

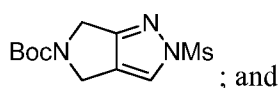
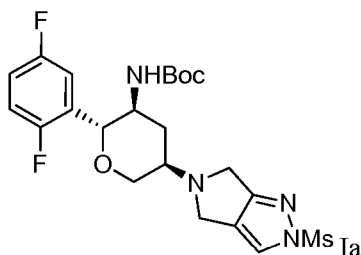


- (51) International Patent Classification:
A61K 31/4162 (2006.01) *C07D 487/04* (2006.01)
A01N 43/56 (2006.01)
- (21) International Application Number:
PCT/US2015/040674
- (22) International Filing Date:
16 July 2015 (16.07.2015)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
62/026,763 21 July 2014 (21.07.2014) US
- (71) Applicant: **MERCK SHARP & DOHME CORP.**
[US/US]; 126 East Lincoln Avenue, Rahway, New Jersey
07065-0907 (US).
- (72) Inventors; and
(71) Applicants (for US only): **CHUNG, John, Y. L.**
[US/US]; 126 East Lincoln Avenue, Rahway, New Jersey
07065-0907 (US). **PENG, Feng** [CN/US]; 126 East Lin-
coln Avenue, Rahway, New Jersey 07065-0907 (US).
CHEN, Yonggang [CN/US]; 126 East Lincoln Avenue,
Rahway, New Jersey 07065-0907 (US). **KASSIM, Amude**
Mahmoud [US/US]; 126 East Lincoln Avenue, Rahway,
New Jersey 07065-0907 (US). **CHEN, Cheng-yi** [US/US];
201 Mercer Street, Princeton, New Jersey 08540 (US).
MAUST, Mathew [US/US]; 126 East Lincoln Avenue,
Rahway, New Jersey 07065-0907 (US). **MCLAUGHLIN,**

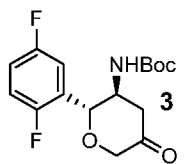
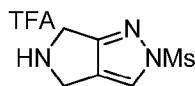
[Continued on next page]

(54) Title: PROCESS FOR PREPARING CHIRAL DIPEPTIDYL PEPTIDASE-IV INHIBITORS

(57) Abstract: A process for preparing a compound of structural Formula Ia: comprising Boc deprotection with TFA of, reductive amination of:.



; and





Mark [GB/US]; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US). **ZACUTO, Michael, J.** [US/US]; 364 Grove Street #1, Jersey City, New Jersey 07302 (US). **CHEN, Qinghao** [US/US]; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US). **TAN, Lushi** [US/US]; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US). **SONG, Zhiguo Jake** [US/US]; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US). **CAO, Yang** [CN/US]; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US). **XU, Feng** [US/US]; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US).

(74) **Common Representative: MERCK SHARP & DOHME CORP.**; 126 East Lincoln Avenue, Rahway, New Jersey 07065-0907 (US).

(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,

NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Declarations under Rule 4.17:

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

Published:

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

TITLE OF THE INVENTION

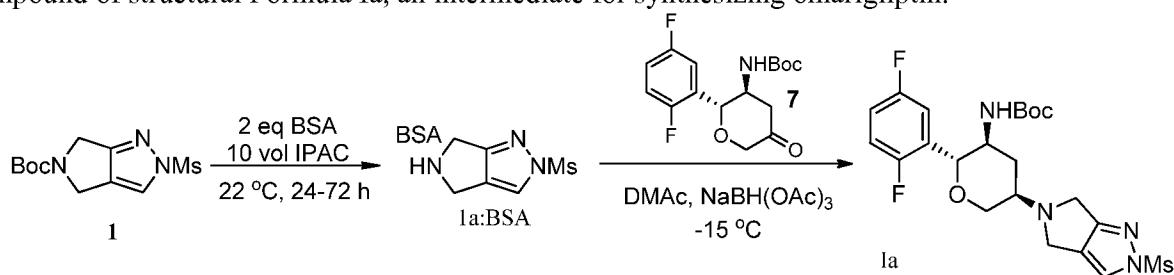
PROCESS FOR PREPARING CHIRAL DIPEPTIDYL PEPTIDASE-IV INHIBITORS

FIELD OF THE INVENTION

5 The present invention is directed to a novel process for the preparation of omarigliptin, (2*R*,3*S*,5*R*)-2-(2,5-difluorophenyl)-5-[2-(methylsulfonyl)-2,6-dihydropyrrolo[3,4-*c*]pyrazol-5(4*H*)-yl]tetrahydro-2*H*-pyran-3-amine, a dipeptidyl peptidase-IV (DPP-4) inhibitor, for the treatment of Type 2 diabetes, and related intermediates.

10 BACKGROUND OF THE INVENTION

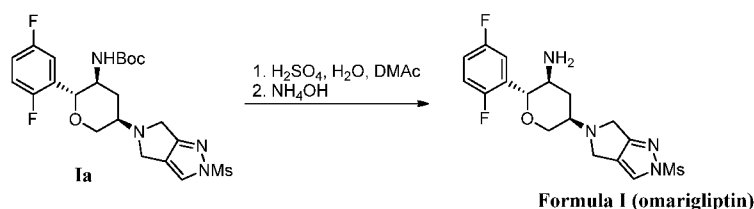
Syntheses of omarigliptin have previously been described in PCT international patent applications numbers WO 2010/056708 and WO2013/003250. The process described in WO 2010/056708 does not result in a favorable yield of the compound of structural Formula Ia, as it results in a racemic mixture. WO2013/003250 describes the following scheme to make the
15 compound of structural Formula Ia, an intermediate for synthesizing omarigliptin:



In WO2013/003250, synthesis of the compound of structural Formula Ia involves using benzenesulfonic acid (BSA) to remove the Boc protecting group of the compound of structural
20 Formula 1, by first forming a BSA salt of the compound of structural Formula 1a. The BSA salt is then isolated and undergoes reductive amination with Boc-ketone of the compound of structural Formula 7, to produce the compound of structural Formula Ia, as a 19:1 diastereomeric mixture. The BSA mediated Boc deprotection requires up to 72 h to reach full conversion.

An alternative process which eliminates the need to isolate the BSA salt of the compound
25 of Formula 1a and reduces the overall reaction time of the process is desired. The inventors have now discovered a process for making the compound of structural Formula Ia which eliminates the step of isolating a salt of the compound of structural Formula 1a and reduces the overall reaction time. The present process also produces an end-of reaction homogeneous solution via reductive amination, which facilitates crystallization of the compound of structural Formula Ia.
30 The described process also improves the diastereoselectivity, overall yield, cost and cycle time over the process described in WO2013/003250.

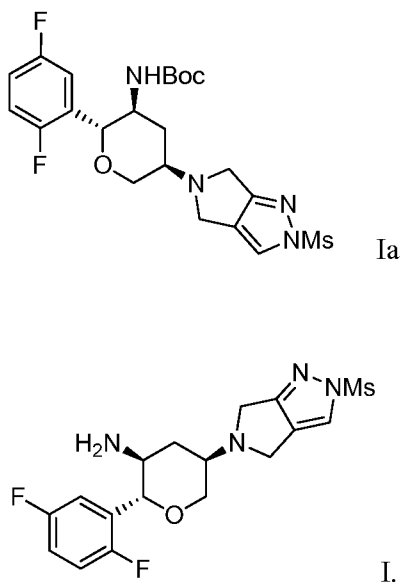
WO2013/003250 also describes the Boc deprotection of the compound of Formula Ia to produce omarigliptin (Formula I) shown below. As described in WO2013/003250, the Boc deprotection of the compound of Formula Ia involves aging the substrate in aqueous sulfuric acid in DMAc at 30 °C for 15-20 h, then working up with ammonium hydroxide. This work up produces large amounts of poorly soluble ammonium sulfate which co-crystallizes with the desired product. As a result, isolation of the desired product requires a long cycle time for filtration, washing and drying.



Because the processes described herein use trifluoroacetic acid with or without a co-solvent for the transformation of the compound of Formula Ia to omarigliptin, which offers good solubility for the compound of Formula Ia, omarigliptin is achieved with fast reaction kinetics and good purity profiles.

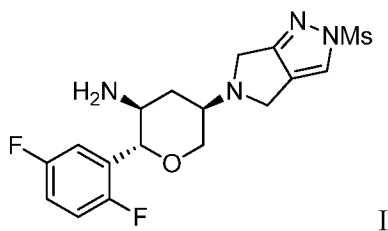
SUMMARY OF THE INVENTION

Described herein are processes for preparing the compounds of structural Formula Ia and Formula I:



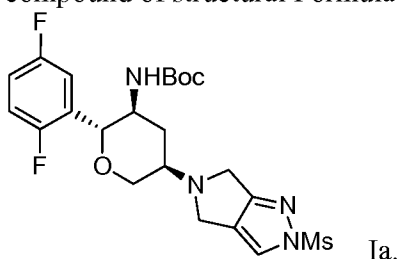
DETAILED DESCRIPTION OF THE INVENTION

One aspect of the present invention is concerned with a process for preparing a compound of structural Formula I:



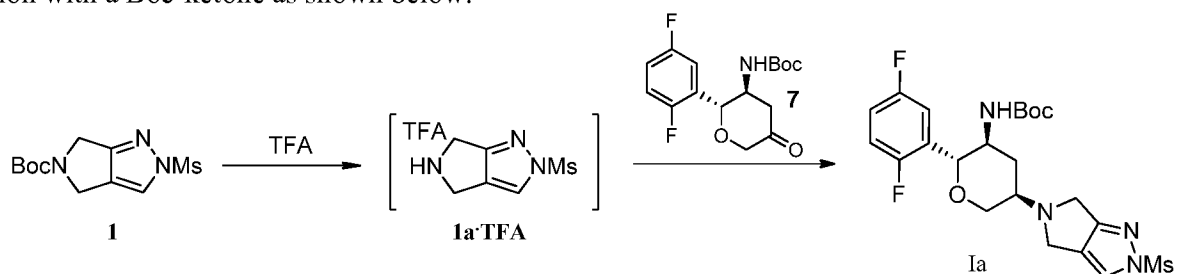
5

which comprises deprotecting a compound of structural Formula Ia:

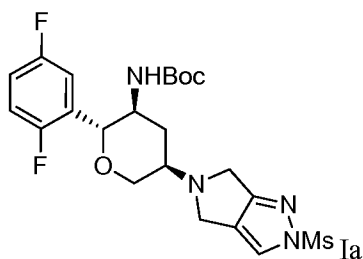


Another aspect of the invention is concerned with a process for preparing the compound of structural Formula Ia, wherein the process comprises a one-pot, two step through process comprising trifluoroacetic acid (TFA) Boc-deprotection of a Boc-mesyl-pyrazole and reductive amination with a Boc-ketone as shown below:

10

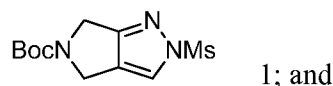


Described herein is a process for preparing a compound of structural Formula Ia:



15

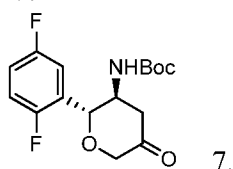
comprising Boc deprotection with TFA of a compound of structural Formula 1:



reductive amination of:



with a compound of structural Formula 7:



10 In certain embodiments, the process is done as a through process, meaning that the process proceeds from the starting materials of compounds of structural Formula 1 and Formula 7, to the compound of Formula Ia or Formula I with no isolation of any intermediates.

