MODULATORS OF ATP-BINDING CASSETTE TRANSPORTERS

[0001] CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] This application claims the priority of U.S. application serial nos. 61/112,152 and 61/112,145, both of which were filed on November 6, 2008. The entire contents of these applications are incorporated herein in their entirety.

[0003] TECHNICAL FIELD OF THE INVENTION

[0004] The present invention relates to modulators of ATP-Binding Cassette ("ABC") transporters or fragments thereof, including Cystic Fibrosis Transmembrane Conductance Regulator ("CFTR"), compositions thereof and methods therewith. The present invention also relates to methods of treating ABC transporter mediated diseases using such modulators.

[0005] BACKGROUND OF THE INVENTION

[0006] ABC transporters are a family of membrane transporter proteins that regulate the transport of a wide variety of pharmacological agents, potentially toxic drugs, and xenobiotics, as well as anions. ABC transporters are homologous membrane proteins that bind and use cellular adenosine triphosphate (ATP) for their specific activities. Some of these transporters were discovered as multidrug resistance proteins (like the MDR1-P glycoprotein, or the multidrug resistance protein, MRP1), defending malignant cancer cells against chemotherapeutic agents. To date, 48 ABC Transporters have been identified and grouped into 7 families based on their sequence identity and function.

[0007] ABC transporters regulate a variety of important physiological roles within the body and provide defense against harmful environmental compounds. Because of this, they represent important potential drug targets for the treatment of diseases associated with defects in the transporter, prevention of drug transport out of the target cell, and intervention in other diseases in which modulation of ABC transporter activity may be beneficial.

[0008] One member of the ABC transporter family commonly associated with disease is the cAMP/ATP-mediated anion channel, CFTR. CFTR is expressed in a variety of cells types, including absorptive and secretory epithelia cells, where it regulates anion flux across the membrane, as well as the activity of other ion channels and proteins. In epithelia cells, normal

functioning of CFTR is critical for the maintenance of electrolyte transport throughout the body, including respiratory and digestive tissue. CFTR is composed of approximately 1480 amino acids that encode a protein made up of a tandem repeat of transmembrane domains, each containing six transmembrane helices and a nucleotide binding domain. The two transmembrane domains are linked by a large, polar, regulatory (R)-domain with multiple phosphorylation sites that regulate channel activity and cellular trafficking.

[0009] The gene encoding CFTR has been identified and sequenced (See Gregory, R. J. et al. (1990) Nature 347:382-386; Rich, D. P. et al. (1990) Nature 347:358-362), (Riordan, J. R. et al. (1989) Science 245:1066-1073). A defect in this gene causes mutations in CFTR resulting in Cystic Fibrosis ("CF"), the most common fatal genetic disease in humans. Cystic Fibrosis affects approximately one in every 2,500 infants in the United States. Within the general United States population, up to 10 million people carry a single copy of the defective gene without apparent ill effects. In contrast, individuals with two copies of the CF associated gene suffer from the debilitating and fatal effects of CF, including chronic lung disease.

[0010] In patients with cystic fibrosis, mutations in CFTR endogenously expressed in respiratory epithelia leads to reduced apical anion secretion causing an imbalance in ion and fluid transport. The resulting decrease in anion transport contributes to enhanced mucus accumulation in the lung and the accompanying microbial infections that ultimately cause death in CF patients. In addition to respiratory disease, CF patients typically suffer from gastrointestinal problems and pancreatic insufficiency that, if left untreated, results in death. In addition, the majority of males with cystic fibrosis are infertile and fertility is decreased among females with cystic fibrosis. In contrast to the severe effects of two copies of the CF associated gene, individuals with a single copy of the CF associated gene exhibit increased resistance to cholera and to dehydration resulting from diarrhea – perhaps explaining the relatively high frequency of the CF gene within the population.

[0011] Sequence analysis of the CFTR gene of CF chromosomes has revealed a variety of disease causing mutations (Cutting, G. R. et al. (1990) Nature 346:366-369; Dean, M. et al. (1990) Cell 61:863:870; and Kerem, B-S. et al. (1989) Science 245:1073-1080; Kerem, B-S et al. (1990) Proc. Natl. Acad. Sci. USA 87:8447-8451). To date, > 1000 disease causing mutations in the CF gene have been identified (http://www.genet.sickkids.on.ca/cftr/). The most prevalent

mutation is a deletion of phenylalanine at position 508 of the CFTR amino acid sequence, and is commonly referred to as ΔF508-CFTR. This mutation occurs in approximately 70% of the cases of cystic fibrosis and is associated with a severe disease.

[0012] The deletion of residue 508 in ΔF508-CFTR prevents the nascent protein from folding correctly. This results in the inability of the mutant protein to exit the ER, and traffic to the plasma membrane. As a result, the number of channels present in the membrane is far less than observed in cells expressing wild-type CFTR. In addition to impaired trafficking, the mutation results in defective channel gating. Together, the reduced number of channels in the membrane and the defective gating lead to reduced anion transport across epithelia leading to defective ion and fluid transport. (Quinton, P. M. (1990), FASEB J. 4: 2709-2727). Studies have shown, however, that the reduced numbers of ΔF508-CFTR in the membrane are functional, albeit less than wild-type CFTR. (Dalemans et al. (1991), Nature Lond. 354: 526-528; Denning et al., supra; Pasyk and Foskett (1995), J. Cell. Biochem. 270: 12347-50). In addition to ΔF508-CFTR, other disease causing mutations in CFTR that result in defective trafficking, synthesis, and/or channel gating could be up- or down-regulated to alter anion secretion and modify disease progression and/or severity.

[0013] Although CFTR transports a variety of molecules in addition to anions, it is clear that this role (the transport of anions) represents one element in an important mechanism of transporting ions and water across the epithelium. The other elements include the epithelial Na^+ channel, ENaC, $Na^+/2Cl^-/K^+$ co-transporter, Na^+-K^+-ATPase pump and the basolateral membrane K^+ channels, that are responsible for the uptake of chloride into the cell.

[0014] These elements work together to achieve directional transport across the epithelium via their selective expression and localization within the cell. Chloride absorption takes place by the coordinated activity of ENaC and CFTR present on the apical membrane and the Na^+-K^+-ATPase pump and Cl- channels expressed on the basolateral surface of the cell. Secondary active transport of chloride from the luminal side leads to the accumulation of intracellular chloride, which can then passively leave the cell via Cl^- channels, resulting in a vectorial transport. Arrangement of $Na^+/2Cl^-/K^+$ co-transporter, Na^+-K^+-ATPase pump and the basolateral membrane K^+ channels on the basolateral surface and CFTR on the luminal side coordinate the secretion of chloride via CFTR on the luminal side. Because water is probably never actively

transported itself, its flow across epithelia depends on tiny transepithelial osmotic gradients generated by the bulk flow of sodium and chloride.

[0015] In addition to Cystic Fibrosis, modulation of CFTR activity may be beneficial for other diseases not directly caused by mutations in CFTR, such as secretory diseases and other protein folding diseases mediated by CFTR. These include, but are not limited to, chronic obstructive pulmonary disease (COPD), dry eye disease, and Sjögren's Syndrome.

[0016] COPD is characterized by airflow limitation that is progressive and not fully reversible. The airflow limitation is due to mucus hypersecretion, emphysema, and bronchiolitis. Activators of mutant or wild-type CFTR offer a potential treatment of mucus hypersecretion and impaired mucociliary clearance that is common in COPD. Specifically, increasing anion secretion across CFTR may facilitate fluid transport into the airway surface liquid to hydrate the mucus and optimized periciliary fluid viscosity. This would lead to enhanced mucociliary clearance and a reduction in the symptoms associated with COPD. Dry eye disease is characterized by a decrease in tear aqueous production and abnormal tear film lipid, protein and mucin profiles. There are many causes of dry eye, some of which include age, Lasik eye surgery, arthritis, medications, chemical/thermal burns, allergies, and diseases, such as Cystic Fibrosis and Sjögrens's syndrome. Increasing anion secretion via CFTR would enhance fluid transport from the corneal endothelial cells and secretory glands surrounding the eye to increase corneal hydration. This would help to alleviate the symptoms associated with dry eye disease. Sjögrens's syndrome is an autoimmune disease in which the immune system attacks moisture-producing glands throughout the body, including the eye, mouth, skin, respiratory tissue, liver, vagina, and gut. Symptoms, include, dry eye, mouth, and vagina, as well as lung disease. The disease is also associated with rheumatoid arthritis, systemic lupus, systemic sclerosis, and polymypositis/dermatomyositis. Defective protein trafficking is believed to cause the disease, for which treatment options are limited. Modulators of CFTR activity may hydrate the various organs afflicted by the disease and help to elevate the associated symptoms.

[0017] As discussed above, it is believed that the deletion of residue 508 in ΔF508-CFTR prevents the nascent protein from folding correctly, resulting in the inability of this mutant protein to exit the ER, and traffic to the plasma membrane. As a result, insufficient amounts of the mature protein are present at the plasma membrane and chloride transport within epithelial

tissues is significantly reduced. In fact, this cellular phenomenon of defective ER processing of ABC transporters by the ER machinery has been shown to be the underlying basis not only for CF disease, but for a wide range of other isolated and inherited diseases. The two ways that the ER machinery can malfunction is either by loss of coupling to ER export of the proteins leading to degradation, or by the ER accumulation of these defective/misfolded proteins [Aridor M, et al., Nature Med., 5(7), pp 745- 751 (1999); Shastry, B.S., et al., Neurochem. International, 43, pp 1-7 (2003); Rutishauser, J., et al., Swiss Med Wkly, 132, pp 211-222 (2002); Morello, JP et al., TIPS, 21, pp. 466- 469 (2000); Bross P., et al., Human Mut., 14, pp. 186-198 (1999)]. The diseases associated with the first class of ER malfunction are Cystic fibrosis (due to misfolded ΔF508-CFTR as discussed above), Hereditary emphysema (due to a1-antitrypsin; non Piz variants), Hereditary hemochromatosis, Coagulation-Fibrinolysis deficiencies, such as Protein C deficiency, Type 1 hereditary angioedema, Lipid processing deficiencies, such as Familial hypercholesterolemia, Type 1 chylomicronemia, Abetalipoproteinemia, Lysosomal storage diseases, such as I-cell disease/Pseudo-Hurler, Mucopolysaccharidoses (due to Lysosomal processing enzymes), Sandhof/Tay-Sachs (due to β-Hexosaminidase), Crigler-Najjar type II (due to UDP-glucuronyl-sialyc-transferase), Polyendocrinopathy/Hyperinsulemia, Diabetes mellitus (due to Insulin receptor), Laron dwarfism (due to Growth hormone receptor), Myleoperoxidase deficiency, Primary hypoparathyroidism (due to Preproparathyroid hormone), Melanoma (due to Tyrosinase). The diseases associated with the latter class of ER malfunction are Glycanosis CDG type 1, Hereditary emphysema (due to α1-Antitrypsin (PiZ variant), Congenital hyperthyroidism, Osteogenesis imperfecta (due to Type I, II, IV procollagen), Hereditary hypofibrinogenemia (due to Fibrinogen), ACT deficiency (due to α1-Antichymotrypsin), Diabetes insipidus (DI), Neurophyseal DI (due to Vasopvessin hormone/V2-receptor), Neprogenic DI (due to Aquaporin II), Charcot-Marie Tooth syndrome (due to Peripheral myelin protein 22), Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease (due to βAPP and presenilins), Parkinson's disease, Amyotrophic lateral sclerosis, Progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, Spinocerebullar ataxia type I, Spinal and bulbar muscular atrophy, Dentatorubal pallidoluysian, and Myotonic dystrophy, as well as Spongiform encephalopathies, such as Hereditary Creutzfeldt-Jakob disease (due to Prion protein processing defect), Fabry disease (due to lysosomal α-galactosidase A) and Straussler-Scheinker syndrome (due to Prp

processing defect).

[0018] In addition to up-regulation of CFTR activity, reducing anion secretion by CFTR modulators may be beneficial for the treatment of secretory diarrheas, in which epithelial water transport is dramatically increased as a result of secretagogue activated chloride transport. The mechanism involves elevation of cAMP and stimulation of CFTR.

[0019] Although there are numerous causes of diarrhea, the major consequences of diarrheal diseases, resulting from excessive chloride transport are common to all, and include dehydration, acidosis, impaired growth and death.

[0020] Acute and chronic diarrheas represent a major medical problem in many areas of the world. Diarrhea is both a significant factor in malnutrition and the leading cause of death (5,000,000 deaths/year) in children less than five years old.

[0021] Secretory diarrheas are also a dangerous condition in patients of acquired immunodeficiency syndrome (AIDS) and chronic inflammatory bowel disease (IBD). 16 million travelers to developing countries from industrialized nations every year develop diarrhea, with the severity and number of cases of diarrhea varying depending on the country and area of travel.

[0022] Diarrhea in barn animals and pets such as cows, pigs and horses, sheep, goats, cats and dogs, also known as scours, is a major cause of death in these animals. Diarrhea can result from any major transition, such as weaning or physical movement, as well as in response to a variety of bacterial or viral infections and generally occurs within the first few hours of the animal's life.

[0023] The most common diarrhea causing bacteria is enterotoxogenic E-coli (ETEC) having the K99 pilus antigen. Common viral causes of diarrhea include rotavirus and coronavirus. Other infectious agents include cryptosporidium, giardia lamblia, and salmonella, among others.

[0024] Symptoms of rotaviral infection include excretion of watery feces, dehydration and weakness. Coronavirus causes a more severe illness in the newborn animals, and has a higher mortality rate than rotaviral infection. Often, however, a young animal may be infected with more than one virus or with a combination of viral and bacterial microorganisms at one time. This dramatically increases the severity of the disease.

[0025] Accordingly, there is a need for modulators of an ABC transporter activity, and compositions thereof, that can be used to modulate the activity of the ABC transporter in the cell

membrane of a mammal.

[0026] There is a need for methods of treating ABC transporter mediated diseases using such modulators of ABC transporter activity.

[0027] There is a need for methods of modulating an ABC transporter activity in an *ex vivo* cell membrane of a mammal.

[0028] There is a need for modulators of CFTR activity that can be used to modulate the activity of CFTR in the cell membrane of a mammal.

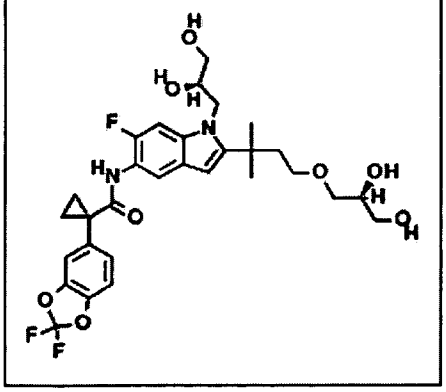
[0029] There is a need for methods of treating CFTR-mediated diseases using such modulators of CFTR activity.

[0030] There is a need for methods of modulating CFTR activity in an *ex vivo* cell membrane of a mammal.

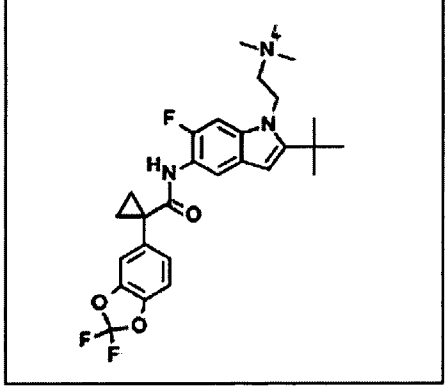
[0031] SUMMARY OF THE INVENTION

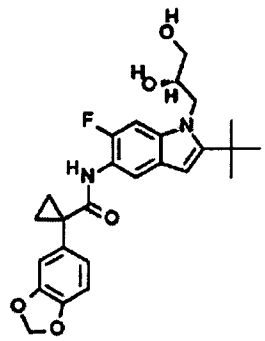
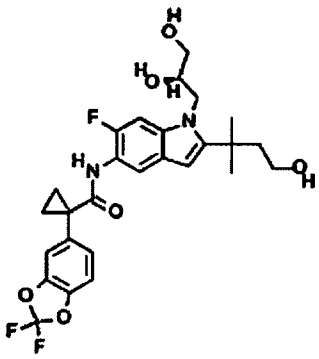
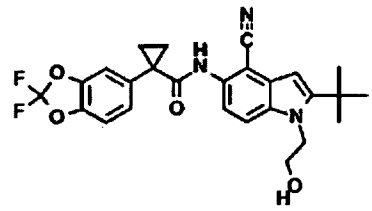
It has now been found that compounds of this invention, and pharmaceutically acceptable compositions thereof, are useful as modulators of ABC transporter activity, particularly CTFR activity. These compounds are

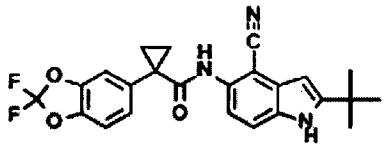
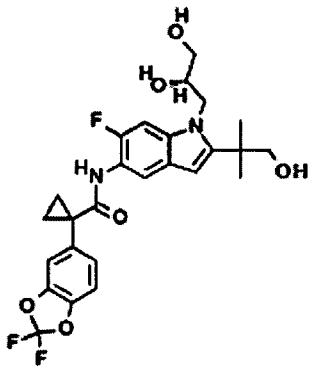
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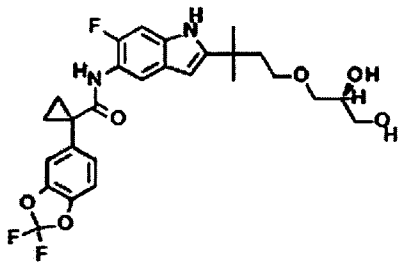
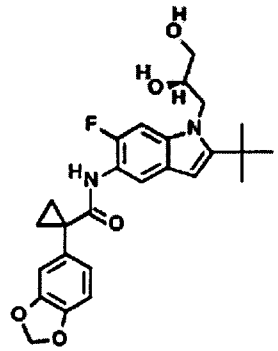


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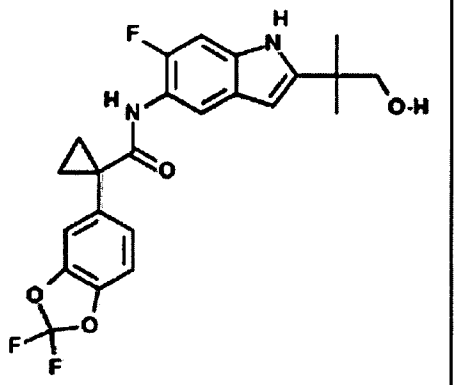


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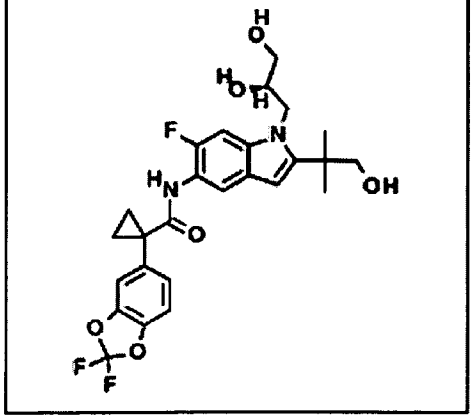
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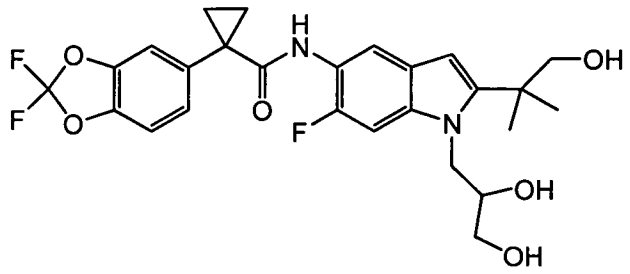


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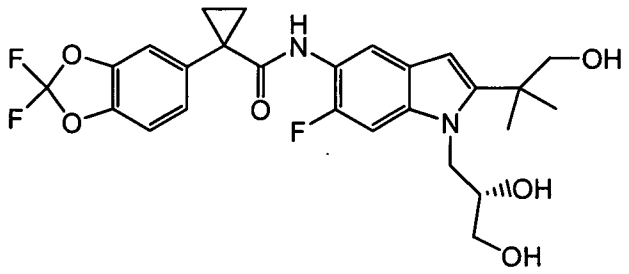
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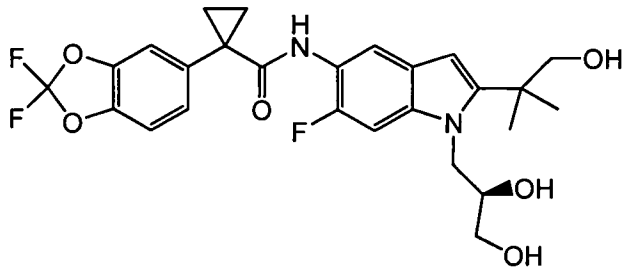
. In some embodiments, the compounds is



. In other embodiments , the compound is



. In still other embodiments, the compound is



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[0032] The compounds and pharmaceutically acceptable compositions are useful for treating or lessening the severity of a variety of diseases, disorders, or conditions, including, but not limited to, cystic fibrosis, hereditary emphysema, hereditary hemochromatosis, coagulation-fibrinolysis deficiencies, such as protein C deficiency, Type 1 hereditary angioedema, lipid processing deficiencies, such as familial hypercholesterolemia, Type 1 chylomicronemia,

abetalipoproteinemia, lysosomal storage diseases, such as I-cell disease/pseudo-Hurler, mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, polyendocrinopathy/hyperinsulemia, diabetes mellitus, laron dwarfism, myleoperoxidase deficiency, primary hypoparathyroidism, melanoma, glycanosis CDG type 1, hereditary emphysema, congenital hyperthyroidism, osteogenesis imperfecta, hereditary hypofibrinogenemia, ACT deficiency, diabetes insipidus, neurophysiol, nephrogenic, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis, progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, spinocerebullar ataxia type I, spinal and bulbar muscular atrophy, dentatorubal pallidoluysian, and myotonic dystrophy, as well as spongiform encephalopathies, such as hereditary Creutzfeldt-Jakob disease, Fabry disease, Straussler-Scheinker syndrome, COPD, dry-eye disease, and Sjögren's disease.

[0033] Unexpectedly, the compounds of this invention possess therapeutically advantageous properties.

[0034] DETAILED DESCRIPTION OF THE INVENTION

[0035] I. DEFINITIONS

[0036] As used herein, the following definitions shall apply unless otherwise indicated.

[0037] The term "ABC-transporter" as used herein means an ABC-transporter protein or a fragment thereof comprising at least one binding domain, wherein said protein or fragment thereof is present in vivo or in vitro. The term "binding domain" as used herein means a domain on the ABC-transporter that can bind to a modulator. See, e.g., Hwang, T. C. et al., J. Gen. Physiol. (1998): 111(3), 477-90.

[0038] The term "CFTR" as used herein means cystic fibrosis transmembrane conductance regulator or a mutation thereof capable of regulator activity, including, but not limited to, ΔF508 CFTR and G551D CFTR (see, e.g., http://www.genet.sickkids.on.ca/cftr/, for CFTR mutations).

[0039] The term "modulating" as used herein means increasing or decreasing, e.g. activity, by a measurable amount. Compounds that modulate ABC Transporter activity, such as CFTR activity, by increasing the activity of the ABC Transporter, e.g., a CFTR anion channel, are

called agonists. Compounds that modulate ABC Transporter activity, such as CFTR activity, by decreasing the activity of the ABC Transporter, e.g., CFTR anion channel, are called antagonists. An agonist interacts with an ABC Transporter, such as CFTR anion channel, to increase the ability of the receptor to transduce an intracellular signal in response to endogenous ligand binding. An antagonist interacts with an ABC Transporter, such as CFTR, and competes with the endogenous ligand(s) or substrate(s) for binding site(s) on the receptor to decrease the ability of the receptor to transduce an intracellular signal in response to endogenous ligand binding.

[0040] The phrase "treating or reducing the severity of an ABC Transporter mediated disease" refers both to treatments for diseases that are directly caused by ABC Transporter and/or CFTR activities and alleviation of symptoms of diseases not directly caused by ABC Transporter and/or CFTR anion channel activities. Examples of diseases whose symptoms may be affected by ABC Transporter and/or CFTR activity include, but are not limited to, Cystic fibrosis, Hereditary emphysema, Hereditary hemochromatosis, Coagulation-Fibrinolysis deficiencies, such as Protein C deficiency, Type 1 hereditary angioedema, Lipid processing deficiencies, such as Familial hypercholesterolemia, Type 1 chylomicronemia, Abetalipoproteinemia, Lysosomal storage diseases, such as I-cell disease/Pseudo-Hurler, Mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, Polyendocrinopathy/Hyperinsulemia, Diabetes mellitus, Laron dwarfism, Myleoperoxidase deficiency, Primary hypoparathyroidism, Melanoma, Glycanosis CDG type 1, Hereditary emphysema, Congenital hyperthyroidism, Osteogenesis imperfecta, Hereditary hypofibrinogenemia, ACT deficiency, Diabetes insipidus (DI), Neurophysiol DI, Nephrogenic DI, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis, Progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders such as Huntington, Spinocerebullar ataxia type I, Spinal and bulbar muscular atrophy, Dentatorubal pallidoluysian, and Myotonic dystrophy, as well as Spongiform encephalopathies, such as Hereditary Creutzfeldt-Jakob disease, Fabry disease, Straussler-Scheinker syndrome, COPD, dry-eye disease, and Sjogren's disease.

[0041] For purposes of this invention, the chemical elements are identified in accordance with the Periodic Table of the Elements, CAS version, Handbook of Chemistry and Physics, 75th Ed. Additionally, general principles of organic chemistry are described in "Organic Chemistry",

Thomas Sorrell, University Science Books, Sausolito: 1999, and "March's Advanced Organic Chemistry", 5th Ed., Ed.: Smith, M.B. and March, J., John Wiley & Sons, New York: 2001, the entire contents of which are hereby incorporated by reference.

[0042] As described herein, compounds of the invention may optionally be substituted with one or more substituents, such as are illustrated generally above, or as exemplified by particular classes, subclasses, and species of the invention.

[0043] As used herein the term "aliphatic" encompasses the terms alkyl, alkenyl, alkynyl, each of which being optionally substituted as set forth below.

[0044] As used herein, an "alkyl" group refers to a saturated aliphatic hydrocarbon group containing 1-12 (e.g., 1-8, 1-6, or 1-4) carbon atoms. An alkyl group can be straight or branched. Examples of alkyl groups include, but are not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, sec-butyl, tert-butyl, n-pentyl, n-heptyl, or 2-ethylhexyl. An alkyl group can be substituted (i.e., optionally substituted) with one or more substituents such as halo, phospho, cycloaliphatic [e.g., cycloalkyl or cycloalkenyl], heterocycloaliphatic [e.g., heterocycloalkyl or heterocycloalkenyl], aryl, heteroaryl, alkoxy, aroyl, heteroaroyl, acyl [e.g., (aliphatic)carbonyl, (cycloaliphatic)carbonyl, or (heterocycloaliphatic)carbonyl], nitro, cyano, amido [e.g., (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl)carbonylamino, (heterocycloalkylalkyl)carbonylamino, heteroarylcarbonylamino, heteroaralkylcarbonylamino alkylaminocarbonyl, cycloalkylaminocarbonyl, heterocycloalkylaminocarbonyl, arylaminocarbonyl, or heteroarylaminocarbonyl], amino [e.g., aliphaticamino, cycloaliphaticamino, or heterocycloaliphaticamino], sulfonyl [e.g., aliphatic-SO_2-], sulfinyl, sulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, carboxy, carbamoyl, cycloaliphaticoxy, heterocycloaliphaticoxy, aryloxy, heteroaryloxy, aralkyloxy, heteroarylalkoxy, alkoxycarbonyl, alkylcarbonyloxy, or hydroxy. Without limitation, some examples of substituted alkyls include carboxyalkyl (such as HOOC-alkyl, alkoxycarbonylalkyl, and alkylcarbonyloxyalkyl), cyanoalkyl, hydroxyalkyl, alkoxyalkyl, acylalkyl, aralkyl, (alkoxyaryl)alkyl, (sulfonylamino)alkyl (such as (alkyl-SO_2-amino)alkyl), aminoalkyl, amidoalkyl, (cycloaliphatic)alkyl, or haloalkyl.

[0045] As used herein, an "alkenyl" group refers to an aliphatic carbon group that contains 2-

8 (e.g., 2-12, 2-6, or 2-4) carbon atoms and at least one double bond. Like an alkyl group, an alkenyl group can be straight or branched. Examples of an alkenyl group include, but are not limited to allyl, isoprenyl, 2-butenyl, and 2-hexenyl. An alkenyl group can be optionally substituted with one or more substituents such as halo, phospho, cycloaliphatic [e.g., cycloalkyl or cycloalkenyl], heterocycloaliphatic [e.g., heterocycloalkyl or heterocycloalkenyl], aryl, heteroaryl, alkoxy, aroyl, heteroaroyl, acyl [e.g., (aliphatic)carbonyl, (cycloaliphatic)carbonyl, or (heterocycloaliphatic)carbonyl], nitro, cyano, amido [e.g., (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl)carbonylamino, (heterocycloalkylalkyl)carbonylamino, heteroarylcarbonylamino, heteroaralkylcarbonylamino alkylaminocarbonyl, cycloalkylaminocarbonyl, heterocycloalkylaminocarbonyl, arylaminocarbonyl, or heteroarylaminocarbonyl], amino [e.g., aliphaticamino, cycloaliphaticamino, heterocycloaliphaticamino, or aliphaticsulfonylamino], sulfonyl [e.g., alkyl-SO_2-, cycloaliphatic-SO_2-, or aryl-SO_2-], sulfinyl, sulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, carboxy, carbamoyl, cycloaliphaticoxy, heterocycloaliphaticoxy, aryloxy, heteroaryloxy, aralkyloxy, heteroaralkoxy, alkoxycarbonyl, alkylcarbonyloxy, or hydroxy. Without limitation, some examples of substituted alkenyls include cyanoalkenyl, alkoxyalkenyl, acylalkenyl, hydroxyalkenyl, aralkenyl, (alkoxyaryl)alkenyl, (sulfonylamino)alkenyl (such as (alkyl-SO_2-amino)alkenyl), aminoalkenyl, amidoalkenyl, (cycloaliphatic)alkenyl, or haloalkenyl.

