

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

(19) World Intellectual Property Organization  
International Bureau



(10) International Publication Number  
**WO 2017/004543 A1**

(43) International Publication Date  
5 January 2017 (05.01.2017)

(51) International Patent Classification:  
*C07D 233/32* (2006.01)   *A61P 35/00* (2006.01)  
*A61K 31/4166* (2006.01)

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(21) International Application Number:  
PCT/US2016/040736

(22) International Filing Date:  
1 July 2016 (01.07.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
62/187,636                    1 July 2015 (01.07.2015)            US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, 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).

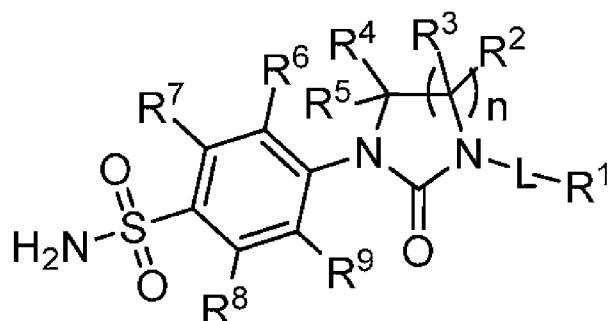
**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

**Published:**

- with international search report (Art. 21(3))

(54) Title: ARYL SULFONAMIDE COMPOUNDS AS CARBONIC ANHYDRASE INHIBITORS AND THEIR THERAPEUTIC USE



**Formula (I)**

(57) Abstract: Disclosed herein are compounds having the following structure useful as inhibitors of carbonic anhydrase IX (CAIX) and XII, and particularly useful for reducing or eliminating metastases see Formula (I).

**ARYL SULFONAMIDE COMPOUNDS AS CARBONIC ANHYDRASE  
INHIBITORS AND THEIR THERAPEUTIC USE**

**BACKGROUND**

Technical Field

5                   The present disclosure relates generally to the field of inhibitors of carbonic anhydrase IX (CAIX) and XII (CAXII), such as aryl sulfonamide compounds, and use of such compounds in treating and/or preventing various human diseases, including those related to CAIX and CAXII, especially in the treatment of cancer related to hypoxia and metastasis, and the depletion of  
10                   cancer stem cells in mammals.

Description of the Related Art

                  Hypoxia is a biologically and clinically relevant feature of solid cancers, and its presence has important implications for tumor phenotype, cancer progression, metastasis, and is correlated with poor prognosis in many  
15                   types of solid tumors (Chaudary and Hill, *Breast Dis.* 2006-2007, 26:55-64; Milani and Harris, *Eur. J. Cancer*, 2008, 44(18):2766-2773). Hypoxia is also associated with resistance of tumors to conventional treatment with radiotherapy and chemotherapy. A hypoxic environment is known to promote epithelial to mesenchymal transition (EMT) of cancer cells, leading to increased  
20                   metastatic propensity. It also provides a niche environment for cancer stem cells (CSCs), a subset of cancer cells with tumor-initiating properties, including the capacity of self-renewal, and resistance to current anti-cancer therapies (Scheel and Weinberg, *Semin. Cancer Biol.*, 2012, 22(5-6):396-403). Importantly, the inability to effectively eradicate these aggressive,  
25                   treatment-resistant tumor cells results in recurrence and distant metastasis, the truly deadly aspects of cancer.

                  The capacity of cancer cells to adapt to the inherently hostile conditions of low oxygen provides a selective advantage compared to normal cells, and supports their expansion and dissemination (Sedlakova *et al.*, *Front.*

Physiol., 2014, 4:400). Adaptation of cancer cells to hypoxia involves activation of the HIF-1 $\alpha$  signaling cascade (Lendhal *et al.*, Nat. Rev. Genet., 2009, 10(12):821-32), culminating in the downstream regulation of several critical cellular processes, including induction of a glycolytic switch (Sedlakova *et al.*, 5 Front. Physiol., 2014, 4:400; Gatenby and Gillies, Nat. Rev. Cancer., 2008, 8(1):56-61; Neri and Supuran, Nat. Rev. Drug Discov., 2011, 10(10):767-77) that leads to increased production of acidic metabolites, including lactic acid, protons, and carbon dioxide (CO<sub>2</sub>) (Parks *et al.*, J. Cell Physiol., 2011, 226(2):299-308). To avoid prolonged intracellular acidosis, the presence of 10 which rapidly affects cellular functions vital to cell survival, (Gatenby and Gillies, Nat. Rev. Cancer., 2004, 4(11):891-899; Neri and Supuran, Nat. Rev. Drug Discov., 2011, 10(10):767-77) tumor cells activate a network of proteins and buffer systems that function to maintain pH homeostasis (Gatenby and Gillies, Nat. Rev. Cancer., 2004, 4(11):891-899; Neri and Supuran, Nat. Rev. Drug 15 Discov., 2011, 10(10):767-77; Fang *et al.*, Semin. Cancer Biol., 2008, 18(5):330-7; Gatenby and Gillies, Nat. Rev. Cancer., 2008, 8(1):56-61). The membrane-bound, exofacial carbonic anhydrases, especially tumor-associated CAIX and CAXII, are critical components of this pH regulatory system (Neri and Supuran, Nat. Rev. Drug Discov., 2011, 10(10):767-77; Supuran, Nat. Rev. 20 Drug Discov., 2008, 7(2):168-81; McDonald *et al.*, Oncotarget., 2012, 3(1):84-97).

CAIX is a cell surface, HIF-1 $\alpha$ -inducible metalloenzyme that 25 functions to catalyze the reversible hydration of CO<sub>2</sub> to bicarbonate (HCO<sub>3</sub><sup>-</sup>) and protons (H<sup>+</sup>) (Gatenby and Gillies, Nat. Rev. Cancer., 2008, 8(1):56-61). In hypoxic tumors, CAIX enables the maintenance of pH favorable for cancer cell survival and growth, and simultaneously participates in extracellular acidification, facilitating tumor cell migration, invasion, and metastasis (Swietach *et al.*, J. Biol. Chem., 2009, 284(30):20299-310; Supuran, Nat. Rev. Drug Discov., 2008, 7(2):168-81). Furthermore, suppressing CAIX or inhibiting 30 its activity results in depletion of cancer stem cells and inhibition of EMT.

Therefore, inhibiting CAIX activity interferes with pH regulation, reducing cancer cell survival (especially cancer stem cells), and attenuating invasion, ultimately inhibiting tumor growth and metastasis (Supuran, *Nat. Rev. Drug Discov.*, 2008, 7(2):168-81; Lou *et al.*, *Cancer Res.*, 2011, 71(9):3364-76). CAIX expression is 5 highly restricted in human normal tissue but the overexpression in solid tumors is associated with poor prognosis in many cancers including lung, colon, breast, cervix, bladder, pancreas, ovaries, brain, head and neck, and oral cavity. In addition, clinical studies have revealed a correlation between CAIX expression and metastatic disease (Lou *et al.*, *Cancer Res.*, 2011, 71(9):3364-76; 10 Lancaster *et al.*, *Cancer Res.*, 2001, 61(17):6394-9; Kim *et al.*, *J. Cancer Res. Clin. Oncol.*, 2006, 132(5):302-8; De Schutter *et al.*, *BMC Cancer*, 2005, 5:42; Liao *et al.*, *Gynecol. Oncol.*, 2010, 116(3):452-8.; Garcia *et al.*, *Hum. Pathol.*, 2007, 38(6):830-41).

CAIX is an attractive target for anticancer therapy for several 15 reasons. It is selectively expressed on the extracellular surface of tumor cells and shows highly restricted expression in normal tissue (Supuran, *Nat. Rev. Drug Discov.*, 2008, 7(2):168-81). It is a functional regulator of processes critical for tumor growth and metastasis, including pH regulation, survival, and adhesion/migration. Furthermore, genetic silencing of CAIX in preclinical tumor 20 models *in vivo* has demonstrated the requirement of CAIX for the growth of hypoxic tumors and their metastasis (Chiche *et al.*, *Cancer Res.*, 2009, 69(1):358-368; Lou *et al.*, *Cancer Res.*, 2011, 71(9):3364-76; McIntyre *et al.*, *Clin. Cancer Res.*, 2012, 18(11):3100-11).

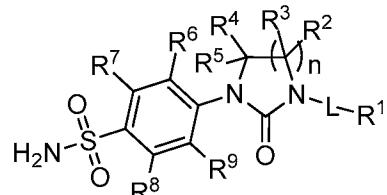
Analogous to CAIX, CAXII is a membrane-bound, exofacial 25 carbonic anhydrase that catalyzes the reversible hydration of carbon dioxide (Gatenby and Gillies, *Nat. Rev. Cancer.*, 2004, 4(11):891-899; Wykoff *et al.*, *Am. J. Pathol.*, 2001, 158(3):1011-9). Similar to CAIX, its expression is limited in normal tissue, but it is expressed in many types of human cancer, including pancreatic, colorectal, oral, brain, lung, ovarian, breast, and T-cell lymphoma 30 and is likely also involved in pH regulation and cancer cell survival (Watson et

al., Br. J. Cancer, 2003, 88(7):1065-70; Wykoff et al., Am. J. Pathol., 2001, 158(3):1011-9; Gondi et al., Cancer Res., 2013, 73(21):6494-503; Ilie et al., Lung Cancer, 2013, 82(1):16-23; Gatenby & Gillies, Nat. Rev. Cancer., 2004, 4(11):891-899). It is noteworthy that co-expression of CAIX and CAXII is 5 evident in some types of cancers, suggesting that a degree of redundancy may exist between CAIX and CAXII in these cases (McIntyre et al., Clin. Cancer Res., 2012, 18(11):3100-11). In cancer types where both isoforms are expressed or where inhibition of CAIX potentially results in partial compensation by CAXII, concurrent selective inhibition of both targets may be necessary.

## 10 SUMMARY

The present disclosure provides aryl sulfonamide derivatives that are capable of inhibiting the activity of CAIX and CAXII. Methods of using such derivatives to inhibit the activity of CAIX and CAXII and pharmaceutical compositions comprising such derivatives are also disclosed.

15 One embodiment provides a compound of Formula (I):



Formula (I)

wherein:

20  $R^1$  is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

$R^2$ ,  $R^3$ ,  $R^4$ , and  $R^5$  are the same or different and independently hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

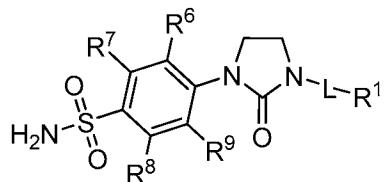
$R^6$ ,  $R^7$ ,  $R^8$ , and  $R^9$  are the same or different and independently hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

25  $L$  is a direct bond or  $(C(R^{10})_2)_p$ ;

$n = 1, 2$  or  $3$ ; and

p = 1 to 4;  
 each R<sup>10</sup> is the same or different and independently hydrogen or alkyl;  
 a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a pharmaceutical composition thereof or a prodrug thereof,  
 provided that the compound of Formula (I) is not 4-[3-[cis-4-(aminomethyl)-4-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-benzenesulfonamide.

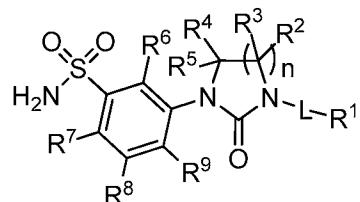
10 A further embodiment provides a compound of Formula (I), wherein n is 1, and R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> are each hydrogen, and the compound is represented by a structure of Formula (Ia):



Formula (Ia)

15 wherein R<sup>1</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup>, R<sup>10</sup>, L and p are as defined as above.

Another embodiment provides compounds of Formula (II):



Formula (II)

wherein R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup>, R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, R<sup>9</sup>, R<sup>10</sup>, L, n and p are as defined above, provided that the compound of Formula (II) is not 4-[3-[cis-4-(aminomethyl)-3-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]benzenesulfonamide.

Yet another embodiment provides a pharmaceutical composition comprising a compound of any one of Formulae (I), (Ia) or (II) and a pharmaceutically acceptable excipient.

Further embodiments provide for methods for treating solid

5 tumors expressing CAIX comprising administering to a subject in need thereof a pharmaceutically effective amount of a compound of Formula (I), (Ia) or (II), or a pharmaceutical composition comprising the same.

In more specific embodiments, the cancer may be, without limitation, astrocytoma/glioblastoma, bladder cancer, breast cancer, colorectal

10 carcinoma, esophageal adenocarcinoma, gastrointestinal stromal tumors, gastric cancer, head and neck cancer, hepatocellular carcinoma, lung cancer, melanoma, ovarian cancer, pancreatic ductal adenocarcinoma, renal cell carcinoma, thyroid cancer, or uterine endometrial cancer.

#### DETAILED DESCRIPTION OF THE DISCLOSURE

##### 15 Definitions

Certain chemical groups named herein are preceded by a shorthand notation indicating the total number of carbon atoms that are to be found in the indicated chemical group. For example; C<sub>7</sub>-C<sub>12</sub>alkyl describes an alkyl group, as defined below, having a total of 7 to 12 carbon atoms, and C<sub>4</sub>-

20 C<sub>12</sub>cycloalkylalkyl describes a cycloalkylalkyl group, as defined below, having a total of 4 to 12 carbon atoms. The total number of carbons in the shorthand notation does not include carbons that may exist in substituents of the group described.

Accordingly, as used in the specification and appended claims,

25 unless specified to the contrary, the following terms have the meaning indicated:

"Amino" refers to the -NH<sub>2</sub> radical.

"Cyano" refers to the -CN radical.

"Nitro" refers to the -NO<sub>2</sub> radical.

"Oxo" refers to the =O substituent.

"Thioxo" refers to the =S substituent.

"Alkyl" refers to a straight or branched hydrocarbon chain radical,

when unsubstituted, consisting solely of carbon and hydrogen atoms,

5 containing no unsaturation, having from one to twelve carbon atoms, preferably one to eight carbon atoms or one to six carbon atoms, and which is attached to the rest of the molecule by a single bond, e.g., methyl, ethyl, *n*-propyl, 1-methylethyl (*iso*-propyl), *n*-butyl, *n*-pentyl, 1,1-dimethylethyl (*t*-butyl), and the like. Unless stated otherwise specifically in the specification, an alkyl group

10 may be optionally substituted by one of the following groups: alkenyl, amino, halo, haloalkenyl, cyano, nitro, aryl, cycloalkyl, heterocyclyl, heteroaryl, -OR<sup>14</sup>, -OC(O)R<sup>14</sup>, -N(R<sup>14</sup>)<sub>2</sub>, -C(O)R<sup>14</sup>, -C(O)OR<sup>14</sup>, -C(O)N(R<sup>14</sup>)<sub>2</sub>, -N(R<sup>14</sup>)C(O)OR<sup>16</sup>, -N(R<sup>14</sup>)C(O)R<sup>16</sup>, -N(R<sup>14</sup>)(S(O)<sub>t</sub>R<sup>16</sup>) (where *t* is 1 to 2), -S(O)<sub>t</sub>OR<sup>16</sup> (where *t* is 1 to 2), -S(O)<sub>t</sub>R<sup>16</sup> (where *t* is 0 to 2),

15 and -S(O)<sub>t</sub>N(R<sup>14</sup>)<sub>2</sub> (where *t* is 1 to 2) where each R<sup>14</sup> is independently hydrogen, alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl (optionally substituted with one or more halo groups), aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl; and each R<sup>16</sup> is alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl, and where

20 each of the above substituents is unsubstituted unless otherwise indicated.

Thus, "alkyl" includes unsubstituted and substituted alkyl.

"Alkenyl" refers to a straight or branched hydrocarbon chain

radical group when unsubstituted, consisting solely of carbon and hydrogen

atoms, containing at least one double bond, having from two to twelve carbon

25 atoms, preferably one to eight carbon atoms and which is attached to the rest of the molecule by a single bond, e.g., ethenyl, prop-1-enyl, but-1-enyl, pent-1-enyl, penta-1,4-dienyl, and the like. Unless stated otherwise specifically in the specification, an alkenyl group may be optionally substituted by one of the following groups: alkyl, amino, halo, haloalkyl, haloalkenyl, cyano, nitro, aryl,

30 aralkyl, cycloalkyl, cycloalkylalkyl, heterocyclyl, heterocyclylalkyl, heteroaryl,

heteroarylalkyl, -OR<sup>14</sup>,  
-OC(O)R<sup>14</sup>, -N(R<sup>14</sup>)<sub>2</sub>, -C(O)R<sup>14</sup>, -C(O)OR<sup>14</sup>, -C(O)N(R<sup>14</sup>)<sub>2</sub>, -N(R<sup>14</sup>)C(O)OR<sup>16</sup>, -N(R<sup>14</sup>)C(O)R<sup>16</sup>, -N(R<sup>14</sup>)(S(O)<sub>t</sub>R<sup>16</sup>) (where t is 1 to 2), -S(O)<sub>t</sub>OR<sup>16</sup> (where t is 1 to 2), -S(O)<sub>t</sub>R<sup>16</sup> (where t is 0 to 2), and -S(O)<sub>t</sub>N(R<sup>14</sup>)<sub>2</sub> (where t is 1 to 2) where  
5 each R<sup>14</sup> is independently hydrogen, alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl; and each R<sup>16</sup> is alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl, and where each of the above substituents is unsubstituted. Thus, "alkenyl" includes unsubstituted and  
10 substituted alkenyl.

"Alkylene" and "alkylene chain" refer to a straight or branched divalent hydrocarbon chain, linking the rest of the molecule to a radical group, consisting solely of carbon and hydrogen, containing no unsaturation and having from one to twelve carbon atoms, preferably having from one to eight  
15 carbons, e.g., methylene, ethylene, propylene, *n*-butylene, and the like. The alkylene chain may be attached to the rest of the molecule and to the radical group through one carbon within the chain or through any two carbons within the chain.

"Alkoxy" refers to a radical of the formula -OR<sub>a</sub> where R<sub>a</sub> is an  
20 alkyl radical as defined above. The alkyl part of the alkoxy radical may be optionally substituted as defined above for an alkyl radical. In particular, the alkyl portion of the alkoxy may be further substituted with amino, halo, haloalkyl, haloalkenyl, cyano, hydroxy, nitro, or alkoxy.

"Aryl" refers to aromatic monocyclic or multi-cyclic hydrocarbon  
25 ring system, when unsubstituted, consisting only of hydrogen and carbon and containing from 6 to 19 carbon atoms, preferably 6 to 10 carbon atoms, where the ring system may be partially or fully saturated. Aryl groups include, but are not limited to groups such as fluorenyl, phenyl and naphthyl. Unless stated otherwise specifically in the specification, the term "aryl" or the prefix "ar-" (such  
30 as in "aralkyl") is meant to include aryl radicals optionally substituted by one or

more substituents selected from the group consisting of alkyl, alkenyl, amino, halo, haloalkyl, haloalkenyl, cyano, nitro, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heterocyclyl, heterocyclylalkyl, heteroaryl, heteroarylalkyl, -

5       $R^{15}$ -OR<sup>14</sup>,  $R^{15}$ -OC(O)-R<sup>14</sup>, -R<sup>15</sup>-N(R<sup>14</sup>)<sub>2</sub>, -R<sup>15</sup>-C(O)R<sup>14</sup>, -R<sup>15</sup>-C(O)OR<sup>14</sup>,  
-R<sup>15</sup>-C(O)N(R<sup>14</sup>)<sub>2</sub>, -R<sup>15</sup>-N(R<sup>14</sup>)C(O)OR<sup>16</sup>, -R<sup>15</sup>-N(R<sup>14</sup>)C(O)R<sup>16</sup>, -R<sup>15</sup>-N(R<sup>14</sup>)(S(O)<sub>t</sub>  
R<sup>16</sup>) (where t is 1 to 2), -R<sup>15</sup>-S(O)<sub>t</sub>OR<sup>16</sup> (where t is 1 to 2), -R<sup>15</sup>-S(O)<sub>t</sub>R<sup>16</sup> (where  
t is 0 to 2), and -R<sup>15</sup>-S(O)<sub>t</sub>N(R<sup>14</sup>)<sub>2</sub> (where t is 1 to 2) where each R<sup>14</sup> is  
independently hydrogen, alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl,  
heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl; each R<sup>15</sup> is

10     independently a direct bond or a straight or branched alkylene or alkenylene  
chain; and each R<sup>16</sup> is alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl,  
heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl, and where each of  
the above substituents is unsubstituted. Thus, "aryl" includes unsubstituted and  
substituted aryl.

15     "Aralkyl" refers to a radical of the formula -R<sub>a</sub>R<sub>b</sub> where R<sub>a</sub> is an  
alkyl radical as defined above and R<sub>b</sub> is one or more aryl radicals as defined  
above, e.g., benzyl, diphenylmethyl and the like. The aryl part of the aralkyl  
radical may be optionally substituted as described above for an aryl group. The  
alkyl part of the aralkyl radical may be optionally substituted as defined above  
20     for an alkyl group.

25     "Aralkenyl" refers to a radical of the formula -R<sub>c</sub>R<sub>b</sub> where R<sub>c</sub> is an  
alkenyl radical as defined above and R<sub>b</sub> is one or more aryl radicals as defined  
above, which may be optionally substituted as described above. The aryl part  
of the aralkenyl radical may be optionally substituted as described above for an  
aryl group. The alkenyl part of the aralkenyl radical may be optionally  
substituted as defined above for an alkenyl group.

