PROCESS AND INTERMEDIATES FOR PREPARING INTEGRASE INHIBITORS

Priority of Invention

This application claims priority under 35 U.S.C. 119(e) from United States Provisional Patent Application Number 60/844,020 filed 12 September 2006, and from United States Provisional Patent Application Number 60/905,365 filed 07 March 2007.

Background of the Invention

International Patent Application Publication Number WO 2004/046115 provides certain 4-oxoquinolone compounds that are useful as HIV integrase inhibitors. The compounds are reported to be useful as anti-HIV agents.

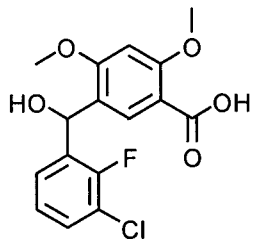
International Patent Application Publication Number WO 2005/113508 provides certain specific crystaline forms of one of these 4-oxoquinolone compounds, 6-(3-chloro-2-fluorobenzyl)-1-[(S)-1-hydroxymethyl-2-methylpropyl]-7-methoxy -4-oxo-1,4-dihydroquinolone-3-carboxylic acid. The specific crystalline forms are reported to have superior physical and chemical stability compared to other physical forms of the compound.

There is currently a need for improved methods for preparing the 4-oxoquinolone compounds reported in International Patent Application Publication Number WO 2004/046115 and in International Patent Application Publication Number WO 2005/113508. In particular, there is a need for new synthetic methods that are simpler or less expensive to carry out, that provide an increased yield, or that eliminate the use of toxic or costly reagents.

Summary of the Invention

The present invention provides new synthetic processes and synthetic intermediates that are useful for preparing the 4-oxoquinolone compounds reported in International Patent Application Publication Number WO 2004/046115 and in International Patent Application Publication Number WO 2005/113508.

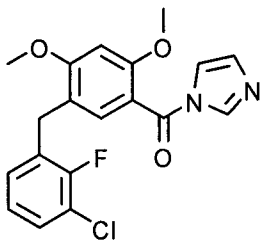
Accordingly, in one embodiment the invention provides a compound of formula **3**:



3

or a salt thereof.

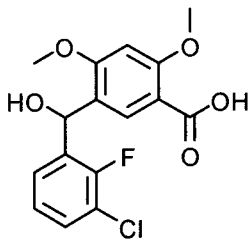
In another embodiment the invention provides a compound of formula **5a**:



5a

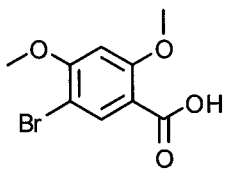
or a salt thereof.

In another embodiment the invention provides a method for preparing a compound of formula **3**:



3

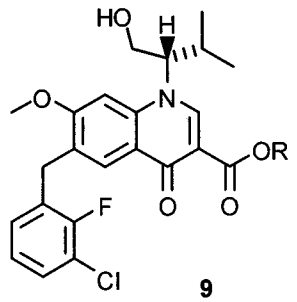
or a salt thereof comprising converting a corresponding compound of formula **2**:



2

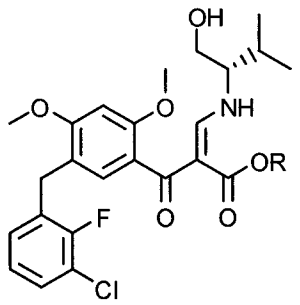
or a salt thereof to the compound of formula **3** or the salt thereof.

In another embodiment the invention provides a method for preparing a compound of formula **9**:



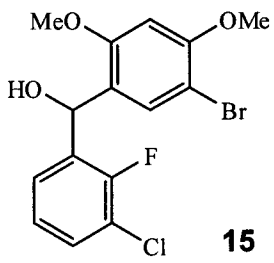
9

wherein R is C_1-C_6alkyl, comprising cyclizing a corresponding compound of formula **8**:



8

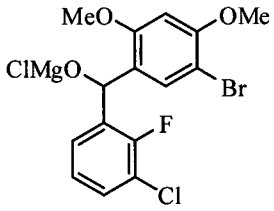
In another embodiment the invention provides a compound of formula **15**:



15

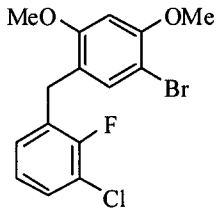
or a salt thereof.

In another embodiment the invention provides a compound of formula **15a**:



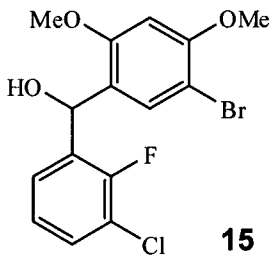
15a

In another embodiment the invention provides a compound of formula **16**:



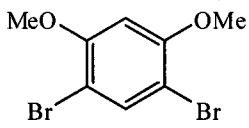
16

In another embodiment the invention provides a method for preparing a compound of formula **15**:



15

or a salt thereof comprising converting a corresponding compound of formula **14**:



14

to the compound of formula **15** or the salt thereof.

The invention also provides other synthetic processes and synthetic intermediates disclosed herein that are useful for preparing the 4-oxoquinone compounds.

Detailed Description

The following definitions are used, unless otherwise described: halo is fluoro, chloro, bromo, or iodo. Alkyl denotes both straight and branched groups, but reference to an individual radical such as propyl embraces only the straight chain radical, a branched chain isomer such as isopropyl being specifically referred to.

It will be appreciated by those skilled in the art that a compound having a chiral center may exist in and be isolated in optically active and racemic forms. Some compounds may exhibit polymorphism. It is to be understood that the present invention encompasses processes for preparing any racemic, optically-active, polymorphic, tautomeric, or stereoisomeric form, or mixtures thereof, of a compound described herein, it being well known in the art how to prepare optically active forms (for example, by resolution of the racemic form by recrystallization techniques, by synthesis from optically-active starting materials, by chiral synthesis, or by chromatographic separation using a chiral stationary phase).

Specific and preferred values listed below for radicals, substituents, and ranges, are for illustration only; they do not exclude other defined values or other values within defined ranges for the radicals and substituents.

Specifically, C_1-C_6alkyl can be methyl, ethyl, propyl, isopropyl, butyl, iso-butyl, sec-butyl, pentyl, 3-pentyl, or hexyl.

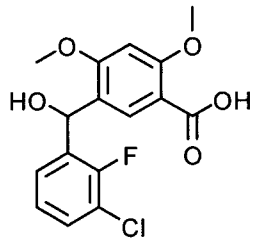
A specific value for R_a is methyl.

A specific value for R_b is methyl.

A specific value for R_c is 1-imidazolyl.

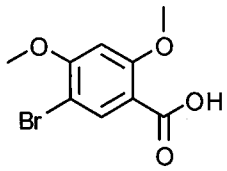
A specific value for R is ethyl.

In one embodiment, the invention provides a method for preparing a compound of formula **3**:



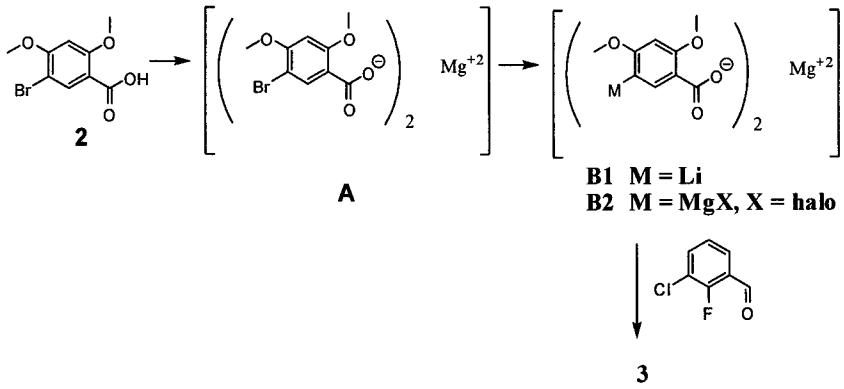
3

or a salt thereof comprising converting a corresponding compound of formula **2**:



2

or a salt thereof to the compound of formula **3** or the a salt thereof. As illustrated below, the reaction can conveniently be carried out by combining Compound **2** with a polar aprotic solvent (e.g., tetrahydrofuran) and cooling the mixture below room temperature (e.g., to about -20 °C).



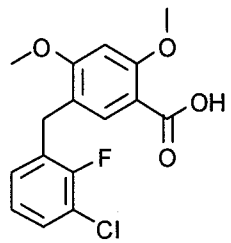
2 **A** **B1 M = Li** **B2 M = MgX, X = halo** **3**

This mixture can be treated with a first organometallic reagent (e.g., a dialkylmagnesium, dialkylzinc, an alkylmagnesium halide, a trialkylaluminum, or a metal hydride reagent) to form a carboxylate salt. For example, the mixture can be treated with about 0.5 equivalents of dibutylmagnesium or butylethylmagnesium, or about one equivalent of butylethylmagnesium-butanol adduct, to afford Compound **A**. The resulting mixture can be combined with a second organometallic reagent (e.g., an alkyllithium or alkylmagnesium halide) to

form an organometallic compound (Compound **B1** or **B2**). Typically, this is performed at a reduced temperature to affect metal/halogen exchange. For example, the resulting mixture can be combined with about 1.2-2.2 equivalents of an alkyl lithium (e.g., about 1.8 equivalents *n*-butyllithium or *tert*-butyllithium) at about -50 ± 50 °C to afford an organo-lithium compound (Compound **B1**). In one embodiment of the invention metal/halogen exchange reaction can be carried out at a temperature of about -20 ± 20 °C. The progress of the metal/halogen exchange reaction can be monitored by any suitable technique (e.g., by HPLC). Upon completion of the reaction, 3-chloro-2-fluorobenzaldehyde (about 1.3. equivalents) can be added. The progress of the addition reaction can be monitored by any suitable technique (e.g., by HPLC). Compound **3** can be isolated by any suitable technique (e.g., by chromatography or crystallization). This method avoids any contamination issues and the cost associated with the use of other reagents (e.g. transition metals such as palladium reagents).

In one embodiment of the invention the compound of formula **2** or a salt thereof is prepared by brominating 2,4-dimethoxybenzoic acid. The reaction can be carried out using standard bromination conditions.

In one embodiment of the invention a compound of formula **3** or a salt thereof is converted to a compound of formula **4**:

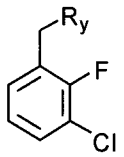


4

or a salt thereof. About 1 to 5 hydride equivalents of a silane reducing agent (e.g., phenyldimethylsilane, polymethylhydrosiloxane, or chlorodimethylsilane, or a trialkylsilane such as triethylsilane) are combined with a suitable acid (e.g., trifluoroacetic acid, triflic acid or acetic acid). The reaction can conveniently be carried out by using about 1.2 to 2.0 hydride equivalents of triethylsilane and about 5 to 10 equivalents of trifluoroacetic acid. To this mixture is added Compound **3** or a salt thereof. Compound **3** or a salt thereof can conveniently be added to the

mixture at a reduced temperature, for example, about 0 ± 10 °C. The progress of the reaction can be monitored by any suitable technique (e.g., by HPLC). Upon completion of the reaction, Compound **4** or a salt thereof can be isolated using any suitable technique (e.g., by chromatography or crystallization). Compound **4** or a salt thereof can also be prepared by adding trifluoroacetic acid to Compound **3** in a suitable solvent and then adding a silane reducing agent to provide Compound **4**.

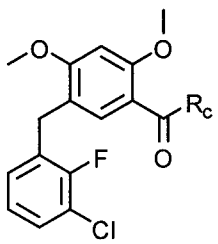
Alternatively, Compound **4** or a salt thereof can be prepared by forming a corresponding organometallic compound from Compound **2** and reacting the organometallic compound with Compound **11**:



11

wherein R_y is a suitable leaving group (e.g., a triflate, mesylate, tosylate, or brosylate, etc.).