[0046] As used herein, an "alkynyl" group refers to an aliphatic carbon group that contains 2-8 (e.g., 2-12, 2-6, or 2-4) carbon atoms and has at least one triple bond. An alkynyl group can be straight or branched. Examples of an alkynyl group include, but are not limited to, propargyl and butynyl. An alkynyl group can be optionally substituted with one or more substituents such as aroyl, heteroaroyl, alkoxy, cycloalkyloxy, heterocycloalkyloxy, aryloxy, heteroaryloxy, aralkyloxy, nitro, carboxy, cyano, halo, hydroxy, sulfo, mercapto, sulfanyl [e.g., aliphaticsulfanyl or cycloaliphaticsulfanyl], sulfinyl [e.g., aliphaticsulfinyl or cycloaliphaticsulfinyl], sulfonyl [e.g., aliphatic-SO_2-, aliphaticamino-SO_2-, or cycloaliphatic-SO_2-], amido [e.g., aminocarbonyl, alkylaminocarbonyl, alkylcarbonylamino, cycloalkylaminocarbonyl, heterocycloalkylaminocarbonyl, cycloalkylcarbonylamino, arylaminocarbonyl, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl)carbonylamino, (cycloalkylalkyl)carbonylamino, heteroaralkylcarbonylamino, heteroarylcarbonylamino or

heteroarylaminocarbonyl], urea, thiourea, sulfamoyl, sulfamide, alkoxycarbonyl, alkylcarbonyloxy, cycloaliphatic, heterocycloaliphatic, aryl, heteroaryl, acyl [e.g., (cycloaliphatic)carbonyl or (heterocycloaliphatic)carbonyl], amino [e.g., aliphaticamino], sulfoxy, oxo, carboxy, carbamoyl, (cycloaliphatic)oxy, (heterocycloaliphatic)oxy, or (heteroaryl)alkoxy.

[0047] As used herein, an "amido" encompasses both "aminocarbonyl" and "carbonylamino". These terms when used alone or in connection with another group refer to an amido group such as $-N(R^X)-C(O)-R^Y$ or $-C(O)-N(R^X)_2$, when used terminally, and $-C(O)-N(R^X)-$ or $-N(R^X)-C(O)-$ when used internally, wherein R^X and R^Y are defined below. Examples of amido groups include alkylamido (such as alkylcarbonylamino or alkylaminocarbonyl), (heterocycloaliphatic)amido, (heteroaralkyl)amido, (heteroaryl)amido, (heterocycloalkyl)alkylamido, arylamido, aralkylamido, (cycloalkyl)alkylamido, or cycloalkylamido.

[0048] As used herein, an "amino" group refers to $-NR^XR^Y$ wherein each of R^X and R^Y is independently hydrogen, aliphatic, cycloaliphatic, (cycloaliphatic)aliphatic, aryl, araliphatic, heterocycloaliphatic, (heterocycloaliphatic)aliphatic, heteroaryl, carboxy, sulfanyl, sulfinyl, sulfonyl, (aliphatic)carbonyl, (cycloaliphatic)carbonyl, ((cycloaliphatic)aliphatic)carbonyl, arylcarbonyl, (araliphatic)carbonyl, (heterocycloaliphatic)carbonyl, ((heterocycloaliphatic)aliphatic)carbonyl, (heteroaryl)carbonyl, or (heteroaraliphatic)carbonyl, each of which being defined herein and being optionally substituted. Examples of amino groups include alkylamino, dialkylamino, or arylamino. When the term "amino" is not the terminal group (e.g., alkylcarbonylamino), it is represented by $-NR^X-$. R^X has the same meaning as defined above.

[0049] As used herein, an "aryl" group used alone or as part of a larger moiety as in "aralkyl", "aralkoxy", or "aryloxyalkyl" refers to monocyclic (e.g., phenyl); bicyclic (e.g., indenyl, naphthalenyl, tetrahydronaphthyl, tetrahydroindenyl); and tricyclic (e.g., fluorenyl tetrahydrofluorenyl, or tetrahydroanthracenyl, anthracenyl) ring systems in which the monocyclic ring system is aromatic or at least one of the rings in a bicyclic or tricyclic ring system is aromatic. The bicyclic and tricyclic groups include benzofused 2-3 membered carbocyclic rings. For example, a benzofused group includes phenyl fused with two or more C_{4-8} carbocyclic moieties. An aryl is optionally substituted with one or more substituents

including aliphatic [e.g., alkyl, alkenyl, or alkynyl]; cycloaliphatic; (cycloaliphatic)aliphatic; heterocycloaliphatic; (heterocycloaliphatic)aliphatic; aryl; heteroaryl; alkoxy; (cycloaliphatic)oxy; (heterocycloaliphatic)oxy; aryloxy; heteroaryloxy; (araliphatic)oxy; (heteroaraliphatic)oxy; aroyl; heteroaroyl; amino; oxo (on a non-aromatic carbocyclic ring of a benzofused bicyclic or tricyclic aryl); nitro; carboxy; amido; acyl [e.g., (aliphatic)carbonyl; (cycloaliphatic)carbonyl; ((cycloaliphatic)aliphatic)carbonyl; (araliphatic)carbonyl; (heterocycloaliphatic)carbonyl; ((heterocycloaliphatic)aliphatic)carbonyl; or (heteroaraliphatic)carbonyl]; sulfonyl [e.g., aliphatic-SO_2- or amino-SO_2-]; sulfinyl [e.g., aliphatic-S(O)- or cycloaliphatic-S(O)-]; sulfanyl [e.g., aliphatic-S-]; cyano; halo; hydroxy; mercapto; sulfoxy; urea; thiourea; sulfamoyl; sulfamide; or carbamoyl. Alternatively, an aryl can be unsubstituted.

[0050] Non-limiting examples of substituted aryls include haloaryl [e.g., mono-, di (such as *p,m*-dihaloaryl), and (trihalo)aryl]; (carboxy)aryl [e.g., (alkoxycarbonyl)aryl, ((aralkyl)carbonyloxy)aryl, and (alkoxycarbonyl)aryl]; (amido)aryl [e.g., (aminocarbonyl)aryl, (((alkylamino)alkyl)aminocarbonyl)aryl, (alkylcarbonyl)aminoaryl, (arylaminocarbonyl)aryl, and (((heteroaryl)amino)carbonyl)aryl]; aminoaryl [e.g., ((alkylsulfonyl)amino)aryl or ((dialkyl)amino)aryl]; (cyanoalkyl)aryl; (alkoxy)aryl; (sulfamoyl)aryl [e.g., (aminosulfonyl)aryl]; (alkylsulfonyl)aryl; (cyano)aryl; (hydroxyalkyl)aryl; ((alkoxy)alkyl)aryl; (hydroxy)aryl, ((carboxy)alkyl)aryl; (((dialkyl)amino)alkyl)aryl; (nitroalkyl)aryl; (((alkylsulfonyl)amino)alkyl)aryl; ((heterocycloaliphatic)carbonyl)aryl; ((alkylsulfonyl)alkyl)aryl; (cyanoalkyl)aryl; (hydroxyalkyl)aryl; (alkylcarbonyl)aryl; alkylaryl; (trihaloalkyl)aryl; *p*-amino-*m*-alkoxycarbonylaryl; *p*-amino-*m*-cyanoaryl; *p*-halo-*m*-aminoaryl; or (*m*-(heterocycloaliphatic)-*o*-(alkyl))aryl.

[0051] As used herein, an "araliphatic" such as an "aralkyl" group refers to an aliphatic group (e.g., a C_{1-4} alkyl group) that is substituted with an aryl group. "Aliphatic," "alkyl," and "aryl" are defined herein. An example of an araliphatic such as an aralkyl group is benzyl.

[0052] As used herein, an "aralkyl" group refers to an alkyl group (e.g., a C_{1-4} alkyl group) that is substituted with an aryl group. Both "alkyl" and "aryl" have been defined above. An example of an aralkyl group is benzyl. An aralkyl is optionally substituted with one or more substituents such as aliphatic [e.g., alkyl, alkenyl, or alkynyl, including carboxyalkyl,

hydroxyalkyl, or haloalkyl such as trifluoromethyl], cycloaliphatic [e.g., cycloalkyl or cycloalkenyl], (cycloalkyl)alkyl, heterocycloalkyl, (heterocycloalkyl)alkyl, aryl, heteroaryl, alkoxy, cycloalkyloxy, heterocycloalkyloxy, aryloxy, heteroaryloxy, aralkyloxy, heteroaralkyloxy, aroyl, heteroaroyl, nitro, carboxy, alkoxycarbonyl, alkylcarbonyloxy, amido [e.g., aminocarbonyl, alkylcarbonylamino, cycloalkylcarbonylamino, (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl)carbonylamino, (heterocycloalkylalkyl)carbonylamino, heteroarylcarbonylamino, or heteroaralkylcarbonylamino], cyano, halo, hydroxy, acyl, mercapto, alkylsulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, or carbamoyl.

[0053] As used herein, a "bicyclic ring system" includes 8-12 (e.g., 9, 10, or 11) membered structures that form two rings, wherein the two rings have at least one atom in common (e.g., 2 atoms in common). Bicyclic ring systems include bicycloaliphatics (e.g., bicycloalkyl or bicycloalkenyl), bicycloheteroaliphatics, bicyclic aryls, and bicyclic heteroaryls.

[0054] As used herein, a "carbocycle" or "cycloaliphatic" group encompasses a "cycloalkyl" group and a "cycloalkenyl" group, each of which being optionally substituted as set forth below.

[0055] As used herein, a "cycloalkyl" group refers to a saturated carbocyclic mono- or bicyclic (fused or bridged) ring of 3-10 (e.g., 5-10) carbon atoms. Examples of cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, adamantyl, norbornyl, cubyl, octahydro-indenyl, decahydro-naphthyl, bicyclo[3.2.1]octyl, bicyclo[2.2.2]octyl, bicyclo[3.3.1]nonyl, bicyclo[3.3.2.]decyl, bicyclo[2.2.2]octyl, adamantyl, or ((aminocarbonyl)cycloalkyl)cycloalkyl.

[0056] A "cycloalkenyl" group, as used herein, refers to a non-aromatic carbocyclic ring of 3-10 (e.g., 4-8) carbon atoms having one or more double bonds. Examples of cycloalkenyl groups include cyclopentenyl, 1,4-cyclohexa-di-enyl, cycloheptenyl, cyclooctenyl, hexahydro-indenyl, octahydro-naphthyl, cyclohexenyl, cyclopentenyl, bicyclo[2.2.2]octenyl, or bicyclo[3.3.1]nonenyl.

[0057] A cycloalkyl or cycloalkenyl group can be optionally substituted with one or more substituents such as phosphor, aliphatic [e.g., alkyl, alkenyl, or alkynyl], cycloaliphatic, (cycloaliphatic) aliphatic, heterocycloaliphatic, (heterocycloaliphatic) aliphatic, aryl, heteroaryl, alkoxy, (cycloaliphatic)oxy, (heterocycloaliphatic)oxy, aryloxy, heteroaryloxy, (araliphatic)oxy,

(heteroaraliphatic)oxy, aroyl, heteroaroyl, amino, amido [e.g., (aliphatic)carbonylamino, (cycloaliphatic)carbonylamino, ((cycloaliphatic)aliphatic)carbonylamino, (aryl)carbonylamino, (araliphatic)carbonylamino, (heterocycloaliphatic)carbonylamino, ((heterocycloaliphatic)aliphatic)carbonylamino, (heteroaryl)carbonylamino, or (heteroaraliphatic)carbonylamino], nitro, carboxy [e.g., HOOC-, alkoxycarbonyl, or alkylcarbonyloxy], acyl [e.g., (cycloaliphatic)carbonyl, ((cycloaliphatic) aliphatic)carbonyl, (araliphatic)carbonyl, (heterocycloaliphatic)carbonyl, ((heterocycloaliphatic)aliphatic)carbonyl, or (heteroaraliphatic)carbonyl], cyano, halo, hydroxy, mercapto, sulfonyl [e.g., alkyl-SO_2- and aryl-SO_2-], sulfinyl [e.g., alkyl-S(O)-], sulfanyl [e.g., alkyl-S-], sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, or carbamoyl.

[0058] As used herein, the term "heterocycle" or "heterocycloaliphatic" encompasses a heterocycloalkyl group and a heterocycloalkenyl group, each of which being optionally substituted as set forth below.

[0059] As used herein, a "heterocycloalkyl" group refers to a 3-10 membered mono- or bicylic (fused or bridged) (e.g., 5- to 10-membered mono- or bicyclic) saturated ring structure, in which one or more of the ring atoms is a heteroatom (e.g., N, O, S, or combinations thereof). Examples of a heterocycloalkyl group include piperidyl, piperazyl, tetrahydropyranyl, tetrahydrofuryl, 1,4-dioxolanyl, 1,4-dithianyl, 1,3-dioxolanyl, oxazolidyl, isoxazolidyl, morpholinyl, thiomorpholyl, octahydrobenzofuryl, octahydrochromenyl, octahydrothiochromenyl, octahydroindolyl, octahydropyrindinyl, decahydroquinolinyl, octahydrobenzo[*b*]thiopheneyl, 2-oxa-bicyclo[2.2.2]octyl, 1-aza-bicyclo[2.2.2]octyl, 3-aza-bicyclo[3.2.1]octyl, and 2,6-dioxa-tricyclo[3.3.1.$0^{3,7}$]nonyl. A monocyclic heterocycloalkyl group can be fused with a phenyl moiety to form structures, such as tetrahydroisoquinoline, which would be categorized as heteroaryls.

[0060] A "heterocycloalkenyl" group, as used herein, refers to a mono- or bicylic (e.g., 5- to 10-membered mono- or bicyclic) non-aromatic ring structure having one or more double bonds, and wherein one or more of the ring atoms is a heteroatom (e.g., N, O, or S). Monocyclic and bicyclic heterocycloaliphatics are numbered according to standard chemical nomenclature.

[0061] A heterocycloalkyl or heterocycloalkenyl group can be optionally substituted with one or more substituents such as phosphor, aliphatic [e.g., alkyl, alkenyl, or alkynyl], cycloaliphatic,

(cycloaliphatic)aliphatic, heterocycloaliphatic, (heterocycloaliphatic)aliphatic, aryl, heteroaryl, alkoxy, (cycloaliphatic)oxy, (heterocycloaliphatic)oxy, aryloxy, heteroaryloxy, (araliphatic)oxy, (heteroaraliphatic)oxy, aroyl, heteroaroyl, amino, amido [e.g., (aliphatic)carbonylamino, (cycloaliphatic)carbonylamino, ((cycloaliphatic) aliphatic)carbonylamino, (aryl)carbonylamino, (araliphatic)carbonylamino, (heterocycloaliphatic)carbonylamino, ((heterocycloaliphatic) aliphatic)carbonylamino, (heteroaryl)carbonylamino, or (heteroaraliphatic)carbonylamino], nitro, carboxy [e.g., HOOC-, alkoxycarbonyl, or alkylcarbonyloxy], acyl [e.g., (cycloaliphatic)carbonyl, ((cycloaliphatic) aliphatic)carbonyl, (araliphatic)carbonyl, (heterocycloaliphatic)carbonyl, ((heterocycloaliphatic)aliphatic)carbonyl, or (heteroaraliphatic)carbonyl], nitro, cyano, halo, hydroxy, mercapto, sulfonyl [e.g., alkylsulfonyl or arylsulfonyl], sulfinyl [e.g., alkylsulfinyl], sulfanyl [e.g., alkylsulfanyl], sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, or carbamoyl.

[0062] A "heteroaryl" group, as used herein, refers to a monocyclic, bicyclic, or tricyclic ring system having 4 to 15 ring atoms wherein one or more of the ring atoms is a heteroatom (e.g., N, O, S, or combinations thereof) and in which the monocyclic ring system is aromatic or at least one of the rings in the bicyclic or tricyclic ring systems is aromatic. A heteroaryl group includes a benzofused ring system having 2 to 3 rings. For example, a benzofused group includes benzo fused with one or two 4 to 8 membered heterocycloaliphatic moieties (e.g., indolizyl, indolyl, isoindolyl, 3H-indolyl, indolinyl, benzo[*b*]furyl, benzo[*b*]thiophenyl, quinolinyl, or isoquinolinyl). Some examples of heteroaryl are azetidinyl, pyridyl, 1H-indazolyl, furyl, pyrrolyl, thienyl, thiazolyl, oxazolyl, imidazolyl, tetrazolyl, benzofuryl, isoquinolinyl, benzthiazolyl, xanthene, thioxanthene, phenothiazine, dihydroindole, benzo[1,3]dioxole, benzo[b]furyl, benzo[b]thiophenyl, indazolyl, benzimidazolyl, benzthiazolyl, puryl, cinnolyl, quinolyl, quinazolyl,cinnolyl, phthalazyl, quinazolyl, quinoxalyl, isoquinolyl, 4H-quinolizyl, benzo-1,2,5-thiadiazolyl, or 1,8-naphthyridyl.

[0063] Without limitation, monocyclic heteroaryls include furyl, thiophenyl, 2H-pyrrolyl, pyrrolyl, oxazolyl, thazolyl, imidazolyl, pyrazolyl, isoxazolyl, isothiazolyl, 1,3,4-thiadiazolyl, 2H-pyranyl, 4-H-pranyl, pyridyl, pyridazyl, pyrimidyl, pyrazolyl, pyrazyl, or 1,3,5-triazyl. Monocyclic heteroaryls are numbered according to standard chemical nomenclature.

[0064] Without limitation, bicyclic heteroaryls include indolizyl, indolyl, isoindolyl, 3H-indolyl, indolinyl, benzo[*b*]furyl, benzo[*b*]thiophenyl, quinolinyl, isoquinolinyl, indolizinyl, isoindolyl, indolyl, benzo[*b*]furyl, bexo[*b*]thiophenyl, indazolyl, benzimidazyl, benzthiazolyl, purinyl, 4H-quinolizyl, quinolyl, isoquinolyl, cinnolyl, phthalazyl, quinazolyl, quinoxalyl, 1,8-naphthyridyl, or pteridyl. Bicyclic heteroaryls are numbered according to standard chemical nomenclature.

[0065] A heteroaryl is optionally substituted with one or more substituents such as aliphatic [e.g., alkyl, alkenyl, or alkynyl]; cycloaliphatic; (cycloaliphatic)aliphatic; heterocycloaliphatic; (heterocycloaliphatic)aliphatic; aryl; heteroaryl; alkoxy; (cycloaliphatic)oxy; (heterocycloaliphatic)oxy; aryloxy; heteroaryloxy; (araliphatic)oxy; (heteroaraliphatic)oxy; aroyl; heteroaroyl; amino; oxo (on a non-aromatic carbocyclic or heterocyclic ring of a bicyclic or tricyclic heteroaryl); carboxy; amido; acyl [e.g., aliphaticcarbonyl; (cycloaliphatic)carbonyl; ((cycloaliphatic)aliphatic)carbonyl; (araliphatic)carbonyl; (heterocycloaliphatic)carbonyl; ((heterocycloaliphatic)aliphatic)carbonyl; or (heteroaraliphatic)carbonyl]; sulfonyl [e.g., aliphaticsulfonyl or aminosulfonyl]; sulfinyl [e.g., aliphaticsulfinyl]; sulfanyl [e.g., aliphaticsulfanyl]; nitro; cyano; halo; hydroxy; mercapto; sulfoxy; urea; thiourea; sulfamoyl; sulfamide; or carbamoyl. Alternatively, a heteroaryl can be unsubstituted.

[0066] Non-limiting examples of substituted heteroaryls include (halo)heteroaryl [e.g., mono- and di-(halo)heteroaryl]; (carboxy)heteroaryl [e.g., (alkoxycarbonyl)heteroaryl]; cyanoheteroaryl; aminoheteroaryl [e.g., ((alkylsulfonyl)amino)heteroaryl and ((dialkyl)amino)heteroaryl]; (amido)heteroaryl [e.g., aminocarbonylheteroaryl, ((alkylcarbonyl)amino)heteroaryl, ((((alkyl)amino)alkyl)aminocarbonyl)heteroaryl, (((heteroaryl)amino)carbonyl)heteroaryl, ((heterocycloaliphatic)carbonyl)heteroaryl, and ((alkylcarbonyl)amino)heteroaryl]; (cyanoalkyl)heteroaryl; (alkoxy)heteroaryl; (sulfamoyl)heteroaryl [e.g., (aminosulfonyl)heteroaryl]; (sulfonyl)heteroaryl [e.g., (alkylsulfonyl)heteroaryl]; (hydroxyalkyl)heteroaryl; (alkoxyalkyl)heteroaryl; (hydroxy)heteroaryl; ((carboxy)alkyl)heteroaryl; (((dialkyl)amino)alkyl]heteroaryl; (heterocycloaliphatic)heteroaryl; (cycloaliphatic)heteroaryl; (nitroalkyl)heteroaryl; (((alkylsulfonyl)amino)alkyl)heteroaryl; ((alkylsulfonyl)alkyl)heteroaryl; (cyanoalkyl)heteroaryl; (acyl)heteroaryl [e.g., (alkylcarbonyl)heteroaryl]; (alkyl)heteroaryl, and (haloalkyl)heteroaryl [e.g., trihaloalkylheteroaryl].

[0067] A "heteroaraliphatic" (such as a heteroaralkyl group) as used herein, refers to an aliphatic group (e.g., a C_{1-4} alkyl group) that is substituted with a heteroaryl group. "Aliphatic," "alkyl," and "heteroaryl" have been defined above.

[0068] A "heteroaralkyl" group, as used herein, refers to an alkyl group (e.g., a C_{1-4} alkyl group) that is substituted with a heteroaryl group. Both "alkyl" and "heteroaryl" have been defined above. A heteroaralkyl is optionally substituted with one or more substituents such as alkyl (including carboxyalkyl, hydroxyalkyl, and haloalkyl such as trifluoromethyl), alkenyl, alkynyl, cycloalkyl, (cycloalkyl)alkyl, heterocycloalkyl, (heterocycloalkyl)alkyl, aryl, heteroaryl, alkoxy, cycloalkyloxy, heterocycloalkyloxy, aryloxy, heteroaryloxy, aralkyloxy, heteroaralkyloxy, aroyl, heteroaroyl, nitro, carboxy, alkoxycarbonyl, alkylcarbonyloxy, aminocarbonyl, alkylcarbonylamino, cycloalkylcarbonylamino, (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino, (heterocycloalkyl)carbonylamino, (heterocycloalkylalkyl)carbonylamino, heteroarylcarbonylamino, heteroaralkylcarbonylamino, cyano, halo, hydroxy, acyl, mercapto, alkylsulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, or carbamoyl.

[0069] As used herein, "cyclic moiety" and "cyclic group" refer to mono-, bi-, and tri-cyclic ring systems including cycloaliphatic, heterocycloaliphatic, aryl, or heteroaryl, each of which has been previously defined.

[0070] As used herein, a "bridged bicyclic ring system" refers to a bicyclic heterocyclicaliphatic ring system or bicyclic cycloaliphatic ring system in which the rings are bridged. Examples of bridged bicyclic ring systems include, but are not limited to, adamantanyl, norbornanyl, bicyclo[3.2.1]octyl, bicyclo[2.2.2]octyl, bicyclo[3.3.1]nonyl, bicyclo[3.2.3]nonyl, 2-oxabicyclo[2.2.2]octyl, 1-azabicyclo[2.2.2]octyl, 3-azabicyclo[3.2.1]octyl, and 2,6-dioxa-tricyclo[3.3.1.$0^{3,7}$]nonyl. A bridged bicyclic ring system can be optionally substituted with one or more substituents such as alkyl (including carboxyalkyl, hydroxyalkyl, and haloalkyl such as trifluoromethyl), alkenyl, alkynyl, cycloalkyl, (cycloalkyl)alkyl, heterocycloalkyl, (heterocycloalkyl)alkyl, aryl, heteroaryl, alkoxy, cycloalkyloxy, heterocycloalkyloxy, aryloxy, heteroaryloxy, aralkyloxy, heteroaralkyloxy, aroyl, heteroaroyl, nitro, carboxy, alkoxycarbonyl, alkylcarbonyloxy, aminocarbonyl, alkylcarbonylamino, cycloalkylcarbonylamino, (cycloalkylalkyl)carbonylamino, arylcarbonylamino, aralkylcarbonylamino,

(heterocycloalkyl)carbonylamino, (heterocycloalkylalkyl)carbonylamino, heteroarylcarbonylamino, heteroaralkylcarbonylamino, cyano, halo, hydroxy, acyl, mercapto, alkylsulfanyl, sulfoxy, urea, thiourea, sulfamoyl, sulfamide, oxo, or carbamoyl.

[0071] As used herein, an "acyl" group refers to a formyl group or R^X-C(O)- (such as alkyl-C(O)-, also referred to as "alkylcarbonyl") where R^X and "alkyl" have been defined previously. Acetyl and pivaloyl are examples of acyl groups.

[0072] As used herein, an "aroyl" or "heteroaroyl" refers to an aryl-C(O)- or a heteroaryl-C(O)-. The aryl and heteroaryl portion of the aroyl or heteroaroyl is optionally substituted as previously defined.

[0073] As used herein, an "alkoxy" group refers to an alkyl-O- group where "alkyl" has been defined previously.

[0074] As used herein, a "carbamoyl" group refers to a group having the structure -O-CO-NR^XR^Y or -NR^X-CO-O-R^Z, wherein R^X and R^Y have been defined above and R^Z can be aliphatic, aryl, araliphatic, heterocycloaliphatic, heteroaryl, or heteroaraliphatic.

[0075] As used herein, a "carboxy" group refers to -COOH, -$COOR^X$, -OC(O)H, -$OC(O)R^X$, when used as a terminal group; or -OC(O)- or -C(O)O- when used as an internal group.

[0076] As used herein, a "haloaliphatic" group refers to an aliphatic group substituted with 1-3 halogen. For instance, the term haloalkyl includes the group -CF_3.

[0077] As used herein, a "mercapto" group refers to -SH.

[0078] As used herein, a "sulfo" group refers to -SO_3H or -SO_3R^X when used terminally or -$S(O)_3$- when used internally.

[0079] As used herein, a "sulfamide" group refers to the structure -NR^X-$S(O)_2$-NR^YR^Z when used terminally and -NR^X-$S(O)_2$-NR^Y- when used internally, wherein R^X, R^Y, and R^Z have been defined above.

[0080] As used herein, a "sulfonamide" group refers to the structure -$S(O)_2$-NR^XR^Y or -NR^X-$S(O)_2$-R^Z when used terminally; or -$S(O)_2$-NR^X- or -NR^X -$S(O)_2$- when used internally, wherein R^X, R^Y, and R^Z are defined above.

[0081] As used herein a "sulfanyl" group refers to -S-R^X when used terminally and -S- when used internally, wherein R^X has been defined above. Examples of sulfanyls include aliphatic-S-, cycloaliphatic-S-, aryl-S-, or the like.

[0082] As used herein a "sulfinyl" group refers to -S(O)-R^X when used terminally and -S(O)- when used internally, wherein R^X has been defined above. Exemplary sulfinyl groups include aliphatic-S(O)-, aryl-S(O)-, (cycloaliphatic(aliphatic))-S(O)-, cycloalkyl-S(O)-, heterocycloaliphatic-S(O)-, heteroaryl-S(O)-, or the like.

[0083] As used herein, a "sulfonyl" group refers to-$S(O)_2$-R^X when used terminally and -$S(O)_2$- when used internally, wherein R^X has been defined above. Exemplary sulfonyl groups include aliphatic-$S(O)_2$-, aryl-$S(O)_2$-, (cycloaliphatic(aliphatic))-$S(O)_2$-, cycloaliphatic-$S(O)_2$-, heterocycloaliphatic-$S(O)_2$-, heteroaryl-$S(O)_2$-, (cycloaliphatic(amido(aliphatic)))-$S(O)_2$-or the like.

[0084] As used herein, a "sulfoxy" group refers to -O-SO-R^X or -SO-O-R^X, when used terminally and -O-S(O)- or -S(O)-O- when used internally, where R^X has been defined above.

[0085] As used herein, a "halogen" or "halo" group refers to fluorine, chlorine, bromine or iodine.

[0086] As used herein, an "alkoxycarbonyl," which is encompassed by the term carboxy, used alone or in connection with another group refers to a group such as alkyl-O-C(O)-.

[0087] As used herein, an "alkoxyalkyl" refers to an alkyl group such as alkyl-O-alkyl-, wherein alkyl has been defined above.

[0088] As used herein, a "carbonyl" refer to -C(O)-.

[0089] As used herein, an "oxo" refers to =O.

[0090] As used herein, the term "phospho" refers to phosphinates and phosphonates. Examples of phosphinates and phosphonates include -P(O)(R^P)$_2$, wherein R^P is aliphatic, alkoxy, aryloxy, heteroaryloxy, (cycloaliphatic)oxy, (heterocycloaliphatic)oxy aryl, heteroaryl, cycloaliphatic or amino.

[0091] As used herein, an "aminoalkyl" refers to the structure (R^X)$_2$N-alkyl-.

[0092] As used herein, a "cyanoalkyl" refers to the structure (NC)-alkyl-.

[0093] As used herein, a "urea" group refers to the structure $-NR^X-CO-NR^YR^Z$ and a "thiourea" group refers to the structure $-NR^X-CS-NR^YR^Z$ when used terminally and $-NR^X-CO-NR^Y-$ or
$-NR^X-CS-NR^Y-$ when used internally, wherein R^X, R^Y, and R^Z have been defined above.

[0094] As used herein, a "guanidine" group refers to the structure $-N=C(N(R^XR^Y))N(R^XR^Y)$ or
$-NR^X-C(=NR^X)NR^XR^Y$ wherein R^X and R^Y have been defined above.

[0095] As used herein, the term "amidino" group refers to the structure $-C=(NR^X)N(R^XR^Y)$ wherein R^X and R^Y have been defined above.

[0096] In general, the term "vicinal" refers to the placement of substituents on a group that includes two or more carbon atoms, wherein the substituents are attached to adjacent carbon atoms.

[0097] In general, the term "geminal" refers to the placement of substituents on a group that includes two or more carbon atoms, wherein the substituents are attached to the same carbon atom.

[0098] The terms "terminally" and "internally" refer to the location of a group within a substituent. A group is terminal when the group is present at the end of the substituent not further bonded to the rest of the chemical structure. Carboxyalkyl, i.e., $R^XO(O)C$-alkyl is an example of a carboxy group used terminally. A group is internal when the group is present in the middle of a substituent of the chemical structure. Alkylcarboxy (e.g., alkyl-C(O)O- or alkyl-OC(O)-) and alkylcarboxyaryl (e.g., alkyl-C(O)O-aryl- or alkyl-O(CO)-aryl-) are examples of carboxy groups used internally.

[0099] As used herein, an "aliphatic chain" refers to a branched or straight aliphatic group (e.g., alkyl groups, alkenyl groups, or alkynyl groups). A straight aliphatic chain has the structure
$-[CH_2]_v-$, where v is 1-12. A branched aliphatic chain is a straight aliphatic chain that is substituted with one or more aliphatic groups. A branched aliphatic chain has the structure $-[CQQ]_v-$ where each Q is independently a hydrogen or an aliphatic group; however, Q shall be

an aliphatic group in at least one instance. The term aliphatic chain includes alkyl chains, alkenyl chains, and alkynyl chains, where alkyl, alkenyl, and alkynyl are defined above.