30     "Cycloalkyl" refers to a stable non-aromatic monocyclic or bicyclic  
hydrocarbon radical, when unsubstituted, consisting solely of carbon and  
hydrogen atoms, having from three to fifteen carbon atoms, preferably having  
from three to twelve carbon atoms, and which is saturated or unsaturated and

attached to the rest of the molecule by a single bond, e.g., cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, decalinyl and the like. Unless otherwise stated specifically in the specification, the term "cycloalkyl" is meant to include cycloalkyl radicals which are optionally substituted by one or more substituents

5 selected from the group consisting of alkyl, alkenyl, amino, halo, haloalkyl, haloalkenyl, cyano, nitro, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heterocyclyl, heterocyclylalkyl, heteroaryl, heteroarylalkyl,  $-R^{15}-OR^{14}$ ,  $-R^{15}-OC(O)-R^{14}$ ,  $-R^{15}-N(R^{14})_2$ ,  $-R^{15}C(O)R^{14}$ ,  $-R^{15}C(O)OR^{14}$ ,  $-R^{15}-C(O)N(R^{14})_2$ ,  $-R^{15}-N(R^{14})C(O)OR^{16}$ , -

10  $R^{15}-N(R^{14})C(O)R^{16}$ ,  $-R^{15}-N(R^{14})(S(O)_tR^{16})$  (where t is 1 to 2),  $-R^{15}-S(O)_tOR^{16}$  (where t is 1 to 2),  $-R^{15}-S(O)_tR^{16}$  (where t is 0 to 2), and  $-R^{15}-S(O)_tN(R^{14})_2$  (where t is 1 to 2) where each  $R^{14}$  is independently hydrogen, alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl; each  $R^{15}$  is independently a direct bond or a

15 straight or branched alkylene or alkenylene chain; and each  $R^{16}$  is alkyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl, and where each of the above substituents is unsubstituted. Thus, "cycloalkyl" includes unsubstituted and substituted cycloalkyl.

20 "Cycloalkylalkyl" refers to a radical of the formula  $-R_aR_d$  where  $R_a$  is an alkyl radical as defined above and  $R_d$  is a cycloalkyl radical as defined above. The cycloalkyl part of the cycloalkyl radical may be optionally substituted as defined above for a cycloalkyl radical. The alkyl part of the cycloalkyl radical may be optionally substituted as defined above for an alkyl radical.

25 "Halo" refers to bromo, chloro, fluoro or iodo.

"Haloalkyl" refers to an alkyl radical, as defined above, that is substituted by one or more halo radicals, as defined above. One or more carbons of the alkyl radical may be substituted by the one or more halo radicals. Examples of haloalkyl include, e.g., trifluoromethyl, difluoromethyl,

trichloromethyl, 2,2,2-trifluoroethyl, 1-fluoromethyl-2-fluoroethyl, 3-bromo-2-fluoro-propyl, 1-bromomethyl-2-bromoethyl, and the like. The alkyl part of the haloalkyl radical may be optionally substituted as defined above for an alkyl group.

5 "Heterocyclyl" refers to a stable 3- to 18-membered non-aromatic ring radical including, as ring atoms, at least one carbon atom and from one to five heteroatoms selected from the group consisting of nitrogen, oxygen and sulfur. For purposes of this disclosure, the heterocyclyl radical may be a monocyclic, bicyclic, tricyclic or tetracyclic ring system, which may include fused 10 or bridged ring systems; and the nitrogen, carbon or sulfur atoms in the heterocyclyl radical may be optionally oxidized; and the nitrogen atom may be optionally quaternized; and the heterocyclyl radical may be partially or fully saturated. Examples of such heterocyclyl radicals include, but are not limited to, dioxolanyl, decahydroisoquinolyl, imidazolinyl, imidazolidinyl, isothiazolidinyl, 15 isoxazolidinyl, morpholinyl, octahydroindolyl, octahydroisoindolyl, 2-oxopiperazinyl, 2-oxopiperidinyl, 2-oxopyrrolidinyl, oxazolidinyl, piperidinyl, piperazinyl, 4-piperidonyl, pyrrolidinyl, pyrazolidinyl, thiazolidinyl, tetrahydrofuryl, trithianyl, tetrahydropyranyl, thiomorpholinyl, thiamorpholinyl, 1-oxo-thiomorpholinyl, and 1,1-dioxo-thiomorpholinyl. Unless stated otherwise 20 specifically in the specification, the term "heterocyclyl" is meant to include heterocyclyl radicals as defined above which are optionally substituted by one or more substituents selected from the group consisting of alkyl, alkenyl, amino, halo, haloalkyl, haloalkenyl, cyano, oxo, thioxo, nitro, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heterocyclyl, heterocyclylalkyl, heteroaryl, 25 heteroarylalkyl,  $-R^{15}-OR^{14}$ ,  $-R^{15}-$   
 $OC(O)-R^{14}$ ,  $-R^{15}-N(R^{14})_2$ ,  $-R^{15}-C(O)R^{14}$ ,  $-R^{15}-C(O)OR^{14}$ ,  $-R^{15}-C(O)N(R^{14})_2$ ,  $-R^{15}-$   
 $N(R^{14})C(O)OR^{16}$ ,  $-R^{15}-N(R^{14})C(O)R^{16}$ ,  $-R^{15}-N(R^{14})(S(O)_tR^{16})$  (where t is 1 to 2),  
 $-R^{15}-S(O)_tOR^{16}$  (where t is 1 to 2),  $-R^{15}-S(O)_tR^{16}$  (where t is 0 to 2),  
and  $-R^{15}-S(O)_tN(R^{14})_2$  (where t is 1 to 2) where each  $R^{14}$  is independently 30 hydrogen, alkyl, alkenyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl,

heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl; each R<sup>15</sup> is independently a direct bond or a straight or branched alkylene or alkenylene chain; and each R<sup>16</sup> is alkyl, alkenyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl, and where

5 each of the above substituents is unsubstituted. Heterocyclyl, as defined herein, may be monovalent or divalent. When the heterocyclyl is a substituent of another moiety, the heterocyclyl is monovalent, which means that the heterocyclyl is connected to the other moiety by a single ring atom. An example of a monovalent heterocyclyl can be found in the radical of

10 heterocyclylalkyl, in which a heterocyclyl group is a substituent of an alkyl group. When heterocyclyl is a linker moiety, the heterocyclyl is a divalent radical. Thus, "heterocyclyl" includes unsubstituted and substituted heterocyclyl.

"Heterocyclylalkyl" refers to a radical of the formula -R<sub>a</sub>R<sub>e</sub> where

15 R<sub>a</sub> is an alkyl radical as defined above and R<sub>e</sub> is a heterocyclyl radical as defined above, and if the heterocyclyl is a nitrogen-containing heterocyclyl, the heterocyclyl may be attached to the alkyl radical at the nitrogen atom. The alkyl part of the heterocyclylalkyl radical may be optionally substituted as defined above for an alkyl group. The heterocyclyl part of the heterocyclylalkyl radical

20 may be optionally substituted as defined above for a heterocyclyl group.

"Heteroaryl" refers to a 5- to 18-membered aromatic ring radical including, as ring atoms, at least one carbon atom and from one to five heteroatoms selected from the group consisting of nitrogen, oxygen and sulfur. For purposes of this disclosure, the heteroaryl radical may be a monocyclic,

25 bicyclic, tricyclic or tetracyclic ring system, which may include fused or bridged ring systems; and the nitrogen, carbon or sulfur atoms in the heteroaryl radical may be optionally oxidized; and the nitrogen atom may be optionally quaternized. Examples include, but are not limited to, azepinyl, acridinyl, benzimidazolyl, benzthiazolyl, benzindolyl, benzothiadiazolyl,

30 benzonaphthofuranyl, benzoxazolyl, benzodioxolyl, benzodioxinyl,

benzopyranyl, benzopyranonyl, benzofuranyl, benzofuranonyl, benzothienyl (benzothiophenyl), benzotriazolyl, benzo[4,6]imidazo[1,2-a]pyridinyl, carbazolyl, cinnolinyl, dibenzofuranyl, furanyl, furanonyl, isothiazolyl, imidazolyl, indolyl, indazolyl, isoindolyl, indolinyl, isoindolinyl, indolizinyl, isoxazolyl, naphthyridinyl, 5 oxadiazolyl, 2-oxoazepinyl, oxazolyl, oxiranyl, phenazinyl, phenothiazinyl, phenoazinyl, phthalazinyl, pteridinyl, purinyl, pyrrolyl, pyrazolyl, pyridinyl, pyrazinyl, pyrimidinyl, pyridazinyl, quinazolinyl, quinoxalinyl, quinolinyl, quinuclidinyl, isoquinolinyl, thiazolyl, thiadiazolyl, triazolyl, tetrazolyl, triazinyl, and thiophenyl. Unless stated otherwise specifically in the specification, the 10 term "heteroaryl" is meant to include heteroaryl radicals as defined above which are optionally substituted by one or more substituents selected from the group consisting of alkyl, alkenyl, amino, halo, haloalkyl, haloalkenyl, cyano, oxo, thioxo, nitro, aryl, aralkyl, cycloalkyl, cycloalkylalkyl, heterocyclyl, heterocyclylalkyl, heteroaryl, heteroarylalkyl,  $-R^{15}-OR^{14}$ ,  $-R^{15}-OC(O)-R^{14}$ ,  $-R^{15}-N(R^{14})_2$ ,  $-R^{15}-C(O)R^{14}$ ,  $-R^{15}-C(O)OR^{14}$ ,  $-R^{15}-C(O)N(R^{14})_2$ ,  $-R^{15}-N(R^{14})C(O)OR^{16}$ ,  $-R^{15}-N(R^{14})C(O)R^{16}$ ,  $-R^{15}-N(R^{14})(S(O)_tR^{16})$  (where t is 1 to 2),  $-R^{15}-S(O)_tOR^{16}$  (where t is 1 to 2),  $-R^{15}-S(O)_tR^{16}$  (where t is 0 to 2), and  $-R^{15}-S(O)_tN(R^{14})_2$  (where t is 1 to 2) where each  $R^{14}$  is independently hydrogen, alkyl, alkenyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, 15 heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl; each  $R^{15}$  is independently a direct bond or a straight or branched alkylene or alkenylene chain; and each  $R^{16}$  is alkyl, alkenyl, haloalkyl, cycloalkyl, cycloalkylalkyl, aryl, aralkyl, heterocyclyl, heterocyclylalkyl, heteroaryl or heteroarylalkyl, and where each of the above substituents is unsubstituted. Heteroaryl, as defined herein, 20 may be monovalent or divalent. When heteroaryl is a substituent of another moiety, the heteroaryl is monovalent, which means that the heteroaryl is connected to the other moiety by a single ring atom. An example of a monovalent heteroaryl can be found in the radical of heteroarylalkyl, in which an alkyl group is substituted with a heteroaryl group. When heteroaryl is a linker, 25

the heteroaryl is a divalent radical. Thus, "heteroaryl" includes unsubstituted and substituted heteroaryl.

"Heteroarylalkyl" refers to a radical of the formula -R<sub>a</sub>R<sub>f</sub> where R<sub>a</sub> is an alkyl radical as defined above and R<sub>f</sub> is a heteroaryl radical as defined above. The heteroaryl part of the heteroarylalkyl radical may be optionally substituted as defined above for a heteroaryl group. The alkyl part of the heteroarylalkyl radical may be optionally substituted as defined above for an alkyl group.

"Prodrugs" refers to a compound that may be converted under physiological conditions or by solvolysis to a biologically active compound of any one of Formulae (I), (Ia) or (II). Thus, the term "prodrug" refers to a metabolic precursor of a compound of any one of Formulae (I), (Ia) or (II) that is pharmaceutically acceptable; the latter is also referred to as a "parent compound." A prodrug may be inactive when administered to a subject in need thereof, but is converted *in vivo* to an active compound, *i.e.*, the parent compound. Prodrugs are typically rapidly transformed *in vivo* to yield the parent compound, for example, by hydrolysis in blood. The prodrug compound often offers advantages of solubility, tissue compatibility or delayed release in a mammalian organism (see, Bundgard, H., *Design of Prodrugs* (1985), pp. 7-9, 21-24, Elsevier, Amsterdam).

The term "prodrug" is also meant to include any covalently bonded carriers which release the active compound of the disclosure *in vivo* when such prodrug is administered to a mammalian subject. Prodrugs of a compound of the disclosure may be prepared by modifying functional groups present in the compound of the any one of Formulae (I), (Ia) or (II) in such a way that the modifications are cleaved, either in routine manipulation or *in vivo*, to the parent compound. Prodrugs include compounds of any one of Formulae (I), (Ia) or (II) wherein a hydroxy, amino or mercapto group is bonded to any group that, when the prodrug is administered to a mammalian subject, cleaves to restore the free hydroxy, free amino or free mercapto group, respectively.

Examples of prodrugs include, but are not limited to, acetate, formate and benzoate, and phosphate derivatives of alcohol or amine functional groups in the compounds of any one of Formulae (I), (Ia) or (II).

"Stable compound" and "stable structure" are meant to indicate a 5 compound that is sufficiently robust to survive isolation to a useful degree of purity from a reaction mixture, and formulation into an efficacious therapeutic agent.

"Mammal" or "mammalian subject" or "subject" includes humans and domestic animals, such as cats, dogs, swine, cattle, sheep, goats, horses, 10 rabbits, and the like.

"Optional" or "optionally" means that the subsequently described event of circumstances may or may not occur, and that the description includes instances where said event or circumstance occurs and instances in which it does not. For example, "optionally substituted aryl" means that the aryl radical 15 may or may not be substituted and that the description includes both substituted aryl radicals and aryl radicals having no substitution.

"Pharmaceutically acceptable carrier, diluent or excipient" includes without limitation any adjuvant, carrier, excipient, glidant, sweetening agent, diluent, preservative, dye/colorant, flavor enhancer, surfactant, wetting 20 agent, dispersing agent, suspending agent, stabilizer, isotonic agent, solvent, or emulsifier which has been approved by the United States Food and Drug Administration as being acceptable for use in humans or domestic animals.

"Pharmaceutically acceptable acid addition salt" refers to those salts which retain the biological effectiveness and properties of the free bases, 25 which are not biologically or otherwise undesirable, and which are formed with inorganic acids such as, but not limited to, hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid and the like, and organic acids such as, but not limited to, acetic acid, 2,2-dichloroacetic acid, adipic acid, alginic acid, ascorbic acid, aspartic acid, benzenesulfonic acid, benzoic acid, 4-30 acetamidobenzoic acid, camphoric acid, camphor-10-sulfonic acid, capric acid,

caproic acid, caprylic acid, carbonic acid, cinnamic acid, citric acid, cyclamic acid, dodecylsulfuric acid, ethane-1,2-disulfonic acid, ethanesulfonic acid, 2-hydroxyethanesulfonic acid, formic acid, fumaric acid, galactaric acid, gentisic acid, glucoheptonic acid, gluconic acid, glucuronic acid, glutamic acid, glutaric acid, 2-oxo-glutaric acid, glycerophosphoric acid, glycolic acid, hippuric acid, isobutyric acid, lactic acid, lactobionic acid, lauric acid, maleic acid, malic acid, malonic acid, mandelic acid, methanesulfonic acid, mucic acid, naphthalene-1,5-disulfonic acid, naphthalene-2-sulfonic acid, 1-hydroxy-2-naphthoic acid, nicotinic acid, oleic acid, orotic acid, oxalic acid, palmitic acid, pamoic acid, propionic acid, pyroglutamic acid, pyruvic acid, salicylic acid, 4-aminosalicylic acid, sebacic acid, stearic acid, succinic acid, tartaric acid, thiocyanic acid, *p*-toluenesulfonic acid, trifluoroacetic acid, undecylenic acid, and the like.

"Pharmaceutically acceptable base addition salt" refers to those salts which retain the biological effectiveness and properties of the free acids, which are not biologically or otherwise undesirable. These salts are prepared from addition of an inorganic base or an organic base to the free acid. Salts derived from inorganic bases include, but are not limited to, the sodium, potassium, lithium, ammonium, calcium, magnesium, iron, zinc, copper, manganese, aluminum salts and the like. Preferred inorganic salts are the ammonium, sodium, potassium, calcium, and magnesium salts. Salts derived from organic bases include, but are not limited to, salts of primary, secondary, and tertiary amines, substituted amines including naturally occurring substituted amines, cyclic amines and basic ion exchange resins, such as ammonia, isopropylamine, trimethylamine, diethylamine, triethylamine, tripropylamine, diethanolamine, ethanolamine, deanol, 2-dimethylaminoethanol, 2-diethylaminoethanol, dicyclohexylamine, lysine, arginine, histidine, caffeine, procaine, hydрабamine, choline, betaine, benethamine, benzathine, ethylenediamine, glucosamine, methylglucamine, theobromine, triethanolamine, tromethamine, purines, piperazine, piperidine, *N*-ethylpiperidine, polyamine resins and the like. Particularly preferred organic bases are isopropylamine,

diethylamine, ethanolamine, trimethylamine, dicyclohexylamine, choline and caffeine.

Often crystallizations produce a solvate of the compound of the disclosure. As used herein, the term "solvate" refers to an aggregate that

- 5 comprises one or more molecules of a compound of the disclosure with one or more molecules of solvent. The solvent may be water, in which case the solvate may be a hydrate. Alternatively, the solvent may be an organic solvent. Thus, the compounds of the present disclosure may exist as a hydrate, including a monohydrate, dihydrate, hemihydrate, sesquihydrate, trihydrate, 10 tetrahydrate and the like, as well as the corresponding solvated forms. The compound of the disclosure may be true solvates, while in other cases, the compound of the disclosure may merely retain adventitious water or be a mixture of water plus some adventitious solvent.

A "pharmaceutical composition" refers to a formulation of a

- 15 compound of the disclosure and a medium generally accepted in the art for the delivery of the biologically active compound to mammals, e.g., humans. Such a medium includes all pharmaceutically acceptable carriers, diluents or excipients therefor.

"Therapeutically effective amount" refers to that amount of a

- 20 compound of the disclosure which, when administered to a mammal, preferably a human, is sufficient to effect treatment, as defined below, of a disease or condition in the mammal, preferably a human. The amount of a compound of the disclosure which constitutes a "therapeutically effective amount" will vary depending on the compound, the condition and its severity, and the age of the 25 mammal to be treated, but can be determined routinely by one of ordinary skill in the art having regard to his own knowledge and to this disclosure.

"Treating" or "treatment" as used herein covers the treatment of the disease or condition of interest in a mammal, preferably a human, having the disease or disorder of interest, and includes:

- (i) preventing the disease or condition from occurring in a mammal, in particular, when such mammal is predisposed to the condition but has not yet been diagnosed as having it;
- (ii) inhibiting the disease or condition, *i.e.*, arresting its development; or
- (iii) relieving the disease or condition, *i.e.*, causing regression of the disease or condition.

As used herein, the terms "disease" and "condition" may be used interchangeably or may be different in that the particular malady or condition 10 may not have a known causative agent (so that etiology has not yet been worked out) and it is therefore not yet recognized as a disease but only as an undesirable condition or syndrome, wherein a more or less specific set of symptoms have been identified by clinicians.

The compounds of the disclosure, or their pharmaceutically 15 acceptable salts may contain one or more asymmetric centers and may thus give rise to enantiomers, diastereomers, and other stereoisomeric forms that may be defined, in terms of absolute stereochemistry, as (R)- or (S)- or, as (D)- or (L)- for amino acids. The present disclosure is meant to include all such possible isomers, as well as their racemic and optically pure forms. Optically 20 active (+) and (-), (R)- and (S)-, or (D)- and (L)- isomers may be prepared using chiral synthons or chiral reagents, or resolved using conventional techniques, such as HPLC using a chiral column. When the compounds described herein contain olefinic double bonds or other centers of geometric asymmetry, and unless specified otherwise, it is intended that the compounds include both *E* 25 and *Z* geometric isomers. Likewise, all tautomeric forms are also intended to be included.

A "stereoisomer" refers to a compound made up of the same atoms bonded by the same bonds but having different three-dimensional structures, which are not interchangeable. The present disclosure contemplates 30 various stereoisomers and mixtures thereof and includes "enantiomers", which

refers to two stereoisomers whose molecules are non-superimposeable mirror images of one another.

A "tautomer" refers to a proton shift from one atom of a molecule to another atom of the same molecule. The present disclosure includes

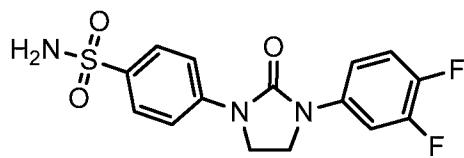
5 tautomers of any said compounds.

An "isotopically enriched derivative" refers to a compound wherein one or more atoms are replaced 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

10 the compounds of the disclosure comprises isotopes of hydrogen, such as  $^2\text{H}$  and  $^3\text{H}$ , carbon, such as  $^{11}\text{C}$ ,  $^{13}\text{C}$  and  $^{14}\text{C}$ , chlorine, such as  $^{38}\text{Cl}$ , fluorine, such as  $^{18}\text{F}$ , iodine, such as  $^{123}\text{I}$  and  $^{125}\text{I}$ , nitrogen, such as  $^{13}\text{N}$  and  $^{15}\text{N}$ , oxygen, such as  $^{15}\text{O}$ ,  $^{17}\text{O}$  and  $^{18}\text{O}$ , phosphorus, such as  $^{31}\text{P}$ ,  $^{32}\text{P}$  and  $^{33}\text{P}$ , and sulphur, such as  $^{35}\text{S}$ . Substitution with heavier isotopes such as deuterium, i.e.  $^2\text{H}$ , may afford  
15 certain therapeutic advantages resulting from greater metabolic stability, for example, increased in vivo half-life or reduced dosage requirements and hence may be preferred in some circumstances. Isotopically-enriched compounds of the disclosure can generally be prepared by conventional techniques known to those skilled in the art or by processes analogous to those described in the  
20 accompanying Examples and Preparations Sections using an appropriate isotopically-enriched reagent in place of the non-enriched reagent previously employed.

The chemical naming protocol and structure diagrams used herein employ and rely the chemical naming features as utilized by Chemdraw  
25 version 12.0.2.1076 (available from Cambridgesoft Corp., Cambridge, MA).

For example, a compound of formula (I), as set forth above in the Summary of this disclosure, where  $\text{R}^1$  is 3,4-difluorophenyl,  $\text{R}^2$ ,  $\text{R}^3$ ,  $\text{R}^4$ ,  $\text{R}^5$ ,  $\text{R}^6$ ,  $\text{R}^7$ ,  $\text{R}^8$ , and  $\text{R}^9$  are each hydrogen, L is a direct bond and n is 1, i.e., a compound of the following formula:

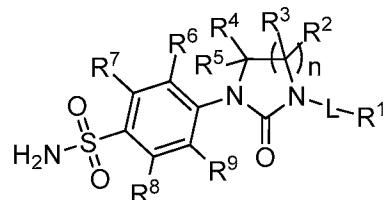


is named herein as: 4-(3-(3,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

## EMBODIMENTS OF THE DISCLOSURE

### 5 Embodiments

One embodiment provides a compound of Formula (I):



Formula (I)

wherein:

10  $R^1$  is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

$R^2$ ,  $R^3$ ,  $R^4$ , and  $R^5$  are the same or different and independently from hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

$R^6$ ,  $R^7$ ,  $R^8$ , and  $R^9$  are the same or different and independently

15 hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

$L$  is a direct bond or  $(C(R^{10})_2)_p$ ;

$n$  = 1, 2 or 3; and

$p$  = 1 to 4;

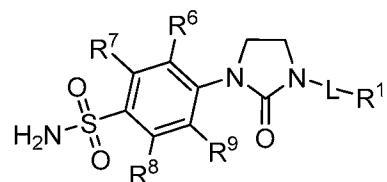
each  $R^{10}$  is the same or different and independently hydrogen or

20 alkyl;

a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a pharmaceutical composition thereof or a prodrug thereof,

provided that the compound of Formula (I) is not 4-[3-[cis-4-(aminomethyl)-4-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-benzenesulfonamide.

