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Fortsættes ...

DESCRIPTION

Description

TECHNICAL FIELD

[0001] This disclosure relates to certain diaryl macrocycle compounds, specifically (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one for use in the treatment of cancer in mammals, especially in humans.

BACKGROUND

[0002] Protein kinases are key regulators for cell growth, proliferation and survival. Genetic and epigenetic alterations accumulate in cancer cells leading to abnormal activation of signal transduction pathways which drive malignant processes. (Manning, G.; Whyte, D. B.; Martinez, R.; Hunter, T.; Sudarsanam, S. The protein kinase complement of the human genome. *Science* 2002, 298, 1912-1934). Pharmacological inhibition of these signaling pathways presents promising intervention opportunities for targeted cancer therapies. (Sawyers, C. Targeted cancer therapy. *Nature* 2004, 432, 294-297).

[0003] Anaplastic lymphoma kinase (ALK), along with leukocyte tyrosine kinase (LTK), belongs to the insulin receptor (IR) superfamily of receptor tyrosine kinases. ALK is mainly expressed in the central and peripheral nervous systems suggesting a potential role in normal development and function of the nervous system. (Pulford K, et al *Cell Mol. Life Sci.* 2004, 61, 2939). ALK was first discovered as a fusion protein, NPM (nucleophosmin)-ALK encoded by a fusion gene arising from the t(2;5)(p23;q35) chromosomal translocation in anaplastic large cell lymphoma (ALCL) cell lines in 1994. (Morris SW, et al *Science* 1994, 263, 1281.) More than twenty distinct ALK translocation partners have been discovered in many cancers, including ALCL (60-90% incidence), inflammatory myofibroblastic tumours (IMT, 50-60%), non-small cell lung carcinomas (NSCLC, 3-7%), colorectal cancers (CRC, 0-2.4%), breast cancers (0-2.4%), and other carcinomas with rare incidence. (Grande E, et al *Mol. Cancer Ther.* 2011, 10, 569.) Oncogenic point mutations of ALK have been discovered in both familial and sporadic cases of neuroblastoma. (Mossé YP, et al *Nature* 2008, 455, 930-935.) Both fusion and mutant ALKs are highly oncogenic, which generate considerable interest and efforts in developing ALK inhibitors for the treatment of haematopoietic, solid, and mesenchymal tumors with abnormal ALK gene. (Grande, E, et al *Mol. Cancer Ther.* 2011, 10, 569-579.) Crizotinib was approved by the US Food and Drug Administration for the treatment of ALK-positive non-small cell lung

cancer. Similar with many targeted therapies of kinase inhibitors, crizotinib drug resistance developed in about 10 months. Mechanisms of drug resistance include target gene amplification or overexpression, development of secondary missense mutations, and use of alternative signaling pathway (so-called "bypass resistance"). As a result, second-generation ALK inhibitors have been developed to be more potent against wild and many mutant ALKs. One such mutation is the gatekeeper mutation ALK^{L1196M}. Ceritinib was approved by the US Food and Drug Administration for the treatment of patients with ALK-positive non-small cell lung cancer showing disease progression or who are intolerant to crizotinib. Although many second generation ALK inhibitors have been investigated in clinical trials, new ALK mutations resistant to the second generation ALK inhibitors have emerged. For example, the G1202R mutation has been found in tumors resistant to crizotinib, ceritinib, and alectinib. (Politi K, Clin Cancer Res. 2014, 20, 5576.) Novel isoforms of ALK consisting primarily of the intracellular tyrosine kinase domain was found to express in ~ 11% of melanomas and sporadically in other human cancer types, but not in normal tissues (Wiesner T, et al Nature 2015, 526, 453-457). These new ALK isoforms stimulate multiple oncogenic signalling pathways, and are sensitive to ALK inhibitors, suggesting potential clinical benefits from ALK inhibition.

[0004] Non-small cell lung cancers harboring *ALK* gene rearrangements are sensitive to treatment with the ALK inhibitor crizotinib. However, the emergence of drug resistance is universal and rapidly limits clinical applicability. The mechanisms of resistance include ALK gene amplification, acquired ALK missense mutations, bypass pathway activation, and epithelial-mesenchymal transition (EMT) (Katayama R 2012). (Katayama R., et al Sci Transl Med. 2012, 4(120):120ra17) Bypass and EMT constitute majority of the acquired resistant population. It is worth to note that 30-40% of ALK fusion positive patients have intrinsic resistance to ALK inhibitor treatment. ALK rearranged NSCLCs are typically adenocarcinoma characterized by a solid signetring cell pattern that is frequently associated with a metastatic phenotype and linked to an epithelial-mesenchymal transition (EMT) phenotype. (Voena C, et al. Oncotarget, 2016, April 23, 8955) The H2228 cell line with *EML4-ALK* v3 fusion gene displayed a mesenchymal phenotype with directly suppressing E-cadherin and up-regulating vimentin expression, as well as expression of other genes involved in EMT. H2228 cell line confers intrinsic resistance to crizotinib and other ALK inhibitors. Therefore, it is necessary to develop a polypharmacology ALK inhibitor being able to target EMT and metastasis. Bypass resistance occurs when the original driver oncogene and a secondary bypass track redundantly maintain downstream signaling to promote cell survival and proliferation. For example, ALK inhibition in patient-derived ALK models has been shown to up-regulate SRC activity. The combination of a Src tyrosine kinase inhibitor with an ALK inhibitor was shown to effectively suppress downstream signaling, generated a synergistic inhibition effect, and re-sensitized the ALK inhibitors in the patient-derived ALK models *in vitro* and *in vivo*. (Crystal AS, Science. 2014, 346, 1480.) The identification of new ALK inhibitors that can counter broad secondary ALK mutations including ALK^{G1202R} and inhibit Src signaling will be important and highly desired for effectively overcoming ALK drug resistance and sustaining the response to ALK inhibitor treatment.

[0005] ROS1 protein is a receptor tyrosine kinase, closely related to the ALK/LTK and insulin

receptor kinase family. Although normal physiologic functions of human ROS1 kinase have not been fully understood, the abnormal expression and variable constitutively activating fusion forms of ROS1 kinase have been reported in a number of cancers including glioblastoma, non-small cell lung cancer, cholangiocarcinoma, ovarian cancer, gastric adenocarcinoma, colorectal cancer, inflammatory myo fibroblastic tumor, angiosarcoma, and epithelioid hemangioendothelioma. (Kurtis DD, et al Clin Cancer Res 2013, 19 (15), 1.) FIG-ROS1 fusion protein was the first fusion protein of ROS1 discovered in 2003 in a human glioblastoma multiforme. (Charest A, et al Genes Chromosomes Cancer 2003, 37, 58) Several fusion proteins with ROS1 kinase including TPM3, SDC4, SLC34A2, CD74, EZR, and LRIG3 have been reported from human lung cancers, suggesting the oncogenic role of ROS1 kinase in lung cancers. (Takeuchi K, et al Nat. Med. 2012, 18, 378) The survey of activated tyrosine kinases signaling in 23 cholangiocarcinoma patients confirmed the presence of FIG-ROS1 kinase fusion in 8.7% of cholangiocarcinoma patients. (Gu TL, et al PLoS One. 2011, 6, e15640.) More and more ROS1 fusion partners including KDEL2, CCDC6, MSN, LIMA1, CLTC, NPkB2, NCOR2, CEP85L, TMEM106B, HLA-A, MYO5A, PPFIBP1, ERC1, PWWP2A, CLIP1, ZCCHC8, SHTN1, TFG, and YWHAE have been reported from various human cancers (Uquen A, et al Future Oncol. 2016, June 3, Epub ahead of print) Taken together, ROS1 kinase is a promising molecular based target candidate for cancers with aberrant ROS kinase activities. The ALK/MET/ROS1 inhibitor crizotinib has demonstrated marked efficacy in patients with NSCLC whose tumors are positive for ROS1 genetic abnormalities. (Shaw AT, et al N Engl J Med 2015, 372, 683). As expected ROS1 rearrangement-positive patients who responded to crizotinib eventually experienced disease progression. The secondary ROS1^{G2032R} mutation and bypass signaling are associated with the resistance. (Awad MM, et al N Engl J Med 2013, 368, 2395) It is desired to develop the next generation of ROS1 inhibitor to overcome the resistance.

[0006] The tropomyosin-related receptor tyrosine kinases (Trks) are high-affinity receptors for neurotrophins (NTs), a nerve growth factor (NGF) family. Trk was originally cloned as an oncogene fused with the tropomyosin gene in the extracellular domain. The activating mutations caused by chromosomal rearrangements or mutations in TRK family have been reported in many cancers. (Vaishnavi A, et al Cancer Discov. 2015, 5, 25) Because Trks play important roles in pain sensation as well as tumour cell growth and survival signaling, inhibitors of Trk receptor kinases might provide benefit for pain and cancer treatment.

[0007] The Janus family of kinases (JAKs) include JAK1, JAK2, JAK3 and TYK2, and are cytoplasmic non-receptor tyrosine kinases required for the physiologic signaling of cytokines and growth factors. (Quintas-Cardama A, et al., Nat. Rev. Drug Discov. 2011, 10(2), 127) Aberrant regulation of JAK/STAT pathways has been implicated in multiple human pathological diseases, including cancer (JAK2) and rheumatoid arthritis (JAK1, JAK3). A gain-of-function mutation of JAK2 (JAK2V617F) has been discovered with high frequency in MPN patients. (Levine RL, et al. Cancer Cell 2005, 7, 387) The mutation in the JH2 pseudokinase domain of JAK2 leads to constitutively kinase activity. Cells containing the JAK2V617F mutation acquire cytokine-independent growth ability and often become tumor, providing strong rationale for the development of JAK inhibitors as a targeted therapy. In addition, hyperactivation of the

JAK2/signal transducers and activators of transcription 3 (JAK2/STAT3) is responsible for abnormal dendritic cell differentiation leading to abnormal dendritic cell differentiation and accumulation of immunosuppressive myeloid cells in cancer (Nefedova Y, et al. *Cancer Res* 2005, 65, 9525). In Pten-null senescent tumors, activation of the JAK2/STAT3 pathway establishes an immunosuppressive tumor microenvironment that contributes to tumor growth and chemoresistance (Toso A, et al. *Cell Reports* 2014, 9, 75). JAK2 gene fusions with the TEL(ETV6) (TEL-JAK2) and PCM1 genes have been found in leukemia patients. (Lacronique V, et al. *Science* 1997, 278, 5341, 1309-12. Reiter A, et al. *Cancer Res.* 2005, 65, 7, 2662-7.) It was reported that JAK/STAT3 signaling pathway was aberrantly increased in EGFR inhibitor-resistant EGFR-mutant non-small cell lung cancer (NSCLC) cells, and JAK2 inhibition overcomes acquired resistance to EGFR inhibitors that support the use of combination therapy with JAK and EGFR inhibitors for the treatment of EGFR-dependent NSCLC. (Gao SP, et al. *Sci Signal.* 2016, 9 (421):ra33) JAK/STAT3 signaling promotes cancer hallmarks in the tumor and its environment, including proliferation, survival, angiogenesis, tumor metabolism while suppressing antitumor immunity. (Buchert M, et al. *Oncogene*, 2016, 35, 939-951) Inhibition of cytokine-dependent activation of the JAK/STAT3 pathway with JAK inhibitors may also afford orthogonal treatment opportunities for other oncogene-addicted cancer cells that have gained drug resistance. Focal amplification of JAK2 gene was observed in postchemotherapy triple-negative breast cancers (TNBCs) in a group of 9p24-amplified tumors, suggesting a role in tumorigenicity and chemoresistance. (Balko JM, et al. *Sci Transl Med.* 2016, 8(334):ra53) Therefore, pharmacologic inhibition of the JAK2 signaling pathway can be an important new therapeutic strategy to enhance antitumor activity.

c-Src is a nonreceptor tyrosine kinase. The Src family (SFK) comprises of eight members in humans (Src, Fyn, Yes, Lyn, Lck, Hck, Blk and Fgr) with a molecular weight between 52-62 KDa. Src and its family members are deregulated in many types of cancer. Src is a key downstream transducer of many RTKs, including EGFR, HER2, and c-Met. Activation of Src signaling has been implicated in conferring therapeutic resistance to targeted antiendocrine therapies, receptor tyrosine kinase therapies, traditional chemotherapies, and radiation therapies. (Zhang S, et al *Trends Pharmacol Sci.* 2012, 33, 122). SRC can promote signaling from growth factor receptors in a number of ways including participation in signaling pathways required for DNA synthesis, control of receptor turn-over, actin cytoskeleton rearrangement, migration, adhesion, invasion, motility, and survival. (Bromann PA, *Oncogene* 2004, 23, 7957-7968) A prominent role of Src in tumor progression-related events such as the epithelial-mesenchymal transition (EMT) and the development of metastasis have been reported through the interaction with the potent metastasis suppressor, N-myc downstream regulated gene 1 (NDRG1), that regulates cancer cell migration by inhibiting Src activity. (Liu W, et al. *Oncotarget.* 2015, 6: 35522-35541) Although EGFR inhibitors have achieved a significant success in the majority of NSCLC patients harbor EGFR-activating mutations, a subset of patients with EGFR mutations are refractory to EGFR-TKIs. Resistance to EGFR inhibitors reportedly involves SRC activation and induction of epithelial-to-mesenchymal transition (EMT). The primary resistance to EGFR-TKIs is associated with higher levels of CRIPTO1 expression. CRIPTO1 activated SRC and ZEB1 to promote EMT via microRNA-205 (miR-205) downregulation. Therefore, co-targeting EGFR and SRC may overcome intrinsic EGFR-inhibitor resistance in patients with CRIPTO1-positive, EGFR-mutated NSCLC. (Park, K-S, et al. *J Clin Invest.* 2014, 124(7):3003-3015) Focal Adhesion

Kinase (FAK) is a 125 kDa non-receptor tyrosine kinase and plays a significant role in adhesion, survival, motility, metastasis, angiogenesis, lymphangiogenesis, cancer stem cell functions, tumor microenvironment and epithelial to mesenchymal transition (EMT). (Golubovskaya VM, Front Biosci (Landmark Ed). ; 19: 687-706) Nuclear FAK controls chemokine transcription, Tregs, and evasion of antitumor immunity, and the small-molecule FAK kinase inhibitor VS-4718 drives depletion of Tregs and promotes a CD8+ T cell-mediated anti-tumor response. (Serrels A, et al, Cells 2015, 163, 160-173). Therefore, FAK inhibitors may trigger immune-mediated tumor regression. FAK is hyperactivated in human pancreatic ductal adenocarcinoma (PDAC) and correlates with immunosuppressive tumor microenvironment (TME). Targeting focal adhesion kinase renders pancreatic cancers responsive to checkpoint immunotherapy by overcoming the fibrotic and immunosuppressive PDAC TME in mouse models. (Jiang H, et al. Nat Med. 2016, Jul 4 [Epub ahead of print]). Recently it was reported that saracatinib, a selective SRC inhibitor, can re-sensitize ALK inhibitor-resistant cell lines, demonstrating a therapeutic role of SRC inhibition in overcoming ALK inhibitor resistance. (Crystal AS, et al. Science 2014, 346, 1480-1486) Therefore, Src/FAK inhibitor may play important roles in combinatorial regimens in overcoming resistance to current anticancer therapies and in preventing metastatic recurrence, EMT and cancer treatment resistance. AMP-activated protein kinase family member 5 (ARK5), also called NAUK1 is an upstream regulator of AMPK and limits protein synthesis via inhibition of rapamycin 1 (mTORC1) signalling pathway. ARK5 maintains expression of mitochondrial respiratory chain complexes and respiratory capacity for efficient glutamine metabolism. ARK5 is highly expressed in both primary NSCLC tissues and cell lines, that is functionally associated with NSCLC metastasis and a predictor of poor prognosis for NSCLC patients. ARK5 modulated the migration and invasion of NSCLC cells and played crucial roles in mTOR pathway. (Shi L, et al. Br J Cancer. 2014, 111(12):2316-27) It was reported that ARK5 confers doxorubicin resistance in HCC via inducing EMT. (Xu T, et al. Cancer Lett. 2016, 377(2):140-8) Deregulated expression of the MYC oncoprotein is associated with many human tumors. MYC promotes cell growth and proliferation, and alters cellular metabolism. Inhibition of ARK5 leads to a collapse of cellular ATP levels in cells expressing deregulated MYC, and prolongs survival in MYC-driven mouse models of hepatocellular carcinoma. (Liu L, et al. Nature, 2012, 483, 608-612) Therefore, Targeting cellular energy homeostasis by ARK5 inhibitor is a valid therapeutic strategy to eliminate tumor cells with deregulated MYC expression.

[0008] Src is a non-receptor tyrosine kinase that is deregulated in many types of cancer, and a key downstream transducer of many RTKs, including EGFR, HER2, and c-Met. Activation of Src signaling has been implicated in conferring therapeutic resistance to targeted antiendocrine therapies, receptor tyrosine kinase therapies, traditional chemotherapies, and radiation therapies. (Zhang S, et al Trends Pharmacol Sci. 2012, 33, 122). Src inhibitor may play important roles in combinatorial regimens in overcoming resistance to current anticancer therapies and in preventing metastatic recurrence. Cytoplasmic tyrosine kinases (also known as non-receptor tyrosine kinases) of the Src family (SFKs) play important roles in signal transduction induced by a large number of extracellular stimuli including growth factors and integrins. Elevated SFK activity is found in more than 80% of human colorectal cancer (CRC) and this has been associated with poor clinical outcome. (Summy JM, et al. Cancer Metastasis

Rev. 2003, 22, 337-358) The SFK member Yes regulates specific oncogenic signalling pathways important for colon cancer progression that is not shared with c-Src. (Scancier F. et al. PLoS One. 2011, 6(2): e17237) WASF2-FGR fusion genes were found in lung squamous carcinoma, ovarian serous cystadenocarcinoma, and skin cutaneous melanoma. (Stransky N, et al. Nature Communications 2014, 5, 4846) Estrogen receptor-positive (ER⁺) breast cancers adapt to hormone deprivation and become resistant to antiestrogen therapy. Mutations in the inhibitory SH2 domain of the SRC family kinase (SFK) LYN were related to ER⁺ tumors that remained highly proliferative after treatment with the aromatase inhibitor letrozole. LYN was upregulated in multiple ER⁺ breast cancer lines resistant to long-term estrogen deprivation. (Schwarz LJ, et al. J Clin Invest. 2014, 124, 5490-5502) Therefore, targeting LYN will be a rational strategy overcoming the escape from antiestrogens in a subset of ER⁺ breast cancers. It was reported that LYN was overexpressed in castrate-resistant prostate cancer (CRPC), enhanced AR transcriptional activity, and accelerated CRPC progression, and targeting Lyn kinase induced AR dissociation from the molecular chaperone Hsp90, leading to its ubiquitination and proteasomal degradation. (Zardan A., et al. Oncogenesis 2014, 3, e115) The Lyn tyrosine kinase is a potential therapeutic target for the treatment of CRPC. The Src family kinase FYN is involved in signal transduction pathways in the nervous system, as well as the development and activation of T lymphocytes under normal physiological conditions. Activation of Fyn is observed in various cancers, including melanoma, glioblastoma, squamous cell carcinoma, prostate and breast cancers. (Elias D., et al. Pharmacological Research 2015, 100, 250-254) Fyn was upregulated in tamoxifen-resistant breast cancer cell lines and plays a key role in the resistance mechanism. Peripheral T-cell lymphomas (PTCLs) are a heterogeneous group of aggressive non Hodgkin lymphomas with poor prognosis. FYN activating mutations were found in PTCL, and promoted the growth of cells transformed via expression of activated FYN mutant alleles. SRC kinase inhibitors may play important roles in the treatment of PTCLs. (Couronne L, et al. Blood 2013, 122, 811).

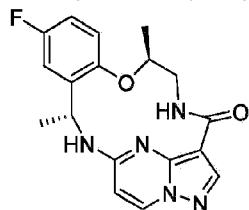
[0009] Discoidin domain receptors (DDR_s) are activated by matrix collagens and have been implicated in numerous cellular functions such as proliferation, differentiation, adhesion, migration, and invasion. DDR_s play a role in cancer progression by regulating the interactions of tumor cells with their surrounding collagen matrix. DDR1 is a direct p53 transcriptional target, and the activation of DDR1 is associated with p53-dependent DNA damage. DDR1 activated the MAPK cascade in a Ras-dependent manner. Inhibition of DDR1 function led to increased apoptosis of wild-type p53-containing cells in response to genotoxic stress through a caspase-dependent pathway. (Ongusaha PP, et al. EMBO J. 2003, 22, 1289-1301) DDR_s were identified as one of several major activated tyrosine kinases carrying somatic mutations in lung cancer (Hammerman PS, et al. Cancer Discov. 2011, 1, 78-89.), serous and clear cell endometrial cancer (Rudd ML, et al. BMC Cancer 2014, 14, 884), as well as in acute myeloid leukemia. (Tomasson MH, et al. Blood 2008, 111:4797-4808) Advanced Kirsten rat sarcoma viral oncogene homolog (*KRAS*)-mutant lung adenocarcinoma is challenging because of a lack of effective targeted therapies. The concomitant inhibition of both DDR1 and Notch signaling induced the regression of *KRAS*; *TP53*-mutant patient-derived lung xenografts (PDX), indicating the combined inhibition of DDR1 and Notch signaling could be an effective targeted therapy for

patients with *KRAS*-mutant lung adenocarcinoma. (Ambrogia C, et al, Nature Medicine, 2016, 22, 270-277).

[0010] It is desirable to prepare compounds that have activity against disease-driving kinase inhibitors, especially compounds that have activity against multiple kinases, including against multiple genetically altered kinases for use as therapeutic agents in treating diseases. New compounds with polypharmacology profiles are also desired for targeting the primary oncogene drivers and their acquired resistance mechanisms including secondary mutations, bypath signaling, EMT, cancer sternness, and metastasis.