[00100] The phrase "optionally substituted" is used interchangeably with the phrase "substituted or unsubstituted." As described herein, compounds of the invention can optionally be substituted with one or more substituents, such as are illustrated generally above, or as exemplified by particular classes, subclasses, and species of the invention. As described herein, the variables R_1, R_2, and R_3, and other variables contained in formulae described herein encompass specific groups, such as alkyl and aryl. Unless otherwise noted, each of the specific groups for the variables R_1, R_2, and R_3, and other variables contained therein can be optionally substituted with one or more substituents described herein. Each substituent of a specific group is further optionally substituted with one to three of halo, cyano, oxo, alkoxy, hydroxy, amino, nitro, aryl, cycloaliphatic, heterocycloaliphatic, heteroaryl, haloalkyl, and alkyl. For instance, an alkyl group can be substituted with alkylsulfanyl and the alkylsulfanyl can be optionally substituted with one to three of halo, cyano, oxo, alkoxy, hydroxy, amino, nitro, aryl, haloalkyl, and alkyl. As an additional example, the cycloalkyl portion of a (cycloalkyl)carbonylamino can be optionally substituted with one to three of halo, cyano, alkoxy, hydroxy, nitro, haloalkyl, and alkyl. When two alkoxy groups are bound to the same atom or adjacent atoms, the two alkxoy groups can form a ring together with the atom(s) to which they are bound.

[00101] In general, the term "substituted," whether preceded by the term "optionally" or not, refers to the replacement of hydrogen radicals in a given structure with the radical of a specified substituent. Specific substituents are described above in the definitions and below in the description of compounds and examples thereof. Unless otherwise indicated, an optionally substituted group can have a substituent at each substitutable position of the group, and when more than one position in any given structure can be substituted with more than one substituent selected from a specified group, the substituent can be either the same or different at every position. A ring substituent, such as a heterocycloalkyl, can be bound to another ring, such as a cycloalkyl, to form a spiro-bicyclic ring system, e.g., both rings share one common atom. As one of ordinary skill in the art will recognize, combinations of substituents envisioned by this invention are those combinations that result in the formation of stable or chemically feasible compounds.

[00102] The phrase "stable or chemically feasible," as used herein, refers to compounds that are not substantially altered when subjected to conditions to allow for their production, detection, and preferably their recovery, purification, and use for one or more of the purposes disclosed herein. In some embodiments, a stable compound or chemically feasible compound is one that is not substantially altered when kept at a temperature of 40 °C or less, in the absence of moisture or other chemically reactive conditions, for at least a week.

[00103] As used herein, an "effective amount" is defined as the amount required to confer a therapeutic effect on the treated patient, and is typically determined based on age, surface area, weight, and condition of the patient. The interrelationship of dosages for animals and humans (based on milligrams per meter squared of body surface) is described by Freireich et al., Cancer Chemother. Rep., 50: 219 (1966). Body surface area may be approximately determined from height and weight of the patient. See, e.g., Scientific Tables, Geigy Pharmaceuticals, Ardsley, New York, 537 (1970). As used herein, "patient" refers to a mammal, including a human.

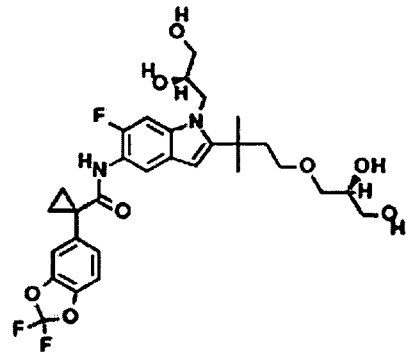
[00104] Unless otherwise stated, structures depicted herein are also meant to include all isomeric (e.g., enantiomeric, diastereomeric, and geometric (or conformational)) forms of the structure; for example, the R and S configurations for each asymmetric center, (Z) and (E) double bond isomers, and (Z) and (E) conformational isomers. Therefore, single stereochemical isomers as well as enantiomeric, diastereomeric, and geometric (or conformational) mixtures of the present compounds are within the scope of the invention. Unless otherwise stated, all tautomeric forms of the compounds of the invention are within the scope of the invention. Additionally, unless otherwise stated, structures depicted herein are also meant to include compounds that differ only in the presence of one or more isotopically enriched atoms. For example, compounds having the present structures except for the replacement of hydrogen by deuterium or tritium, or the replacement of a carbon by a ^{13}C- or ^{14}C-enriched carbon are within the scope of this invention. Such compounds are useful, for example, as analytical tools or probes in biological assays, or as therapeutic agents.

[00105] Compounds of the present invention are useful modulators of ABC transporters and are useful in the treatment of ABC transporter mediated diseases.

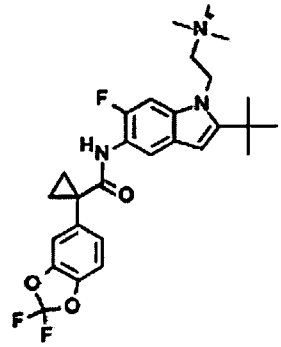
[00106] II. COMPOUNDS

[00107] Compounds of the present invention are

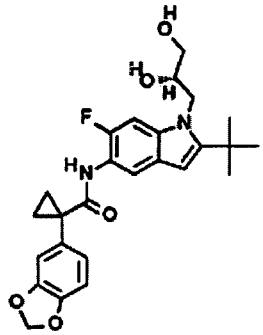
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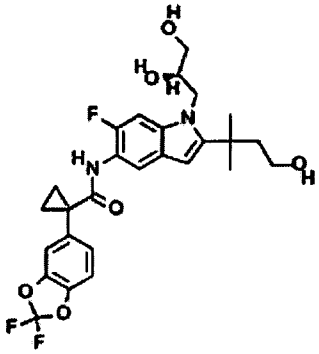
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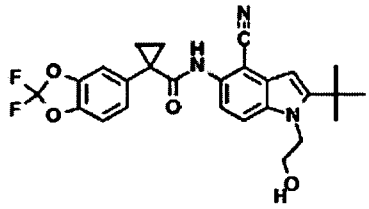
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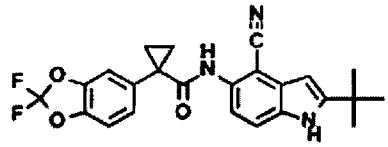
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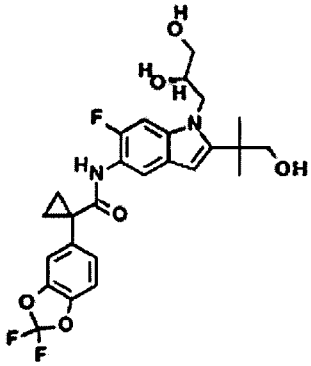
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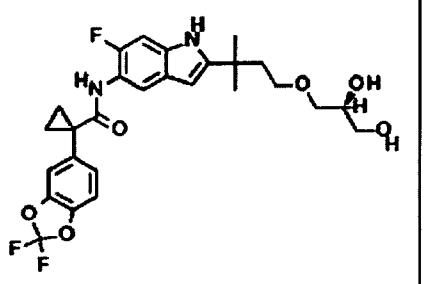
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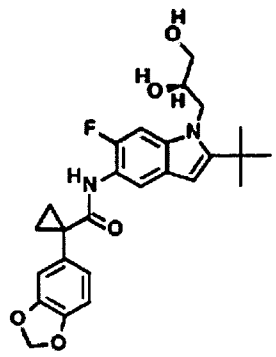
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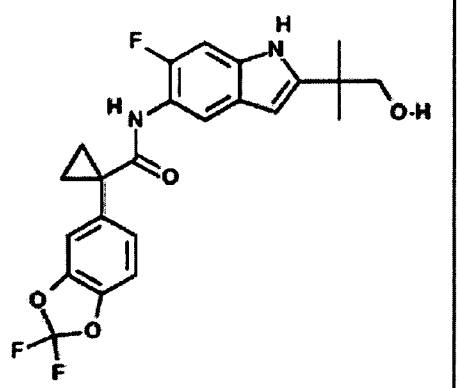
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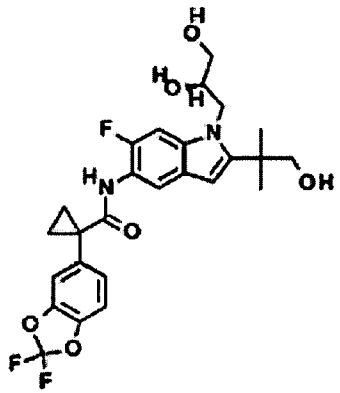
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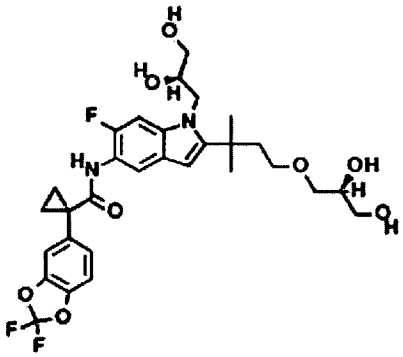
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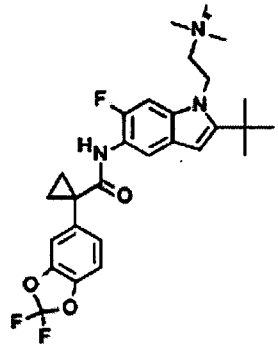
[00108] In another aspect, the present invention relates to a pharmaceutical composition comprising (i) a compound of the present invention; and (ii) a pharmaceutically acceptable carrier. In another embodiment, the composition further comprises an additional agent selected from a mucolytic agent, bronchodialator, an anti-biotic, an anti-infective agent, an anti-inflammatory agent, CFTR corrector, or a nutritional agent. In another embodiment, the composition further comprises an additional agent selected from compounds disclosed in U.S. Patent Application Serial No. 11/165,818, published as U.S. Published Patent Application No. 2006/0074075, filed June 24, 2005, and hereby incorporated by reference in its entirety. In another embodiment, the composition further comprises N-(5-hydroxy-2,4-ditert-butyl-phenyl)-4-oxo-1H-quinoline-3-carboxamide. These compositions are useful for treating the diseases described below including cystic fibrosis. These compositions are also useful in the kits described below.

[00109] In another aspect, the present invention relates to a method of increasing the number of functional ABC transporters in a membrane of a cell, comprising the step of contacting said cell with a compound selected from

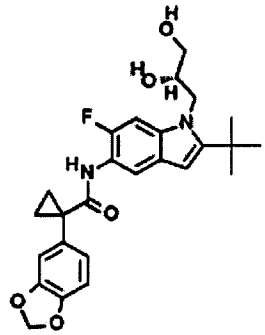
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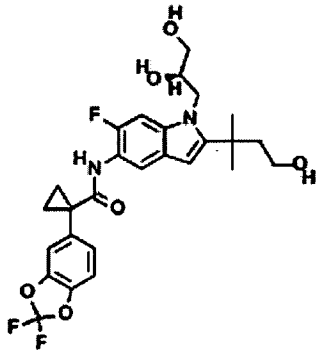
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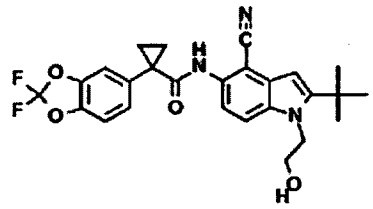
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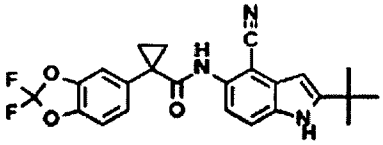
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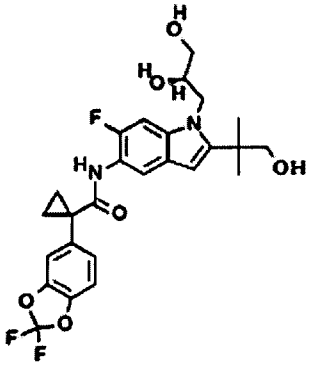
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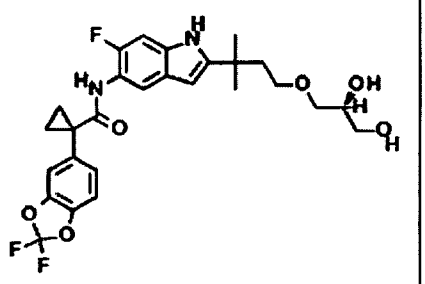
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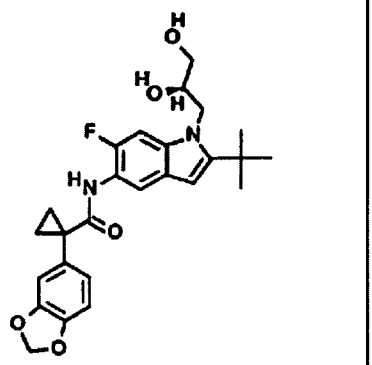
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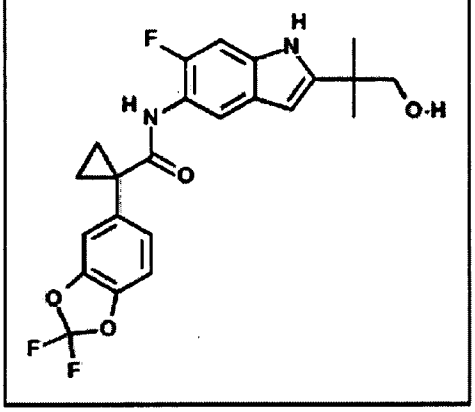
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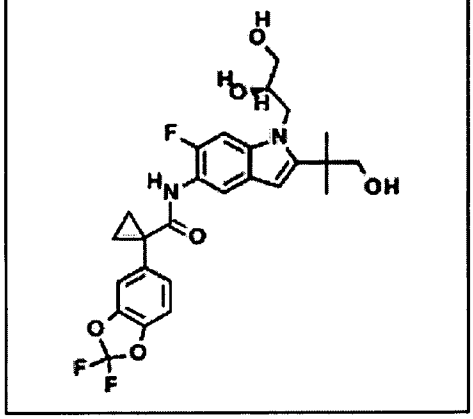


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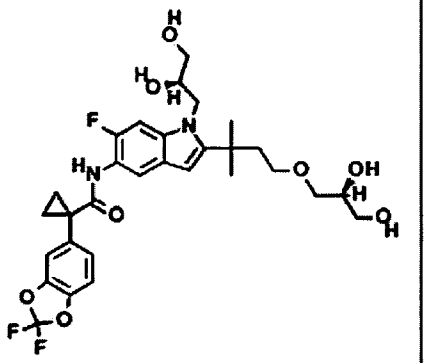
[00110] In one embodiment of this method, said condition, disease, or disorder is selected from cystic fibrosis, hereditary emphysema, hereditary hemochromatosis, coagulation-fibrinolysis deficiencies, such as protein C deficiency, Type 1 hereditary angioedema, lipid processing deficiencies, such as familial hypercholesterolemia, Type 1 chylomicronemia, abetalipoproteinemia, lysosomal storage diseases, such as I-cell disease/pseudo-Hurler, mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, polyendocrinopathy/hyperinsulemia, diabetes mellitus, laron dwarfism, myleoperoxidase deficiency, primary hypoparathyroidism, melanoma, glycanosis CDG type 1, hereditary emphysema, congenital hyperthyroidism, osteogenesis imperfecta, hereditary hypofibrinogenemia, ACT deficiency, diabetes insipidus (di), neurophyseal di, neprogenic DI, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis, progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, spinocerebullar ataxia type I, spinal and bulbar muscular atrophy, dentatorubal

pallidoluysian, and myotonic dystrophy, as well as spongiform encephalopathies, such as hereditary Creutzfeldt-Jakob disease, Fabry disease, Straussler-Scheinker syndrome, COPD, dry-eye disease, and Sjögren's disease.

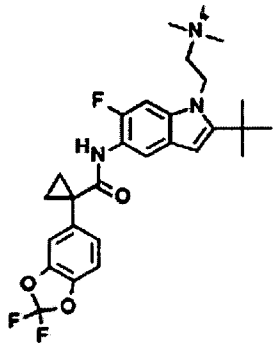
[00111] In another aspect, the present invention relates to a kit for use in measuring the activity of a ABC transporter or a fragment thereof in a biological sample *in vitro* or *in vivo*, comprising:

(i) a first composition comprising a compound selected from

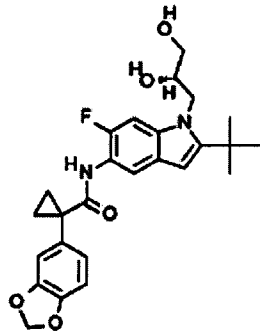
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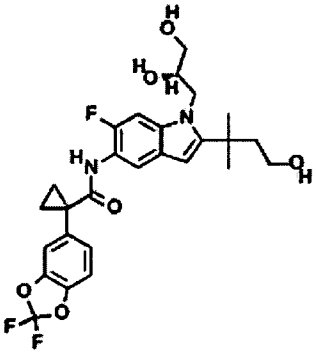
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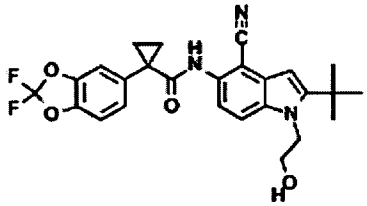
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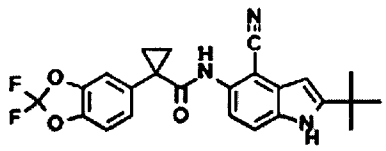
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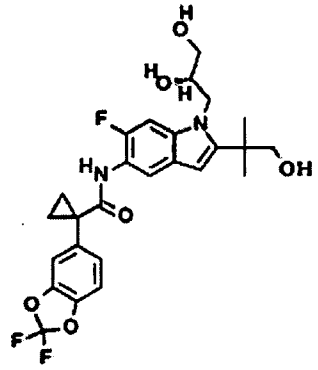
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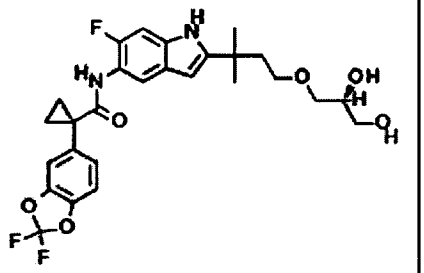
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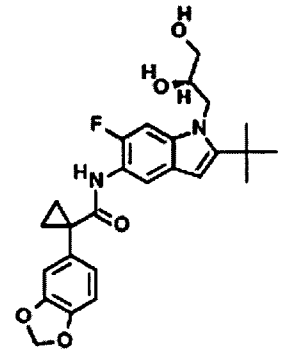
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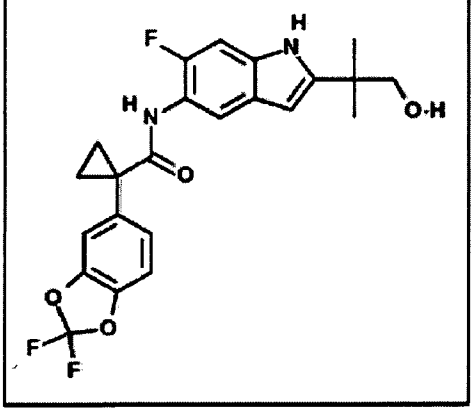
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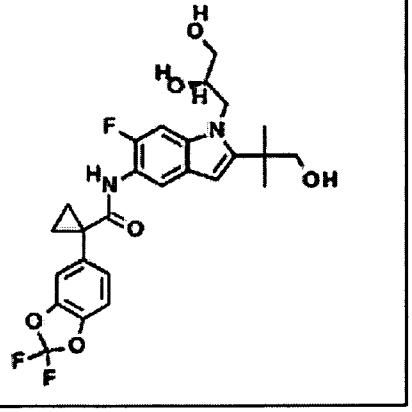


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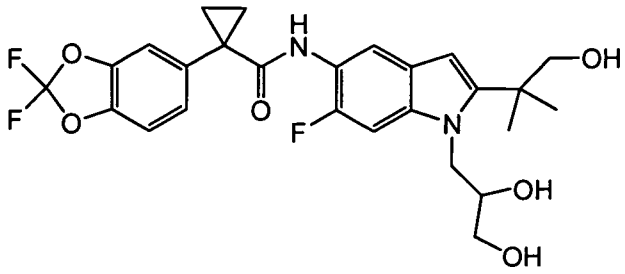
; and

b) measuring activity of said ABC transporter or a fragment thereof.

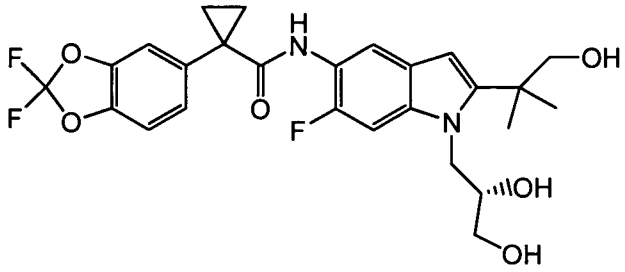
[00112] In one embodiment, the kit further comprises instructions for a) contacting an additional composition with the biological sample; b) measuring the activity of said ABC transporter or a fragment thereof in the presence of said additional compound, and c) comparing the activity of the ABC transporter in the presence of the additional compound with the density of the ABC transporter in the presence of said first composition.

[00113] In one embodiment, the kit is used to measure the density of CFTR.

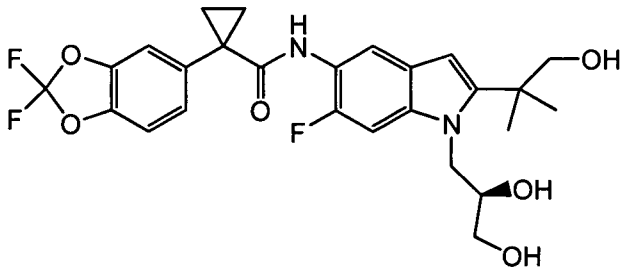
[00114] In certain embodiments of all of the foregoing aspects, the compound is



[00115] In other embodiments of all of the foregoing aspects, the compound is



[00116] In still other embodiments of all of the foregoing aspects, the compound is



[00117] IV. GENERIC SYNTHETIC SCHEMES

[00118] The compounds of of this invention may be readily synthesized from commercially available or known starting materials by known methods. Exemplary synthetic routes to produce compounds of this invention are provided herein.

[00119] V. FORMULATIONS, ADMINISTRATIONS, AND USES

[00120] Accordingly, in another aspect of the present invention, pharmaceutically acceptable compositions are provided, wherein these compositions comprise any of the compounds as described herein, and optionally comprise a pharmaceutically acceptable carrier, adjuvant or vehicle. In certain embodiments, these compositions optionally further comprise one or more

additional therapeutic agents.

[00121] It will also be appreciated that certain of the compounds of present invention can exist in free form for treatment, or where appropriate, as a pharmaceutically acceptable derivative or a prodrug thereof. According to the present invention, a pharmaceutically acceptable derivative or a prodrug includes, but is not limited to, pharmaceutically acceptable salts, esters, salts of such esters, or any other adduct or derivative which upon administration to a patient in need is capable of providing, directly or indirectly, a compound as otherwise described herein, or a metabolite or residue thereof.

[00122] As used herein, the term "pharmaceutically acceptable salt" refers to those salts which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of humans and lower animals without undue toxicity, irritation, allergic response and the like, and are commensurate with a reasonable benefit/risk ratio. A "pharmaceutically acceptable salt" means any non-toxic salt or salt of an ester of a compound of this invention that, upon administration to a recipient, is capable of providing, either directly or indirectly, a compound of this invention or an inhibitorily active metabolite or residue thereof.

[00123] Pharmaceutically acceptable salts are well known in the art. For example, S. M. Berge, et al. describes pharmaceutically acceptable salts in detail in J. Pharmaceutical Sciences, 1977, 66, 1-19, incorporated herein by reference. Pharmaceutically acceptable salts of the compounds of this invention include those derived from suitable inorganic and organic acids and bases. Examples of pharmaceutically acceptable, nontoxic acid addition salts are salts of an amino group formed with inorganic acids such as hydrochloric acid, hydrobromic acid, phosphoric acid, sulfuric acid and perchloric acid or with organic acids such as acetic acid, oxalic acid, maleic acid, tartaric acid, citric acid, succinic acid or malonic acid or by using other methods used in the art such as ion exchange. Other pharmaceutically acceptable salts include adipate, alginate, ascorbate, aspartate, benzenesulfonate, benzoate, bisulfate, borate, butyrate, camphorate, camphorsulfonate, citrate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, formate, fumarate, glucoheptonate, glycerophosphate, gluconate, hemisulfate, heptanoate, hexanoate, hydroiodide, 2-hydroxy-ethanesulfonate, lactobionate, lactate, laurate, lauryl sulfate, malate, maleate, malonate, methanesulfonate, 2-naphthalenesulfonate, nicotinate, nitrate, oleate, oxalate, palmitate, pamoate, pectinate, persulfate, 3-phenylpropionate, phosphate, picrate,

pivalate, propionate, stearate, succinate, sulfate, tartrate, thiocyanate, p-toluenesulfonate, undecanoate, valerate salts, and the like. Salts derived from appropriate bases include alkali metal, alkaline earth metal, ammonium and $N^+(C_{1-4}alkyl)_4$ salts. This invention also envisions the quaternization of any basic nitrogen-containing groups of the compounds disclosed herein. Water or oil-soluble or dispersible products may be obtained by such quaternization. Representative alkali or alkaline earth metal salts include sodium, lithium, potassium, calcium, magnesium, and the like. Further pharmaceutically acceptable salts include, when appropriate, nontoxic ammonium, quaternary ammonium, and amine cations formed using counterions such as halide, hydroxide, carboxylate, sulfate, phosphate, nitrate, loweralkyl sulfonate and aryl sulfonate.

[00124] As described above, the pharmaceutically acceptable compositions of the present invention additionally comprise a pharmaceutically acceptable carrier, adjuvant, or vehicle, which, as used herein, includes any and all solvents, diluents, or other liquid vehicle, dispersion or suspension aids, surface active agents, isotonic agents, thickening or emulsifying agents, preservatives, solid binders, lubricants and the like, as suited to the particular dosage form desired. Remington's Pharmaceutical Sciences, Sixteenth Edition, E. W. Martin (Mack Publishing Co., Easton, Pa., 1980) discloses various carriers used in formulating pharmaceutically acceptable compositions and known techniques for the preparation thereof. Except insofar as any conventional carrier medium is incompatible with the compounds of the invention, such as by producing any undesirable biological effect or otherwise interacting in a deleterious manner with any other component(s) of the pharmaceutically acceptable composition, its use is contemplated to be within the scope of this invention. Some examples of materials which can serve as pharmaceutically acceptable carriers include, but are not limited to, ion exchangers, alumina, aluminum stearate, lecithin, serum proteins, such as human serum albumin, buffer substances such as phosphates, glycine, sorbic acid, or potassium sorbate, partial glyceride mixtures of saturated vegetable fatty acids, water, salts or electrolytes, such as protamine sulfate, disodium hydrogen phosphate, potassium hydrogen phosphate, sodium chloride, zinc salts, colloidal silica, magnesium trisilicate, polyvinyl pyrrolidone, polyacrylates, waxes, polyethylene-polyoxypropylene-block polymers, wool fat, sugars such as lactose, glucose and sucrose; starches such as corn starch and potato starch; cellulose and its derivatives such as sodium carboxymethyl cellulose, ethyl cellulose and cellulose acetate; powdered tragacanth;

malt; gelatin; talc; excipients such as cocoa butter and suppository waxes; oils such as peanut oil, cottonseed oil; safflower oil; sesame oil; olive oil; corn oil and soybean oil; glycols; such a propylene glycol or polyethylene glycol; esters such as ethyl oleate and ethyl laurate; agar; buffering agents such as magnesium hydroxide and aluminum hydroxide; alginic acid; pyrogen-free water; isotonic saline; Ringer's solution; ethyl alcohol, and phosphate buffer solutions, as well as other non-toxic compatible lubricants such as sodium lauryl sulfate and magnesium stearate, as well as coloring agents, releasing agents, coating agents, sweetening, flavoring and perfuming agents, preservatives and antioxidants can also be present in the composition, according to the judgment of the formulator.

[00125] In yet another aspect, the present invention provides a method of treating a condition, disease, or disorder implicated by ABC transporter activity. In certain embodiments, the present invention provides a method of treating a condition, disease, or disorder implicated by a deficiency of ABC transporter activity, the method comprising administering a composition comprising a compound selected from 308-312, 313, 315, 316, 318, 320, and 322 to a subject, preferably a mammal, in need thereof.

[00126] In certain preferred embodiments, the present invention provides a method of treating Cystic fibrosis, Hereditary emphysema, Hereditary hemochromatosis, Coagulation-Fibrinolysis deficiencies, such as Protein C deficiency, Type 1 hereditary angioedema, Lipid processing deficiencies, such as Familial hypercholesterolemia, Type 1 chylomicronemia, Abetalipoproteinemia, Lysosomal storage diseases, such as I-cell disease/Pseudo-Hurler, Mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, Polyendocrinopathy/Hyperinsulemia, Diabetes mellitus, Laron dwarfism, Myleoperoxidase deficiency, Primary hypoparathyroidism, Melanoma, Glycanosis CDG type 1, Hereditary emphysema, Congenital hyperthyroidism, Osteogenesis imperfecta, Hereditary hypofibrinogenemia, ACT deficiency, Diabetes insipidus (DI), Neurophyseal DI, Neprogenic DI, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis, Progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, Spinocerebullar ataxia type I, Spinal and bulbar muscular atrophy, Dentatorubal pallidoluysian, and Myotonic dystrophy, as well as Spongiform encephalopathies, such as Hereditary Creutzfeldt-Jakob disease (due to Prion protein processing defect), Fabry disease,

Straussler-Scheinker disease, secretory diarrhea, polycystic kidney disease, chronic obstructive pulmonary disease (COPD), dry eye disease, and Sjögren's Syndrome, comprising the step of administering to said mammal an effective amount of a composition comprising a a compound selected from 308-312, 313, 315, 316, 318, 320, and 322, or a preferred embodiment thereof as set forth above.

[00127] According to an alternative preferred embodiment, the present invention provides a method of treating cystic fibrosis comprising the step of administering to said mammal a composition comprising the step of administering to said mammal an effective amount of a composition comprising a compound selected from 308-312, 313, 315, 316, 318, 320, and 322 , or a preferred embodiment thereof as set forth above.