In certain embodiments, the process described herein further comprises the step of crystallizing Formula Ia. Crystallization of the compounds can be done using methods known in the art.

15 The amount of TFA used in the process described herein should be enough to allow the reaction to occur. The amount of TFA used can be between about 1-5 volumes. The term “volume” used herein refers to 1ml of TFA to 1g of the starting material, which in the process described herein is optionally the Boc protected mesyl pyrazole. In certain embodiments, the amount of TFA used is about 2-5 volumes. In other embodiments the amount of TFA used is about 3-5 volumes. In still other embodiments, the amount of TFA used is about 1 volume. In still other embodiments, the amount of TFA used is about 2 volumes. In still other embodiments, the amount of TFA used is about 3 volumes. In still other embodiments, the amount of TFA used is about 4 volumes. In still other embodiments, the amount of TFA used is about 5 volumes.

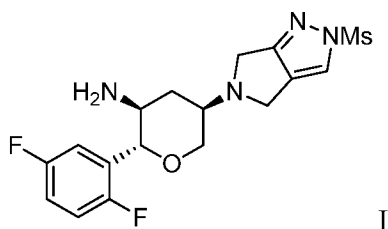
25 In specific embodiments, the TFA used is neat, meaning void of any water or other co-solvent. However, a solvent system comprising TFA and a co-solvent may be used. In certain embodiments, a solvent system comprising at least 90% of TFA and a co-solvent can be used. In certain embodiments, a solvent system comprising about 90-99.9% of TFA and a co-solvent can be used. In certain embodiments, the co-solvent can be present in an amount of between about 0.1-10%. Examples of co-solvents include, but are not limited to, water and DMAc.

30

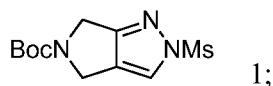
One feature of the process for preparing the compound of structural Formulas Ia and I described herein, is that the presently described process results in improved yields of the compound of structural Formula Ia and I as compared to previously known processes. In certain embodiments, the yield of the compound of structural Formula Ia and I is at least about 80% by weight. In other embodiments, yield of the compound of structural Formula Ia and I is at least about 85% by weight. In other embodiments, yield of the compound of structural Formula Ia and I is at least about 90% by weight. In other embodiments, yield of the compound of structural Formula Ia and I is at least about 95% by weight.

Another feature of the processes for preparing the compound of Formula Ia and I, described herein is that the presently described process results in molecules of improved diastereomeric selectivity as compared to previously known processes. In certain embodiments, the diastereomeric selectivity is at least 20:1. In other embodiments, the diastereomeric selectivity is at least 25:1. In still other embodiments, the diastereomeric selectivity is about 30:1.

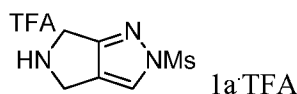
Also described herein are processes for preparing a compound of structural Formula I. In certain embodiments described herein, the process of preparing a compound of structural Formula I:



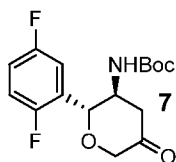
comprising Boc deprotection with TFA of a compound of structural Formula 1:



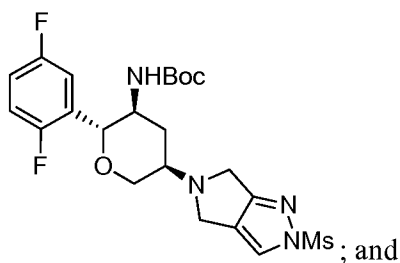
reductive amination of:



with a compound of structural Formula 7:



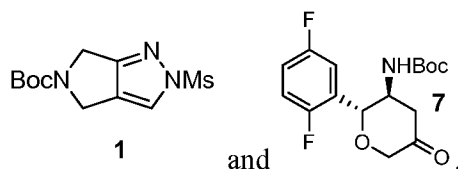
which results in the compound of structural Formula Ia:



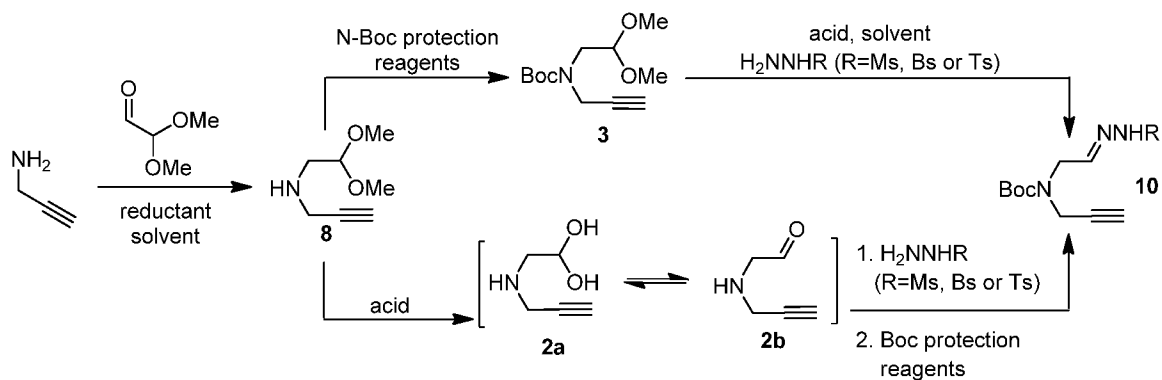
- 5 removing the Boc group of the compound of structural Formula Ia.

Additionally, in certain embodiments, the process of preparing the compound of Formula I may further include crystallizing the compound of Formula Ia prior to removing the Boc protecting group.

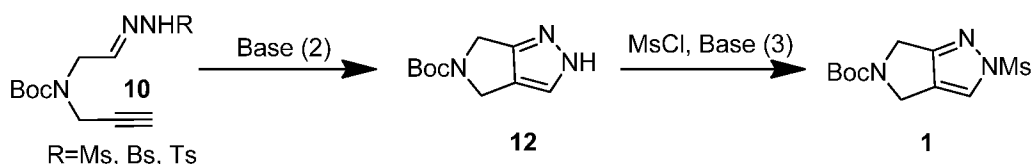
- Also described herein are processes for preparing compounds of Formula 1 and
 10 Formula 7, which are used as intermediates for preparing compounds of Formula I and Formula Ia:



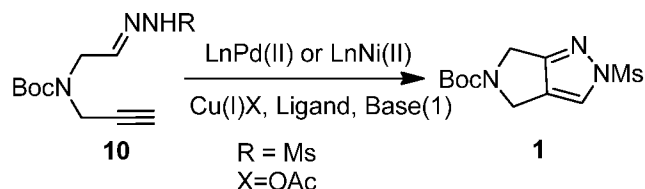
- 15 In certain embodiments, the compound of structural Formula 1 is prepared by the following processes:



and,



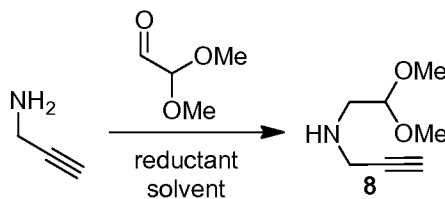
or alternatively



5

In certain embodiments of the processes described herein, the compound of Formula 1 is prepared by the following: first, Compound 10 is prepared from reductive amination of propargyl amine and glyoxal dimethyl acetal, followed by hydrolysis of dimethyl acetal in the presence of an acid, then hydrazone formation with mesyl, besyl or tosylhydrazide (H₂NNHR, wherein R= Ms, Bs or Ts). Treatment of Compound 10 with a base, and optionally solvent at 40-80 °C affords Compound 12 which is taken on to the compound of Formula 1. Each step forming an independent aspect of the present invention, is discussed in detail below.

Step 1:

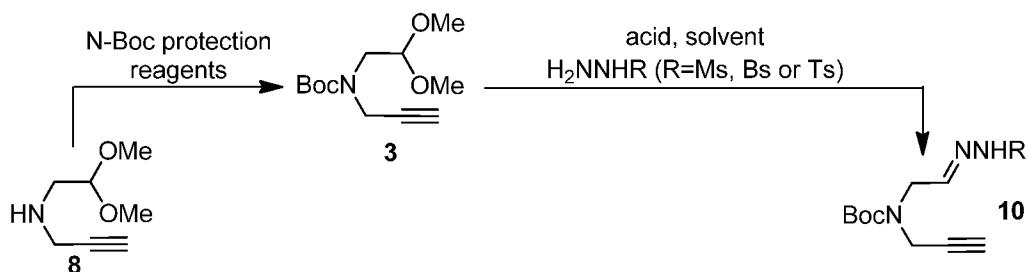


15

In certain embodiments, to arrive at Compound 8, a reductant was added to a mixture of glyoxal dimethyl acetal and propargyl amine in a solvent. Suitable reductants include, but are not limited to, sodium triacetoxymethylborohydride (STAB) and sodium borohydride/alkyl or aryl carboxylic acid mixtures. A preferred reductant is STAB. Suitable solvents include but are not

limited to, ethanol, methanol, amyl alcohol, ethylene glycol, THF, methyl tertiary-butyl ether (MTBE), dioxane, toluene, dichlorobenzenes, dichloromethane, methyl tetrahydrofuran (MeTHF), acetone, ethyl acetate (EtOAc), acetone, dimethylformamide (DMF), dimethyl sulfoxide (DMSO), N-methylpyrrolidone (NMP), N,N-dimethylacetamide (DMAc), acetonitrile (MeCN), dichloroethane (DCE) and isopropanol. A preferred solvent is THF.

