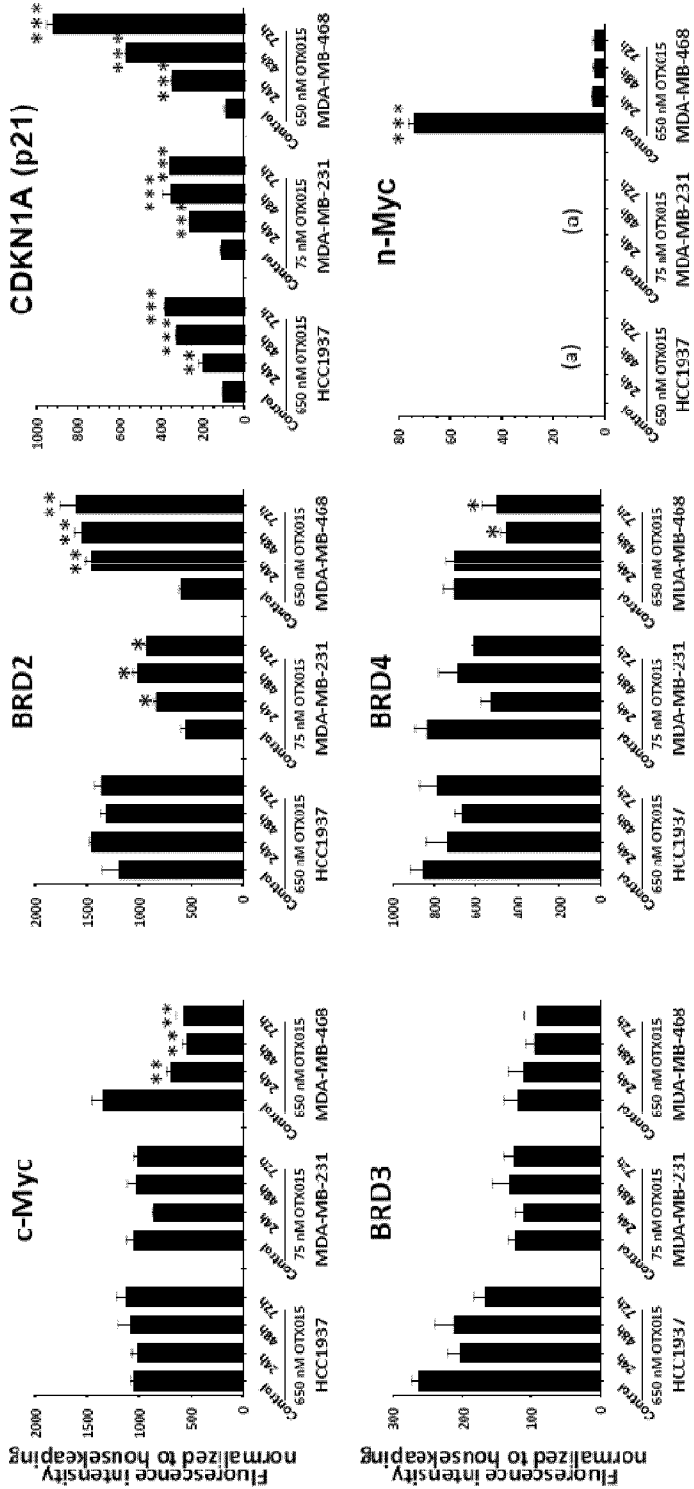


FIG. 20B



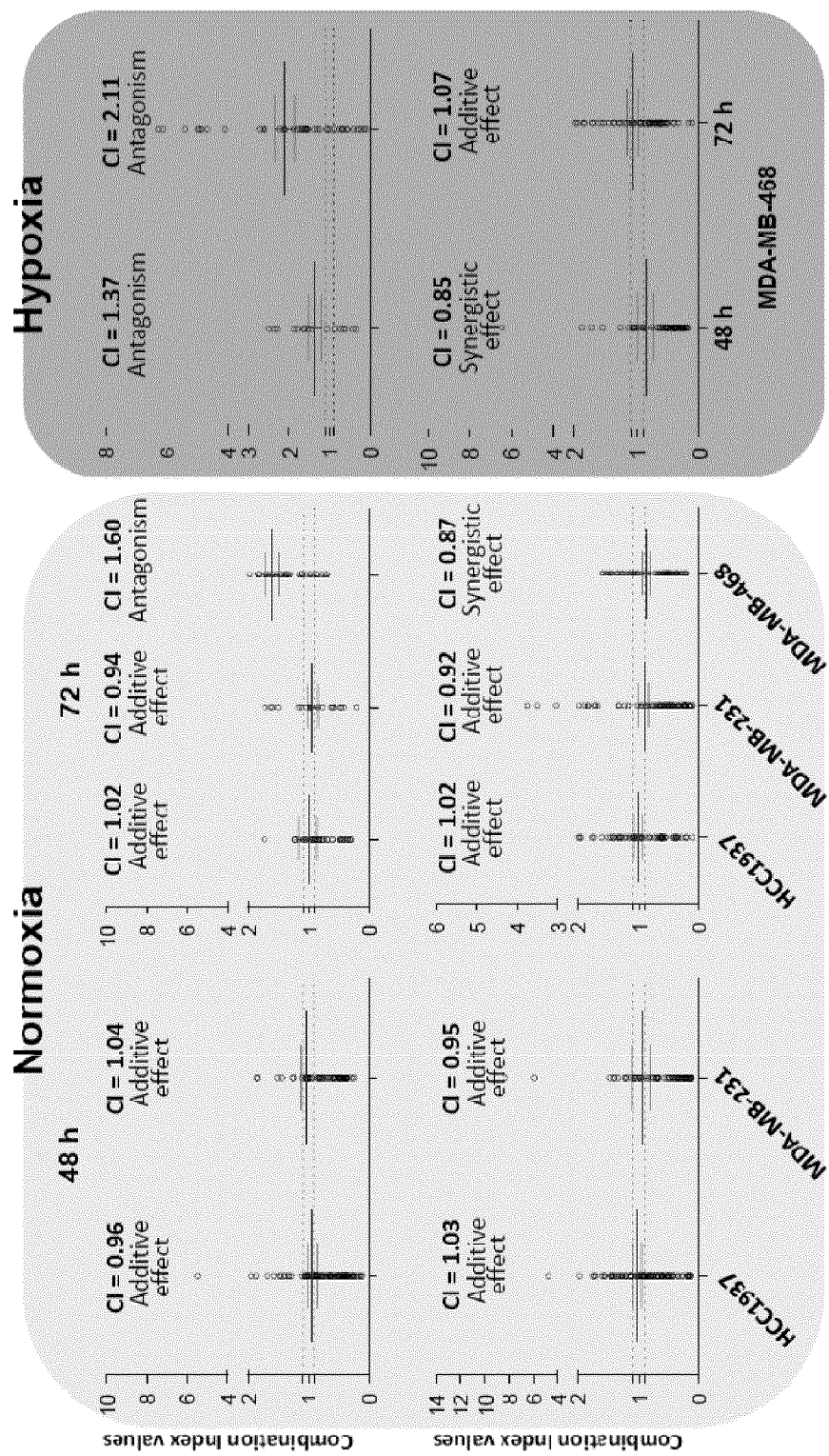


FIG. 21