[00128] According to the invention an "effective amount" of the compound or pharmaceutically acceptable composition is that amount effective for treating or lessening the severity of one or more of Cystic fibrosis, Hereditary emphysema, Hereditary hemochromatosis, Coagulation-Fibrinolysis deficiencies, such as Protein C deficiency, Type 1 hereditary angioedema, Lipid processing deficiencies, such as Familial hypercholesterolemia, Type 1 chylomicronemia, Abetalipoproteinemia, Lysosomal storage diseases, such as I-cell disease/Pseudo-Hurler, Mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, Polyendocrinopathy/Hyperinsulemia, Diabetes mellitus, Laron dwarfism, Myleoperoxidase deficiency, Primary hypoparathyroidism, Melanoma, Glycanosis CDG type 1, Hereditary emphysema, Congenital hyperthyroidism, Osteogenesis imperfecta, Hereditary hypofibrinogenemia, ACT deficiency, Diabetes insipidus (DI), Neurophyseal DI, Neprogenic DI, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis, Progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, Spinocerebullar ataxia type I, Spinal and bulbar muscular atrophy, Dentatorubal pallidoluysian, and Myotonic dystrophy, as well as Spongiform encephalopathies, such as Hereditary Creutzfeldt-Jakob disease, Fabry disease, Straussler-Scheinker disease, secretory diarrhea, polycystic kidney disease, chronic obstructive pulmonary disease (COPD), dry eye disease, and Sjögren's Syndrome.

[00129] The compounds and compositions, according to the method of the present invention, may be administered using any amount and any route of administration effective for treating or lessening the severity of one or more of Cystic fibrosis, Hereditary emphysema, Hereditary hemochromatosis, Coagulation-Fibrinolysis deficiencies, such as Protein C deficiency, Type 1 hereditary angioedema, Lipid processing deficiencies, such as Familial hypercholesterolemia, Type 1 chylomicronemia, Abetalipoproteinemia, Lysosomal storage diseases, such as I-cell disease/Pseudo-Hurler, Mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, Polyendocrinopathy/Hyperinsulemia, Diabetes mellitus, Laron dwarfism, Myleoperoxidase deficiency, Primary hypoparathyroidism, Melanoma, Glycanosis CDG type 1, Hereditary emphysema, Congenital hyperthyroidism, Osteogenesis imperfecta, Hereditary hypofibrinogenemia, ACT deficiency, Diabetes insipidus (DI), Neurophyseal DI, Neprogenic DI, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, Amyotrophic lateral sclerosis, Progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, Spinocerebullar ataxia type I, Spinal and bulbar muscular atrophy, Dentatorubal pallidoluysian, and Myotonic dystrophy, as well as Spongiform encephalopathies, such as Hereditary Creutzfeldt-Jàkob disease, Fabry disease, Straussler-Scheinker disease, secretory diarrhea, polycystic kidney disease, chronic obstructive pulmonary disease (COPD), dry eye disease, and Sjögren's Syndrome.

[00130] The exact amount required will vary from subject to subject, depending on the species, age, and general condition of the subject, the severity of the infection, the particular agent, its mode of administration, and the like. The compounds of the invention are preferably formulated in dosage unit form for ease of administration and uniformity of dosage. The expression "dosage unit form" as used herein refers to a physically discrete unit of agent appropriate for the patient to be treated. It will be understood, however, that the total daily usage of the compounds and compositions of the present invention will be decided by the attending physician within the scope of sound medical judgment. The specific effective dose level for any particular patient or organism will depend upon a variety of factors including the disorder being treated and the severity of the disorder; the activity of the specific compound employed; the specific composition employed; the age, body weight, general health, sex 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 coincidental with the specific compound employed, and like factors well known in the medical arts. The term "patient", as used herein, means an animal, preferably a mammal, and most preferably a human.

[00131] The pharmaceutically acceptable compositions of this invention can be administered to humans and other animals orally, rectally, parenterally, intracisternally, intravaginally, intraperitoneally, topically (as by powders, ointments, or drops), bucally, as an oral or nasal spray, or the like, depending on the severity of the infection being treated. In certain embodiments, the compounds of the invention may be administered orally or parenterally at dosage levels of about 0.01 mg/kg to about 50 mg/kg and preferably from about 1 mg/kg to about 25 mg/kg, of subject body weight per day, one or more times a day, to obtain the desired therapeutic effect.

[00132] Liquid dosage forms for oral administration include, but are not limited to, pharmaceutically acceptable emulsions, microemulsions, solutions, suspensions, syrups and elixirs. In addition to the active compounds, the liquid dosage forms may contain inert diluents commonly used in the art such as, for example, water or other solvents, solubilizing agents and emulsifiers such as ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol, 1,3-butylene glycol, dimethylformamide, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor, and sesame oils), glycerol, tetrahydrofurfuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan, and mixtures thereof. Besides inert diluents, the oral compositions can also include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, and perfuming agents.

[00133] Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions may be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution, suspension or emulsion in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, U.S.P. and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid are used in the preparation of injectables.

[00134] The injectable formulations can be sterilized, for example, by filtration through a bacterial-retaining filter, or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable medium prior to use.

[00135] In order to prolong the effect of a compound of the present invention, it is often desirable to slow the absorption of the compound from subcutaneous or intramuscular injection. This may be accomplished by the use of a liquid suspension of crystalline or amorphous material with poor water solubility. The rate of absorption of the compound then depends upon its rate of dissolution that, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally administered compound form is accomplished by dissolving or suspending the compound in an oil vehicle. Injectable depot forms are made by forming microencapsule matrices of the compound in biodegradable polymers such as polylactide-polyglycolide. Depending upon the ratio of compound to polymer and the nature of the particular polymer employed, the rate of compound release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable formulations are also prepared by entrapping the compound in liposomes or microemulsions that are compatible with body tissues.

[00136] Compositions for rectal or vaginal administration are preferably suppositories which can be prepared by mixing the compounds of this invention with suitable non-irritating excipients or carriers such as cocoa butter, polyethylene glycol or a suppository wax which are solid at ambient temperature but liquid at body temperature and therefore melt in the rectum or vaginal cavity and release the active compound.

[00137] Solid dosage forms for oral administration include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the active compound is mixed with at least one inert, pharmaceutically acceptable excipient or carrier such as sodium citrate or dicalcium phosphate and/or a) fillers or extenders such as starches, lactose, sucrose, glucose, mannitol, and silicic acid, b) binders such as, for example, carboxymethylcellulose, alginates, gelatin, polyvinylpyrrolidinone, sucrose, and acacia, c) humectants such as glycerol, d) disintegrating agents such as agar--agar, calcium carbonate, potato or tapioca starch, alginic acid, certain silicates, and sodium carbonate, e) solution retarding agents such as paraffin, f) absorption

accelerators such as quaternary ammonium compounds, g) wetting agents such as, for example, cetyl alcohol and glycerol monostearate, h) absorbents such as kaolin and bentonite clay, and i) lubricants such as talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate, and mixtures thereof. In the case of capsules, tablets and pills, the dosage form may also comprise buffering agents.

[00138] Solid compositions of a similar type may also be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like. The solid dosage forms of tablets, dragees, capsules, pills, and granules can be prepared with coatings and shells such as enteric coatings and other coatings well known in the pharmaceutical formulating art. They may optionally contain opacifying agents and can also be of a composition that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions that can be used include polymeric substances and waxes. Solid compositions of a similar type may also be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polethylene glycols and the like.

[00139] The active compounds can also be in microencapsulated form with one or more excipients as noted above. The solid dosage forms of tablets, dragees, capsules, pills, and granules can be prepared with coatings and shells such as enteric coatings, release controlling coatings and other coatings well known in the pharmaceutical formulating art. In such solid dosage forms the active compound may be admixed with at least one inert diluent such as sucrose, lactose or starch. Such dosage forms may also comprise, as is normal practice, additional substances other than inert diluents, e.g., tableting lubricants and other tableting aids such a magnesium stearate and microcrystalline cellulose. In the case of capsules, tablets and pills, the dosage forms may also comprise buffering agents. They may optionally contain opacifying agents and can also be of a composition that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions that can be used include polymeric substances and waxes.

[00140] Dosage forms for topical or transdermal administration of a compound of this invention include ointments, pastes, creams, lotions, gels, powders, solutions, sprays, inhalants

or patches. The active component is admixed under sterile conditions with a pharmaceutically acceptable carrier and any needed preservatives or buffers as may be required. Ophthalmic formulation, eardrops, and eye drops are also contemplated as being within the scope of this invention. Additionally, the present invention contemplates the use of transdermal patches, which have the added advantage of providing controlled delivery of a compound to the body. Such dosage forms are prepared by dissolving or dispensing the compound in the proper medium. Absorption enhancers can also be used to increase the flux of the compound across the skin. The rate can be controlled by either providing a rate controlling membrane or by dispersing the compound in a polymer matrix or gel.

[00141] As described generally above, the compounds of the invention are useful as modulators of ABC transporters. Thus, without wishing to be bound by any particular theory, the compounds and compositions are particularly useful for treating or lessening the severity of a disease, condition, or disorder where hyperactivity or inactivity of ABC transporters is implicated in the disease, condition, or disorder. When hyperactivity or inactivity of an ABC transporter is implicated in a particular disease, condition, or disorder, the disease, condition, or disorder may also be referred to as a "ABC transporter-mediated disease, condition or disorder". Accordingly, in another aspect, the present invention provides a method for treating or lessening the severity of a disease, condition, or disorder where hyperactivity or inactivity of an ABC transporter is implicated in the disease state.

[00142] The activity of a compound utilized in this invention as a modulator of an ABC transporter may be assayed according to methods described generally in the art and in the Examples herein.

[00143] It will also be appreciated that the compounds and pharmaceutically acceptable compositions of the present invention can be employed in combination therapies, that is, the compounds and pharmaceutically acceptable compositions can be administered concurrently with, prior to, or subsequent to, one or more other desired therapeutics or medical procedures. The particular combination of therapies (therapeutics or procedures) to employ in a combination regimen will take into account compatibility of the desired therapeutics and/or procedures and the desired therapeutic effect to be achieved. It will also be appreciated that the therapies employed may achieve a desired effect for the same disorder (for example, an inventive

compound may be administered concurrently with another agent used to treat the same disorder), or they may achieve different effects (e.g., control of any adverse effects). As used herein, additional therapeutic agents that are normally administered to treat or prevent a particular disease, or condition, are known as "appropriate for the disease, or condition, being treated".

[00144] The amount of additional therapeutic agent present in the compositions of this invention will be no more than the amount that would normally be administered in a composition comprising that therapeutic agent as the only active agent. Preferably the amount of additional therapeutic agent in the presently disclosed compositions will range from about 50% to 100% of the amount normally present in a composition comprising that agent as the only therapeutically active agent.

[00145] The compounds of this invention or pharmaceutically acceptable compositions thereof may also be incorporated into compositions for coating an implantable medical device, such as prostheses, artificial valves, vascular grafts, stents and catheters. Accordingly, the present invention, in another aspect, includes a composition for coating an implantable device comprising a compound of the present invention as described generally above, and in classes and subclasses herein, and a carrier suitable for coating said implantable device. In still another aspect, the present invention includes an implantable device coated with a composition comprising a compound of the present invention as described generally above, and in classes and subclasses herein, and a carrier suitable for coating said implantable device. Suitable coatings and the general preparation of coated implantable devices are described in US Patents 6,099,562; 5,886,026; and 5,304,121. The coatings are typically biocompatible polymeric materials such as a hydrogel polymer, polymethyldisiloxane, polycaprolactone, polyethylene glycol, polylactic acid, ethylene vinyl acetate, and mixtures thereof. The coatings may optionally be further covered by a suitable topcoat of fluorosilicone, polysaccarides, polyethylene glycol, phospholipids or combinations thereof to impart controlled release characteristics in the composition.

[00146] Another aspect of the invention relates to modulating ABC transporter activity in a biological sample or a patient (e.g., in vitro or in vivo), which method comprises administering to the patient, or contacting said biological sample with a compound of formula I or a composition comprising said compound. The term "biological sample", as used herein, includes,

without limitation, cell cultures or extracts thereof; biopsied material obtained from a mammal or extracts thereof; and blood, saliva, urine, feces, semen, tears, or other body fluids or extracts thereof.

[00147] Modulation of ABC transporter activity in a biological sample is useful for a variety of purposes that are known to one of skill in the art. Examples of such purposes include, but are not limited to, the study of ABC transporters in biological and pathological phenomena; and the comparative evaluation of new modulators of ABC transporters.

[00148] In yet another embodiment, a method of modulating activity of an anion channel in vitro or in vivo, is provided comprising the step of contacting said channel with a compound selected from 308-312, 313, 315, 316, 318, 320, and 322. In preferred embodiments, the anion channel is a chloride channel or a bicarbonate channel. In other preferred embodiments, the anion channel is a chloride channel.

[00149] According to an alternative embodiment, the present invention provides a method of increasing the number of functional ABC transporters in a membrane of a cell, comprising the step of contacting said cell with a compound selected from 308-312, 313, 315, 316, 318, 320, and 322. The term "functional ABC transporter" as used herein means an ABC transporter that is capable of transport activity. In preferred embodiments, said functional ABC transporter is CFTR.

[00150] According to another preferred embodiment, the activity of the ABC transporter is measured by measuring the transmembrane voltage potential. Means for measuring the voltage potential across a membrane in the biological sample may employ any of the known methods in the art, such as optical membrane potential assay or other electrophysiological methods.

[00151] The optical membrane potential assay utilizes voltage-sensitive FRET sensors described by Gonzalez and Tsien (See, Gonzalez, J. E. and R. Y. Tsien (1995) "Voltage sensing by fluorescence resonance energy transfer in single cells" Biophys J 69(4): 1272-80, and Gonzalez, J. E. and R. Y. Tsien (1997) "Improved indicators of cell membrane potential that use fluorescence resonance energy transfer" Chem Biol 4(4): 269-77) in combination with instrumentation for measuring fluorescence changes such as the Voltage/Ion Probe Reader (VIPR) (See, Gonzalez, J. E., K. Oades, et al. (1999) "Cell-based assays and instrumentation for screening ion-channel targets" Drug Discov Today 4(9): 431-439).

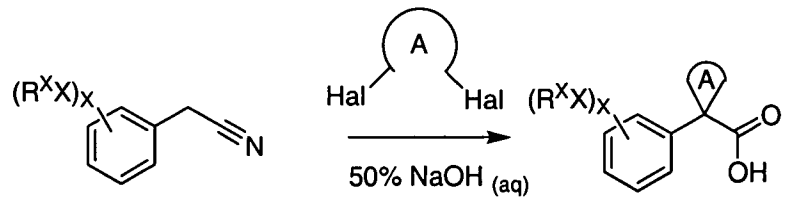
[00152] These voltage sensitive assays are based on the change in fluorescence resonant energy transfer (FRET) between the membrane-soluble, voltage-sensitive dye, $DiSBAC_2(3)$, and a fluorescent phospholipid, CC2-DMPE, which is attached to the outer leaflet of the plasma membrane and acts as a FRET donor. Changes in membrane potential (V_m) cause the negatively charged $DiSBAC_2(3)$ to redistribute across the plasma membrane and the amount of energy transfer from CC2-DMPE changes accordingly. The changes in fluorescence emission can be monitored using VIPR™ II, which is an integrated liquid handler and fluorescent detector designed to conduct cell-based screens in 96- or 384-well microtiter plates.

[00153] In another aspect the present invention provides a kit for use in measuring the activity of a ABC transporter or a fragment thereof in a biological sample in vitro or in vivo comprising (i) a composition comprising a compound selected from 308-312, 313, 315, 316, 318, 320, and 322 or any of the above embodiments; and (ii) instructions for a.) contacting the composition with the biological sample and b.) measuring activity of said ABC transporter or a fragment thereof. In one embodiment, the kit further comprises instructions for a.) contacting an additional composition with the biological sample; b.) measuring the activity of said ABC transporter or a fragment thereof in the presence of said additional compound, and c.) comparing the activity of the ABC transporter in the presence of the additional compound with the density of the ABC transporter in the presence of a compound selected from 308-312, 313, 315, 316, 318, 320, and 322. In preferred embodiments, the kit is used to measure the density of CFTR.

[00154] In order that the invention described herein may be more fully understood, the following examples are set forth. It should be understood that these examples are for illustrative purposes only and are not to be construed as limiting this invention in any manner.

[00155] VI. PREPARATIONS AND EXAMPLES

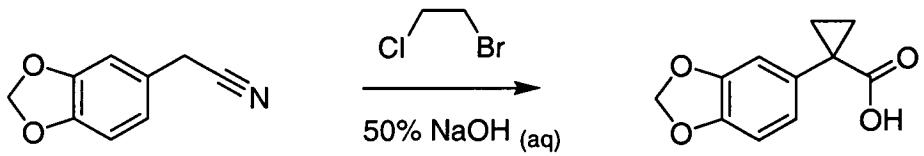
[00156] **General Procedure I: Carboxylic Acid Building Block**



Hal = Cl, Br, I

[00157] Benzyltriethylammonium chloride (0.025 equivalents) and the appropriate dihalo compound (2.5 equivalents) were added to a substituted phenyl acetonitrile. The mixture was heated at 70 °C and then 50 % sodium hydroxide (10 equivalents) was slowly added to the mixture. The reaction was stirred at 70 °C for 12-24 hours to ensure complete formation of the cycloalkyl moiety and then heated at 130 °C for 24-48 hours to ensure complete conversion from the nitrile to the carboxylic acid. The dark brown / black reaction mixture was diluted with water and extracted with dichloromethane three times to remove side products. The basic aqueous solution was acidified with concentrated hydrochloric acid to pH less than one and the precipitate which began to form at pH 4 was filtered and washed with 1 M hydrochloric acid two times. The solid material was dissolved in dichloromethane and extracted two times with 1 M hydrochloric acid and one time with a saturated aqueous solution of sodium chloride. The organic solution was dried over sodium sulfate and evaporated to dryness to give the cycloalkylcarboxylic acid. Yields and purities were typically greater than 90%.

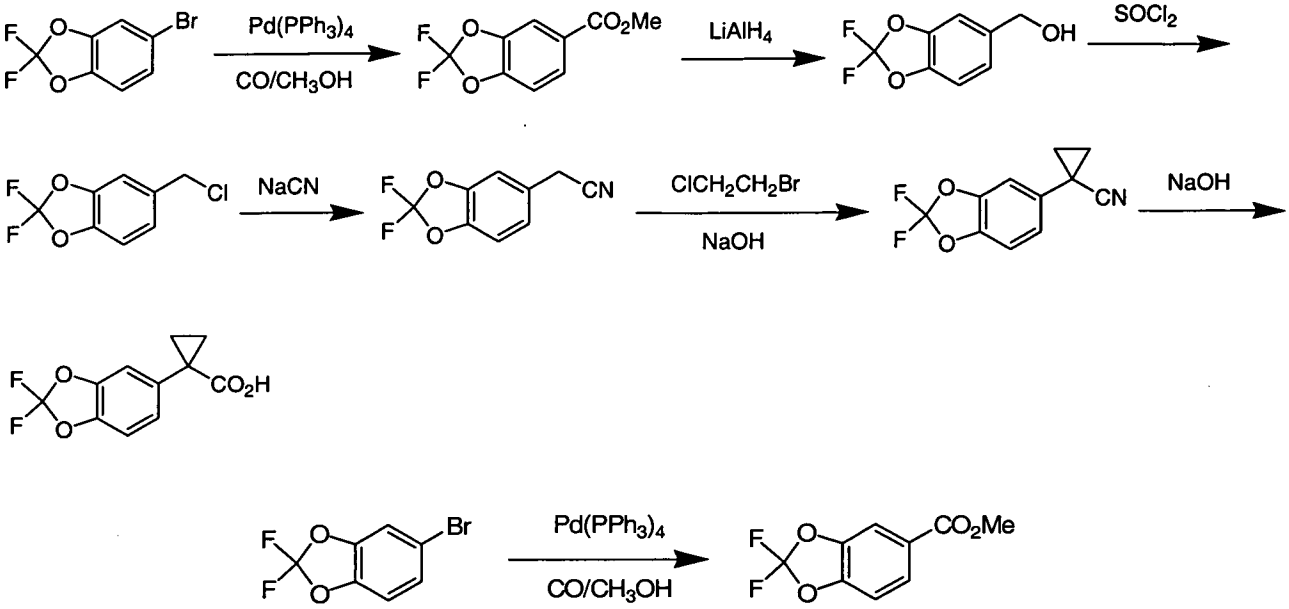
[00158] Example 1: 1-Benzo[1,3]dioxol-5-yl-cyclopropanecarboxylic acid



[00159] A mixture of 2-(benzo[d][1,3]dioxol-5-yl)acetonitrile (5.10 g 31.7 mmol), 1-bromo-2-chloro-ethane (9.00 mL 109 mmol), and benzyltriethylammonium chloride (0.181 g, 0.795 mmol) was heated at 70 °C and then 50% (wt./wt.) aqueous sodium hydroxide (26 mL) was slowly added to the mixture. The reaction was stirred at 70 °C for 24 hours and then heated at 130 °C for 48 hours. The dark brown reaction mixture was diluted with water (400 mL) and extracted once with an equal volume of ethyl acetate and once with an equal volume of dichloromethane. The basic aqueous solution was acidified with concentrated hydrochloric acid to pH less than one and the precipitate filtered and washed with 1 M hydrochloric acid. The solid material was dissolved in dichloromethane (400 mL) and extracted twice with equal volumes of 1 M hydrochloric acid and once with a saturated aqueous solution of sodium chloride. The organic solution was dried over sodium sulfate and evaporated to dryness to give a white to slightly off-white solid (5.23 g, 80%) ESI-MS *m/z* calc. 206.1, found 207.1 $(M+1)^+$.

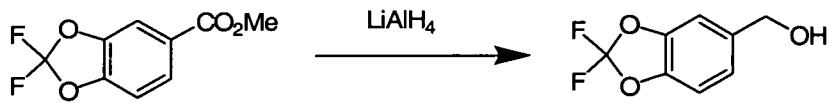
Retention time 2.37 minutes. ^{1}H NMR (400 MHz, DMSO-d_6) δ 1.07-1.11 (m, 2H), 1.38-1.42 (m, 2H), 5.98 (s, 2H), 6.79 (m, 2H), 6.88 (m, 1H), 12.26 (s, 1H).

[00160] Example 2: 1-(2,2-Difluoro-benzo[1,3]dioxol-5-yl)-cyclopropanecarboxylic acid



[00161] 2,2-Difluoro-benzo[1,3]dioxole-5-carboxylic acid methyl ester

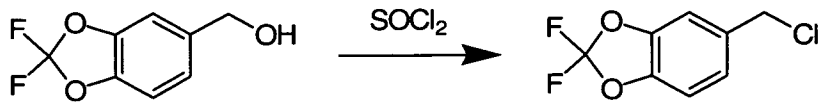
[00162] A solution of 5-bromo-2,2-difluoro-benzo[1,3]dioxole (11.8 g, 50.0 mmol) and tetrakis(triphenylphosphine)palladium (0) [$Pd(PPh_3)_4$, 5.78 g, 5.00 mmol] in methanol (20 mL) containing acetonitrile (30 mL) and triethylamine (10 mL) was stirred under a carbon monoxide atmosphere (55 PSI) at 75 °C (oil bath temperature) for 15 hours. The cooled reaction mixture was filtered and the filtrate was evaporated to dryness. The residue was purified by silica gel column chromatography to give crude 2,2-difluoro-benzo [1,3] dioxole-5-carboxylic acid methyl ester (11.5 g), which was used directly in the next step.



[00163] (2,2-Difluoro-benzo[1,3]dioxol-5-yl)-methanol

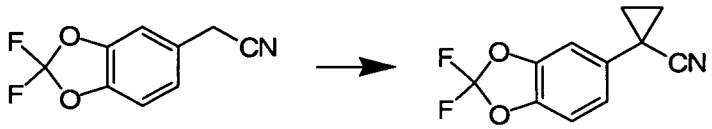
[00164] Crude 2,2-difluoro-benzo[1,3]dioxole-5-carboxylic acid methyl ester (11.5 g) dissolved in 20 mL of anhydrous tetrahydrofuran (THF) was slowly added to a suspension of lithium aluminum hydride (4.10 g, 106 mmol) in anhydrous THF (100 mL) at 0 °C. The mixture was then warmed to room temperature. After being stirred at room temperature for 1 hour, the

reaction mixture was cooled to 0 °C and treated with water (4.1 g), followed by sodium hydroxide (10% aqueous solution, 4.1 mL). The resulting slurry was filtered and washed with THF. The combined filtrate was evaporated to dryness and the residue was purified by silica gel column chromatography to give (2,2-difluoro-benzo[1,3]dioxol-5-yl)-methanol (7.2 g, 38 mmol, 76 % over two steps) as a colorless oil.



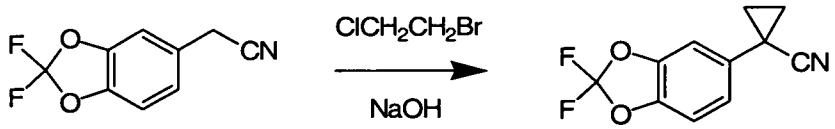
[00165] 5-Chloromethyl-2,2-difluoro-benzo[1,3]dioxole

[00166] Thionyl chloride (45 g, 38 mmol) was slowly added to a solution of (2,2-difluoro-benzo[1,3]dioxol-5-yl)-methanol (7.2 g, 38 mmol) in dichloromethane (200 mL) at 0 °C. The resulting mixture was stirred overnight at room temperature and then evaporated to dryness. The residue was partitioned between an aqueous solution of saturated sodium bicarbonate (100 mL) and dichloromethane (100 mL). The separated aqueous layer was extracted with dichloromethane (150 mL) and the organic layer was dried over sodium sulfate, filtrated, and evaporated to dryness to give crude 5-chloromethyl-2,2-difluoro-benzo[1,3]dioxole (4.4 g) which was used directly in the next step.



[00167] (2,2-Difluoro-benzo[1,3]dioxol-5-yl)-acetonitrile

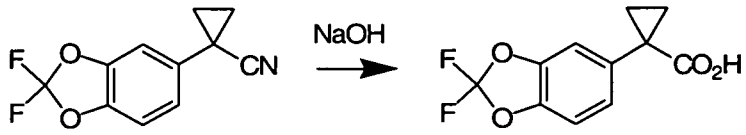
[00168] A mixture of crude 5-chloromethyl-2,2-difluoro-benzo[1,3]dioxole (4.4 g) and sodium cyanide (1.36 g, 27.8 mmol) in dimethylsulfoxide (50 mL) was stirred at room temperature overnight. The reaction mixture was poured into ice and extracted with ethyl acetate (300 mL). The organic layer was dried over sodium sulfate and evaporated to dryness to give crude (2,2-difluoro-benzo[1,3]dioxol-5-yl)-acetonitrile (3.3 g) which was used directly in the next step.



[00169] 1-(2,2-Difluoro-benzo[1,3]dioxol-5-yl)-cyclopropanecarbonitrile

[00170] Sodium hydroxide (50% aqueous solution, 10 mL) was slowly added to a mixture of crude (2,2-difluoro-benzo[1,3]dioxol-5-yl)-acetonitrile, benzyltriethylammonium chloride (3.00 g, 15.3 mmol), and 1-bromo-2-chloroethane (4.9 g, 38 mmol) at 70 °C.

[00171] The mixture was stirred overnight at 70 °C before the reaction mixture was diluted with water (30 mL) and extracted with ethyl acetate. The combined organic layers were dried over sodium sulfate and evaporated to dryness to give crude 1-(2,2-difluoro-benzo[1,3]dioxol-5-yl)-cyclopropanecarbonitrile, which was used directly in the next step.

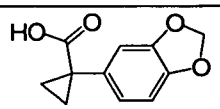
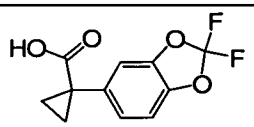


[00172] 1-(2,2-Difluoro-benzo[1,3]dioxol-5-yl)-cyclopropanecarboxylic acid

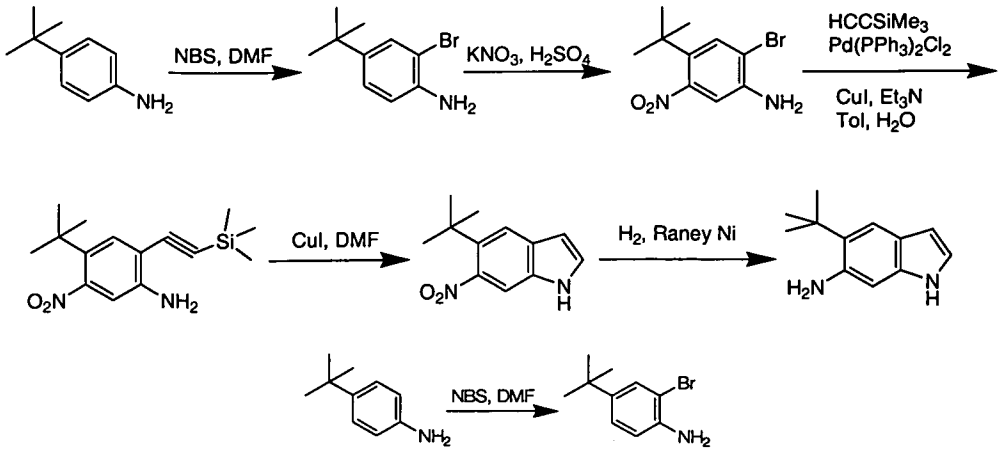
[00173] 1-(2,2-Difluoro-benzo[1,3]dioxol-5-yl)-cyclopropanecarbonitrile (crude from the last step) was refluxed in 10% aqueous sodium hydroxide (50 mL) for 2.5 hours. The cooled reaction mixture was washed with ether (100 mL) and the aqueous phase was acidified to pH 2 with 2M hydrochloric acid. The precipitated solid was filtered to give 1-(2,2-difluoro-benzo[1,3]dioxol-5-yl)-cyclopropanecarboxylic acid as a white solid (0.15 g, 1.6% over four steps). ESI-MS *m/z* calc. 242.04, found 241.58 $(M+1)^+$; ^1H NMR ($CDCl_3$) δ 7.14-7.04 (m, 2H), 6.98-6.96 (m, 1H), 1.74-1.64 (m, 2H), 1.26-1.08 (m, 2H).

[00174] The following Table 2 contains a list of carboxylic acid building blocks that were commercially available, or prepared by one of the three methods described above:

Table 2: Carboxylic acid building blocks.

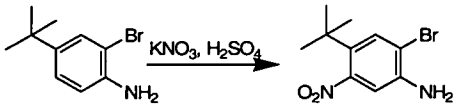
Name	Structure
1-benzo[1,3]dioxol-5-ylcyclopropane-1-carboxylic acid	
1-(2,2-difluorobenzo[1,3]dioxol-5-yl)cyclopropane-1-carboxylic acid	

[00175] Example 3: 5-*tert*-Butyl-1H-indol-6-ylamine



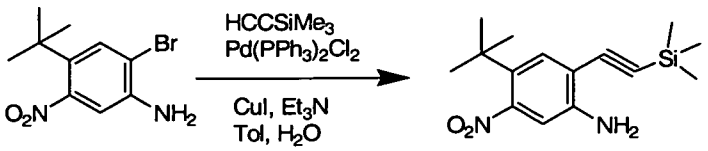
[00176] 2-Bromo-4-*tert*-butyl-phenylamine

[00177] To a solution of 4-*tert*-Butyl-phenylamine (447 g, 3.00 mol) in DMF (500 mL) was added dropwise NBS (531 g, 3.00 mol) in DMF (500 mL) at room temperature. Upon completion, the reaction mixture was diluted with water and extracted with EtOAc. The organic layer was washed with water, brine, dried over Na_2SO_4 and concentrated. The crude product was directly used in the next step without further purification.