In another embodiment of the invention the compound of formula **4** or a salt thereof is converted to a compound of formula **5'**:

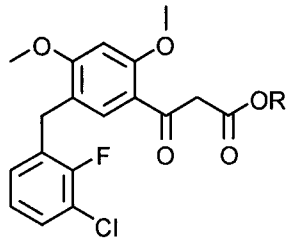


5'

or a salt thereof, wherein R_c is a leaving group. The carboxylic acid functional group of Compound **4** can be converted to an activated species, for example an acid chloride or an acyl imidazolide (Compound **5'**) by treatment with a suitable reagent, such as, for example, thionyl chloride, oxalyl chloride , cyanuric chloride or 1,1'-carbonyldiimidazole in a suitable solvent (e.g., toluene or tetrahydrofuran). Any suitable leaving group R_c can be incorporated into the molecule, provided the compound of formula **5'** can be subsequently converted to a compound of formula

6. The reaction can conveniently be carried out using about 1 equivalent of 1,1'-carbonyldiimidazole in tetrahydrofuran.

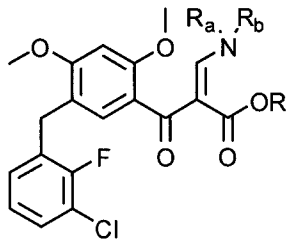
In another embodiment of the invention a compound of formula **5'** or a salt thereof can be converted to a compound of formula **6**:



6

or a salt thereof, wherein R is C_1-C_6alkyl. For example, a compound of formula **5'** can be combined with about 1 to 5 equivalents of a monoalkyl malonate salt and about 1 to 5 equivalents of a magnesium salt in a suitable solvent. Conveniently, a compound of formula **5'** can be combined with about 1.7 equivalents of potassium monoethyl malonate and about 1.5 equivalents of magnesium chloride. A suitable base, for example triethylamine or imidazole, can be added to the reaction. The reaction can conveniently be carried out at an elevated temperature (e.g., about 100 ± 50 °C) and monitored for completion by any suitable technique (e.g., by HPLC). Upon completion of the reaction, Compound **6** can be isolated using any suitable technique (e.g., by chromatography or crystallization).

In another embodiment of the invention the compound of formula **6** or a salt thereof, can be converted to a corresponding compound of formula **7**:



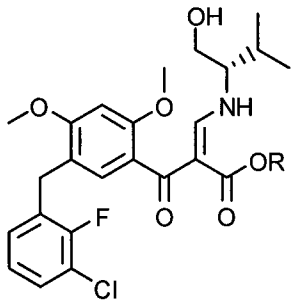
7

wherein R_a and R_b are each independently C_1-C_6alkyl; and R is C_1-C_6alkyl.

Compound **6** can be converted to an activated alkylidene analog, such as Compound **7**, by treatment with a formate group donor such as a dimethylformamide dialkyl acetal (e.g., dimethylformamide dimethyl acetal) or a trialkylorthoformate. The reaction can be carried out at elevated temperature

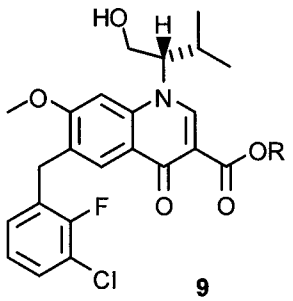
(e.g., about 100 ± 50 °C). This reaction may be accelerated by the addition of an acid catalyst, such as, for example, an alkanoic acid, a benzoic acid, a sulfonic acid or a mineral acid. About 500 ppm to 1 % acetic acid can conveniently be used. The progress of the reaction can be monitored by any suitable technique (e.g., by HPLC). Compound **7** can be isolated or it can be used directly to prepare a compound of formula **8** as described below.

In another embodiment of the invention the compound of formula **7** can be converted to a corresponding compound of formula **8**:



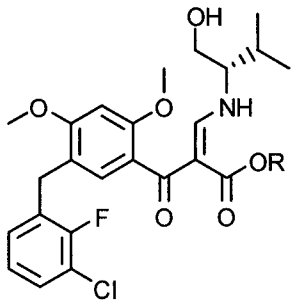
8

wherein R is C_1-C_6alkyl. Compound **7** can be combined with (*S*)-2-amino-3-methyl-1-butanol (*S*-Valinol, about 1.1 equivalents) to provide compound **8.** The progress of the reaction can be monitored by any suitable technique (e.g., by HPLC). The compound of formula **8** can be isolated or used directly to prepare a compound of formula **9** as described below. In another embodiment, the invention provides a method for preparing a compound of formula **9**:



9

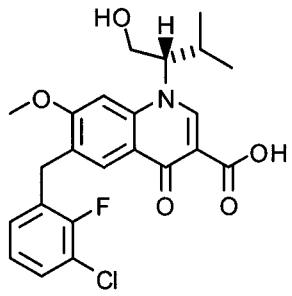
wherein R is C_1-C_6alkyl, comprising cyclizing a corresponding compound of formula **8**:



8

Compound **8** can be cyclized to provide Compound **9** by treatment with a silylating reagent (e.g., *N,O*-bis(trimethylsilyl)acetamide, *N,O*-bis(trimethylsilyl)trifluoroacetamide or hexamethyldisilazane). The reaction can be conducted in a polar aprotic solvent (e.g., dimethylformamide, dimethylacetamide, N-methylpyrrolidinone or acetonitrile). A salt (e.g., potassium chloride, lithium chloride, sodium chloride or magnesium chloride) can be added to accelerate the reaction. Typically, about 0.5 equivalents of a salt such as potassium chloride is added. The reaction may be conducted at elevated temperature (e.g., a temperature of about 100 ± 20 °C) if necessary to obtain a convenient reaction time. The progress of the reaction can be monitored by any suitable technique (e.g., by HPLC). During the workup, an acid can be used to hydrolyze any silyl ethers that form due to reaction of the silylating reagent with the alcohol moiety of compound **8**. Typical acids include mineral acids, sulfonic acids, or alkanoic acids. One specific acid that can be used is aqueous hydrochloric acid. Upon completion of the hydrolysis, Compound **9** can be isolated by any suitable method (e.g., by chromatography or by crystallization). In the above conversion, the silating reagent transiently protects the alcohol and is subsequently removed. This eliminates the need for separate protection and deprotection steps, thereby increasing the efficiency of the conversion.

In another embodiment of the invention the compound of formula **9** is converted to a compound of formula **10**:



10

Compound **9** can be converted to Compound **10** by treatment with a suitable base (e.g., potassium hydroxide, sodium hydroxide or lithium hydroxide). For example, about 1.3 equivalents of potassium hydroxide can conveniently be used. This reaction may be conducted in any suitable solvent, such as, for example, tetrahydrofuran, methanol, ethanol or isopropanol, or a mixture thereof. The solvent can also include water. A mixture of isopropanol and water can conveniently be used. The progress of the reaction can be monitored by any suitable technique (e.g., by HPLC). The initially formed carboxylate salt can be neutralized by treatment with an acid (e.g., hydrochloric acid or acetic acid). For example, about 1.5 equivalents of acetic acid can conveniently be used. Following neutralization, Compound **10** can be isolated using any suitable technique (e.g., by chromatography or crystallization).

In another embodiment of the invention the compound of formula **10** can be crystalized by adding a seed crystal to a solution that comprises the compound of formula **10.** International Patent Application Publication Number WO 2005/113508 provides certain specific crystaline forms of 6-(3-chloro-2-fluorobenzyl)-1-[(S)-1-hydroxymethyl-2-methylpropyl]-7-methoxy-4-oxo-1,4-dihydroquinolone-3-carboxylic acid. The entire contents of International Patent Application Publication Number WO 2005/113508 is incorporated herein by reference (in particular, see pages 12-62 therein). The specific crystaline forms are identified therein as Crystal Form II and Crystal Form III. Crystal form II has an X-ray powder diffraction pattern having characteristic diffraction peaks at diffraction angles 2θ(°) of 6.56, 13.20, 19.86, 20.84, 21.22, and 25.22 as measured by an X-ray powder diffractometer. Crystal form III has an X-ray powder diffraction pattern

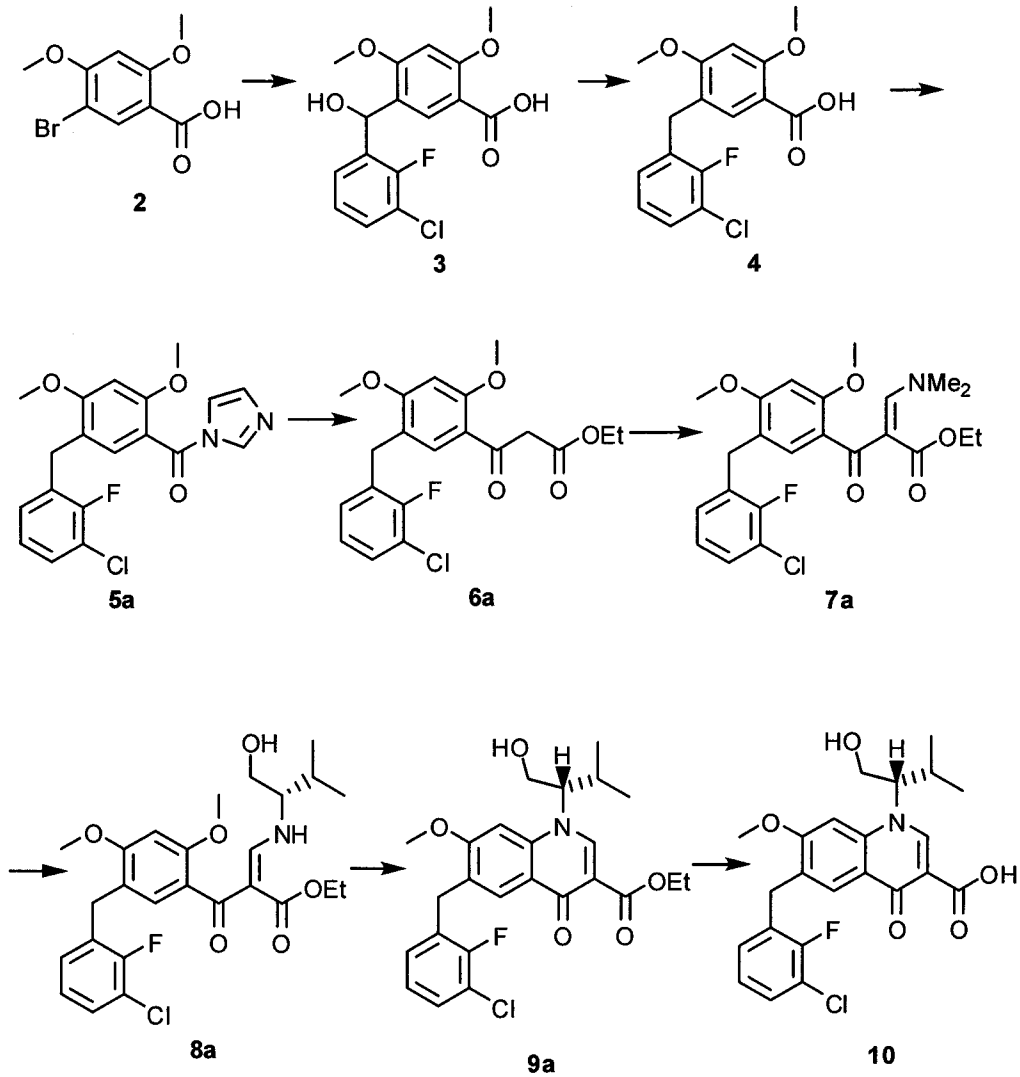
having characteristic diffraction peaks at diffraction angles 2θ(°) of 8.54, 14.02, 15.68, 17.06, 17.24, 24.16, and 25.74 as measured by an X-ray powder diffractometer. International Patent Application Publication Number WO 2005/113508 also describes how to prepare a crystaline form of 6-(3-chloro-2-fluorobenzyl)-1-[(S)-1-hydroxymethyl-2-methylpropyl]-7-methoxy-4-oxo-1,4-dihydroquinolone-3-carboxylic acid that have an extrapolated onset temperature of about 162.1 °C, as well as how to prepare a seed crystal having a purity of crystal of not less than about 70%. Accordingly, seed crystals of 6-(3-chloro-2-fluorobenzyl)-1-[(S)-1-hydroxymethyl-2-methylpropyl]-7-methoxy-4-oxo-1,4-dihydroquinolone-3-carboxylic acid can optionally be prepared as described in International Patent Application Publication Number WO 2005/113508. Advantageously, the process illustrated in Scheme I below provides a crude mixture of Compound **10** that can be directly crystallized to provide Crystal Form III without additional purification (e.g. without the prior formation of another polymorph such as Crystal Form II, or without some other form of prior purification), see Example 6 below.