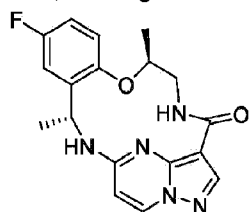
SUMMARY

[0011] The compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one (also herein referred to as "Compound 1"), represented by the formula



has been shown to be a potent small-molecule multi-target kinase inhibitor showing activity against wild-type and mutant ALK (anaplastic lymphoma kinase), wild-type and mutant ROS1 (ROS1 proto-oncogene receptor tyrosine kinase), the TRK family of kinases (tropomyosin-related receptor tyrosine kinases, TRKA/B/C), JAK2 of the Janus family of kinases and SRC (c-Src family of protein tyrosine kinases (SFKs)). Compound 1 has properties, including anti-tumor properties, which are pharmacologically mediated through inhibition of receptor and non-receptor tyrosine kinases. Compound 1 is disclosed in International Patent Application No. PCT/US2015/012597.

[0012] The present invention provides for a compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one, having the formula



or a pharmaceutically acceptable salt thereof, for use in treating cancer in a patient, wherein the cancer is mediated by

1. (i) a genetically altered ALK that is an EML4-ALK fusion protein having at least one mutation selected from the group consisting of L1196M, G1202R, D1203R, L1152P/R, F1174C/L/V, C1156Y, I1171N, G1123S, S1206Y, G1269S/A, and 1151T insertion; or

2. (ii) a genetically altered ALK that is a TPR-ALK fusion protein having a L1196M point mutation; or
3. (iii) a genetically altered ALK having one or more point mutations selected from the group consisting of R1050H, F1174C//L/S/V, F1245C//L/V, R1275L/Q, T1151M, M1166R, I1170N, I1170S, I1171N, I1183T, L1196M, A1200V, L1204F, L1240V, D1270G, Y1278S, R1192P, G1128A, G1286R, and T1343I; or
4. (iv) an LMNA-TRKA fusion protein; or
5. (v) a QKI-TRKB or ETV6-TRKB fusion protein; or
6. (vi) an ETV6-TRKC fusion protein.

[0013] In some embodiments, the cancer is a cancer mediated by a genetically altered ALK that is an EML4-ALK fusion protein comprising at least one mutation selected from the group consisting of L1196M, G1202R, D1203R, L1152P/R, F1174C/L/V, C1156Y, I1171N, G1123S, S1206Y, G1269S/A, and 1151T insertion.

[0014] In some embodiments, the cancer is a cancer mediated by a genetically altered ALK that is a TPR-ALK fusion protein having a L1196M point mutation.

[0015] In some embodiments, the cancer is a cancer mediated by ALK having one or more point mutations selected from the group consisting of R1050H, F1174C//L/S/V, F1245C//L/V, R1275L/Q, T1151M, M1166R, I1170N, I1170S, I1171N, I1183T, L1196M, A1200V, L1204F, L1240V, D1270G, Y1278S, R1192P, G1128A, G1286R, and T1343I. In some embodiments, the point mutation is a mutation at F1174. In some embodiments, the point mutation is a mutation of ALK at F1245. In some embodiments, the point mutation is a mutation of ALK at R1275.

[0016] In some embodiments, the cancer is a cancer mediated by a fusion protein comprising a fragment of a protein encoded by a TRKA gene and a fragment of a protein encoded by a LMNA gene. In some embodiments, the genetically altered TRKA is a LMNA-TRKA fusion protein. In some embodiments, the LMNA-TRKA fusion protein is a wild-type protein. In some embodiments, the LMNA-TRKA fusion protein comprises at least one resistance mutation. In some embodiments, the LMNA-TRKA fusion protein is a wild-type protein. In some embodiments, the LMNA-TRKA fusion protein comprises at least one resistance mutation comprising a G595R point mutation.

[0017] In some embodiments, the cancer is a cancer mediated by a fusion protein comprising a fragment of a protein encoded by a TRKB gene and a fragment of a protein encoded by a QKI gene or TEL gene. In some embodiments, the disease or cancer is a cancer mediated by a fusion protein comprising a fragment of a protein encoded by a TRKB gene and a fragment of a protein encoded by a QKI gene. In some embodiments, the disease or cancer is a cancer mediated by a fusion protein comprising a fragment of a protein encoded by a TRKB gene and a fragment of a protein encoded by a TEL gene. In some embodiments, the genetically altered TRKB is a QKI-TRKB or TEL-TRKB fusion protein. In some embodiments, the genetically

altered TRKB is a TEL-TRKB fusion protein. In some embodiments, the genetically altered TRKB is a QKI-TRKB fusion protein. In some embodiments, the QKI-TRKB or TEL-TRKB fusion protein is a wild-type protein. In some embodiments, the QKI-TRKB fusion protein is a wild-type protein. In some embodiments, the TEL-TRKB fusion protein is a wild-type protein. In some embodiments, the QKI-TRKB or TEL-TRKB fusion protein comprises at least one resistance mutation. In some embodiments, the QKI-TRKB fusion protein comprises at least one resistance mutation. In some embodiments, the TEL-TRKB fusion protein comprises at least one resistance mutation. In some embodiments, the TEL-TRKB fusion protein comprises a G639R point mutation.

[0018] In some embodiments, the cancer is a cancer mediated by a fusion protein comprising a fragment of a protein encoded by a TRKC gene and a fragment of a protein encoded by an ETV6 gene. In some embodiments, the genetically altered TRKC is an ETV6-TRKC fusion protein. In some embodiments, the ETV6-TRKC fusion protein is a wild-type protein. In some embodiments, the ETV6-TRKC fusion protein comprises at least one resistance mutation. In some embodiments, the ETV6-TRKC fusion protein comprises a G623R point mutation.

[0019] In some embodiments, the cancer is a cancer exhibiting bypass resistance.

[0020] In some embodiments, the cancer is selected from the group consisting of ALCL, NSCLC, neuroblastoma, inflammatory myofibroblastic tumor, adult renal cell carcinoma, pediatric renal cell carcinoma, breast cancer, colonic adenocarcinoma, glioblastoma, glioblastoma multiforme and anaplastic thyroid cancer.

[0021] In some embodiments, the cancer is NSCLC.

[0022] In some embodiments, the patient has been previously treated with a cancer therapeutic. In some embodiments, the patient has been previously treated with a cancer therapeutic, and the cancer has developed resistance to the cancer therapeutic. In some embodiments, the resistance is a primary intrinsic resistance. In some embodiments, the resistance is an acquired resistance from mutation(s). In some embodiments, the resistance is a bypass resistance. In some embodiments, the resistance is an EMT-based resistance.

[0023] Additional embodiments, features, and advantages of the disclosure will be apparent from the following detailed description and through practice of the disclosure. The compound of the present disclosure can be described in any of the following embodiments.

[0024] In one embodiment, the invention provides a compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one, or a pharmaceutically acceptable salt thereof, for use in treating cancer in a patient, wherein the cancer is mediated by a genetically altered ALK that is an EML4-ALK fusion protein comprising at least one mutation selected from the group consisting of L1196M, G1202R, D1203R, L1152P/R, F1174C/L/V, C1156Y, I1171N, G1123S, S1206Y, G1269S/A, and 1151T insertion

[0025] In one embodiment, the mutation is L1196M.

[0026] In one embodiment, the mutation is G1202R.

[0027] In one embodiment, the mutation is L1152P.

[0028] In one embodiment, the mutation is F11174C.

[0029] In one embodiment, the mutation is C1156Y.

[0030] In one embodiment, the mutation is I1171N.

[0031] In one embodiment, the mutation is G1269S.

[0032] In one embodiment, the mutation is 1151T insertion.

[0033] In one embodiment, the invention provides a compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one, or a pharmaceutically acceptable salt thereof, for use in treating cancer in a patient, wherein the cancer is mediated by a genetically altered ALK that is a TPR-ALK fusion protein comprising a L1196M point mutation.

[0034] In one embodiment, the invention provides a compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one, or a pharmaceutically acceptable salt thereof, for use in treating cancer in a patient, wherein the cancer is mediated by a genetically altered ALK having one or more point mutations selected from the group consisting of R1050H, F1174C/I/L/S/V, F1245C/I/L/V, R1275L/Q, T1151M, M1166R, I1170N, I1170S, I1171N, I1183T, L1196M, A1200V, L1204F, L1240V, D1270G, Y1278S, R1192P, G1128A, G1286R, and T1343I.

[0035] In one embodiment, the point mutation is a mutation of ALK at F1174.

[0036] In one embodiment, the point mutation is a mutation of ALK at F1245.

[0037] In one embodiment, the point mutation is a mutation of ALK at R1275.

[0038] In one embodiment, the cancer is selected from the group consisting of ALCL, NSCLC, neuroblastoma, inflammatory myofibroblastic tumor, adult renal cell carcinoma, pediatric renal cell carcinoma, breast cancer, colonic adenocarcinoma, glioblastoma, glioblastoma multiforme and anaplastic thyroid cancer.

[0039] In one embodiment, the cancer is NSCLC.

[0040] In one embodiment, the invention provides a compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one, or a pharmaceutically acceptable salt thereof, for use in treating cancer in a patient, wherein the cancer is mediated by a genetically altered TRKA which is a LMNA-TRKA fusion protein.

[0041] In one embodiment, the LMNA-TRKA fusion protein is a wild-type protein.

[0042] In one embodiment, the LMNA-TRKA fusion protein comprises at least one resistance mutation, including a LMNA-TRKA fusion protein comprising a G595R point mutation.

[0043] In one embodiment, the invention provides a compound (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one, or a pharmaceutically acceptable salt thereof, for use in treating cancer in a patient, wherein the cancer is mediated by QKI-TRKB or TEL-TRKB, including TEL-TRKB comprising a G639R point mutation.

[0044] In one embodiment, the cancer is mediated by a ETV6-TRKC fusion protein, including a genetically altered ETV6-TRKC fusion protein, including a ETV6-TRKC fusion protein comprising a G623R point mutation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0045]

FIG. 1 shows the effect of Compound 1 on apoptosis of Karpas-299 cells. FIG. 1A shows Karpas-299 cell apoptosis after incubation in various concentrations of Compound 1 for 48 hours; FIG. 1B shows Karpas-299 cells were collected, lysed and analyzed by SDS-PAGE and immunoblotted with PARP and Actin antibodies.

FIG. 2 shows the effect of Compound 1 on wound healing in HCC78 and HT-1080 cells.

FIG. 3 shows gels demonstrating that Compound 1 down-regulates EGFR expression. FIG. 3A shows results after 4 hour exposure to Compound 1 at 0 nM, 30 nM, 100 nM, 300 nM and 1000 nM; FIG. 3B shows results after 24 hour exposure to Compound 1 at 0 nM, 30 nM, 100 nM, 300 nM and 1000 nM.

FIG. 4 shows gels demonstrating that Compound 1 down-regulates CD44 expression as compared to the same experiment with crizotinib which does not show down-regulation of CD44 expression. FIG. 4A shows results after exposure to Compound 1 at 0 nM, 30 nM, 100 nM, 300 nM and 1000 nM; FIG. 4B shows results after exposure to crizotinib at 0 nM, 30 nM, 100 nM, 300 nM and 1000 nM.

FIG. 5 shows the effect of Compound 1 on tumor growth in the Karpas-299 *in vivo* model at

various doses, (○) control, (■) 15 mg/kg, (•) 50 mg/kg.

FIG. 6 shows the stability of animal body weight in the Karpas-299 *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (•) 50 mg/kg.

FIG. 7 shows the effect of Compound 1 on tumor growth in the NIH3T3 EML4-ALK WT *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (•) 50 mg/kg.

FIG. 8 shows the stability of animal body weight in the NIH3T3 EML4-ALK WT *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (•) 50 mg/kg.

FIG. 9 shows the effect of Compound 1 on tumor growth in the NIH3T3 SDC4-ROS1 WT *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (•) 50 mg/kg.

FIG. 10 shows the effect of Compound 1 on tumor growth in the KM12 *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 11 shows the stability of animal body weight in the KM12 *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 12 shows the inhibition of NPM-ALK phosphorylation by Compound 1 in the Karpas-299 *in vivo* model.

FIG. 13 shows the effect of Compound 1 on tumor growth in the KM12 *in vivo* model at various doses, (○) control, (■) 1 mg/kg, (•) 3 mg/kg, (▲) 15 mg/kg.

FIG. 14 shows the stability of animal body weight in the KM12 *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 1 mg/kg, (•) 3 mg/kg, (▲) 15 mg/kg.

FIG. 15 shows the effect of Compound 1 on tumor growth in the Ba/F3 EML4-ALK WT *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 16 shows the stability of animal body weight in the Ba/F3 EML4-ALK WT *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 17 shows the effect of Compound 1 on tumor growth in the Ba/F3 EML4-ALK G1202R *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 18 shows the stability of animal body weight in the Ba/F3 EML4-ALK G1202R *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 19 shows the effect of Compound 1 on tumor growth in the Ba/F3 CD74-ROS1 WT *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (•) 75 mg/kg.

FIG. 20 shows the stability of animal body weight in the Ba/F3 CD74-ROS1 WT *in vivo* model

following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (●) 75 mg/kg.

FIG. 21 shows the effect of Compound 1 on tumor growth in the BalF3 CD74-ROS1 G2032R *in vivo* model at various doses, (○) control, (■) 15 mg/kg, (●) 75 mg/kg.

FIG. 22 shows the stability of animal body weight in the Ba/F3 CD74-ROS1 G2032R *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 15 mg/kg, (●) 75 mg/kg.

FIG. 23 shows the effect of Compound 1 on tumor growth in the NIH3T3 LMNA-TRKA WT *in vivo* model at various doses, (○) control, (■) 3 mg/kg, (●) 15 mg/kg.

FIG. 24 shows the stability of animal body weight in the NIH3T3 LMNA-TRKA WT *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 3 mg/kg, (●) 15 mg/kg.

FIG. 25 shows the effect of Compound 1 on tumor growth in the NIH3T3 LMNA-TRKA G595R *in vivo* model at various doses, (○) control, (■) 3 mg/kg, (●) 15 mg/kg, (A) 60 mg/kg.

FIG. 26 shows the stability of animal body weight in the NIH3T3 LMNA-TRKA G595R *in vivo* model following administration of Compound 1 at various doses, (○) control, (■) 3 mg/kg, (●) 15 mg/kg, (A) 60 mg/kg.

DETAILED DESCRIPTION

[0046] Before the present disclosure is further described, it is to be understood that this disclosure is not limited to particular embodiments described, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the present disclosure will be limited only by the appended claims.

[0047] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this disclosure belongs. If a definition set forth in this section is contrary to or otherwise inconsistent with a definition set forth in a patent, application, or other publication that is referred to herein, the definition set forth in this section prevails over the definition referred to herein.

[0048] As used herein and in the appended claims, the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. It is further noted that the claims may be drafted to exclude any optional element. As such, this statement is intended to serve as antecedent basis for use of such exclusive terminology as "solely," "only" and the like in connection with the recitation of claim elements, or use of a "negative" limitation.

[0049] As used herein, the terms "including," "containing," and "comprising" are used in their open, non-limiting sense.

[0050] To provide a more concise description, some of the quantitative expressions given herein are not qualified with the term "about". It is understood that, whether the term "about" is used explicitly or not, every quantity given herein is meant to refer to the actual given value, and it is also meant to refer to the approximation to such given value that would reasonably be inferred based on the ordinary skill in the art, including equivalents and approximations due to the experimental and/or measurement conditions for such given value. Whenever a yield is given as a percentage, such yield refers to a mass of the entity for which the yield is given with respect to the maximum amount of the same entity that could be obtained under the particular stoichiometric conditions. Concentrations that are given as percentages refer to mass ratios, unless indicated differently.

[0051] Except as otherwise noted, the methods and techniques of the present embodiments are generally performed according to conventional methods well known in the art and as described in various general and more specific references that are cited and discussed throughout the present specification. See, e.g., Loudon, Organic Chemistry, Fourth Edition, New York: Oxford University Press, 2002, pp. 360-361, 1084-1085; Smith and March, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Fifth Edition, Wiley-Interscience, 2001.

Definitions

[0052] As used herein, the term "pharmaceutically acceptable salt" refers to those salts which counter ions which may be used in pharmaceuticals. See, generally, S.M. Berge, et al., "Pharmaceutical Salts," J. Pharm. Sci., 1977, 66, 1-19. Preferred pharmaceutically acceptable salts are those that are pharmacologically effective and suitable for contact with the tissues of subjects without undue toxicity, irritation, or allergic response. A compound described herein may possess a sufficiently acidic group, a sufficiently basic group, both types of functional groups, or more than one of each type, and accordingly react with a number of inorganic or organic bases, and inorganic and organic acids, to form a pharmaceutically acceptable salt. Such salts include:

1. (1) acid addition salts, which can be obtained by reaction of the free base of the parent compound with inorganic acids such as hydrochloric acid, hydrobromic acid, nitric acid, phosphoric acid, sulfuric acid, and perchloric acid and the like, or with organic acids such as acetic acid, oxalic acid, (D) or (L) malic acid, maleic acid, methane sulfonic acid, ethanesulfonic acid, p-toluenesulfonic acid, salicylic acid, tartaric acid, citric acid, succinic acid or malonic acid and the like; or
2. (2) salts formed when an acidic proton present in the parent compound either is replaced by a metal ion, e.g., an alkali metal ion, an alkaline earth ion, or an aluminum ion; or coordinates with an organic base such as ethanolamine, diethanolamine,

triethanolamine, trimethamine, N-methylglucamine, and the like.

[0053] Pharmaceutically acceptable salts are well known to those skilled in the art, and any such pharmaceutically acceptable salt may be contemplated in connection with the embodiments described herein. Examples of pharmaceutically acceptable salts include sulfates, pyrosulfates, bisulfates, sulfites, bisulfites, phosphates, monohydrogen-phosphates, dihydrogenphosphates, metaphosphates, pyrophosphates, chlorides, bromides, iodides, acetates, propionates, decanoates, caprylates, acrylates, formates, isobutyrate, caproates, heptanoates, propiolates, oxalates, malonates, succinates, suberates, sebacates, fumarates, maleates, butyne-1,4-dioates, hexyne-1,6-dioates, benzoates, chlorobenzoates, methylbenzoates, dinitrobenzoates, hydroxybenzoates, methoxybenzoates, phthalates, sulfonates, methylsulfonates, propylsulfonates, besylates, xylenesulfonates, naphthalene-1-sulfonates, naphthalene-2-sulfonates, phenylacetates, phenylpropionates, phenylbutyrates, citrates, lactates, γ -hydroxybutyrates, glycolates, tartrates, and mandelates. Lists of other suitable pharmaceutically acceptable salts are found in Remington's Pharmaceutical Sciences, 17th Edition, Mack Publishing Company, Easton, Pa., 1985.

[0054] For Compound 1 that contains a basic nitrogen, a pharmaceutically acceptable salt may be prepared by any suitable method available in the art, for example, treatment of the free base with an inorganic acid, such as hydrochloric acid, hydrobromic acid, sulfuric acid, sulfamic acid, nitric acid, boric acid, phosphoric acid, and the like, or with an organic acid, such as acetic acid, phenylacetic acid, propionic acid, stearic acid, lactic acid, ascorbic acid, maleic acid, hydroxymaleic acid, isethionic acid, succinic acid, valeric acid, fumaric acid, malonic acid, pyruvic acid, oxalic acid, glycolic acid, salicylic acid, oleic acid, palmitic acid, lauric acid, a pyranosidyl acid, such as glucuronic acid or galacturonic acid, an α -hydroxy acid, such as mandelic acid, citric acid, or tartaric acid, an amino acid, such as aspartic acid or glutamic acid, an aromatic acid, such as benzoic acid, 2-acetoxybenzoic acid, naphthoic acid, or cinnamic acid, a sulfonic acid, such as laurylsulfonic acid, p-toluenesulfonic acid, methanesulfonic acid, or ethanesulfonic acid, or any compatible mixture of acids such as those given as examples herein, and any other acid and mixture thereof that are regarded as equivalents or acceptable substitutes in light of the ordinary level of skill in this technology.

[0055] As used herein, the term "genetically altered" refers to a permanent alteration in the DNA sequence that makes up a gene that can result in a change in the protein sequence encoded by the gene. A gene that is "genetically altered" as described herein, can possess changes in DNA sequence, and/or protein sequence encoded by the DNA sequence, that range in size; for example, a single nucleotide (a.k.a. a single nucleotide polymorphism, SNP or point mutation), a multiple nucleotide polymorphism (MNPs), a large segment of a chromosome that includes multiple genes, such as a gene fusion, and the like. Examples of gene fusions include, but are not limited to, those which are the result of a chromosomal inversion in which a portion of a chromosomal DNA encoding one or more genes rearranges to provide a fusion of two genes not ordinarily in communication in the DNA sequence, such as

EML4-ALK (see for example, Soda, M. et al., *Nature*, 2007, 448, 561-567), those which are the result of a deletion in the DNA sequence (an "interstitial deletion") in which part of a DNA sequence of a chromosome is deleted to provide a fusion of two genes not ordinarily in communication in the DNA sequence, such as TMPRSS2-ERG (see for example, Yu J. et al., *Cancer Cell*, 2010, 17, 5, 443-54), or those which are the result of a translocation in which a portion of chromosomal DNA is spliced and inserted into the same or a different chromosome to provide a fusion of two genes not ordinarily in communication in the DNA sequence, such as BCR-ABL (see for example, Advani, A.S. et al. *Leukemia Research*, 2002, 26, 8, 713-720). One of skill in the art will readily appreciate that such gene fusions can be found in multiple variants depending on the individual in which the gene fusion has occurred, and each of such variants is contemplated by the methods described herein.

[0056] A "genetically altered" gene, or the protein encoded by such gene, can occur as hereditary mutations which can be inherited from a parent and are sometimes referred to as germline mutations, or a "genetically altered" gene, or the protein encoded by such gene, can occur as an acquired (or somatic) mutation that occurs at some point during a person's life. In some instances, a "genetically altered" gene can be described as a de novo (new) mutation, and can be either hereditary or somatic. It will be further understood that "genetically altered" can refer to a situation in which more than one of the changes in DNA sequence described herein can occur in a patient simultaneously, such as a SNP (or point mutation) and a translocation. Such situations can arise from, but are not solely the result of, so-called "acquired resistance" in which a patient having been treated with a kinase inhibitor can develop a mutation in the DNA sequence that reduces the effectiveness of the treatment. Non-limiting examples of such acquired resistance mutations include the point mutation L1196M, G1202R, L1152P, F1174C, C1156Y, I1171N, G1269S, and the 1151T insertion that occur in the EML4-ALK gene fusion.