A further embodiment provides a compound of Formula (I),  
 5 wherein n is 1, and R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> are each hydrogen, and the compound is  
 represented by a structure of Formula (Ia):



Formula (Ia)

wherein:

10 R<sup>1</sup> is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, and R<sup>9</sup> are the same or different and independently hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

L is a direct bond or (C(R<sup>10</sup>)<sub>2</sub>)<sub>p</sub>;

15 p = 1 to 4; and

each R<sup>10</sup> is the same or different and independently hydrogen or alkyl;

a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a

20 pharmaceutical composition thereof or a prodrug thereof,

provided that the compound of Formula (I) is not 4-[3-[cis-4-(aminomethyl)-4-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-benzenesulfonamide.

In various embodiments, R<sup>1</sup> is aryl, including substituted aryl, and  
 25 L is a direct bond or a methylene (-CH<sub>2</sub>-).

In more specific embodiments, R<sup>1</sup> is substituted aryl (e.g., phenyl) substituted by one or substituents selected from the group consisting of halo, alkyl, alkoxy, heterocyclyl, haloalkyl, cyano and acetyl.

In more specific embodiments, a compound of Formula (I) or (Ia)

5 is as follows:

- 4-(3-(4-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(4-fluorobenzyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2-fluoro-4-(4-methylpiperazin-1-yl)phenyl)-2-oxoimidazolidin-1-10 yl)benzenesulfonamide;
- 4-(2-oxo-3-(*p*-tolyl)imidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(3-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(3,5-dimethylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 15 4-(2-oxo-3-(3,4,5-trimethoxyphenyl)imidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2-fluoro-4-morpholinophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(4-bromo-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(4-chloro-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(2-oxo-3-(4-(trifluoromethyl)phenyl)imidazolidin-1-yl)benzenesulfonamide;
- 20 4-(3-(4-chloro-3-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2-fluoro-4-methoxyphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2-fluoro-5-(trifluoromethyl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(4-(2-methoxyethoxy)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 25 4-(3-(2-isopropylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(3,5-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(3-chloro-4-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(3,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;
- 4-(3-(2-chloro-5-(trifluoromethyl)phenyl)-2-oxoimidazolidin-1-30 yl)benzenesulfonamide;

4-(3-(4-butoxy-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
 4-(3-(4-butoxyphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
 4-(3-(4-cyanophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide; or  
 4-(3-(4-acetylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

5 In other embodiments, R<sup>1</sup> is cycloalkyl, including substituted cycloalkyl, and L is a direct bond or a methylene (-CH<sub>2</sub>-).

In more specific embodiments, a compound of Formula (I) or (Ia) is as follows:

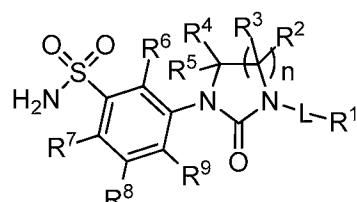
10 4-(3-cyclopentyl-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
 4-(3-cyclohexyl-2-oxoimidazolidin-1-yl)benzenesulfonamide; or  
 4-(3-(cyclopropylmethyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

In other embodiments, R<sup>1</sup> is heteroaryl, including substituted heteroaryl, and L is a direct bond or a methylene (-CH<sub>2</sub>-).

15 In a more specific embodiment, a compound of Formula (I) or (Ia) is:

4-(3-(5-fluoropyridin-2-yl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

Another embodiment provides compounds of Formula (II):



Formula (II)

20 wherein:

R<sup>1</sup> is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, and R<sup>5</sup> are the same or different and independently from hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

25 R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, and R<sup>9</sup> are the same or different and independently hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

L is a direct bond or (C(R<sup>10</sup>)<sub>2</sub>)<sub>p</sub>;

n = 1, 2 or 3; and  
p = 1 to 4;  
each R<sup>10</sup> is the same or different and independently hydrogen or alkyl;

5 a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a pharmaceutical composition thereof or a prodrug thereof,  
provided that the compound of Formula (II) is not 4-[3-[cis-4-(aminomethyl)-3-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-

10 benzenesulfonamide.

Yet another embodiment provides a pharmaceutical composition comprising a compound of Formula (I), (Ia) or (II) and a pharmaceutically acceptable excipient.

Another embodiment provides a method for suppressing tumor

15 growth, invasion and/or tumor metastases in a mammal comprising administering to said mammal with a pharmaceutical composition having a compound of any one of Formulae (I), (Ia) or (II).

Another embodiment provides a method for reducing breast cancer cells number or mass in a mammal comprising administering to said

20 mammal with a pharmaceutical composition having a compound of any one of Formulae (I), (Ia) or (II).

Another embodiment provides a method of depleting cancer stem cells in a mammalian cancer stem cell population comprising contacting the mammalian cancer stem cell population with a compound of any one of

25 Formulae (I), (Ia) or (II).

Another embodiment provides a method of inducing cell death in hypoxic cancer cells comprising contacting the hypoxic cancer cells with a compound of any one of Formulae (I), (Ia) or (II).

The tumors or cancer cells that may be treated include tumor or

30 cancer cells of breast, lung, pancreatic, renal, prostate, cervical, colorectal

cancer, or glioblastoma, according to various embodiments. Any cancer or tumor or cell population treated herein may express CAIX or CAXII over and above the normal level for non-cancerous like-originated tissues.

In particular, treating a mammal having cancer or a tumor using  
5 the pharmaceutical compositions of the present disclosure includes reducing or eliminating metastases.

In more specific embodiments, the cancers being treated include, without limitation, astrocytoma/glioblastoma, bladder cancer, breast cancer, colorectal carcinoma, esophageal adenocarcinoma, gastrointestinal stromal  
10 tumors, gastric cancer, head and neck cancer, hepatocellular carcinoma, lung cancer, melanoma, ovarian cancer, pancreatic ductal adenocarcinoma, renal cell carcinoma, thyroid cancer, or uterine endometrial cancer.

In further embodiments, the method of treatment disclosed herein may include administering (either simultaneously or sequentially) an additional  
15 chemotherapeutic or other anticancer agents.

#### Utility and Testing of the Compounds of the Disclosure

The present disclosure relates to compounds, pharmaceutical compositions and methods of using the compounds and pharmaceutical compositions for the treatment and/or prevention of diseases and conditions  
20 mediated by the activity of CAIX or CAXII individually or by any combination of them, preferably diseases and conditions related to characterized by angiogenesis and/or cell proliferation and migration, and especially a disease and condition related to cancer, and the like, by administering an effective amount of a compound of the disclosure.

25 The compounds of the disclosure modulate, preferably inhibit, the activity of human CAIX or CAXII individually or by any combination of them.

The general value of the compounds of the disclosure in modulating, especially inhibiting, the activity of CAIX or CAXII individually or by any combination of them can be determined using the assay described below in  
30 Example 29.

The compounds of the instant disclosure are inhibitors of CAIX or CAXII individually or inhibitors of any combination of them and are useful for treating diseases and disorders in humans and other organisms, including all those human diseases and disorders which are the result of abnormal activity of

5 CAIX or CAXII individually or any combination of them or which may be ameliorated by modulation of the activity of CAIX or CAXII individually or any combination of them.

As defined herein, a disease or condition mediated by the abnormal activity of CAIX or CAXII individually or any combination of them is 10 defined as any disease or condition in which the activity of CAIX or CAXII individually or any combination of them is elevated and/or where inhibition of the activity of CAIX or CAXII individually or any combination of them can be demonstrated to bring about symptomatic improvements for the individual so treated. As defined herein, a disease or condition mediated by the abnormal 15 activity of CAIX or CAXII individually or any combination of them includes, but is not limited to, a disease or condition which is, or is related to cancer. For purposes of this disclosure, Diseases and conditions which are alleviated by the modulation of the activity of CAIX or CAXII individually or any combination of them include, but are not limited to, solid tumors, including, but not limited to, 20 breast, renal, endometrial, ovarian, thyroid, and non-small cell lung carcinoma, melanoma, prostate carcinoma, sarcoma, gastric cancer and uveal melanoma; endometriosis, vascular disease/injury including, but not limited to, restenosis, atherosclerosis and thrombosis, psoriasis; visual impairment due to macular degeneration; diabetic retinopathy and retinopathy of prematurity; kidney 25 disease including, but not limited to, glomerulonephritis, diabetic nephropathy and renal transplant rejection, rheumatoid arthritis; osteoarthritis, osteoporosis and cataracts.

In addition to the foregoing, the compounds of the disclosure are useful in treating diseases and conditions which are affected by the following 30 biological processes: Invasion, migration, metastasis, or drug resistance as

manifested in cancer; stem cell biology as manifested in cancer; invasion, migration, adhesion, or angiogenesis as manifested in endometriosis; vascular remodeling as manifested in cardiovascular disease, hypertension or vascular injury; bone homeostasis as manifested in osteoporosis or osteoarthritis; viral infection as manifested, for example, in ebola virus infection; or differentiation as manifested in obesity.

The following animal models provide guidance to one of ordinary skill in the art in testing the compounds of the disclosure for their use in treating the disease or condition indicated.

10 The compounds of the disclosure may be used or tested for their use in treating solid tumors by, respectively, administering a pharmaceutically effective amount or testing the compounds in the xenograft in SCID mouse model using human cancer cell lines which express CAIX or CAXII or co-expressing any combination of these them including, but not limited to, HT-29, 15 PDAC, MDA-MB-231, SK-OV-3, OVCAR-8, DU145, H1299, ACHN, A498 and Caki-1.

20 The compounds of the disclosure may be used or tested for their use in treating endometriosis by, respectively, administering a pharmaceutically effective amount to a subject in need thereof or using the syngenic mouse model of endometriosis (see Somigliana, E. et al., "Endometrial ability to implant in ectopic sites can be prevented by interleukin-12 in a murine model of endometriosis", Hum. Reprod. 1999, 14(12), 2944-2950). The compounds may also be tested for their use in treating endometriosis by using the rat model of endometriosis (see Lebovic, D.I. et al., "Peroxisome proliferator-activated 25 receptor-gamma induces regression of endometrial explants in a rat model of endometriosis", Fertil. Steril., 2004, 82 Suppl 3, 1008-1013).

30 Typically, a successful inhibitory therapeutic agent of the activity of CAIX or CAXII individually or any combination of them will meet some or all of the following criteria. Oral availability should be at or above 20% Animal model efficacy is less than about 20 mg/Kg, 2 mg/Kg, 1 mg/Kg, or 0.5 mg/Kg

and the target human dose is between 10 and 250 mg/70 Kg, although doses outside of this range may be acceptable. ("mg/Kg" means milligrams of compound per kilogram of body mass of the subject to whom it is being administered). The required dosage should preferably be no more than about 5 once or twice a day or at meal times. The therapeutic index (or ratio of toxic dose to therapeutic dose) should be greater than 10. The IC<sub>50</sub> ("Inhibitory Concentration - 50%") is a measure of the amount of compound required to achieve 50% inhibition of the kinase activity, over a specific time period, in a kinase activity assay. Any process for measuring the kinase activity of CAIX or 10 CAXII, preferably human CAIX or CAXII, may be utilized to assay the activity of the compounds useful in the methods of the disclosure in inhibiting said CAIX or CAXII activity. Compounds of the disclosure demonstrate an IC<sub>50</sub> in a 15 to 60 minute recombinant human assay of preferably less than 10  $\mu$ M, less than 5  $\mu$ M, less than 2.5  $\mu$ M, less than 1  $\mu$ M, less than 750 nM, less than 500 nM, less 15 than 250 nM, less than 100 nM, less than 50 nM, and most preferably less than 20 nM. Compounds of the disclosure may show reversible inhibition or irreversible inhibition and preferably do not inhibit other carbonic anhydrases.

The activities of the compounds of the disclosure as CAIX or CAXII inhibitors were tested using the recombinant human CAIX or CAXII 20 proteins and employing stopped-flow method for which the procedure is known to someone skilled in the art or as described in Example 29. When tested in this assay, compounds of the disclosure had greater than 50% inhibitory activity at 10  $\mu$ M concentration of the test compound, preferably greater than 60% inhibitory activity at 10  $\mu$ M concentration of the test compound, more preferably 25 greater than 70% inhibitory activity at 10  $\mu$ M concentration of the test compound, and even more preferably greater than 80% inhibitory activity at 10  $\mu$ M concentration of the test compound, and the most preferably greater than 90% inhibitory activity at 10  $\mu$ M concentration of the test compound, thereby demonstrating that the compounds of the disclosure are potent inhibitors of the 30 activity of CAIX and CAXII.

These results provide the basis for analysis of the structure-activity relationship (SAR) between test compounds and the inhibitory activity of CAIX or CAXII. Certain-groups tend to provide more potent inhibitory compounds. SAR analysis is one of the tools those skilled in the art may 5 employ to identify preferred embodiments of the compounds of the disclosure for use as therapeutic agents. Other methods of testing the compounds disclosed herein are also readily available to those skilled in the art. Thus, in addition, the determination of the ability of a compound to inhibit CAIX or CAXII activity may be accomplished in vivo. In one such embodiment this is 10 accomplished by administering said chemical agent to an animal afflicted with a certain tumor xenograft model and subsequently detecting a change in tumor growth rate in said animal thereby identifying a therapeutic agent useful in treating the said tumors. In such embodiment, the animal may be a human, such as a human patient afflicted with such a disorder and in need of treatment 15 of said disorder.

In specific embodiments of such in vivo processes, said change in CAIX or CAXII activity in said animal is a decrease in activity, preferably wherein said CAIX or CAXII inhibiting agent does not substantially inhibit the biological activity of other carbonic anhydrases.

20 The compounds of the disclosure can be used in combination with other therapeutic agents. Examples of alkylating agents that can be carried out in combination with include, but not limited to, fluorouracil (5-FU) alone or in further combination with leukovorin; other pyrimidine analogs such as UFT, capecitabine, gemcitabine and cytarabine, the alkyl sulfonates, e.g., busulfan 25 (used in the treatment of chronic granulocytic leukemia), imrosulfan and piposulfan; aziridines, e.g., benzodepa, carboquone, meturedopa and uredepa; ethyleneimines and methylmelamines, e.g., altretamine, triethylenemelamine, triethylenephosphoramide, triethylenethiophosphoramide and trimethylolmelamine; and the nitrogen mustards, e.g., chlorambucil (used in the 30 treatment of chronic lymphocytic leukemia, primary macroglobulinemia and

non-Hodgkin's lymphoma), cyclophosphamide (used in the treatment of Hodgkin's disease, multiple myeloma, neuroblastoma, breast cancer, ovarian cancer, lung cancer, Wilm' s tumor and rhabdomyosarcoma), estramustine, ifosfamide, novembrichin, prednimustine and uracil mustard (used in the 5 treatment of primary thrombocytosis, non-Hodgkin's lymphoma, Hodgkin's disease and ovarian cancer); and triazines, e.g., dacarbazine (used in the treatment of soft tissue sarcoma).

Examples of antimetabolite chemotherapeutic agents that can be carried out in combination with include, but not limited to, folic acid analogs, 10 e.g., methotrexate (used in the treatment of acute lymphocytic leukemia, choriocarcinoma, mycosis fungiodes, breast cancer, head and neck cancer and osteogenic sarcoma) and pteropterin; and the purine analogs such as mercaptopurine and thioguanine which find use in the treatment of acute granulocytic, acute lymphocytic and chronic granulocytic leukemias. Examples 15 of natural product-based chemotherapeutic agents that can be carried out in combination with include, but not limited to, the vinca alkaloids, e.g., vinblastine (used in the treatment of breast and testicular cancer), vincristine and vindesine; the epipodophyllotoxins, e.g., etoposide and teniposide, both of which are useful in the treatment of testicular cancer and Kaposi's sarcoma; the 20 antibiotic chemotherapeutic agents, e.g., daunorubicin, doxorubicin, epirubicin, mitomycin (used to treat stomach, cervix, colon, breast, bladder and pancreatic cancer), dactinomycin, temozolomide, plicamycin, bleomycin (used in the treatment of skin, esophagus and genitourinary tract cancer); and the enzymatic chemotherapeutic agents such as L-asparaginase.

25 Examples of other signal transduction inhibiting agents that can be carried out in combination with include, but not limited to, gefitinib, erlotinib, sorafenib, herceptin, imatinib, dasatinib, sunitinib, nilotinib, lapatinib, pazopanib, vandetanib, vemurafenib, crizotinib, ruxolitinib, axitinib, bosutinib, regorafenib, tofacitinib, cabozantinib, ponatinib, dabrafenib, trametinib, and afatinib.

Other agents can be used in combination with the compound of the disclosure include, but not limited to, COX-II inhibitors, such as, but not limited to, Vioxx, Celebrex (celecoxib), valdecoxib, paracoxib, rofecoxib; matrix metalloproteinase inhibitors, such as, but not limited to, AG-3340, RO 32-3555, 5 and RS 13-0830.

Pharmaceutical Compositions of the Disclosure and Administration

The present disclosure also relates to pharmaceutical composition containing the compounds of the any one of Formulae (I), (Ia) or (II) disclosed herein. In one embodiment, the present disclosure relates to a composition 10 comprising compounds of any one of Formulae (I), (Ia) or (II) in a pharmaceutically acceptable carrier and in an amount effective to modulate the activity of CAIX or CAXII individually or in any combination of them or to treat diseases related to angiogenesis and/or cell proliferation and migration, and especially cancer and the like when administered to an animal, preferably a 15 mammal, most preferably a human patient. In an embodiment of such composition, the patient has solid tumor expressing CAIX before administration of said compound of the disclosure and the compound of the disclosure is present in an amount effective to modulate or inhibit the over-expression of CAIX.

20 The pharmaceutical compositions useful herein also contain a pharmaceutically acceptable carrier, including any suitable diluent or excipient, which includes any pharmaceutical agent that does not itself induce the production of antibodies harmful to the individual receiving the composition, and which may be administered without undue toxicity. Pharmaceutically 25 acceptable carriers include, but are not limited to, liquids, such as water, saline, glycerol and ethanol, and the like. A thorough discussion of pharmaceutically acceptable carriers, diluents, and other excipients is presented in REMINGTON'S PHARMACEUTICAL SCIENCES (Mack Pub. Co., N.J. current edition).

Those skilled in the art are also familiar with determining administration methods (oral, intravenous, inhalation, sub-cutaneous, etc.), dosage forms, suitable pharmaceutical excipients and other matters relevant to the delivery of the compounds to a subject in need thereof.

5 In an alternative use of the disclosure, the compounds of the disclosure can be used in *in vitro* or *in vivo* studies as exemplary agents for comparative purposes to find other compounds also useful in treatment of, or protection from, the various diseases disclosed herein.

Administration of the compounds of the disclosure, or their 10 pharmaceutically acceptable salts, in pure form or in an appropriate pharmaceutical composition, can be carried out via any of the accepted modes of administration of agents for serving similar utilities. The pharmaceutical compositions of the disclosure can be prepared by combining a compound of the disclosure with an appropriate pharmaceutically acceptable carrier, diluent 15 or excipient, and may be formulated into preparations in solid, semi-solid, liquid or gaseous forms, such as tablets, capsules, powders, granules, ointments, solutions, suppositories, injections, inhalants, gels, microspheres, and aerosols. Typical routes of administering such pharmaceutical compositions include, 20 without limitation, oral, topical, transdermal, inhalation, parenteral, sublingual, buccal, rectal, vaginal, and intranasal. The term parenteral as used herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection or infusion techniques. Pharmaceutical compositions of the disclosure are formulated so as to allow the active ingredients contained therein to be bioavailable upon administration of the composition to a patient. Compositions 25 that will be administered to a subject or patient take the form of one or more dosage units, where for example, a tablet may be a single dosage unit, and a container of a compound of the disclosure in aerosol form may hold a plurality of dosage units. Actual methods of preparing such dosage forms are known, or will be apparent, to those skilled in this art; for example, see Remington: The 30 Science and Practice of Pharmacy, 20th Edition (Philadelphia College of

Pharmacy and Science, 2000). The composition to be administered will, in any event, contain a therapeutically effective amount of a compound of the disclosure, or a pharmaceutically acceptable salt thereof, for treatment of a disease or condition of interest in accordance with the teachings of this

5 disclosure.

A pharmaceutical composition of the disclosure may be in the form of a solid or liquid. In one aspect, the carrier(s) are particulate, so that the compositions are, for example, in tablet or powder form. The carrier(s) may be liquid, with the compositions being, for example, an oral oil, injectable liquid or

10 an aerosol, which is useful in, for example, inhalatory administration.

When intended for oral administration, the pharmaceutical composition is preferably in either solid or liquid form, where semi-solid, semi-liquid, suspension and gel forms are included within the forms considered herein as either solid or liquid.

15 As a solid composition for oral administration, the pharmaceutical composition may be formulated into a powder, granule, compressed tablet, pill, capsule, chewing gum, wafer or the like form. Such a solid composition will typically contain one or more inert diluents or edible carriers. In addition, one or more of the following may be present: binders such as carboxymethylcellulose,

20 ethyl cellulose, microcrystalline cellulose, gum tragacanth or gelatin; excipients such as starch, lactose or dextrins, disintegrating agents such as alginic acid, sodium alginate, Primogel, corn starch and the like; lubricants such as magnesium stearate or Sterotex; glidants such as colloidal silicon dioxide; sweetening agents such as sucrose or saccharin; a flavoring agent such as peppermint, methyl salicylate or orange flavoring; and a coloring agent.