In cases where compounds identified herein are sufficiently basic or acidic to form stable acid or base salts, the invention also provides salts of such compounds. Such salts may be useful as intermediates, for example, for purifying such compounds. Examples of useful salts include organic acid addition salts formed with acids, for example, tosylate, methanesulfonate, acetate, citrate, malonate, tartarate, succinate, benzoate, ascorbate, α-ketoglutarate, and α-glycerophosphate. Suitable inorganic salts may also be formed, including hydrochloride, sulfate, nitrate, bicarbonate, and carbonate salts.

Salts may be obtained using standard procedures well known in the art, for example by reacting a sufficiently basic compound such as an amine with a suitable acid affording an anion. Alkali metal (for example, sodium, potassium, or lithium) or alkaline earth metal (for example calcium or magnesium) salts of carboxylic acids, for example, can also be made.

The invention will now be illustrated by the following non-limiting Examples. An integrase inhibitor of formula **10** can be prepared as illustrated in the following Scheme 1.

SCHEME 1



Example 1: Preparation of Compound **3**

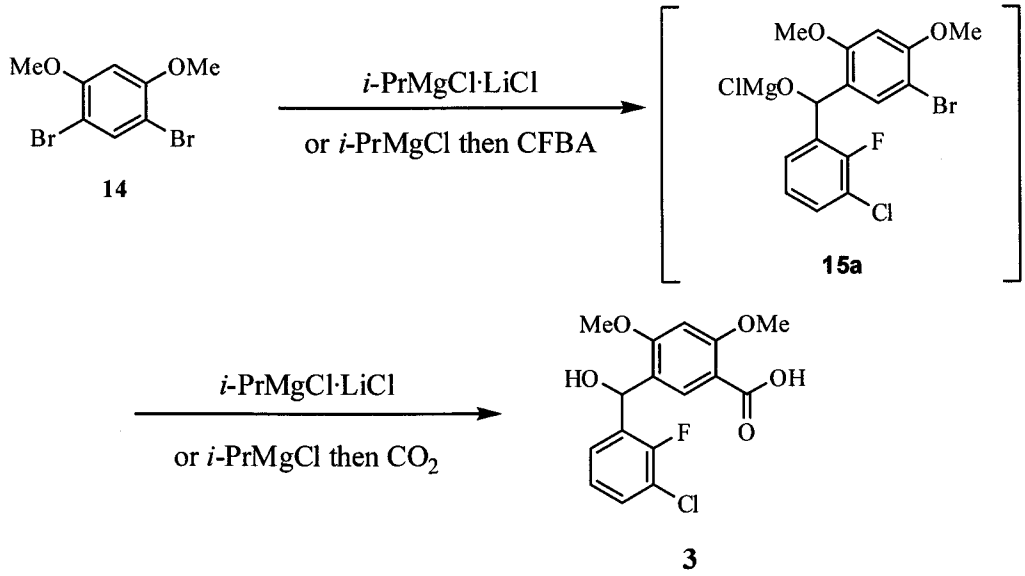
Compound **2** (10 g) was combined with 192 mL of THF and cooled to -20 °C. The mixture was treated successively with 21 mL of 1 M

dibutylmagnesium solution in heptane and 19.2 mL of 2.5 M *n*-butyllithium solution in hexane while maintaining the temperature at -20 °C. 3-Chloro-2-fluorobenzaldehyde (7.3 g) was added and the mixture allowed to warm to 0 °C. After 2 hours at that temperature the reaction was quenched by the addition of 55 mL of 2 M hydrochloric acid. The phases were separated and the organic phase was extracted with 92 mL of ethyl acetate. The combined organic layers were washed with 92 mL of saturated aqueous sodium chloride. The organic phase was concentrated and the product precipitated by the addition of 200 mL heptane. The slurry was filtered and the product air dried to yield Compound **3**: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 12.15 (br s, 1H), 7.81 (s, 1H), 7.42 (t, J = 7.2 Hz, 1H), 7.26 (t, J = 6.8 Hz, 1H), 7.15 (t, J = 7.8 Hz, 1H), 6.77 (s, 1H), 6.09 (d, J = 4.7 Hz, 1H), 5.90 (d, J = 4.9 Hz, 1H), 3.84 (s, 3H), 3.80 (s, 3H).

Alternatively, Compound **3** can be prepared as follows.

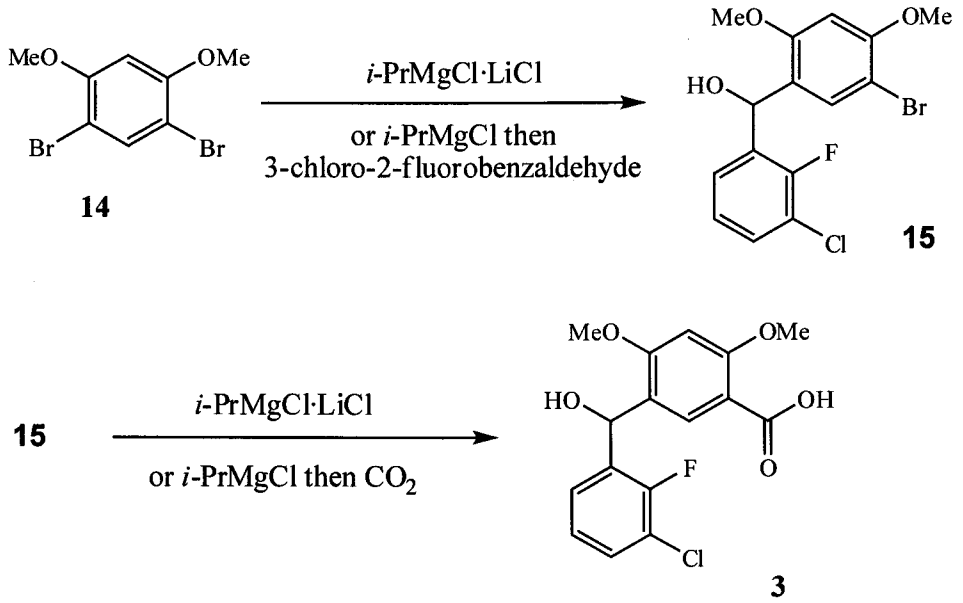
Compound **2** (20 g) was combined with 300 mL of THF and cooled to -20 °C. The mixture was treated successively with 75.93 g mL of butylethylmagnesium-butanol adduct (BEM-B) solution in heptane and 35.08 g of 28 wt% *t*-butyllithium solution in heptane while maintaining the temperature at -20 °C. 3-Chloro-2-fluorobenzaldehyde (15.80 g) was added and the mixture allowed to warm to 0 °C. After 2 hours at that temperature the reaction was quenched by the addition of 2M hydrochloric acid. The phases were separated and the organic phase was extracted with ethyl acetate. The organic phase was dried over sodium sulfate and the product was precipitated by the addition of MTBE. The slurry was filtered and the product air dried to yield Compound **3** (18.00 g; 69.1 % yield): ^{1}H NMR (DMSO-d_6, 400 MHz) δ 12.15 (br s, 1H), 7.81 (s, 1H), 7.42 (t, J = 7.2 Hz, 1H), 7.26 (t, J = 6.8 Hz, 1H), 7.15 (t, J = 7.8 Hz, 1H), 6.77 (s, 1H), 6.09 (d, J = 4.7 Hz, 1H), 5.90 (d, J = 4.9 Hz, 1H), 3.84 (s, 3H), 3.80 (s, 3H).

Compound **3** can also be prepared as illustrated in the following Scheme.



Compound **14** (10 g) was combined with 28 mL of THF and 9 mL of bisdimethylaminoethyl ether before being cooled to 0 °C. Isopropylmagnesium chloride (22.9 mL of a 2.07 M solution in THF) was added and the mixture was allowed to warm to room temperature overnight. Additional isopropylmagnesium chloride (5 mL) was added to improve conversion before 3-chloro-2-fluorobenzaldehyde (4.4 mL) was added. After stirring at ambient temperature for 2 hours 38.6 g of a 14 wt% THF solution of isopropylmagnesium chloride lithium chloride complex was added. After stirring overnight at ambient temperature CO_2 gas was bubbled into the reaction mixture. When conversion was complete the reaction was quenched to pH <3 with 2 M hydrochloric acid. The phases were separated and the organic phase was extracted with ethyl acetate. The combined organic layers were washed with saturated aqueous sodium chloride. The organic phase was concentrated and the product precipitated by the addition of MTBE. The slurry was filtered and the product air dried to yield Compound **3**: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 12.15 (br s, 1H), 7.81 (s, 1H), 7.42 (t, J = 7.2 Hz, 1H), 7.26 (t, J = 6.8 Hz, 1H), 7.15 (t, J = 7.8 Hz, 1H), 6.77 (s, 1H), 6.09 (d, J = 4.7 Hz, 1H), 5.90 (d, J = 4.9 Hz, 1H), 3.84 (s, 3H), 3.80 (s, 3H).

Compound **3** can also be prepared as illustrated in the following Scheme.



Example 2: Preparation of Compound **4**.

Triethylsilane (6.83 g) was added to trifluoroacetic acid (33.13 g) that had been pre-cooled in an ice bath. Compound **3** (10 g) was added to the mixture keeping the temperature below 15 °C. After stirring for 2 h MTBE was added to precipitate the product. The slurry was filtered and the product washed with additional MTBE. After drying, 9.12 g of Compound **4** was isolated: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 12.11 (br s, 1H), 7.47 (s, 1H), 7.42-7.38 (m, 1H), 7.14-7.08 (m, 2H), 6.67 (s, 1H), 3.87-3.84 (m, 8H).

Alternatively, Compound **4** can be prepared as follows.

Triethylsilane (7.50 g) was added to trifluoroacetic acid (49.02 g) that had been pre-cooled in an ice bath. Compound **3** (14.65 g) was added to the mixture keeping the temperature below 15 °C. After stirring for 1 h a solution of 17.63 g sodium acetate in 147 mL methanol was added. The mixture was heated to reflux for 3 hours then cooled to 0 °C. The slurry was filtered and the product washed with additional methanol. After drying 12.3 g of Compound **4** (89.7 % yield) was isolated: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 12.11 (br s, 1H), 7.47 (s, 1H),

7.42-7.38 (m, 1H), 7.14-7.08 (m, 2H), 6.67 (s, 1H), 3.87-3.84 (m, 8H).

Example 3: Preparation of Compound **5a.**

Imidazole (0.42 g) and 1,1'-carbonyldiimidazole (5.49 g) were slurried in 30 mL of THF at ambient temperature. Compound **4** (10 g) was added in one portion and the mixture was stirred at ambient temperature until the reaction was complete by HPLC. The resulting slurry was filtered and the solids washed with MTBE. The solids were dried to yield Compound **5a**: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 7.99 (s, 1H), 7.52 (s, 1H), 7.41-7.38 (m, 1H), 7.30 (s, 1H), 7.12-7.08 (m, 2H), 7.04 (s, 1H), 6.81 (s, 1H), 3.91 (s, 2H), 3.90 (s, 3H), 3.79 (s, 3H).

Example 4: Preparation of Compound **6a**.