[0057] As used herein, the term "intrinsic resistance" refers to the pre-existing resistance of disease cells, especially cancer cells, to drug treatment, especially chemotherapy treatment. It will be appreciated that intrinsic resistance can result in resistance of the cells to a single drug, a small group of structurally related drugs, or a several drugs of differing chemical structure (so-called "multidrug resistance" or "MDR"). (Monti, E. 2007. *Molecular Determinants of Intrinsic Multidrug Resistance in Cancer Cells and Tumors* In B. Teicher (Ed.), *Cancer Drug Resistance* (pp. 241-260). Totowa, New Jersey: Humana Press Inc.). It will be appreciated that intrinsic resistance can be the result of one or more host-related factors and/or the genetic make-up of the cells. Such factors include but are not limited to immunomodulation; pharmacogenetic factors such as failure to achieve optimal serum drugs levels due to altered ADME or low tolerance to drug-induced side effects; restricted drug access to the tumor site; and microenvironmental cues. Such genetic make-up factors include, but are not limited to altered expression of drug transporters; qualitative alterations of drug target(s); quantitative alterations of drug target(s); changes in intracellular drug handling/metabolism; changes in DNA repair activities, and alteration in apoptotic pathways. (Gottesman, M.M., *Annu. Rev. Med.*, 2002, 53, 516-527).

[0058] As used herein, the term "therapeutically effective amount" refers to that amount of active compound or pharmaceutical agent that elicits the biological or medicinal response in a patient, which includes alleviation of the symptoms of the disease or disorder being treated. In one aspect, the therapeutically effective amount is that which may treat or alleviate the disease or symptoms. The specific therapeutically-effective dose level for any particular patient will depend upon a variety of factors, including the disorder being treated and the severity of the disorder; activity of the specific compound employed; the specific composition employed; the age, body weight, general health, gender and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific compound employed; the duration of the treatment; drugs used in combination or coincidentally with the specific compound employed; and like factors. An exemplary dose is in the range of about from about 0.1 mg to 1 g daily, or about 1 mg to 50 mg daily, or about 50 to 250 mg daily, or about 250 mg to 1 g daily. The total dosage may be given in single or divided dosage units (e.g., BID, TID, QID).

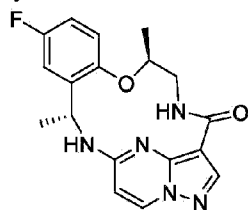
[0059] As used herein, the term "disease" includes cancer.

[0060] As used herein, the term "cancer" includes, but is not limited to, ALCL, NSCLC, neuroblastoma, inflammatory myofibroblastic tumor, adult renal cell carcinoma, pediatric renal cell carcinoma, breast cancer, ER⁺ breast cancer, colonic adenocarcinoma, glioblastoma, glioblastoma multiforme, anaplastic thyroid cancer, cholangiocarcinoma, ovarian cancer, gastric adenocarcinoma, colorectal cancer, inflammatory myofibroblastic tumor, angiosarcoma, epithelioid hemangioendothelioma, intrahepatic cholangiocarcinoma, thyroid papillary cancer, spitzoid neoplasms, sarcoma, astrocytoma, brain lower grade glioma, secretory breast carcinoma, mammary analogue carcinoma, acute myeloid leukemia, congenital mesoblastic nephroma, congenital fibrosarcomas, Ph-like acute lymphoblastic leukemia, thyroid carcinoma, skin cutaneous melanoma, head and neck squamous cell carcinoma, pediatric glioma CML, prostate cancer, lung squamous carcinoma, ovarian serous cystadenocarcinoma, skin cutaneous melanoma, castrate-resistant prostate cancer, Hodgkin lymphoma, and serous and clear cell endometrial cancer.

Embodiments

[0061] In some embodiments, Compound 1 described herein is for use in methods for the treatment of cancer comprising administering to a patient in need of treatment a therapeutically effective amount of a compound having activity against at least one tyrosine kinase selected from genetically altered ALK, TRKA, TRKB and TRKC as described herein. In some embodiments, the compound has activity against at least one tyrosine or serine/threonine kinase selected from the group consisting of ALK, ROS1, TRKA, TRKB, TRKC, JAK2, SRC, FAK and ARK5, at least one being genetically altered ALK, TRKA, TRKB or TRKC as described herein. In some embodiments, the compound has activity against at least two tyrosine or serine/threonine kinases selected from the group consisting of ALK, ROS1, TRKA, TRKB, TRKC, JAK2, SRC, FAK and ARK5, at least one being genetically altered ALK, TRKA, TRKB or

TRKC as described herein. In some embodiments, the at least one, or the at least two of the tyrosine or serine/threonine kinases are genetically altered. The compound is of the formula I



I

, or a pharmaceutically acceptable salt thereof.

[0062] According to the present disclosure, the cancer mediated by or associated with a genetically altered tyrosine kinase includes but is not limited to, ALCL, NSCLC, neuroblastoma, inflammatory myofibroblastic tumor, adult renal cell carcinoma, pediatric renal cell carcinoma, breast cancer, colonic adenocarcinoma, glioblastoma, glioblastoma multiforme, anaplastic thyroid cancer, cholangiocarcinoma, ovarian cancer, gastric adenocarcinoma, colorectal cancer, inflammatory myofibroblastic tumor, angiosarcoma, epithelioid hemangioendothelioma, intrahepatic cholangiocarcinoma, thyroid papillary cancer, spitzoid neoplasms, sarcoma, astrocytoma, brain lower grade glioma, secretory breast carcinoma, mammary analogue carcinoma, acute myeloid leukemia, congenital mesoblastic nephroma, congenital fibrosarcomas, Ph-like acute lymphoblastic leukemia, thyroid carcinoma, skin cutaneous melanoma, head and neck squamous cell carcinoma, pediatric glioma CML, and prostate cancer. In some embodiments, the cancer is NSCLC.

[0063] In some embodiments, the present disclosure relates to the treatment of cancer in a patient that has received a prior treatment with one or more therapeutic agents. In some embodiments, the patient has been previously treated with one or more chemotherapeutic agents. In still other embodiments, the patient has been previously treated with one or more chemotherapeutic agents and developed an acquired resistance to the treatment. In still other embodiments, the patient has been previously treated with one or more chemotherapeutic agents and developed bypass resistance to the treatment. In still other embodiments, the patient has been previously treated with one or more chemotherapeutic agents and developed bypass resistance to the treatment regulated by SRC or JAK2.

[0064] Other chemotherapeutic agents which the patient may be treated with prior to treatment with the compound described herein include but are not limited to kinase inhibitors, adrenocorticoids and corticosteroids, alkylating agents, peptide and peptidomimetic signal transduction inhibitors, antiandrogens, antiestrogens, androgens, aclamycin and aclamycin derivatives, estrogens, antimetabolites, platinum compounds, amanitins, plant alkaloids, mitomycins, discodermolides, microtubule inhibitors, epothilones, inflammatory and proinflammatory agents, purine analogs, pyrimidine analogs, camptothecins and dolastatins. In some embodiments, the chemotherapeutic agent the patient received previous to treatment with one or more compounds described herein can be one or more of afatinib, axitinib, alectinib, bosutinib, brigatini, cabozantinib, ceritinib, crizotinib, dabrafenib, dasatinib, erlotinib, everolimus, gefitinib, ibrutinib, imatinib, lapatinib, lenvatinib, nilotinib, nintedanib, palbociclib,

pazopanib, ponatinib, regorafenib, ruxolitinib, sirolimus, sorafenib, sunitinib, tofacitinib, temsirolimus, trametinib, vandetanib, vemurafenib, methotrexate, busulfan, carboplatin, chlorambucil, cisplatin, tamoxiphen, taxol, paclitaxel, docetaxel, cytosine arabinoside, cyclophosphamide, daunomycin, rhizoxin, prednisone, hydroxyurea, teniposide, vincristine, vinblastine, eribulin, camptothecin, irinotecan, geldanamycin, estramustine and nocodazole. In some embodiments, the methods described herein provide treatment of a patient previously treated with a kinase inhibitor selected from the group consisting of afatinib, alectinib, axitinib, bosutinib, brigatini, cabozantinib, ceritinib, crizotinib, dabrefenib, dasatinib, erlotinib, everolimus, gefitinib, ibrutinib, imatinib, lapatinib, lenvatinib, nilotinib, nintedanib, palbociclib, pazopanib, ponatinib, regorafenib, ruxolitinib, sirolimus, sorafenib, sunitinib, tofacitinib, temsirolimus, trametinib, vandetanib and vemurafenib. In some embodiments, the patient was previously treated with crizotinib.

Pharmaceutical Compositions

[0065] For treatment purposes, pharmaceutical compositions comprising the compound described herein may further comprise one or more pharmaceutically-acceptable excipients. A pharmaceutically-acceptable excipient is a substance that is non-toxic and otherwise biologically suitable for administration to a subject. Such excipients facilitate administration of the compounds described herein and are compatible with the active ingredient. Examples of pharmaceutically-acceptable excipients include stabilizers, lubricants, surfactants, diluents, anti-oxidants, binders, coloring agents, bulking agents, emulsifiers, or taste-modifying agents. In preferred embodiments, pharmaceutical compositions according to the invention are sterile compositions. Pharmaceutical compositions may be prepared using compounding techniques known or that become available to those skilled in the art.

[0066] Sterile compositions are also contemplated by the invention, including compositions that are in accord with national and local regulations governing such compositions.

[0067] The pharmaceutical compositions and compound described herein may be formulated as solutions, emulsions, suspensions, or dispersions in suitable pharmaceutical solvents or carriers, or as pills, tablets, lozenges, suppositories, sachets, dragees, granules, powders, powders for reconstitution, or capsules along with solid carriers according to conventional methods known in the art for preparation of various dosage forms. Pharmaceutical compositions of the invention may be administered by a suitable route of delivery, such as oral, parenteral, rectal, nasal, topical, or ocular routes, or by inhalation. Preferably, the compositions are formulated for intravenous or oral administration.

[0068] For oral administration, the compound the invention may be provided in a solid form, such as a tablet or capsule, or as a solution, emulsion, or suspension. To prepare the oral compositions, the compounds of the invention may be formulated to yield a dosage of, e.g., from about 0.1 mg to 1 g daily, or about 1 mg to 50 mg daily, or about 50 to 250 mg daily, or about 250 mg to 1 g daily. Oral tablets may include the active ingredient(s) mixed with

compatible pharmaceutically acceptable excipients such as diluents, disintegrating agents, binding agents, lubricating agents, sweetening agents, flavoring agents, coloring agents and preservative agents. Suitable inert fillers include sodium and calcium carbonate, sodium and calcium phosphate, lactose, starch, sugar, glucose, methyl cellulose, magnesium stearate, mannitol, sorbitol, and the like. Exemplary liquid oral excipients include ethanol, glycerol, water, and the like. Starch, polyvinyl-pyrrolidone (PVP), sodium starch glycolate, microcrystalline cellulose, and alginic acid are exemplary disintegrating agents. Binding agents may include starch and gelatin. The lubricating agent, if present, may be magnesium stearate, stearic acid, or talc. If desired, the tablets may be coated with a material such as glyceryl monostearate or glyceryl distearate to delay absorption in the gastrointestinal tract, or may be coated with an enteric coating.

[0069] Capsules for oral administration include hard and soft gelatin capsules. To prepare hard gelatin capsules, active ingredient(s) may be mixed with a solid, semi-solid, or liquid diluent. Soft gelatin capsules may be prepared by mixing the active ingredient with water, an oil, such as peanut oil or olive oil, liquid paraffin, a mixture of mono and di-glycerides of short chain fatty acids, polyethylene glycol 400, or propylene glycol.

[0070] Liquids for oral administration may be in the form of suspensions, solutions, emulsions, or syrups, or may be lyophilized or presented as a dry product for reconstitution with water or other suitable vehicle before use. Such liquid compositions may optionally contain: pharmaceutically-acceptable excipients such as suspending agents (for example, sorbitol, methyl cellulose, sodium alginate, gelatin, hydroxyethylcellulose, carboxymethylcellulose, aluminum stearate gel and the like); non-aqueous vehicles, e.g., oil (for example, almond oil or fractionated coconut oil), propylene glycol, ethyl alcohol, or water; preservatives (for example, methyl or propyl p-hydroxybenzoate or sorbic acid); wetting agents such as lecithin; and, if desired, flavoring or coloring agents.

[0071] For parenteral use, including intravenous, intramuscular, intraperitoneal, intranasal, or subcutaneous routes, the agents of the invention may be provided in sterile aqueous solutions or suspensions, buffered to an appropriate pH and isotonicity or in parenterally acceptable oil. Suitable aqueous vehicles include Ringer's solution and isotonic sodium chloride. Such forms may be presented in unit-dose form such as ampoules or disposable injection devices, in multidose forms such as vials from which the appropriate dose may be withdrawn, or in a solid form or pre-concentrate that can be used to prepare an injectable formulation. Illustrative infusion doses range from about 1 to 1000 $\mu\text{g/kg/minute}$ of agent admixed with a pharmaceutical carrier over a period ranging from several minutes to several days.

[0072] For nasal, inhaled, or oral administration, the inventive pharmaceutical compositions may be administered using, for example, a spray formulation also containing a suitable carrier. The inventive compositions may be formulated for rectal administration as a suppository.

[0073] For topical applications, the compound of the present invention is preferably formulated as creams or ointments or a similar vehicle suitable for topical administration. For topical

administration, the inventive compound may be mixed with a pharmaceutical carrier at a concentration of about 0.1% to about 10% of drug to vehicle. Another mode of administering the agent of the invention may utilize a patch formulation to effect transdermal delivery.

Drug Combinations

[0074] The compound described herein may be used in pharmaceutical compositions or methods in combination with one or more additional active ingredients in the treatment of the diseases and disorders described herein. Further additional active ingredients include other therapeutics or agents that mitigate adverse effects of therapies for the intended disease targets. Such combinations may serve to increase efficacy, ameliorate other disease symptoms, decrease one or more side effects, or decrease the required dose of the inventive compound. The additional active ingredients may be administered in a separate pharmaceutical composition from the compound of the present invention or may be included with the compound of the present invention in a single pharmaceutical composition. The additional active ingredients may be administered simultaneously with, prior to, or after administration of the compound of the present invention.

[0075] Combination agents include additional active ingredients are those that are known or discovered to be effective in treating the diseases and disorders described herein, including those active against another target associated with the disease. For example, compositions and formulations of the invention, as well as methods of treatment, can further comprise other drugs or pharmaceuticals, e.g., other active agents useful for treating or palliative for the target diseases or related symptoms or conditions.

[0076] Other chemotherapeutic agents suitable for use in combination in the methods described herein include but are not limited to kinase inhibitors, adrenocorticoids and corticosteroids, alkylating agents, peptide and peptidomimetic signal transduction inhibitors, antiandrogens, antiestrogens, androgens, aclamycin and aclamycin derivatives, estrogens, antimetabolites, platinum compounds, amanitins, plant alkaloids, mitomycins, discodermolides, microtubule inhibitors, epothilones, inflammatory and proinflammatory agents, purine analogs, pyrimidine analogs, camptothecins and dolastatins. In some embodiments, chemotherapeutic agents suitable for combination treatments in the methods described herein include but are not limited to one or more of afatinib, alectinib, axitinib, bosutinib, brigatini, cabozantinib, ceritinib, crizotinib, dabrafenib, dasatinib, erlotinib, everolimus, gefitinib, ibrutinib, imatinib, lapatinib, lenvatinib, nilotinib, nintedanib, palbociclib, pazopanib, ponatinib, regorafenib, ruxolitinib, sirolimus, sorafenib, sunitinib, tofacitinib, temsirolimus, trametinib, vandetanib, vemurafenib, methotrexate, busulfan, carboplatin, chlorambucil, cisplatin, tamoxiphen, taxol, paclitaxel, docetaxel, cytosine arabinoside, cyclophosphamide, daunomycin, rhizoxin, prednisone, hydroxyurea, teniposide, vincristine, vinblastine, eribulin, camptothecin, irinotecan, geldanamycin, estramustine and nocodazole. chemotherapeutic agents suitable for combination treatments in the methods described herein include but are not limited to one or more kinase inhibitor selected from the group consisting of afatinib, alectinib, axitinib, bosutinib,

brigatini, cabozantinib, ceritinib, crizotinib, dabrafenib, dasatinib, erlotinib, everolimus, gefitinib, ibrutinib, imatinib, lapatinib, lenvatinib, nilotinib, nintedanib, palbociclib, pazopanib, ponatinib, regorafenib, ruxolitinib, sirolimus, sorafenib, sunitinib, tofacitinib, temsirolimus, trametinib, vandetanib and vemurafenib. In some embodiments, the patient was previously treated with crizotinib. For pain indications, suitable combination agents include anti-inflammatories such as NSAIDs. The pharmaceutical compositions of the invention may additionally comprise one or more of such active agents, and methods of treatment may additionally comprise administering an effective amount of one or more of such active agents.

Diagnostic Tests

[0077] In some embodiments, the present disclosure provides methods for treating cancer in a patient previously identified as having a genetically altered tyrosine or serine/threonine kinase, such as a gene fusion. In some embodiments, the present disclosure provides methods for treating disease in a patient comprising (i) identifying a genetically altered tyrosine or serine/threonine kinase in the patient, and (ii) administering to the patient a therapeutically effective amount of a compound useful in the treatment of such disease.

[0078] It will be appreciated that the diagnosing or identifying a patient as having a genetically altered tyrosine or serine/threonine kinase can be accomplished by any number of diagnostic tests known to one of skill in the art. For example, such diagnostic tests include, but are not limited to, fluorescence *in situ* hybridization (FISH), polymerase chain reaction (PCR), immunohistochemistry (IHC), whole genome sequencing, next generation sequencing, and the like. It will also be appreciated that any of the methods known in the art and applicable to diagnosing a patient or identifying a patient in connection with the present disclosure involve the transformation of a biological sample from one state of matter to another by direct modification, synthesis or by direct non-covalent connection to provide a modified sample that can be used to determine whether the subject has or does not have a genetically altered tyrosine or serine/threonine kinase. In some embodiments, "diagnosing" or "identifying" with respect to the disease state of a patient means applying a diagnostic test, such as FISH, PCR or IHC, to a biological sample obtained from the patient.

[0079] It will be appreciated that FISH is a test that "maps" the genetic material in a person's cells. This test can be used to visualize specific genes or portions of genes. FISH is a cytogenetic technique that uses fluorescent probes that bind to only those parts of the chromosome with a high degree of sequence complementarity. Such FISH tests can be used to identify a patient with a genetically altered tyrosine or serine/threonine kinase by any method known in the art, and such test can be used in combination with the methods described herein as either a means of prior identification of a patient for treatment, or the concomitant identification of a patient for treatment.

[0080] It will be appreciated that IHC refers to the process of detecting antigens (e.g., proteins) in cells of a tissue section by exploiting the principle of antibodies binding specifically to

antigens in biological tissues. Immunohistochemical staining is widely used in the diagnosis of abnormal cells such as those found in cancerous tumors. Specific molecular markers are characteristic of particular cellular events such as proliferation or cell death (apoptosis). Visualising an antibody-antigen interaction can be accomplished in a number of ways. In the most common instance, an antibody is conjugated to an enzyme, such as peroxidase, that can catalyse a colour-producing reaction. Alternatively, the antibody can also be tagged to a fluorophore, such as fluorescein or rhodamine. Such IHC tests can be used to identify a patient with a genetically altered tyrosine or serine/threonine kinase by any method known in the art, and such test can be used in combination with the methods described herein as either a means of prior identification of a patient for treatment, or the concomitant identification of a patient for treatment.

[0081] It will be appreciated that PCR refers to a technology in molecular biology used to amplify a single copy or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence. Such PCR tests can be used to identify a patient with a genetically altered tyrosine or serine/threonine kinase by any method known in the art, and such test can be used in combination with the methods described herein as either a means of prior identification of a patient for treatment, or the concomitant identification of a patient for treatment.

[0082] It will be appreciated that whole genome sequencing or next-generation sequencing refers to a process that determines the complete DNA sequence of an organism's genome at a single time. This entails sequencing all of an organism's chromosomal DNA as well as DNA contained in the mitochondria. Such whole genome sequencing tests can be used to identify a patient with a genetically altered tyrosine or serine/threonine kinase by any method known in the art, and such test can be used in combination with the methods described herein as either a means of prior identification of a patient for treatment, or the concomitant identification of a patient for treatment.

EXAMPLES

[0083] The examples and preparations provided below further illustrate and exemplify particular aspects of embodiments of the disclosure. It is to be understood that the scope of the present disclosure is not limited in any way by the scope of the following examples.

[0084] Examples 8, 10, 12-13, 15 and 18-19 are for illustrative purpose only.