25

When the pharmaceutical composition is in the form of a capsule, for example, a gelatin capsule, it may contain, in addition to materials of the above type, a liquid carrier such as polyethylene glycol or oil.

The pharmaceutical composition may be in the form of a liquid, for

30 example, an elixir, syrup, solution, emulsion or suspension. The liquid may be

for oral administration or for delivery by injection, as two examples. When intended for oral administration, preferred composition contain, in addition to the present compounds, one or more of a sweetening agent, preservatives, dye/colorant and flavor enhancer. In a composition intended to be administered 5 by injection, one or more of a surfactant, preservative, wetting agent, dispersing agent, suspending agent, buffer, stabilizer and isotonic agent may be included.

The liquid pharmaceutical compositions of the disclosure, whether they be solutions, suspensions or other like form, may include one or more of the following adjuvants: sterile diluents such as water for injection, saline 10 solution, preferably physiological saline, Ringer's solution, isotonic sodium chloride, fixed oils such as synthetic mono or diglycerides which may serve as the solvent or suspending medium, polyethylene glycols, glycerin, propylene glycol or other solvents; antibacterial agents such as benzyl alcohol or methyl paraben; antioxidants such as ascorbic acid or sodium bisulfite; chelating 15 agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates and agents for the adjustment of tonicity such as sodium chloride or dextrose. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic.

Physiological saline is a preferred adjuvant. An injectable pharmaceutical 20 composition is preferably sterile. A liquid pharmaceutical composition of the disclosure intended for either parenteral or oral administration should contain an amount of a compound of the disclosure such that a suitable dosage will be obtained. Typically, this amount is at least 0.01% of a compound of the disclosure in the composition. When intended for oral administration, this 25 amount may be varied to be between 0.1 and about 70% of the weight of the composition. Preferred oral pharmaceutical compositions contain between about 4% and about 75% of the compound of the disclosure. Preferred pharmaceutical compositions and preparations according to the present disclosure are prepared so that a parenteral dosage unit contains between 0.01 30 to 10% by weight of the compound prior to dilution of the disclosure.

The pharmaceutical composition of the disclosure may be intended for topical administration, in which case the carrier may suitably comprise a solution, emulsion, ointment or gel base. The base, for example, may comprise one or more of the following: petrolatum, lanolin, polyethylene glycols, bee wax, mineral oil, diluents such as water and alcohol, and emulsifiers and stabilizers. Thickening agents may be present in a pharmaceutical composition for topical administration. If intended for transdermal administration, the composition may include a transdermal patch or iontophoresis device. Topical formulations may contain a concentration of the compound of the disclosure from about 0.1 to about 10% w/v (weight per unit volume). The pharmaceutical composition of the disclosure may be intended for rectal administration, in the form, for example, of a suppository, which will melt in the rectum and release the drug. The composition for rectal administration may contain an oleaginous base as a suitable nonirritating excipient. Such bases include, without limitation, lanolin, cocoa butter and polyethylene glycol. The pharmaceutical composition of the disclosure may include various materials, which modify the physical form of a solid or liquid dosage unit. For example, the composition may include materials that form a coating shell around the active ingredients. The materials that form the coating shell are typically inert, and may be selected from, for example, sugar, shellac, and other enteric coating agents. Alternatively, the active ingredients may be encased in a gelatin capsule.

The pharmaceutical composition of the disclosure in solid or liquid form may include an agent that binds to the compound of the disclosure and thereby assists in the delivery of the compound. Suitable agents that may act in this capacity include a monoclonal or polyclonal antibody, a protein or a liposome. The pharmaceutical composition of the disclosure may consist of dosage units that can be administered as an aerosol. The term aerosol is used to denote a variety of systems ranging from those of colloidal nature to systems consisting of pressurized packages. Delivery may be by a liquefied or

compressed gas or by a suitable pump system that dispenses the active ingredients. Aerosols of compounds of the disclosure may be delivered in single phase, bi-phasic, or tri-phasic systems in order to deliver the active ingredient(s). Delivery of the aerosol includes the necessary container,

5 activators, valves, subcontainers, and the like, which together may form a kit. One of ordinary skill in the art, without undue experimentation may determine preferred aerosols. The pharmaceutical compositions of the disclosure may be prepared by methodology well known in the pharmaceutical art. For example, a pharmaceutical composition intended to be administered by injection can be

10 prepared by combining a compound of the disclosure with sterile, distilled water so as to form a solution. A surfactant may be added to facilitate the formation of a homogeneous solution or suspension. Surfactants are compounds that non-covalently interact with the compound of the disclosure so as to facilitate dissolution or homogeneous suspension of the compound in the aqueous

15 delivery system.

The compounds of the disclosure, or their pharmaceutically acceptable salts, are administered in a therapeutically effective amount, which will vary depending upon a variety of factors including the activity of the specific compound employed; the metabolic stability and length of action of the

20 compound; the age, body weight, general health, sex, and diet of the patient; the mode and time of administration; the rate of excretion; the drug combination; the severity of the particular disorder or condition; and the subject undergoing therapy. Generally, a therapeutically effective daily dose is (for a 70 kg mammal) from about 0.001 mg/kg (i.e., 0.7 mg) to about 100 mg/kg (i.e., 7.0

25 gm); preferably a therapeutically effective dose is (for a 70 kg mammal) from about 0.01 mg/kg (i.e., 7 mg) to about 50 mg/kg (i.e., 3.5 g); more preferably a therapeutically effective dose is (for a 70 kg mammal) from about 1 mg/kg (i.e., 70 mg) to about 25 mg/kg (i.e., 1.75 g).

Compounds of any one of Formulae (I), (Ia) or (II), or

30 pharmaceutically acceptable derivatives thereof, may also be administered

simultaneously with, prior to, or after administration of one or more other therapeutic agents. Such combination therapy includes administration of a single pharmaceutical dosage formulation which contains a compound of the disclosure and one or more additional active agents, as well as administration 5 of the compound of the disclosure and each active agent in its own separate pharmaceutical dosage formulation. For example, a compound of the disclosure and the other active agent can be administered to the patient together in a single oral dosage composition such as a tablet or capsule, or each agent administered in separate oral dosage formulations. Where separate dosage 10 formulations are used, the compounds of the disclosure and one or more additional active agents can be administered at essentially the same time, i.e., concurrently, or at separately staggered times, i.e., sequentially; combination therapy is understood to include all these regimens.

#### Isotopic Enrichment of Compounds

15 Isotopic enrichment is a process by which the relative abundance of the isotopes of a given element are altered, thus producing a form of the element that has been enriched in one particular isotope and depleted in its other isotopic forms. Isotopic enrichment of a drug are used for the following applications: reducing or eliminating unwanted metabolites; increasing the half-life of the parent drug; decreasing the number of doses needed to achieve a 20 desired effect; decreasing the amount of a dose necessary to achieve a desired effect; increasing the formation of active metabolites, if any are formed; and/or decreasing the production of deleterious metabolites in specific tissues and/or create a more effective drug and/or a safer drug for combination therapy, 25 whether the combination therapy is intentional or not.

Replacement of an atom for one of its isotopes often will result in a change in the reaction rate of a chemical reaction. This phenomenon is known as the Kinetic Isotope Effect. For example, if a C-H bond is broken during a rate-determining step in a chemical reaction (i.e. the step with the 30 highest transition state energy), substitution of a deuterium for that hydrogen

will cause a decrease in the reaction rate and the process will slow down. This phenomenon is known as the Deuterium Kinetic Isotope Effect (Foster *et. al.*, *Adv. Drug Res.*, 1985, 14, 1-36; Kushner *et. al.*, *Can. J. Physiol. Pharmacol.*, 1999, 77, 79-88).

5 Improvement of metabolism, pharmacokinetics, pharmacodynamics, and toxicity profiles of pharmaceuticals by isotopic enrichment such as deuteration has been demonstrated by the following examples: Lijinsky *et. al.*, *J. Nat. Cancer Inst.*, 1982, 69, 1127-1133; Gately *et. al.*, *J. Nucl. Med.*, 1986, 27, 388-394; Gordon *et. al.*, *Drug Metab. Dispos.*, 10 1987, 15, 589-594; Mangold *et. al.*, *Mutation Res.*, 1994, 308, 33-42; Zello *et. al.*, *Metabolism*, 1994, 43, 487-491; Wade D., *Chem. Biol. Interact.*, 1999, 117, 191-217.

#### Preparation of the Compounds of the Disclosure

15 It is understood that in the following description, combinations of substituents and/or variables of the depicted formulae are permissible only if such contributions result in stable compounds.

It will also be appreciated by those skilled in the art that in the process described below the functional groups of intermediate compounds may need to be protected by suitable protecting groups. Such functional groups 20 include hydroxy, amino, mercapto and carboxylic acid. Suitable protecting groups for hydroxy include trialkylsilyl or diarylalkylsilyl (e.g., *t*-butyldimethylsilyl, *t*-butyldiphenylsilyl or trimethylsilyl), tetrahydropyranyl, benzyl, and the like. Suitable protecting groups for amino, amidino and guanidino include *t*-butoxycarbonyl, benzyloxycarbonyl, and the like. Suitable protecting groups for 25 mercapto include -C(O)-R" (where R" is alkyl, aryl or arylalkyl), *p*-methoxybenzyl, trityl and the like. Suitable protecting groups for carboxylic acid include alkyl, aryl or arylalkyl esters.

Protecting groups may be added or removed in accordance with standard techniques, which are well-known to those skilled in the art and as 30 described herein.

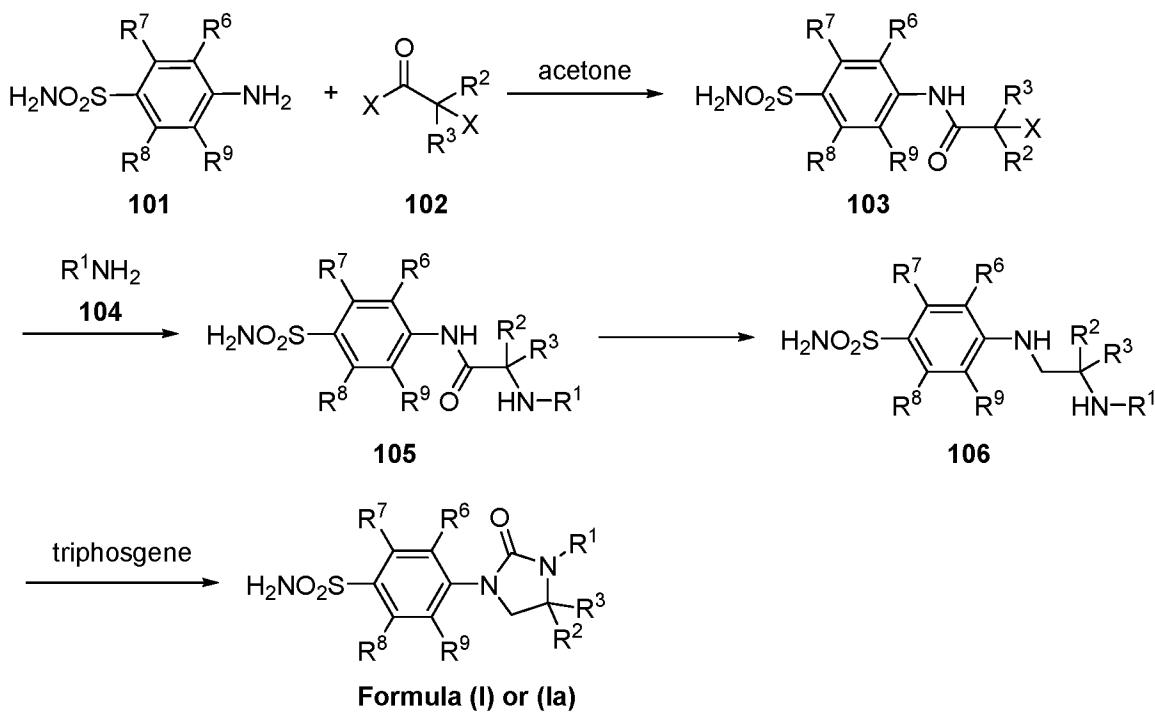
The use of protecting groups is described in detail in Green, T.W. and P.G.M. Wutz, *Protective Groups in Organic Synthesis* (1999), 3rd Ed., Wiley. The protecting group may also be a polymer resin such as a Wang resin or a 2-chlorotriptyl-chloride resin.

5 It will also be appreciated by those skilled in the art, although such protected derivatives of compounds of this disclosure may not possess pharmacological activity as such, they may be administered to a mammal and thereafter metabolized in the body to form compounds of the disclosure which are pharmacologically active. Such derivatives may therefore be described as  
10 "prodrugs". All prodrugs of compounds of this disclosure are included within the scope of the disclosure.

The following Reaction Schemes illustrate methods to make compounds of this disclosure. It is understood that one of those skilled in the art would be able to make these compounds by similar methods or by methods  
15 known to one skilled in the art. In general, starting components may be obtained from sources such as Sigma Aldrich, Lancaster Synthesis, Inc., Maybridge, Matrix Scientific, TCI, and Fluorochem USA, etc. or synthesized according to sources known to those skilled in the art (see, e.g., Advanced  
20 Organic Chemistry: Reactions, Mechanisms, and Structure, 5th edition (Wiley, December 2000)) or prepared as described in this disclosure.

In general, compounds of formula (I), where L is a direct bond, R<sup>4</sup> and R<sup>5</sup> are hydrogen and n is 1 can be synthesized following the general procedure as described in Reaction Scheme 1. X represents Cl or Br.

## REACTION SCHEME 1



The starting materials for the above reaction scheme are

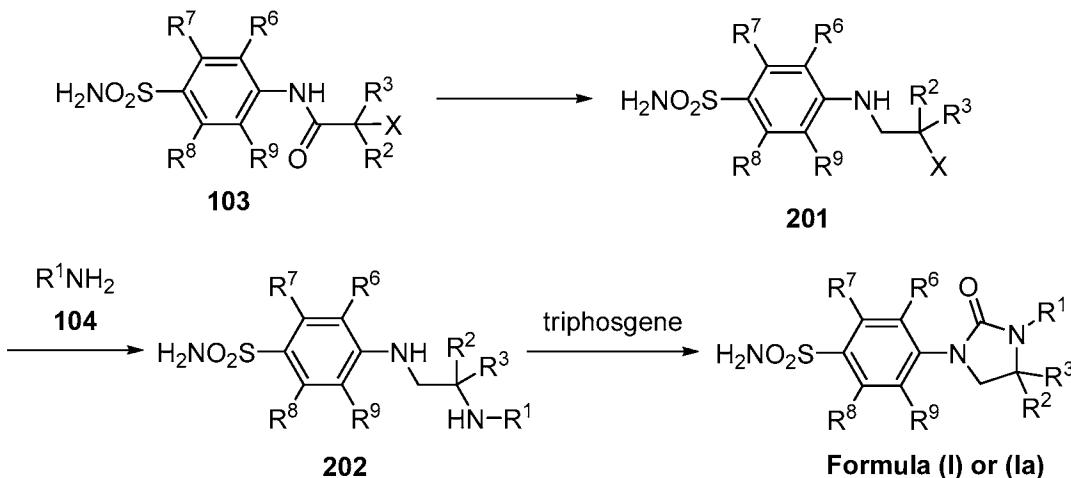
5 commercially available or can be prepared according to methods known to one skilled in the art or by methods disclosed herein. In general, the compounds of the disclosure are prepared in the above reaction scheme as follows:

The starting aryl sulfonamide 101 reacts with haloacetyl halide 102 to generate compound 103. Treatment of compound 103 with an amine

10 104 generates compound 105 which is reduced by a reducing reagent, such as, but not limited to, borane to generate the diamine compound 106. This diamine compound is cyclized by the treatment with triphosgene to afford the imidazolidinone compound of formula (I) of the disclosure where L is a direct bond,  $R^4$  and  $R^5$  are hydrogen and n is 1.

15 Alternatively, compounds of formula (I) of this disclosure where L is a direct bond, R<sup>4</sup> and R<sup>5</sup> are hydrogen and n is 1 can be synthesized following the general procedure as described in Reaction Scheme 2.

## REACTION SCHEME 2



The starting materials for the above reaction scheme are commercially available or can be prepared according to methods known to one skilled in the art or by methods disclosed herein. In general, the compounds of the disclosure are prepared in the above reaction scheme as follows:

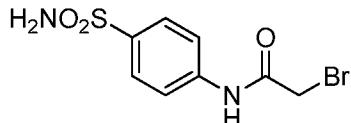
Reduction of compound 103 with a reducing reagent, such as, but not limited to, borane generates compound 201 which is treated with an amine 104 to generate the diamine compound 202. This diamine compound is 10 cyclized by the treatment with triphosgene to afford the imidazolidinone compound of formula (I) of the disclosure where L is a direct bond, R<sup>4</sup> and R<sup>5</sup> are hydrogen and n is 1.

More specific details on synthetic techniques for compounds of any one of Formulae (I), (Ia) or (II) are provided herein. Unless otherwise provided, all reagents and reaction conditions employed in synthesis are known to those skilled in the art and are available from ordinary commercial sources.

## PREPARATIONS

### PREPARATION 1

#### PREPARATION OF 2-BROMO-N-(4-SULFAMOYLPHENYL)ACETAMIDE



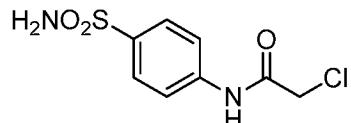
5 Sulfanilamide (8.61 g, 50.0 mmol) was suspended in acetone (20 mL) and the suspension was cooled to 0 °C in an ice bath. Bromoacetyl bromide (4.14 mL, 47.5 mmol) was added drop-wise. After white solids appeared, the reaction mixture was heated to 55 °C for 10 minutes with stirring. The mixture was cooled to ambient temperature, and ice-water was added,

10 then stirred for a while and filtered. The solid collected was washed with more ice-water, and then suspended in ethanol (100 mL). The suspension was stirred at ambient temperature for 20 minutes, and filtered. The white solid was collected and dried *in vacuo* to afford the title compound in 42% yield (5.85 g).

15  $^1\text{H}$  NMR (300 MHz, DMSO-*d*<sub>6</sub>)  $\delta$  10.72 (s, 1H), 10.01 (s, 1H), 7.90-7.80 (m, 4H), 7.80-7.73 (m, 4H), 7.28 (br s, 2H), 4.09 (s, 2H), 4.04 (s, 2H).

### PREPARATION 2

#### PREPARATION OF 2-CHLORO-N-(4-SULFAMOYLPHENYL)ACETAMIDE

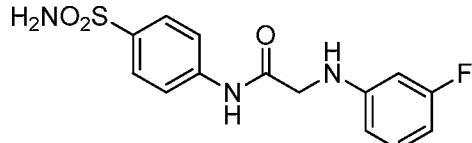


20 Sulfanilamide (10.0 g, 58.1 mmol) was suspended in acetone (30 mL), chloroacetyl chloride (4.49 mL, 55.3 mmol) was added drop-wise at ambient temperature. The reaction mixture was stirred at 95 °C for 1 hour and then cooled to ambient temperature. Ice-water was added and the resulting mixture was stirred for a while and filtered. The solid collected was washed with ice-water and re-crystallized from ethanol. The solid was collected by filtration 25 and dried *in vacuo* to afford the title compound as a white solid (8.84 g) and the

filtrate was concentrated to yield more product (3.42 g). The total yield was 89%.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  10.61 (s, 1H), 7.81-7.71 (m, 4H), 7.26 (br s, 2H), 4.29 (s, 2H).

### PREPARATION 3

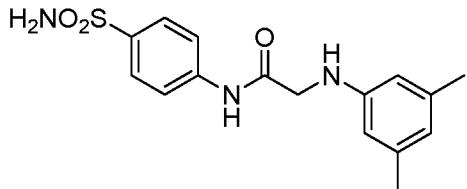
#### 5 PREPARATION OF 2-((3-FLUOROPHENYL)AMINO)-N-(4-SULFAMOYLPHENYL)ACETAMIDE



2-Chloro-N-(4-sulfamoylphenyl)acetamide (108 mg, 0.434 mmol), 3-fluoroaniline (0.25 mL, 2.57 mmol) and potassium iodide (10 mg) were mixed in 15 mL of tetrahydrofuran. The mixture was stirred at 110 °C overnight, cooled 10 to ambient temperature, and concentrated. The residue was purified by column chromatography eluted with dichloromethane:methanol (100:1 to 100:3, then 10:1) to afford the title compound as an off-white solid in 60% yield (83.6 mg).  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  10.37 (s, 1H), 7.80-7.73 (m, 4H), 7.47-7.41 (m, 1H), 7.23 (br s, 2H), 7.12-7.04 (m, 1H), 6.87 (br s, 1H), 6.61-6.55 (m, 1H), 15 5.80 (br s, 1 H), 3.95 (d,  $J$  = 6.0 Hz, 2H).

#### PREPARATION 3.1

#### PREPARATION OF 2-((3,5-DIMETHYLPHENYL)AMINO)-N-(4-SULFAMOYLPHENYL)ACETAMIDE



20 Following the procedure as described in Preparation 3, making variations using 3,5-dimethylaniline to replace 3-fluoroaniline to react with 2-chloro-N-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 70% yield.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  10.24 (s, 1H), 7.80-

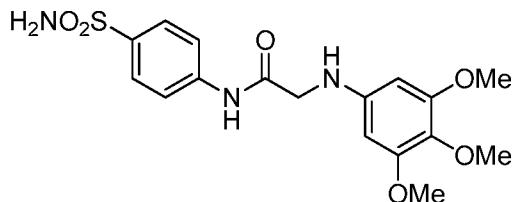
7.73 (m, 4H), 7.23 (br s, 2H), 6.24 (s, 1H), 6.22 (s, 2H), 5.78 (br s, 1H), 3.86 (br s, 2H), 2.13 (s, 6H).

### PREPARATION 3.2

#### PREPARATION OF *N*-(4-SULFAMOYLPHENYL)-2-((3,4,5-TRIMETHOXYPHENYL)AMINO)-

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##### ACETAMIDE

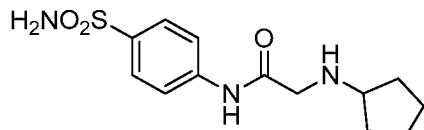


Following the procedure as described in Preparation 3, making variations using 3,4,5-trimethoxyaniline to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as 10 a brownish solid in 38% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.32 (s, 1H), 7.76-7.70 (m, 4H), 7.21 (br s, 2H), 5.91 (s, 2H), 5.79 (t,  $J$  = 6.4 Hz, 1H), 3.86 (d,  $J$  = 6.4 Hz, 2H), 3.66 (s, 6H), 3.50 (s, 3H).