Imidazole (0.42 g) and 1,1'-carbonyldiimidazole (5.49 g) were slurried in 30 mL of THF at ambient temperature. Compound **5a** (10 g) was added in one portion and the mixture was stirred at ambient temperature for 4 hours to form a slurry of compound **5a**. In a separate flask, 8.91 g of potassium monoethyl malonate was slurried in 40 mL of THF. Magnesium chloride (4.40 g) was added and the resulting slurry was warmed to 55 °C for 90 minutes. The slurry of Compound **5a** was transferred to the magnesium chloride/potassium monoethyl malonate mixture and stirred at 55 °C overnight. The mixture was then cooled to room temperature and quenched by the dropwise addition of 80 mL of 28 wt% aqueous H_3PO_4. The phases were separated and the organic phase was washed successively with aqueous $NaHSO_4$, $KHCO_3$ and NaCl solutions. The organic phase was concentrated to an oil and then coevaporated with ethanol. The resulting solid was dissolved in 30 mL ethanol and 6 mL water. Compound **6a** was crystalized by cooling. The solid was isolated by filtation and the product was washed with aqueous ethanol. After drying Compound **6a** was obtained: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 7.51 (s, 1H), 7.42-7.38 (m, 1H), 7.12-7.10 (m, 2H), 6.70 (s, 1H), 4.06 (q, J = 7.0 Hz, 2H), 3.89 (s, 8H), 3.81 (s, 2H), 1.15 (t, J = 7.0 Hz, 3H).

Alternatively, Compound **6a** can be prepared as follows.

Carbonyldiimidazole (10.99 g) was slurried in 60 mL of THF at ambient temperature. Compound **4** (20 g) was added in one portion and the mixture was stirred at ambient temperature for 30 min to form a slurry of compound **5a**. In a separate flask 15.72 g of potassium monoethyl malonate was slurried in 100 mL of THF. Magnesium chloride (6.45 g) was added and the resulting slurry was warmed to 55 °C for 5 hours. The slurry of Compound **5a** was transferred to the magnesium chloride/potassium monoethyl malonate mixture and stirred at 55 °C overnight. The mixture was then cooled to room temperature and quenched onto 120 mL of 28 wt% aqueous H_3PO_4. The phases were separated and the organic phase was washed successively with aqueous $KHCO_3$ and NaCl solutions. The organic phase was concentrated to an oil and then coevaporated with ethanol. The resulting solid was dissolved in 100 mL ethanol and 12 mL water. Compound **6a** was crystallized by cooling. The solid was isolated by filtation and the product was washed with aqueous ethanol. After drying 21.74 g Compound **6a** (89 % yield) was obtained: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 7.51 (s, 1H), 7.42-7.38 (m, 1H), 7.12-7.10 (m, 2H), 6.70 (s, 1H), 4.06 (q, J = 7.0 Hz, 2H), 3.89 (s, 8H), 3.81 (s, 2H), 1.15 (t, J = 7.0 Hz, 3H).

Example 5: Preparation of Compound **9a**.

Compound **6a** (20 g) was stirred with 6.6 g dimethylformamide dimethyl acetal, 66 g toluene and 0.08 g glacial acetic acid. The mixture was warmed to 90 °C for 4 hours. The mixture was then cooled to ambient temperature and 5.8 g (S)-2-amino-3-methyl-1-butanol was added. The mixture was stirred at ambient temperature for 1 hour before being concentrated to a thick oil. Dimethylformamide (36 g), potassium chloride (1.8 g) and bis(trimethylsilyl)acetamide (29.6 g) were added and the mixture was warmed to 90 °C for 1 h. The mixture was cooled to room temperature and diluted with 200 g dichloromethane. Dilute hydrochloride acid (44 g , about 1N) was added and the mixture stirred at ambient temperature for 20 min. The phases were separated and the organic phase was washed successively with water, aqueous sodium

bicarbonate and water. The solvent was exchanged to acetonitrile and the volume was adjusted to 160 mL. The mixture was heated to clarity, cooled slightly, seeded and cooled to crystallize Compound **9a**. The product was isolated by filtration and washed with additional cold acetonitrile. Vacuum drying afforded Compound **9a**: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 8.61 (s, 1H), 7.86 (s, 1H), 7.45 (t, J = 7.4 Hz, 1H), 7.26 (s, 1H), 7.23-7.14 (m, 2H), 5.10 (br s, 1H), 4.62 (br s, 1H), 4.18 (q, J = 7.0 Hz, 2H), 4.03 (s, 2H), 3.96 (s, 3H), 3.92-3.84 (m, 1H), 3.78-3.75 (m, 1H), 2.28 (br s, 1H), 1.24 (t, J = 7.0 Hz, 3H), 1.12 (d, J = 6.4 Hz, 3H), 0.72 (d, J = 6.4 Hz, 3H).

Alternatively, Compound **9a** can be prepared as follows.

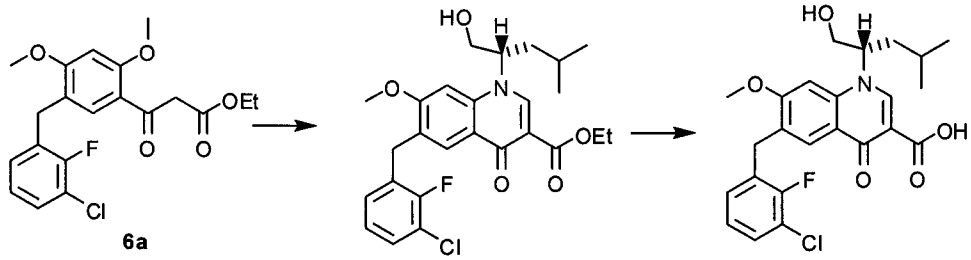
Compound **6a** (50 g) was stirred with 17.5 g dimethylformamide dimethyl acetal, 90 g DMF and 0.2 g glacial acetic acid. The mixture was warmed to 65 °C for 3 hours. The mixture was then cooled to ambient temperature and 14.5 g (S)-2-amino-3-methyl-1-butanol and 25 g toluene were added. The mixture was stirred at ambient temperature overnight before being concentrated by distillation. Potassium chloride (4.5 g) and bis(trimethylsilyl)acetamide (80.2 g) were added and the mixture was warmed to 90 °C for 2 h. The mixture was cooled to room temperature and diluted with 250 g dichloromethane. Dilute hydrochloride acid (110 g of ~1N) was added and the mixture stirred at ambient temperature for 30 min. The phases were separated and the organic phase was washed successively with water, aqueous sodium bicarbonate and water. The solvent was exchanged to acetonitrile by distillation. The mixture was heated to clarity, cooled slightly, seeded and cooled to crystallize Compound **9a**. The product was isolated by filtration and washed with additional cold acetonitrile. Vacuum drying afforded 48.7 g (81 % yield) of Compound **9a**: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 8.61 (s, 1H), 7.86 (s, 1H), 7.45 (t, J = 7.4 Hz, 1H), 7.26 (s, 1H), 7.23-7.14 (m, 2H), 5.10 (br s, 1H), 4.62 (br s, 1H), 4.18 (q, J = 7.0 Hz, 2H), 4.03 (s, 2H), 3.96 (s, 3H), 3.92-3.84 (m, 1H), 3.78-3.75 (m, 1H), 2.28 (br s, 1H), 1.24 (t, J = 7.0 Hz, 3H), 1.12 (d, J = 6.4 Hz, 3H), 0.72 (d, J = 6.4 Hz, 3H).

Example 6: Preparation of Compound **10**.

Compound **9a** (6.02 g) was slurried in 36 mL isopropanol and 24 mL of water. Aqueous potassium hydroxide (2.04 g of 45 wt % solution) was added and the mixture warmed to 40 °C. After 3 hours 1.13 g glacial acetic acid was added the mixture seeded with 10 mg of Compound **10**. The mixture was cooled in an ice bath for 2 hours and the solid was isolated by filtration. The cake was washed with aqueous isopropanol and dried to give Compound **10**: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 15.42 (s, 1H), 8.87 (s, 1H), 8.02 (s, 1H), 7.48-7.45 (m, 2H), 7.23 (t, J = 6.8 Hz, 1H), 7.17 (t, J = 7.8 Hz, 1H), 5.18 (br s, 1H), 4.86 (br s, 1H), 4.10 (s, 2H), 4.02 (s, 3H), 3.97-3.96 (m, 1H), 3.79-3.76 (m, 1H), 2.36 (br s, 1H), 1.14 (d, J = 6.3 Hz, 3H), 0.71 (d, J = 6.3 Hz, 3H).

Example 7: Preparation of Compound **13**.

The conversion of Compound **7a** to Compound **9a** described in Example 5 above produced a second product that was believed to result from the presence of (S)-2-amino-4-methyl-1-pentanol in the (S)-2-amino-3-methyl-1-butanol reagent. As illustrated below, an independent synthesis of Compound **13** was carried out to confirm the identity of the second product.



6a **12** **13**

Compound **13** was prepared from Compound **12** using a procedure analogous to the preparation of Compound **10** in Example 6 above. Following the workup described, the product was extracted into anisole. The desired product was isolated as a foam after removal of the solvent: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 8.80 (s, 1H), 8.02 (s, 1H), 7.48-7.44 (m, 2H), 7.23 (t, J = 7.2 Hz, 1H), 7.16 (t, J = 7.6 Hz, 1H), 5.19 (br s, 1H), 4.09 (s, 2H), 4.00 (s, 3H), 3.77 (br s, 2H),

1.94-1.87 (m, 1H), 1.82-1.75 (m, 1H), 1.43 (hept, J = 6.4 Hz, 1H), 0.89 (d, J = 6.4 Hz, 3H), 0.85 (d, J = 6.8 Hz, 3H).

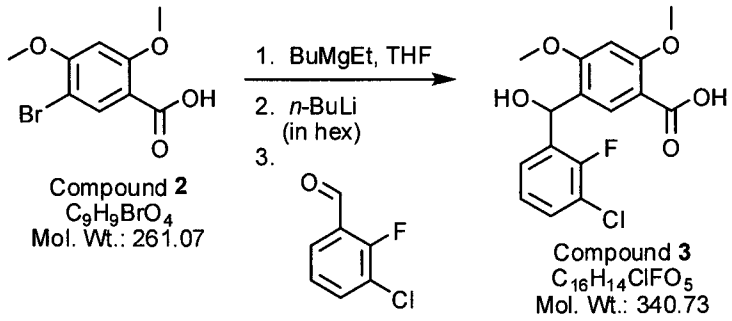
The intermediate Compound **12** was prepared as follows.

a. Compound **12** was prepared from Compound **6a** using a procedure analogous to the preparation of Compound **9a**, except (S)-(+)-2-amino-4-methyl-1-pentanol was used in place of (S)-2-amino-3-methyl-1-butanol. The desired product was isolated as a foam after concentrating the final acetonitrile solution to dryness: ^{1}H NMR (DMSO-d_6, 400 MHz) δ 8.54 (s, 1H), 7.86 (s, 1H), 7.46-7.43 (m, 1H), 7.25 (s, 1H), 7.22-7.14 (m, 2H), 4.97 (br s, 1H), 4.20-4.16 (m, 2H), 4.03 (s, 2H), 3.95 (s, 3H), 3.73 (br s, 2H), 1.83-1.82 (m, 1H), 1.72-1.69 (m, 1H), 1.43 (hept, J = 6.4 Hz, 1H), 1.24 (t, J = 7.2 Hz, 3H), 0.88 (d, J = 6.4 Hz, 3H), 0.84 (d, J = 6.4 Hz, 3H).

Compound **13** is useful as an HIV integrase inhibitor as described in International Patent Application Publication Number WO 2004/046115. Accordingly, the invention also provides Compound **13** or a salt thereof, as well as methods for preparing Compound **13** or a salt thereof. The invention also provides a composition comprising Compound **10** or a salt thereof and Compound **13** or a salt thereof, as well as a compositions comprising Compound **9a** or a salt thereof and Compound **12** or a salt thereof. Such compositions are useful for preparing integrase inhibitors described in International Patent Application Publication Number WO 2004/046115.