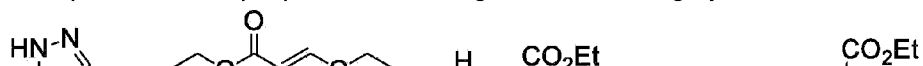
Abbreviations

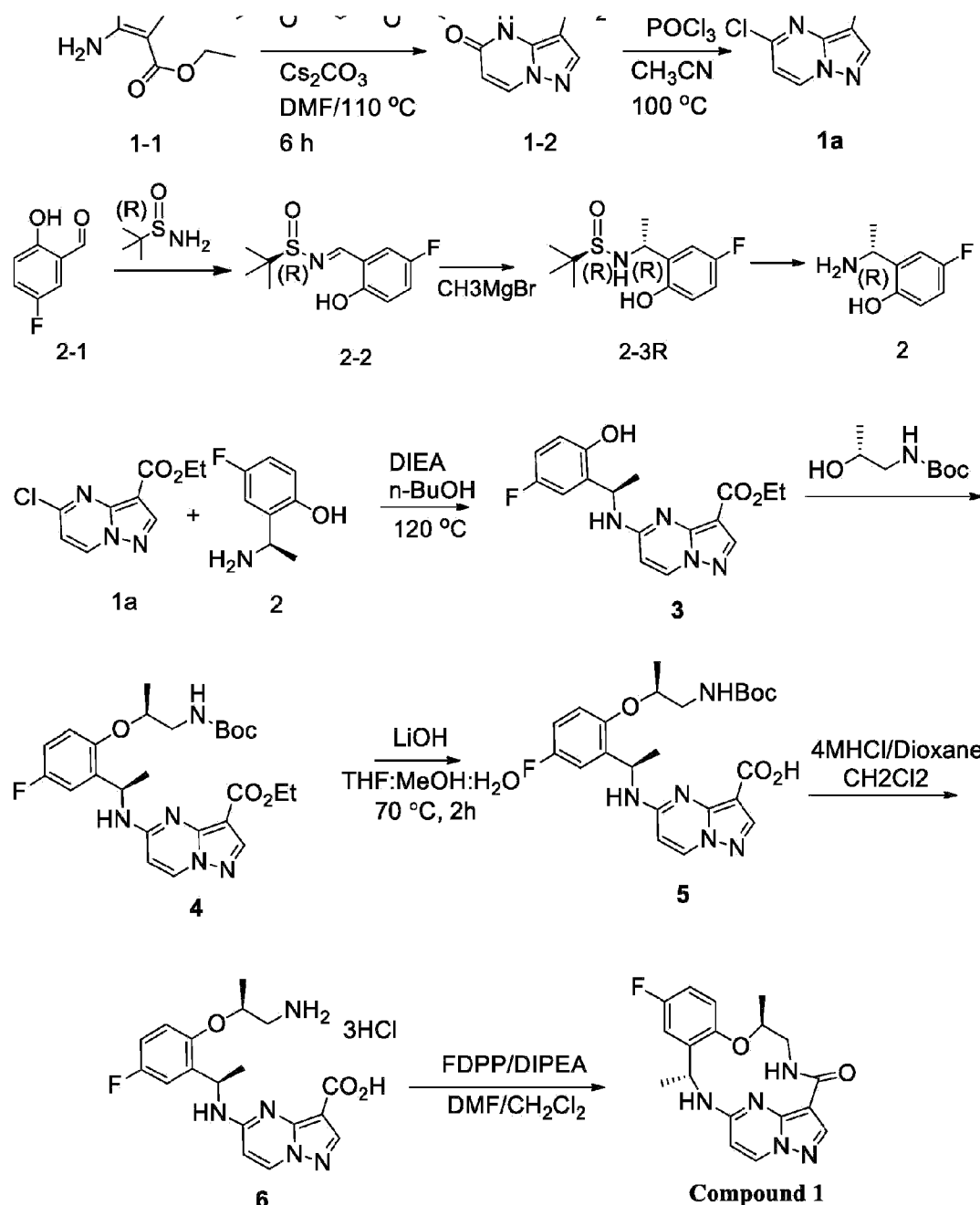
[0085] The examples described herein use materials, including but not limited to, those described by the following abbreviations known to those skilled in the art:

g	grams
eq	equivalents
mmol	millimoles
mol	moles
mL	milliliters
L	liters
EtOAc or EA	ethyl acetate
MeCN	acetonitrile
DCM	dichloromethane
DEAD	diethyl azodicarboxylate
MHz	megahertz
δ	chemical shift
THF	tetrahydrofuran
PE	petroleum ether
R _f	retardation factor
DMSO- <i>d</i> ₆	deuterated dimethyl sulfoxide
CDCl ₃	deuterated chloroform
n-BuOH	n-butanol
DIEA	n,n-diisopropylethylamine
TMSCl	trimethylsilyl chloride
min	minutes
hrs, hr or h	hours
TLC	thin layer chromatography
M	molar
MS	mass spectrum
<i>m/z</i>	mass-to-charge ratio
FDPP	pentafluorophenyl diphenylphosphinate
DMAP	4-(dimethylamino)pyridine
DMF	N,N-dimethylformamide

Synthesis of Compound 1

[0086] Compound 1 was prepared according to the following synthetic scheme:





Example 1: Preparation of 5-chloropyrazolo[1,5-a]pyrimidine-3-carboxylate (1a).

Step 1: Preparation of ethyl 5-oxo-4H-pyrazolo[1,5-a]pyrimidine-3-carboxylate (1-2)

[0087] To a mixture of ethyl 5-amino-1H-pyrazole-4-carboxylate (Sigma-Aldrich, 150.00 g, 1.08 mmol) and ethyl (*E*)-3-ethoxyprop-2-enoate (Sigma-Aldrich, 292.16 g, 2.03 mol) in DMF (3.2 L) was added Cs₂CO₃ (656.77 g, 2.02 mol) in one portion at 20 °C under N₂. The mixture was stirred at 110 °C for 6 h. TLC (PE: EtOAc=1: 1) showed the reaction was completed. The

mixture was cooled to 20 °C and filtered through a celite pad. The filter cake was washed with ethyl acetate (3X30 mL). The filtrate was added to H₂O (2 L) and acidified with HOAc to pH=4. The resultant precipitate was filtered to afford **1-2** (173.00 g, 834.98 mmol, 86.36% yield) as a white solid: ¹H NMR (400 MHz, DMSO-d₆) δ 8.54 (d, *J*=7.91 Hz, 1H), 8.12 (s, 1H), 6.13 (d, *J*=7.91 Hz, 1H), 4.27 (q, *J*=7.11 Hz, 2H), 1.28 (t, *J*=7.09 Hz, 3H).

Step 2: Preparation of 5-chloropyrazolo[1,5-a]pyrimidine-3-carboxylate (1)

[0088] To a mixture of **1-2** (158.00 g, 762.59 mmol) in MeCN (1.6 L) was added POCl₃ (584.64 g, 3.81 mol) at 20 °C under N₂. The mixture was stirred at 100 °C for 2 h. TLC (PE: EA=1: 1) showed the reaction was completed. The mixture was cooled to 20 °C and poured into ice-water (5000 mL) in portions at 0 °C and stirred for 20 min. The precipitate was filtered and dried to afford **1a** (110.00 g, 487.52 mmol, 63.93% yield) as a white solid: ¹H NMR (400 MHz, DMSO-d₆) δ 9.33 (d, *J*=7.28 Hz, 1H), 8.66 (s, 1H), 7.41 (d, *J*=7.15 Hz, 1H), 4.31 (q, *J*=7.15 Hz, 2H), 1.32 (t, *J*=7.09 Hz, 3H).

Example 2: Preparation of (*R*)-2-(1-aminoethyl)-4-fluorophenol (2).

Step 1: Preparation of (*R*)-*N*-(5-fluoro-2-hydroxybenzylidene)-2-methylpropane-2-sulfinamide (2-2)

[0089] To a solution of (*R*)-2-methylpropane-2-sulfinamide (Sigma-Aldrich, 150.00 g, 1.24 mol, 1.00 eq.) and 5-fluoro-2-hydroxybenzaldehyde (**2-1**) (Sigma-Aldrich, 173.74 g, 1.24 mol, 1.00 eq.) in DCM (2.00 L) was added Cs₂CO₃ (646.43 g, 1.98 mol, 1.60 eq.). The mixture was stirred at 16 °C for 16 hours. TLC (PE:EtOAc=5:1) showed the reaction was completed. The reaction mixture was quenched by addition of H₂O (1000 mL) at 0 °C and then extracted with EtOAc (500 mLx4). The combined organic layers were washed with brine (1000 mL) and dried over Na₂SO₄, filtered and concentrated under reduced pressure to give **2-2** (230.00 g, 945.33 mmol, 76.24% yield). ¹H NMR (CDCl₃, 400MHz) δ 8.64 (s, 1H), 7.22 - 7.11 (m, 2H), 7.03 - 6.95 (m, 1H), 1.28 (s, 9H).

Step 2: Preparation of (*R*)-*N*-((*R*)-1-(5-fluoro-2-hydroxyphenyl)ethyl)-2-methylpropane-2-sulfinamide (2-3R)

[0090] To a solution of (*R*)-*N*-(5-fluoro-2-hydroxybenzylidene)-2-methylpropane-2-sulfinamide (**2-2**) (200.00 g, 822.03 mmol, 1.00 eq.) in THF (2.5 L) was added MeMgBr (490.09 g, 4.11 mol, 5.00 eq.) drop-wise at -65 °C under N₂ over a period of 30 min. The mixture was then

warmed to ambient temperature and stirred for 18 hours. TLC (PE:EtOAc=1:1) showed the reaction was complete with the production of two diastereomers. The reaction mixture was quenched by addition of H₂O (2 L) at 0 °C, the mixture was extracted with EtOAc (500 mLx3). The combined organic layers were washed with brine (500 mL), dried over Na₂SO₄, filtered and concentrated under reduced pressure to give a residue. The residue was purified by column chromatography (SiO₂, Petroleum ether/Ethyl acetate=50/1 to 1:1) to give (*R*)-*N*-((*R*)-1-(5-fluoro-2-hydroxyphenyl)ethyl)-2-methylpropane-2-sulfinamide (**2-3R**) (125 g, the top, less polar spot with R_f: 0.5, PE: EA=1:1). ¹HNMR (CDCl₃, 400MHz) δ: 9.17 (s, 1H), 6.68 (dd, *J*=3.0, 8.8 Hz, 1H), 6.47 (dt, *J*=3.0, 8.4 Hz, 1H), 6.31 (dd, *J*=4.8, 8.8 Hz, 1H), 5.11 (d, *J*=8.0 Hz, 1H), 4.28 (quin, *J*=7.2 Hz, 1H), 1.43 (d, *J*=6.8 Hz, 3H), 1.20 (s, 9H).

Step 3: Preparation of (*R*)-2-(1-aminoethyl)-4-fluorophenol (**2**)

[0091] A solution of (*R*)-*N*-((*R*)-1-(5-fluoro-2-hydroxyphenyl)ethyl)-2-methylpropane-2-sulfinamide (**2-3R**) (125 g, 481.99 mmol, 1.00 eq.) in HCl/dioxane (1.5 L, 4N) was stirred at ambient temperature for 2 hours. TLC (PE:EtOAc=2:1) showed the reaction was complete. The mixture was filtered to give (*R*)-2-(1-aminoethyl)-4-fluorophenol (**2**) HCl salt (85 g, 443.56 mmol, 90.03% yield) as a white solid. ¹HNMR (*d*-DMSO, 400 MHz) δ 10.24 (s, 1H), 8.48 (br. s., 3H), 7.31 (dd, *J*=2.9, 9.7 Hz, 1H), 7.05 - 6.99 (m, 1H), 6.98 - 6.93 (m, 1H), 4.59 - 4.45 (m, 1H), 1.46 (d, *J*=6.8 Hz, 3H).

Example 3: Preparation of (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one (Compound 1).

Step 1: Preparation of ethyl (*R*)-5-((1-(5-fluoro-2-hydroxyphenyl)ethyl)amino)pyrazolo[1,5-*a*]pyrimidine-3-carboxylate (**3**)

[0092] To a solution of (*R*)-2-(1-aminoethyl)-4-fluorophenol (**2**) (85 g, 443.56 mmol, 1.00 eq.) and ethyl 5-chloropyrazolo[1,5-*a*]pyrimidine-3-carboxylate (**1a**) (100.08 g, 443.56 mmol, 1.00 eq.) in *n*-BuOH (2 L) was added DIEA (343.96 g, 2.66 mol, 6.00 eq.). The mixture was stirred at 120 °C for 2 hrs. TLC (PE:EtOAc=1:1) showed the reaction was completed. The reaction mixture was diluted with H₂O (500 mL) at 16 °C, and extracted with EtOAc (500 mLx3). The combined organic layers were washed with brine (500 mL), dried over Na₂SO₄, filtered and concentrated under reduced pressure to give a residue. The residue was purified by column chromatography (SiO₂, Petroleum ether/Ethyl acetate=10/1 to 1:3) to give ethyl (*R*)-5-((1-(5-fluoro-2-hydroxyphenyl)ethyl)amino)pyrazolo[1,5-*a*]pyrimidine-3-carboxylate (**3**) (122 g, 349.34 mmol, 78.76% yield, ee>99% purity) as a white solid. ¹HNMR (CDCl₃, 400MHz) δ 9.28 (br. s., 1H), 8.26 (s, 1H), 8.14 (d, *J*=7.5 Hz, 1H), 6.95 - 6.89 (m, 2H), 6.87 - 6.80 (m, 1H), 6.18 (d,

$J=7.5$ Hz, 1H), 5.98 (d, $J=8.3$ Hz, 1H), 5.71 - 5.54 (m, 1H), 4.50 - 4.35 (m, 2H), 1.60 (d, $J=6.8$ Hz, 3H), 1.42 (t, $J=7.2$ Hz, 3H).

Step 2: Preparation of ethyl 5-(((*R*)-1-(2-(((*S*)-1-((tert-butoxycarbonyl)amino)propan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylate (4)

[0093] A mixture of ethyl (*R*)-5-((1-(5-fluoro-2-hydroxyphenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylate (**3**) (10.00 g, 29.04 mmol) and tert-butyl (*R*)-(2-hydroxypropyl)carbamate (Combi-Blocks, 7.63 g, 43.56 mmol) was azeotrope dried from DCM/toluene, and then re-dissolved in DCM (11.62 mL). To the solution was added PPh_3 (11.43 g, 43.56 mmol), and the mixture was stirred until the starting materials were completely dissolved. To the solution was added DEAD (8.81 g, 43.56 mmol) over 5 min with mixing. The reaction was stirred for 3 hours. The reaction mixture was diluted with DCM (125 mL), followed by addition of aqueous NaOH solution (2M, 100 mL). The mixture was stirred vigorously for 12 hours and the layers were separated. The aqueous layer was further extracted with DCM (3 x 50 mL). The combined extracts were washed with brine (50 mL), dried with Na_2SO_4 , and concentrated under reduced pressure. The residue was purified with flash chromatography (Teledyne ISCO system, silica (330 g), 0-40% ethyl acetate in hexane to provide ethyl 5-(((*R*)-1-(2-(((*S*)-1-((tert-butoxycarbonyl)amino)propan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylate (**4**) (8.88 g, 60.9% yield). LC-MS m/z 502.2 ($\text{M}+\text{H}$)⁺. ^1H NMR (400MHz, CHLOROFORM-d) δ 8.24 (s, 1H), 8.21 (d, $J=7.6$ Hz, 1H), 7.04 (d, $J=8.4$ Hz, 1H), 6.87 (d, $J=6.0$ Hz, 2H), 6.13 (d, $J=7.2$ Hz, 1H), 5.91 (br. s., 1H), 4.58 (d, $J=3.6$ Hz, 1H), 4.43 - 4.28 (m, 2H), 3.52 - 3.34 (m, 2H), 1.54 (d, $J=6.8$ Hz, 3H), 1.47 - 1.36 (m, 12H), 1.30 (d, $J=6.4$ Hz, 3H).

Step 3: Preparation of 5-(((*R*)-1-(2-(((*S*)-1-((tert-butoxycarbonyl)amino)propan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylic acid (5)

[0094] To a solution of ethyl 5-(((*R*)-1-(2-(((*S*)-1-((tert-butoxycarbonyl)amino)propan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylate (**4**) (6.98 g, 13.92 mmol, 1 eq.) in methanol (65 mL) and THF (20 mL) was added LiOH (2M, 47.9 mL, 95.8 mmol). The mixture was heated at 70 °C for 3 hrs, cooled to ambient temperature, and then quenched with aq. HCl (2M, 95.8 mL) to adjust pH<5. The reaction mixture was extracted with CH_2Cl_2 (3X50 mL), and dried over Na_2SO_4 . After filtration, evaporation, and high vacuum dry, a white solid of 5-(((*R*)-1-(2-(((*S*)-1-((tert-butoxycarbonyl)amino)propan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylic acid (**5**) was obtained which was used in the next step without further purification. LC-MS m/z 474.2 ($\text{M}+\text{H}$)⁺.

Step 4: Preparation of 5-(((*R*)-1-(2-(((*S*)-1-aminopropan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-a]pyrimidine-3-carboxylic acid (6)

[0095] To a solution of 5-(((*R*)-1-(2-(((*S*)-1-((tert-butoxycarbonyl)amino)propan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-*a*]pyrimidine-3-carboxylic acid (**5**) (6.59 g, 13.92 mmol) in CH₂Cl₂ (130 mL) was added HCl in dioxane (4 M, 30.4 mL). Keep stirring at room temperature for 2 hours until the reaction was shown to be completed by LC-MS. The reaction mixture was concentrated, and high vacuum dried to provide compound **6** as a white solid which was used in the next step without further purification. LC-MS *m/z* 374.2 (M+H)⁺.

Step 5: Preparation of (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one (Compound 1).

[0096] 5-(((*R*)-1-(2-(((*S*)-1-aminopropan-2-yl)oxy)-5-fluorophenyl)ethyl)amino)pyrazolo[1,5-*a*]pyrimidine-3-carboxylic acid (**6**) (5.20 g, 13.93 mmol) was dissolved in DMF (75 mL) to make Solution A. To a solution of Hunig's base (DIPEA) (14.40 g, 111.4 mmol) in DMF (150 mL) and DCM (350 mL) was added solution A (25 mL) and one third of the total FDPP (5.62 g, 14.63 mmol) sequentially. The reaction was stirred for 1 hour, and LC-MS showed the completion of the coupling reaction. The same process was repeated for 2 more times. The final solution was stirred at ambient temperature for 63 hour (or until the reaction was shown to be completed by LC-MS). The reaction was quenched by addition of aqueous Na₂CO₃ solution (2M, 150 mL), and the mixture was stirred for 15 min, and extracted with DCM (3 x 150 mL). The combined extracts were dried with Na₂SO₄, concentrated under reduced pressure, and purified on a flash chromatography (Teledyne ISCO system, silica (220 g), 0-7.5% methanol in dichloromethane) to provide (7*S*,13*R*)-11-fluoro-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-one (**Compound 1**) (4.38 g, 12.33 mmol, 88.5% yield) as a white solid. LC-MS: *m/z* [M+H]⁺ 356.2. ¹H NMR (500 MHz, DMSO-*d*₆) δ ppm 9.82 (dd, *J*=8.02, 2.29 Hz, 1 H), 8.81 (d, *J*=6.87 Hz, 1 H), 8.58 (d, *J*=7.45 Hz, 1 H), 8.04 (s, 1 H), 7.12 (dd, *J*=9.45, 3.15 Hz, 1 H), 6.99 - 7.05 (m, 1 H), 6.94 - 6.99 (m, 1 H), 6.36 (d, *J*=7.45 Hz, 1 H), 5.53 (m, 1 H), 4.45 - 4.52 (m, 1 H), 3.90 (ddd, *J*=13.46, 8.31, 4.01 Hz, 1 H), 3.10 - 3.17 (m, 1 H), 1.46 (d, *J*=6.30 Hz, 3 H), 1.44 (d, *J*=7.45 Hz, 3 H).

In-Vitro Assays

Materials and Methods

Kinase Binding Assay Method

[0097] Kinase binding assays were performed at DiscoverX using the general KINOMEScan *K_d*

Protocol (Fabian, M. A. et al., "A small molecule-kinase interaction map for clinical kinase inhibitors," Nat. Biotechnol. 2005, 23(3):329-36). For most assays, kinase-tagged T7 phage strains were prepared in an *E. coli* host derived from the BL21 strain. *E. coli* were grown to log-phase and infected with T7 phage and incubated with shaking at 32°C until lysis. The lysates were centrifuged and filtered to remove cell debris. The remaining kinases were produced in HEK-293 cells and subsequently tagged with DNA for qPCR detection. Streptavidin-coated magnetic beads were treated with biotinylated small molecule ligands for 30 minutes at room temperature to generate affinity resins for kinase assays. The liganded beads were blocked with excess biotin and washed with blocking buffer (SeaBlock (Pierce), 1% BSA, 0.05% Tween 20, 1 mM DTT) to remove unbound ligand and to reduce nonspecific binding. Binding reactions were assembled by combining kinases, liganded affinity beads, and test compounds in 1x binding buffer (20% SeaBlock, 0.17x PBS, 0.05% Tween 20, 6 mM DTT). All reactions were performed in polystyrene 96-well plates in a final volume of 0.135 mL. The assay plates were incubated at room temperature with shaking for 1 hour and the affinity beads were washed with wash buffer (1x PBS, 0.05% Tween 20). The beads were then re-suspended in elution buffer (1x PBS, 0.05% Tween 20, 0.5 µM non-biotinylated affinity ligand) and incubated at room temperature with shaking for 30 minutes. The kinase concentration in the eluates was measured by qPCR.

[0098] Binding constants (K_d s) were calculated with a standard dose-response curve using the Hill equation: $\text{Response} = \text{Background} + (\text{Signal} - \text{Background}) / (1 + (K_d^{\text{Hill Slope}} / \text{Dose}^{\text{Hill Slope}}))$. The Hill Slope was set to -1. Curves were fitted using a non-linear least square fit with the Levenberg-Marquardt algorithm.

Biochemical Kinase Assay Method

[0099] The biochemical kinase assay was performed at Reaction Biology Corporation (www.reactionbiology.com, Malvern, PA) following the procedures described in the reference (Anastassiadis T, et al Nat Biotechnol. 2011, 29, 1039). Specific kinase / substrate pairs along with required cofactors were prepared in reaction buffer; 20 mM Hepes pH 7.5, 10 mM MgCl₂, 1 mM EGTA, 0.02% Brij35, 0.02 mg/ml BSA, 0.1 mM Na₃VO₄, 2 mM DTT, 1% DMSO (for specific details of individual kinase reaction components see Supplementary Table 2). Compounds were delivered into the reaction, followed ~ 20 minutes later by addition of a mixture of ATP (Sigma, St. Louis MO) and ³³P ATP (Perkin Elmer, Waltham MA) to a final concentration of 10 µM. Reactions were carried out at room temperature for 120 min, followed by spotting of the reactions onto P81 ion exchange filter paper (Whatman Inc., Piscataway, NJ). Unbound phosphate was removed by extensive washing of filters in 0.75% phosphoric acid. After subtraction of background derived from control reactions containing inactive enzyme, kinase activity data was expressed as the percent remaining kinase activity in test samples compared to vehicle (dimethyl sulfoxide) reactions. IC₅₀ values and curve fits were obtained using Prism (GraphPad Software).

Cell lines and cell culture:

[0100] Human lung cancer cell line NCI-H2228 was obtained from ATCC. Cell lines 293T, NIH3T3, Ba/F3, and HCC78 were purchased from DSMZ. Karpas-299 cell line was purchased from Sigma. KM12 cell line was obtained from NCI.