### PREPARATION 3.3

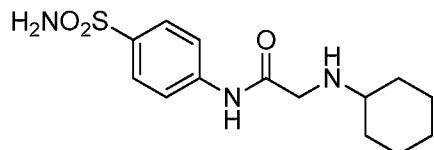
#### PREPARATION OF 2-(CYCLOPENTYLAMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

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Following the procedure as described in Preparation 3, making variations using cyclopentanamine to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 84% yield.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  7.79-7.71 (m, 4H), 20 7.22 (br s, 2H), 3.50 (s, 2H), 3.21-3.11 (m, 1H), 1.84-1.34 (m, 8H).

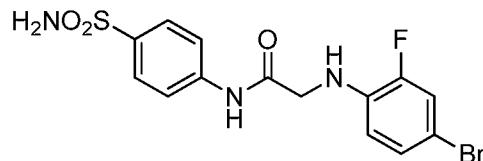
## PREPARATION 3.4

PREPARATION OF 2-(CYCLOHEXYLAMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

Following the procedure as described in Preparation 3, making 5 variations using cyclohexanamine to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 71% yield.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ):  $\delta$  7.77-7.71 (m, 4H), 7.22 (br s, 2H), 3.47 (s, 2H), 2.58-2.52 (m, 1H), 1.84-1.79 (m, 2H), 1.70-1.62 (m, 2H), 1.58-1.50 (m, 1H), 1.23-1.00 (m, 5H).

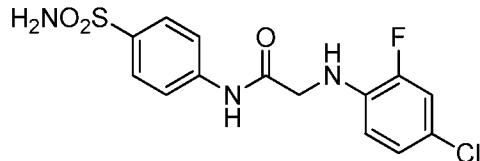
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## PREPARATION 3.5

PREPARATION OF 2-((4-BROMO-2-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

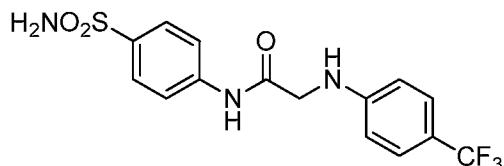
Following the procedure as described in Preparation 3, making 15 variations using 4-bromo-2-fluoroaniline to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 80% yield.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO}-d_6$ ):  $\delta$  10.32 (s, 1H), 7.77-7.71 (m, 4H), 7.32-7.28 (m, 1H), 7.21 (br s, 2H), 7.15-7.10 (m, 1H), 6.57 (t,  $J$  = 8.8 Hz, 1H), 5.97 (br s, 1H), 3.96 (s, 2H).

## PREPARATION 3.6

PREPARATION OF 2-((4-CHLORO-2-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

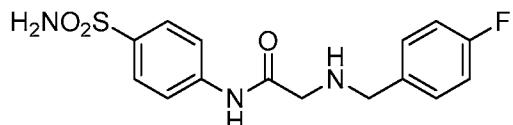
5 Following the procedure as described in Preparation 3, making variations using 4-chloro-2-fluoroaniline to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 80% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.32 (s, 1H), 7.76-7.70 (m, 4H), 7.22-7.18 (m, 3H), 7.03-6.99 (m, 1H), 6.61 (t,  $J$  = 8.8 Hz, 1H),  
10 3.96 (s, 2H).

## PREPARATION 3.7

PREPARATION OF *N*-(4-SULFAMOYLPHENYL)-2-((4-(TRIFLUOROMETHYL)PHENYL)AMINO)ACETAMIDE

15 Following the procedure as described in Preparation 3, making variations using 4-(trifluoromethyl)aniline to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 47% yield.

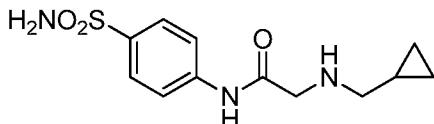
## PREPARATION 3.8

20 PREPARATION OF 2-((4-FLUOROBENZYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

Following the procedure as described in Preparation 3, making variations using 4-fluorobenzylamine to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in quantitative yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.11 (br s, 5 1H), 7.77-7.71 (m, 4H), 7.51-7.45 (m, 2H), 7.41-7.35 (m, 2H), 7.28-7.18 (m, 4H), 7.15-7.09 (m, 2H), 4.00 (s, 2H), 3.72 (s, 2H).

### PREPARATION 3.9

PREPARATION OF 2-((CYCLOPROPYLMETHYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

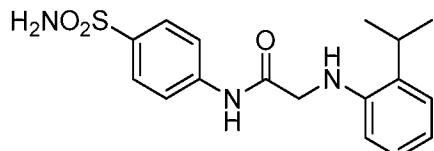


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Following the procedure as described in Preparation 3, making variations using cyclopropylmethanamine to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 77% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.79-7.71 (m, 4H), 7.20 (br s, 2H), 3.31 (s, 2H), 2.39 (d,  $J$  = 6.8 Hz, 1H), 0.93-0.83 (m, 1H), 0.40-0.35 (m, 2H), 0.10-0.05 (m, 2H).

### PREPARATION 3.10

PREPARATION OF 2-((2-ISOPROPYLPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE



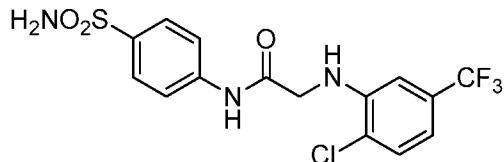
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Following the procedure as described in Preparation 3, making variations using 2-isopropylaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 63% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.32 (s, 1H), 7.77-7.72 (m, 4H), 7.22 (br s, 2H), 7.05 (dd,  $J$  = 7.6, 1.6 Hz, 1H), 7.00-6.94 (m, 1H),

6.62-6.57 (m, 1H), 6.40 (dd,  $J$  = 7.6, 1.2 Hz, 1H), 5.38 (br s, 1H), 3.94 (s, 2H), 3.06-2.98 (m, 1H), 1.18 (d,  $J$  = 6.8 Hz, 6H).

### PREPARATION 3.11

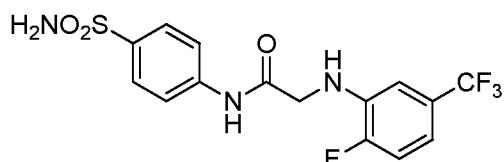
5 PREPARATION OF 2-((2-CHLORO-5-(TRIFLUOROMETHYL)PHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE



Following the procedure as described in Preparation 3, making variations using 2-chloro-5-trifluoromethylaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 30% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.45 (s, 1H), 7.77-7.70 (m, 4H), 7.49 (dd,  $J$  = 8.0, 0.8 Hz, 1H), 7.22 (br s, 2H), 6.93-6.89 (m, 1H), 6.84 (d,  $J$  = 2.0 Hz, 1H), 6.14 (t,  $J$  = 6.0 Hz, 1H), 4.13 (d,  $J$  = 6.0 Hz, 2H).

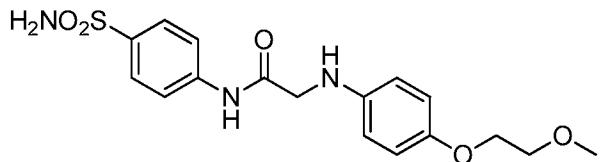
### PREPARATION 3.12

15 PREPARATION OF 2-((2-FLUORO-5-(TRIFLUOROMETHYL)PHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE



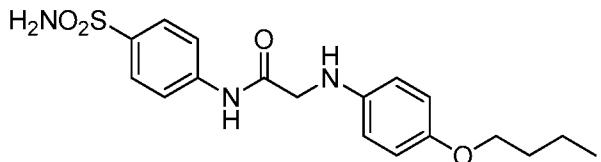
Following the procedure as described in Preparation 3, making variations using 2-fluoro-5-trifluoromethylaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 37% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.38 (s, 1H), 7.76-7.70 (m, 4H), 7.28-7.18 (m, 3H), 6.94-6.88 (m, 2H), 6.28-6.20 (m, 1H), 4.06 (d,  $J$  = 6.0 Hz, 2H).

## PREPARATION 3.13

PREPARATION OF 2-((4-(2-METHOXYETHOXY)PHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

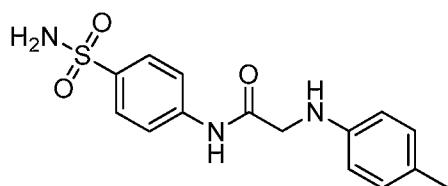
5 Following the procedure as described in Preparation 3, making variations using 4-(2-methoxyethoxy)aniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a brownish solid in 41% yield.

## PREPARATION 3.14

10 PREPARATION OF 2-((4-BUTOXYPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

Following the procedure as described in Preparation 3, making variations using 4-butoxyaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 86% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  10.21 (s, 1H), 7.75-7.70 (m, 4H), 7.20 (br s, 2H), 6.73-6.68 (m, 2H), 6.56-6.50 (m, 2H), 3.83-3.77 (m, 4H), 1.64-1.56 (m, 2H), 1.42-1.32 (m, 2H), 0.89 (t, *J* = 7.6 Hz, 3H).

## PREPARATION 3.15

PREPARATION OF *N*-(4-SULFAMOYLPHENYL)-2-(*p*-TOLYLAMINO)ACETAMIDE

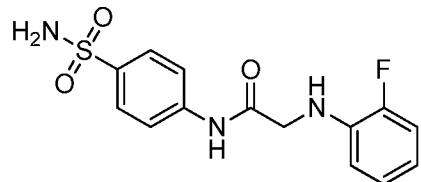
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Following the procedure as described in Preparation 3, making variations using *p*-toluidine to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 35% yield.

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### PREPARATION 3.16

#### PREPARATION OF 2-((2-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

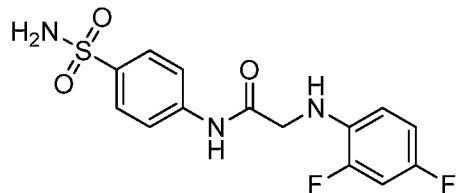


Following the procedure as described in Preparation 3, making variations using 2-fluoroaniline to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 26% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.34 (s, 1H), 7.85-7.70 (m, 4H), 7.23 (br s, 2H), 7.10-6.90 (m, 2H), 6.67-6.55 (m, 2H), 5.75 (t,  $J$  = 6.3 Hz, 1H), 3.97 (d,  $J$  = 6.3 Hz, 2H).

### PREPARATION 3.17

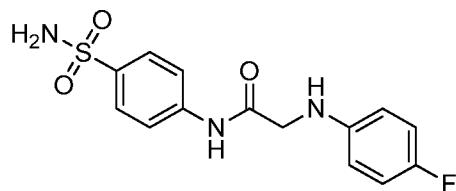
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#### PREPARATION OF 2-((2,4-DIFLUOROPHENYL)AMINO)-*N*-(4-



Following the procedure as described in Preparation 3, making variations using 2,4-difluoroaniline to replace 3-fluoroaniline to react with 2-chloro-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 42% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.34 (s, 1H), 7.85-7.70 (m, 4H), 7.22 (br s, 2H), 7.20-7.05 (m, 1H), 6.60-6.90 (m, 2H), 6.70-6.55 (m, 1H), 5.70 (m, 1H), 3.97 (d,  $J$  = 6.3 Hz, 2H).

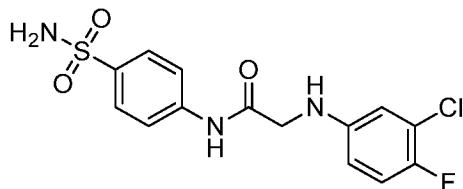
## PREPARATION 3.18

PREPARATION OF 2-((4-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

Following the procedure as described in Preparation 3, making

5 variations using 4-fluoroaniline to replace 3-fluoroaniline to react with 2-chloro-  
 10 *N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white  
 solid in 23% yield.

## PREPARATION 3.19

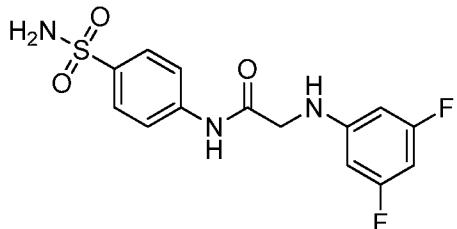
PREPARATION OF 2-((3-CHLORO-4-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

Following the procedure as described in Preparation 3, making

variations using 3-chloro-4-fluoroaniline to replace 3-fluoroaniline to react with  
 15 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as  
 a white solid in 66% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.33 (s, 1H), 7.77-  
 7.73 (m, 4H), 7.22 (br s, 2H), 7.10 (t,  $J$  = 9.2 Hz 1H), 6.70 (dd,  $J$  = 6.4, 3.2  
 Hz, 1H), 6.58-6.50 (m, 1H), 3.90 (s, 2H).

## PREPARATION 3.20

## PREPARATION OF 2-((3,5-DIFLUOROPHENYL)AMINO)-N-(4-SULFAMOYLPHENYL)ACETAMIDE

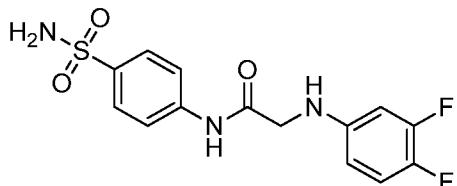


5 Following the procedure as described in Preparation 3, making variations using 3,5-difluoroaniline to replace 3-fluoroaniline to react with 2-bromo-N-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 67% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.39 (s, 1H), 7.77-7.70 (m, 4H), 7.27 (br s, 2H), 6.30-6.15 (m, 4H), 3.93 (s, 2H).

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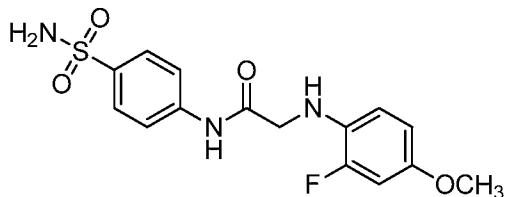
## PREPARATION 3.21

## PREPARATION OF 2-((3,4-DIFLUOROPHENYL)AMINO)-N-(4-SULFAMOYLPHENYL)ACETAMIDE



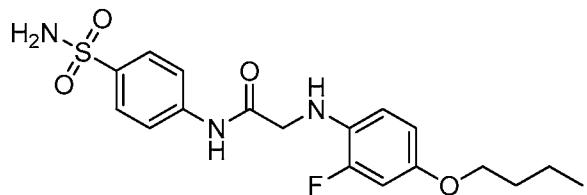
15 Following the procedure as described in Preparation 3, making variations using 3,4-difluoroaniline to replace 3-fluoroaniline to react with 2-bromo-N-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a brownish solid in 96% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.32 (s, 1H), 7.75-7.65 (m, 4H), 7.30-7.05 (m, 3H), 6.65-6.50 (m, 2H), 6.45-6.30 (m, 1H), 3.90 (s, 2H).

## PREPARATION 3.22

PREPARATION OF 2-((2-FLUORO-4-METHOXYPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

Following the procedure as described in Preparation 3, making variations using 2-fluoro-4-methoxyaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a brownish solid in 94% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.32 (s, 1H), 7.73 (br s, 4H), 7.21 (br s, 2H), 6.77 (dd,  $J$  = 10.8, 2.8 Hz, 1H), 6.57 (td,  $J$  = 8.8, 2.8 Hz, 1H), 6.35 (dd,  $J$  = 8.8, 3.2 Hz, 1H), 5.18 (br s, 1H), 3.90 (s, 2H), 3.81 (s, 3H).

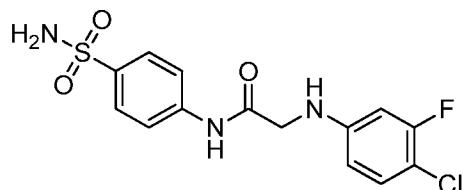
## PREPARATION 3.23

PREPARATION OF 2-((4-BUTOXY-2-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

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Following the procedure as described in Preparation 3, making variations using 4-butoxy-2-fluoroaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 73% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.36 (s, 1H), 7.77-20 7.70 (m, 4H), 7.22 (br s, 2H), 6.78-6.72 (m, 1H), 6.58-6.52 (m, 1H), 6.38-6.32 (m, 1H), 5.13 (br s, 1H), 3.98 (t,  $J$  = 6.0 Hz, 2H), 3.91 (t,  $J$  = 7.5 Hz, 2H), 1.75-1.70 (m, 2H), 1.49-1.43 (m, 2H), 0.93 (t,  $J$  = 7.5 Hz, 3H).

## PREPARATION 3.24

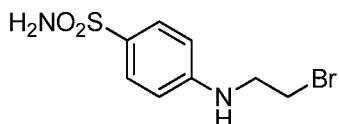
PREPARATION OF 2-((4-CHLORO-3-FLUOROPHENYL)AMINO)-*N*-(4-SULFAMOYLPHENYL)ACETAMIDE

5 Following the procedure as described in Preparation 3, making variations using 4-chloro-3-fluoroaniline to replace 3-fluoroaniline to react with 2-bromo-*N*-(4-sulfamoylphenyl)acetamide, the title compound was obtained as a white solid in 80% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  10.34 (s, 1H), 7.80-7.65 (m, 4H), 7.30-7.10 (m, 3H), 6.54 (dd,  $J$  = 12.5, 2.6 Hz, 1H), 6.43 (dd,  $J$  = 8.8, 2.6 Hz, 1H), 3.94 (s, 2H).

10

## PREPARATION 4

## PREPARATION OF 4-((2-BROMOETHYL)AMINO)BENZENESULFONAMIDE



15 2-Bromo-*N*-(4-sulfamoylphenyl)acetamide (1.82 g, 6.21 mmol) was suspended in tetrahydrofuran (10 mL), and borane dimethyl sulfide complex (2 M in tetrahydrofuran, 7.75 mL, 15.5 mmol) was added slowly at ambient temperature. The mixture was refluxed for 1 hour and then cooled to ambient temperature. Methanol (10 mL) was added at 0 °C, and the resulting mixture was stirred at 0 °C for 10 minutes. Hydrogen chloride (gas) was bubbled in to change the pH <2. The mixture was then refluxed for 30 minutes and cooled to ambient temperature. The residue was treated with aqueous sodium hydroxide to pH >12, and extracted with ethyl acetate (3 X 80 mL), dried over MgSO<sub>4</sub>. After filtration and removal of the solvent, the residue was treated with dichloromethane and filtered. The solid collected was dried *in*

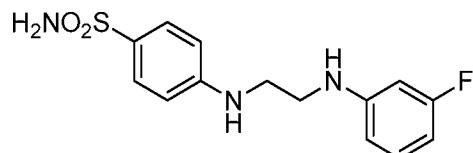
20

*vacuo* to afford the title compound as an off-white solid in 67% yield (1.15 g). <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.52-7.47 (m, 2H), 6.90 (br s, 2H), 6.67-6.63 (m, 2H), 6.60 (t, *J* = 6.0 Hz, 1H), 3.58-3.47 (m, 4H).

#### PREPARATION 4.1

5

##### PREPARATION OF 4-((2-((3-FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

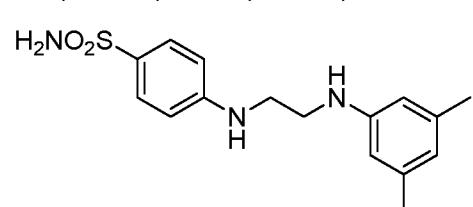


Following the procedure as described in Preparation 4, making variations using 2-((3-fluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to 10 replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a brown liquid in quantitative yield and used for next step reaction without further purification.

#### PREPARATION 4.2

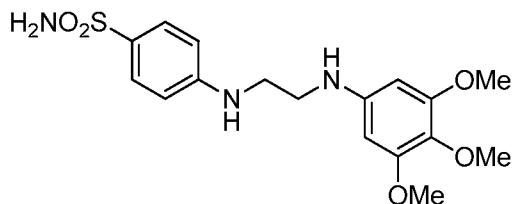
15

##### PREPARATION OF 4-((2-((3,5-DIMETHYLPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



Following the procedure as described in Preparation 4, making variations using 2-((3,5-dimethylphenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to 20 replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 56% yield. <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>): 7.51-7.46 (m, 2H), 6.87 (br s, 2H), 6.64-6.58 (m, 2H), 6.37 (t, *J* = 5.6 Hz, 1H), 6.22-6.17 (m, 3H), 5.39 (t, *J* = 5.6 Hz, 1H), 3.25-3.14 (m, 4H), 2.12 (s, 6H).

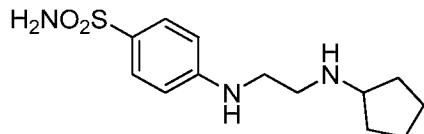
## PREPARATION 4.3

PREPARATION OF 4-((2-((3,4,5-  
TRIMETHOXYPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

5 Following the procedure as described in Preparation 4, making variations using *N*-(4-sulfamoylphenyl)-2-((3,4,5-trimethoxyphenyl)amino)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 74% yield.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  7.52-7.45 (m, 2H), 6.87 (br s, 2H), 6.65-6.58 (m, 2H), 6.38 (t,  $J$  = 6.0 Hz, 1H), 5.84 (s, 2H), 5.42 (t,  $J$  = 6.0 Hz, 1H), 3.65 (s, 6H), 3.49 (s, 3H), 3.26-3.12 (m, 4H).

## PREPARATION 4.4

## PREPARATION OF 4-((2-(CYCLOPENTYLAMINO)ETHYL)AMINO)BENZENESULFONAMIDE

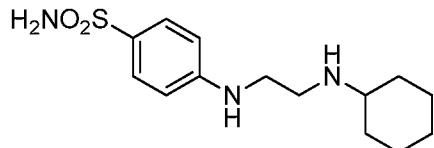


15 Following the procedure as described in Preparation 4, making variations using 2-(cyclopentylamino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 80% yield.