Alternatively, Compound **10** can be prepared from Compound **2** as described in the following illustrative Examples 8-12 that are based on 1 kg of starting material.

Example 8. Preparation of a Compound of Formula **3**.



Compound **2**
$C_9H_9BrO_4$
Mol. Wt.: 261.07

Compound **3**
$C_{16}H_{14}ClFO_5$
Mol. Wt.: 340.73

Compound **2** is combined with anhydrous tetrahydrofuran and warmed to form a solution or thin slurry. The mixture is cooled to -20 to -30 °C and butylethylmagnesium in heptane is added. In a separate reactor *n*-butyllithium in hexane is combined with cold (-20 to -30 °C) tetrahydrofuran. The compound **2**/butylethylmangesium slurry is transferred to the *n*-butyllithium solution while keeping the mixture at -20 to -30 °C. The lithium/halogen exchange reaction is monitored for completion by HPLC. Once complete, a solution of 3-chloro-2-fluorobenzaldehyde in tetrahydrofuran is added. After 1 hour the mixture is warmed to 0 °C and monitored by HPLC for reaction completion. Once complete, the reaction is quenched with aqueous hydrochloric acid to pH 1 to 3. The phases are separated and the aqueous phase is extracted twice with ethyl acetate. The combined organic phases are dried with sodium sulfate at 18 to 25 °C. After removing the sodium sulfate by filtration the solvent is exchanged to MTBE and the resulting slurry cooled to 0 °C. The product is isolated by filtration, washed with cold MTBE and dried at NMT 40 °C to yield Compound **3**.

Material	M.W.	Wt. Ratio	Mole Ratio
Compound **2**	261.07	1.00	1.00
THF	72.11	11.4	
BuEtMg (15% w/w in heptane)	110.48	~1.8	0.55-0.6
n-BuLi (in hexane)	64.06	~1.9	1.8
Aldehyde	158.56	0.79	1.3
2M HCl	36.5	3.8	
37% HCl	36.5	0.33	
EtOAc	88.11	4.6	
Na_2SO_4	142.04	2	
MTBE	88.15	9.5	

1. Charge 1.00 kg Compound **2** and 8.7 kg THF to the reactor (1).
2. Heat the mixture to 45-50 °C to dissolve all solids or until a thin, uniform slurry is formed with no heavy solids resting on the bottom of the reactor.
3. Cool the contents of the reactor (1) to -20 to -30 °C.
4. Charge BuEtMg (15% w/w in heptane) (~1.8 kg; 0.6 eq.) to reactor (1) maintaining the temperature of the reaction mixture below -20 °C during the addition.
5. In a separate reactor (2) charge 2.6 kg THF and cool to -20 to -30 °C.
6. To reactor (2) charge *n*-BuLi (in hexane) (1.9 kg, 1.8 eq.) maintaining the temperature below -20 °C during the addition.
7. Transfer the contents of reactor (1) to reactor (2) maintaining the temperature below -20 °C during the addition.
8. To reactor (3) charge 0.5 kg of THF and cool to -20 to -30 °C.
9. Transfer contents of reactor (3) to reactor (1) then on to reactor (2) as a wash forward.
10. Approximately 15 minutes after the reactor contents have been combined, sample the reaction mixture and analyze by HPLC to determine completion of lithium/halogen exchange. (Typically there is 1–8 % of Compound **2** remaining. If the amount of Compound **2** is greater than 8 % sample the reaction again after at least 30 min. before charging additional *n*-BuLi).
11. In an appropriate container combine 0.79 kg of aldehyde and 0.79 kg THF.

12. Charge contents of the container to the reactor. Maintain the temperature of the reaction mixture below -20 °C during addition.

13. Agitate the reaction mixture at -20 °C for 1 h then warm to 0 °C.

14. Quench the reaction mixture by adjusting the pH with 2 M HCl (~3.8 kg) to a pH of 1 to 3.

15. Separate the phases.

16. Extract the aqueous phase with 2.3 kg EtOAc.

17. Extract the aqueous phase with 2.3 kg EtOAc.

18. Discard the aqueous phase.

19. Combine organic phases and dry with 2 kg of Na_2SO_4 for at least 1 h. The temperature of the organic phase should be 20 – 25 °C before Na_2SO_4 addition.

20. Filter the slurry to remove Na_2SO_4.

21. Concentrate the combined organic phases by vacuum distillation to ~1.5 L (should form a thick slurry).

22. Charge 2.8 kg methyl *t*-butyl ether (MTBE) to the slurry.

23. Concentrate the mixture to ~1.5 L.

24. Charge 2.8 kg MTBE to the slurry.

25. Concentrate the mixture to ~1.5 L.

26. Charge 1.9 kg MTBE to the slurry.

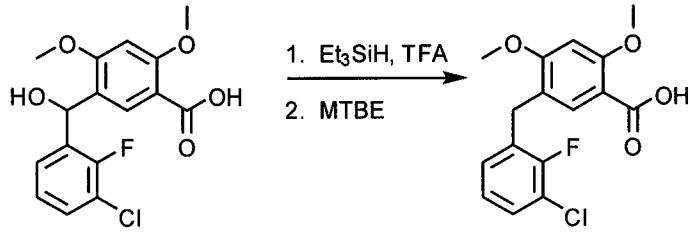
27. Cool the slurry to ~0 °C and isolate Compound **3** by filtration.

28. Wash forward the distillation vessel with 1.9 kg MTBE pre-cooled to ~0 °C.

29. Deliquor the cake until a granular solid is obtained. The purity of Compound **3** can be improved if necessary by reslurry in 6 volumes of 85:15 toluene:HOAc.

30. Dry the wet cake under vacuum at < 40 °C.

Example 9. Preparation of a Compound of Formula **4**.



Compound **3**
$C_{16}H_{14}ClFO_5$
Mol. Wt.: 340.73

Compound **4**
$C_{16}H_{14}ClFO_4$
Mol. Wt.: 324.73

Compound **3** is combined with trifluoroacetic acid and stirred to form a solution. The solution is cooled to -3 to 3 °C and triethylsilane is added while maintaining the temperature at NMT 15 °C. The reaction is monitored for completion by HPLC. Once complete, MTBE is added to precipitate Compound **4** and the mixture is cooled to 0 °C. The product is isolated by filtration, washed with MTBE and dried at NMT 60 °C to yield Compound **4**.

Material	M.W.	Wt. Ratio	Mole Ratio
Compound **3**	340.73	1.00	1.00
MTBE	88.15	5.6	
TFA	114.02	1.7	5
Et_3SiH	116.28	0.4	1.2

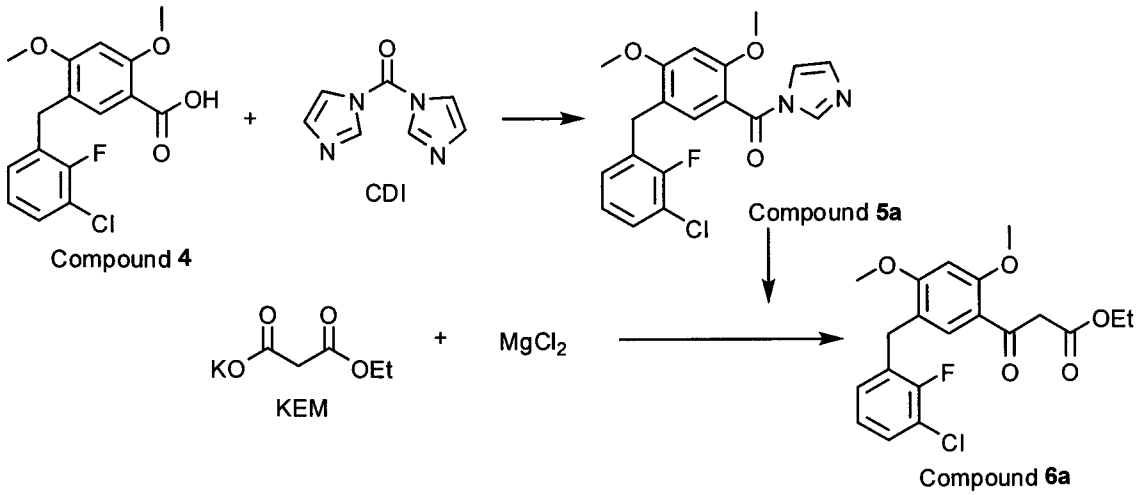
1. Dissolve 1.00 kg Compound **3** in1.7 kg TFA.
2. Cool the reaction mixture to -3 to 3 °C.
3. Charge 0.4 kg triethylsilane to the reaction mixture. Maintain the temperature of the reaction mixture less than 15 °C during this addition.
4. Sample the reaction mixture 30 minutes after the addition of the triethylsilane and analyze by HPLC to verify the complete conversion of Compound **3** to Compound **4**.
5. Charge 4.0 kg MTBE to the reaction mixture maintaining the temperature of the mixture below 15 °C during addition.
6. Cool the mixture to 0 °C and agitate for at least 30 min.

7. Isolate Compound **4** by filtration and wash the reaction vessel forward with 1.6 kg MTBE.

8. Dry the Compound **4** obtained under vacuum at < 60 °C.

Note: The purity of Compound **4** may be improved by reslurry in 4 volumes of acetone. The slurry is warmed to 40 °C for 2 hours and cooled to 18 to 25 °C for 12 hours before filtration and washing with two 1 volume portions of acetone.

Example 10. Preparation of a Compound of Formula **6a**.



Carbonyldiimidazole and imidazole are combined with anhydrous tetrahydrofuran. Compound **4** is added to this mixture to form Compound **5a** and the reaction is monitored by HPLC. In a separate reactor potassium monoethylmalonate is combined with tetrahydrofuran before anhydrous magnesium chloride is added while maintaining the temperature NMT 30 °C. The resulting slurry is warmed to 50 °C and held for at least two hours before the Compound **5a** mixture is added. The reaction is monitored by HPLC. Once the formation of Compound **5a** is complete, the mixture is cooled to 18 to 25 °C and added to aqueous phosphoric acid to quench. The organic phase is washed with aqueous sodium bisulfate, brine, potassium bicarbonate and brine solutions before being polish filtered. The solvent is exchanged for anhydrous ethanol. Water is added and the mixture is warmed to dissolve solids, cooled to about 40 °C, seeded with Compound **6a** and cooled to 0 to 5 °C. The product is filtered, washed with cold aqueous ethanol and dried at NMT 40 °C to yield Compound **6a**.

Material	M.W.	Wt. Ratio	Mole Ratio
Compound **4**	324.73	1.000	1.00
THF	72.11	7.11	
Imidazole	68.08	0.042	0.20
CDI	162.15	0.55	1.10
KEM	170.2	0.89	1.70
$MgCl_2$	95.21	0.44	1.50
H_3PO_4 (85 wt%)	98.00	2.3	
$NaHSO_4$	120.06	0.24	
$KHCO_3$	100.12	0.50	
NaCl	58.44	0.48	
SDA 2B-2 EtOH (0.5% heptane)	46.07	~10 kg	

Procedure:

1. Charge 0.55 kg CDI and 0.042 kg imidazole to reactor 1.
2. Charge 2.67 kg THF to reactor 1 and agitate to form a slurry.
3. Charge 1.00 kg Compound **4** to reactor 1 in portions to moderate the CO_2 offgas. This addition is endothermic
4. Charge 0.89 kg KEM to reactor 2.
5. Charge 4.45 kg THF to reactor 2 and agitate to form a slurry.
6. Charge 0.44 kg $MgCl_2$ to reactor 2 (can be added in portions to moderate exotherm).
7. Warm the contents of reactor 2 to 50 °C and agitate at that temperature for at least two hours.
8. Transfer the contents of reactor 1 to reactor 2. Mixture will become thick temporarily if transferred very rapidly.
9. Agitate the contents of reactor 2 for at least 12 hours at 50 °C.
10. Cool the slurry to ambient temperature.
11. Quench the reaction by transferring the reaction mixture onto 7.0 kg of 28 wt% aqueous H_3PO_4 (2.3 kg 85 wt% H_3PO_4 dissolved in 4.7 kg H_2O). This addition is exothermic. Final pH of aqueous layer should be 1-2.
12. Wash the organic (top) phase with 1.2 kg of 20 wt% aqueous $NaHSO_4$ (0.24 kg of $NaHSO_4$ dissolved in 0.96 kg H_2O). Final pH of aqueous layer should be 1-2.