[0101] NIH3T3 was maintained in DMEM medium supplemented with 10% fetal bovine serum and 100 U/mL of penicillin/streptomycin. HCC78, Karpas-299 and H2228 were maintained in RPMI-1640 supplemented with 10% fetal bovine serum with 100 U/mL of penicillin/streptomycin. Ba/F3 cells were maintained in RPMI-1640 supplemented with 10% fetal bovine serum, 10% (Vol/Vol) conditioned media from the WHI-3B myelomonocytic IL-3 secreting cells and 100 U/mL of penicillin/streptomycin. BaF3 stable cell lines were maintained in RPMI-1640 supplemented with 10% fetal bovine serum, 100 U/mL of penicillin, and 0.5 µg/mL puromycin solution.

Cloning and Ba/F3 or NIH3T3 stable cell line creation

[0102] The EML4-ALK gene (variant 1) was synthesized at GenScript and cloned into pCDH-CMV-MCS-EF1-Puro plasmid (System Biosciences, Inc). EML4-ALK point mutations G1202R, L1196M, L1152P, F1174C, C1156Y, 11171N, G1269S, and 1151T insertion were generated at GenScript by PCR and confirmed by sequencing. Ba/F3-EML4-ALK wild type and mutants were generated by transducing Ba/F3 cells with lentivirus containing EML4-ALK wide type or mutants. Stable cell lines were selected by puromycin treatment, followed by IL-3 withdrawal. Briefly, 5×10^6 Ba/F3 cells were transduced with lentivirus supernatant in the presence of 8 µg/mL protamine sulfate. The transduced cells were subsequently selected with 1 µg/mL puromycin in the presence of IL3-containing medium RPMI1640, plus 10% FBS. After 10-12 days of selection, the surviving cells were further selected for IL3 independent growth.

[0103] SDC4-ROS1 wild type, CD74-ROS1 wild type, and their G2032R mutant genes were synthesized at GenScript and cloned into pCDH-CMV-MCS-EF1-Puro plasmid (System Biosciences, Inc), and confirmed by sequencing. Ba/F3 SDC4-ROS1, CD74-ROS1 and corresponding G2032R mutants were generated by transducing Ba/F3 cells with lentivirus containing the fusion genes. Stable cell lines were selected by puromycin treatment, followed by IL-3 withdrawal. Briefly, 5×10^6 Ba/F3 cells were transduced with lentivirus supernatant in the presence of 8 µg/mL protamine sulfate. The transduced cells were subsequently selected with 1 µg/mL puromycin in the presense of IL3-containing medium RPMI1640, plus 10% FBS. After 10-12 days of selection, the surviving cells were further selected for IL3 independent growth.

[0104] Ba/F3 TPR-ALK and Ba/F3 TPR-ALK L1196M cell lines were created at Advanced Cellular Dynamics, Inc. and cell proliferation assays were performed there. The ACD panel itself is comprised of 92 unique kinases individually expressed in a common lymphoid cell line

(mouse Ba/F3 cells). Each cell line is dependent upon activity of the recombinant kinase for survival.

[0105] SDC4-ROS1 L2026M and D2033N mutant genes were synthesized at GenScript and cloned into pCDH-CMV-MCS-EF1-Puro plasmid (System Biosciences, Inc), and confirmed by sequencing. Ba/F3 CD74-ROS1 L2026M and D2033N mutants were generated by transducing Ba/F3 cells with lentivirus containing the fusion genes. Stable cell lines were selected by puromycin treatment, followed by IL-3 withdrawal. Briefly, 5×10^6 Ba/F3 cells were transduced with lentivirus supernatant in the presence of $8 \mu\text{g/mL}$ protamine sulfate. The transduced cells were subsequently selected with $1 \mu\text{g/mL}$ puromycin in the presense of IL3-containing medium RPMI1640, plus 10% FBS. After 10-12 days of selection, the surviving cells were further selected for IL3 independent growth.

[0106] LMNA-TRKA wild type, and its G595R mutant genes were synthesized at GenScript and cloned into pCDH-CMV-MCS-EF1-Puro plasmid (System Biosciences, Inc), and confirmed by sequencing. Ba/F3 LMNA-TRKA and corresponding G595R mutant were generated by transducing Ba/F3 cells with lentivirus containing the fusion genes. Stable cell lines were selected by puromycin treatment, followed by IL-3 withdrawal. Briefly, 5×10^6 Ba/F3 cells were transduced with lentivirus supernatant in the presence of $8 \mu\text{g/mL}$ protamine sulfate. The transduced cells were subsequently selected with $1 \mu\text{g/mL}$ puromycin in the presense of IL3-containing medium RPMI1640, plus 10% FBS. After 10-12 days of selection, the surviving cells were further selected for IL3 independent growth.

[0107] TEL-TRKB (also named as ETV6-TRKB) wild type and its G639R mutant genes were synthesized at GenScript and cloned into pCDH-CMV-MCS-EF1-Puro plasmid (System Biosciences, Inc), and confirmed by sequencing. Ba/F3 TEL-TRKB and corresponding G639R mutants were generated by transducing Ba/F3 cells with lentivirus containing the fusion genes. Stable cell lines were selected by puromycin treatment, followed by IL-3 withdrawal. Briefly, 5×10^6 Ba/F3 cells were transduced with lentivirus supernatant in the presence of $8 \mu\text{g/mL}$ protamine sulfate. The transduced cells were subsequently selected with $1 \mu\text{g/mL}$ puromycin in the presense of IL3-containing medium RPMI1640, plus 10% FBS. After 10-12 days of selection, the surviving cells were further selected for IL3 independent growth.

[0108] TEL-TRKC (also named as ETV6-TRKC) wild type and its G623R mutant genes were synthesized at GenScript and cloned into pCDH-CMV-MCS-EF1-Puro plasmid (System Biosciences, Inc), and confirmed by sequencing. Ba/F3 TEL-TRKC and corresponding G623R mutant were generated by transducing Ba/F3 cells with lentivirus containing the fusion genes. Stable cell lines were selected by puromycin treatment, followed by IL-3 withdrawal. Briefly, 5×10^6 Ba/F3 cells were transduced with lentivirus supernatant in the presence of $8 \mu\text{g/mL}$ protamine sulfate. The transduced cells were subsequently selected with $1 \mu\text{g/mL}$ puromycin in the presense of IL3-containing medium RPMI1640, plus 10% FBS. After 10-12 days of selection, the surviving cells were further selected for IL3 independent growth.

[0109] NIH3T3 ALK or ROS1 stable cell lines were generated by transducing the cells with lentivirus containing EML4-ALK wild type and G1202R mutant genes, SDC4-ROS1 wild type, CD74-ROS1 wild type and their G2032R mutant genes. The transduced cells were subsequently selected with 1 µg/mL puromycin.

[0110] NIH3T3 ROS1, or TRKA, or TRKB, or TRKC stable cell lines were generated by transducing the cells with lentivirus containing CD74-ROS1 L2026M and D2033N mutant genes, LMNA-TRKA wild type and G595R mutant genes, TEL-TRKB wild type and G639R mutant genes, TEL-TRKB wild type and G623R mutant genes, respectively. The transduced cells were subsequently selected with 1 µg/mL puromycin.

Cell proliferation assays:

[0111] Two thousand cells per well were seeded in 384 well white plate for 24 hrs, and then treated with compounds for 72 hours (37 °C, 5% CO₂). Cell proliferation was measured using CellTiter-Glo luciferase-based ATP detection assay (Promega) following the manufacturer's protocol. IC₅₀ determinations were performed using GraphPad Prism software (GraphPad, Inc., San Diego, CA).

[0112] The cell proliferation assay of Ba/F3 TPR-ALK and Ba/F3 TPR-ALK L1196M cell lines were performed at Advanced Cellular Dynamics, Inc. The inhibition of kinase activity leads to cell death, which is monitored via ATP concentration using CellTiter-Glo (Promega). Cell lines were maintained in RPMI-1640 culture media containing 10% fetal calf serum and antibiotics. Cells in logarithmic-phase growth were harvested and 5,000 cells were distributed into each well of a 384-well plate in 50 µL of growth media. Parental cells (only) were seeded in the presence of 10 ng/mL IL3 to support cell growth and survival. Fifty nanoliters diluted compound were added to appropriate wells, in duplicate, and the cells were cultured for 48 hours at 37C in a humidified 5% CO₂ atmosphere. Viability was determined by adding 15 µL CellTiter-Glo and measuring luminescence, which is reported as relative light units (RLU) measured in counts per second.

Immunoblotting for cellular kinase phosphorylation assays

[0113] NSCLC cell line H2228 (harboring endogenous EML4-ALK fusion gene), HCC78 cells (harboring endogenous SLC34A2-ROS1 fusion gene), Karpas-299 cells (harboring endogenous NPM-ALK fusion gene) or SET-2 (harboring endogenous JAK2V617F activating mutation) were cultured in RPMI medium, and KM12 (harboring endogenous TPM3-TRKA fusion gene) cell line was cultured in DMEM medium, both supplemented with 10% fetal bovine serum and 100 U/mL of penicillin/streptomycin. Ba/F3 and NIH3T3 cells stably expressing ALK or ROS1 (WT or mutant) were culture as mentioned above. Half a million cells per well were seeded in 24 well plate for 24 hrs, and then treated with compounds for 4 hours. Cells were

collected after treatment and lysed in RIPA buffer (50 mM Tris, pH 7.4, 150 mM NaCl, 1% NP-40, 0.5% Deoxycholate, 0.1% SDS) supplemented with 10 mM EDTA, 1X Halt protease and phosphatase inhibitors (Thermo Scientific). Protein lysates (approximately 20 µg) was resolved on 4-12% Bolt Bis-Tris precasted gels with MES running buffer (Life Technologies), transferred to nitrocellulose membranes using Trans-Blot Turbo Transfer System (Bio-Rad) and detected with antibodies targeting phosphorylated ALK Y1604 (Cell Signaling Technology), total ALK (Cell Signaling Technology), phosphorylated ROS1 and total ROS1 (Cell Signaling Technology), phosphorylated TRK A/B (Cell Signaling Technology), total TRKA antibody (Santa Cruz Biotechnology), phosphorylated STAT3 and STAT3, total STAT3 and STAT3 (Cell Signaling Technology), phosphorylated AKT (Cell Signaling Technology), total AKT (Cell Signaling Technology), phosphorylated ERK (Cell Signaling Technology), total ERK (Cell Signaling Technology) and Tubulin (Sigma). Antibodies were typically incubated overnight at 4 °C with gentle shake, followed by washes and incubation with the appropriate HRP-conjugated secondary antibodies. Membranes were incubated with chemiluminescent substrate for 5 min at room temperature (SuperSignal West Femto, Thermo Scientific). The chemiluminescent images were acquired with a C-DiGit Imaging System (LI-COR Biosciences). The relative density of the chemiluminescent bands were quantified via Image Studio Digits from LICOR. The half inhibitory concentration (IC₅₀) value is calculated using non-linear regression analysis through GraphPad Prism software (GraphPad, Inc., San Diego, CA).

[0114] NSCLC cell line H2228 (harboring endogenous EML4-ALK fusion gene) was cultured in RPMI medium supplemented with 10% fetal bovine serum and 100 U/mL of penicillin/streptomycin. Ba/F3 and NIH3T3 cells stably expressing ROS1, or TRKA, or TRKB, or TRKC (WT or mutant) were cultured as mentioned above. Half a million cells per well were seeded in 24 well plate for 24 hrs, and then treated with compounds for 4 hours. Cells were collected after treatment and lysed in RIPA buffer (50 mM Tris, pH 7.4, 150 mM NaCl, 1% NP-40, 0.5% Deoxycholate, 0.1% SDS) supplemented with 10 mM EDTA, 1X Halt protease and phosphatase inhibitors (Thermo Scientific). Protein lysates (approximately 20 µg) was resolved on 4-12% Bolt Bis-Tris precasted gels with MES running buffer (Life Technologies), transferred to nitrocellulose membranes using Trans-Blot Turbo Transfer System (Bio-Rad) and detected with antibodies targeting phosphorylated phosphorylated ROS1 and total ROS1 (Cell Signaling Technology), phosphorylated TRK A/B (Cell Signaling Technology), total TRKA antibody (Santa Cruz Biotechnology), phosphorylated SRC Y416 (Cell Signaling Technology), total SRC (Cell Signaling Technology), phosphorylated FAK Y576/577 (Cell Signaling Technology), total FAK (Cell Signaling Technology), phosphorylated paxillin Y118 (Cell Signaling Technology), total paxillin (Cell Signaling Technology), phosphorylated EGFR and total EGFR, CD44, and Tubulin (Sigma). Antibodies were typically incubated overnight at 4 °C with gentle shake, followed by washes and incubation with the appropriate HRP-conjugated secondary antibodies. Membranes were incubated with chemiluminescent substrate for 5 min at room temperature (SuperSignal West Femto, Thermo Scientific). The chemiluminescent images were acquired with a C-DiGit Imaging System (LI-COR Biosciences). The relative density of the chemiluminescent bands were quantified via Image Studio Digits from LICOR. The half inhibitory concentration (IC₅₀) value is calculated using non-linear regression analysis through GraphPad Prism software (GraphPad, Inc., San Diego, CA).

Apoptosis/caspase activity assays.

[0115] Karpas-299 cells were maintained in RPMI medium supplemented with 10% fetal bovine serum and antibiotics. Five hundred thousand cells per well were seeded in 12-well plate and various concentration of compounds were introduced and incubated for 48 hrs. The cells were then collected and lysed in a lysis buffer (20mM HEPES, 150 mM NaCl, 10 mM KCl, 5 mM EDTA, 1% NP40) supplemented with Halt protease and phosphatase inhibitors (Thermo Scientific). For caspase assays, approximately 20 µg of cell lysate were incubated with 20 µl of caspase-3 glo reagent (Promega), and the enzyme activity was measured by the release of luminescence after 20 min incubation at 37°C. For western blotting, cell lysate were boiled and analyzed by SDS-PAGE/immunoblotting using anti-caspase-3 (Cell Signaling Technology), anti-PARP (Cell Signaling Technology), or anti-actin (Cell Signaling Technology) antibodies. Antibodies were typically incubated overnight at 4 °C with gentle shake, followed by washes and incubation with the appropriate HRP-conjugated secondary antibodies. Membranes were incubated with chemiluminescent substrate for 5 min at room temperature (SuperSignal West Femto, Thermo Scientific), and the chemiluminescent images were obtained with a C-DiGit Imaging System (LI-COR Biosciences).

Scratch Wound Healing Assay

[0116] HT1080 or HCC78 cells in RPMI medium supplemented with 10% fetal bovine serum and antibiotics were seeded in 24-well plate. After 12-24 hours, confluent cell monolayers were gently scraped with a sterile pipette tip to form a scratch. The plates were washed with fresh medium, and the cells were incubated with medium alone or medium containing various concentration of compounds. After 12-24 hours, the plates were examined and recorded by an EVOS FL microscopy (Life Technology) to monitor resealing of the cell monolayer.

In-Vivo Methods**Cell lines**

[0117] Cell lines were cultured using standard techniques in DMEM or RPMI-1640 medium (Corning, Inc) with 10% fetal bovine serum (Thermo Fisher Scientific, Inc) at 37°C in a humidified atmosphere with 5% CO₂. For implantation, cells were harvested and pelleted by centrifugation at 250g for 2 minutes. Cells were washed once and resuspended in serum-free medium, with 50% matrigel (v/v) as needed.

Subcutaneous Xenograft Models in Immune Compromised Mice

[0118] Female athymic nude mice and SCID/Beige mice (5-8 weeks of age) were obtained from Charles River Laboratory and were housed in Innovive IVC disposable cages on HEPA filtered ventilated racks with ad libitum access to rodent chow and water. Five million cells in 100 μ L serum-free medium were implanted subcutaneously in the right flank region of the mouse. Karpas299 cells were implanted into the SCID/Beige mice. KM12 cells, NIH3T3 EML4-ALK wild type mutant cells, and NIH3T3 SCD4-ROS1 wild type mutant cells were implanted into the athymic nude mice, respectively. All models except KM12 were implanted with 50% matrigel (Corning, Inc) in the medium. Tumor size and body weight were measured on designated days. Tumor size was measured with an electronic caliper and tumor volume was calculated as the product of length * width² * 0.5. Mice were randomized by tumor size into treatment groups when tumor volume reached about 100-200 mm³ and Compound 1 were administered orally (BID) at determined dosage.

[0119] Female athymic nude mice and SCID/Beige mice (5-8 weeks of age) were obtained from Charles River Laboratory and were housed in Innovive IVC disposable cages on HEPA filtered ventilated racks with ad libitum access to rodent chow and water. Five million cells in 100 μ L serum-free medium were implanted subcutaneously in the right flank region of the mouse. Ba/F3 EML4-ALK wild type and G1202R mutant cells, Ba/F3 CD74-ROS1 wild type and G2032R mutant cells were implanted into the SCID/Beige mice. NIH3T3 CD74-ROS1 G2032 mutant cells, NIH3T3 LMNA-TRKA wild type and G595R mutant cells were implanted into the athymic nude mice, respectively. All models were implanted with 50% matrigel (Corning, Inc) in the medium. Tumor size and body weight were measured on designated days. Tumor size was measured with an electronic caliper and tumor volume was calculated as the product of length * width² * 0.5. Mice were randomized by tumor size into treatment groups when tumor volume reached about 100-200 mm³ and Compound 1 were administered orally (BID) at determined dosage.

Tumor Processing and immunoblotting for in vivo Pharmacodynamic Studies

[0120] Mice bearing xenograft tumors were humanely euthanized and tumors were resected and snap frozen in liquid nitrogen and stored at -80°C. Frozen tumor samples were processed at 4°C in 1× Cell Lysis Buffer (Cell Signaling Technologies) to extract proteins. SDS loading samples were prepared by adding one volume of 4X LDS Sample Buffer (Life Technologies, Inc) to three volumes of protein lysate. Tumor SDS protein samples were processed by SDS-PAGE and immunoblotted with rabbit anti-phosphorylated ALK and mouse anti-actin antibodies (Cell Signaling Technologies). The signals from immunoblot were detected by C-DiGit Blot Scanner from LI-COR and the signal intensity were quantified using the Image Studio Digit software (LI-COR).

Data and Results:

Example 4a: Kinase binding affinities and enzymatic kinase activities of Compound 1.

[0121] The kinase binding affinity of Compound 1 was screened at DiscoverX in a panel of 460 kinases followed by the determination of the K_d for the hits. Compound 1 demonstrated strong binding affinities with ALK, ROS1, TRKA/B/C, JAK2, SRC, FAK and ARK5 (Table 1). Furthermore, the enzymatic kinase inhibition activities of Compound 1 at 10 μ M ATP concentration were determined at Reaction Biology, and the results of IC_{50} were summarized in Table 1.

Table 1

Target	ALK	ROS1	TRKA	TRKB	TRKC	JAK2	SRC	FAK	ARK5
K_d (nM)	5.7	0.19	0.019	0.054	0.088	0.082	12.0	27	3.7
IC_{50} (nM)	1.04	0.0706	0.826	0.0517	0.0956	1.04	5.29	6.96	4.46

Example 4b: Enzymatic kinase activities of Compound 1.

[0122] The kinase binding affinity of Compound 1 was screened at DiscoverX in a panel of 460 kinases. The kinase hits of compound 1 were further confirmed in the recombinant enzymatic kinase inhibition assay using 10 μ M ATP concentration at Reaction Biology, and the IC_{50} results were summarized in Table 1b.

Table 1b.

Target	IC_{50} (nM) at 10 μ M ATP	Target	IC_{50} (nM) at 10 μ M ATP	Target	IC_{50} (nM) at 10 μ M ATP
TRKB	0.05	SNARK	13.0	JAK3	50
ROS1	0.07	HCK	16.4	EPHA8	50.2
TRKC	0.1	IRR	18.1	IGFR	111
TRKA	0.83	LCK	18.6	PLK4	126
ALK	1.04	JAK1	19	AXL	149
JAK2	1.04	TYK2	21.6	MARK3	512
FYN	1.05	LTK	21.8		
LYN	1.66	DDR2	23		
YES	2.15	BTK	23.7		
FOR	3.05	TNK2	24.1		
TXK	3.17	EPHA1	25.0		

Target	IC ₅₀ (nM) at 10 μ M ATP	Target	IC ₅₀ (nM) at 10 μ M ATP	Target	IC ₅₀ (nM) at 10 μ M ATP
ARK5	4.46	BLK	32.3		
SRC	5.3	GRK7	35.2		
DDR1	5.7	PYK2	39.9		
FAK	6.96	RET	47.1		

Example 5: Assessment of Compound 1 activity against a panel of ALK mutations.

[0123] Compound 1 was evaluated against ALK resistant mutations in enzymatic kinase assays with 10 μ M ATP concentration at Reaction Biology, Inc. The results were summarized in Table 2. Potent inhibition by Compound 1 was observed among wild type and mutant ALKs and ROS1s.

Table 2

	NPM-ALK	ALK Wild	ALK T1151M	ALK 1151Tins	ALK L1152R	ALK C1156Y	ALK F1174L
IC ₅₀ (nM)	1.23	1.04	0.49	2.16	1.23	0.93	1.46
	ALK F1174S	ALK L1196M	ALK G1202R	ALK S1206R	ALK G1269A	ALK G1269S	ALK R1275Q
IC ₅₀ (nM)	1.02	1.08	1.21	0.53	5.5	14.1	2.79
	ROS1 WT	ROS1 G2032R	ROS1-TPM3				
IC ₅₀ (nM)	0.0706	0.456	0.113				

Example 6: Compound 1 potently inhibited cell proliferation in primary cell lines with oncogenic fusion or mutated genes of ALK, ROS1, TRKA or JAK2.

[0124] ALK fusions are major malignancy drivers in multiple cancer types and cancer cell lines, including lymphoma cell line Karpas-299 harboring NPM-ALK fusion gene, non-small cell lung cancer cell line H2228 harboring EML4-ALK fusion gene, non-small cell lung cancer cell line HCC78 harboring SLC34A2-ROS1 fusion gene, colorectal cancer cell line KM12 harboring TPM3-TRKA fusion gene, and leukemia cell line SET-2 harboring JAK2 V617F mutation. The anti-proliferating activities of Compound 1 on these cell lines were evaluated and the results were summarized in Table 3.

Example 7: Evaluation of Compound 1 activity against a panel of ALK gene mutations in engineered Ba/F3 cell lines.