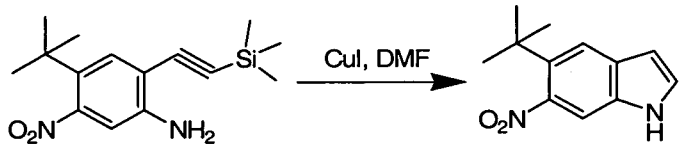
[00178] 2-Bromo-4-*tert*-butyl-5-nitro-phenylamine

[00179] 2-Bromo-4-*tert*-butyl-phenylamine (160 g, 0.71 mol) was added dropwise to H_2SO_4 (410 mL) at room temperature to yield a clear solution. This clear solution was then cooled down to –5 to –10 °C. A solution of KNO_3 (83 g, 0.82 mol) in H_2SO_4 (410 mL) was added dropwise while the temperature was maintained between –5 to –10 °C. Upon completion, the reaction mixture was poured into ice / water and extracted with EtOAc. The combined organic layers were washed with 5% Na_2CO_3 and brine, dried over Na_2SO_4 and concentrated. The residue was purified by a column chromatography (ethyl acetate/petroleum ether 1:10) to give 2-bromo-4-*tert*-butyl-5-nitro-phenylamine as a yellow solid (150 g, 78%).



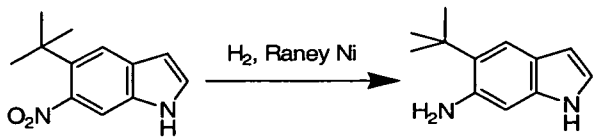
[00180] 4-*tert*-Butyl-5-nitro-2-trimethylsilanylethynyl-phenylamine

[00181] To a mixture of 2-bromo-4-*tert*-butyl-5-nitro-phenylamine (27.3 g, 100 mmol) in toluene (200 mL) and water (100 mL) was added Et_3N (27.9 mL, 200 mmol), $Pd(PPh_3)_2Cl_2$ (2.11 g, 3.00 mmol), CuI (950 mg, 0.500 mmol) and trimethylsilyl acetylene (21.2 mL, 150 mmol) under a nitrogen atmosphere. The reaction mixture was heated at 70 °C in a sealed pressure flask for 2.5 h., cooled down to room temperature and filtered through a short plug of Celite. The filter cake was washed with EtOAc. The combined filtrate was washed with 5% NH_4OH solution and water, dried over Na_2SO_4 and concentrated. The crude product was purified by column chromatography (0 – 10 % ethyl acetate/petroleum ether) to provide 4-*tert*-butyl-5-nitro-2-trimethylsilanylethynyl-phenylamine as a brown viscous liquid (25 g, 81 %).



[00182] 5-*tert*-Butyl-6-nitro-1H-indole

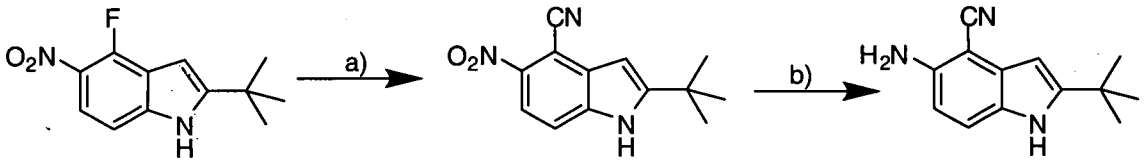
[00183] To a solution of 4-*tert*-butyl-5-nitro-2-trimethylsilanylethynyl-phenylamine (25 g, 86 mmol) in DMF (100 mL) was added CuI (8.2 g, 43 mmol) under a nitrogen atmosphere. The mixture was heated at 135 °C in a sealed pressure flask overnight, cooled down to room temperature and filtered through a short plug of Celite. The filter cake was washed with EtOAc. The combined filtrate was washed with water, dried over Na_2SO_4 and concentrated. The crude product was purified by column chromatography (10 – 20 % ethyl aetate/hexane) to provide 5-*tert*-butyl-6-nitro-1H-indole as a yellow solid (13 g, 69 %).



[00184] 5-*tert*-Butyl-1H-indol-6-ylamine

[00185] Raney Nickel (3 g) was added to 5-*tert*-butyl-6-nitro-1H-indole (15 g, 67 mmol) in methanol (100 mL). The mixture was stirred under hydrogen (1 atm) at 30 °C for 3 h. The catalyst was filtered off. The filtrate was dried over Na_2SO_4 and concentrated. The crude dark brown viscous oil was purified by column chromatography (10 – 20 % ethyl acetate/petroleum ether) to give 5-*tert*-butyl-1H-indol-6-ylamine as a gray solid (11 g, 87 %). ^{1}H NMR (300 MHz, DMSO-d6) δ 10.3 (br s, 1H), 7.2 (s, 1H), 6.9 (m, 1H), 6.6 (s, 1H), 6.1 (m, 1H), 4.4 (br s, 2H), 1.3 (s, 9H).

[00186] Example 4: 5-Amino-2-tert-butyl-1H-indole-4-carbonitrile



a) KCN, DMSO; b) Pd/C, EtOAc

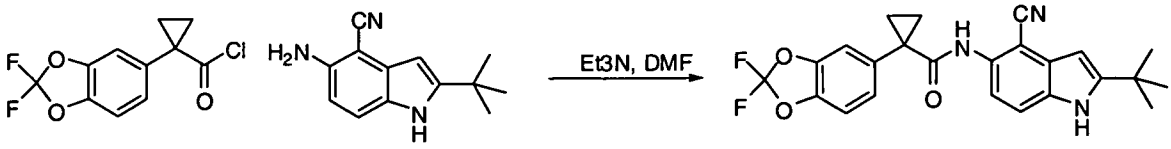
[00187] Step a: 2-tert-butyl-5-nitro-1H-indole-4-carbonitrile

[00188] To a solution of 2-tert-butyl-4-fluoro-5-nitro-1H-indole (4.0 g, 17 mmol) in DMSO (30 mL) was added KCN (3.4 g, 51 mmol). The mixture was stirred at 70°C for 3 hours, and poured into water (80 mL) and extracted with ethyl acetate (50 mL × 3). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under *vacuum*. The residue was purified by column chromatography on silica gel (7% EtOAc in petroleum ether) to afford 2-tert-butyl-5-nitro-1H-indole-4-carbonitrile (2.2 g, 53%). ^{1}H NMR (DMSO, 300 MHz) δ 12.23 (br s, 1 H), 8.09 (d, J = 9.0 Hz, 1 H), 7.75 (d, J = 9.0 Hz, 1 H), 6.50 (s, 1 H), 1.38 (s, 9 H). MS (ESI) m/z: 244.2 [M+H$^+$].

[00189] Step b: 5-amino-2-tert-butyl-1H-indole-4-carbonitrile

[00190] To a solution of 2-tert-butyl-5-nitro-1H-indole-4-carbonitrile (550 mg, 2.3 mmol) in EtOAc (10 mL) was added Raney Ni (0.1 g) under a nitrogen atmosphere. The mixture was stirred under hydrogen atmosphere (1 atm) at room temperature for 1 h. The catalyst was filtered over Celite and the filtrate was evaporated in *vacuo* to afford 5-amino-2-tert-butyl-1H-indole-4-carbonitrile (250 mg, 51%). ^{1}H NMR (DMSO, 300 MHz) δ 10.93 (br s, 1 H), 7.25 (d, J = 8.7 Hz, 1 H), 6.49 (d, J = 8.7 Hz, 1 H), 5.94 (d, J = 2.1 Hz, 1 H), 5.40 (br s, 2 H), 1.30 (s, 9 H). MS (ESI) m/z: 214.0 [M+H$^+$].

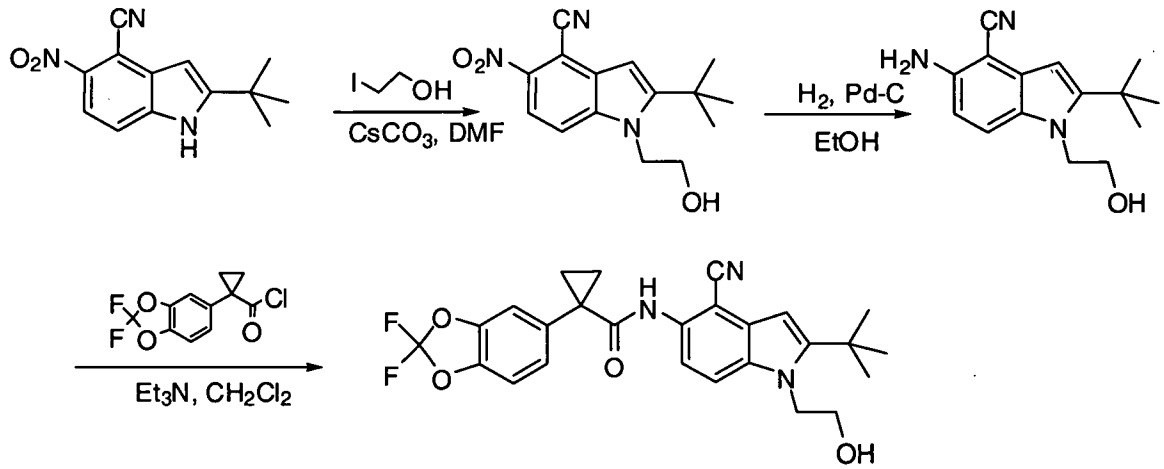
[00191] Example 6: N-(2-tert-butyl-4-cyano-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide



[00192] Step a: N-(2-tert-butyl-4-cyano-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide

[00193] 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarbonyl chloride (26 mg, 0.1 mmol) was added to a solution of 5-amino-2-tert-butyl-1H-indole-4-carbonitrile (21 mg, 0.1 mmol) and triethylamine (41.7 μL, 0.3 mmol) in DMF (1 mL). The reaction was stirred at room temperature overnight, then filtered and purified by reverse-phase HPLC to yield the product, N-(2-tert-butyl-4-cyano-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide. ESI-MS *m/z* calc. 437.2, found 438.7 $(M+1)^+$. Retention time 2.10 minutes. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 11.48 (s, 1H), 8.88 (s, 1H), 7.52 (d, J = 8.5 Hz, 2H), 7.41 (d, J = 8.3 Hz, 1H), 7.32 (dd, J = 1.5, 8.3 Hz, 1H), 7.03 (d, J = 8.6 Hz, 1H), 6.21 (d, J = 1.8 Hz, 1H), 1.51 - 1.49 (m, 2H), 1.36 (s, 9H), 1.18 - 1.16 (m, 2H).

[00194] Example 7: N-(2-tert-butyl-4-cyano-1-(2-hydroxyethyl)-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide



[00195] Step a: 2-tert-butyl-1-(2-hydroxyethyl)-5-nitro-1H-indole-4-carbonitrile

[00196] A mixture of 2-tert-butyl-5-nitro-1H-indole-4-carbonitrile (200 mg, 0.82 mmol), 2-iodoethanol (77 μL, 0.98 mmol), cesium carbonate (534 mg, 1.64 mmol) and DMF (1.3 mL) was heated to 90 °C overnight. Then more 2-iodoethanol (77 μL, 0.98 mmol) was added and the reaction was stirred at 90 °C for 3 days. The reaction mixture was partitioned between ethyl acetate and water. The aqueous layer was washed with ethyl acetate and then the combined ethyl acetate layers were washed with water (x3) and brine, dried over $MgSO_4$ and concentrated. The residue was purified by column chromatography (50 – 100% CH_2Cl_2 – Hexanes) to yield the product as a yellow solid (180 mg, ~25% purity by NMR, product co-elutes with the indole starting material). ESI-MS *m/z* calc. 287.1, found 288.5 $(M+1)^+$. Retention time 1.59 minutes. ^1H NMR (400 MHz, DMSO-*d6*) δ 12.23 (s, 1H), 8.14 (d, J = 9.1 Hz, 1H), 8.02 (d, J = 9.1 Hz, 1H), 6.60 (s, 1H), 5.10 (t, J = 5.5 Hz, 1H), 4.55 (t, J = 6.3 Hz, 2H), 3.78 - 3.73 (m, 2H) and 1.49 (s, 9H) ppm.

[00197] Step b: 5-amino-2-tert-butyl-1-(2-hydroxyethyl)-1H-indole-4-carbonitrile

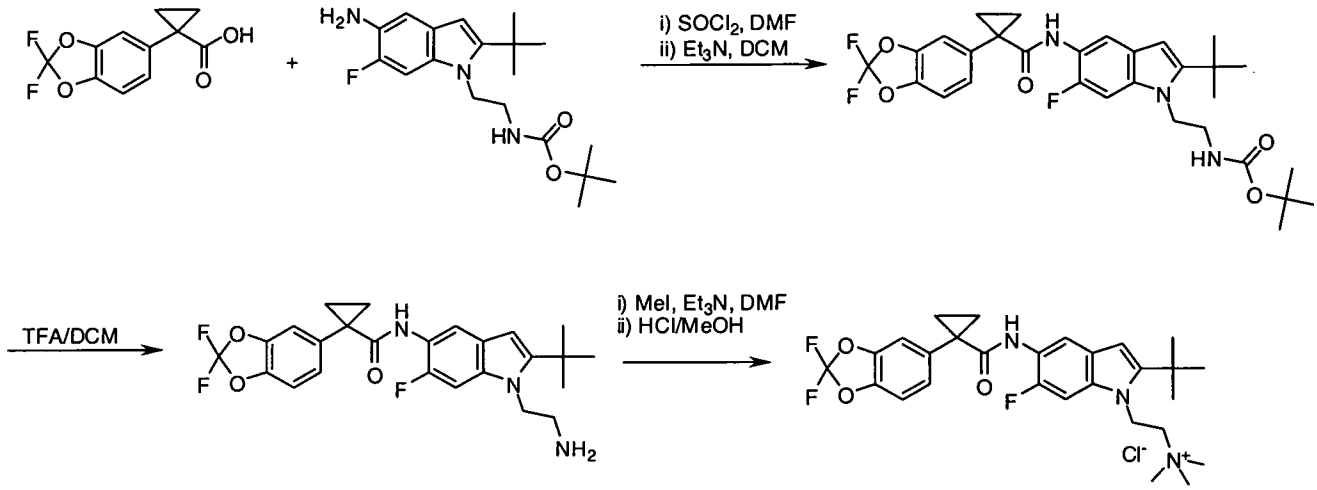
[00198] To a solution of 2-tert-butyl-1-(2-hydroxyethyl)-5-nitro-1H-indole-4-carbonitrile (180 mg, 0.63 mmol) in ethanol (6 mL) under N_2 atmosphere was added Pd-C (5% wt, 18 mg). The reaction was flushed with N_2 (g) and then with H_2 (g) and stirred under H_2 (atm) at room temperature for 1.5 hours. The reaction was filtered over Celite and concentrated to yield the product (150 mg, 93 %). ESI-MS *m/z* calc. 257.2, found 258.5 $(M+1)^+$. Retention time 1.26 minutes.

[00199] Step c: N-(2-tert-butyl-4-cyano-1-(2-hydroxyethyl)-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide

[00200] 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarbonyl chloride (196 mg, 0.75 mmol) was added to a solution of 5-amino-2-tert-butyl-1-(2-hydroxyethyl)-1H-indole-4-carbonitrile (150 mg, 0.58 mmol) and triethylamine (242 μL, 1.74 mmol) in dichloromethane (2 mL). The reaction was stirred at room temperature overnight. The reaction mixture was diluted with dichloromethane and extracted with 1N HCl solution (x2), saturated $NaHCO_3$ solution (x2), brine, dried over $MgSO_4$, filtered and concentrated. The residue was dissolved in DMSO and purified by reverse-phase HPLC to yield the product, N-(2-tert-butyl-4-cyano-1-(2-hydroxyethyl)-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide. ESI-MS *m/z* calc. 481.2, found 482.5 $(M+1)^+$. Retention time

1.99 minutes. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 8.93 (s, 1H), 7.71 (d, J = 8.8 Hz, 1H), 7.51 (s, 1H), 7.42 (d, J = 8.3 Hz, 1H), 7.33 (d, J = 1.6 Hz, 1H), 7.08 (d, J = 8.8 Hz, 1H), 6.28 (s, 1H), 5.05 (t, J = 5.6 Hz, 1H), 4.42 (t, J = 6.8 Hz, 2H), 3.70 - 3.65 (m, 2H), 1.51 - 1.48 (m, 2H), 1.44 (s, 9H), 1.19 - 1.16 (m, 2H).

[00201] Example 8: 2-(2-*tert*-butyl-5-(1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamido)-6-fluoro-1H-indol-1-yl)-N,N,N-trimethylethanaminium chloride



[00202] Step a: *tert*-Butyl 2-(2-*tert*-butyl-5-(1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamido)-6-fluoro-1H-indol-1-yl)ethylcarbamate

[00203] To 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxylic acid (90.14 mg, 0.3722 mmol) in thionyl chloride (81.28 μL, 1.117 mmol) was added *N,N* -dimethyl formamide (8.204 μL, 0.1064 mmol). The reaction mixture was stirred at room temperature for 30 minutes before excess thionyl chloride and *N,N* -dimethyl formamide were removed *in vacuo* to yield the acid chloride. The acid chloride was then dissolved in dichloromethane (1.5 mL) and added slowly to a solution of *tert*-butyl 2-(5-amino-2-*tert*-butyl-6-fluoro-1H-indol-1-yl)ethylcarbamate (156.1 mg, 0.4467 mmol) and triethylamine (155.6 μL, 1.117 mmol) in dichloromethane (1.5 mL). The resulting reaction mixture was stirred at room temperature for 21 hours. The reaction mixture was diluted with dichloromethane (5 mL) and washed with 1N aqueous HCl (5 mL) and a saturated aqueous $NaHCO_3$ solution (5 mL). The organic layer was dried over Na_2SO_4, filtered and evaporated under reduced pressure. The crude product was purified by column

chromatography on silica gel (0-30% ethyl acetate in hexane) to yield *tert*-butyl 2-(2-*tert*-butyl-5-(1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamido)-6-fluoro-1H-indol-1-yl)ethylcarbamate as a white solid (140 mg, 66%). ESI-MS *m/z* calc. 573.2, found 574.7 $(M+1)^+$. Retention time 2.41 minutes. 1H NMR (400.0 MHz, DMSO) d 8.35 (s, 1H), 7.53 (s, 1H), 7.44 - 7.41 (m, 2H), 7.34 - 7.29 (m, 2H), 7.13 - 7.10 (m, 1H), 6.17 (s, 1H), 4.24 - 4.20 (m, 2H), 3.20 - 3.17 (m, 2H), 1.48-1.45 (m, 2H), 1.41 (s, 18H) and 1.15-1.12 (m, 2H) ppm.

[00204] Step b: N-(1-(2-aminoethyl)-2-*tert*-butyl-6-fluoro-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide

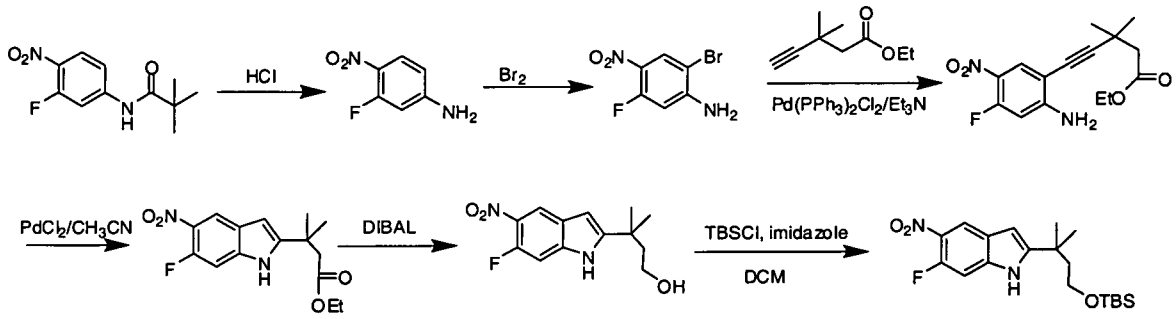
[00205] To a solution of *tert*-butyl 2-(2-*tert*-butyl-5-(1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamido)-6-fluoro-1H-indol-1-yl)ethylcarbamate (137.5 mg, 0.24 mmol) in dichloromethane (1.8 mL) was added trifluoroacetic acid (444 μL, 5.8 mmol) and the mixture was stirred at room temperature for 1 hour. The reaction was diluted with dichloromethane and washed with saturated aqueous $NaHCO_3$ solution (3 mL) and brine (3 mL). The organic layer was dried over Na_2SO_4, filtered and evaporated under reduced pressure. The crude product was purified by column chromatography on silica gel (0-10% methanol in dichloromethane) to yield N-(1-(2-aminoethyl)-2-*tert*-butyl-6-fluoro-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide as a white solid (93.7 mg, 82%). ESI-MS *m/z* calc. 473.19, found 474.5 $(M+1)^+$. Retention time 1.61 minutes.

[00206] Step c: 2-(2-*tert*-butyl-5-(1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamido)-6-fluoro-1H-indol-1-yl)-N,N,N-trimethylethanaminium chloride

[00207] To a clear solution of N-(1-(2-aminoethyl)-2-*tert*-butyl-6-fluoro-1H-indol-5-yl)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamide (50 mg, 0.1056 mmol) in *N,N*-dimethyl formamide (1 mL), methyl iodide (336.8 mg, 147.7 μL, 2.37 mmol) and triethylamine (106.9 mg, 147.2 μL, 1.05 mmol) were added and the mixture was heated at 80 °C for 2 hours. The crude product was purified by reverse phase preparative HPLC. 22 mg of this product were dissolved in 1.25 M HCl in methanol (112 μL, 0.14 mmol) and heated at 60 °C for 1 hour. The reaction was cooled to room temperature. The product was first dried and then dissolved in dichloromethane and dried again. This procedure was repeated four times to yield 2-(2-*tert*-butyl-5-(1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxamido)-6-fluoro-1H-indol-1-yl)-N,N,N-trimethylethanaminium chloride. ESI-MS *m/z* calc. 516.25, found 516.7 $(M+1)^+$.

Retention time 1.69 minutes. 1H NMR (400.0 MHz, DMSO) d 8.43 (s, 1H), 7.53 (s, 1H), 7.45 - 7.41 (m, 2H), 7.36 - 7.31 (m, 2H), 6.27 (s, 1H), 4.74 - 4.70 (m, 2H), 3.57 - 3.53 (m, 2H), 3.29 (s, 9H), 1.48 - 1.42 (m, 11H), and 1.15 (dd, J = 3.9, 6.8 Hz, 2H) ppm.

[00208] Example 9: 2-(4-(Tert-butyldimethylsilyloxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole



[00209] Step a: 3-fluoro-4-nitroaniline

[00210] A mixture of N-(3-fluoro-4-nitro-phenyl)-2, 2-dimethyl-propionamide (87.0 g, 0.36 mol) in CH_2Cl_2 (400 mL) and 6N hydrochloric acid (800 mL) was heated to reflux for 2 hours. The reaction mixture was cooled to room temperature. The reaction mixture was diluted with 1000 mL of ethyl acetate and potassium carbonate (500.0 g) was added portion wise. The aqueous solution was separated and the organic layer was washed with brine and dried over anhydrous Na_2SO_4. The solvent was removed by evaporation under reduced pressure; the residue was purified by column chromatography on silica gel (petroleum ether / ethyl acetate 30: 1) to afford 3-fluoro-4-nitroaniline (56.0 g, 99 %). ^1H NMR (300 MHz, $CDCl_3$) δ 8.07 (t, J = 8.7 Hz, 1 H), 7.86 (dd, J = 2.1, 13.2 Hz 1 H), 7.59 (brs, 2 H), 7.22 (s, 1 H).

[00211] Step b: 2-bromo-5-fluoro-4-nitroaniline

[00212] To a solution of 3-fluoro-4-nitroaniline (56 g, 0.36 mol) in acetic acid (500 mL) was added drop-wise bromine (17.7 mL, 0.36 mol) over 1 hour. The reaction mixture was stirred for 1 hour at 0-5 °C in an ice bath. The reaction mixture was basified with saturated Na_2CO_3 and extracted with ethyl acetate (200 mL x 3). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure to yield a residue that was purified by column chromatography on silica gel (petroleum ether / ethyl acetate 10 : 1)

to give the 2-bromo-5-fluoro-4-nitroaniline (45.6 g, 84 %) as a yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29 (d, J = 7.6 Hz, 1 H), 653 (d, J = 12.4 Hz, 1 H), 4.94 (br s, 2 H).

[00213] Step c: ethyl 5-(2-amino-4-fluoro-5-nitrophenyl)-3,3-dimethylpent-4-ynoate

[00214] To a solution of 2-bromo-5-fluoro-4-nitroaniline (45.7 g, 0.19 mol) and ethyl 3,3-dimethylpent-4-ynoate (88.3 g, 0.57 mol) in Et_3N (700 mL) was added $Pd(PPh_3)_2Cl_2$ (13.8 g, 0.02 mol) and CuI (3.6 g, 0.02 mol) under N_2. The reaction mixture was stirred at 70°C for 8 hours. The reaction mixture was diluted with 500 mL of ethyl acetate and 1500 mL of water. The organic layer was separated and the aqueous phase was extracted with ethyl acetate (500 mL×3), the combined organic layers were washed with brine and dried over anhydrous Na_2SO_4, filtered and evaporated under reduced pressure and the residue was purified by column chromatography on silica gel (petroleum ether / ethyl acetate 10: 1) to give ethyl-5-(2-amino-4-fluoro-5- nitrophenyl)-3,3-dimethylpent-4-ynoate (34.5 g, 57 %). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.05 (d, J = 8.1Hz, 1 H), 6.36 (d, J = 13.2 Hz, 1 H), 5.60 (brs, 2 H), 4.16 (q, J = 7.2 Hz, 2 H), 2.51 (s, 2 H), 1.40 (s, 6 H), 1.28 (t, J = 7.2 Hz, 3 H).

[00215] Step d: ethyl 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutanoate

[00216] To a mixture of ethyl 5-(2-amino-4-fluoro-5-nitrophenyl)-3, 3-dimethylpent-4-ynoate (34.5 g, 0.11 mol) and $PdCl_2$ (10.4 g, 58.6 nmol) in CH_3CN (350 mL) was heated to reflux for 1.5 hours. The reaction mixture was cooled down to room temperature. Ethyl acetate (300 mL) was added, the precipitate was filtered off and washed with methanol. The filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (petroleum ether / ethyl acetate 40: 1) to give ethyl 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutanoate (34.0 g, 98 %) as a deep yellow solid. ^{1}H NMR (300 MHz, $CDCl_3$) δ 10.11 (brs, 1 H), 8.30 (d, J = 7.2 Hz, 1 H), 7.14 (d, J = 11.7 Hz, 1 H), 6.35 (d, J = 1.5 Hz, 1 H), 4.17 (q, J = 7.2 Hz, 2 H), 2.69 (s, 2 H), 1.51 (s, 6 H), 1.25 (t, J = 7.2 Hz, 3 H).

[00217] Step e: 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol

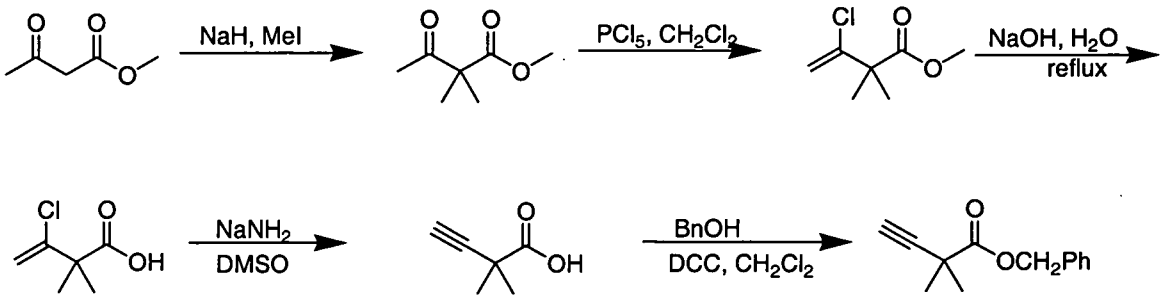
[00218] To a solution of ethyl 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutanoate (34 g, 0.11 mol) in dry CH_2Cl_2 (400 mL) was added drop-wise DIBAL-H (283.4 mL, 0.27 mol) over 2 hours at -78°C. The reaction mixture was stirred for 10 hours at -78°C and then quenched by adding water (200 mL). The precipitate was filtered off and washed with methanol. The filtrate

was extracted with CH_2Cl_2 (200 mL×3), the combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether / ethyl acetate 50: 1) to give 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol (6.6 g, 22 %). ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.35 (brs, 1 H), 8.30 (d, *J* = 7.6 Hz, 1 H), 7.11 (d, *J* = 12.0 Hz, 1 H), 6.35 (d, *J* = 1.2 Hz, 1 H), 3.74 (t, *J* = 6.4 Hz, 2 H), 1.9 (t, *J* = 6.4 Hz, 2 H), 1.4 (s, 6 H).

[00219] Step f: 2-(4-(tert-butyldimethylsilyloxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole

[00220] To a solution of 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol (6.6 g, 25 mmol) in CH_2Cl_2 (80 mL) was added TBSCl (3.7 g, 25 nmol) and imidazole (4.2 g, 62 nmol) at 0°C. The reaction mixture was stirred at room temperature for 12 hours. The precipitate was filtered off and washed with the methanol. The filtrate was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel (petroleum ether / ethyl acetate 10: 1) to give the desired product as a brown solid (5.0 g, 53 %). ^{1}H NMR (300 MHz, $CDCl_3$) δ 9.80 (brs, 1 H), 8.30 (d, *J* = 7.2 Hz,1 H), 7.05 (d, *J* = 11.7 Hz, 1 H), 6.33 (t, *J* = 1.2 Hz, 1 H), 3.7 (t, *J* = 6.0 Hz, 2 H), 1.91 (t, *J* = 6.0 Hz, 2 H), 1.42 (s , 6 H), 0.94 (s , 9 H), 0.12 (s , 6 H). MS (ESI) m/z ($M+H^+$): 381.1.