20  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.49-7.44 (m, 2H), 6.86 (br s, 2H), 6.61-6.56 (m, 2H), 6.25 (t,  $J$  = 6.4 Hz, 1H), 3.12-3.07 (m, 2H), 3.00-2.93 (m, 1H), 2.64 (t,  $J$  = 6.4 Hz, 2H), 1.73-1.51 (m, 4H), 1.50-1.37 (m, 2H), 1.30-1.20 (m, 2H).

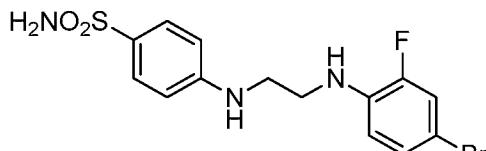
## PREPARATION 4.5

## PREPARATION OF 4-((2-(CYCLOHEXYLAMINO)ETHYL)AMINO)BENZENESULFONAMIDE



Following the procedure as described in Preparation 4, making  
 5 variations using 2-(cyclohexylamino)-*N*-(4-sulfamoylphenyl)acetamide to  
 replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl  
 sulfide complex, the title compound was obtained as a white solid in 35% yield.  
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.49-7.44 (m, 2H), 6.86 (br s, 2H), 6.61-6.56  
 (m, 2H), 6.25 (t, *J* = 6.0 Hz, 1H), 3.09 (q, *J* = 6.0 Hz, 2H), 2.69 (t, *J* = 6.0 Hz,  
 10 2H), 2.38-2.29 (m, 1H), 1.82-1.72 (m, 2H), 1.68-1.59 (m, 2H), 1.56-1.47 (m,  
 1H), 1.24-1.14 (m, 3H), 1.03-0.95 (m, 2H).

## PREPARATION 4.6

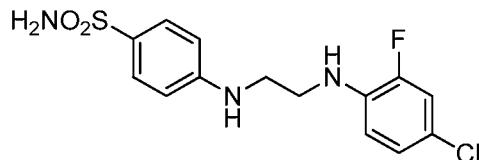
PREPARATION OF 4-((2-((4-BROMO-2-  
 FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

15

Following the procedure as described in Preparation 4, making  
 variations using 2-((4-bromo-2-fluorophenyl)amino)-*N*-(4-  
 sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-  
 sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the  
 20 title compound was obtained as a white solid in 74% yield. <sup>1</sup>H NMR (400 MHz,  
 DMSO-*d*<sub>6</sub>):  $\delta$  7.51-7.46 (m, 2H), 7.25 (dd, *J* = 11.2, 2.4 Hz, 1H), 7.14-7.09 (m,  
 1H), 6.88 (br s, 2H), 6.68 (t, *J* = 8.8 Hz, 1H), 6.64-6.58 (m, 2H), 6.44-6.38 (m,  
 1H), 5.72-5.64 (m, 1H), 3.27-3.20 (m, 4H).

## PREPARATION 4.7

## PREPARATION OF 4-((2-((4-CHLORO-2-FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

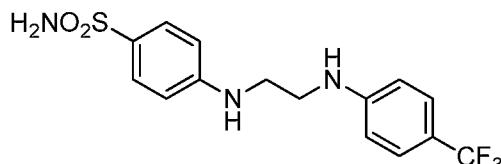


5 Following the procedure as described in Preparation 4, making variations using 2-((4-chloro-2-fluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 41% yield.

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## PREPARATION 4.8

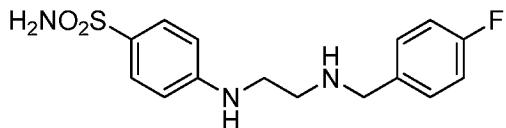
## PREPARATION OF 4-((2-((4-(TRIFLUOROMETHYL)PHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



15 Following the procedure as described in Preparation 4, making variations using *N*-(4-sulfamoylphenyl)-2-((4-(trifluoromethyl)phenyl)amino)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 67% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.51-7.47 (m, 2H), 7.35 (d,  $J$  = 8.4 Hz, 2H), 6.88 (br s, 2H), 6.66 (d,  $J$  = 8.4 Hz, 2H), 6.64-6.60 (m, 2H), 6.44-6.38 (m, 1H), 3.28-3.24 (m, 4H).

## PREPARATION 4.9

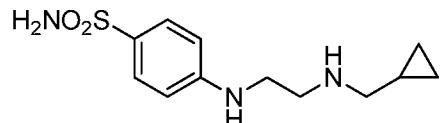
## PREPARATION OF 4-((2-((4-FLUOROBENZYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



5 Following the procedure as described in Preparation 4, making variations using 2-((4-fluorobenzyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 45% yield.  
10  $^1\text{H}$  NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.49-7.44 (m, 2H), 7.38-7.32 (m, 2H), 7.13-7.07 (m, 2H), 6.87 (br s, 2H), 6.61-6.56 (m, 2H), 6.27 (t, *J* = 6.0 Hz, 1H), 3.69 (s, 2H), 3.14 (q, *J* = 6.0 Hz, 2H), 2.66 (t, *J* = 6.4 Hz, 2H).

## PREPARATION 4.10

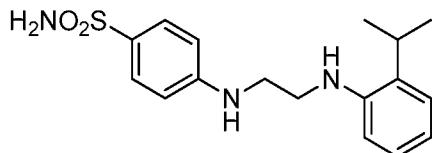
## PREPARATION OF 4-((2-((CYCLOPROPYLMETHYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



15 Following the procedure as described in Preparation 4, making variations using 2-((cyclopropylmethyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 53% yield.  $^1\text{H}$  NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.48-7.43 (m, 2H), 6.86 (br s, 2H), 6.62-6.57 (m, 2H), 6.27 (t, *J* = 5.6 Hz, 1H), 3.11 (q, *J* = 6.4 Hz, 2H), 2.69 (t, *J* = 6.4 Hz, 2H), 2.37 (d, *J* = 6.4 Hz, 2H), 1.80 (br s, 1H), 0.88-0.78 (m, 1H), 0.39-0.34 (m, 2H), 0.08-0.04 (m, 2H).

## PREPARATION 4.11

## PREPARATION OF 4-((2-((2-ISOPROPYLPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

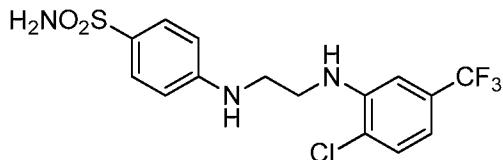


5 Following the procedure as described in Preparation 4, making variations using 2-((2-isopropylphenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a brown syrup in 86% yield.

10

## PREPARATION 4.12

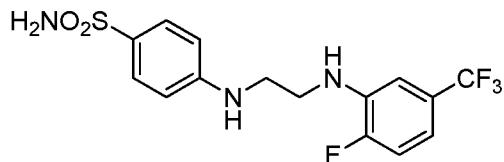
## PREPARATION OF 4-((2-((2-CHLORO-5-(TRIFLUOROMETHYL)PHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



15 Following the procedure as described in Preparation 4, making variations using 2-((2-chloro-5-(trifluoromethyl)phenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 54% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.51-7.46 (m, 2H), 7.44 (dd, *J* = 8.4, 0.8 Hz, 1H), 6.94 (d, *J* = 2.0 Hz, 1H), 6.89 (br s, 2H), 6.88-6.84 (m, 1H), 6.66-6.61 (m, 2H), 6.48 (t, *J* = 6.0 Hz, 1H), 5.90 (t, *J* = 6.0 Hz, 1H), 3.42-3.35 (m, 2H), 3.30-3.24 (m, 2H).

## PREPARATION 4.13

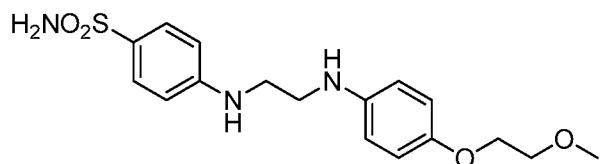
## PREPARATION OF 4-((2-((2-FLUORO-5-(TRIFLUOROMETHYL)PHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



5 Following the procedure as described in Preparation 4, making variations using 2-((2-fluoro-5-(trifluoromethyl)phenyl)amino)-N-(4-sulfamoylphenyl)acetamide to replace 2-bromo-N-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 63% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.51-7.46 (m, 2H), 7.21 (dd,  $J$  = 12.0, 8.8 Hz, 1H), 6.94 (dd,  $J$  = 8.0, 2.0 Hz, 1H), 6.92-6.82 (m, 3H), 6.65-6.60 (m, 2H), 6.46-6.41 (m, 1H), 6.02-5.96 (m, 1H), 3.36-3.28 (m, 4H).

## PREPARATION 4.14

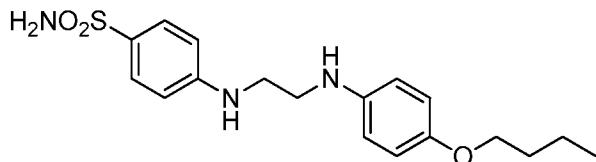
## PREPARATION OF 4-((2-((4-(2-METHOXYETHOXY)PHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



15 Following the procedure as described in Preparation 4, making variations using 2-((4-(2-methoxyethoxy)phenyl)amino)-N-(4-sulfamoylphenyl)-acetamide to replace 2-bromo-N-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a brownish solid in 72% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.51-7.45 (m, 2H), 6.87 (br s, 2H), 6.73-6.68 (m, 2H), 6.63-6.58 (m, 2H), 6.54-6.48 (m, 2H), 6.37 (t,  $J$  = 5.6 Hz, 1H), 5.18 (t,  $J$  = 5.6 Hz, 1H), 3.94-3.90 (m, 2H), 3.58-3.55 (m, 2H), 3.26 (s, 3H), 3.24-3.20 (m, 2H), 3.18-3.10 (m, 2H).

## PREPARATION 4.15

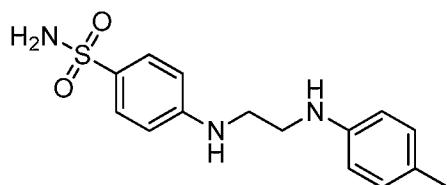
## PREPARATION OF 4-((2-((4-BUTOXYPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



5 Following the procedure as described in Preparation 4, making variations using 2-((4-butoxyphenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 47% yield.

10  $^1\text{H}$  NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.51-7.46 (m, 2H), 6.88 (br s, 2H), 6.71-6.66 (m, 2H), 6.63-6.59 (m, 2H), 6.53-6.48 (m, 2H), 6.38 (t, *J* = 5.6 Hz, 1H), 5.16 (t, *J* = 5.6 Hz, 1H), 3.80 (t, *J* = 6.4 Hz, 2H), 3.27-3.20 (m, 2H), 3.18-3.10 (m, 2H), 1.65-1.57 (m, 2H), 1.43-1.33 (m, 2H), 0.89 (t, *J* = 7.6 Hz, 3H).

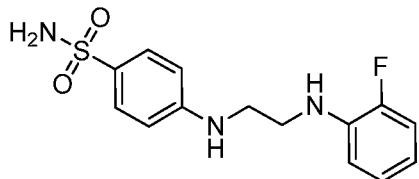
## PREPARATION 4.16

PREPARATION OF 4-((2-(*p*-TOLYLAMINO)ETHYL)AMINO)BENZENESULFONAMIDE

15 Following the procedure as described in Preparation 4, making variations using *N*-(4-sulfamoylphenyl)-2-(*p*-tolylamino)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 36% yield.  $^1\text{H}$

20 NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.52-7.49 (m, 2H), 6.98-6.92 (m, 4H), 6.68 (br s, 2H), 6.52-6.48 (m, 2H), 6.55-6.51 (m, 2H), 6.40 (t, *J* = 5.2 Hz, 1H), 5.37 (t, *J* = 5.2 Hz, 1H), 3.30-3.10 (m, 4H), 2.14 (s, 3H).

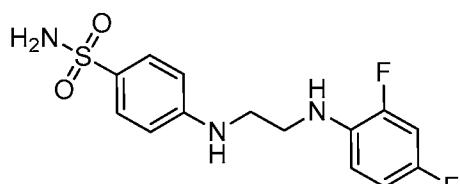
## PREPARATION 4.17

PREPARATION OF 4-((2-((2-  
FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

5 Following the procedure as described in Preparation 4, making variations using 2-((2-fluorophenyl)amino)-N-(4-sulfamoylphenyl)acetamide to replace 2-bromo-N-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 95% yield.

10  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.48 (d,  $J$  = 8.8 Hz, 2H), 7.02-6.92 (m, 2H), 6.88 (br s, 2H), 6.73 (m, 1H), 6.62 (d,  $J$  = 8.8 Hz, 2H), 6.57-6.58 (m, 1H), 6.43 (t,  $J$  = 5.2 Hz, 1H), 5.42 (br s, 1H), 3.30-3.22 (m, 4H).

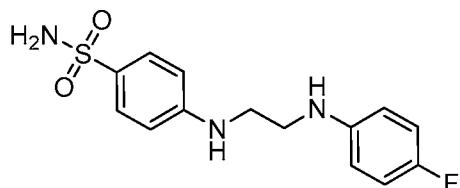
## PREPARATION 4.18

PREPARATION OF 4-((2-((2,4-  
DIFLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

15 Following the procedure as described in Preparation 4, making variations using 2-((2,4-difluorophenyl)amino)-N-(4-sulfamoylphenyl)acetamide to replace 2-bromo-N-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 91% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.53 (d,  $J$  = 8.7 Hz, 2H), 7.15-7.05 (m, 1H), 6.92 (br s, 2H), 6.90-6.82 (m, 1H), 6.81-6.70 (m, 1H), 6.65 (d,  $J$  = 8.7 Hz, 2H), 6.47 (br s, 1H), 5.36 (br s, 1H), 3.40-3.20 (m, 4H).

## PREPARATION 4.19

## PREPARATION OF 4-((2-((4-FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



5 Following the procedure as described in Preparation 4, making variations using 2-((4-fluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 75% yield.

10  $^1\text{H}$  NMR (300 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.51 (d, *J* = 8.8 Hz, 2H), 7.00-6.81 (m, 4H), 6.63 (d, *J* = 8.8 Hz, 2H), 6.60-6.50 (m, 2H), 6.45-6.35 (m, 1H), 5.56 (m, 1H), 3.45-3.10 (m, 4H).

## PREPARATION 4.20

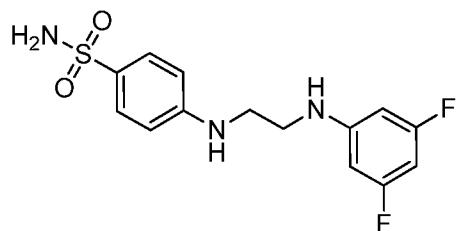
## PREPARATION OF 4-((2-((3-CHLORO-4-FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



15 Following the procedure as described in Preparation 4, making variations using 2-((3-chloro-4-fluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 62% yield.  $^1\text{H}$  NMR (300 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.49 (d, *J* = 8.8 Hz, 2H), 7.11-7.06 (m, 1H), 6.88 (br s, 2H), 6.65 (dd, *J* = 6.0, 2.8 Hz, 1H), 6.61 (d, *J* = 8.8 Hz, 2H), 6.58-6.48 (m, 1H), 6.38 (t, *J* = 6.0 Hz, 1H), 6.53 (t, *J* = 6.0 Hz, 1H), 3.30-3.10 (m, 4H).

## PREPARATION 4.21

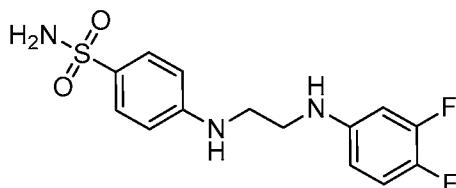
## PREPARATION OF 4-((2-((3,5-DIFLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



5 Following the procedure as described in Preparation 4, making variations using 2-((3,5-difluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 55% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.49 (d,  $J$  = 8.8 Hz, 2H), 6.89 (br s, 2H), 6.61 (d,  $J$  = 8.8 Hz, 2H), 6.40-6.30 (m, 2H), 6.20 (d,  $J$  = 11.2 Hz, 2H), 3.30-3.15 (m, 4H).

## PREPARATION 4.22

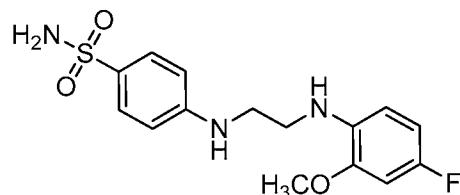
## PREPARATION OF 4-((2-((3,4-DIFLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



15 Following the procedure as described in Preparation 4, making variations using 2-((3,4-difluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 84% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.48 (d,  $J$  = 9.2 Hz, 2H), 7.10-7.05 (m, 1H), 6.88 (br s, 2H), 6.61 (d,  $J$  = 9.2 Hz, 2H), 6.68-6.48 (m, 1H), 6.38-6.30 (m, 1H), 3.30-3.10 (m, 4H).

## PREPARATION 4.23

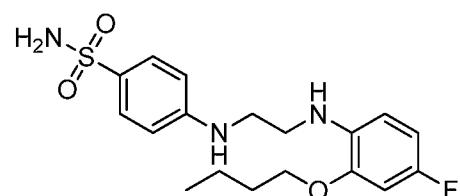
## PREPARATION OF 4-((2-((2-FLUORO-4-METHOXYPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



Following the procedure as described in Preparation 4, making variations using 2-((2-fluoro-4-methoxyphenyl)amino)-*N*-(4-sulfamoylphenyl)-acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 68% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.48 (d,  $J$  = 9.2 Hz, 2H), 6.88 (br s, 2H), 6.73 (dd,  $J$  = 10.4, 2.8 Hz, 1H), 6.61 (d,  $J$  = 9.2 Hz, 2H), 6.56 (td,  $J$  = 8.8, 2.8 Hz, 1H), 6.52-6.52 (m, 1H), 6.44 (t,  $J$  = 5.8 Hz, 1H), 4.79 (t,  $J$  = 5.8 Hz, 1H), 3.75 (s, 3H), 3.45-3.15 (m, 4H).

## PREPARATION 4.24

## PREPARATION OF 4-((2-((4-BUTOXY-2-FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE

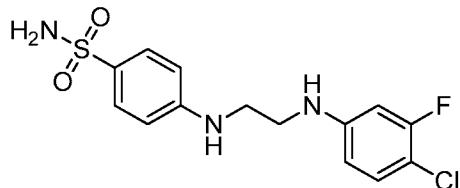


Following the procedure as described in Preparation 4, making variations using 2-((4-butoxy-2-fluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 80% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.47 (d,  $J$  = 8.8 Hz, 2H), 6.87 (br s, 2H), 6.73 (dd,  $J$  = 10.8, 2.8 Hz, 1H), 6.61 (d,  $J$  = 8.8 Hz, 2H), 6.57-6.40 (m, 3H), 4.69 (t,  $J$  = 5.8 Hz, 1H),

3.92 (t,  $J$  = 6.4 Hz, 2H), 3.30-3.20 (m, 4H), 1.69-1.61 (m, 2H), 1.45-1.36 (m, 2H), 1.03 (t,  $J$  = 7.2 Hz, 3H).

#### PREPARATION 4.25

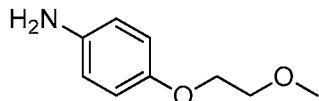
5 PREPARATION OF 4-((2-((4-CHLORO-3-FLUOROPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



Following the procedure as described in Preparation 4, making variations using 2-((4-chloro-3-fluorophenyl)amino)-*N*-(4-sulfamoylphenyl)acetamide to replace 2-bromo-*N*-(4-sulfamoylphenyl)acetamide to react with borane dimethyl sulfide complex, the title compound was obtained as a white solid in 59% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.48 (d,  $J$  = 8.8 Hz, 2H), 7.16 (t,  $J$  = 8.8 Hz, 1H), 6.88 (br s, 2H), 6.61 (d,  $J$  = 8.8 Hz, 2H), 6.51 (dd,  $J$  = 12.8, 2.8 Hz, 1H), 6.45–6.38 (m, 1H), 6.37 (t,  $J$  = 8.8 Hz, 1H), 6.17 (t,  $J$  = 8.8 Hz, 1H), 3.15-3.30 (m, 4H).

15 PREPARATION 5

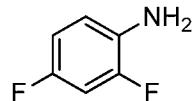
PREPARATION OF 4-(2-METHOXYETHOXY)ANILINE



1-(2-Methoxyethoxy)-4-nitrobenzene (1.02 g, 5.17 mmol) and 10% palladium on carbon (150 mg) were mixed in methanol (30 mL). After 20 degassing, hydrogen gas balloon was applied to the mixture. The reaction mixture was stirred for 2 hours at ambient temperature, and then filtered through Celite. The filtrate was concentrated, and the residue was dried *in vacuo* to afford the title compound as a brown liquid in 70% yield (604 mg) and used for next step reaction without further purification.

## PREPARATION 5.1

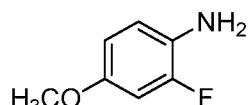
## PREPARATION OF 2,4-DIFLUOROANILINE



Following the procedure as described in Preparation 5, making  
 5 variations using 2,4-difluoro-1-nitrobenzene to replace 1-(2-methoxyethoxy)-4-nitrobenzene, the title compound was obtained in 92% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.95-6.65 (m, 3H), 3.62 (br s, 2H).

## PREPARATION 5.2

## PREPARATION OF 2-FLUORO-4-METHOXYANILINE

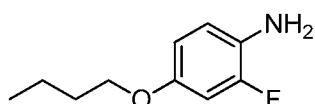


10 Following the procedure as described in Preparation 5, making variations using 2-fluoro-4-methoxy-1-nitrobenzene to replace 1-(2-methoxyethoxy)-4-nitrobenzene, the title compound was obtained in 72% yield.  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.64-6.43 (m, 3H), 3.83 (s, 3H), 3.65 (br s, 2H).

15

## PREPARATION 5.3

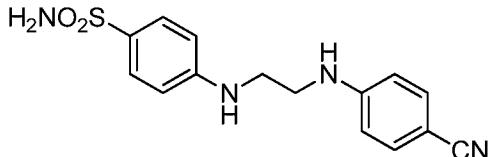
## PREPARATION OF 4-BUTOXY-2-FLUOROANILINE



Following the procedure as described in Preparation 5, making variations using 4-butoxy-2-fluoro-1-nitrobenzene to replace 1-(2-methoxyethoxy)-4-nitrobenzene, the title compound was obtained in 83% yield.  
 20  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ):  $\delta$  6.64-6.45 (m, 3H), 3.98 (t,  $J$  = 6.5 Hz, 2H), 3.65 (br s, 2H), 1.87-1.78 (m, 2H), 1.56-1.45 (m, 2H), 1.00 (t,  $J$  = 7.5 Hz, 3H).