[0125] Furthermore, we used Ba/F3 cells engineered to express wild type EML4-ALK fusion gene and mutant EML4-ALKs. The growth of Ba/F3 cells is dependent on interleukin-3 (IL-3). With ectopic expression of EML4-ALK gene, Ba/F3 cell growth becomes IL-3 independent, and relies on the kinase activity of the oncogenic fusion ALK. Compound 1 potently inhibited the cell proliferation of various Ba/F3 cell lines with engineered expression of wild and mutant EML4-ALKs, and the results were summarized in Table 3.

[0126] The inhibition of cell proliferation of Ba/F3 TPR-ALK and Ba/F3 TPR-ALK L1196M cell lines were performed at Advanced Cellular Dynamics. Compound 1 demonstrated potent inhibition in both cell lines (Table 3).

Example 8: Evaluation of Compound 1 activity against ROS1 in engineered Ba/F3 cell lines.

[0127] Ba/F3 cells were engineered to express the oncogenic SDC4-ROS1, SDC4-ROS1^{G2032R}, CD74-ROS1, and CD74-ROS1^{G2032R} fusion genes, respectively. The engineered Ba/F3 cells with fusion ROS1 genes were used to examine the inhibiting activity of Compound 1 on wild and mutant ROS1 fusion genes. The results of cell growth inhibition were summarized in Table 3.

[0128] Ba/F3 cells were engineered to express the oncogenic CD74-ROS1^{L2026M}, and CD74-ROS1^{D2033N} fusion genes, respectively. The engineered Ba/F3 cells with fusion ROS1 genes were used to examine the inhibiting activity of Compound 1. The results of cell growth inhibition were summarized in Table 3.

[0129] Ba/F3 cells were engineered to express the oncogenic LMNA-TRKA and LMNA-TRKA^{G595R} fusion genes, respectively. The engineered Ba/F3 cells with fusion TRKA genes were used to examine the inhibiting activity of Compound 1. The results of cell growth inhibition were summarized in Table 3.

[0130] Ba/F3 cells were engineered to express the oncogenic TEL-TRKB (also named as ETV6-TRKB) and TEL-TRKB^{G639R} fusion genes, respectively. The engineered Ba/F3 cells with fusion TRKB genes were used to examine the inhibiting activity of Compound 1s. The results of cell growth inhibition were summarized in Table 3.

[0131] Ba/F3 cells were engineered to express the oncogenic TEL-TRKC (also named as

ETV6-TRKC), and TEL-TRKC^{G621R} fusion genes, respectively. The engineered Ba/F3 cells with fusion TRKC genes were used to examine the inhibiting activity of Compound 1. The results of cell growth inhibition were summarized in Table 3.

Table 3

Assays	IC ₅₀ (nM)
Cell proliferation of Karpas-299 cell line	23.7
Cell proliferation of NCI-H2228 cell line	73
Cell proliferation of HCC78 cell line	0.3
Cell proliferation of KM12 cell line	0.3
Cell proliferation of SET-2 cell line	169
Cell proliferation of Ba/F3 EML4-ALK wild type cell line	17.8
Cell proliferation of Ba/F3 EML4-ALK G1202R cell line	20.5
Cell proliferation of Ba/F3 EML4-ALK L1152P cell line	85
Cell proliferation of Ba/F3 EML4-ALK L1196M cell line	50
Cell proliferation of Ba/F3 EML4-ALK F1174C cell line	54
Cell proliferation of Ba/F3 EML4-ALK C1156Y cell line	98
Cell proliferation of Ba/F3 TPR-ALK wild type cell line	12
Cell proliferation of Ba/F3 TPR-ALK L1196M cell line	13.4
Cell proliferation of Ba/F3 CD74-ROS1 wild type cell line	0.2
Cell proliferation of Ba/F3 CD74-ROS1 G2032R cell line	8.4
Cell proliferation of Ba/F3 SDC4-ROS1 wild type cell line	0.2
Cell proliferation of Ba/F3 SDC4-ROS1 G2032R cell line	5
Cell proliferation of Ba/F3 +IL3 parental	1236
Cell proliferation of Ba/F3 CD74-ROS1 L2026M cell line	5
Cell proliferation of Ba/F3 CD74-ROS1 D2033N cell line	0.2
Cell proliferation of Ba/F3 LMNA-TRKA cell line	0.2
Cell proliferation of Ba/F3 LMNA-TRKA G595R cell line	0.4
Cell proliferation of Ba/F3 TEL-TRKB (ETV6-TRKB) cell line	0.2
Cell proliferation of Ba/F3 TEL-TRKB (ETV6-TRKB) G639R cell line	0.6
Cell proliferation of Ba/F3 TEL-TRKC (ETV6-TRKC) cell line	0.2
Cell proliferation of Ba/F3 TEL-TRKC (ETV6-TRKC) G623R cell line	3

Example 9: Mechanism of action of Compound 1 in cells.

[0132] The pharmacodynamic inhibiting activity of Compound 1 on ALK, ROS1, TRKA and

SRC, and the corresponding downstream signaling in cells was evaluated, and the results were summarized in Table 4. Compound 1 caused suppression of ALK autophosphorylation as well as the downstream STAT3 and AKT phosphorylation at IC₅₀s of around 1-3 nM in Karpas-299 cell line, which harbors NPM-ALK fusion gene. Compound 1 inhibited ROS 1 autophosphorylation as well as the downstream STAT3 and AKT phosphorylation at IC₅₀s around 1-3 nM in HCC78 cell line, which harbors SLC34A2-ROS 1 fusion gene. Compound 1 inhibited TRKA autophosphorylation as well as the downstream AKT and ERK phosphorylation at IC₅₀s around 0.3 nM in KM12 cell line, which harbors TPM3-TRKA fusion gene. Compound 1 inhibited STATS phosphorylation at IC₅₀ around 158 nM in SET-2 cell line, which harbors JAK2 V617F mutation. Compound 1 inhibited autophosphorylation of ALK with IC₅₀ of 20-30 nM in Ba/F3 engineered stable cell lines encoding wild type or G1202R mutant EML4-ALK v1 fusion genes. Compound 1 inhibited autophosphorylation of ROS1 in Ba/F3 engineered stable cell lines encoding wild type or G2032R mutant CD74-ROS1 or SDC4-ROS1 fusion genes. The pharmacodynamic inhibiting activity of Compound 1 on TRKA, TRKB, TRKC, and FAK signaling in cells was evaluated, and the results were summarized in Table 4a. Compound 1 inhibited FAK phosphorylation as well as the SRC substrate paxillin phosphorylation at IC₅₀ around 103 nM in NCI-H2228 cell line, which harbors EML4-ALK fusion gene with upregulated SRC and FAK signaling. Compound 1 inhibited autophosphorylation of ROS1 in Ba/F3 engineered stable cell lines encoding L2026M, or D2033N mutant CD74-ROS1 fusion genes. Compound 1 inhibited autophosphorylation of TRKA in NIH3T3 engineered stable cell lines encoding wild type or G595R mutant LMNA-TRKA fusion genes. Compound 1 inhibited autophosphorylation of TRKB in NIH3T3 engineered stable cell lines encoding wild type or G639R mutant TEL-TRKB, also named as ETV6-TRKB fusion genes.

Table 4

Assays	IC ₅₀ (nM)
ALK phosphorylation of Karpas-299 cell line	0.9
ALK phosphorylation of NCI-H2228 cell line	5.8
ALK phosphorylation of Ba/F3 EML4-ALK WT cell line	29.9
ALK phosphorylation of Ba/F3 EML4-ALK G1202R cell line	18.4
ROS1 phosphorylation of HCC78 cell line	2
ROS1 phosphorylation of Ba/F3 CD74-ROS1 WT cell line	0.3
ROS1 phosphorylation of Ba/F3 CD74-ROS1 G2032R cell line	3
ROS1 phosphorylation of Ba/F3 SDC4-ROS1 WT cell line	0.5
ROS1 phosphorylation of Ba/F3 SDC4-ROS1 G2032R cell line	2
TRKA phosphorylation of KM12 cell line	0.35
STATS phosphorylation of SET-2 cell line	158
SRC phosphorylation of H2228 cell line	102
ROS1 phosphorylation of Ba/F3 CD74-ROS1 L2026M cell line	10
ROS1 phosphorylation of Ba/F3 CD74-ROS1 D2033N cell line	<1

Assays	IC ₅₀ (nM)
TRKA phosphorylation of NIH3T3 LMNA-TRKA cell line	0.01
TRKA phosphorylation of NIH3T3 LMNA-TRKA G595R cell	0.1
TRKB phosphorylation of NIH3T3 TEL-TRKB cell line	<0.1
TRKB phosphorylation of NIH3T3 TEL-TRKB G639R cell	1
FAK phosphorylation of NCI-H2228 cell line	100

[0133] Compound 1 increased the number of apoptotic Karpas-299 cells. After 48 hours treatment with Compound 1, Karpas-299 cells were lysed and evaluated with the caspase 3/7 cleavage caspase 3 glo assay or PARP in western blotting assay. The results were presented in FIG. 1.

[0134] Compound 1 inhibited HCC78 or HT1080 cell migration after 12 hour treatment in the scratch wound healing assays. The results were presented in FIG. 2

Compound 1 down-regulated EGFR expression in H2228 cells

[0135] The activation of SRC kinase activity upregulates RTK expression level, leading to the bypass signaling pathway resistance. The inhibition of SRC will result in the down regulation of RTKs. Compound 1 down-regulated EGFR expression in a dose- and time-dependent manner as shown in FIG. 3.

Compound 1 down-regulated EGFR expression in H2228 cells

[0136] CD44 is a biomarker of cancer stemness. A high expression level of CD44 was discovered in H2228 cells. Compound 1 suppressed CD44 expression level in H2228 cells in a concentration-dependent manner after 48 hours treatment as shown in FIG. 4, indicating that compound 1 has the potential to inhibit cancer stemness.

In-Vivo Studies

Antitumor Efficacy of Compound 1 in Xenograft Tumor Models

[0137] The antitumor efficacy of Compound 1 was evaluated in several tumor xenograft models representing cancer populations in which dysregulation of ALK, ROS1 or TRKA is implicated.

Example 10: Karpas 299 ALCL Model

[0138] The NPM-ALK fusion gene in Karpas 299 cells is proved as the driver for tumor growth. SCID/Beige mice bearing Karpas 299 tumors (at the average tumor size of 160 mm³) were dosed with Compound 1 orally BID for seven days (FIG. 5). The control group of mice were given vehicle only. Tumor volume (TMV) was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 5. An * denotes that the mean TMVs are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. Tumor growth inhibition (TGI) was calculated as $100\% * \{1 - [(TMV_{\text{Treated Last Day of Treatment}} - TMV_{\text{Treated First Day of Treatment}}) / (TMV_{\text{Control on Last Day of Treatment}} - TMV_{\text{Control on First Day of Treatment}})]\}$ when $TMV_{\text{Treated Last Day of Treatment}} \geq TMV_{\text{Treated First Day of Treatment}}$. In the case of $TMV_{\text{Treated Last Day of Treatment}} < TMV_{\text{Treated First Day of Treatment}}$, tumor regression (REG) was calculated as $100\% * (1 - TMV_{\text{Treated Last Day of Treatment}} / TMV_{\text{Treated First Day of Treatment}})$. In this study, Compound 1 demonstrated the ability to inhibit tumor growth at 59% and 94% at the dosages of 15 mg/kg and 50 mg/kg BID, respectively. In addition, 4 of 8 mice in the 50 mg/kg treatment group exhibited tumor regression. Body weight of the mice were measured on the designated days of the mice and no body weight loss was observed in the Compound 1 treatment groups (FIG. 6).

Example 11: NIH3T3 EML4-ALK wildtype (WT) Model

[0139] Athymic nude mice bearing the NIH3T3 EML4-ALK WT tumors (at the average tumor size of 120 mm³) were dosed with Compound 1 orally BID for 12 days (FIG. 7). The control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown as mean $\pm$ sem in FIG. 7. An * denotes that the mean tumor volumes are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment of Compound 1 at 50 mg/kg/BID resulted in 41% tumor regression, with 8 of 8 mice exhibited tumor regression. Compound 1 at the dosage of 15 mg/kg/BID demonstrated the ability to inhibit tumor growth at a TGI of 90%, with 2 of 8 mice exhibited tumor regression. Body weight of the mice were measured on the designated days of the mice and no body weight loss was observed in the Compound 1 treatment groups (FIG. 8).

Example 12: NIH3T3 SDC4-ROS1 WT Model

[0140] The SDC4-ROS1 fusion gene is considered as the driver for tumor progression in NSCLC. Athymic nude mice bearing the NIH3T3 SDC4-ROS1 WT tumors (at the average tumor size of 100 mm³) were dosed with Compound 1 orally BID for 26 days (FIG. 9). The

control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 9. An * denotes that the mean tumor volumes are significantly less in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment of Compound 1 at 50 mg/kg resulted in 69% tumor regression, with 7 of 7 mice exhibited tumor regression. Mice in the 15 mg/kg Compound 1 group also demonstrated 39% tumor regression, with 7 of 8 mice in this group exhibited tumor regression.

Example 13: KM12 Colorectal Cancer Model

[0141] The aberrant activity of the TPM3-TRKA is considered as the underlying driver for tumor growth in the KM12 model. Athymic nude mice bearing the KM12 tumors (at the average tumor size of 100 mm³) were dosed with Compound 1 orally BID for seven days (FIG. 10). Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 10. An * denotes that the mean tumor volumes are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, Compound 1 at the dosage of 15 mg/kg and 75 mg/kg resulted in 13% and 11% tumor regression, respectively. In the 15 mg/kg group, 8 of 8 mice exhibited tumor regression. In the 75 mg/kg group, 5 of 8 mice exhibited tumor regression. No loss of body weight were observed in mice treated with Compound 1 compared to those with vehicle control (FIG. 11).

Example 14: Relationship of ALK inhibition to anti-tumor efficacy following oral administration of Compound 1

[0142] To evaluate the effect of Compound 1 on the inhibition of ALK phosphorylation, Karpas 299 tumors were harvested at either 3 hour or 12 hour after last dose of Compound 1 in a repeated dosing study (15 mg/kg or 50 mg/kg, BID for seven 7 days). The level of ALK phosphorylation was determined by immunoblotting combined with signal quantification by the Image Studio Digit Software. The ability of Compound 1 to inhibit ALK phosphorylation was illustrated in FIG. 12. At the dose of 50 mg/kg, ALK phosphorylation was reduced to <5% of the control level at 3 hours post oral administration of Compound 1 and was maintained at about 10% of the control level at 12 hours post dosing. This level of phosphorylation inhibition corresponds to 94% TGI. At the dose of 15 mg/kg, ALK phosphorylation was reduced to <10% of the control level at 3 hours post oral administration and was maintained at about 21% of the control level at 12 hours post dosing. This level of ALK phosphorylation corresponds to 59% of TGI. These results support the link between inhibition of ALK, the target of Compound 1, and the degree of antitumor efficacy in a NPM-ALK-dependent tumor model.

Example 15: Dose Dependent studies in KM12 Colorectal Cancer Model

[0143] To investigate the dose-dependent effect of Compound 1 on tumor inhibition in the KM12 colorectal cancer model, athymic nude mice bearing the KM12 tumors (at the average tumor size of 125 mm³) were dosed with Compound 1 orally BID for seven days at dosages equal or lower than 15 mg/kg for seven days (FIG. 13). Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 13. An * denotes that the mean tumor volumes are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, Compound 1 inhibited tumor growth in a dose-dependent manner. Treatment with Compound 1 at the dosage of 15 mg/kg resulted in 1% tumor regression, with 5 of 10 mice exhibiting tumor regression. Compound 1 at the dosage of 3 mg/kg demonstrated the ability to inhibit tumor growth at a TGI of 91%, with 2 of 10 mice exhibiting tumor regression. Compound 1 at the dosage of 1 mg/kg demonstrated the ability to inhibit tumor growth at a TGI of 77%. No loss of body weight were observed in mice treated with Compound 1 compared to those with vehicle control (FIG. 14).

Example 16: Ba/F3 EML4-ALK WT Model

[0144] SCID/Beige mice bearing the Ba/F3 EML4-ALK WT tumors (at the average tumor size of 190 mm³) were dosed with Compound 1 orally BID for 14 days (FIG. 15). The control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown as mean $\pm$ sem in FIG. 15. An * denotes that the mean tumor volumes are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment with Compound 1 at 75 mg/kg resulted in 54% tumor regression, with 6 of 8 mice exhibiting tumor regression. Compound 1 at the dosage of 15 mg/kg/BID demonstrated the ability to inhibit tumor growth at a TGI of 74%. Body weight of the mice were measured on the designated days and no body weight loss was observed in the Compound 1 treatment groups (FIG. 16).

Example 17: Ba/F3 EML4-ALK G1202R Model

[0145] To investigate the effect of Compound 1 on inhibiting the growth of tumors containing the drug-resistant solvent front mutations, SCID/Beige mice bearing the Ba/F3 EML4-ALK G1202R tumors (at the average tumor size of 210 mm³) were dosed with Compound 1 orally BID for 17 days (FIG. 17). The control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown as mean $\pm$ sem in FIG. 17. An * denotes that the mean tumor volumes are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment of Compound 1 at 75 mg/kg resulted in tumor growth inhibition with a TGI of 99%. 4 of 8 mice exhibited tumor regression in this group. Compound 1

at the dosage of 15 mg/kg demonstrated the ability to inhibit tumor growth at a TGI of 56%. Body weight of the mice were measured on the designated days and no body weight loss was observed in the Compound 1 treatment groups (FIG. 18).

Example 18: Ba/F3 CD74-ROS1 WT Model

[0146] The CD74-ROS1 fusion gene is considered as one of the drivers for tumor progression in NSCLC. SCID/Beige mice bearing the Ba/F3 CD74-ROS1 WT tumors (at the average tumor size of 200 mm³) were dosed with Compound 1 orally BID for 12 days (FIG. 19). The control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 19. An * denotes that the mean tumor volumes are significantly less in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment with Compound 1 at 75 mg/kg resulted in 100% tumor regression, with 8 of 8 mice exhibiting complete tumor regression. Mice in the 15 mg/kg Compound 1 group also demonstrated 97% tumor regression, with 8 of 8 mice in this group exhibiting tumor regression. Body weight of the mice were measured on the designated days and no body weight loss was observed in the Compound 1 treatment groups (FIG. 20).

Example 19: Ba/F3 CD74-ROS1 G2032R Model

[0147] To investigate the effect of Compound 1 on inhibiting the growth of tumors containing the drug-resistant solvent front mutations, SCID/Beige mice bearing the Ba/F3 CD74-ROS1 G2032R tumors (at the average tumor size of 210 mm³) were dosed with Compound 1 orally BID for 11 days (FIG. 21). The control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 21. An * denotes that the mean tumor volumes are significantly less in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment with Compound 1 at 75 mg/kg resulted in 100% tumor regression, with 8 of 8 mice exhibiting complete tumor regression. Compound 1 at the dosage of 15 mg/kg/BID demonstrated the ability to inhibit tumor growth at a TGI of 99%, with 2 of 8 mice in this group exhibiting tumor regression. Body weight of the mice were measured on the designated days and no body weight loss was observed in the Compound 1 treatment groups (FIG. 22).

Example 20: NIH3T3 LMNA-TRKA WT Model

[0148] The LMNA-TRKA fusion gene is considered as one of the drivers for tumor progression in colorectal cancer. Athymic nude mice bearing the NIH3T3 LMNA-TRKA WT tumors (at the

average tumor size of 240 mm³) were dosed with Compound 1 orally BID for five days (FIG. 23). Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 23. An * denotes that the mean tumor volumes are significantly lower in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment with Compound 1 at the dosage of 15 mg/kg resulted in 28% tumor regression, with 7 of 8 mice exhibiting tumor regression. Compound 1 at the dosage of 3 mg/kg demonstrated the ability to inhibit tumor growth at a TGI of 100%, with 3 of 8 mice exhibiting tumor regression. No loss of body weight were observed in mice treated with Compound 1 compared to those with vehicle control (FIG. 24).

Example 21: NIH3T3 LMNA-TRKA G595R Model

[0149] To investigate the effect of Compound 1 on inhibiting the growth of tumors containing the drug-resistant solvent front mutations, athymic nude mice bearing the NIH3T3 LMNA-TRKA G595R tumors (at the average tumor size of 230 mm³) were dosed with Compound 1 orally BID for five days (FIG. 25). The control group of mice were given vehicle only. Tumor volume was measured by caliper on the indicated days and is shown at mean $\pm$ sem in FIG. 25. An * denotes that the mean tumor volumes are significantly less in the treated group compared to that of the control group ($p < 0.05$) as determined by two-way repeated ANOVA followed by post hoc analysis. In this study, treatment with Compound 1 at 60 mg/kg resulted in 23% tumor regression, with 10 of 10 mice exhibiting tumor regression. Compound 1 at the dosage of 15 mg/kg demonstrated the ability to inhibit tumor growth at a TGI of 97%, with 3 of 8 mice in this group exhibiting tumor regression. Compound 1 at the dosage of 3 mg/kg demonstrated the ability to inhibit tumor growth at a TGI of 56%. Body weight of the mice were measured on the designated days and no body weight loss was observed in the Compound 1 treatment groups (FIG. 26).

REFERENCES CITED IN THE DESCRIPTION

Cited references

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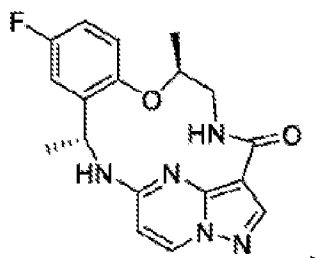
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CHIRAL DIARYLMAKROCYKLUS OG ANVENDELSE DERAFF I BEHANDLING AF CANCER
PATENTKRAV

1. Forbindelse (7S,13R)-11-fluor-7,13-dimethyl-6,7,13,14-tetrahydro-1,15-ethenopyrazolo[4,3-*f*][1,4,8,10]benzoxatriazacyclotridecin-4(5*H*)-on med formelen



5

eller et farmaceutisk acceptabelt salt deraf, til anvendelse i behandling af cancer hos en patient, hvor canceren er medieret af

(i) en genetisk ændret ALK, der er et EML4-ALK-fusionsprotein med mindst én mutation valgt fra gruppen bestående af L1196M, G1202R, D1203R, L1152P/R, F1174C/L/V, C1156Y, I1171N, G1123S, S1206Y, G1269S/A og 1151T-insertion; eller

(ii) en genetisk ændret ALK, der er et TPR-ALK-fusionsprotein med en L1196M-punktmutation; eller

(iii) en genetisk ændret ALK med én eller flere punktmutationer valgt fra gruppen bestående af R1050H, F1174C/I/L/S/V, F1245C/I/L/V, R1275L/Q, T1151M, M1166R, I1170N, I1170S, I1171N, I1183T, L1196M, A1200V, L1204F, L1240V, D1270G, Y1278S, R1192P, G1128A, G1286R og T1343I; eller

(iv) et LMNA-TRKA-fusionsprotein eller

(v) et QKI-TRKB- eller ETV6-TRKB-fusionsprotein; eller

(vi) et ETV6-TRKC-fusionsprotein.