[00221] Example 10: Benzyl 2,2-dimethylbut-3-ynoate



[00222] Step a: methyl 2,2-dimethyl-3-oxobutanoate

[00223] To a suspension of NaH (28.5 g, 0.718 mol, 60%) in THF (270 mL) was added dropwise a solution of 3-oxo-butyric acid methyl ester (78.6 g, 0.677 mol) in THF (70 mL) at 0 °C. The mixture was stirred for 0.5 hours at 0 °C. MeI (99.0 g, 0.698 mol) was added dropwise at 0 °C. The resultant mixture was warmed to room temperature and stirred for 1 hour. NaH

(28.5 g, 0.718 mol, 60%) was added in portions at 0 °C and the resulting mixture was continued to stir for 0.5 h at 0 °C. MeI (99.0 g, 0.698 mol) was then added dropwise at 0 °C. The reaction mixture was warmed to room temperature and stirred overnight. The mixture was poured into ice water. The organic layer was separated. The aqueous phase was extracted with EtOAc (300 mL × 3). The combined organic layers were dried and evaporated under reduced pressure to give methyl 2,2-dimethyl-3-oxobutanoate (52 g, 53%), which was used directly in the next step.

[00224] Step b: methyl 3-chloro-2,2-dimethylbut-3-enoate

[00225] To a suspention of PCl_5 (161 g, 0.772 mol) in dichloromethane (600 mL) was added dropwise methyl 2,2-dimethyl-3-oxobutanoate (52 g, 0.361 mol, crude from last step) at 0 °C, followed by the addition of approximately 20 drops of dry DMF. The mixture was heated at reflux overnight. After cooling, the reaction mixture was slowly poured into ice water. The organic layer was separated and the aqueous phase was extracted with dichloromethane (300 mL × 3). The combined organic layers were washed with saturated aqueous $NaHCO_3$ solution and dried over anhydrous Na_2SO_4. The solvent was evaporated to give the product, methyl 3-chloro-2,2-dimethylbut-3-enoate which was used without further purification (47 g, 82%).

[00226] Step c: 3-chloro-2,2-dimethylbut-3-enoic acid

[00227] A mixture of methyl 3-chloro-2,2-dimethylbut-3-enoate (42.0 g, 0.26 mol) and NaOH (12.4 g, 0.31 mol) in water (300 mL) was heated at reflux overnight. After cooling, the reaction mixture was extracted with ether. The organic layer contained 20g of methyl 3-chloro-2,2-dimethylbut-3-enoate (48 % recovered). The aqueous layer was acidified with cold 20% HCl solution and was extracted with ether (250 mL × 3). The combined organic layers were dried and evaporated under reduced pressure to give 3-chloro-2,2-dimethylbut-3-enoic acid (17 g, 44 %), which was used directly in the next step.

[00228] Step d: 2,2-dimethylbut-3-ynoic acid

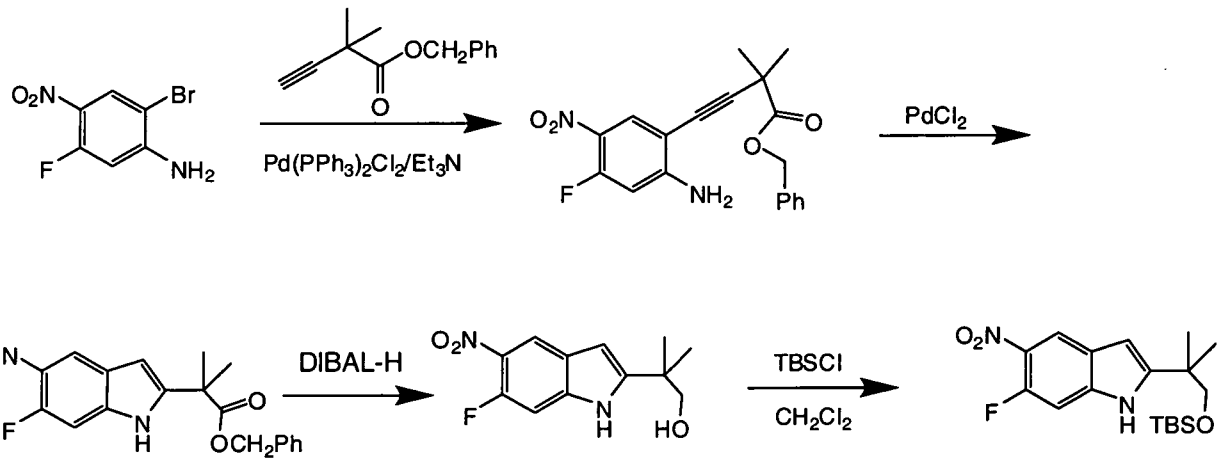
[00229] To a three-neck flask (500 mL) was added $NaNH_2$ (17.8 g, 0.458 mmol, pellets) and DMSO (50 mL). The mixture was stirred at room temperature until no more NH_3 (g) was given off. A solution of 3-chloro-2,2-dimethylbut-3-enoic acid (17.0 g, 114 mmol) in DMSO (50 mL) was added dropwise at 0 °C. The mixture was warmed and stirred at 50 °C for 5 hours, then stirred at room temperature overnight. The mixture was poured into cold 20% HCl solution, and

then extracted three times with ether. The ether extracts were dried over anhydrous Na_2SO_4 and concentrated to give a 6:1 ratio of starting material and alkyne product. The residue was re-dried using ether and Na_2SO_4 and re-subjected to the reaction conditions above. The reaction mixture was worked up in the same manner to provide 2,2-dimethylbut-3-ynoic acid (12.0 g, 94 %).

[00230] benzyl 2,2-dimethylbut-3-ynoate

[00231] To a stirred solution of 2,2-dimethylbut-3-ynoic acid (87.7 g, 0.782 mmol) and benzyl alcohol (114.6 g, 0.938 mol) in dichloromethane (800 mL) was added DCC (193.5 g, 0.938 mmol) at -20 °C. The reaction mixture was stirred at room temperature overnight and then the solvent was evaporated in *vacuo*. The residue was purified by chromatography on silica gel (2% ethyl acetate in petroleum ether as eluant) to afford benzyl 2,2-dimethylbut-3-ynoate (100 g, 59 % yield). ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.37-7.36 (m, 5 H), 5.19 (s, 2 H), 2.28 (s, 1 H), 1.52 (s, 6 H).

[00232] Example 11: 2-(1-(Tert-butyldimethylsilyloxy)-2-methylpropan-2-yl)-6-fluoro-5-nitro-1H-indole



[00233] Step a: benzyl 4-(2-amino-4-fluoro-5-nitrophenyl)-2,2-dimethylbut-3-ynoate

[00234] To a solution of 2-bromo-5-fluoro-4-nitroaniline (23.0 g, 0.1 mol) in Et_3N (250 mL) was added benzoic 2,2-dimethylbut-3-ynoic anhydride (59.0 g, 0.29 mol), CuI (1.85 g) and $Pd(PPh_3)_2Cl_2$ (2.3 g) at room temperature. The mixture was stirred at 80°C overnight. After cooling to room temperature, the reaction was quenched with water and the aqueous layer was extracted with ethyl acetate (100 mL × 3). The combined organic layer was dried over anhydrous

Na_2SO_4, the solvent was evaporated *in vacuo*. The residue was purified by chromatography on silica gel (10% ethyl acetate in petroleum ether) to give benzyl 4-(2-amino-4-fluoro-5-nitrophenyl)-2,2-dimethylbut-3-ynoate (20.0 g, 56%). ^{1}H NMR (400 MHz, $CDCl_3$) 8.05 (d, J = 8.4 Hz, 1 H), 7.39-7.38 (m, 5 H), 6.33 (d, J = 13.2 Hz, 1 H), 5.20 (s, 2 H), 4.89 (br s, 2 H), 1.61 (s, 6 H).

[00235] Step b: benzyl 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate

[00236] To a solution of benzyl 4-(2-amino-4-fluoro-5-nitrophenyl)-2,2-dimethylbut-3-ynoate (20.0 g, 56 mmol) in acetonitrile (100 mL) was added $PdCl_2$ (5.0 g, 28 mmol) at room temperature. The mixture was stirred at 80°C overnight. The mixture was filtered off and the solvent was evaporated in *vacuo*, the residue was purified by chromatography on silica gel (10% EtOAc in petroleum ether) to give benzyl 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate (18.0 g, 90%). ^{1}H NMR (300 MHz, $CDCl_3$) 8.96 (br s, 1 H), 8.33 (d, J = 7.2 Hz, 1 H) 7.35-7.28 (m, 5 H) 7.08 (d, J = 11.7 Hz, 1 H), 6.47 (s, 1 H), 5.18 (s, 2 H) 1.69 (s, 6 H).

[00237] Step c: 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol

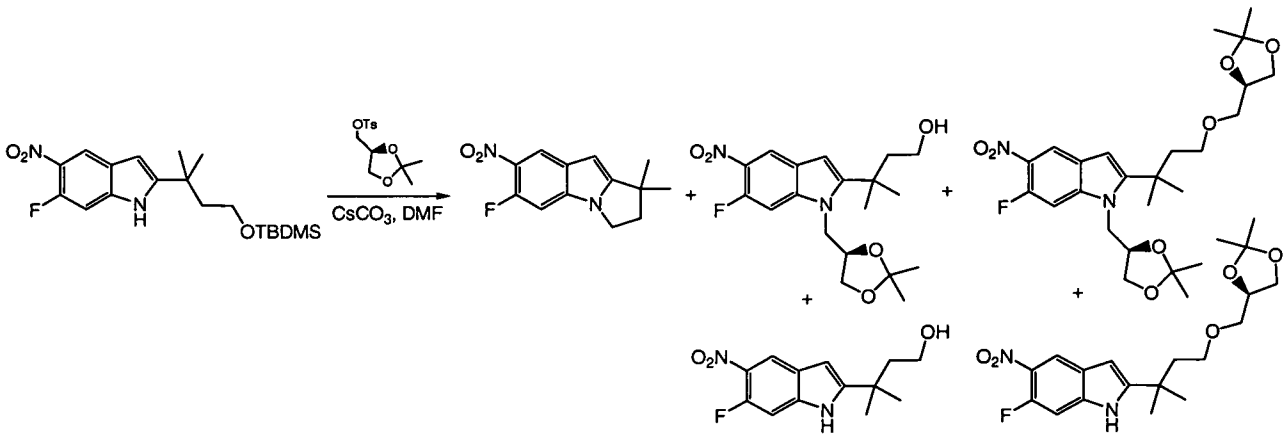
[00238] To a solution of benzyl 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate (18.0 g, 0.05 mol) in CH_2Cl_2 (100 mL) was added DIBAL-H (12 mL) at -78°C. The mixture was stirred for 1 h at that temperature and was warmed to room temperature. The reaction was quenched with water and the aqueous layer was extracted with EtOAc (100 mL × 3). The combined organic layers were dried over anhydrous Na_2SO_4, the solvent was evaporated *in vacuo*. The residue was purified by chromatography on silica gel (10% EtOAc in petroleum ether) to give 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol (10.0 g, 77%). ^{1}H NMR (300 MHz, $CDCl_3$) 9.37 (s, 1 H), 8.32 (d, J = 7.2 Hz, 1 H), 7.11 (d, J = 11.7 Hz, 1 H), 6.36 (s, 1 H), 3.73 (d, J = 5.1 Hz 2 H), 1.97 (t, J = 5.1 Hz, 1 H), 1.39 (s, 6 H).

[00239] Step d: 2-(1-(tert-butyldimethylsilyloxy)-2-methylpropan-2-yl)-6-fluoro-5-nitro-1H-indole

[00240] To a stirred solution of 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol (10.0g) in CH_2Cl_2 was added TBSCl (8.9 g), imidazole (8.1g, 0.12 mol) at room temperature. The mixture was stirred overnight. The solvent was evaporated *in vacuo* and the residue was

purified by chromatography on silica gel (10% EtOAc in petroleum ether) to give 2-(1-(tert-butyldimethylsilyloxy)-2-methylpropan-2-yl)-6-fluoro-5-nitro-1H-indole (5.3 g, 38 %). ^{1}H NMR (300 MHz, $CDCl_3$) 9.51 (s, 1 H), 8.31 (d, J = 7.5 Hz, 1 H), 7.02 (d, J = 11.7 Hz, 1 H), 6.32 (s, 1 H), 3.63 (s, 2 H), 1.35 (s, 6 H), 0.99 (s, 9 H), 0.11 (s, 6 H).

[00241] Example 12: 6-fluoro-1,1-dimethyl-7-nitro-2,3-dihydro-1H-pyrrolo[1,2-a]indole, (R)-3-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol, 2-(4-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-1-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indole, 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol and (R)-2-(4-((2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole

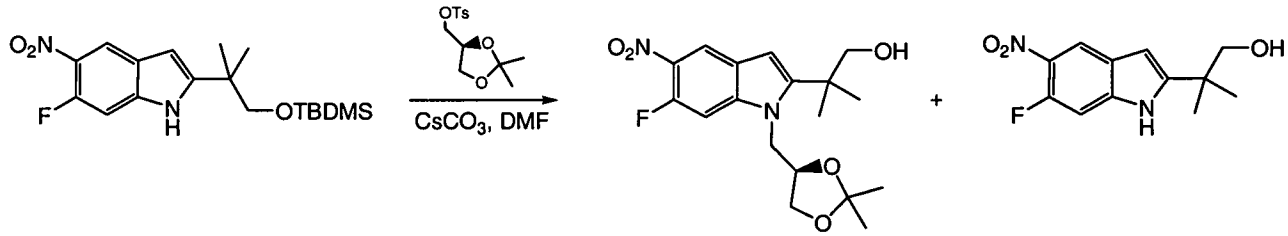


[00242] Step a: 6-fluoro-1,1-dimethyl-7-nitro-2,3-dihydro-1H-pyrrolo[1,2-a]indole, (R)-3-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol, 2-(4-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-1-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indole, 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol and (R)-2-(4-((2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole

[00243] To a solution of 2-(4-(tert-butyldimethylsilyloxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole (1.9 g, 5.0 mmol) and (S)-(2,2-dimethyl-1,3-dioxolan-4-yl)methyl 4-methylbenzenesulfonate (2.86 g, 10.0 mmol) in DMF (10 mL) was added Cs_2CO_3 (4.88 g, 15.0 mmol). The mixture was heated at 90 °C for 24 hours. The reaction was partitioned between ethyl acetate and water. The aqueous layer was extracted with ethyl acetate and the combined organic layers were washed with brine and dried over $MgSO_4$. After the removal of solvent, the

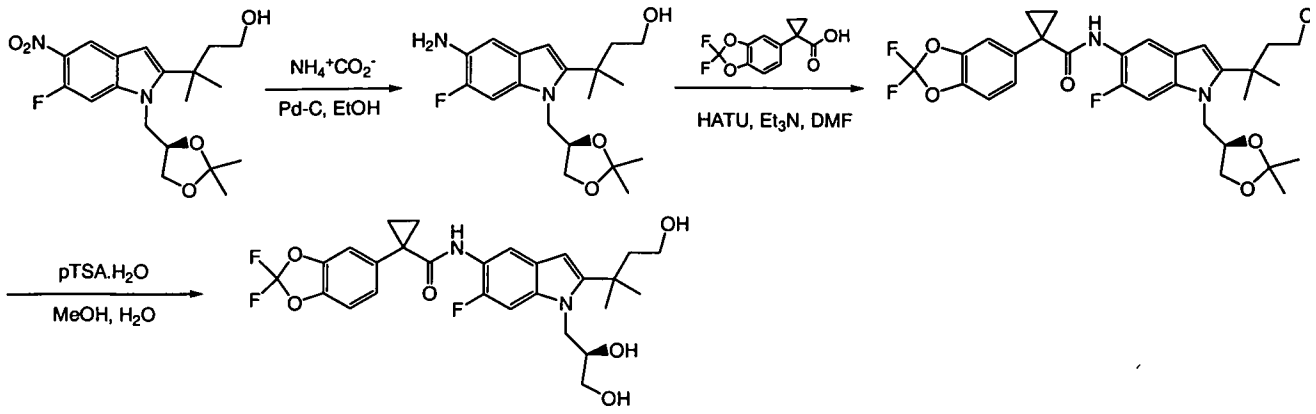
residue was purified by column chromatography (10-50% ethyl acetate - hexane) to afford 6-fluoro-1,1-dimethyl-7-nitro-2,3-dihydro-1H-pyrrolo[1,2-a]indole (600 mg, 48%). ESI-MS *m/z* calc. 248.1, found 249.2 $(M+1)^+$. Retention time 2.00 minutes; 2-(4-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-1-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indole (270 mg, containing some (R)-2-(4-((2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole). ESI-MS *m/z* calc. 494.2 and 380.2, found 495.4 and 381.4 $(M+1)^+$. Retention time 2.12 and 1.92 minutes; (R)-3-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol (1.0 g, containing some 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol). ESI-MS *m/z* calc. 380.2 and 266.1, found 381.2 and 267.2 $(M+1)^+$. Retention time 1.74 and 1.48 minutes.

[00244] Example 13: (R)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol and 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol



[00245] A mixture containing (R)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol and 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol was obtained following the procedure shown above starting from 2-(1-(tert-butyldimethylsilyloxy)-2-methylpropan-2-yl)-6-fluoro-5-nitro-1H-indole. (R)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol, ESI-MS *m/z* calc. 366.2, found 367.2 $(M+1)^+$. Retention time 1.71 minutes; 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol, ESI-MS *m/z* calc. 252.1, found 253.4 $(M+1)^+$. Retention time 1.42 minutes.

[00246] Example 14: (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide



[00247] Step a: (R)-3-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-3-methylbutan-1-ol

[00248] To a solution of (R)-3-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol containing some 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol (500 mg, 1.3 mmol) in ethanol (10 mL) was added ammonium formate (500 mg, 7.9 mmol) and Pd/C (10%, 139 mg, 0.13 mmol). The mixture was refluxed for 5 min. The Pd catalyst was removed via filtration through Celite and washed with ethanol. The filtrate was evaporated to dryness and purified by column chromatography (30-50% ethyl acetate-hexanes) to provide (R)-3-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-3-methylbutan-1-ol (220 mg, 48 %, contains some 3-(5-amino-6-fluoro-1H-indol-2-yl)-3-methylbutan-1-ol). ESI-MS *m/z* calc. 350.2 found 351.4 $(M+1)^+$. Retention time 0.94 minutes.

[00249] Step b: (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

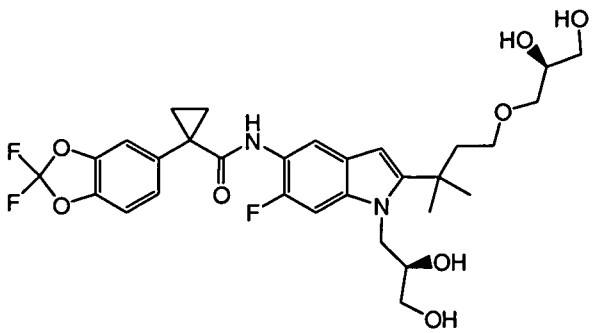
[00250] To a mixture of 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxylic acid (183 mg, 0.75 mmol), (R)-3-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-3-methylbutan-1-ol containing some 3-(5-amino-6-fluoro-1H-indol-2-yl)-3-methylbutan-1-ol (220 mg, 0.63 mmol) and HATU (287 mg, 0.75 mmol) in DMF (3.0 mL) was added triethylamine (0.21 mL, 1.5 mmol). The reaction was stirred at room temperature overnight and then partitioned between ethyl acetate and water. The aqueous layer was extracted with ethyl acetate and the combined organic layers were washed with brine and dried over $MgSO_4$. After the removal of solvent, the residue was purified by column chromatography (20-

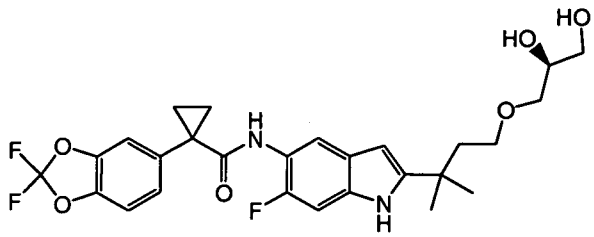
40% ethyl acetate - hexanes) to afford (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide (315 mg, 87 %, contains some 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide). ESI-MS *m/z* calc. 574.2 found 575.7 $(M+1)^+$. Retention time 2.08 minutes.

[00251] Step c: (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

[00252] To a solution of (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide containing some 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide (315 mg, 0.55 mmol) in methanol (3 mL) and water (0.3 mL) was added p-TsOH.H_2O (21 mg, 0.11 mmol). The mixture was heated at 80 °C for 30 minutes. The reaction was partitioned between ethyl acetate and water and the aqueous layer was extracted with ethyl acetate twice. The combined organic layers were washed with saturated. $NaHCO_3$ solution and brine and dried over $MgSO_4$. After the removal of solvent, the residue was purified by column chromatography (20-80% ethyl acetate - hexanes) to provide (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(4-hydroxy-2-methylbutan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide (92 mg, 31%). ESI-MS *m/z* calc. 534.2, found 535.5 $(M+1)^+$. Retention time 1.72 minutes. ^1H NMR (400 MHz, DMSO-*d6*) δ 8.32 (s, 1H), 7.53 (d, J = 1.0 Hz, 1H), 7.43 - 7.31 (m, 4H), 6.17 (s, 1H), 4.97 - 4.92 (m, 2H), 4.41 (dd, J = 2.4, 15.0 Hz, 1H), 4.23 (t, J = 5.0 Hz, 1H), 4.08 (dd, J = 8.6, 15.1 Hz, 1H), 3.87 (s, 1H), 3.48 - 3.44 (m, 1H), 3.41 - 3.33 (m, 1H), 3.20 (dd, J = 7.4, 12.7 Hz, 2H), 1.94 - 1.90 (m, 2H), 1.48 - 1.45 (m, 2H), 1.42 (s, 3H), 1.41 (s, 3H) and 1.15 - 1.12 (m, 2H) ppm.

[00253] Example 15: 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-((S)-2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-1-((R)-2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide and (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-(2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide

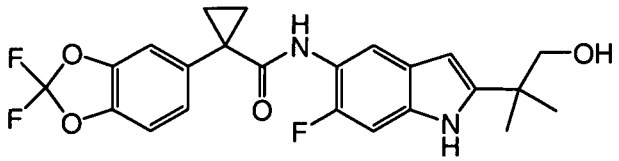




[00254] 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-((S)-2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-1-((R)-2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide and (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-(2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide

[00255] 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-((S)-2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-1-((R)-2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide and (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-(2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide were made following a scheme similar as shown above starting from 2-(4-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-1-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indole containing some (R)-2-(4-((2,2-dimethyl-1,3-dioxolan-4-yl)methoxy)-2-methylbutan-2-yl)-6-fluoro-5-nitro-1H-indole). 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-((S)-2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-1-((R)-2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide, ESI-MS *m/z* calc. 608.2, found 609.5 $(M+1)^+$. Retention time 1.67 minutes. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 8.32 (s, 1H), 7.53 (s, 1H), 7.43 - 7.31 (m, 4H), 6.19 (s, 1H), 4.95 - 4.93 (m, 2H), 4.51 (d, J = 5.0 Hz, 1H), 4.42 - 4.39 (m, 2H), 4.10 - 4.04 (m, 1H), 3.86 (s, 1H), 3.49 - 3.43 (m, 2H), 3.41 - 3.33 (m, 1H), 3.30 - 3.10 (m, 6H), 2.02 - 1.97 (m, 2H), 1.48 - 1.42 (m, 8H) and 1.13 (dd, J = 4.0, 6.7 Hz, 2H) ppm ; (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(2-(4-(2,3-dihydroxypropoxy)-2-methylbutan-2-yl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide, ESI-MS *m/z* calc. 534.2, found 535.5 $(M+1)^+$. Retention time 1.81 minutes. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 10.91 (d, J = 1.5 Hz, 1H), 8.30 (s, 1H), 7.53 (s, 1H), 7.42 - 7.33 (m, 3H), 7.03 (d, J = 10.9 Hz, 1H), 6.07 (d, J = 1.6 Hz, 1H), 4.56 (d, J = 5.0 Hz, 1H), 4.43 (t, J = 5.7 Hz, 1H), 3.51 - 3.46 (m, 1H), 3.31 - 3.13 (m, 6H), 1.88 (t, J = 7.3 Hz, 2H), 1.48 - 1.45 (m, 2H), 1.31 (s, 6H) and 1.15 - 1.12 (m, 2H) ppm.

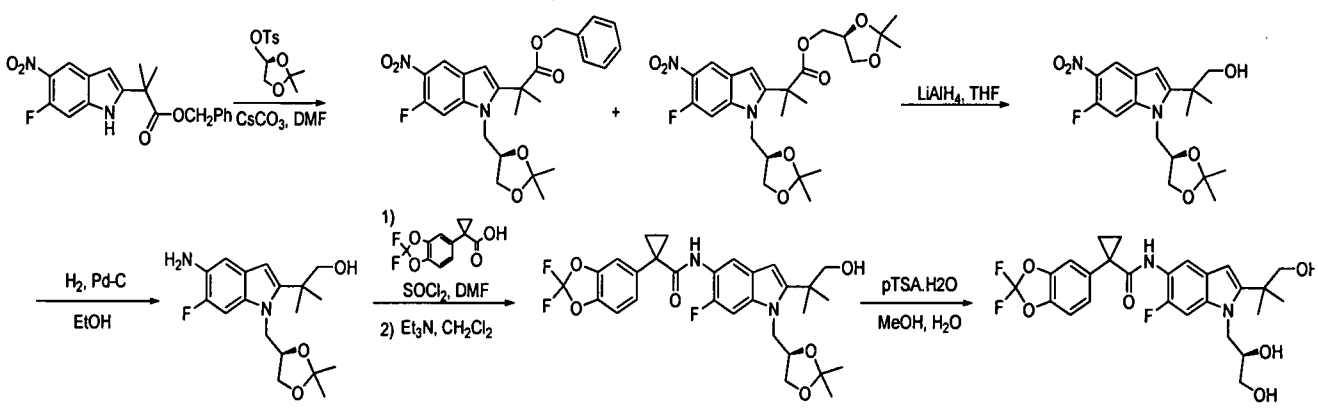
[00256] Example 16: 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide



[00257] 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

[00258] 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide was made following the scheme shown above starting from a mixture containing (R)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol and 3-(6-fluoro-5-nitro-1H-indol-2-yl)-3-methylbutan-1-ol. ESI-MS *m/z* calc. 446.2, found 447.5 $(M+1)^+$. Retention time 1.88 minutes. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (s, 1H), 8.20 (d, J = 7.7 Hz, 1H), 7.30 - 7.21 (m, 3H), 7.12 (d, J = 8.2 Hz, 1H), 6.94 (d, J = 11.2 Hz, 1H), 6.18 (s, 1H), 3.64 (s, 2H), 1.75 (dd, J = 3.8, 6.8 Hz, 2H), 1.34 (s, 6H) and 1.14 (dd, J = 3.9, 6.9 Hz, 2H) ppm.

[00259] Example 17: (R)-1-(2,2-Difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide



[00260] Step a: (R)-Benzyl 2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate and ((S)-2,2-Dimethyl-1,3-dioxolan-4-yl)methyl 2-(1-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate

[00261] Cesium carbonate (8.23 g, 25.3 mmol) was added to a mixture of benzyl 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate (3.0 g, 8.4 mmol) and (S)-(2,2-dimethyl-1,3-dioxolan-4-yl)methyl 4-methylbenzenesulfonate (7.23 g, 25.3 mmol) in DMF (17 mL). The reaction was stirred at 80 °C for 46 hours under nitrogen atmosphere. The mixture was then partitioned between ethyl acetate and water. The aqueous layer was extracted with ethyl acetate. The combined ethyl acetate layers were washed with brine, dried over $MgSO_4$, filtered and concentrated. The crude product, a viscous brown oil which contains both of the products shown above, was taken directly to the next step without further purification. (R)-Benzyl 2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate, ESI-MS *m/z* calc. 470.2, found 471.5 $(M+1)^+$. Retention time 2.20 minutes. ((S)-2,2-Dimethyl-1,3-dioxolan-4-yl)methyl 2-(1-(((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate, ESI-MS *m/z* calc. 494.5, found 495.7 $(M+1)^+$. Retention time 2.01 minutes.

[00262] Step b: (R)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol

[00263] To the crude reaction mixture obtained in step (a) was dissolved in THF (42 mL) and cooled in an ice-water bath. $LiAlH_4$ (16.8 mL of 1 M solution, 16.8 mmol) was added drop-wise. After the addition was complete, the reaction was stirred for an additional 5 minutes. The reaction was quenched by adding water (1 mL), 15% NaOH solution (1 mL) and then water (3 mL). The mixture was filtered over Celite, and the solids were washed with THF and ethyl acetate. The filtrate was concentrated and purified by column chromatography (30-60% ethyl acetate- hexanes) to obtain the product as a brown oil (2.68g, 87 % over 2 steps). ESI-MS *m/z* calc. 366.4, found 367.3 $(M+1)^+$. Retention time 1.68 minutes. ^1H NMR (400 MHz, DMSO-*d6*) δ 8.34 (d, J = 7.6 Hz, 1H), 7.65 (d, J = 13.4 Hz, 1H), 6.57 (s, 1H), 4.94 (t, J = 5.4 Hz, 1H), 4.64 - 4.60 (m, 1H), 4.52 - 4.42(m, 2H), 4.16 - 4.14 (m, 1H), 3.76 - 3.74 (m, 1H), 3.63 - 3.53 (m, 2H), 1.42 (s, 3H), 1.38 - 1.36 (m, 6H) and 1.19 (s, 3H) ppm

[00264] Step c: (R)-2-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-2-methylpropan-1-ol

[00265] (R)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol (2.5 g, 6.82 mmol) was dissolved ethanol (70 mL) and the reaction was flushed with N_2. Then Pd-C (250 mg, 5% wt) was added. The reaction was flushed with nitrogen again and then stirred under H_2 (atm). After 2.5 hours only partial conversion to the product was observed by LCMS. The reaction was filtered through Celite and concentrated. The residue was re-subjected to the conditions above. After 2 hours LCMS indicated complete conversion to product. The reaction mixture was filtered through Celite. The filtrate was concentrated to yield the product as a black solid (1.82 g, 79 %). ESI-MS *m/z* calc. 336.2, found 337.5 $(M+1)^+$. Retention time 0.86 minutes. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 7.17 (d, J = 12.6 Hz, 1H), 6.76 (d, J = 9.0 Hz, 1H), 6.03 (s, 1H), 4.79 - 4.76 (m, 1H), 4.46 (s, 2H), 4.37 - 4.31 (m, 3H),4.06 (dd, J = 6.1, 8.3 Hz, 1H), 3.70 - 3.67 (m, 1H), 3.55 - 3.52 (m, 2H), 1.41 (s, 3H), 1.32 (s, 6H) and 1.21 (s, 3H) ppm.