## PREPARATION 6

## PREPARATION OF 4-((2-((4-CYANOPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



5 4-((2-Bromoethyl)amino)benzenesulfonamide (200 mg, 0.716 mmol), 4-cyanoaniline (216 mg, 1.83 mmol) and KI (12 mg) were mixed in dichloromethane (2.0 mL) in a opened tube and stirred at 120 °C for 10 min. The tube was then sealed and the mixture was stirred at 140 °C overnight, cooled to ambient temperature and concentrated. The residue was treated with 10 dichloromethane and filtered. The resulting solid was heated in methanol and filtered. The solid obtained was heated in acetonitrile and filtered. The filtrate was concentrated and the residue was treated with dichloromethane and filtered. The solid was collected and dried *in vacuo* to afford the title compound as a yellowish solid in 31% yield (70.4 mg).  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.51-7.47 (m, 2H), 7.45-7.41 (m, 2H), 6.88 (br s, 2H), 6.75-6.70 (m, 1H), 6.66-6.60 (m, 4H), 6.42-6.38 (m, 1H), 3.29-3.23 (m, 4H).

## PREPARATION 6.1

## PREPARATION OF 4-((2-((4-ACETYLPHENYL)AMINO)ETHYL)AMINO)BENZENESULFONAMIDE



20

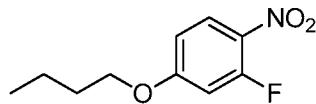
Following the procedure as described in Preparation 6, making variations using 4-acetyl aniline to replace 4-cyanoaniline to react with 4-((2-bromoethyl)amino)benzenesulfonamide, the title compound was obtained as a yellow solid in 25% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.73-7.67 (m, 2H),

7.52-7.47 (m, 2H), 6.88 (br s, 2H), 6.66-6.60 (m, 4H), 6.44-6.39 (m, 1H), 3.30-3.25 (m, 4H), 2.37 (s, 3H).

## PREPARATION 7

### PREPARATION OF 4-BUTOXY-2-FLUORO-1-NITROBENZENE

5



Butanol (1.56 mL, 17.09 mmol) was added dropwise to a suspension of potassium *t*-butoxide (3.47 g, 30.96 mmol) in dichloromethane (30 mL) at 0 °C. The resulting mixture was stirred 30 minutes, followed by the dropwise addition of 2,4-difluoro-1-nitrobenzene (1.7 mL, 15.48 mmol) at 0°C.

10 The mixture was stirred at ambient temperature for 2 hours and the solvent was removed *in vacuo*. The residue was extracted 3 times with ethyl acetate. The organic layer was washed with brine, dried over sodium sulfate and filtered. The filtrated was evaporated *in vacuo* and the residue was purified by column chromatography eluted with hexanes:ethyl acetate (9:1) to afford the title

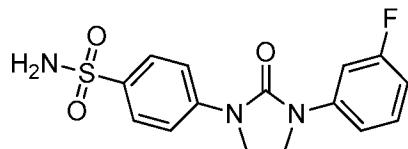
15 compound in 66% yield (2.2 g).  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.91 (dd,  $J$  = 9.2, 3.2 Hz, 1H), 7.80 (dd,  $J$  = 10.4, 2.4 Hz, 1H), 6.68 (td,  $J$  = 8.8, 2.4 Hz, 1H), 4.08 (t,  $J$  = 6.4 Hz, 2H). 1.90-1.77 (m, 2H), 1.60-1.45 (m, 2H), 0.99 (t,  $J$  = 7.5 Hz, 3H).

## EXAMPLES

20

### EXAMPLE 1

#### SYNTHESIS OF 4-(3-(3-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

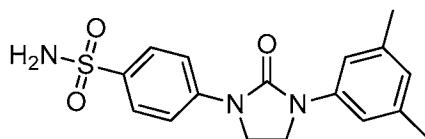


To a solution of 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzene-sulfonamide (80 mg, 0.258 mmol) in tetrahydrofuran (10 mL) was added triphosgene (38 mg, 0.129 mmol) solution in tetrahydrofuran (2.5 mL). The resulting mixture was stirred at ambient 5 temperature for 1 hour, and filtered. The filtrate was concentrated and the residue was purified column chromatography eluted with dichloromethane:methanol, 100:1) to afford a white solid in 19% yield (16 mg).  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  7.84-7.80 (m, 4H), 7.70-7.60 (m, 1H), 7.43 (m, 1H), 7.27 (br s, 2H), 6.97-6.89 (m, 1H), 4.04-4.00 (m, 4H).

10

## EXAMPLE 2

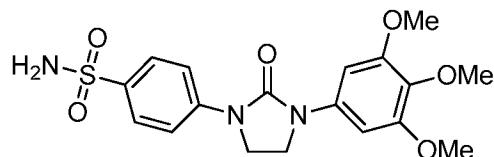
## SYNTHESIS OF 4-(3-(3,5-DIMETHYLPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



Following the procedure as described in Example 1, making 15 variations using 4-((2-((3,5-dimethylphenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as an off-white solid in 34% yield.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  7.79-7.75 (m, 4H), 7.24 (m, 2H), 7.21 (br s, 2H), 6.73-20 6.70 (m, 1H), 4.02-3.88 (m, 4H), 2.25 (s, 6H).

## EXAMPLE 3

## SYNTHESIS OF 4-(2-OXO-3-(3,4,5-TRIMETHOXYPHENYL)IMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

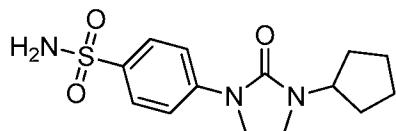


Following the procedure as described in Example 1, making variations using 4-((2-((3,4,5-trimethoxyphenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, 5 the title compound was obtained as an off-white solid in 50% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.80-7.76 (m, 4H), 7.23 (br s, 2H), 6.95 (s, 2H), 4.01-3.97 (m, 4H), 3.77 (s, 6H), 3.62 (s, 3H).

#### EXAMPLE 4

##### SYNTHESIS OF 4-(3-CYCLOPENTYL-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

10



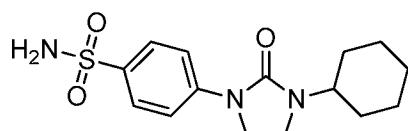
Following the procedure as described in Example 1, making variations using 4-((2-(cyclopentylamino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 50% yield.

15  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.74-7.68 (m, 4H), 7.16 (br s, 2H), 4.22-4.17 (m, 1H), 3.83-3.77 (m, 2H), 3.48-3.42 (m, 2H), 1.80-1.48 (m, 8H).

#### EXAMPLE 5

##### SYNTHESIS OF 4-(3-CYCLOHEXYL-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

20

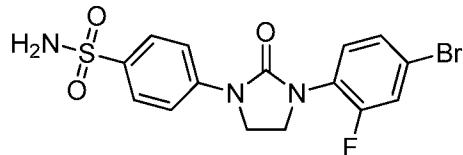


Following the procedure as described in Example 1, making variations using 4-((2-(cyclohexylamino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 35% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.73-7.66 (m, 4H), 7.16 (br s, 2H), 3.82-3.76

(m, 2H), 3.60 (tt,  $J$  = 11.6, 3.6 Hz, 1H), 3.47-3.41 (m, 2H), 1.78-1.71 (m, 2H), 1.67-1.55 (m, 3H), 1.46-1.36 (m, 2H), 1.35-1.23 (m, 2H), 1.13-1.00 (m, 1H).

### EXAMPLE 6

#### SYNTHESIS OF 4-(3-(4-BROMO-2-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

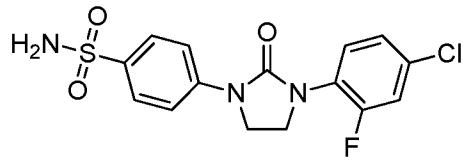


Following the procedure as described in Example 1, making variations using 4-((2-((4-bromo-2-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as an off-white solid in 77% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.80-7.73 (m, 4H), 7.66 (dd,  $J$  = 6.8, 2.4 Hz, 1H), 7.53 (t,  $J$  = 8.8 Hz, 1H), 7.48-7.44 (m, 1H), 7.23 (br s, 2H), 4.07-4.00 (m, 2H), 3.97-3.91 (m, 2H).

15

### EXAMPLE 7

#### SYNTHESIS OF 4-(3-(4-CHLORO-2-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

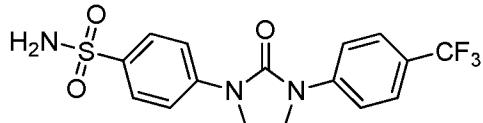


Following the procedure as described in Example 1, making variations using 4-((2-((4-chloro-2-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as an off-white solid in 65% yield.  $^1\text{H}$  NMR

(400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.80-7.74 (m, 4H), 7.61-7.53 (m, 2H), 7.37-7.33 (m, 1H), 7.23 (br s, 2H), 4.07-4.01 (m, 2H), 3.97-3.91 (m, 2H).

### EXAMPLE 8

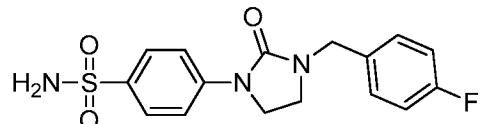
SYNTHESIS OF 4-(2-OXO-3-(4-(TRIFLUOROMETHYL)PHENYL)IMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



Following the procedure as described in Example 1, making variations using 4-((2-((4-(trifluoromethyl)phenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 65% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.84 (d, *J* = 8.8 Hz, 2H), 7.81-7.79 (m, 4H), 7.72 (d, *J* = 8.8 Hz, 2H), 7.25 (br s, 2H), 4.05-4.01 (m, 4H).

### EXAMPLE 9

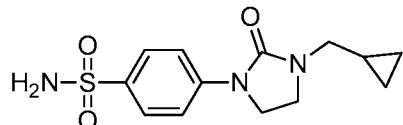
SYNTHESIS OF 4-(3-(4-FLUOROBENZYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



Following the procedure as described in Example 1, making variations using 4-((2-((4-fluorobenzyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 40% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.76-7.70 (m, 4H), 7.37-7.31 (m, 2H), 7.20-7.13 (m, 4H), 4.38 (s, 2H), 3.86-3.80 (m, 2H), 3.40-3.34 (m, 2H).

## EXAMPLE 10

## SYNTHESIS OF 4-(3-(CYCLOPROPYLMETHYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

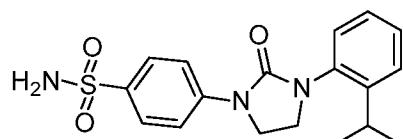


5 Following the procedure as described in Example 1, making variations using 4-((2-((cyclopropylmethyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 51% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.74-7.68 (m, 4H), 7.17 (br s, 2H), 3.86-3.80 (m, 2H), 3.60-3.54 (m, 2H), 3.05 (d, *J* = 7.2 Hz, 2H), 0.96-0.88 (m, 1H), 0.49-0.43 (m, 2H), 0.23-0.17 (m, 2H).

10

## EXAMPLE 11

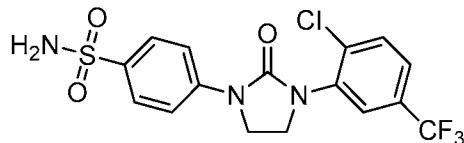
## SYNTHESIS OF 4-(3-(2-ISOPROPYLPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



15 Following the procedure as described in Example 1, making variations using 4-((2-((2-isopropylphenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 43% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.78-7.73 (m, 4H), 7.40 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.35-7.28 (m, 2H), 7.26-7.20 (m, 3H), 4.06-4.00 (m, 2H), 3.83-3.78 (m, 2H), 3.13-3.03 (m, 1H), 1.15 (d, *J* = 6.8 Hz, 6H).

## EXAMPLE 12

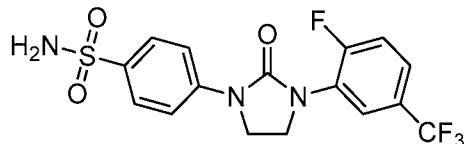
## SYNTHESIS OF 4-(3-(2-CHLORO-5-(TRIFLUOROMETHYL)PHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



5 Following the procedure as described in Example 1, making variations using 4-((2-chloro-5-(trifluoromethyl)phenyl)amino)ethyl)amino)benzene-sulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 80% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  8.00 (d, *J* = 2.0 Hz, 1H), 7.85-7.70 (m, 6H), 7.23 (br s, 2H), 4.10-4.04 (m, 2H), 3.99-3.93 (m, 2H).

## EXAMPLE 13

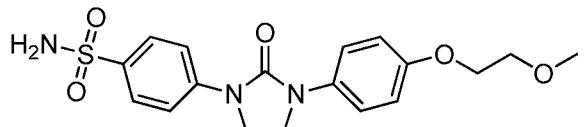
## SYNTHESIS OF 4-(3-(2-FLUORO-5-(TRIFLUOROMETHYL)PHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



15 Following the procedure as described in Example 1, making variations using 4-((2-(2-fluoro-5-(trifluoromethyl)phenyl)amino)ethyl)amino)benzene-sulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 62% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  8.02 (dd, *J* = 6.8, 2.0 Hz, 1H), 7.81-7.74 (m, 4H), 7.71-7.66 (m, 1H), 7.59-7.53 (m, 1H), 7.24 (br s, 2 H), 4.09-3.99 (m, 4H).

## EXAMPLE 14

## SYNTHESIS OF 4-(3-(4-(2-METHOXYETHOXY)PHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

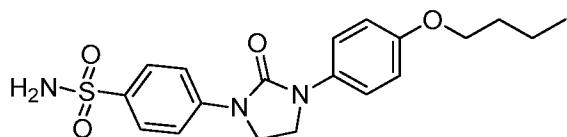


5 Following the procedure as described in Example 1, making variations using 4-((2-((4-(2-methoxyethoxy)phenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 45% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.78-7.75 (m, 4H), 7.53-7.47 (m, 2H), 7.21 (br s, 2H), 6.97-6.92 (m, 2H), 4.07-4.04 (m, 2H), 4.00-3.91 (m, 4H), 3.65-3.61 (m, 2H), 3.29 (s, 3H).

10

## EXAMPLE 15

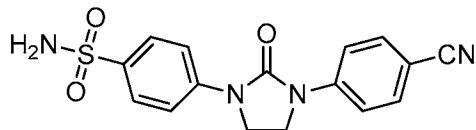
## SYNTHESIS OF 4-(3-(4-BUTOXYPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



15 Following the procedure as described in Example 1, making variations using 4-((2-((4-butoxyphenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 60% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.78-7.75 (m, 4H), 7.51-7.47 (m, 2H), 7.21 (br s, 2H), 6.95-6.90 (m, 2H), 3.96-3.90 (m, 6H), 1.70-1.63 (m, 2H), 1.46-1.37 (m, 2H), 0.91 (t, *J* = 7.6 Hz, 3H).

## EXAMPLE 16

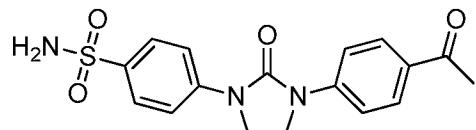
## SYNTHESIS OF 4-(3-(4-CYANOPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



5 Following the procedure as described in Example 1, making variations using 4-((2-((4-cyanophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a yellowish solid in 85% yield.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ):  $\delta$  7.83-7.81 (m, 4H), 7.80-7.78 (m, 4H), 7.25 (br s, 2H), 4.05-4.01 (s, 4H).

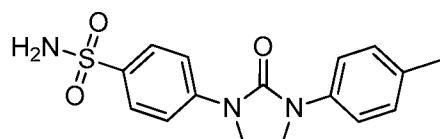
## EXAMPLE 17

## SYNTHESIS OF 4-(3-(4-ACETYLPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



15 Following the procedure as described in Example 1, making variations using 4-((2-((4-acetylphenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a yellow solid in 53% yield.  $^1\text{H}$  NMR (400 MHz,  $\text{DMSO-}d_6$ ):  $\delta$  7.99-7.95 (m, 2H), 7.81-7.79 (m, 4H), 7.79-7.75 (m, 2H), 7.25 (br s, 2H), 4.06-4.01 (m, 4H), 2.53 (s, 3H).

## EXAMPLE 18

SYNTHESIS OF 4-(2-OXO-3-(*P*-TOLYL)IMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

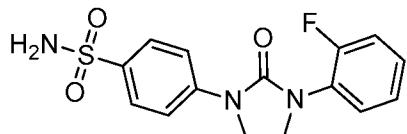
Following the procedure as described in Example 1, making variations using 4-((2-(*p*-tolylamino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 46% yield. <sup>1</sup>H

5 NMR (300 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.82-7.76 (m, 4H), 7.52 (d, *J* = 8.7 Hz, 2H), 7.24 (br s, 2H), 7.18 (d, *J* = 8.7 Hz, 2H), 4.10-3.50 (m, 4H), 2.28 (s, 3H). MS (ES-, *m/z*): 330.3 (M-1).

### EXAMPLE 19

#### SYNTHESIS OF 4-(3-(2-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-

10 YL)BENZENESULFONAMIDE

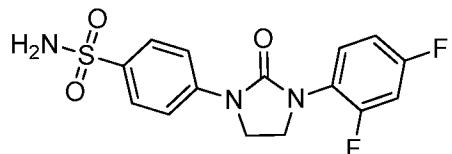


Following the procedure as described in Example 1, making variations using 4-((2-(2-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 53% yield. <sup>1</sup>H NMR (300 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.86-7.76 (m, 4H), 7.58 (m, 1H), 7.35-7.28 (m, 2H), 7.26-7.16 (m, 2H), 4.10-4.00 (m, 2H), 3.99-3.90 (m, 2H); MS (ES-, *m/z*): 334.3 (M-1).

### EXAMPLE 20

20 SYNTHESIS OF 4-(3-(2,4-DIFLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-

YL)BENZENESULFONAMIDE

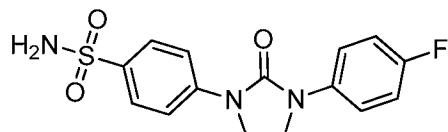


Following the procedure as described in Example 1, making variations using 4-((2-(2,4-

10 difluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 19% yield.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  7.78 (d,  $J$  = 9.6 Hz, 2H), 7.74 (d,  $J$  = 9.6 Hz, 2H), 7.58 (td,  $J$  = 8.8, 6.4 Hz, 1H), 7.38 (m, 1H), 7.23 (br s, 2H), 7.15 (m, 1H), 4.05 (m, 2H), 3.95 (m, 2H). MS (ES+,  $m/z$ ): 354.2 (M+1).

### EXAMPLE 21

#### SYNTHESIS OF 4-(3-(4-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

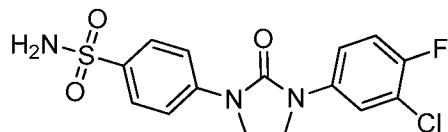


10

15 Following the procedure as described in Example 1, making variations using 4-((2-((4-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 10% yield.  $^1\text{H}$  NMR (300 MHz, DMSO- $d_6$ ):  $\delta$  7.79-7.74 (m, 4H), 7.64-7.59 (m, 2H), 7.28-7.17 (m, 4H), 4.10-3.90 (m, 4H). MS (ES-,  $m/z$ ): 334.3 (M-1).

### EXAMPLE 22

#### SYNTHESIS OF 4-(3-(3-CHLORO-4-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



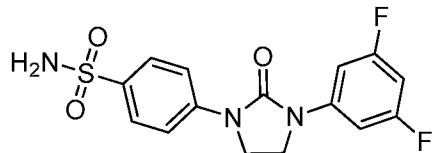
20

25 Following the procedure as described in Example 1, making variations using 4-((2-((3-chloro-4-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 42% yield.  $^1\text{H}$  NMR (300

MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.90 (dd, *J* = 6.4, 2.8 Hz, 1H), 7.82-7.72 (m, 4H), 7.57-7.51 (m, 1H), 7.41 (t, *J* = 8.8 Hz, 1H), 7.24 (br s, 2H), 4.03-3.86 (m, 4H). MS (ES-, *m/z*): 368.2 (M-1).

### EXAMPLE 23

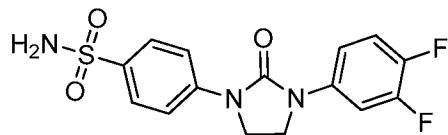
5           SYNTHESIS OF 4-(3-(3,5-DIFLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE



Following the procedure as described in Example 1, making variations using 4-((2-((3,5-difluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 58% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.82-7.74 (m, 4H), 7.39 (dd, *J* = 8.0, 2.4 Hz, 2H), 7.25 (br s, 2H), 7.90 (tt, *J* = 4.8, 2.4 Hz, 1H), 4.08-3.95 (m, 4H). MS (ES-, *m/z*): 352.3 (M-1).

### EXAMPLE 24

10           SYNTHESIS OF 4-(3-(3,4-DIFLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

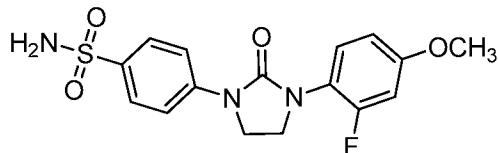


20           Following the procedure as described in Example 1, making variations using 4-((2-((3,4-difluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 57% yield. <sup>1</sup>H NMR (400

MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.86-7.74 (m, 5H), 7.50-7.32 (m, 2H), 7.23 (br s, 2H), 4.05-4.95 (m, 4H). MS (ES-, *m/z*): 352.1 (M-1).

### EXAMPLE 25

#### SYNTHESIS OF 4-(3-(2-FLUORO-4-METHOXYPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

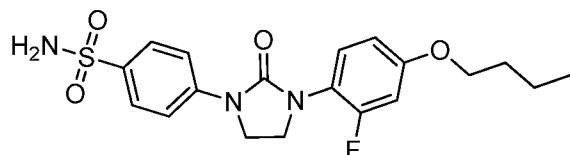


Following the procedure as described in Example 1, making variations using 4-((2-(2-fluoro-4-methoxyphenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 27% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.80-7.70 (m, 4H), 7.35 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.20 (br s, 2H), 7.03 (dd, *J* = 8.0, 2.8 Hz, 1H), 7.80 (td, *J* = 8.8, 2.8 Hz, 1H), 4.01-3.95 (m, 2H), 4.85-3.75 (m, 5H). MS (ES-, *m/z*): 364.2 (M-1).