13. Wash the organic (top) phase with 1.2 kg of 20 wt% aqueous NaCl (0.24 kg of NaCl dissolved in 0.96 kg H_2O)

14. Wash the organic (top) phase with 5.0 kg of 10 wt% aqueous $KHCO_3$ (0.50 kg of $KHCO_3$ dissolved in 4.5 kg H_2O). Final pH of aqueous layer should be 8-10.

15. Wash the organic (top) phase with 1.2 kg of 20 wt% aqueous NaCl (0.24 kg of NaCl dissolved in 0.96 kg H_2O). Final pH of aqueous layer should be 7-9.

16. Concentrate the organic phase and exchange the solvent to EtOH.

17. Adjust the concentration to ~3.5 L/kginput.

18. Charge 0.6 volumes of water.

19. Warm 70 – 80 °C to form a clear solution.

20. Cool to 40 °C and seed with 0.1 wt% Compound **6**.

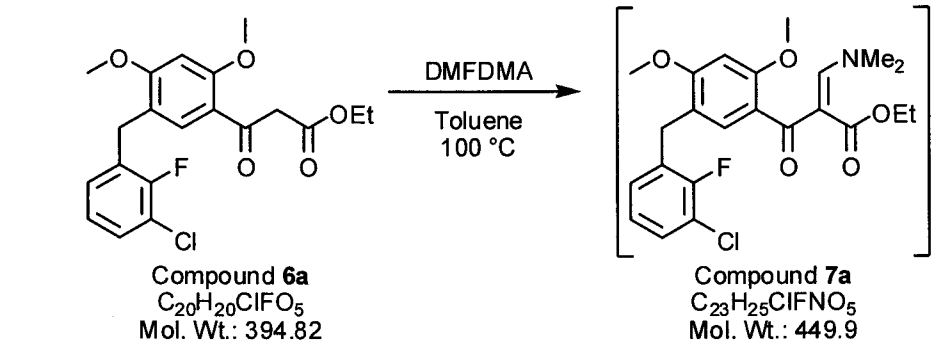
21. Cool slowly to 5 °C.

22. Hold for at least 2 hours.

23. Filter and wash the cake with two 1.35 kg volume portions of 50:50 EtOH:H_2O (1.2 kg EtOH combined with 1.5 kg H_2O).

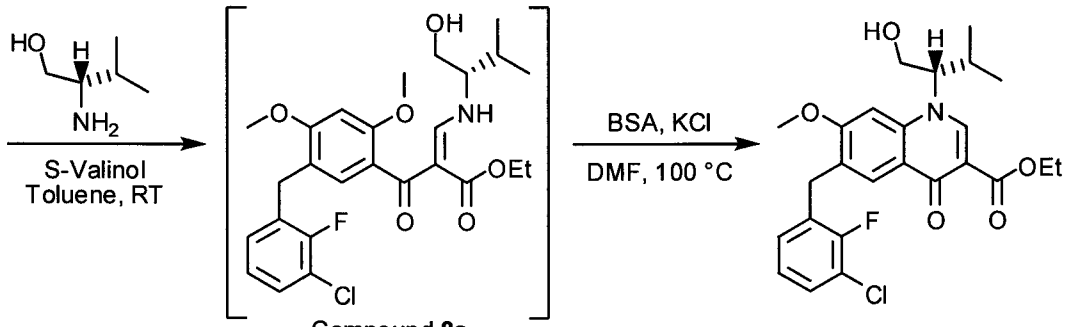
24. Dry the cake at less than 50 °C.

Example 11. Preparation of a Compound of Formula **9a**.



Compound **6a**
$C_{20}H_{20}ClFO_5$
Mol. Wt.: 394.82

Compound **7a**
$C_{23}H_{25}ClFNO_5$
Mol. Wt.: 449.9



Compound **8a**
$C_{26}H_{31}ClFNO_6$
Mol. Wt.: 507.98

Compound **9a**
$C_{25}H_{27}ClFNO_5$
Mol. Wt.: 475.94

Compound **6a** is combined with toluene, *N,N*-dimethylformamide dimethyl acetal and glacial acetic acid before being warmed to 100 °C. The reaction is monitored by HPLC. Once the formation of Compound **7a** is complete the mixture is cooled to 18 to 25 °C before (*S*)-(+)-valinol is added. The reaction is monitored by HPLC. Once the formation of Compound **8a** is complete the mixture is concentrated. The residue is combined with dimethylformamide, potassium chloride and *N,O*-bistrimethylsilyl acetamide and warmed to 100 °C. The reaction is monitored by HPLC. Once complete the mixture is cooled and dichloromethane is added. Aqueous hydrochloric acid is added to desilylate Compound **9a**. This reaction is monitored by TLC. Once complete the organic phase is washed with water, aqueous sodium bicarbonate and water. The solvent is exchanged for acetonitrile and the mixture warmed. The mixture is seeded and

cooled to crystallize Compound **9a**. The product is filtered, washed with cold acetonitrile and dried at NMT 40 °C to yield Compound **9a**.

Material	M.W.	Wt. Ratio	Mole Ratio
Compound **6a**	394.82	1.00	1.00
Toluene	92.14	4.3	
Glacial acetic acid	60.05	0.001	0.007
N,N-dimethylformamide dimethyl acetal	119.16	0.33	1.1
(S)-(+)-Valinol	103.16	0.29	1.1
DMF	73.10	1.8	
KCl	74.55	0.09	0.5
N,O-bis(trimethylsilyl)acetamide	203.43	1.13	2.2
1 N HCl	36.5	2.0	
DCM	84.93	10	
Water	18.02	8	
5% Aq. $NaHCO_3$	84.01	4	
CAN	41.05	QS	
Compound **9a** seeds	475.94	0.005	

1. Charge Reactor 1 with 1.00 kg Compound **6a**.
2. Charge 0.33 kg *N,N*-dimethylformamide dimethyl acetal (1.1 eq), 0.001 kg glacial acetic acid and 3.3 kg toluene to Reactor 1.
3. Warm the mixture to ~100 °C (note that some MeOH may distill during this operation).
4. After 1 h the reaction should be complete by HPLC (~2 % Compound **6a** apparently remaining)[1].
5. Cool the mixture in Reactor 1 to 18 – 25 °C.
6. Charge 0.29 kg (S)-(+)-Valinol (1.1 eq) dissolved in 1.0 kg toluene to Reactor 1 and continue agitation at ambient temperature.
7. After 1 h the reaction should be complete by HPLC (<1 % Compound **6a**).
8. Concentrate the contents of Reactor1 to ~2 L/kg.
9. Charge 1.8 kg DMF, 0.09 kg potassium chloride (0.5 eq,) and 1.13 kg *N,O*-bistrimethylsilyl acetamide (2.2 eq.) to Reactor 1.
10. Warm the mixture in Reactor 1 to ~100 °C.
11. Reaction should be complete in ~1 h (~5% Compound **8a** remaining).

12. Cool the contents of Reactor 1 to 18 – 25 °C.

13. Charge 10 kg DCM to Reactor 1.

14. Charge 2.0 kg 1 N aqueous HCl to Reactor 1 over ~15 min, maintaining the temperature of the mixture < 35 °C.

15. Agitate the mixture for at least 10 min to desilylate Compound **8a**. Monitor the progress of desilylation by TLC.[2]

16. Separate the phases.

17. Wash the organic phase with 4.0 kg water.

18. Wash the organic phase with 4.0 kg 5% aqueous sodium bicarbonate.

19. Wash the organic phase with 4.0 kg water.

20. Concentrate the organic phase by distillation to ~1.5 L/kg Compound **6a**.

21. Solvent exchange to ACN by distillation until a slurry is formed. Adjust the final volume to ~8 L/kg Compound **6a**.

22. Heat the mixture to reflux to redissolve the solid.

23. Cool the solution to 75 °C and charge Compound **9a** seeds.

24. Cool the mixture to 0 °C over at least 2 h and hold at that temperature for at least 1 h.

25. Isolate Compound **9a** by filtration and wash the wet cake with 1.6 kg cold ACN.

26. Dry the wet cake at < 40 °C under vacuum.

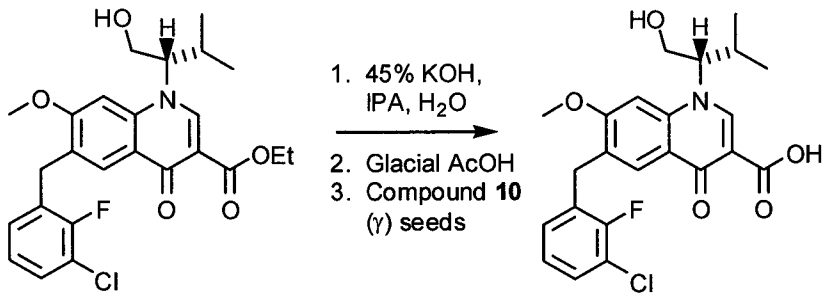
Notes:

1. The HPLC AN of remaining Compound **6a** is exaggerated by a baseline artifact. The HPLC in step shows only 2% of Compound **6a** relative to Compound **8a**. Experiments demonstrated that adding more reagent and extending reaction time typically will not further reduce the observed level of Compound **6a**.

2. TLC method:

   Eluting solvent: 100% ethyl acetate,
   Silylated Compound **9a** Rf: 0.85, Compound **9a** Rf: 0.50.

Example 12. Preparation of a Compound of Formula **10**.



Compound **9a**
$C_{25}H_{27}ClFNO_5$
Mol. Wt.: 475.94

Compund **10**, **γ-form**
[697761-98-1]
$C_{23}H_{23}ClFNO_5$
Mol. Wt.: 447.88

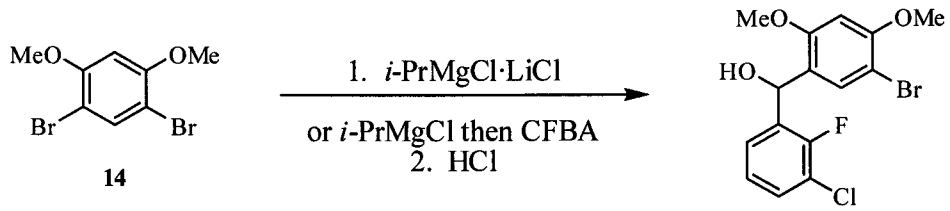
Compound **9a** is combined with aqueous isopropyl alcohol and warmed to 30 to 40 °C. Aqueous potassium hydroxide is added and the reaction is monitored by HPLC. Once complete, glacial acetic acid is added and the mixture warmed to 60 to 70 °C. The solution is hot filtered and cooled to 55 to 65 °C. The solution is seeded (see International Patent Application Publication Number WO 2005/113508) and cooled to 0 °C. The product is isolated by filtration, washed with cold aqueous isopropyl alcohol and dried at NMT 50 °C to yield Compound **10**.

Material	M.W.	Wt. Ratio	Mole Ratio
Compound **9a**	475.94	1.00	1.00
Isopropyl alcohol	60.10	4.7	
Water	18.02	4.0	
45% KOH	56.11	0.34	1.3
Glacial Acetic Acid	60.05	0.19	1.50
Compound **10** seeds	447.88	0.01	

1. Charge 1.00 kg Compound **9a** to Reactor 1.
2. Charge 4.7 kg isopropyl alcohol and 4.0 kg water to Reactor 1.
3. Charge 0.34 kg 45% aqueous KOH to Reactor 1.
4. Warm the mixture in Reactor 1 to 30 – 40 °C.
5. When hydrolysis is complete add 0.19 kg of glacial acetic acid.
6. Warm the mixture to 60 – 70 °C and polish filter the solution to Reactor 2.
7. Cool the mixture in Reactor 2 to 55 – 65 °C.