[00266] Step d: (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

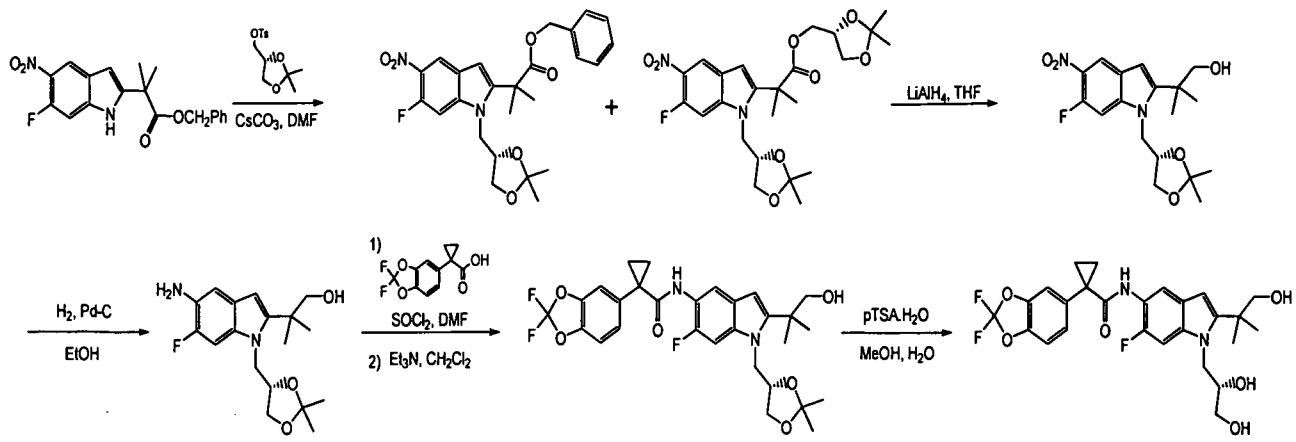
[00267] DMF (3 drops) was added to a stirring mixture of 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxylic acid (1.87 g, 7.7 mmol) and thionyl chloride (1.30 mL, 17.9 mmol). After 1 hour a clear solution had formed. The solution was concentrated under *vacuum* and then toluene (3 mL) was added and the mixture was concentrated again. The toluene step was repeated once more and the residue was placed on high vacuum for 10 minutes. The acid chloride was then dissolved in dichloromethane (10 mL) and added to a mixture of (R)-2-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-2-methylpropan-1-ol (1.8 g, 5.4 mmol) and triethylamine (2.24 mL, 16.1 mmol) in dichloromethane (45 mL). The reaction was stirred at room temperature for 1 hour. The reaction was washed with 1N HCl solution, saturated $NaHCO_3$ solution and brine, dried over $MgSO_4$ and concentrated to yield the product as a black foamy solid (3g, 100%). ESI-MS *m/z* calc. 560.6, found 561.7 $(M+1)^+$. Retention time 2.05 minutes. ^{1}H NMR (400 MHz, DMSO-*d6*) δ 8.31 (s, 1H), 7.53 (s, 1H), 7.42 - 7.40 (m, 2H), 7.34 - 7.30 (m, 3H), 6.24 (s, 1H), 4.51 - 4.48 (m, 1H), 4.39 - 4.34 (m,2H), 4.08

(dd, J = 6.0, 8.3 Hz, 1H), 3.69 (t, J = 7.6 Hz, 1H), 3.58 - 3.51 (m, 2H), 1.48 - 1.45 (m, 2H), 1.39 (s, 3H), 1.34 - 1.33 (m, 6H), 1.18 (s, 3H) and 1.14 - 1.12 (m, 2H) ppm

[00268] Step e: (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

[00269] (R)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide (3.0 g, 5.4 mmol) was dissolved in methanol (52 mL). Water (5.2 mL) was added followed by p-TsOH.H_2O (204 mg, 1.1 mmol). The reaction was heated at 80 °C for 45 minutes. The solution was concentrated and then partitioned between ethyl acetate and saturated $NaHCO_3$ solution. The ethyl acetate layer was dried over $MgSO_4$ and concentrated. The residue was purified by column chromatography (50-100 % ethyl acetate - hexanes) to yield the product as a cream colored foamy solid. (1.3 g, 47 %, ee >98% by SFC). ESI-MS *m/z* calc. 520.5, found 521.7 $(M+1)^+$. Retention time 1.69 minutes. ^1H NMR (400 MHz, DMSO-*d*6) δ 8.31 (s, 1H), 7.53 (s, 1H), 7.42 - 7.38 (m, 2H), 7.33 - 7.30 (m, 2H), 6.22 (s, 1H), 5.01 (d, J = 5.2 Hz, 1H), 4.90 (t, J = 5.5 Hz, 1H), 4.75 (t, J = 5.8 Hz, 1H), 4.40 (dd, J = 2.6, 15.1 Hz, 1H), 4.10 (dd, J = 8.7, 15.1 Hz, 1H), 3.90 (s, 1H), 3.65 - 3.54 (m, 2H), 3.48 - 3.33 (m, 2H), 1.48 - 1.45 (m, 2H), 1.35 (s, 3H), 1.32 (s, 3H) and 1.14 - 1.11 (m, 2H) ppm.

[00270] Example 18: (S)-1-(2,2-Difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide



[00271] Step a: (S)-Benzyl 2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate and ((R)-2,2-Dimethyl-1,3-dioxolan-4-yl)methyl 2-(1-(((S)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate

[00272] Cesium carbonate (2.74 g, 8.4 mmol) was added to a mixture of benzyl 2-(6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate (1.0 g, 2.8 mmol) and (S)-(2,2-dimethyl-1,3-dioxolan-4-yl)methyl 4-methylbenzenesulfonate (3.21 g, 11.2 mmol) in DMF (5.6 mL). The reaction was stirred at 80 °C for 64 hours under nitrogen atmosphere. The mixture was then partitioned between ethyl acetate and water. The aqueous layer was extracted with ethyl acetate. The combined ethyl acetate layers were washed with brine, dried over $MgSO_4$, filtered and concentrated. The crude product, a viscous brown oil which contains both of the products shown above, was taken directly to the next step without further purification. (S)-Benzyl 2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate, ESI-MS *m/z* calc. 470.2, found 471.5 $(M+1)^+$. Retention time 2.22 minutes. ((R)-2,2-Dimethyl-1,3-dioxolan-4-yl)methyl 2-(1-(((S)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate, ESI-MS *m/z* calc. 494.5, found 495.5 $(M+1)^+$. Retention time 2.03 minutes.

[00273] Step b: (S)-2-(1-((2,2-Dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol

[00274] The mixture of crude reaction mixture of (S)-benzyl 2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate and ((R)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl 2-(1-(((S)-2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropanoate was dissolved in THF (15 mL) and cooled in an ice-water bath. $LiAlH_4$ (2.8 mL of 1 M solution, 2.8 mmol) was added dropwise. After addition was complete the reaction was stirred for 5 minutes. The reaction was quenched by adding water (0.5 mL), 15% NaOH solution (0.5 mL) and then water (1.5 mL). The mixture was filtered over Celite, and the solids were washed with THF and ethyl acetate. The filtrate was concentrated and purified by column chromatography (30-60% ethyl acetate- hexanes) to obtain the product as a brown oil (505 mg, 49 % over 2 steps). ESI-MS *m/z* calc. 366.4, found 367.3 $(M+1)^+$. Retention time 1.68 minutes. ^{1}H NMR (400 MHz, DMSO-*d*6) δ 8.34 (d, J = 7.6 Hz, 1H), 7.65(d, J = 13.5 Hz, 1H), 6.57 (s, 1H), 4.94 (t, J = 5.4 Hz, 1H), 4.64 - 4.60 (m, 1H), 4.52 - 4.42 (m, 2H), 4.14 (dd, J = 6.2, 8.4 Hz, 1H), 3.74 (dd, J = 7.0, 8.3 Hz, 1H), 3.63 - 3.53 (m,2H), 1.42 (s, 3H), 1.37 (m, 6H) and 1.19 (s, 3H) ppm.

[00275] Step c: (S)-2-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-2-methylpropan-1-ol

[00276] (S)-2-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-5-nitro-1H-indol-2-yl)-2-methylpropan-1-ol (500 mg, 1.4 mmol) was dissolved ethanol (15 mL) and the reaction was flushed with N_2. Then Pd-C (50 mg, 5% wt) was added. The reaction was flushed with nitrogen again and then stirred under H_2 (atm). After 1 hour only partial conversion to the product was observed by LCMS. The reaction was filtered through Celite and concentrated. The residue was resubjected to the conditions above. After 1 hour LCMS indicated complete conversion to product. The reaction mixture was filtered through Celite. The filtrate was concentrated to yield the product as a black solid (420 mg, 91 %). ESI-MS *m/z* calc. 336.2, found 337.5 $(M+1)^+$. Retention time 0.90 minutes. ^{1}H NMR (400 MHz, DMSO-*d*6) δ 7.17 (d, J = 12.6 Hz, 1H), 6.76 (d, J = 9.0 Hz, 1H), 6.03 (s, 1H), 4.78 (br s, 1H), 4.46 (s, 2H), 4.41 - 4.27 (m, 3H), 4.06(dd, J = 6.1, 8.3 Hz, 1H), 3.70 - 3.67 (m, 1H), 3.53 (dd, J = 10.7, 17.2 Hz, 2H), 1.40 (s, 3H), 1.32 (s, 6H) and 1.21 (s, 3H) ppm.

[00277] Step d: (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

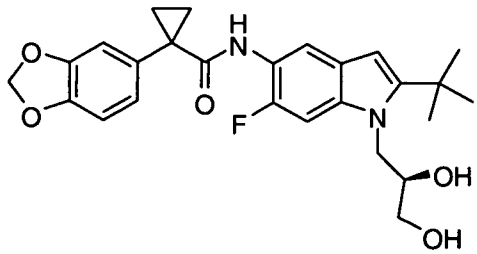
[00278] DMF (3 drops) was added to a stirring mixture of 1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)cyclopropanecarboxylic acid (187 mg, 0.8 mmol) and thionyl chloride (0.13 mL, 1.8 mmol). After 30 minutes a clear solution had formed. A small amount was mixed piperidine to test that the acid chloride had been formed. The solution was concentrated on the rotovap and then toluene (1 mL) was added and the mixture was concentrated again. The toluene step was repeated once more and the residue was placed on high vacuum for 10 minutes. The acid chloride was then dissolved in dichloromethane (2 mL) and added to a mixture of (S)-2-(5-amino-1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-1H-indol-2-yl)-2-methylpropan-1-ol (200 mg, 0.6 mmol) and triethylamine (0.25 mL, 1.8 mmol) in dichloromethane (4 mL). The reaction was stirred at room temperature for 45 minutes. The reaction was washed with 1N HCl solution, saturated $NaHCO_3$ solution and brine, dried over $MgSO_4$ and concentrated to yield the product as a black foamy solid (320 mg, 96 %). ESI-MS *m/z* calc. 560.6, found 561.5 $(M+1)^+$. Retention time 2.05 minutes. ^1H NMR (400 MHz, DMSO-*d6*) δ 8.31 (s, 1H), 7.53 (s, 1H), 7.42 - 7.40 (m, 2H), 7.34 - 7.30 (m, 3H), 6.24 (s, 1H), 4.84 (t, J = 5.5 Hz, 1H), 4.51 - 4.46 (m, 1H), 4.41 - 4.32 (m, 2H), 4.08 (dd, J = 6.0, 8.3 Hz, 1H), 3.71 - 3.67 (m, 1H), 3.58 - 3.50 (m, 2H), 1.48 - 1.45 (m, 2H), 1.40 (s, 3H), 1.34 - 1.33 (m, 6H), 1.18 (s, 3H) and 1.14 - 1.12 (m, 2H) ppm.

[00279] Step e: (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-(2,3-dihydroxypropyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide

[00280] (S)-1-(2,2-difluorobenzo[d][1,3]dioxol-5-yl)-N-(1-((2,2-dimethyl-1,3-dioxolan-4-yl)methyl)-6-fluoro-2-(1-hydroxy-2-methylpropan-2-yl)-1H-indol-5-yl)cyclopropanecarboxamide (290 g, 0.5 mmol) was dissolved in methanol (5 mL). Water (0.5 mL) was added followed by p-TsOH.H_2O (20 mg, 0.1 mmol). The reaction was heated at 80 °C for 45 minutes. The solution was then partitioned between ethyl acetate and saturated $NaHCO_3$ solution. The ethyl acetate layer was dried over $MgSO_4$ and concentrated. The residue was purified by column chromatography (50-100 % ethyl acetate - hexanes) to yield the product as a cream colored foamy solid. (146 mg, 54 %, ee >97% by SFC). ESI-MS *m/z* calc. 520.5, found 521.5 $(M+1)^+$. Retention time 1.67 minutes. ^1H NMR (400 MHz, DMSO-*d6*) δ 8.31 (s, 1H),

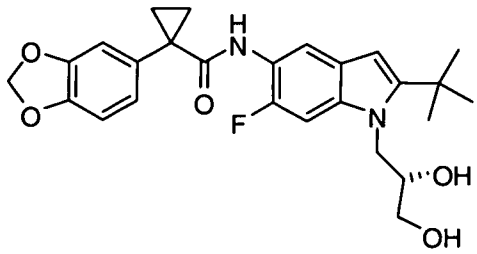
7.53 (d, J = 1.1 Hz, 1H), 7.42 - 7.37 (m, 2H), 7.33 - 7.30 (m, 2H), 6.22 (s, 1H), 5.01 (d, J = 5.0 Hz, 1H), 4.91 (t, J = 5.5 Hz, 1H), 4.75 (t, J = 5.8 Hz, 1H), 4.42 - 4.38 (m, 1H), 4.10 (dd, J = 8.8, 15.1 Hz, 1H), 3.90 (s, 1H), 3.64 - 3.54 (m, 2H), 3.48 - 3.33 (m, 2H), 1.48 - 1.45 (m, 2H), 1.35 (s, 3H), 1.32 (s, 3H) and 1.14 - 1.11 (m, 2H) ppm.

[00281] Example 19: (R)-1-(benzo[d][1,3]dioxol-5-yl)-N-(2-tert-butyl-1-(2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide



[00282] (R)-1-(benzo[d][1,3]dioxol-5-yl)-N-(2-tert-butyl-1-(2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide was prepared using an experimental procedure similar to example 72 from 1-(benzo[d][1,3]dioxol-5-yl)cyclopropanecarboxylic acid and 2-tert-butyl-6-fluoro-5-nitro-1H-indole.

[00283] Example 20: (S)-1-(benzo[d][1,3]dioxol-5-yl)-N-(2-tert-butyl-1-(2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide



[00284] (S)-1-(benzo[d][1,3]dioxol-5-yl)-N-(2-tert-butyl-1-(2,3-dihydroxypropyl)-6-fluoro-1H-indol-5-yl)cyclopropanecarboxamide was prepared using an experimental procedure similar to Example 72 from 1-(benzo[d][1,3]dioxol-5-yl)cyclopropanecarboxylic acid and 2-tert-butyl-6-fluoro-5-nitro-1H-indole.

[00285] A person skilled in the chemical arts can use the examples and schemes along with known synthetic methodologies to synthesize compounds of the present invention, including the

compounds in Table 3, below.

Table 3: Physical data of exemplary compounds.

Cmpd. No.	LC/MS M+1	LC/RT Min	NMR
308	516.7	1.69	^{1}H NMR (400 MHz, DMSO-*d6*) δ 8.32 (s, 1H), 7.53 (s, 1H), 7.43 - 7.31 (m, 4H), 6.19 (s, 1H), 4.95 - 4.93 (m, 2H), 4.51 (d, J = 5.0 Hz, 1H), 4.42 - 4.39 (m, 2H), 4.10 - 4.04 (m, 1H), 3.86 (s, 1H), 3.49 - 3.43 (m, 2H), 3.41 - 3.33 (m, 1H), 3.30 - 3.10 (m, 6H), 2.02 - 1.97 (m, 2H), 1.48 - 1.42 (m, 8H) and 1.13 (dd, J = 4.0, 6.7 Hz, 2H) ppm
309	535.7	1.79	1H NMR (400.0 MHz, DMSO) d 8.43 (s, 1H), 7.53 (s, 1H), 7.45 - 7.41 (m, 2H), 7.36 - 7.31 (m, 2H), 6.27 (s, 1H), 4.74 - 4.70 (m, 2H), 3.57 - 3.53 (m, 2H), 3.29 (s, 9H), 1.48 - 1.42 (m, 11H), and 1.15 (dd, J = 3.9, 6.8 Hz, 2H) ppm.
310	609.5	1.64	
311	535.7	1.7	^{1}H NMR (400 MHz, DMSO-*d6*) δ 8.32 (s, 1H), 7.53 (d, J = 1.0 Hz, 1H), 7.43 - 7.31 (m, 4H), 6.17 (s, 1H), 4.97 - 4.92 (m, 2H), 4.41 (dd, J = 2.4, 15.0 Hz, 1H), 4.23 (t, J = 5.0 Hz, 1H), 4.08 (dd, J = 8.6, 15.1 Hz, 1H), 3.87 (s, 1H), 3.48 - 3.44 (m, 1H), 3.41 - 3.33 (m, 1H), 3.20 (dd, J = 7.4, 12.7 Hz, 2H), 1.94 - 1.90 (m, 2H), 1.48 - 1.45 (m, 2H), 1.42 (s, 3H), 1.41 (s, 3H) and 1.15 - 1.12 (m, 2H) ppm.
312	443	2.31	^{1}H NMR (400 MHz, DMSO-*d6*) δ 8.93 (s, 1H), 7.71 (d, J = 8.8 Hz, 1H), 7.51 (s, 1H), 7.42 (d, J = 8.3 Hz, 1H), 7.33 (d, J = 1.6 Hz, 1H), 7.08 (d, J = 8.8 Hz, 1H), 6.28 (s, 1H), 5.05 (t, J = 5.6 Hz, 1H), 4.42 (t, J = 6.8 Hz, 2H), 3.70 - 3.65 (m, 2H), 1.51 - 1.48 (m, 2H), 1.44 (s, 9H), 1.19 - 1.16 (m, 2H) ppm.
313	521.5	1.69	1H NMR (400.0 MHz, CD3CN) d 7.69 (d, J = 7.7 Hz, 1H), 7.44 (d, J = 1.6 Hz, 1H), 7.39 (dd, J = 1.7, 8.3 Hz, 1H), 7.31 (s, 1H), 7.27 (d, J = 8.3 Hz, 1H), 7.20 (d, J = 12.0 Hz, 1H), 6.34 (s, 1H), 4.32 (d, J = 6.8 Hz, 2H), 4.15 - 4.09 (m, 1H), 3.89 (dd, J = 6.0, 11.5 Hz, 1H), 3.63 - 3.52 (m, 3H), 3.42 (d, J = 4.6 Hz, 1H), 3.21 (dd, J = 6.2, 7.2 Hz, 1H), 3.04 (t, J = 5.8 Hz, 1H), 1.59 (dd, J = 3.8, 6.8 Hz, 2H), 1.44 (s, 3H), 1.33 (s, 3H) and 1.18 (dd, J = 3.7, 6.8 Hz, 2H) ppm

Cmpd. No.	LC/MS M+1	LC/RT Min	NMR
315	482.5	1.99	H NMR (400 MHz, DMSO) 8.93 (s, 1H), 7.71 (d, J = 8.8 Hz, 1H), 7.51 (s, 1H), 7.42 (d, J = 8.3 Hz, 1H), 7.33 (d, J = 1.6 Hz, 1H), 7.08 (d, J = 8.8 Hz, 1H), 6.28 (s, 1H), 5.05 (t, J = 5.6 Hz, 1H), 4.42 (t, J = 6.8 Hz, 2H), 3.70 - 3.65 (m, 2H), 1.51 - 1.48 (m, 2H), 1.44 (s, 9H), 1.19 - 1.16 (m, 2H)
316	438.7	2.1	H NMR (400 MHz, DMSO) 11.48 (s, 1H), 8.88 (s, 1H), 7.52 (d, J = 8.5 Hz, 2H), 7.41 (d, J = 8.3 Hz, 1H), 7.32 (dd, J = 1.5, 8.3 Hz, 1H), 7.03 (d, J = 8.6 Hz, 1H), 6.21 (d, J = 1.8 Hz, 1H), 1.51 - 1.49 (m, 2H), 1.36 (s, 9H), 1.18 - 1.16 (m, 2H) ppm.
318	469.016	1.66	
320	465.7	1.79	H NMR (400 MHz, DMSO) 9.26 (s, 1H), 7.65 (d, J = 1.9 Hz, 1H), 7.49 (d, J = 8.7 Hz, 2H), 7.36 (d, J = 8.9 Hz, 1H), 7.11 (dd, J = 1.9, 8.9 Hz, 1H), 6.89 (d, J = 8.8 Hz, 2H), 6.14 (s, 1H), 4.42 - 4.37 (m, 1H), 4.16 - 4.10 (m, 1H), 3.90 - 3.88 (m, 1H), 3.73 (s, 3H), 3.46 - 3.42 (m, 2H), 1.41 (s, 9H), 1.36 (d, J = 5.0 Hz, 1H), 1.21 (s, 3H), 0.99 (d, J = 5.0 Hz, 1H), 0.84 (s, 3H)
322	521.5	1.67	1H NMR (400.0 MHz, DMSO) d 8.31 (s, 1H), 7.53 (d, J = 1.1 Hz, 1H), 7.42 - 7.37 (m, 2H), 7.33 - 7.30 (m, 2H), 6.22 (s, 1H), 5.01 (d, J = 5.0 Hz, 1H), 4.91 (t, J = 5.5 Hz, 1H), 4.75 (t, J = 5.8 Hz, 1H), 4.42 - 4.38 (m, 1H), 4.10 (dd, J = 8.8, 15.1 Hz, 1H), 3.90 (s, 1H), 3.64 - 3.54 (m, 2H), 3.48 - 3.33 (m, 2H), 1.48 - 1.45 (m, 2H), 1.35 (s, 3H), 1.32 (s, 3H) and 1.14 - 1.11 (m, 2H) ppm

[00286] Example 21: Assays for Detecting and Measuring ΔF508-CFTR Correction Properties of Compounds

[00287] Membrane potential optical methods for assaying ΔF508-CFTR modulation properties of compounds.

[00288] The assay utilizes fluorescent voltage sensing dyes to measure changes in membrane potential using a fluorescent plate reader (e.g., FLIPR III, Molecular Devices, Inc.) as a readout for increase in functional ΔF508-CFTR in NIH 3T3 cells. The driving force for the response is the creation of a chloride ion gradient in conjunction with channel activation by a single liquid

addition step after the cells have previously been treated with compounds and subsequently loaded with a voltage sensing dye.

[00289] Identification of Correction Compounds

[00290] To identify small molecules that correct the trafficking defect associated with ΔF508-CFTR; a single-addition HTS assay format was developed. Assay Plates containing cells are incubated for ~2-4 hours in tissue culture incubator at 37oC, 5%CO_2, 90% humidity. Cells are then ready for compound exposure after adhering to the bottom of the assay plates.

[00291] The cells were incubated in serum-free medium for 16-24 hrs in tissue culture incubator at 37oC, 5%CO_2, 90% humidity in the presence or absence (negative control) of test compound. The cells were subsequently rinsed 3X with Krebs Ringers solution and loaded with a voltage sensing redistribution dye. To activate ΔF508-CFTR, 10 μM forskolin and the CFTR potentiator, genistein (20 μM), were added along with Cl^--free medium to each well. The addition of Cl^--free medium promoted Cl^- efflux in response to ΔF508-CFTR activation and the resulting membrane depolarization was optically monitored using voltage sensor dyes.

[00292] Identification of Potentiator Compounds

[00293] To identify potentiators of ΔF508-CFTR, a double-addition HTS assay format was developed. This HTS assay utilizes fluorescent voltage sensing dyes to measure changes in membrane potential on the FLIPR III as a measurement for increase in gating (conductance) of ΔF508 CFTR in temperature-corrected ΔF508 CFTR NIH 3T3 cells. The driving force for the response is a Cl^- ion gradient in conjunction with channel activation with forskolin in a single liquid addition step using a fluoresecent plate reader such as FLIPR III after the cells have previously been treated with potentiator compounds (or DMSO vehicle control) and subsequently loaded with a redistribution dye.

[00294] Solutions:

[00295] Bath Solution #1: (in mM) NaCl 160, KCl 4.5, $CaCl_2$ 2, $MgCl_2$ 1, HEPES 10, pH 7.4 with NaOH.

[00296] Chloride-free bath solution: Chloride salts in Bath Solution #1 are substituted with gluconate salts.

[00297] Cell Culture

[00298] NIH3T3 mouse fibroblasts stably expressing ΔF508-CFTR are used for optical measurements of membrane potential. The cells are maintained at 37 °C in 5% CO_2 and 90 % humidity in Dulbecco's modified Eagle's medium supplemented with 2 mM glutamine, 10 % fetal bovine serum, 1 X NEAA, β-ME, 1 X pen/strep, and 25 mM HEPES in 175 cm^2 culture flasks. For all optical assays, the cells were seeded at ~20,000/well in 384-well matrigel-coated plates and cultured for 2 hrs at 37 °C before culturing at 27 °C for 24 hrs. for the potentiator assay. For the correction assays, the cells are cultured at 27 °C or 37 °C with and without compounds for 16 – 24 hours.

[00299] Electrophysiological Assays for assaying ΔF508-CFTR modulation properties of compounds.

[00300] 1.Ussing Chamber Assay

[00301] Ussing chamber experiments were performed on polarized airway epithelial cells expressing ΔF508-CFTR to further characterize the ΔF508-CFTR modulators identified in the optical assays. Non-CF and CF airway epithelia were isolated from bronchial tissue, cultured as previously described (Galietta, L.J.V., Lantero, S., Gazzolo, A., Sacco, O., Romano, L., Rossi, G.A., & Zegarra-Moran, O. (1998) *In Vitro Cell. Dev. Biol.* **34**, 478-481), and plated onto Costar® Snapwell™ filters that were precoated with NIH3T3-conditioned media. After four days the apical media was removed and the cells were grown at an air liquid interface for >14 days prior to use. This resulted in a monolayer of fully differentiated columnar cells that were ciliated, features that are characteristic of airway epithelia. Non-CF HBE were isolated from non-smokers that did not have any known lung disease. CF-HBE were isolated from patients homozygous for ΔF508-CFTR.

[00302] HBE grown on Costar® Snapwell™ cell culture inserts were mounted in an Ussing chamber (Physiologic Instruments, Inc., San Diego, CA), and the transepithelial resistance and short-circuit current in the presence of a basolateral to apical Cl^- gradient (I_{SC}) were measured using a voltage-clamp system (Department of Bioengineering, University of Iowa, IA). Briefly, HBE were examined under voltage-clamp recording conditions (V_{hold} = 0 mV) at 37 °C. The basolateral solution contained (in mM) 145 NaCl, 0.83 K_2HPO_4, 3.3 KH_2PO_4, 1.2 $MgCl_2$, 1.2 $CaCl_2$, 10 Glucose, 10 HEPES (pH adjusted to 7.35 with NaOH) and the apical solution

contained (in mM) 145 NaGluconate, 1.2 $MgCl_2$, 1.2 $CaCl_2$, 10 glucose, 10 HEPES (pH adjusted to 7.35 with NáOH).

[00303] Identification of Correction Compounds

[00304] Typical protocol utilized a basolateral to apical membrane Cl^- concentration gradient. To set up this gradient, normal ringer was used on the basolateral membrane, whereas apical NaCl was replaced by equimolar sodium gluconate (titrated to pH 7.4 with NaOH) to give a large Cl^- concentration gradient across the epithelium. All experiments were performed with intact monolayers. To fully activate ΔF508-CFTR, forskolin (10 μM), PDE inhibitor, IBMX (100 μM) and CFTR potentiator, genistein (50 μM) were added to the apical side.

[00305] As observed in other cell types, incubation at low temperatures of FRT cells and human bronchial epithelial cells isolated from diseased CF patients (CF-HBE)expressing ΔF508-CFTR increases the functional density of CFTR in the plasma membrane. To determine the activity of correction compounds, the cells were incubated with test compound for 24-48 hours at 37°C and were subsequently washed 3X prior to recording. The cAMP- and genistein-mediated I_{SC} in compound-treated cells was normalized to 37°C controls and expressed as percentage activity of CFTR activity in wt-HBE. Preincubation of the cells with the correction compound significantly increased the cAMP- and genistein-mediated I_{SC} compared to the 37°C controls.

[00306] Identification of Potentiator Compounds

[00307] Typical protocol utilized a basolateral to apical membrane Cl^- concentration gradient. To set up this gradient, normal ringers was used on the basolateral membrane, whereas apical NaCl was replaced by equimolar sodium gluconate (titrated to pH 7.4 with NaOH) to give a large Cl^- concentration gradient across the epithelium. Forskolin (10 μM) and all test compounds were added to the apical side of the cell culture inserts. The efficacy of the putative ΔF508-CFTR potentiators was compared to that of the known potentiator, genistein.

[00308] 2. Patch-clamp Recordings

[00309] Total Cl^- current in ΔF508-NIH3T3 cells was monitored using the perforated-patch recording configuration as previously described (Rae, J., Cooper, K., Gates, P., & Watsky, M. (1991) *J. Neurosci. Methods* **37**, 15-26). Voltage-clamp recordings were performed at 22 °C using an Axopatch 200B patch-clamp amplifier (Axon Instruments Inc., Foster City, CA). The

pipette solution contained (in mM) 150 *N*-methyl-D-glucamine (NMDG)-Cl, 2 $MgCl_2$, 2 $CaCl_2$, 10 EGTA, 10 HEPES, and 240 μg/ml amphotericin-B (pH adjusted to 7.35 with HCl). The extracellular medium contained (in mM) 150 NMDG-Cl, 2 $MgCl_2$, 2 $CaCl_2$, 10 HEPES (pH adjusted to 7.35 with HCl). Pulse generation, data acquisition, and analysis were performed using a PC equipped with a Digidata 1320 A/D interface in conjunction with Clampex 8 (Axon Instruments Inc.). To activate ΔF508-CFTR, 10 μM forskolin and 20 μM genistein were added to the bath and the current-voltage relation was monitored every 30 sec.

[00310] Identification of Correction Compounds

[00311] To determine the activity of correction compounds for increasing the density of functional ΔF508-CFTR in the plasma membrane, we used the above-described perforated-patch-recording techniques to measure the current density following 24-hr treatment with the correction compounds. To fully activate ΔF508-CFTR, 10 μM forskolin and 20μM genistein were added to the cells. Under our recording conditions, the current density following 24-hr incubation at 27°C was higher than that observed following 24-hr incubation at 37 °C. These results are consistent with the known effects of low-temperature incubation on the density of ΔF508-CFTR in the plasma membrane. To determine the effects of correction compounds on CFTR current density, the cells were incubated with 10 μM of the test compound for 24 hours at 37°C and the current density was compared to the 27°C and 37°C controls (% activity). Prior to recording, the cells were washed 3X with extracellular recording medium to remove any remaining test compound. Preincubation with 10 μM of correction compounds significantly increased the cAMP- and genistein-dependent current compared to the 37°C controls.