15

### EXAMPLE 26

#### SYNTHESIS OF 4-(3-(4-BUTOXY-2-FLUOROPHENYL)-2-OXOIMIDAZOLIDIN-1-YL)BENZENESULFONAMIDE

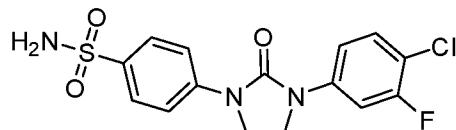


Following the procedure as described in Example 1, making variations using 4-((2-(4-butoxy-2-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 51% yield. <sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>):  $\delta$  7.80-7.70 (m, 4H), 7.33 (dd, *J* = 8.8, 2.4 Hz, 1H), 7.20 (br s, 2H), 7.03 (dd, *J* = 8.0, 2.8 Hz, 1H), 7.80 (td, *J* = 8.8, 2.8 Hz, 1H), 4.01-3.95 (m, 2H), 4.85-3.75 (m, 5H). MS (ES-, *m/z*): 364.2 (M-1).

2H), 7.01 (dd,  $J$  = 8.0, 2.8 Hz, 1H), 6.77 (td,  $J$  = 8.8, 2.8 Hz, 1H), 4.05-3.90 (m, 4H), 3.80-3.70 (m, 2H), 1.68-1.62 (m, 2H), 1.40-1.32 (m, 2H), 0.84 (t,  $J$  = 7.5 Hz, 3H). MS (ES-,  $m/z$ ): 406.3 (M-1).

### EXAMPLE 27

5      SYNTHESIS OF 4-(3-(4-CHLORO-3-FLUOROPHENYL)-2-OXOIMAZOLIDIN-1-YL)BENZENESULFONAMIDE



Following the procedure as described in Example 1, making variations using 4-((2-((4-chloro-3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to replace 4-((2-((3-fluorophenyl)amino)ethyl)amino)benzenesulfonamide to react with triphosgene, the title compound was obtained as a white solid in 54% yield.  $^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  7.82-7.74 (m, 4H), 7.60-7.46 (m, 1H), 7.46-7.36 (m, 1H), 7.24 (br s, 2H), 4.06-3.94 (m, 4H). MS (ES-,  $m/z$ ): 368.1 (M-1).

15      EXAMPLE 28

The following compounds were prepared by a similar procedure as described in Example 1:

Example	Chemical Name	Structure
28.1	4-(3-(5-fluoropyridin-2-yl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	
28.2	4-(3-(2-fluoro-4-(4-methylpiperazin-1-yl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	

28.3	4-(3-(2-fluoro-4-morpholinophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	
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### BIOLOGICAL EXAMPLES

#### EXAMPLE 29

##### ASSESSMENT OF CARBONIC ANHYDRASE INHIBITORY ACTIVITY

An Applied Photophysics stopped-flow instrument was used for

5 assaying the CA-catalyzed CO<sub>2</sub> hydration activity. Phenol red (at 0.2 mM) was used as indicator, working at the absorbance maximum of 557 nm, with 20 mM Hepes (pH 7.4) and 20 mM NaBF<sub>4</sub> (for maintaining constant the ionic strength), following the initial rates of the CA-catalyzed CO<sub>2</sub> hydration reaction for 10-100 seconds. The CO<sub>2</sub> concentrations ranged from 1.7 to 17 mM for the

10 determination of the kinetic parameters and inhibition constants. For each inhibitor, at least six traces of the initial 5-10% of the reaction were used for determining the initial velocity. The uncatalyzed rates were determined in the same manner and subtracted from the total observed rates. Stock solutions of inhibitor (10 mM) were prepared in distilled-deionized water, and dilutions up to

15 0.01 nM were done thereafter with distilled-deionized water. Inhibitor and enzyme solutions were pre-incubated together for 15 minutes at room temperature prior to assay in order to allow for the formation of the E-I complex. The inhibition constants were obtained by nonlinear least-squares methods using PRISM 3, whereas the kinetic parameters for the uninhibited enzymes

20 were from Lineweaver-Burk plots, and represent the mean from at least three different determinations.

The following table summarizes the inhibitory activity on CAIX and CAXII of the compounds of the disclosure. “+” represents the K<sub>i</sub> is > 100 μM; “++” represents the 100 nM < K<sub>i</sub> < 10 nM; and “+++” represents the K<sub>i</sub> < 10 nM.

Ex No.	MW	Chemical Name	K <sub>i</sub> (nM)	
			CAIX	CAXII
1	335.35	4-(3-(3-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	++	++
2	345.42	4-(3-(3,5-dimethylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	++	++
3	407.44	4-(2-oxo-3-(3,4,5-trimethoxyphenyl)imidazolidin-1-yl)benzenesulfonamide	+++	++
4	309.38	4-(3-cyclopentyl-2-oxoimidazolidin-1-yl)benzenesulfonamide	++	++
5	323.41	4-(3-cyclohexyl-2-oxoimidazolidin-1-yl)benzenesulfonamide	++	++
6	414.25	4-(3-(4-bromo-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	++	++
7	369.8	4-(3-(4-chloro-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
8	385.36	4-(2-oxo-3-(4-(trifluoromethyl)phenyl)imidazolidin-1-yl)benzenesulfonamide	+++	+++
9	349.38	4-(3-(4-fluorobenzyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	++	++
10	295.36	4-(3-(cyclopropylmethyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
11	359.44	4-(3-(2-isopropylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++

Ex No.	MW	Chemical Name	K <sub>i</sub> (nM)	
			CAIX	CAXII
12	419.81	4-(3-(2-chloro-5-(trifluoromethyl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
13	403.35	4-(3-(2-fluoro-5-(trifluoromethyl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
14	391.44	4-(3-(4-(2-methoxyethoxy)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
15	389.47	4-(3-(4-butoxyphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
16	342.37	4-(3-(4-cyanophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
17	359.4	4-(3-(4-acetylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
18	331.39	4-(2-oxo-3-( <i>p</i> -tolyl)imidazolidin-1-yl)benzenesulfonamide	++	+++
19	335.35	4-(3-(2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
20	353.34	4-(3-(2,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
21	335.35	4-(3-(4-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
22	369.8	4-(3-(3-chloro-4-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++

Ex No.	MW	Chemical Name	K <sub>i</sub> (nM)	
			CAIX	CAXII
23	353.34	4-(3-(3,5-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++
24	353.34	4-(3-(3,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
25	365.38	4-(3-(2-fluoro-4-methoxyphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
26	407.46	4-(3-(4-butoxy-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
27	369.8	4-(3-(4-chloro-3-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	++
28.1	336.34	4-(3-(5-fluoropyridin-2-yl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+	+
28.2	433.5	4-(3-(2-fluoro-4-(4-methylpiperazin-1-yl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+	+++
28.3	420.46	4-(3-(2-fluoro-4-morpholinophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide	+++	+++

### EXAMPLE 30

#### CELL CULTURE AND HYPOXIC EXPOSURE

The acquisition, generation and culture of the luciferase

5 expressing mouse breast cancer cell lines 4T1, 66cl4 and 67NR, and the human breast cancer cell lines MDA-231 and MDA-231 LM2-4 have been described previously (Lou et al, (2008) Dev Dyn 237:2755-2768; Lou et al, (2011) Cancer Res, 71:3364-3376. For culture in hypoxia, cells were

maintained in 1% O<sub>2</sub> and 5% CO<sub>2</sub> balanced with N<sub>2</sub> at 37 °C in a humidified incubator in a sealed anaerobic workstation.

### EXAMPLE 31

#### GENERATION OF STABLE CELLS

5 shRNAmir vectors targeting mouse CAIX and a non-silencing sequence (Open Biosystems) were transfected into 90% confluent cells using LipofectAMINEPLUS™ (Invitrogen Life Technologies) according to the manufacturer's instructions. Due to the previous utilization of puromycin, transfected cells were selected using hygromycin. Stable shCAIX clones were  
10 derived by limited dilution cloning. For (re-)introduction of CAIX into cells, human CAIX was transfected into 4T1 cells following the same procedure and Zeocin was used for selection.

### EXAMPLE 32

#### MEASUREMENT OF EXTRACELLULAR pH

15 Cells were plated at appropriate density (1 x 10<sup>4</sup> cells/cm<sup>2</sup> for 4T1 cells and its transfected derivatives, 2 x 10<sup>4</sup> cells/cm<sup>2</sup> for 66cl4 cells, 1 x 10<sup>4</sup> cells/cm<sup>2</sup> for 67NR cells and its transfected derivatives) in 60 mm dishes and allowed to recover overnight. A standard volume of 3 ml of fresh media/dish was then added and cells were incubated in normoxia (air + 5% CO<sub>2</sub>) or  
20 hypoxia (1% O<sub>2</sub> and 5% CO<sub>2</sub> balanced with nitrogen) for 72 h. Care was taken to ensure that cultures grown in normoxia and hypoxia were at similar confluence and contained similar cell numbers at the time of medium collection. Collected spent media was maintained at 37 °C and pH was measured immediately using a digital pH meter. Cell counts were performed to ensure that  
25 cell numbers for a given cell line were comparable in both environmental conditions. Cells were harvested on ice for qRT-PCR and Western blot analysis.

## EXAMPLE 33

## CELL PROLIFERATION ASSAY

Cell growth was measured using an MTT cell proliferation kit (Roche Applied Science) according to the manufacturer's instructions. In brief, 5 cells were plated in 96-well plates at a density of  $5 \times 10^3$  cells/cm<sup>2</sup> and allowed to recover overnight. Parallel samples were then incubated in normoxia and hypoxia for 48 to 72 h prior to performing the assay.

## EXAMPLE 34

## 3D MATRIGEL INVASION ASSAY

10 A 3D "on-top" matrigel culture assay was performed as described previously (Lee et al, (2007) Nat Methods 4:359-365). Briefly, MDA-231 LM2-4 Luc+ cells ( $1.5 \times 10^4$  cells/cm<sup>2</sup>) were re-suspended in 100  $\mu$ l/well growth media containing 2x the final concentration of inhibitor and plated into 8-well chamber slides pre-coated with matrigel. Cells were allowed to attach for 45 minutes 15 with side-to-side agitation every 10-15 minutes to prevent clumping of cells in the center of the well. An additional 100  $\mu$ l/well media containing 10% matrigel was added to the cells and cultures were incubated in hypoxia for 4 days. Images were acquired and cultures were fixed for TUNEL using the "whole 20 culture fixation" methodology outlined in Lee et al, (2007) Nat Methods 4:359-365.

## EXAMPLE 35

## SYNGENEIC ORTHOTOPIC TUMORS AND SPONTANEOUS METASTASIS

4T1 cells ( $1 \times 10^6$ ) or 67NR cells ( $2 \times 10^6$ ) were orthotopically implanted into the fourth mammary fat pad of 7-9 week-old female BALB/c mice 25 as described previously (Lou et al, (2011) Cancer Res 71:3364-3376; Lou et al, (2008) Dev Dyn 237:2755-2768). Injection of cell numbers of this magnitude is standard for propagation of these tumors, and is well below that used in other models of tumor growth (Erler, JT. Bennewith, KL,. Icolau, M. Nature 440:

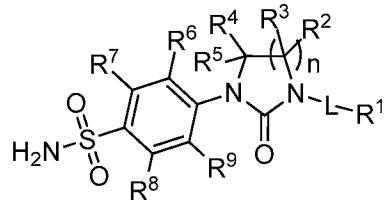
1222-1226). Primary tumor growth rates were calculated from caliper measurements using the modified ellipsoid formula ( $L \times W^2/2$ ). Tumor formation and metastasis progression was monitored and quantified using bioluminescent imaging as previously described (Ebos et al., (2009) Cancer 5 Cell 15:232-239.; Lou et al., (2008) Dev Dyn 237:2755-2768).

All of the U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data 10 Sheet, including U.S. Provisional Patent Application Serial No. 62/187,636, filed July 1, 2015, are incorporated herein by reference, in their entirety.

From the foregoing it will be appreciated that, although specific embodiments of the disclosure have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit 15 and scope of the disclosure. Accordingly, the disclosure is not limited except as by the appended claims.

## WHAT IS CLAIMED IS

## 1. A compound of Formula (I):



Formula (I)

wherein:

$R^1$  is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

$R^2$ ,  $R^3$ ,  $R^4$ , and  $R^5$  are the same or different and independently from hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

$R^6$ ,  $R^7$ ,  $R^8$ , and  $R^9$  are the same or different and independently from hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

$L$  is a direct bond or  $(C(R^{10}))_2$ ;

$n = 1, 2$  or  $3$ ; and

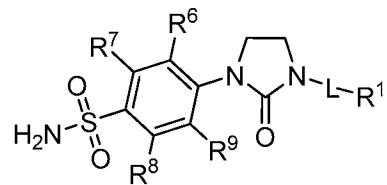
$p = 1$  to  $4$ ;

each  $R^{10}$  is the same or different and independently hydrogen or alkyl;

a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a pharmaceutical composition thereof or a prodrug thereof,

provided that the compound of Formula (I) is not 4-[3-[cis-4-(aminomethyl)-4-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-benzenesulfonamide.

2. The compound of Formula (I), wherein  $n$  is  $1$ , and  $R^2$ ,  $R^3$ ,  $R^4$ ,  $R^5$  are each hydrogen, and is represented by a structure of Formula (Ia):



Formula (Ia)

wherein:

$R^1$  is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

$R^6$ ,  $R^7$ ,  $R^8$ , and  $R^9$  are the same or different and independently hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

$L$  is a direct bond or  $(C(R^{10}))_p$ ;

$p$  = 1 to 4; and

each  $R^{10}$  is the same or different and independently hydrogen or alkyl;

a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a pharmaceutical composition thereof or a prodrug thereof,

provided that the compound of Formula (I) is not 4-[3-[cis-4-(aminomethyl)-4-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-benzenesulfonamide.

3. The compound of claims 1 or 2, wherein,  $R^1$  is aryl and  $L$  is a direct bond or a methylene (-CH<sub>2</sub>-).

4. The compound of any one of claims 1-3 wherein  $R^1$  is aryl substituted by one or more substituents selected from the group consisting of halo, alkyl, alkoxy, heterocyclyl, haloalkyl, cyano and acetyl.

5. The compound of claim 3 or claim 4 being:  
4-(3-(4-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;

4-(3-(2,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-fluorobenzyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-fluoro-4-(4-methylpiperazin-1-yl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(2-oxo-3-(p-tolyl)imidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(3-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(3,5-dimethylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(2-oxo-3-(3,4,5-trimethoxyphenyl)imidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-fluoro-4-morpholinophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-bromo-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-chloro-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(2-oxo-3-(4-(trifluoromethyl)phenyl)imidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-chloro-3-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-fluoro-4-methoxyphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-fluoro-5-(trifluoromethyl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-(2-methoxyethoxy)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-isopropylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(3,5-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(3-chloro-4-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(3,4-difluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(2-chloro-5-(trifluoromethyl)phenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-butoxy-2-fluorophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-butoxyphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-(4-cyanophenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide; or  
4-(3-(4-acetylphenyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

6. The compound of claims 1 or 2, wherein R<sup>1</sup> is cycloalkyl, and L is a direct bond or a methylene (-CH<sub>2</sub>-).

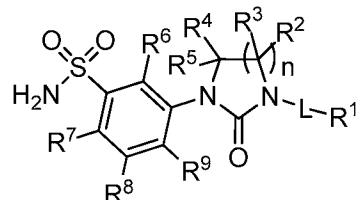
7. The compound of claim 6 being:

4-(3-cyclopentyl-2-oxoimidazolidin-1-yl)benzenesulfonamide;  
4-(3-cyclohexyl-2-oxoimidazolidin-1-yl)benzenesulfonamide; or  
4-(3-(cyclopropylmethyl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

8. The compound of claims 1 or 2, wherein R<sup>1</sup> is heteroaryl, and L is a direct bond or a methylene (-CH<sub>2</sub>-).

9. The compound of claim 8 being 4-(3-(5-fluoropyridin-2-yl)-2-oxoimidazolidin-1-yl)benzenesulfonamide.

10. A compound of Formula (II):



Formula (II)

wherein:

R<sup>1</sup> is alkyl, cycloalkyl, cycloalkylalkyl, haloalkyl, aryl, heterocyclyl, heteroaryl, or alkoxy;

R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, and R<sup>5</sup> are the same or different and independently from hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

R<sup>6</sup>, R<sup>7</sup>, R<sup>8</sup>, and R<sup>9</sup> are the same or different and independently hydrogen, alkyl, cycloalkyl, cycloalkylalkyl, amino, halo, or haloalkyl;

L is a direct bond or (C(R<sup>10</sup>)<sub>2</sub>)<sub>p</sub>;

n = 1, 2 or 3; and

p = 1 to 4;

each R<sup>10</sup> is the same or different and independently hydrogen or alkyl;

a stereoisomer, enantiomer or tautomer thereof, an isotopically enriched derivative thereof, a pharmaceutically acceptable salt thereof, a pharmaceutical composition thereof or a prodrug thereof,

provided that the compound of Formula (II) is not 4-[3-[cis-4-(aminomethyl)-3-(3-chlorophenyl)cyclohexyl]-2-oxo-1-imidazolidinyl]-benzenesulfonamide.

11. A pharmaceutical composition comprising a compound of any one of claims 1-10 and a pharmaceutically acceptable excipient.

12. A method for suppressing solid tumor growth, invasion and/or tumor metastases in a mammal in need thereof comprising administering to said mammal a therapeutically effective amount of the compound according of any one of claims 1-10 or the pharmaceutical composition of claim 11.

13. A method for treating a mammal having cancer comprising administering to said mammal a therapeutically effective amount of the compound according of any one of claims 1-10 or the pharmaceutical composition of claim 11, wherein the cancer is astrocytoma/glioblastoma, bladder cancer, breast cancer, colorectal carcinoma, esophageal adenocarcinoma, gastrointestinal stromal tumors, gastric cancer, head and neck cancer, hepatocellular carcinoma, lung cancer, melanoma, ovarian cancer, pancreatic ductal adenocarcinoma, renal cell carcinoma, thyroid cancer, or uterine endometrial cancer.

14. The method of claim 13 wherein treating the mammal having cancer includes reducing or eliminating metastases.

15. The method of claims 13 or claim 14 further comprising administering an additional chemotherapeutic or other anticancer agents.

16. A method of depleting cancer stem cells in a mammalian cancer stem cell population comprising contacting the mammalian cancer stem cell population with a compound of any one of claim 1-10 or the pharmaceutical composition of claim 11.

17. A method of inducing cell death in hypoxic cancer cells comprising contacting the hypoxic cancer cells with a compound of any one of claims 1-10 or the pharmaceutical composition of claim 11.

18. Use of a compound of any one of claims 1-10 and a pharmaceutical composition of claim 11 for suppressing tumor growth, invasion and/or tumor metastases in a mammal.

19. The use Use of a compound of any one of claims 1-10 and a pharmaceutical composition of claim 11 for of claim 18 wherein the tumor growth, invasion and/or tumor metastases is solid tumor or liquid tumor.

20. Use of a compound of any one of claims 1-10 and a pharmaceutical composition of claim 11 for treating astrocytoma/glioblastoma, bladder cancer, breast cancer, colorectal carcinoma, esophageal adenocarcinoma, gastrointestinal stromal tumors, gastric cancer, head and neck cancer, hepatocellular carcinoma, lung cancer, melanoma, ovarian cancer , pancreatic ductal adenocarcinoma, renal cell carcinoma, thyroid cancer, or uterine endometrial cancer.

21. Use of a compound of any one of claims 1-10 and a pharmaceutical composition of claim 11 for inducing cell death in hypoxic cancer cells.

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2016/040736

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. C07D233/32 A61K31/4166 A61P35/00  
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data, CHEM ABS Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/012485 A1 (BAESCHLIN DANIEL KASPAR [CH] ET AL) 10 January 2013 (2013-01-10) page 48; claim 42; compounds DI7, DI8 -----	6,10-12, 18
Y	CONGIU CENZO ET AL: "Synthesis and carbonic anhydrase I, II, IX and XII inhibition studies of 4-N,N-disubstituted sulfonilamides incorporating 4,4,4-trifluoro-3-oxo-but-1-enyl, phenacylthiourea and imidazol-2(3H)-one/thione moieties", BIOORGANIC & MEDICINAL CHEMISTRY LETTERS, vol. 24, no. 7, 2014, pages 1776-1779, XP028835162, ISSN: 0960-894X, DOI: 10.1016/J.BMCL.2014.02.030 compounds 18,19 ----- -/-	1-4,6,8, 10-21

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance  
"E" earlier application or patent but published on or after the international filing date  
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  
"O" document referring to an oral disclosure, use, exhibition or other means  
"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search  10 August 2016	Date of mailing of the international search report  24/08/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Grassi, Damian

## INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/040736

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FABIO PACCHIANO ET AL: "Ureido-substituted benzenesulfonamides potently inhibit carbonic anhydrase IX and show antimetastatic activity in a model of breast cancer metastasis", JOURNAL OF MEDICINAL CHEMISTRY, AMERICAN CHEMICAL SOCIETY, US, vol. 54, 24 March 2011 (2011-03-24), pages 1896-1902, XP002680226, ISSN: 0022-2623, DOI: 10.1021/JM101541X [retrieved on 2011-03-01] table 1 -----	1-4,6,8, 10-21
A	KESTUTIS RUTKAUSKAS ET AL.: MOLECULES, vol. 19, 2014, pages 17356-17380, XP002760629, table 1; compound 5 -----	1-21
A	WO 2013/023274 A1 (UNIV LAVAL [CA]; C-GAUDREAU RENE [CA]; FORTIN SEBASTIEN [CA]) 21 February 2013 (2013-02-21) compounds 102,103,109 -----	1-21
A	WO 03/013655 A2 (PHARMACIA CORP) 20 February 2003 (2003-02-20) claim 1; compound I -----	1-21
2		

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/040736

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