2. Forbindelse til anvendelse ifølge krav 1, hvor den genetisk ændrede ALK er et EML4-ALK-fusionsprotein med mindst én mutation valgt fra gruppen bestående af L1196M, G1202R, D1203R, L1152P/R, F1174C/L/V, C1156Y, I1171N, G1123S, S1206Y, G1269S/A og 1151T-insertion.

3. Forbindelse til anvendelse ifølge krav 1, hvor den genetisk ændrede ALK er et EML4-ALK-fusionsprotein med mindst én mutation valgt fra gruppen bestående af L1196M, G1202R, L1152P/R, F1174C/L, C1156Y, G1269S og 1151T-insertion.

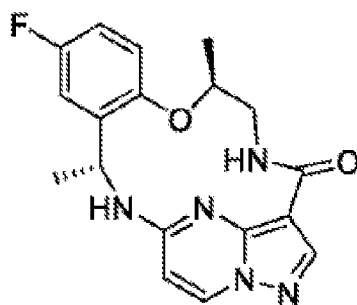
4. Forbindelse til anvendelse ifølge krav 1, hvor den genetisk ændrede ALK er et TPR-ALK-fusionsprotein med en L1196M-punktmutation.

5. Forbindelse til anvendelse ifølge krav 1, hvor den genetisk ændrede ALK har én eller flere punktmutationer valgt fra gruppen bestående af R1050H, F1174C/I/L/S/V, F1245C/I/L/V, R1275L/Q, T1151M, M1166R, I1170N, I1170S, I1171N, I1183T, L1196M, A1200V, L1204F, L1240V, D1270G, Y1278S, R1192P, G1128A, G1286R og T1343I.

6. Forbindelse til anvendelse ifølge krav 1, hvor den genetisk ændrede ALK har én eller flere punktmutationer valgt fra gruppen bestående af F1174S, R1275Q og T1151M.

- 2 -

7. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et LMNA-TRKA-fusionsprotein.
8. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et LMNA-TRKA-fusionsprotein omfattende en G595R-punktmutation.
- 5 9. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et QKI-TRKB- eller et ETV6-TRKB-fusionsprotein.
10. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et ETV6-TRKB-fusionsprotein.
11. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et ETV6-TRKB-fusionsprotein
- 10 omfattende en G639R-punktmutation.
12. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et ETV6-TRKC-fusionsprotein.
13. Forbindelse til anvendelse ifølge krav 1, hvor canceren er medieret af et ETV6-TRKC-fusionsprotein omfattende en G623R-punktmutation.
- 15 14. Forbindelse til anvendelse ifølge et hvilket som helst af kravene 1 til 13, hvor canceren vælges fra gruppen bestående af anaplastisk storcellet lymfom (ALCL), ikke-småcellet lungecancer (NSCLC), neuroblastom, inflammatorisk myofibroblastisk tumor, nyrecellekarcinom hos voksne, pædiatrisk nyrecellekarcinom, brystcancer, colonadenokarcinom, glioblastom, glioblastoma multiforme og anaplastisk thyreoideacancer.
- 20 15. Forbindelse til anvendelse ifølge krav 14, hvor canceren er ikke-småcellet lungecancer (NSCLC).
16. Forbindelse til anvendelse ifølge et hvilket som helst af kravene 1 til 15, hvor forbindelsen har formelen:



DRAWINGS

Drawing

FIG. 1

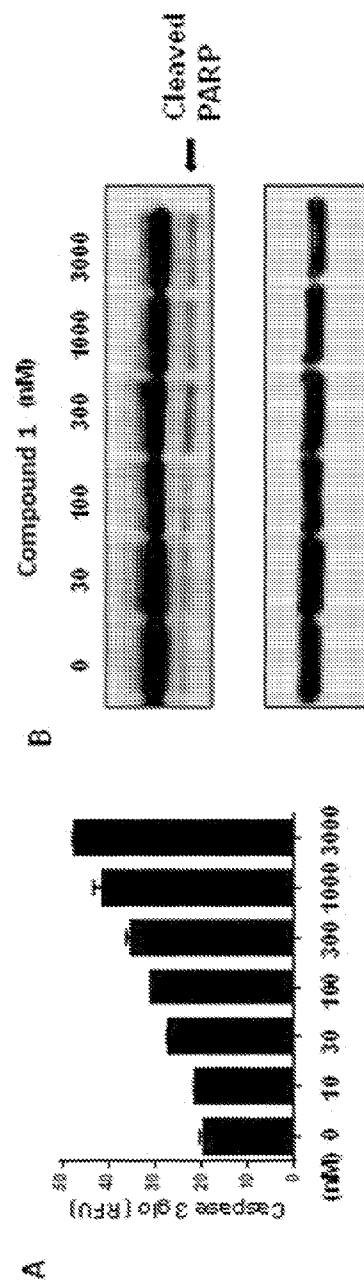


FIG. 2

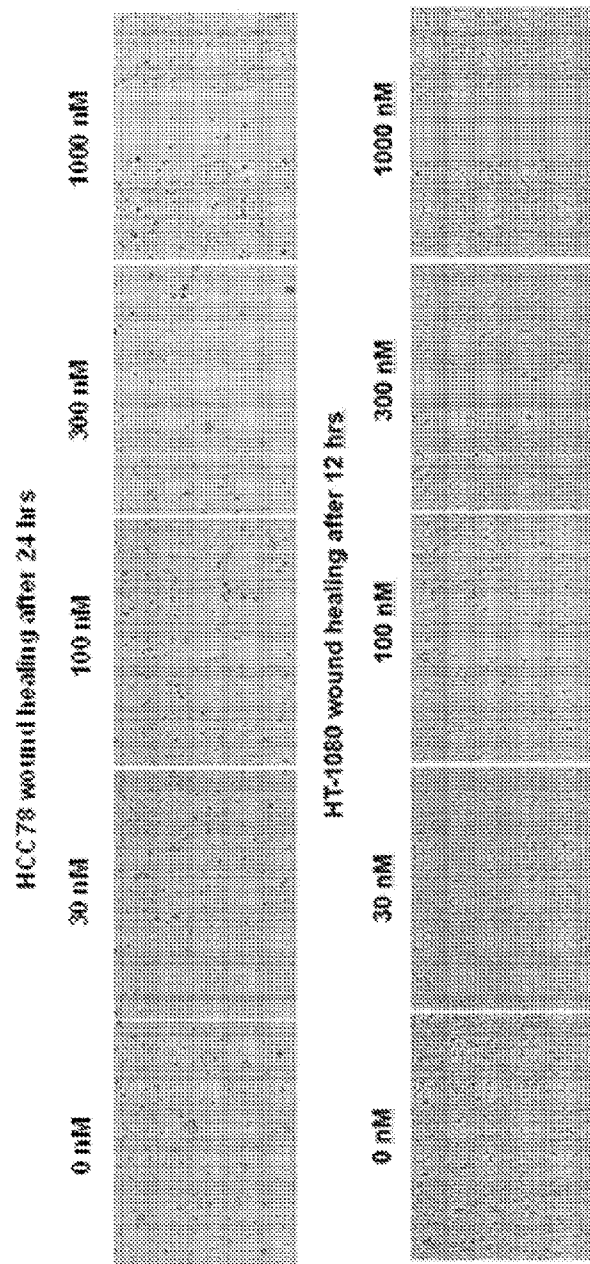


FIG. 5

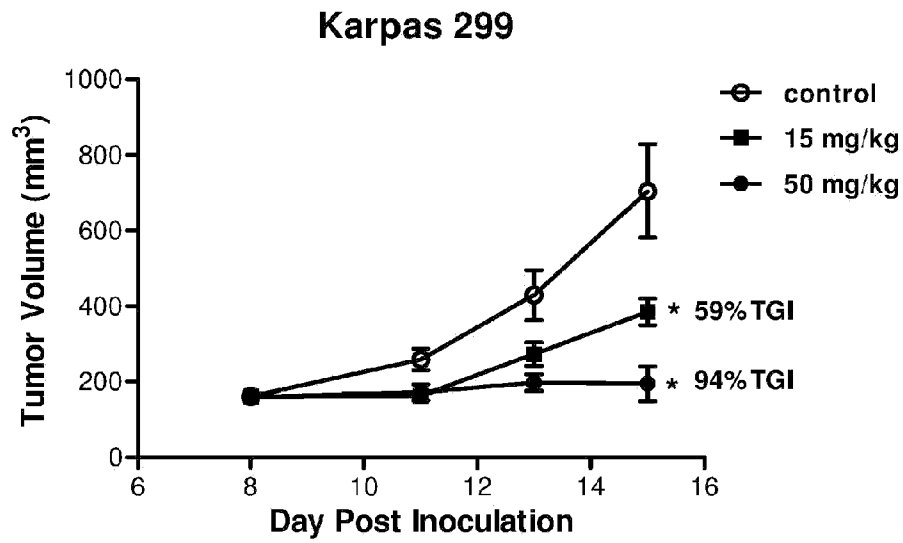


FIG. 6

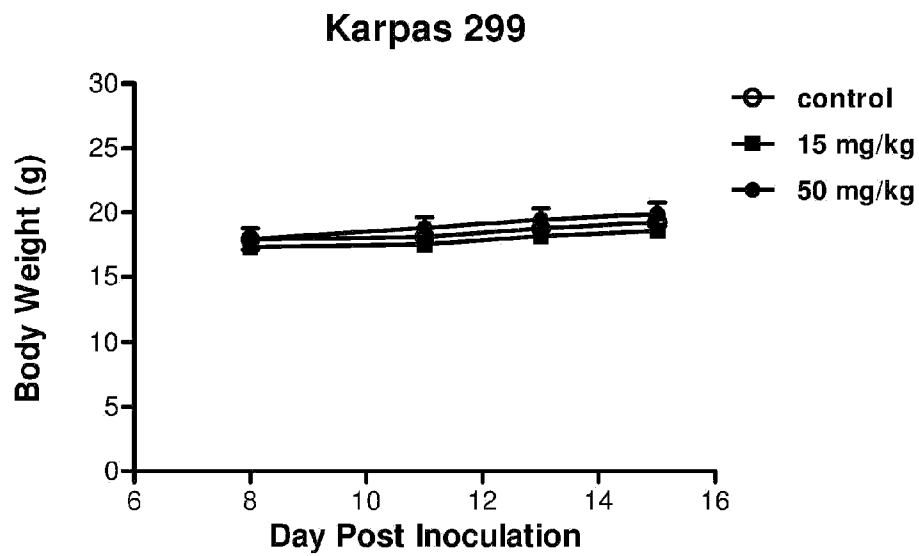


FIG. 7

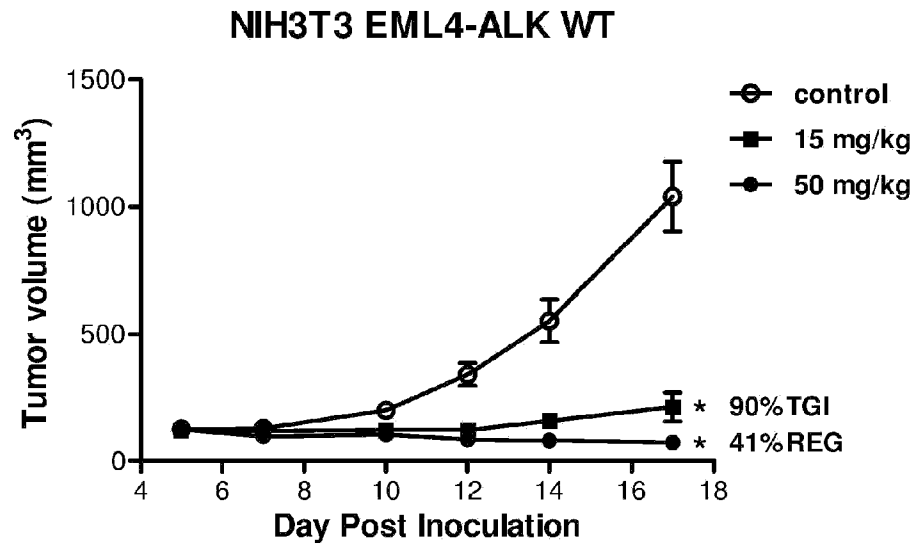


FIG. 8

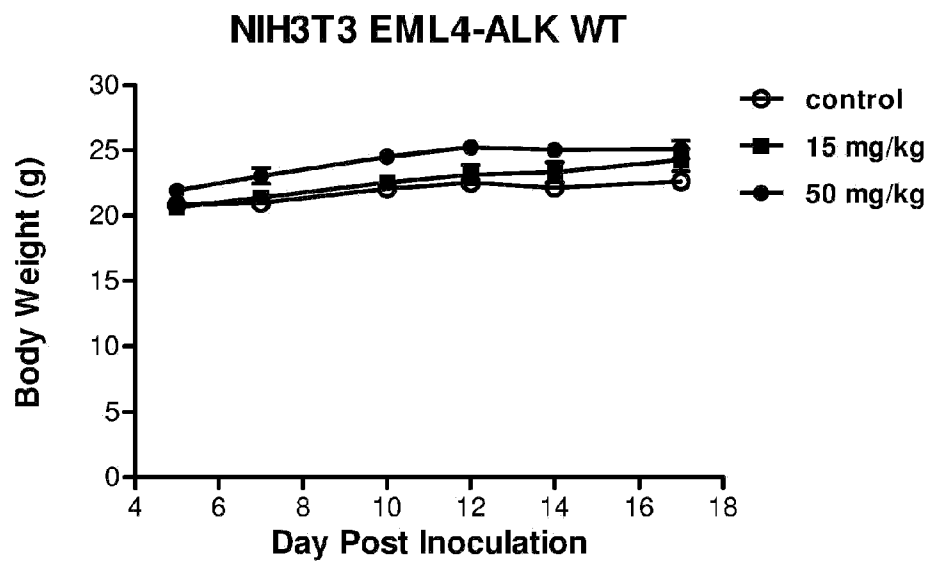


FIG. 9

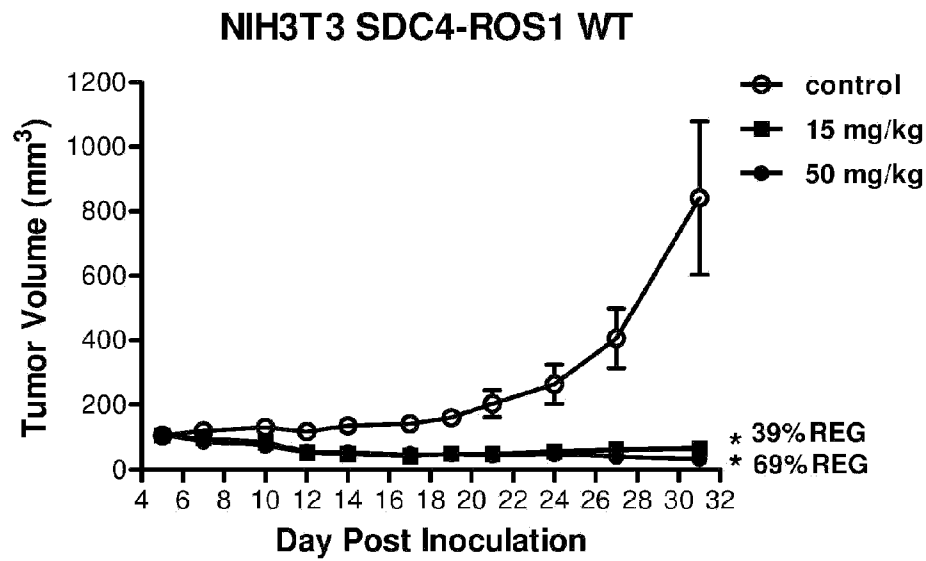


FIG. 10

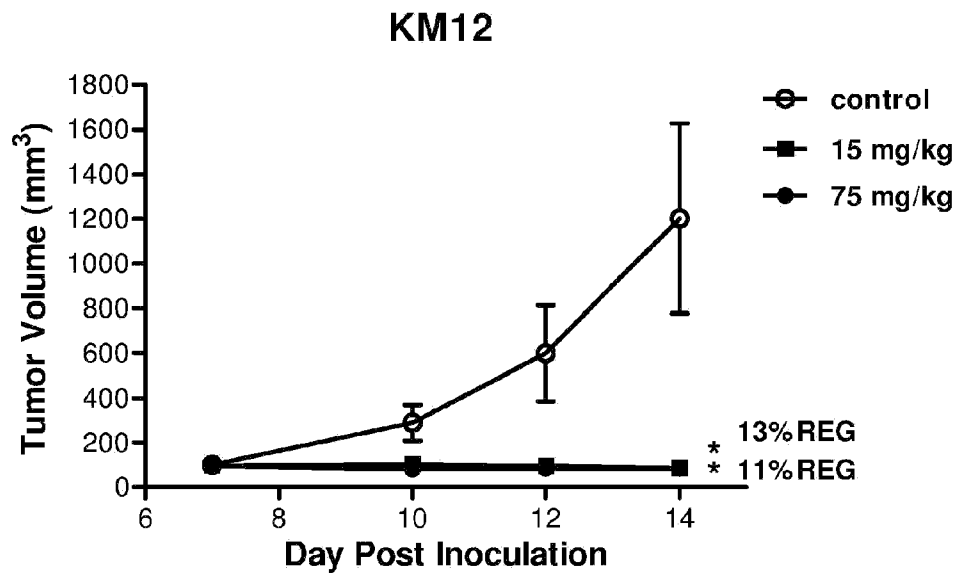


FIG. 11

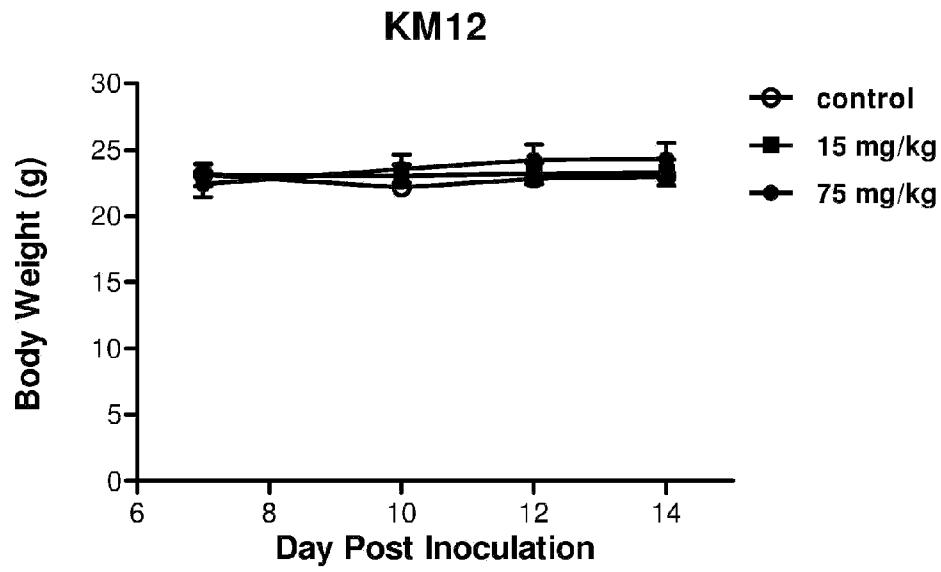


FIG. 12

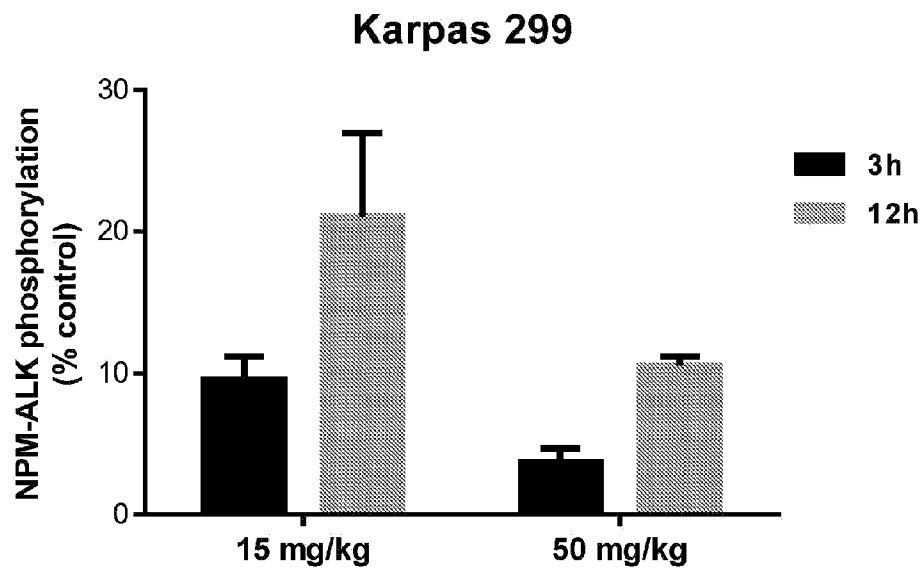


FIG. 13

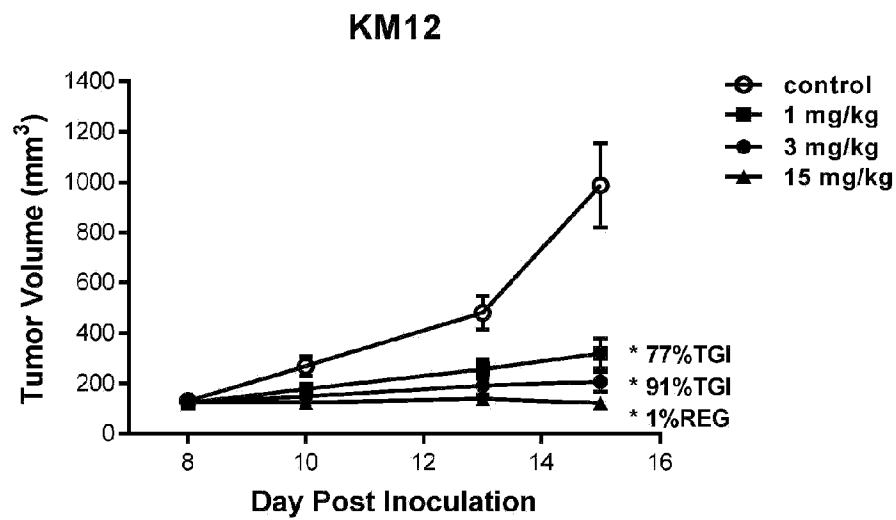


FIG. 14

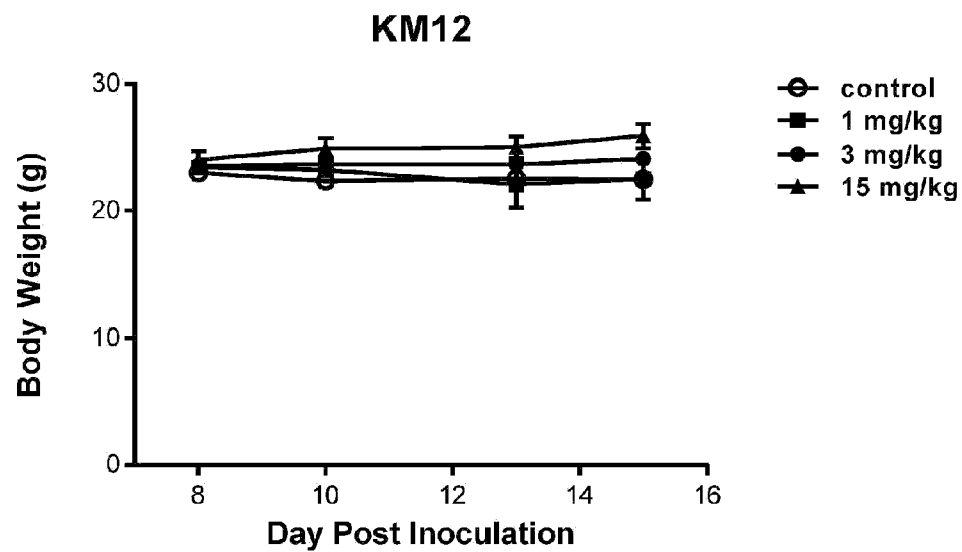


FIG. 15

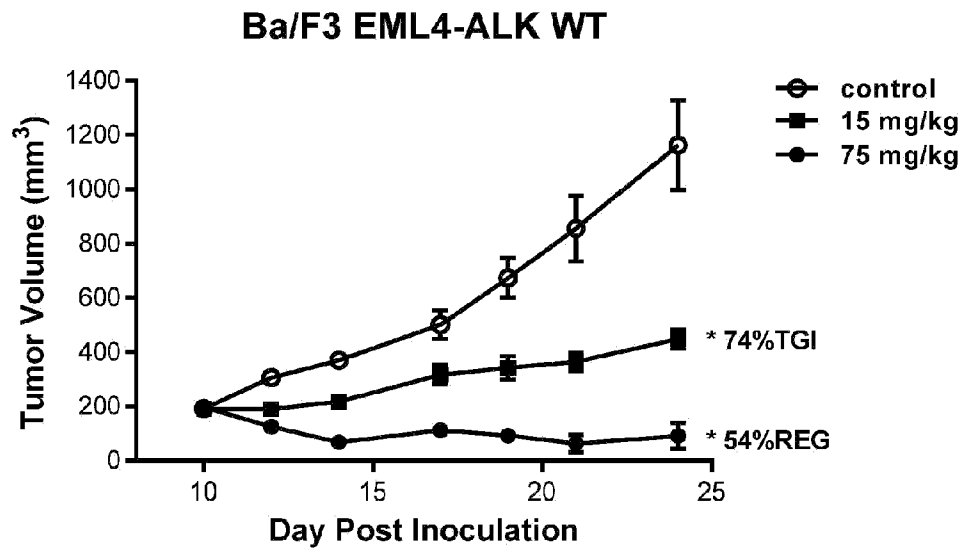


FIG. 16

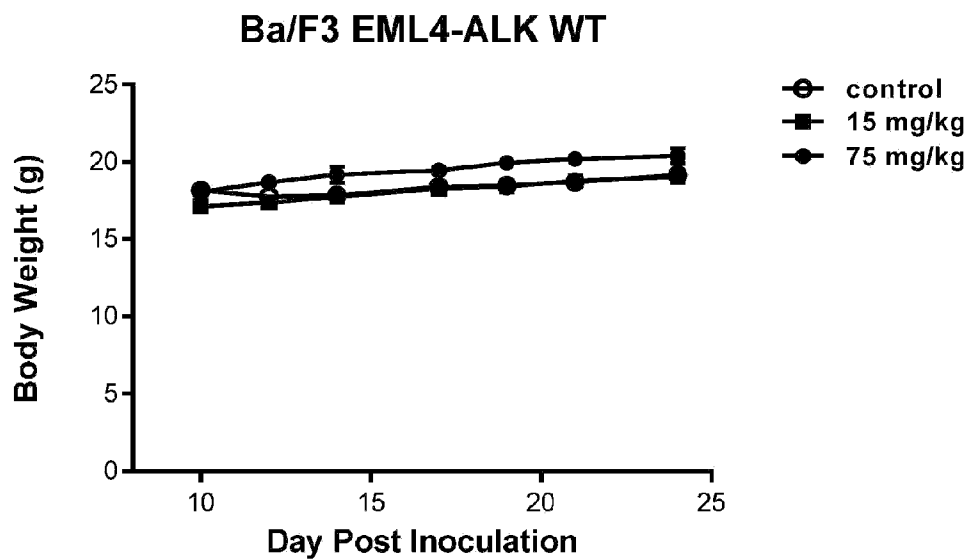


FIG. 17

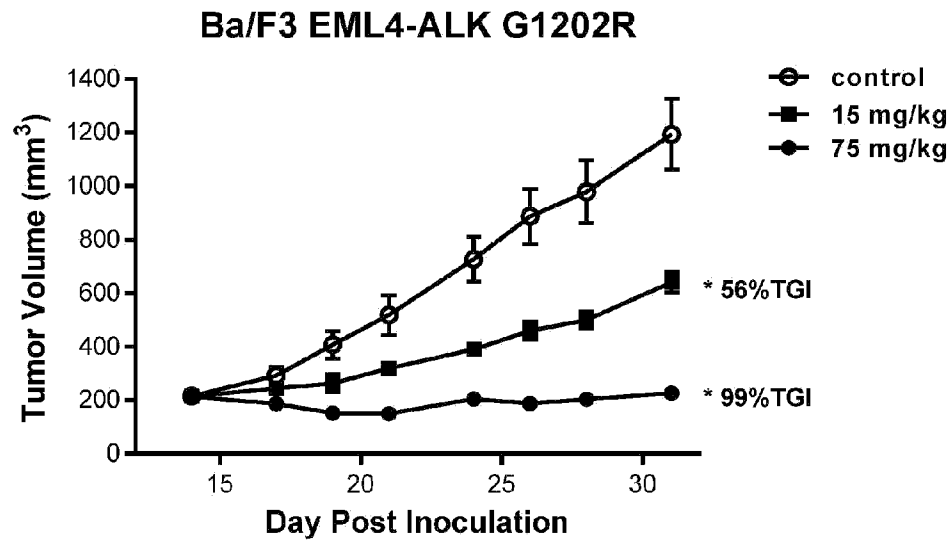


FIG. 18

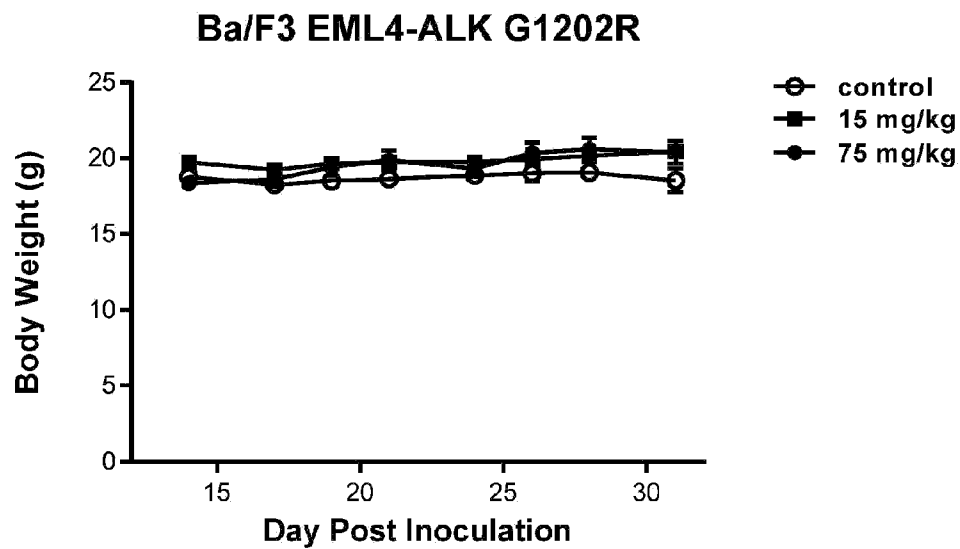


FIG. 19

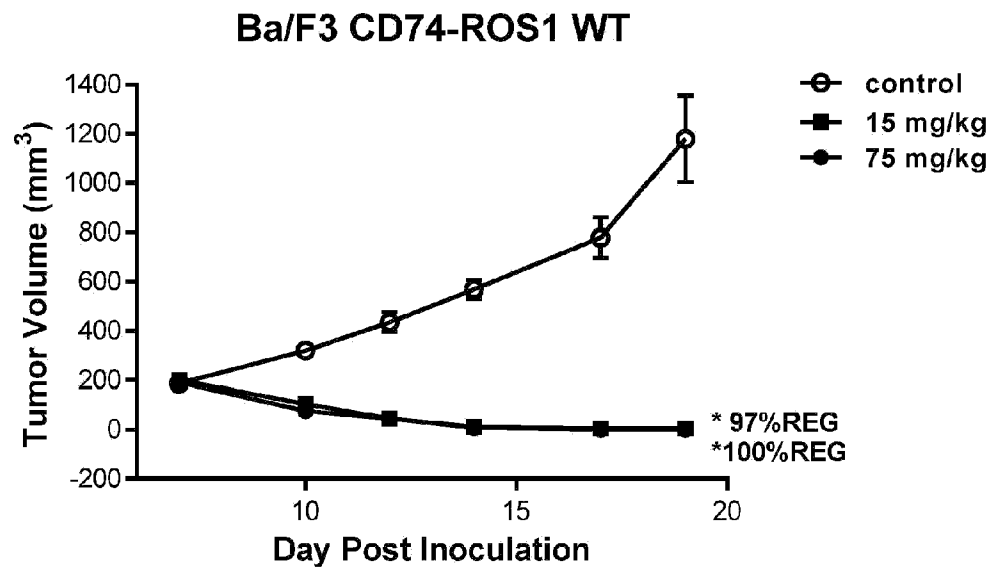


FIG. 20

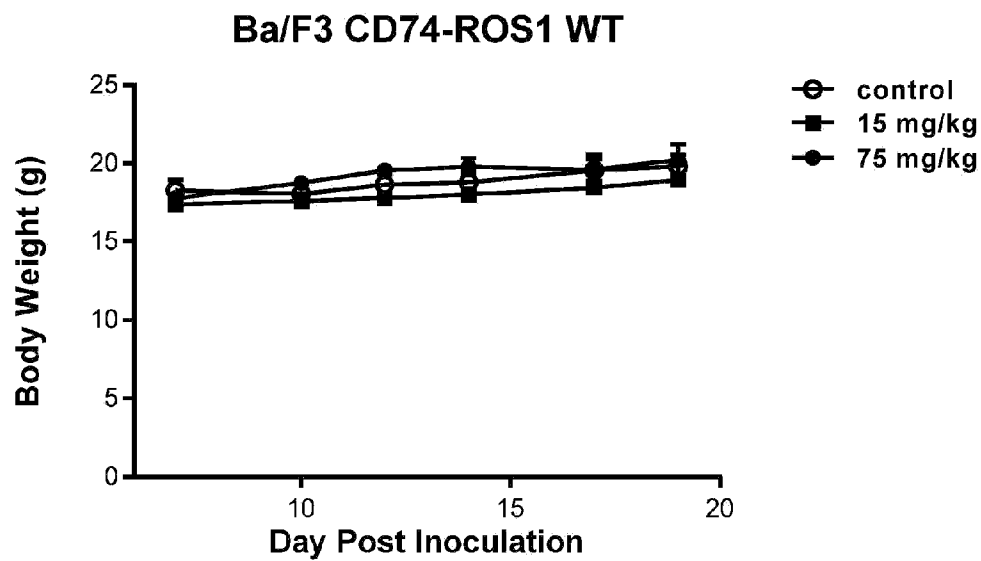


FIG. 21

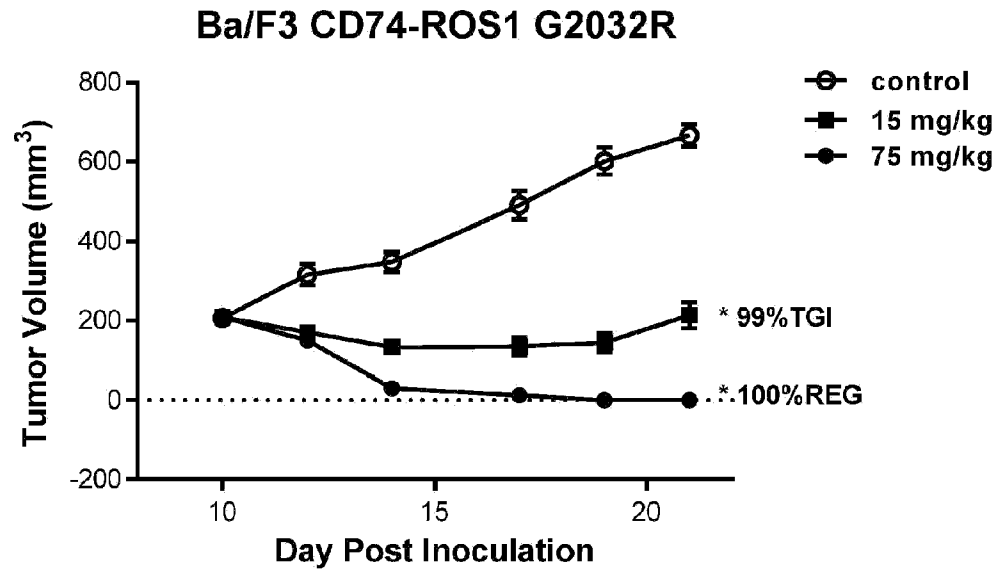


FIG. 22

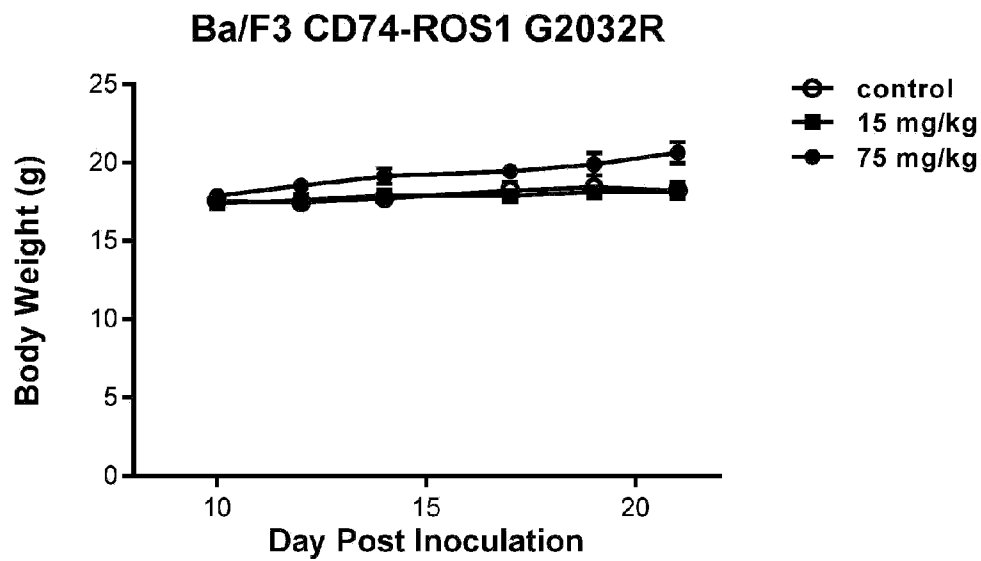


FIG. 23

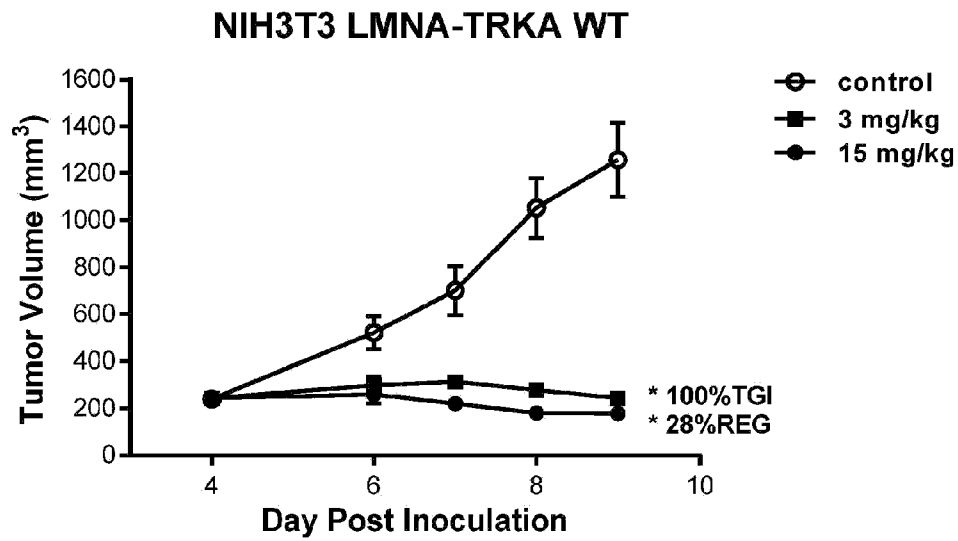


FIG. 24

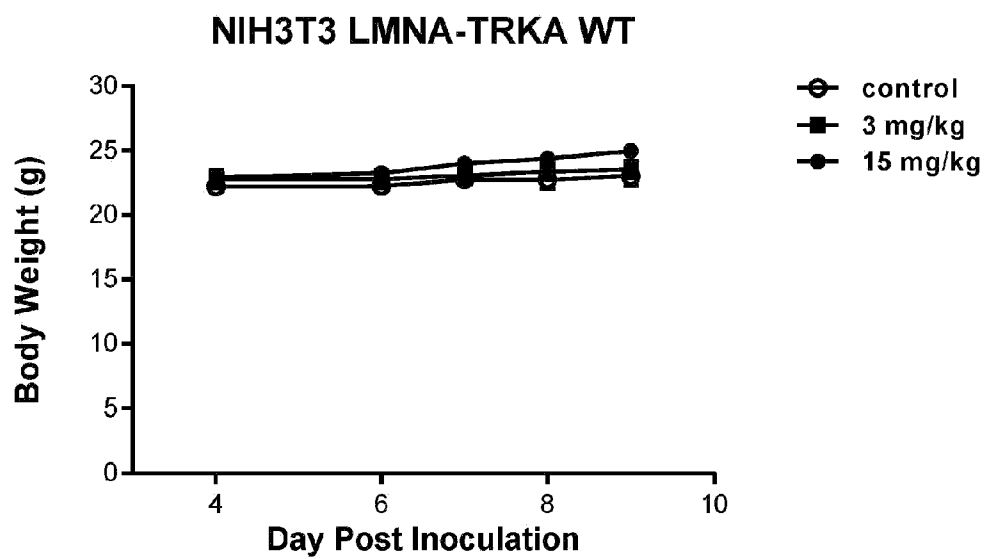


FIG. 25

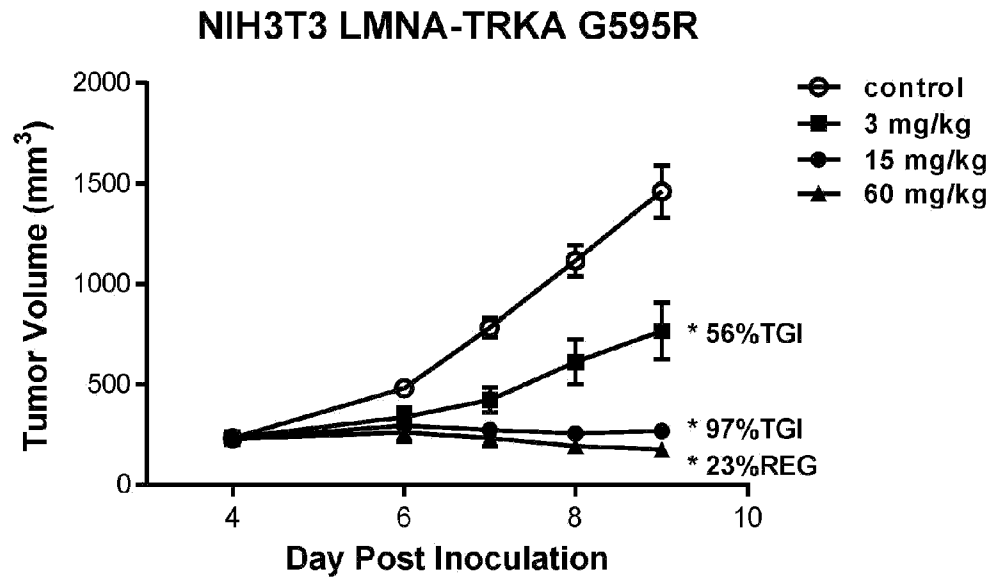


FIG. 26