[00312] Identification of Potentiator Compounds

[00313] The ability of ΔF508-CFTR potentiators to increase the macroscopic ΔF508-CFTR Cl^- current ($I_{\Delta F508}$) in NIH3T3 cells stably expressing ΔF508-CFTR was also investigated using perforated-patch-recording techniques. The potentiators identified from the optical assays evoked a dose-dependent increase in $I\Delta_{F508}$ with similar potency and efficacy observed in the optical assays. In all cells examined, the reversal potential before and during potentiator application was around -30 mV, which is the calculated E_{Cl} (-28 mV).

[00314] Cell Culture

[00315] NIH3T3 mouse fibroblasts stably expressing ΔF508-CFTR are used for whole-cell recordings. The cells are maintained at 37 °C in 5% CO_2 and 90 % humidity in Dulbecco's modified Eagle's medium supplemented with 2 mM glutamine, 10 % fetal bovine serum, 1 X NEAA, β-ME, 1 X pen/strep, and 25 mM HEPES in 175 cm^2 culture flasks. For whole-cell recordings, 2,500 - 5,000 cells were seeded on poly-L-lysine-coated glass coverslips and cultured for 24 - 48 hrs at 27 °C before use to test the activity of potentiators; and incubated with or without the correction compound at 37 °C for measuring the activity of correctors.

[00316] 3.Single-channel recordings

[00317] Gating activity of wt-CFTR and temperature-corrected ΔF508-CFTR expressed in NIH3T3 cells was observed using excised inside-out membrane patch recordings as previously described (Dalemans, W., Barbry, P., Champigny, G., Jallat, S., Dott, K., Dreyer, D., Crystal, R.G., Pavirani, A., Lecocq, J-P., Lazdunski, M. (1991) *Nature* 354, 526 – 528) using an Axopatch 200B patch-clamp amplifier (Axon Instruments Inc.). The pipette contained (in mM): 150 NMDG, 150 aspartic acid, 5 $CaCl_2$, 2 $MgCl_2$, and 10 HEPES (pH adjusted to 7.35 with Tris base). The bath contained (in mM): 150 NMDG-Cl, 2 $MgCl_2$, 5 EGTA, 10 TES, and 14 Tris base (pH adjusted to 7.35 with HCl). After excision, both wt- and ΔF508-CFTR were activated by adding 1 mM Mg-ATP, 75 nM of the catalytic subunit of cAMP-dependent protein kinase (PKA; Promega Corp. Madison, WI), and 10 mM NaF to inhibit protein phosphatases, which prevented current rundown. The pipette potential was maintained at 80 mV. Channel activity was analyzed from membrane patches containing ≤ 2 active channels. The maximum number of simultaneous openings determined the number of active channels during the course of an experiment. To determine the single-channel current amplitude, the data recorded from 120 sec of ΔF508-CFTR activity was filtered "off-line" at 100 Hz and then used to construct all-point amplitude histograms that were fitted with multigaussian functions using Bio-Patch Analysis software (Bio-Logic Comp. France). The total microscopic current and open probability (P_o) were determined from 120 sec of channel activity. The P_o was determined using the Bio-Patch software or from the relationship $P_o = I/i(N)$, where I = mean current, i = single-channel current amplitude, and N = number of active channels in patch.

[00318] Cell Culture

[00319] NIH3T3 mouse fibroblasts stably expressing ΔF508-CFTR are used for excised-

membrane patch-clamp recordings. The cells are maintained at 37 °C in 5% CO_2 and 90 % humidity in Dulbecco's modified Eagle's medium supplemented with 2 mM glutamine, 10 % fetal bovine serum, 1 X NEAA, β-ME, 1 X pen/strep, and 25 mM HEPES in 175 cm^2 culture flasks. For single channel recordings, 2,500 - 5,000 cells were seeded on poly-L-lysine-coated glass coverslips and cultured for 24 - 48 hrs at 27 °C before use.

[00320] The compounds of this invention were found to exhibit Correction activity as measured in the assay described above.

[00321] Compounds of the invention are useful as modulators of ATP binding cassette transporters. Using the procedures described above, the activities, i.e., EC50s, of compounds of the present invention have been measured to be from about 3.8 nM to about 13.5 μM. Furthermore, using those methods described above, the efficacies of compounds of the present invention have been measured to be from about 35 % to about 110 %.

[00322] In Table 4, the following meanings apply:

[00323] EC50: "+++" means <2 uM; "++" means between 2 uM to 5 uM; "+" means between 5 uM to 25 uM.

[00324] % Efficacy: "+" means < 25%; "++" means between 25% and 100%; "+++" means > 100%.

Table 4.

Cmpd. No.	Binned EC50	Binned Max Efficacy
308	++	+++
309	+++	+++
310	+++	+++
311	+++	+++
312	+++	+++
313	+++	+++
315	+++	+++
316	+++	+++
318	+++	+++
320	++	++

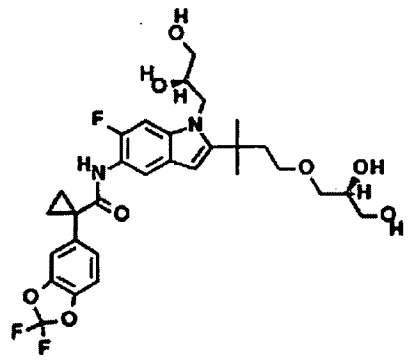
[00325] OTHER EMBODIMENTS

[00326] It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims.

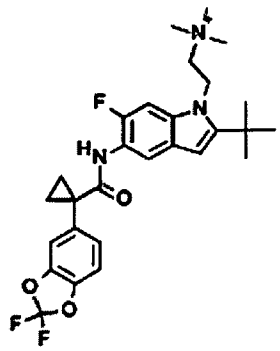
We claim:

1. A compound selected from

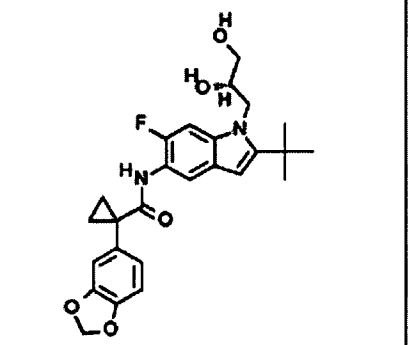
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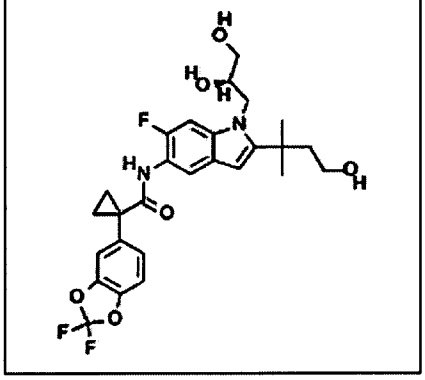
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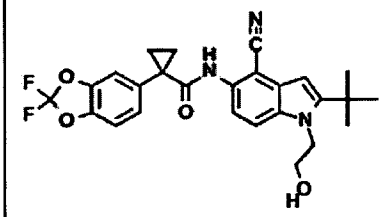
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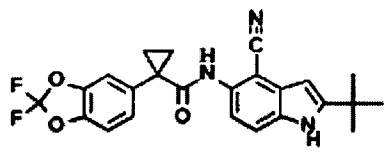
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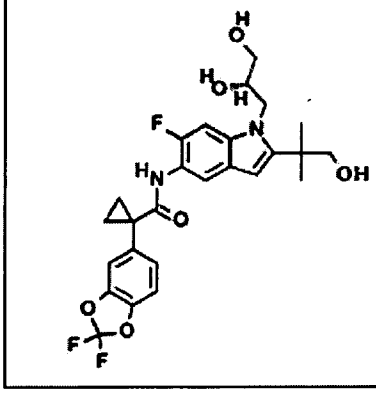
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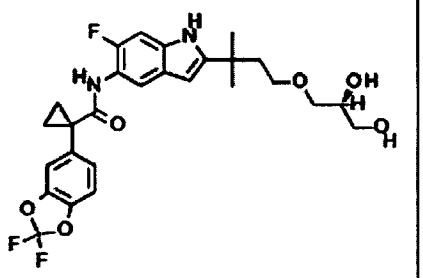
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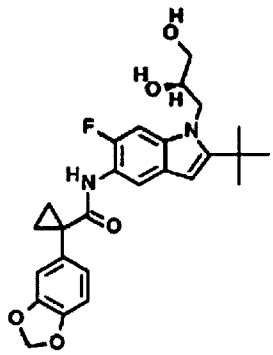
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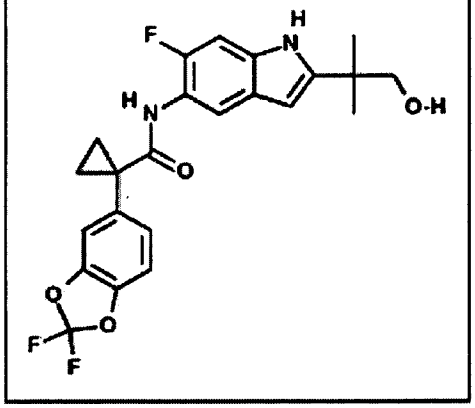
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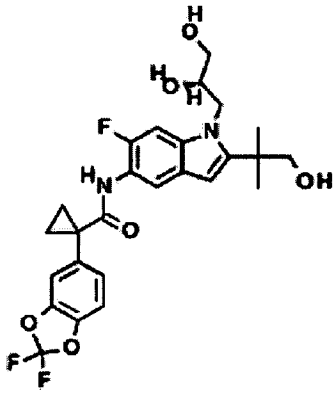


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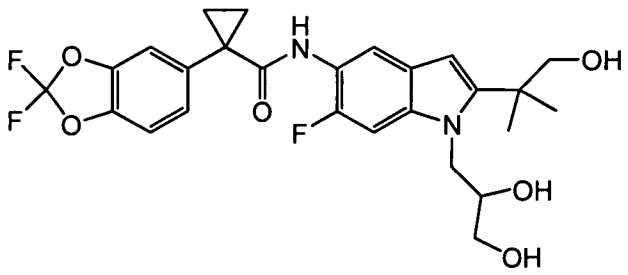


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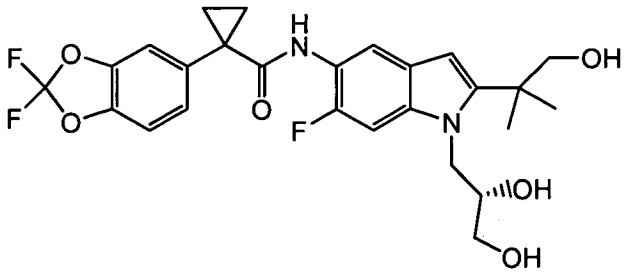
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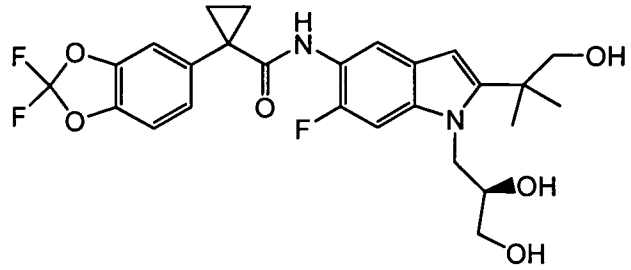
.



2. The compound .



3. The compound .

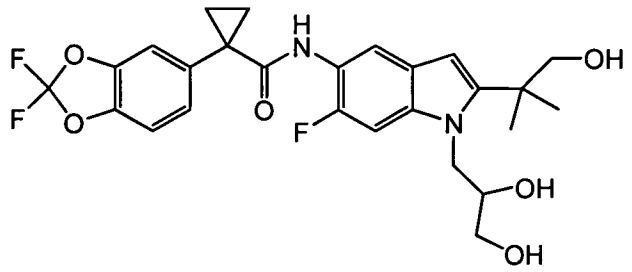
4. The compound  .

5. A pharmaceutical composition comprising

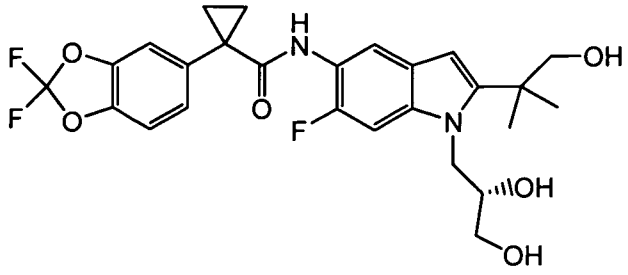
(i) a compound according to claim 1; and

(ii) a pharmaceutically acceptable carrier.

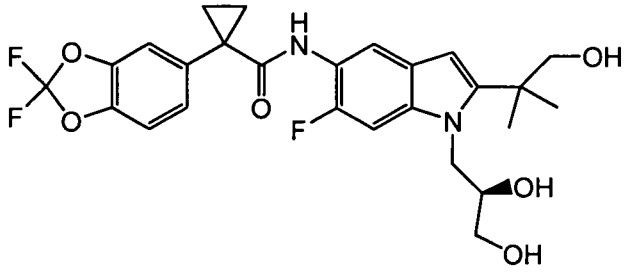
6. The composition of claim 5, further comprising an additional agent selected from a mucolytic agent, bronchodialator, an anti-biotic, an anti-infective agent, an anti-inflammatory agent, CFTR corrector, CFTR potentiator, or a nutritional agent.

7. The composition of claims 5 or 6, wherein the compoud is  .

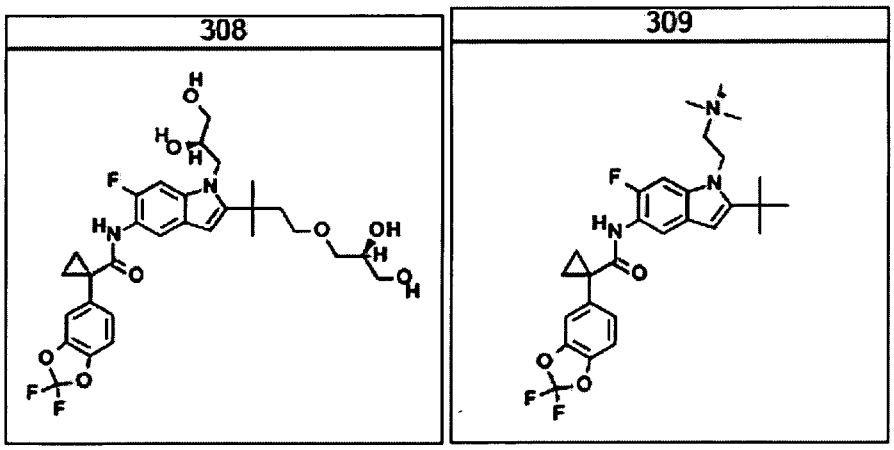
8. The composition of claims 5 or 6, wherein the compound is

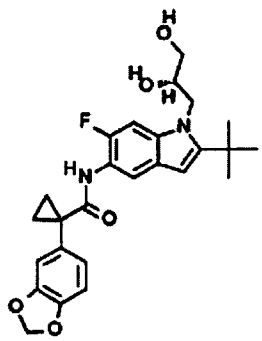
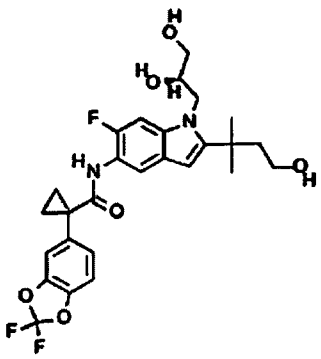
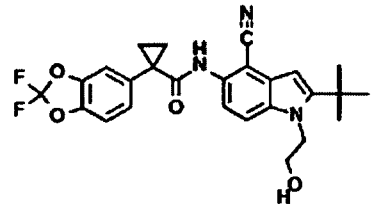


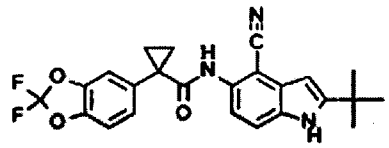
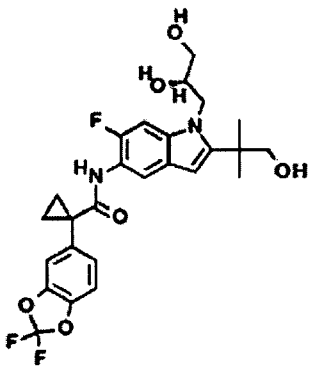
9. The composition of claims 5 or 6, wherein the compound is

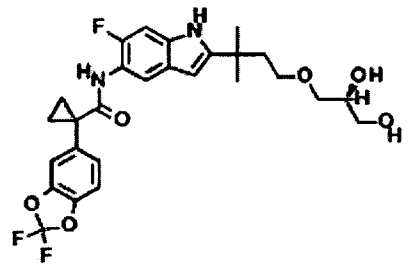
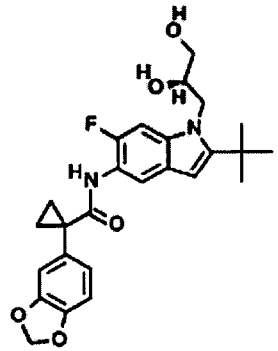


10. A method of increasing the number of functional ABC transporters in a membrane of a cell, comprising the step of contacting said cell with a compound selected from

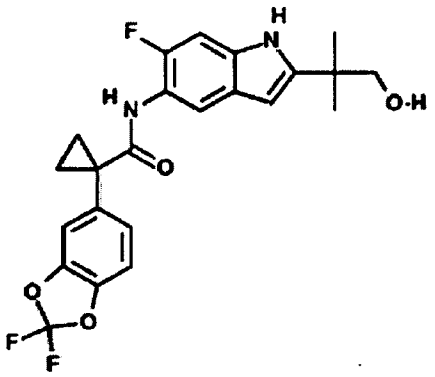


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313	315
	

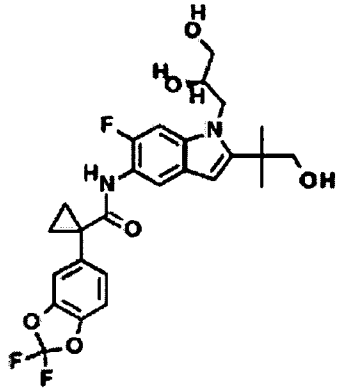
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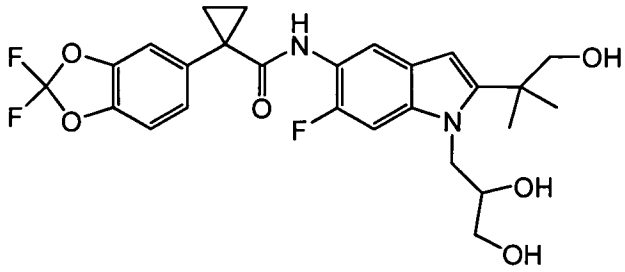
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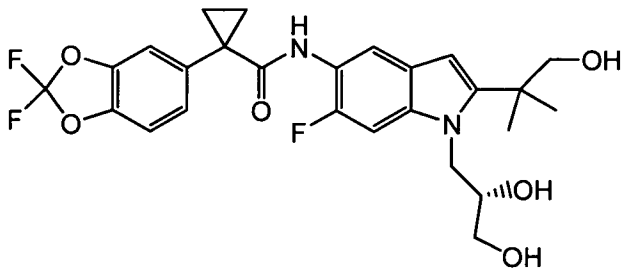
11. The method of claim 10, wherein the ABC transporter is CFTR.

12. The method of claims 10 or 11, wherein the compoud is



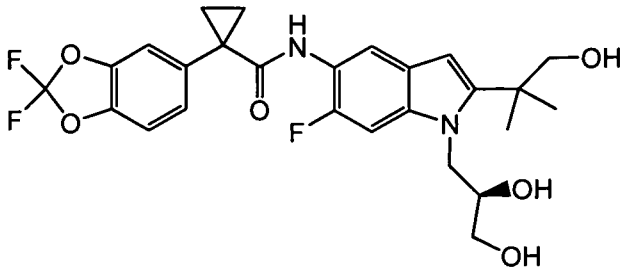
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13. The method of claims 10 or 11, wherein the compound is



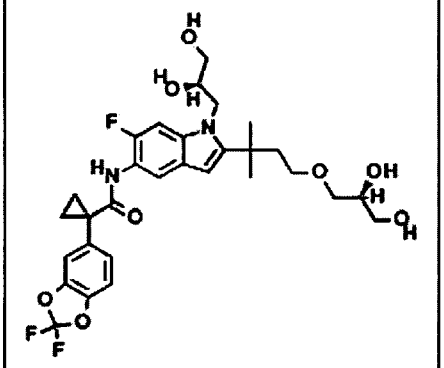
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14. The method of claims 10 or 11, wherein the compound is

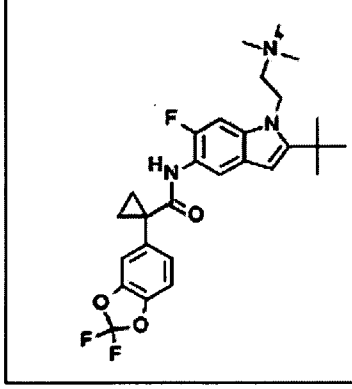


15. A method of treating a condition, disease, or disorder in a patient implicated by ABC transporter activity, comprising the step of administering to said patient a compound selected from

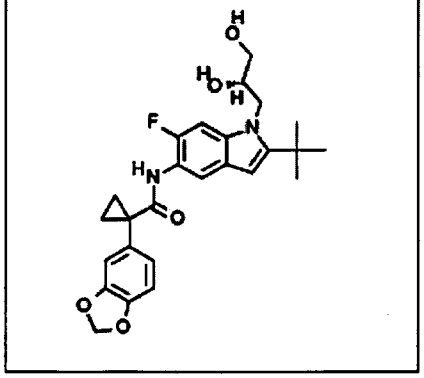
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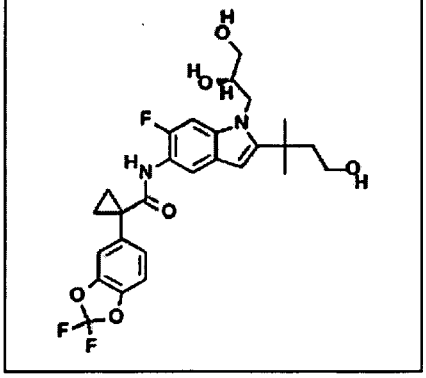
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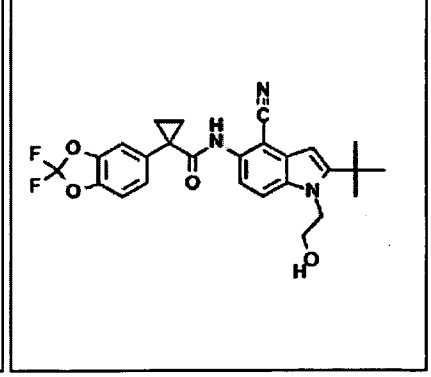
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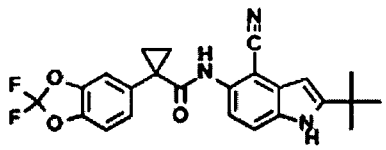
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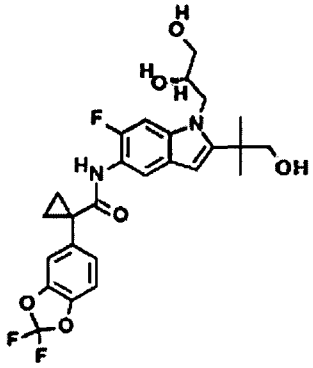
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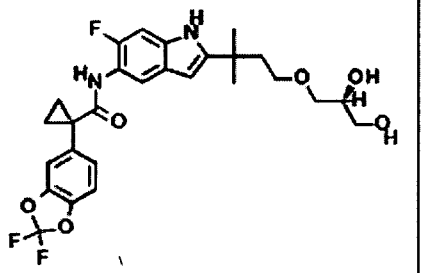
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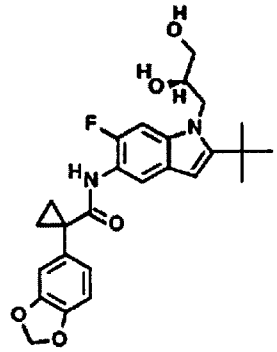
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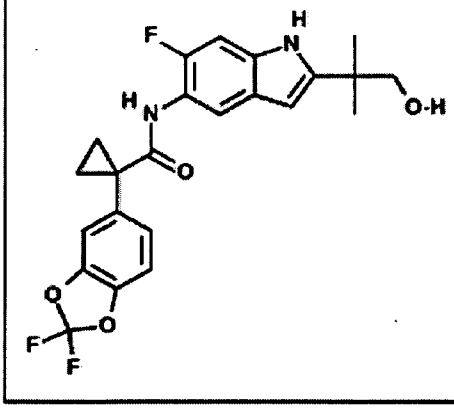
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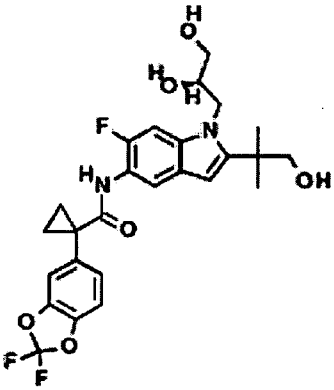


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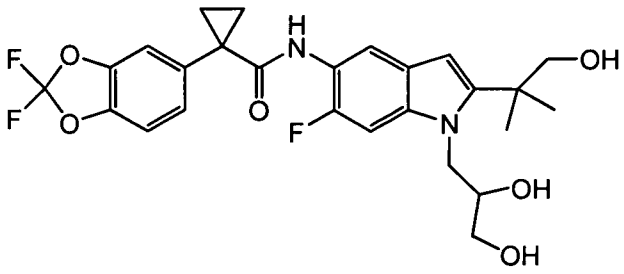
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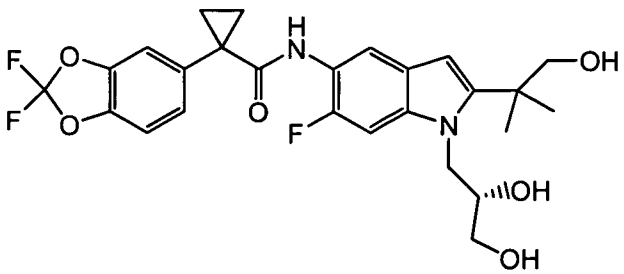
16. The method according to claim 15, wherein said condition, disease, or disorder is selected from cystic fibrosis, hereditary emphysema, hereditary hemochromatosis, coagulation-fibrinolysis deficiencies, such as protein C deficiency, Type 1 hereditary angioedema, lipid processing deficiencies, such as familial hypercholesterolemia, Type 1

chylomicronemia, abetalipoproteinemia, lysosomal storage diseases, such as I-cell disease/pseudo-Hurler, mucopolysaccharidoses, Sandhof/Tay-Sachs, Crigler-Najjar type II, polyendocrinopathy/hyperinsulemia, diabetes mellitus, laron dwarfism, myleoperoxidase deficiency, primary hypoparathyroidism, melanoma, glycanosis CDG type 1, hereditary emphysema, congenital hyperthyroidism, osteogenesis imperfecta, hereditary hypofibrinogenemia, ACT deficiency, diabetes insipidus (di), neurophyseal di, neprogenic DI, Charcot-Marie Tooth syndrome, Perlizaeus-Merzbacher disease, neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis, progressive supranuclear plasy, Pick's disease, several polyglutamine neurological disorders asuch as Huntington, spinocerebullar ataxia type I, spinal and bulbar muscular atrophy, dentatorubal pallidoluysian, and myotonic dystrophy, as well as spongiform encephalopathies, such as hereditary Creutzfeldt-Jakob disease, Fabry disease, Straussler-Scheinker syndrome, COPD, dry-eye disease, and Sjögren's disease.

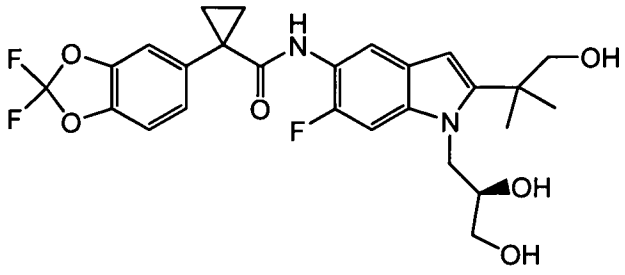
17. The method of claims 15 or 16, wherein the compoud is



18. The method of claims 15 or 16, wherein the compound is



19. The method of claims 15 or 16, wherein the compound is



20. A kit for use in measuring the activity of a ABC transporter or a fragment thereof in a biological sample *in vitro* or *in vivo*, comprising:

(i) a first composition comprising a compound selected from of claim 1; and

(ii) instructions for:

a) contacting the composition with the biological sample;

b) measuring activity of said ABC transporter or a fragment thereof.

21. The kit according to claim 20, further comprising instructions for

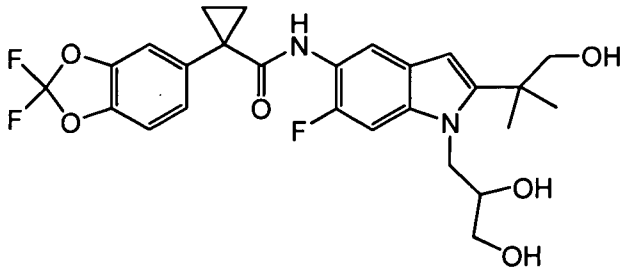
a) contacting an additional composition with the biological sample;

b) measuring the activity of said ABC transporter or a fragment thereof in the presence of said additional compound, and

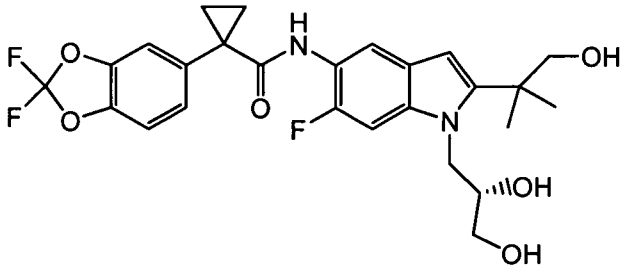
c) comparing the activity of the ABC transporter in the presence of the additional compound with the density of the ABC transporter in the presence of said first composition.

22. The kit of claim 20, wherein the kit is used to measure the density of CFTR.

23. The kit of any of claims 20-22, wherein the compoud is



24. The kit of any of claims 20-22, wherein the compound is



25. The kit of any of claims 20-22, wherein the compound is