Step 2:

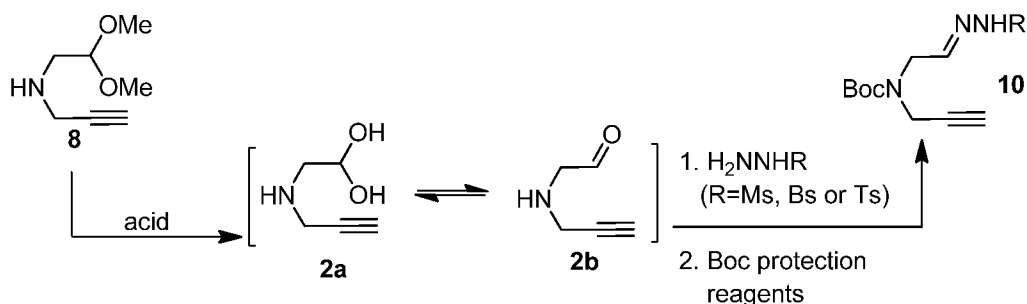


In certain embodiments, to arrive at Compound 10 via Compound 3 (2,2-dimethoxyacetaldehyde), Compound 8 is added to N-Boc protection reagents. Suitable Boc protection reagents include, but are not limited to, Boc-anhydride which can be added under basic conditions.

When Compound 8 is added to N-Boc protection reagents in the above step, N-Boc protection reagents can optionally be in a solvent. Suitable solvents, include, but are not limited, ethanol, methanol, amyl alcohol, ethylene glycol, THF, methyl tertiary-butyl ether (MTBE), dioxane, toluene, dichlorophenyl, dichloromethane, methyl tetrahydrofuran (MeTHF), acetone, ethyl acetate (EtOAc), acetone, dimethylformamide (DMF), dimethyl sulfoxide (DMSO), N-methylpyrrolidone (NMP), N,N-dimethylacetamide (DMAc), acetonitrile (MeCN), dichloroethane (DCE) and isopropanol. A preferred solvent is THF.

To a solution of Compound 3 in solvent, a weak or buffered acid is added. Suitable acids include, but are not limited to, acetic acid, $FeCl_3$, and other Lewis acids. After pH adjustment, mesyl, besyl or tosyl hydrazide (H_2NNHR , wherein $R = Ms, Bs \text{ or } Ts$) is then added. Suitable solvents, include, but are not limited to, ether, ethanol, methanol, amyl alcohol, ethylene glycol, dimethoxyethane (DME), THF, methyl tertiary-butyl ether (MTBE), dioxane, toluene, dichlorophenyl, dichloromethane, methyl tetrahydrofuran (MeTHF), acetone, ethyl acetate (EtOAc), acetone, dimethylformamide (DMF), dimethyl sulfoxide (DMSO), N-methylpyrrolidone (NMP), N,N-dimethylacetamide (DMAc), acetonitrile (MeCN), dichloroethane (DCE) and isopropanol. Preferred solvents include either: DME, DME:water or MeCN:water.

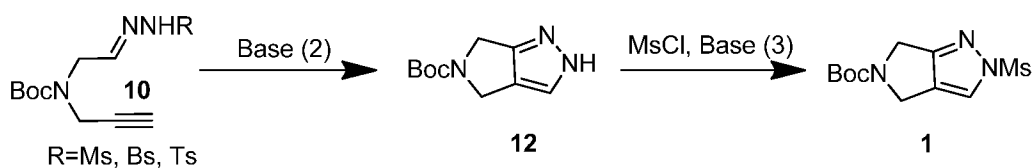
Step 2a:



Alternatively, Compound 10 can be synthesized via Compounds 2a/2b, by adding Compound 8 to acid. Suitable acids include, but are not limited to, sulfuric acid, trifluoroacetic acid, HBr, HCl, R^5SO_3H wherein R^5 is hydrogen, C₁₋₆ alkyl, C₃₋₆ cycloalkyl or aryl. Unless otherwise indicated, the term "C₁₋₆ alkyl" encompasses straight alkyl having a carbon number of 1 to 6 and branched alkyl having a carbon number of 3 to 6. Specific examples thereof include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, tert-butyl, n-pentyl, isopentyl, neopentyl, tert-pentyl, 1-methylbutyl, 2-methylbutyl, 1,2-dimethylpropyl, 1-ethylpropyl, n-hexyl, isohexyl, 1-methylpentyl, 2-methylpentyl, 3-methylpentyl, 1,1-dimethylbutyl, 1,2-dimethylbutyl, 2,2-dimethylbutyl, 1-ethylbutyl, 1,1,2-trimethylpropyl, 1,2,2-trimethylpropyl, 1-ethyl-2-methylpropyl, 1-ethyl-1-methylpropyl, and the like. Unless otherwise indicated, the term "C₃₋₆ cycloalkyl" means cycloalkyls having 3 to 8 carbons, forming one or more carbocyclic rings that are fused. "Cycloalkyl" also includes monocyclic rings fused to an aryl group in which the point of attachment is on the non-aromatic portion. Examples of cycloalkyl include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, tetrahydronaphthyl, decahydronaphthyl, indanyl and the like. Unless otherwise indicated, the term "aryl" includes phenyl, naphthyl, tolyl, and the like.

In certain embodiments, HCl is preferred. Mesyl, besyl or tosyl hydrazide (H_2NNHR , wherein $R = Ms, Bs$ or Ts) is then added. After pH adjustment, then Boc protection reagents are added. Suitable Boc protecting agents include, but are not limited to, Boc_2O .

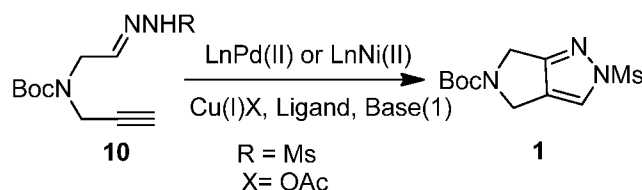
Step 3:



In certain embodiments, to arrive at Compound 1, Compound 10 was added to Base(2) and optionally solvent and the reaction was heated above room temperature. Suitable Base(2) includes, but is not limited to, potassium phosphate (K_3PO_4), K_2CO_3 , $KHCO_3$, Na_2CO_3 , $NaHCO_3$, K_2HPO_4 , Na_3PO_4 , Na_2HPO_4 , and $NaHCO_3$. Suitable solvents include, but are not limited to, toluene, THF, DMAc, hydrazine, EtOH and isopropyl acetate (IPAC).

A solution of mesyl chloride, Base(3) and optionally solvent is added to arrive at the compound of Formula 1. Base(3), that can be used with the processes above includes, but is not limited to, sodium or potassium bis(trimethylsilyl)amide, K_2CO_3 , 1,1,3,3-tetramethylguanidine (TMG), triethylamine, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), alkoxide bases (such as KOtBu) and cesium carbonate (Cs_2CO_3). Solvents that can be used with the processes above include, but are not limited to, toluene, tert-amyl alcohol, DMF, DMAc, 2-MeTHF and THF.

Alternatively, the compound of Formula 1 is prepared by the following process where the mesyl group was retained. Compound 10 is added to a metal catalyst, copper salt, ligand, base and oxidant in solvent affords compound of Formula 1.



Suitable metal catalysts include, but are not limited to, $Pd(OAc)_2$, $PdCl_2(MeCN)_2$, Na_2PdCl_4 , $PdBr_2$, $Pd(TFA)_2$, $Pd(PPh_3)_2Cl_2$ and $Cu(OTf)_2/bipyridyl$. Other catalysts that can be used in the process above include, but are not limited to, $PdCl_2$, $(PPh_3)_2PdCl_2$, (2,2'-bispyridyl) $PdCl_2$, $Pd(OAc)_2$, $PdBr_2$, Na_2PdCl_4 , $Pd(TFA)_2$, $NiCl_2$, $Ni(OAc)_2$, $Ni(acac)_2$, $NiBr_2 \cdot DME$, $Pd(OAc)_2$ or $PdCl_2$ in conjunction with various mono- or bidentate phosphine ligands. Examples of these ligands include, but not limited to, $P(o\text{-tolyl})_3$ (tri-orthotolyl phosphine), $P(furyl)_3$ (trifuryl phosphine), $P(Cy)_3$ (tricyclohexyl phosphine), $P(C_6F_5)_3$ (triperfluorophenylphosphine), dppe (diphenylphosphino ethane), dppp (diphenylphosphino propane), dppb (diphenylphosphino butane), dppf (diphenylphosphino ferrocene), Josiphos, X-Phos and CataXium. Other ligands that can be used as catalysts in the process above include, but are not limited to, various bis-amine ligands, including, but not limited to, TMEDA (N,N,N',N'-tetramethylethylenediamine), DMEDA (N,N'-dimethylethylenediamine), 2,2'-bispyridine, substituted 2,2'-bis-pyridine, 2,2',2''-tris-pyridine, substituted 2,2',2''-tris-pyridine, phenanthroline and substituted phenanthroline. Various bis-heteroatom ligands include, but are not limited to, quinoline, dimethylglycine, proline, picolinic acid, thiophene carboxylic acid,

N,N-disubstituted salicylamide, various bis-imines of cyclohexyldiamine and various 1,3-dicarbonyl substrates.