8. Seed with Compound 10 (see International Patent Application Publication Number WO 2005/113508) as a slurry in 0.28 volumes of 6:4 isopropyl alcohol:water.
9. Cool the mixture to 18 – 25 °C over at least 2 h and agitate to form a slurry.
10. Cool the mixture to 0 °C and agitate for at least 2 h.
11. Isolate Compound **10** by filtration and wash the cake with 3 x 1S cold isopropyl alcohol:water (6:4) solution.
12. Dry the isolated solids at < 50 °C under vacuum.

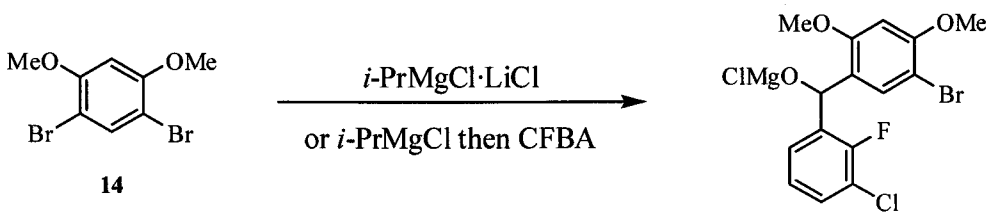
Example 13: Preparation of Compound **15**



14 **15**

Bisdimethylaminoethyl ether (2.84 g) was dissolved in 42 mL THF and cooled in an ice bath. Isopropylmagnesium chloride (8.9 mL of a 2 M solution in THF) followed by Compound **14** (5 g dissolved in 5 mL THF) were added slowly sequentially. The mixture was allowed to warm to ambient temperature and stirred overnight. Next, 2.1 mL of 3-chloro-2-fluorobenzaldehyde was added. After stirring for ~ 1h, the mixture was quenched to pH ~ 7 with 2N HCl. The product was extracted into ethyl acetate and the organic phase was dried over sodium sulfate. The solvent was exchange to heptane to precipitate the product and a mixture of heptanes:MTBE (4:1) was added to form a slurry. After filtration the solid was slurried in toluene, filtered and vacuum dried to yield compound **15**: ^{1}H NMR (CD_3CN, 400 MHz) δ 7.47 (s, 1H), 7.41-7.35 (m, 2H), 7.15 (t, J = 7.4 Hz, 1H), 6.66 (s, 1H), 6.21 (br s, 1H), 3.90 (s, 3H), 3.87 (br s, 1H), 3.81 (s, 3H).

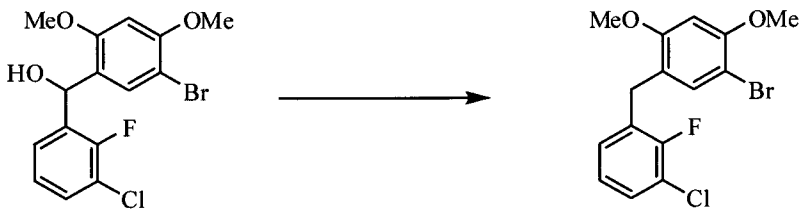
Example 14: Preparation of Compound **15a**



14 **15a**

Compound **14** (5 g), isopropylmagnesium chloride (8.9 mL of 2M solution in THF) and THF (56 mL) were combined at ambient temperature and then warmed to 50 °C for ~5 hours. After cooling to ambient temperature and stirring overnight, 2.1 mL of 3-chloro-2-fluorobenzaldehyde was added dropwise to form a slurry. After stirring overnight the solid was isolated by filtration and washing with MTBE to yield compound **15a**.

Example 15: Preparation of Compound **16**



15 **16**

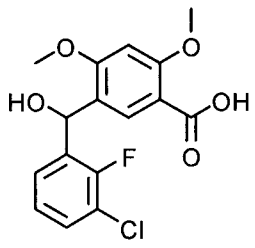
Triethylsilane (1.2 mL) was added to trifluoroacetic acid (2.3 mL) that had been pre-cooled in an ice bath. Compound **15** (1.466 g) was added to the mixture keeping the temperature below 5 °C. After stirring for ~ 2 h ice was added to quench the reaction. The product was extracted with DCM and the organic phase was washed with aq. $NaHCO_3$. The organic phase was dried over Na_2SO_4 and concentrated to dryness. The product was purified by silica gel column chromatography to provide 1.341 g of Compound **16**: ^1H NMR ($CDCl_3$, 400 MHz) δ 7.20 (t, J = 7.0 Hz, 1H), 6.99-6.91 (m, 3H), 6.46 (s, 1H), 3.91 (s, 3H), 3.81 (s, 5H).

All publications, patents, and patent documents are incorporated by reference herein, as though individually incorporated by reference. The invention has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the invention.

CLAIMS

What is claimed is:

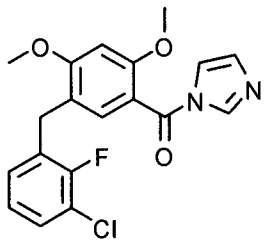
1. A compound of formula **3**:



3

or a salt thereof.

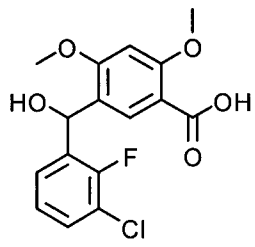
2. A compound of formula **5a**:



5a

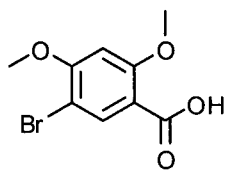
or a salt thereof.

3. A method for preparing a compound of formula **3**:



3

or a salt thereof comprising converting a corresponding compound of formula **2**:



2

or a salt thereof to the compound of formula **3** or the salt thereof.

4. The method of claim 3 wherein the compound of formula **2** is converted to the compound of formula **3** by metalating the compound of formula **2** to provide an organometallic compound and contacting the organometallic compound with 3-chloro-2-fluorobenzaldehyde.

5. The method of claim 4 wherein the organometallic compound is an organo-lithium compound.

6. The method of claim 5 wherein the organo-lithium compound is formed by a treating a compound of formula **2** with a dialkylmagnesium compound followed by treatment with an alkyllithium compound.

7. The method of claim 5 wherein the organo-lithium compound is formed by a treating a compound of formula **2** with dibutylmagnesium or butylethylmagnesium followed by treatment with an alkyllithium compound.

8. The method of claim 6 or 7 wherein the alkyllithium compound is *n*-butyllithium or *t*-butyllithium.

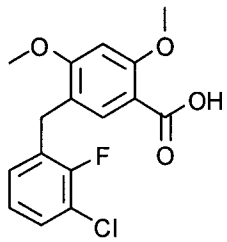
9. The method of claim 6 wherein the compound of formula **2** is treated with the dialkylmagnesium compound followed by treatment with the alkyllithium compound at a temperature of about -50 ± 50 °C.

10. The method of claim 6 wherein the compound of formula **2** is treated with the dialkylmagnesium compound followed by treatment with the alkyllithium compound at a temperature of about -20 ± 20 °C.

11. The method of any one of claims 3-10 further comprising preparing the compound of formula **2** or a salt thereof by brominating 2,4-dimethoxybenzoic acid.

12. The method of claim 11 wherein the 2,4-dimethoxybenzoic acid is brominated by treatment with bromine in the presence of an acid.

13. The method of any one of claims 3-12 further comprising converting the compound of formula **3** or the salt thereof to a compound of formula **4**:



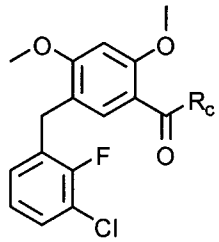
4

or a salt thereof.

14. The method of claim 13 wherein the compound of formula **3** is converted to the compound of formula **4** by treatment with a silane reducing agent in the presence of an acid.

15. The method of claim 14 wherein the silane reducing agent is triethylsilane and the acid is trifluoroacetic acid.

16. The method of any one of claims 13-15 further comprising converting the compound of formula **4** or the salt thereof to a compound of formula **5'**:

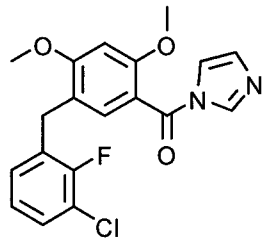


5'

or a salt thereof, wherein R_c is a leaving group.

17. The method of claim 16 wherein R_c is halo or 1-imidazolyl.

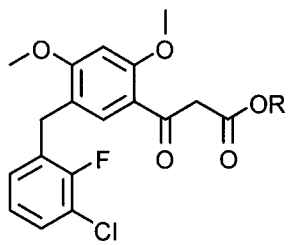
18. The method of claim 16 wherein the compound of formula **5'** is a compound of formula **5a**:



5a

19. The method of claim 18 wherein the compound of formula **4** is converted to the compound of formula **5a** by treatment with 1,1'-carbonyldiimidazole.

20. The method of any one of claims 16-19 further comprising converting the compound of formula **5'** or the salt thereof to a compound of formula **6**:



6

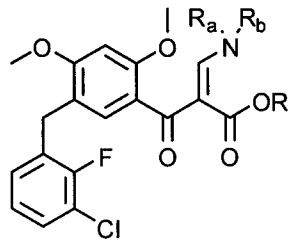
or a salt thereof, wherein R is C_1-C_6alkyl.

21. The method of claim 20 wherein the compound of formula **5'** is converted to the compound of formula **6** by treatment with the corresponding mono-alkylmalonate salt.

22. The method of claim 20 wherein R is ethyl.

23. The method of claim 22 wherein the compound of formula **5'** is converted to the compound of formula **6** by treatment with potassium monoethylmalonate.

24. The method of any one of claims 20-23 further comprising converting the compound of formula **6** or the salt thereof to a compound of formula **7**:



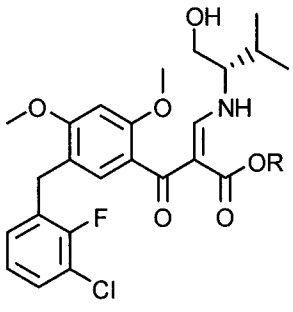
7

wherein R_a and R_b are each independently C_1-C_6alkyl.

25. The method of claim 24 wherein the compound of formula **6** is converted to the compound of formula **7** by treatment with N,N-dimethyformlamide dimethyl acetal.

26. The method of claim 25 wherein the treatment with N,N-dimethyformlamide dimethyl acetal is carried out in the presence of acetic acid at a temperature of about 100 ± 50 °C.

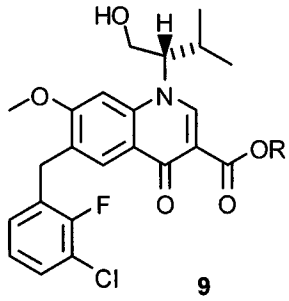
27. The method of any one of claims 24-26 further comprising converting the compound of formula **7** to a compound of formula **8**:



8

28. The method of claim 27 wherein the compound of formula **7** is converted to the compound of formula **8** by treatment with (*S*)-2-amino-3-methyl-1-butanol.

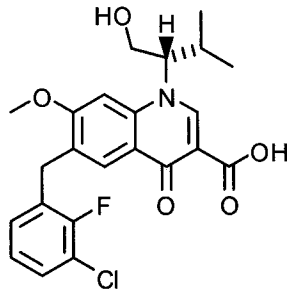
29. The method of claim 27 or 28 further comprising converting the compound of formula **8** to a compound of formula **9**:



9

30. The method of claim 29 wherein the compound of formula **8** is converted to the compound of formula **9** by treatment with potassium chloride and *N,O*-bistrimethylsilylacetamide.