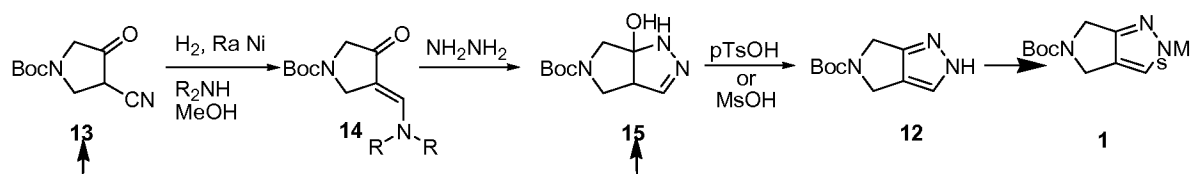
Suitable copper salts that can be used in the process above include, but are not limited to, CuCl, CuCl₂, Cu(OAc)₂, Cu(I)(OAc), CuBr, CuBr₂, Cu(OTf), Cu(OTf)₂

Suitable bases that may be used as Base(1) include, but are not limited to, K₃PO₄, K₂CO₃, KHCO₃, Na₂CO₃, NaHCO₃, K₂HPO₄, Na₃PO₄, Na₂HPO₄, and NaHCO₃.

Suitable solvents that can be used in the process above include, but are not limited to, toluene, DMAc, THF, tert-amyl alcohol, EtOH and IPAC.

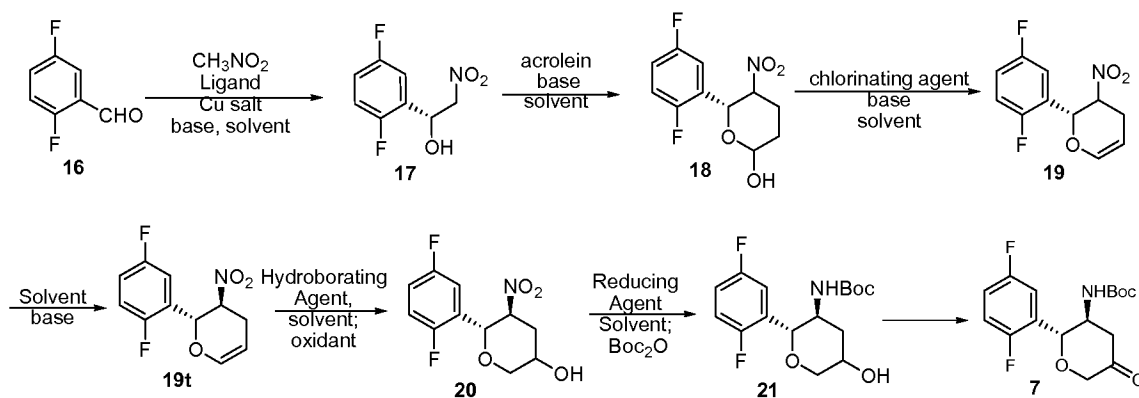
Suitable oxidants that can be used in the process above include, but are not limited to, tert-butyl hydrogen peroxide (TBHP), air, O₂, tert-butyl perbenzoate (tBuOOBz), tert-butyl peracetate (tBuOOAc), benzoquinone, benzoyl peroxide and sodium percarbonate.

In other embodiments of the processes described herein, the compound of Formula 12 is prepared by the following process:



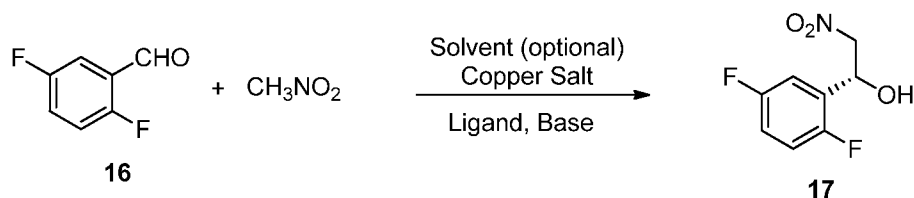
In such embodiments, hydrogenation of keto nitrile, Compound 13, using Raney Ni, Pd or Pt catalyst in methanol or aqueous methanol in the presence of a short chain dialkylamine (R₂NH, wherein R=C₁-C₆ alkyl including but not limited to Me, Et, nPr, branched alkyls and cycloalkyls) affords Compound 14, which upon treatment with hydrazine (hydrate) affords Compound 15. In another embodiment, Compound 13 can be converted to Compound 15 directly by substituting hydrazine for the short chain dialkylamine during the hydrogenation of keto-nitrile 13. Subsequent treatment with pTsOH or MsOH affords Compound 12.

In certain embodiments, the compound of Formula 7 is prepared by the following process:



The compound of structural Formula 7 can be prepared by the following steps, each step of which forms an independent aspect of the present invention:

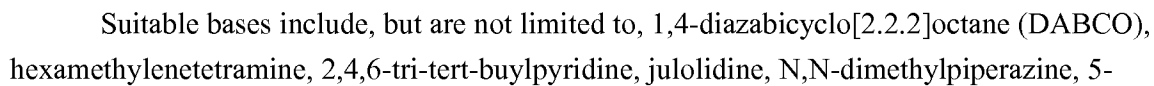
5 Step 1:



With regard to Step 1, Compound 16 is added to copper salt, ligand and a base. To that nitromethane was added. The described reaction can be run without solvent or with solvents. Suitable optional solvents that can be used include, but are not limited to, ethanol, methanol, amyl alcohol, ethylene glycol, THF, methyl tertiary-butyl ether (TBME), dioxane, toluene, dichlorophenyl, dichloromethane, methyl tetrahydrofuran (MeTHF), acetone, ethyl acetate (EtOAc), acetone, dimethylformamide (DMF), dimethyl sulfoxide (DMSO), N-methylpyrrolidone (NMP), N,N-dimethylacetamide (DMAc), acetonitrile (MeCN), dichloroethane (DCE) and isopropanol.

15 Suitable copper salts (both Cu(I) and Cu(II)) that can be used include, but are not limited to, copper benzoate, copper propionate, copper 2-Et-hexanoate, copper acetate, copper trifluoroacetate, copper triflate, copper S-prolinate, copper picolinate and copper halides. In certain embodiments, copper acetate or copper propionate ($\text{Cu}(\text{propionate})_2$) or copper chloride are used. In certain embodiments, copper chloride is preferred.

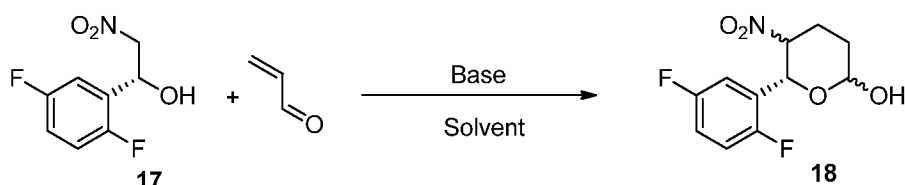
20 Suitable ligands include, but are not limited to,



methylpiperidine, N-methyl-piperidine, N-methyl-pyrrolidine, N-ethyldicyclohexylamine, N-methyldicyclohexylamine, triisopropylamine, 1-aminoadamantane, di-n-butylamine, dicyclohexylamine, triethylamine, 5-methyl-diethylenetriamine, methylguanidine, dimethylaminopyridine, quinidine, and quinulidine. In certain embodiments, DABCO or N,N-dimethylpiperazine is used. The reaction can afford Compound 17 in up to about 95% yield. In certain embodiments, the reaction affords Compound 17 in about 90-95% yield and about 89-94% ee after aqueous work up with EDTA disodium solution, and brine.

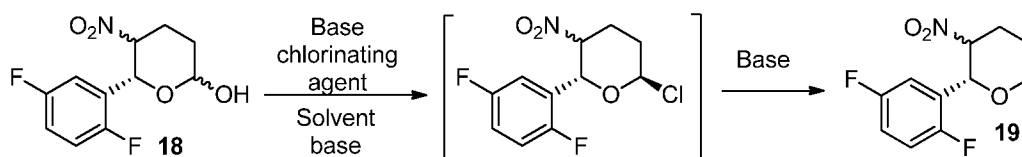
It should be noted that Compound 16 can be replaced with any aldehyde with functional groups that can be converted to the 2, 5-difluoro intermediate at any point in the reaction scheme.

Step 2:



Concerning Step 2, acrolein is added to Compound 17 in base and solvent. Suitable bases include but are not limited to, N, N -diisopropylethylamine (DIPEA). Suitable solvents include but are not limited to, tetrahydrofuran. Step 2 could be carried out with or without aqueous work up of 18.

Step 3:



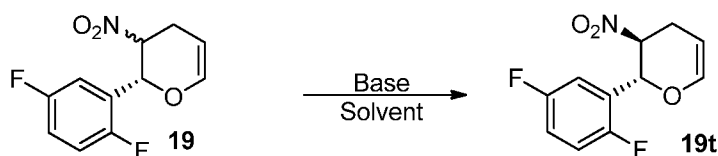
With regard to Step 3, Compound 18 in base is added to a base for chlorination, chlorinating agent and solvent. Solvents that can be used include, but are not limited to, tetrahydrofuran (THF), methyl tertiary-butyl ether (TBME), dioxane, toluene, dichlorobenzene, dichloromethane, methyl tetrahydrofuran (MeTHF), acetone, ethyl acetate (EtOAc), dimethylformamide (DMF), dimethyl sulfoxide (DMSO), N-methylpyrrolidone (NMP), N,N-dimethylacetamide (DMAc), acetonitrile (MeCN), dichloroethane (DCE), and mixtures thereof. In certain embodiments the solvent is acetonitrile. Suitable chlorinating agents include, but are not limited to, mesyl chloride, diethyl chlorophosphate, thionyl chloride and cyanuric chloride. A particular suitable chlorinating agent for the process is MsCl.

Suitable bases for chlorination include, but are not limited to, 1,1,3,3-tetramethylguanidine (TMG), cesium carbonate (Cs_2CO_3), potassium phosphate (K_3PO_4), sodium carbonate (Na_2CO_3), potassium carbonate (K_2CO_3), triethylamine (TEA), 1,4-diazabicyclo[2.2.2]octane (DABCO), 4-dimethylaminopyridine (DMAP), 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) and Hunig's base (*i*Pr₂NEt). In certain embodiments, a suitable base for the chlorination process is *i*Pr₂NEt or triethylamine.

After the reaction is complete a dehydrochlorination base is added. Suitable bases for dehydrochlorination include, but are not limited to pyridine, *N,N*-dimethylaniline, collidines, lutidines, *N*-methyl morpholine, Hunig's base, tri-*n*-butylamine and triethylamine. A particularly suitable base for the process is 2,3,5-collidine.

Suitable reaction temperatures for chlorination are -10 - +10 °C. Suitable dehydrochlorination temperatures are +20 - 50 °C.

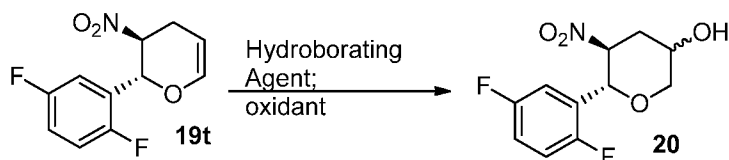
Step 4:



With regard to Step 4, Compound 19 is added to a solvent and base. Solvents that can be used include, but are not limited to, ethanol, methanol, tetrahydrofuran (THF), methyl tertiary-butyl ether (TBME), dioxane, dimethoxyethane (DME), toluene, dichlorobenzene, dichloromethane, methyl tetrahydrofuran (MeTHF), cyclopentyl methyl ether (CPME), acetone, ethyl acetate (EtOAc), isopropyl acetate (IPAC), dimethylformamide (DMF), dimethyl sulfoxide (DMSO), *N*-methylpyrrolidone (NMP), *N,N*-dimethylacetamide (DMAc), acetonitrile (MeCN), dichloroethane (DCE), *n*-propanol, isopropanol, butanols, amyl alcohols, water and mixtures thereof. In certain embodiments, the solvent is a mixture of water and isopropanol.

Suitable bases include, but are not limited to, 1,1,3,3-tetramethylguanidine (TMG), cesium carbonate (Cs_2CO_3), potassium phosphate (K_3PO_4), sodium carbonate (Na_2CO_3), potassium carbonate (K_2CO_3), triethylamine (TEA), 1,4-diazabicyclo[2.2.2]octane (DABCO), 4-dimethylaminopyridine (DMAP), 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), potassium tert-butoxide (KOtBu), Hunig's base (*i*Pr₂NEt), morpholine, *N*-methyl morpholine, imidazole, *s*-collidine, pyridine and diisopropylamine. A particularly suitable base for the process is triethylamine.

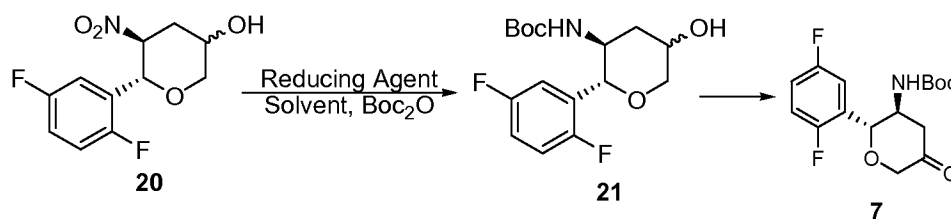
Step 5:



In Step 5, a hydroborating agent and oxidant is added to Compound 19t in solvent.

- 5 Solvents that can be used include, but are not limited to, tetrahydrofuran (THF), methyl tertiary-butyl ether (TBME), dioxane, dimethoxyethane (DME), toluene, dichlorophenyl, dichloromethane, methyl tetrahydrofuran (MeTHF) and cyclopentyl methyl ether (CPME). In certain embodiments the solvent is TBME. Suitable hydroborating agents include, but are not limited to, borane reagents such as, borane THF complex, borane dimethyl sulfide (DMS) complex and $\text{NaBH}_4/\text{BF}_3$ etherate (or THF). Suitable oxidants include, but are not limited to,
- 10 sodium perborate, sodium percarbonate, hydrogen peroxide and hydrogen peroxide urea complex.

Step 6:



15

- With regard to Step 6, Compound 20 was reduced to the amine with a reducing agent in solvent. Optionally, Step 6 can be performed in the presence of an acid. Suitable reducing agents that can be used include, but are not limited to, zinc powder and zinc powder in a solvent with acid, under hydrogenative conditions with catalysts such as Raney nickel, Pt, or Pd.
- 20 Solvents that can be used include, but are not limited to, ethanol, methanol, propanol, isopropanol, tetrahydrofuran (THF), dioxane, N,N-dimethylacetamide (DMAc), acetonitrile (MeCN), water and mixtures thereof. In certain embodiments, the solvent is ethanol or THF. Suitable optional acids include but are not limited to, sulfuric acid, trifluoroacetic acid, HBr, HCl, $\text{R}^5\text{SO}_3\text{H}$ wherein R^5 is hydrogen, C1-6 alkyl, C1-6 cycloalkyl or aryl. Additionally, after
- 25 complete reduction of the nitro to the amine, the mixture can be treated with a base, such as K_2CO_3 , Na_2CO_3 , NaOH or KOH, followed by Boc anhydride to give Compound 21. Compound 7 is obtained from compound 21 via oxidation as described in WO2013/003250.

Representative experimental procedures utilizing the novel process are described below.

However, the invention is not limited to the specific reactants and reaction conditions in the example described below.

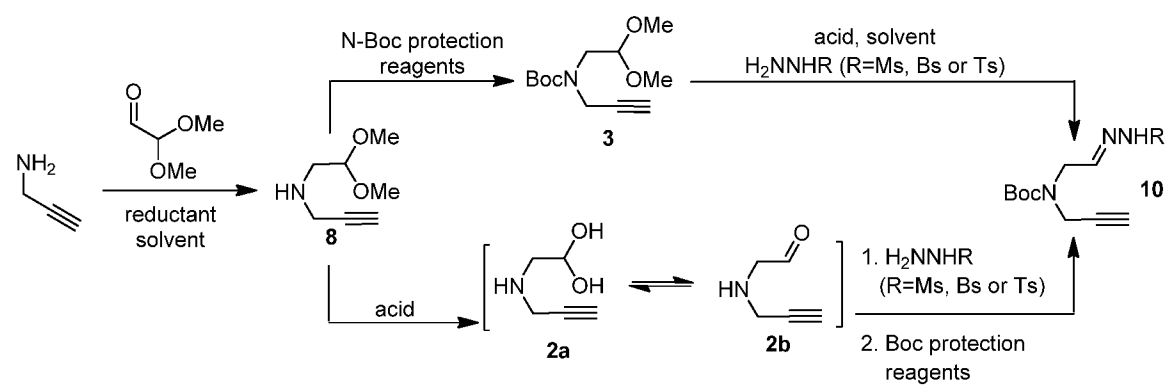
Abbreviations:

5	Boc	=	<i>tert</i> -butyloxycarbonyl
	Bs	=	besyl, benzenesul
	BSA	=	benzenesulfonic acid
	DABCO	=	1,4-diazabicyclo[2.2.2]octane
	DBU	=	diazobicyclo undecene
10	DMF	=	dimethylformamide
	DMAc	=	N,N-Dimethylacetamide
	DMAP	=	4-Dimethylaminopyridine
	DMSO	=	dimethyl sulfoxide
	EDTA	=	ethylenediaminetetraacetic acid
15	ee	=	enantiomeric excess
	EE	=	ethyl
	EtOH	=	ethanol
	EtOAc	=	ethyl acetate
	h	=	hour(s)
20	HPLC	=	high-performance liquid chromatography
	K ₂ CO ₃	=	potassium carbonate
	KOH	=	Potassium hydroxide
	IPA	=	isopropyl alcohol
	L	=	liter(s)
25	Me	=	methyl
	MeCN	=	acetonitrile
	MeTHF	=	methyl tetrahydrofuran
	min	=	minute(s)
	mL	=	milliliter(s)
30	Ms	=	mesyl, methanesulfonyl or CH ₃ SO ₂ -
	MTBE	=	methyl <i>tert</i> -butyl ether
	NaHCO ₃	=	sodium bicarbonate
	Na ₂ SO ₄	=	Sodium sulfate
	NaBH(OAc) ₃	=	Sodium triacetoxyborohydride
35	NMP	=	N-methylpyrrolidone
	nPr	=	N-propyl

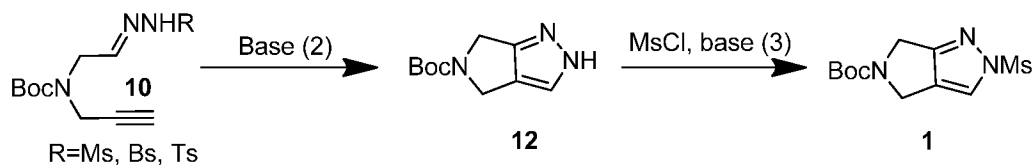
r.t.	=	room temperature
TBME	=	methyl tertiary-butyl ether
TEA	=	triethylamine
Tf	=	trifluoro
5 TFA	=	trifluoroacetic acid
THF	=	tetrahydrofuran
TMG	=	tetramethyl guanidine
Ts	=	p-toluenesulfonyl
v	=	volume(s)

Certain starting materials and reagents are either commercially available or known in the chemical scientific or patent literature. Purification procedures include, for example, distillation, crystallization, and normal or reverse phase high performance liquid chromatography.

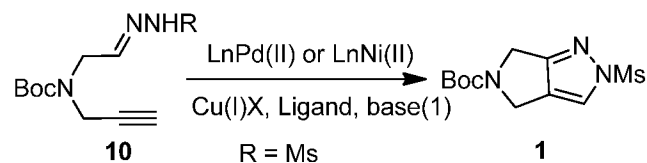
SCHEME 1: Synthesis of Boc Mesyl-Pyrazole



and,



or alternatively



Compound 8

To a solution of propargyl amine (1.05 equivalent) in THF (15-20 volume), glyoxal dimethyl acetal aqueous solution (1 equivalent) was added at 4 °C over 5 minutes. The resulting solution was aged at 0-2°C for 10-15 minutes. Sodium triacetoxymethylborohydride was added in 3 portions (3 x 0.33 equivalents) over 3 hours, while maintaining the temperature between 3-15 °C in between the addition. The resulting mixture was aged for 10 hours. The reaction was quenched by adding cold water, followed by 10N solution of NaOH (5 equivalents) and MTBE (10 volumes). The biphasic layer was stirred vigorously and allowed to settle. The organic layer was separated, washed with aqueous NaCl solution (2x5 volumes) and azeotropically distilled to almost dryness to afford an orange oil, which was used directly in the next step.