31. The method of claim 29 or 30 further comprising converting the compound of formula **9** to a compound of formula **10**:

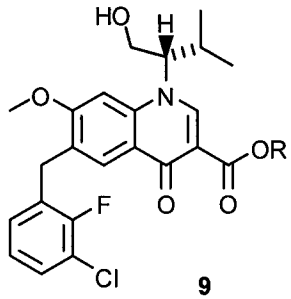


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32. The method of claim 31 wherein the compound of formula **9** is converted to the compound of formula **10** by treatment with a base.

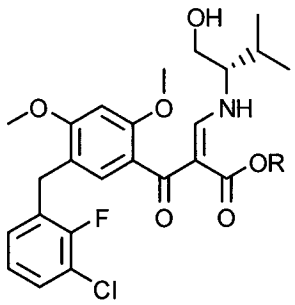
33. The method of claim 32 wherein the compound of formula **9** is converted to the compound of formula **10** by treatment with aqueous potassium hydroxide in aqueous isopropyl alcohol.

34. A method for preparing a compound of formula **9**:



9

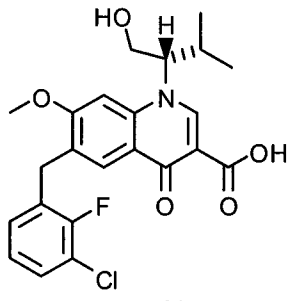
wherein R is C_1-C_6alkyl, comprising cyclizing a corresponding compound of formula **8**:



8

35. The method of claim 34 wherein the compound of formula **8** is cyclized by treatment with potassium chloride and *N,O*-bistrimethylsilylacetamide.

36. The method of claim 34 or 35 further comprising converting the compound of formula **9** to a compound of formula **10**:

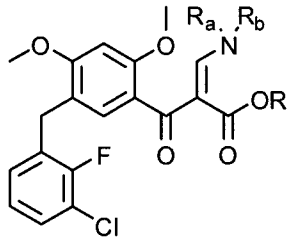


10

37. The method of claim 36 wherein the compound of formula **9** is converted to the compound of formula **10** by treatment with a base.

38. The method of claim 37 wherein the compound of formula **9** is converted to the compound of formula **10** by treatment with aqueous potassium hydroxide in aqueous isopropyl alcohol.

39. The method of any one of claims 34-38 further comprising preparing the compound of formula **8** by converting a corresponding compound of formula **7**:

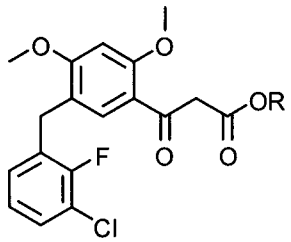


7

wherein R_a and R_b are each independently C_1-C_6alkyl; and R is C_1-C_6alkyl, to the compound of formula **8**.

40. The method of claim 39 wherein the compound of formula **7** is converted to the compound of formula **8** by treatment with (S)-2-amino-3-methyl-1-butanol.

41. The method of claim 39 or 40 further comprising preparing the compound of formula **7** by converting a corresponding compound of formula **6**:



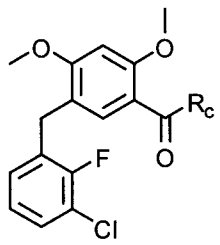
6

or a salt thereof, wherein R is C_1-C_6alkyl to the compound of formula **7**.

42. The method of claim 41 wherein the compound of formula **6** is converted to the compound of formula **7** by treatment with N,N-dimethyformlamide dimethyl acetal.

43. The method of claim 42 wherein the treatment with N,N-dimethyformlamide dimethyl acetal is carried out in the presence of acetic acid at a temperature of about 100 ± 50 °C.

44. The method of any one of claims 41-43 further comprising preparing the compound of formula **6** by converting a compound of formula **5'**:



5'

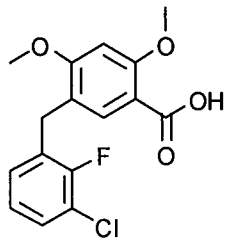
wherein R_c is a leaving group to the compound of formula **6**.

45. The method of claim 44 wherein the compound of formula **5'** is converted to the compound of formula **6** by treatment with the corresponding mono-alkylmalonate salt.

46. The method of claim 45 wherein the mono-alkylmalonate salt is a mono-ethylmalonate salt.

47. The method of claim 45 wherein the compound of formula **5'** is converted to the compound of formula **6** by treatment with potassium monoethylmalonate.

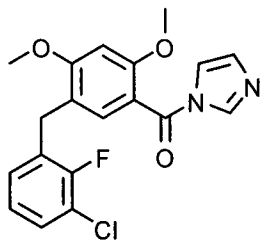
48. The method of any one of claims 44-47 further comprising preparing the compound of formula **5'** by converting a compound of formula **4**:



4

or a salt thereof to the compound of formula **5'**.

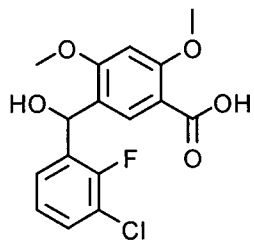
49. The method of claim 48 wherein the compound of formula **5'** is a compound of formula **5a**:



5a

and wherein the compound of formula **4** or a salt thereof is converted to the compound of formula **5a** by treatment with 1,1'-carbonyldiimidazole.

50. The method of claim 48 or 49 further comprising preparing the compound of formula **4** or the salt thereof by converting a compound of formula **3**:



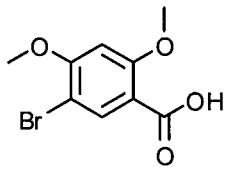
3

or a salt thereof to the compound of formula **4**.

51. The method of claim 50 wherein the compound of formula **3** or the salt thereof is converted to the compound of formula **4** or the salt thereof by treatment with a silane reducing agent in the presence of an acid.

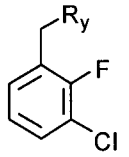
52. The method of claim 51 wherein the silane reducing agent is triethylsilane and the acid is trifluoroacetic acid.

53. The method of claim 48 or 49 wherein the compound of formula **4** or the salt thereof is prepared by forming an organometallic compound from a compound of formula **2**:



2

or a salt thereof and reacting the organometallic compound with Compound **11**:



11

wherein R_y is a suitable leaving group to provide the compound of formula **4**.

54. The method of claim 53 wherein R_y is a triflate, mesylate, tosylate, or brosylate.

55. The method of any one of claims 31-33 and 36-38 further comprising crystallizing the compound of formula **10** by adding a seed crystal to a solution that comprises the compound of formula **10.**

56. The method of claim 55 wherein the seed crystal has an X-ray powder diffraction pattern having characteristic diffraction peaks at diffraction angles 2θ(°) of 6.56, 13.20, 19.86, 20.84, 21.22, and 25.22 as measured by an X-ray powder diffractometer.

57. The method of claim 55 wherein the seed crystal has an X-ray powder diffraction pattern having characteristic diffraction peaks at diffraction angles

2θ(°) of 8.54, 14.02, 15.68, 17.06, 17.24, 24.16, and 25.74 as measured by an X-ray powder diffractometer.

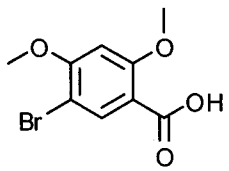
58. The method of claim 55 wherein the seed crystal has an extrapolated onset temperature of about 162.1 ± 5.0 °C.

59. The method of claim 55 or 57 wherein the seed crystal has a purity of crystal of not less than about 70%.

60. The method of any one of claims 31-33 and 36-59 further comprising preparing a pharmaceutical formulation or unit dose form that comprises the compound of formula **10**.

61. The method of any one of claims 31-33 and 36-59 further comprising preparing a kit that comprises the compound of formula **10** and instructions for using the compound in therapy.

62. A salt prepared by treating a compound of formula **2**:



2

with an organometallic reagent.

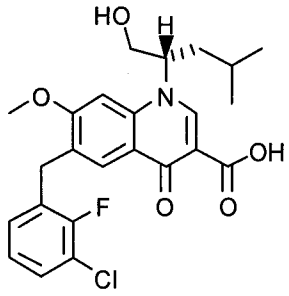
63. The salt of claim 62 wherein the organometallic reagent is a dialkylmagnesium, dialkylzinc, an alkylmagnesium halide, a trialkylaluminum, or a metal hydride reagent.

64. The salt of claim 63 wherein the organometallic reagent is dibutylmagnesium or butylethylmagnesium.

65. The salt of claim 63 wherein the organometallic reagent is butylethylmagnesium-butanol adduct.

66. An organolithium compound prepared by treating the salt as described in any one of claims 62-65 with an alkyllithium reagent.

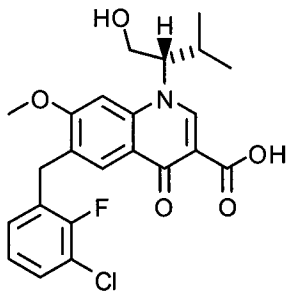
67. Compound **13**:



13

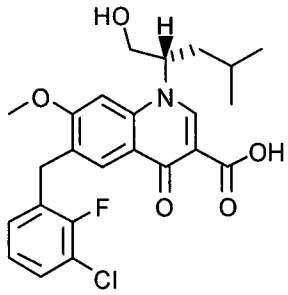
or a salt thereof.

68. A composition comprising Compound **10**:



10

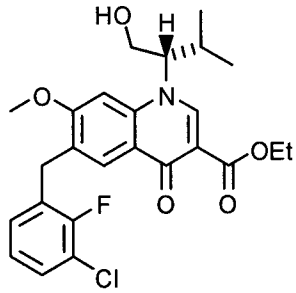
or a salt thereof; and Compound **13**:



13

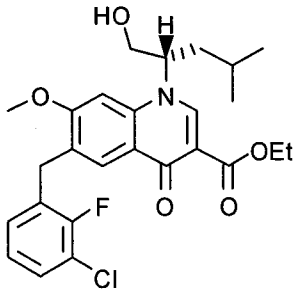
or a salt thereof.

69. A composition comprising Compound **9a**:



9a

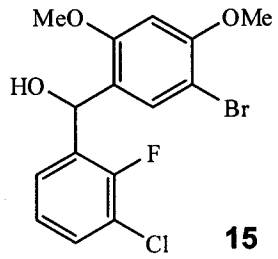
or a salt thereof; and Compound **12**:



12

or a salt thereof.

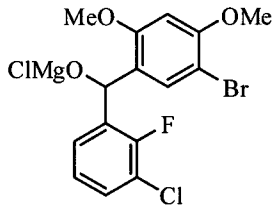
70. A compound of formula **15**:



15

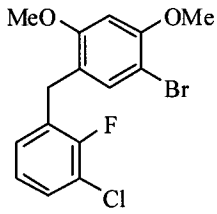
or a salt thereof.

71. A compound of formula **15a**:



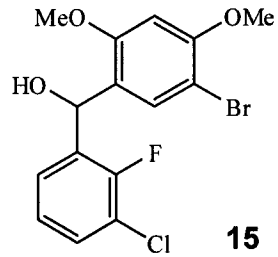
15a

72. A compound of formula **16**:



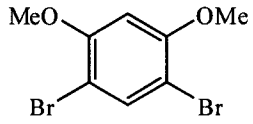
16

73. A method for preparing a compound of formula **15**:



15

or a salt thereof comprising converting a corresponding compound of formula **14**:



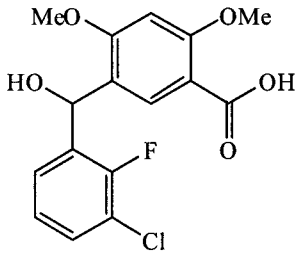
14

to the compound of formula **15** or the salt thereof.

74. The method of claim 73 wherein the compound of formula **14** is converted to the compound of formula **15** or a salt thereof by metalating the compound of formula **14** and treating with 3-chloro-2-fluorobenzaldehyde to provide the compound of formula **15** or the salt thereof.

75. The method of claim 74 wherein the compound of formula **14** is metalated by treatment with isopropylmagnesium chloride.

76. The method of claim 73 further comprising converting the compound of formula **15** or the salt thereof to a compound of formula **3**:



3

or a salt thereof.