Compound 10 via Compounds 2a/2b

A solution of Compound 8 (1 equivalent) in concentrated HCl (4-5 equivalents) was stirred at room temperature for 20 hours and then concentrated in vacuo at 30-35 °C to remove half of its volume. Additional concentrated HCl solution (2 equivalents) was added to the resulting solution and the mixture was aged for another day at room temperature, diluted with MeCN (2 volume) and the pH was adjusted to 4 by adding 50 wt% aqueous NaOH solution. Mesityl hydrazide (1 equivalent) was then added as a solid, and the resulting solution was aged at room temperature overnight. Water (10 volumes) and EtOAc (15 volumes) was added, followed by Boc₂O (1 equivalent) and solid NaHCO₃ to bring the pH to 6-7. Once gas evolution ceased (approximately 5 hours), the aqueous layer was separated, and the organic layer was washed with water (2 volumes) and brine (2 volumes) and concentrated. The crude product was then purified by column chromatography (DCM:EtOAc or Hex:EtOAc) to afford product 10.

Compound 3

To a solution of dimethylacetal amine 8 (1 equivalent) in MTBE (10 volumes) and water (3 volumes) Boc-anhydride (1.1 equivalents) was slowly added between 0-10°C. The pH was adjusted to 6-7 during the reaction by addition of solid NaHCO₃. After aging at room temperature for 5 hours, the organic layer was separated, washed two times with water (3 volume), brine and concentrated to give crude product, which was used directly in the next step.

Compound 10 via Compound 3

To a solution of dimethylacetal Boc-protected amine (Compound 3) (1 equivalent) in MeCN:water (20 volumes) mesityl hydrazide (1.3 equivalents) was added, followed by 5 wt% FeCl₃ on SiO₂ gel (0.5 equivalent). The resulting slurry was aged at 45 °C for several days and filtered. The filtrate was treated with water (5 volumes) and extracted with EtOAc (15 volume). The organic layer was washed two times with water (5 volume) followed by 5 wt% aqueous

NaHCO₃ solution and brine and azeotropically dried to give a crude mixture which was subjected to MTBE crystallization to afford the hydrazone compound **10**.

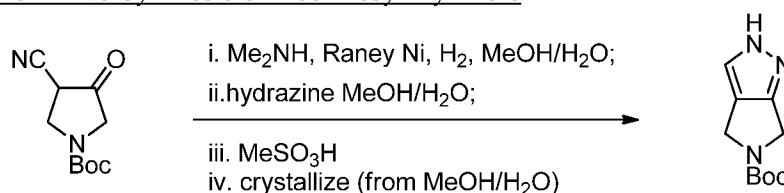
Compound **12**

To a solution of hydrazone (Compound **10** (1 equivalent)) in NMP (10 volumes), K₃PO₄ (4 equivalents) was added at room temperature and the resulting slurry was heated to 45-50°C and aged for 25 hours. Ethyl acetate (20 volumes) was added, the mixture was washed with water (2x5 volume), and the organic layer was washed with brine, dried over Na₂SO₄, filtered and concentrated to give crude product.

Compound **1**

NiBr₂•DME complex (0.05 equivalent), followed by Cu(I)OAc co-catalyst (0.05 equivalent), cyclohexyldiamine ligand (0.1 equivalent) and MeCN (20 volumes) was added to a flask. The resulting mixture was stirred for a couple of minutes and then treated with hydrazone (Compound **10** (1 equivalent)), K₃PO₄ (1 equivalent) and tert-butyl peracetate (tBuOOAc, 1.1 equivalent) as the oxidant. The resulting slurry was aged at 25-30°C for 15 hours and then diluted with EtOAc (10 volumes) and water (5 volumes). The organic layer was separated, washed with 5% EDTA-Na₂ solution (5 volumes), 10% aqueous citric acid solution, 10% aqueous NaHCO₃ and brine. The final organic layer was then treated with resin (100 wt% loading with regard to starting Compound **10**), aged for 3 hours at room temperature, filtered and concentrated in vacuo to afford crude Compound **1**.

SCHEME 2: Alternative Synthesis of Boc Mesyl-Pyrazole



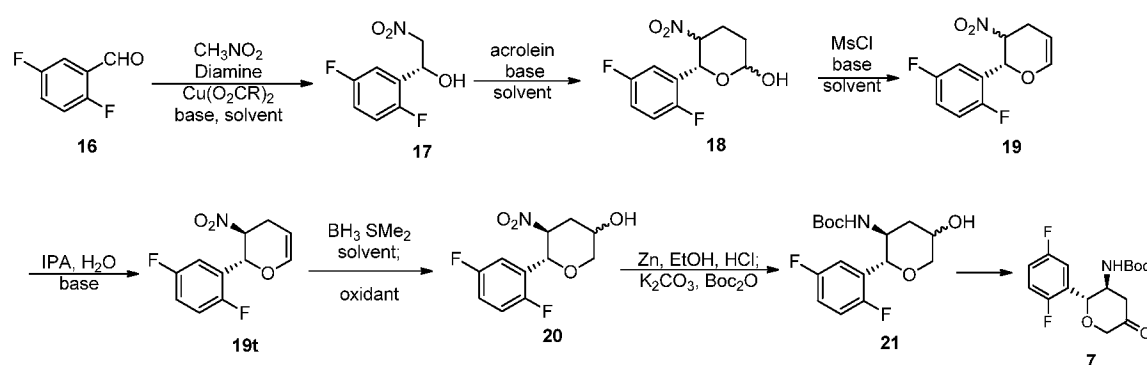
The keto-nitrile (20 g) was dissolved in MeOH (120 mL). A solution of 40 wt% aqueous dimethylamine (80 mL) was added, followed by Raney Ni (0.8 g). The solution was placed under an atmosphere of H₂ and heated to T_i = 35 °C for 22 h. The reaction was then cooled to ambient temperature and the vessel was vented to remove excess H₂. The catalyst was removed via filtration, and the filtrate was subjected to constant volume distillation (at ~35 °C and 50 mm Hg partial pressure) with MeOH in order to remove excess dimethylamine. The resulting crude solution was carried forward.

The crude solution was heated to 40 °C. A solution of 35% aqueous hydrazine (8.6 mL) was added over 30 min. One hour after the addition was complete, the solution was cooled to 22 °C, at which point the pH of the resulting solution was 11.5.

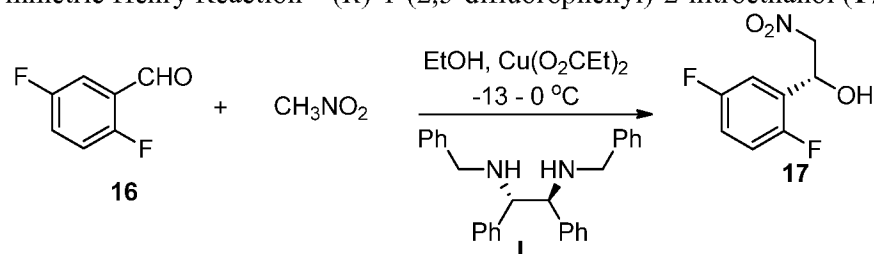
Methanesulfonic acid (11.9 mL) was added slowly, with external cooling, maintaining 25-35 °C until the target pH = 1.5-2 was reached. The resulting solution was aged an additional 18 h. The red solution was concentrated to remove MeOH. Upon cooling, crystallization commenced. Saturated aqueous NaHCO₃ (~6 mL) was added until pH = 6.

The slurry was subjected to slow, careful concentration to remove ~30 mL of solvent from the supernatant. The resulting slurry was stirred for 1 h, after which loss to the supernatant was 7.2 mg/mL. The slurry was filtered. The cake was displaced with 1 cake volume of 5:95 MeOH:water (30 mL), then water (30 mL). The solid was dried for 3 h, after which the solid was collected.

SCHEME 3: Synthesis of the Boc Ketone



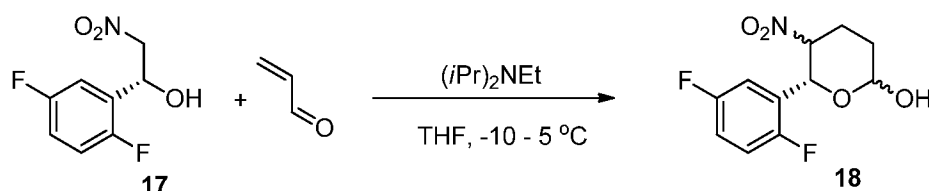
Step 1: Asymmetric Henry Reaction – (R)-1-(2,5-difluorophenyl)-2-nitroethanol (17)



A round bottom flask was charged with ligand L (0.829 g), Cu(II) propionate monohydrate (0.402 g) (or Cu(II) acetate (0.31 g) or CuCl or CuCl₂) and EtOH (350 ml) and agitated at room temperature for 1h. 2,4-Difluorobenzaldehyde (100.0 g) was added followed by DABCO (2.368 g) (or 2,4-dimethylpiperazine) and the mixture was cooled to -5 - -15 °C. Cold (0°C) nitromethane (190 ml or 215 g) was added slowly to the cold solution and the solution was aged at -5 to -15 °C for 20-24 h and at 0 °C for 2-4h. 5 wt% EDTA•2Na (500 ml) followed by

water (200 mL) and MTBE (1.0 L) was added to the cold solution, and the temperature was raised to 20°C. The layers were separated and the organic layer was washed with additional 5 wt% EDTA•2Na (500 ml), followed by water (50 mL) and brine (250 mL). The organic layer, containing Compound **17**, was concentrated to remove nitromethane, then the solvent was

Step 2: Michael-Lactolization – Nitro lactol

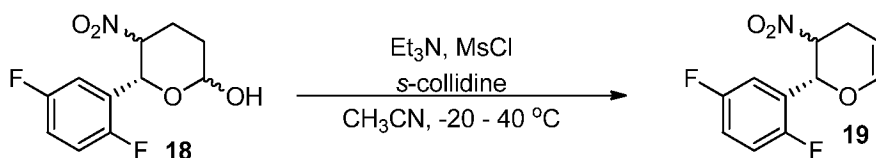


To Compound **17** in 2 volumes of THF (258 mL) from Step 1 under N₂ and cooling at 0 °C, 1 equivalent of Hunig's base was added. 1.15 equivalents of acrolein was added over 1 h via syringe pump at 0-5 °C. The reaction was stirred at -10-0 °C overnight. The resulting mixture was used directly in the next step.

Alternatively, the mixture was concentrated at 0-5 °C to remove excess acrolein, then the residue was flushed with acetonitrile until Hunig's base and water are mostly removed. The residue was taken up in 8 volumes of acetonitrile and used directly in the next step.

Alternatively, at the end of the reaction the mixture was worked up by diluting with MTBE and washing with aqueous citric acid solution, and aqueous NaHCO₃ solution, and the solvent was switched to acetonitrile. Alternatively, the end reaction mixture was taken forward directly to the next step.

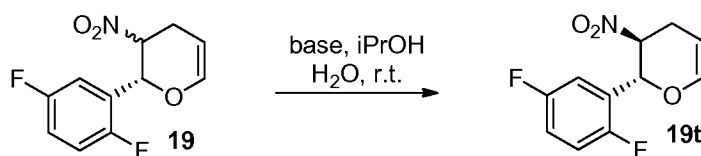
Step 3: Dehydration – Nitro dihydropyrans



1.1 Equivalents of TEA was added to the acetonitrile solution of lactol **18** from Step 2 followed by 1.2 equivalents of mesyl chloride and 1.2 equivalents of S-collidine under < +10 °C. The reaction was aged at 10°C for 0.5-1 h. Alternatively, the end of the reaction mixture from Step 2 was cooled to between -20 °C to 0 °C. Two equivalents of S-collidine and 1.4 equivalents of mesyl chloride were then added. The mixture was heated to 36 °C and aged overnight. The mixture was cooled to room temperature. 15 volumes of MTBE was added and the solution was

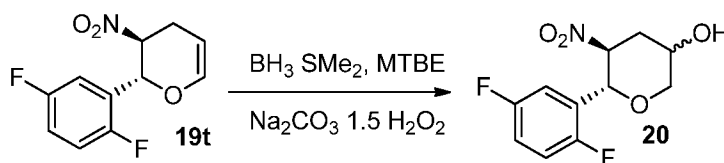
washed with 3 volumes 10 wt% citric acid and 6 volumes water, 10 volumes water, then 3 volumes of 5% NaHCO₃ solution and 6 volumes water. The organic was concentrated with 20 volumes of MTBE using 10 volumes MTBE. The organic solution was stirred with 20-30 wt% AQUAGUARD for 2 hours at room temperature. The mixture was filtered and washed with 2 volumes of MTBE.

Step 4: Dynamic Kinetic Resolution (DKR) crystallization – *Trans*-nitro-dihydropyran (19t)



The organic MTBE solution of Step 3 was solvent switched to 2 volumes of IPA and the final volume was ~300 mL. 10 Mol% of TEA (or DABCO or morpholine or DMAP) was added. Then water (115 mL) was slowly added over 3 hours. The slurry was filtered, washed with 80/20 IPA/water (2x100 mL) and vacuum dried under N₂.

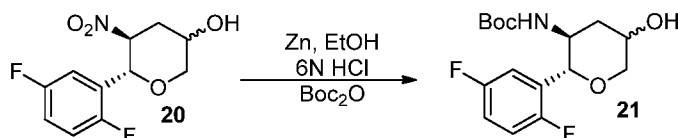
Step 5: Hydroboration/oxidation – *Trans*-nitro-pyranol



To a vessel charged with *trans*-nitro-dihydropyran (10 g), MTBE (100 mL) was added under nitrogen. The mixture was stirred at room temperature to give a clear orange solution. The solution was cooled to +2 °C and borane dimethyl sulfide complex (9.55 ml) was added. The clear solution was aged for 2-5h until >99% conversion by HPLC analysis. The reaction was slowly quenched with water (7.25 ml) keeping at < +9 °C. After the solution was aged at 5°C for 5 min, water (78 mL) was added at < +13 °C. Solid sodium percarbonate (13.26 g, 84 mmol) was added. The suspension was stirred at 5 °C for 15h. The mixture was transferred to a separatory funnel with the aid of 60 mL MTBE and 20 mL water. The mixture was allowed to warm to room temperature. The aqueous phase was back-extracted with 40 mL MTBE. The combined organic phase was washed once with 30 mL half saturated sodium chloride solution, once with 15 mL brine and 15 mL 0.2N HCl, and once with 30 mL half-saturated sodium chloride solution. The organic layer was dried over Na₂SO₄. The organic was filtered, washed

with 10 mL MTBE and concentrated to an oil. The oil was diluted to 200 mL for a 0.191M solution.

Step 6: Nitro Reduction/Boc protection – Pyranol



A 3-neck jacketed round bottom flask equipped with overhead stirrer was charged with 0.191M (5R,6S)-5-nitro-pyran-3-ol (119 ml) (Compound **20**) in ethanol and ethanol (32 ml).

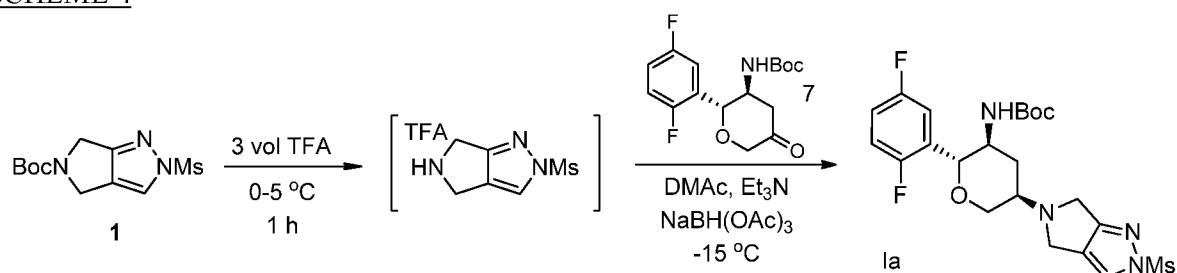
The solution was cooled to 11-12 °C. Cold 6N HCl (19.55 ml, 117 mmol) was added at < +17°C. Zinc dust (12.93 g) was added in five portions (5x2.59g) at < +26 °C. The mixture was stirred at 12 °C for 22 h. 1M K₂CO₃ (76 mL) was added in one portion. MTBE (59 mL) was added then EDTA 2K 2H₂O (22.55 g) was added over 10 min at < +14 °C. To the solution 45 wt% KOH (4.86 mL) solution was added. The solution was cooled to 5 °C, and 1.1 equivalents of Boc₂O (5.46 g) was added. The solution was rinsed with MTBE (10 mL) and stirred at 5 °C for 2h, then at 12 °C for 16h, and then at 24 °C for 10h until >99.5% conversion. The solution was transferred to a separatory funnel with the aid of MTBE (30 mL) and water (5 mL). The organic layer was filtered and washed with MTBE (20 mL). The organic filtrate was concentrated. MTBE (60 mL), water (30 mL) and saturated sodium chloride solution (15 mL) were added. The mixture was warmed in a 30 °C bath to dissolve solid, and then concentrated. The concentrate was flushed with toluene in a 60 °C bath, then concentrated. Toluene (8.4 mL) was added and the mixture was heated to 80 °C. Heptane (70.8 mL) was added over 1h at 80 °C, then cooled slowly to room temperature. The mixture was filtered and washed with 1:2 toluene/heptane (23.55 mL), filterated and vacuum dried under nitrogen until a constant weight.

The purity could be further upgraded by the following procedure: a round bottom flask was charged with the product of Step 6 (7.069 g) from above. EtOH (21 mL) was added and the mixture was heated to 45 °C. Water (31.5 mL) was slowly added over 1 h at 45 °C. The mixture was aged for 1h. Water (31.5 mL) was added in one portion, then cooled slowly to room temperature and aged overnight. The slurry was filtered and washed with 1:3.5 EtOH/water (23.56 mL). Crystals were vacuum dried under nitrogen until a constant weight.

Alternatively, Compound **20** was reduced with 100 psi hydrogen in 20 volume wet THF in the presence of 10-30 wt% Raney nickel at 50 °C. Then the reaction mixture was basified with 2 equivalent of K₂CO₃ and a slight excess Boc₂O to afford crude Compound **21** after aqueous work up.

Compound **7** was obtained from **21** via oxidation as described in WO2013/003250.

SCHEME 4

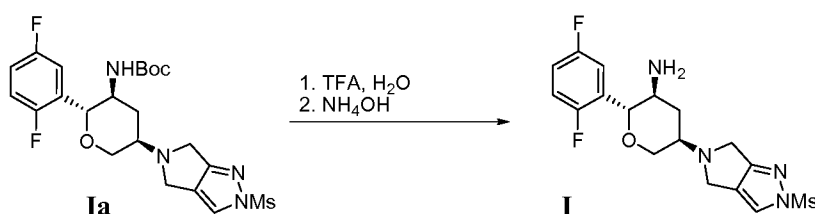


5 Boc-mesyl-pyrazole solid **1** was added to 2.5 volumes of TFA at 0-2 °C, over 2-3 minutes under nitrogen, followed by 0.5 volume of TFA rinse. Conversion to TFA salt was complete within 0.5-1h at 1-2 °C. DMac (14 vol) followed by triethylamine (5 equivalents or 2.3 volumes) were slowly added to the TFA reaction mixture at 0 °C maintaining < +20 °C. Boc-ketone **7** (0.89 equivalent) was then added at -15 °C followed by solid NaBH(OAc)₃ (1.4
10 equivalents) which was added in three portions over 1h. The reaction solution was aged at -15 °C overnight. The solution was then warmed to 22 °C, and after aging for 2-5 h. Diastereomeric ratio was ≥ 96.5:3.5.

The solution was seeded with Boc amine **1** wt% at 22 °C and stirred at 22-40 °C for 2-4 h. 0.36 volume 28% ammonium hydroxide was added over 2-4 h, then, 3.64 volumes 28%
15 ammonium hydroxide was added over 4-10h at 22-60 °C. After cooling to 22 °C, the batch was filtered, washed with 5:1 DMac/water, then water. The wet cake was vacuum dried under nitrogen at ambient affording the product. Diastereoselectivity was ≥ 30:1.

Boc Deprotection of Formula Ia

20

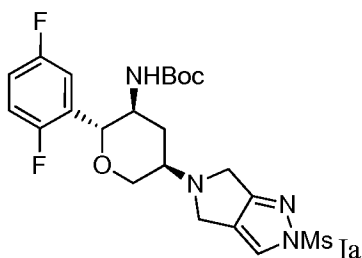


A reactor was charged with 2.5 X (by volume) of trifluoroacetic acid. The batch was cooled to 5-10 °C. The reactor was then charged with 0.4 X (by volume) water. The batch was cooled to 0-5 °C. The reactor was then charged with 1 equivalent (1 kg) of the compound of
25 Formula **Ia** over 0.5-1h while maintaining the temperature between 0 -5°C. The reactor was then charged with 0.5 X (by volume) trifluoroacetic acid to reactor while maintaining the temperature between 0-5°C. The batch was then heated between 15-20°C and aged for 2-2.5 h. The batch was then cooled to between 5-10°C. A crystallizer was charged with water 5.0 X (by

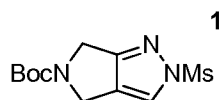
volume) and 0.1 X (by volume) of ammonia water and adjusted to between 3-13°C. To generate a seed bed, Compound I seed (1wt% vs Ia) was added and the temperature as adjusted to between 3-13°C. A solution of ammonia water 3.8 X (by volume) and of the compound of Formula Ia was added simultaneously to the seed bed over 2.5 – 3.5 hours while maintaining
5 temperature at 3-13°C and pH ~9-10. The batch was aged for at least 30 minutes and then filtered. The resulting crystals were washed with 3.0X (by volume) water at 3 – 13°C twice and vacuum dried at $\leq 50^{\circ}\text{C}$ to afford the compound of formula I.

WHAT IS CLAIMED IS:

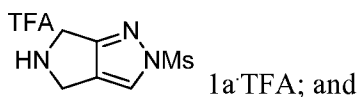
1. A process for preparing a compound of structural Formula Ia:



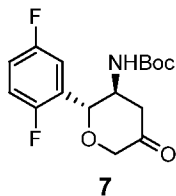
- 5 comprising reacting **1** with TFA:



to produce a TFA salt of **1a**:

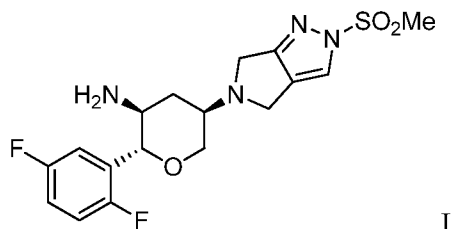


reacting the TFA salt of **1a** with **7** under reductive amination conditions:



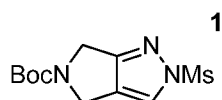
to produce the compound of Formula Ia.

2. The process of Claim 1, wherein the process is done as a through process.
3. The process of Claim 1, further comprising the step of crystallizing Formula Ia.
4. The process of Claim 1, wherein the amount of TFA is 1-5 volumes.
5. The process of Claim 1, wherein the amount of TFA is 3 volumes.
6. A process of preparing a compound of structural Formula I:

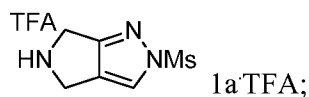


I

comprising reacting **1** with TFA:

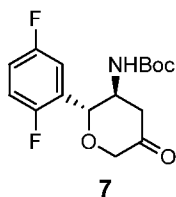
**1**

5 to produce a TFA salt of **1a**:

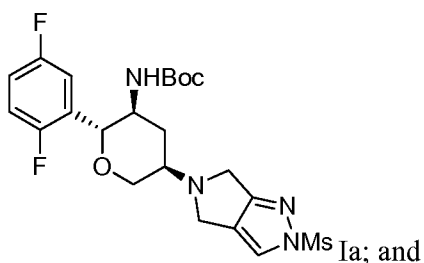


1a·TFA;

reacting the TFA salt of **1a** with **7** under reductive amination conditions:

**7**

10 to produce a compound of Formula Ia;



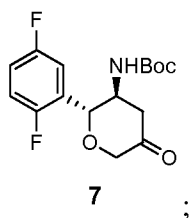
Ia; and

removing the Boc group of Formula Ia to produce the compound of Formula I.

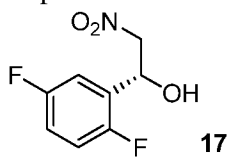
7. The process of Claim 6, wherein the compound of Formula Ia is crystallized prior to removing the Boc protecting group.

15

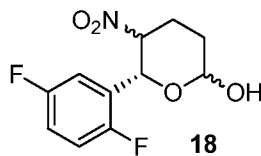
8. A process of preparing a compound of Formula 7



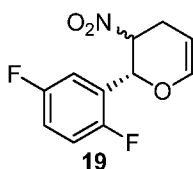
comprising reacting 2,4-difluorobenzaldehyde and nitromethane in the presence of a copper salt,
 5 ligand, base and solvent to produce a compound of Formula **17**:



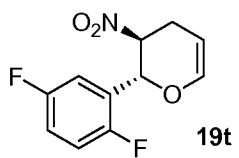
9. The process of Claim 8 further comprising the step of reacting the compound of
 Formula **17** with acrolein in the presence of a base and solvent to produce a compound of
 10 Formula **18**:



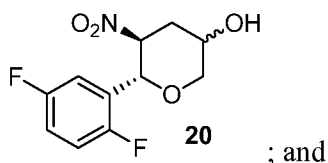
10. The process of Claim 9 further comprising the step of reacting the compound of
 Formula **18** with a chlorinating agent in the presence of a base and a solvent to produce a
 15 compound of Formula **19**:



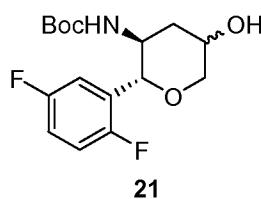
11. The process of Claim 10 further comprising the step of crystallizing the
 compound of Formula **19** under basic conditions to produce a compound of Formula **19t**:



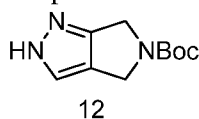
12. The process of Claim 11 further comprising the steps of reacting the compound of Formula 19t with a hydrobrating agent and an oxidant to product a compound of Formula **20**:



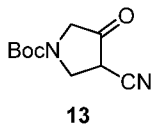
reacting the compound of Formula **20** with a reducing agent and a protecting group to produce a compound of Formula **21**:



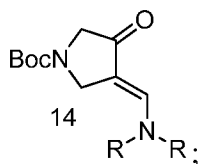
13. A process of making the compound of Formula **12**:



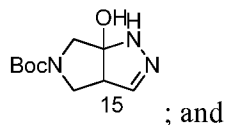
comprising reacting the compound of Formula 13 and (R)₂NH, wherein R is C₁-C₆alkyl in the presence of Raney Ni, Pd or Pt catalyst in methanol or aqueous methanol:



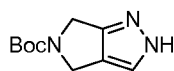
to produce a compound of Formula **14**:



reacting the compound of Formula **14** with hydrazine to produce a compound of Formula **15**:

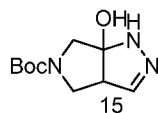


treating the compound of Formula **15** with pTsOH or MsOH to produce the compound of Formula **12**:

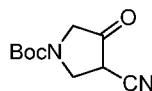
**12**

5

14. A process of making

**15**

comprising hydrogenation of

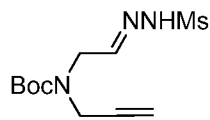
**13**

10

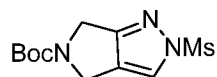
using hydrazine.

15. The process of making a compound of Formula 1 comprising reacting a compound of Formula 10 with a copper salt in the presence of a metal catalyst, a ligand, a base and an oxidant in solvent:

15

**10**

to produce the compound of Formula 1:

**1**

20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US15/40674

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61K 31/4162; A01N 43/56; C07D 487/04 (2015.01)

CPC - A61K 31/4162; C07D 231/00, 487/04

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): A61K 31/4162; A01N 43/56; C07D 487/04 (2015.01)

CPC: A61K 31/4162; C07D 231/00, 487/04 USPC: 544/140, 142; 546/26

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

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

PATSEER (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, Other Countries (INPADOC), RU, AT, CH, TH, BR, PH); ProQuest; Google Scholar; IP.com; SureChEMBL; KEYWORDS: dipeptidyl peptidase inhibit*, process*, prepar*, synthe*, 4 6 dihydropyrrolo 3 4 c pyrazole, methylsulfonyl, 2 5 difluorophenyl, tetrahydro 2H pyran 3 yl, butyloxycarbonyl, Boc, trifluoroacet*, TFA, reductive amination

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y — A	WO 2013/003250 A1 (MERCK SHARP & DOHME CORP., et al.) 03 January 2013; page 12, lines 1-15; page 18, lines 25-35; page 19, lines 10-24, 26-31	1, 6 — 2-5, 7
Y — A	WO 2014/018355 A1 (MERCK SHARP & DOHME CORP.) 30 January 2014; page 29, lines 10-12; page 30, lines 27-30; page 31, lines 1-8, 16-17; page 38, see Scheme 5, step 2; page 38, lines 15-19	1, 6 — 2-5, 7-12
A	WO 2014/061031 A1 (CADILA HEALTHCARE) 24 April 2014; page 21, lines 5-7; page 23, lines 13-20; page 31, lines 26-35; page 32, lines 1-22	2-5, 7-12
A	WO 2010/056708 A1 (MERCK SHARP & DOHME CORP.) 20 May 2010; page 38, see Scheme 1; page 39, lines 15-26; page 45, lines 10-19; page 47, lines 6-12	8-14
A	US 5,869,670 A (HONG, CY et al.) 09 February 1999; column 12, lines 31-48; column 17, lines 15-23	13-14
A	WO 2014/013076 A1 (EISAI R&D MANAGEMENT CO.) 23 January 2014; page 30, see compound 4k	15
A	US 8,431,564 B2 (TIMMERS, CM et al.) 30 April 2013; column 55, lines 1-5, see compound 10f	15

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

11 September 2015 (11.09.2015)

Date of mailing of the international search report

23 OCT 2015

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Shane Thomas

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774