



(51) International Patent Classification:
C07D 487/04 (2006.01)

(21) International Application Number:
PCT/US2016/043402

(22) International Filing Date:
21 July 2016 (21.07.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/195,023 21 July 2015 (21.07.2015) US
62/327,973 26 April 2016 (26.04.2016) US

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

Published:

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

— with amended claims (Art. 19(1))

(54) Title: METHODS OF PREPARING CYTOTOXIC BENZODIAZEPINE DERIVATIVES

(57) Abstract: The invention relates to novel methods for preparing indolinobenzodiazepine dimer compounds and their synthetic precursors.



WO 2017/015495 A1

METHODS OF PREPARING CYTOTOXIC BENZODIAZEPINE DERIVATIVES

REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the filing date, under 35 U.S.C. §119(e), of
5 U.S. Provisional Application No. 62/327,973, filed on April 26, 2016, and
U.S. Provisional Application No. 62/195,023, filed on July 21, 2015. The entire
contents of each of the above-referenced applications are incorporated herein by
reference.

FIELD OF THE INVENTION

10 The present invention relates to novel methods for preparing cytotoxic
indolinobenzodiazepine derivatives.

BACKGROUND OF THE INVENTION

It has been shown that cell-binding agent conjugates of indolinobenzodiazepine
dimers that have one imine functionality and one amine functionality display a much
15 higher therapeutic index (ratio of maximum tolerated dose to minimum effective dose)
in vivo compared to previously disclosed benzodiazepine derivatives having two imine
functionalities. See, for example, WO 2012/128868. The previously disclosed method
for making the indolinobenzodiazepine dimers with one imine functionality and one
amine functionality involves partial reduction of indolinobenzodiazepine dimers having
20 two imine functionalities. The partial reduction step generally leads to the formation of
fully reduced by-product and unreacted starting material, which requires cumbersome
purification step and results in low yield.

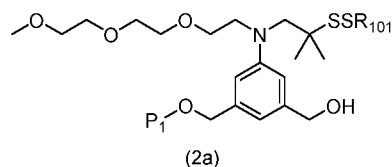
Thus, there exists a need for improved methods for preparing the
indolinobenzodiazepine dimers that are more efficient and suitable for large scale
25 manufacturing process.

SUMMARY OF THE INVENTION

The present invention provides various methods for preparing
indolinobenzodiazepine dimer compounds and their synthetic precursors. Compared to
the previously disclosed method, the methods of the present invention can produce the
30 desired dimer compounds with higher yield without the need of cumbersome

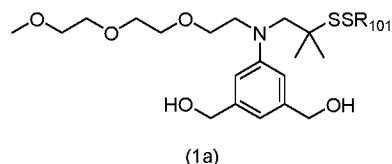
purification steps. These methods are more suitable for large scale manufacturing process.

In a first embodiment, the present invention provides a method of preparing a compound of formula (2a),



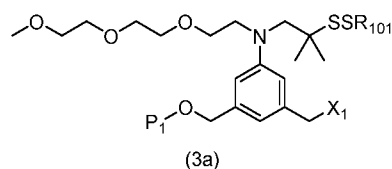
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or a salt thereof, said method comprising introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a) by reacting the compound of formula (1a) with an alcohol protecting reagent,

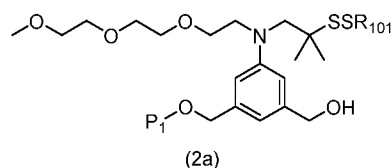


10 wherein P₁ is the alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a second embodiment, the present invention provides a method of preparing a compound of formula (3a),

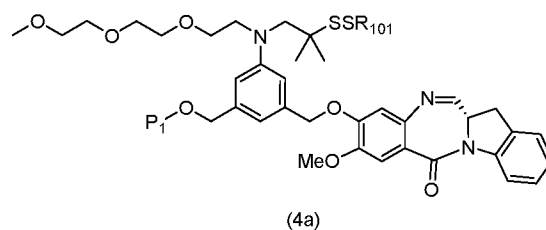


15 or a salt thereof, said method comprising reacting a halogenating reagent or a sulfonating reagent or an esterification reagent with a compound of formula (2a),

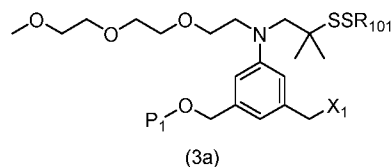


20 wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

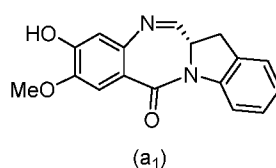
In a third embodiment, the present invention provides a method of preparing a compound of formula (4a),



or a salt thereof, said method comprising reacting a compound of formula (3a)

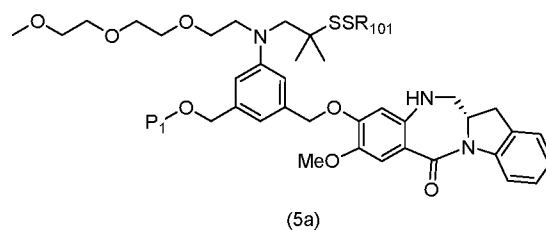


with a monomer compound of the formula (a₁),

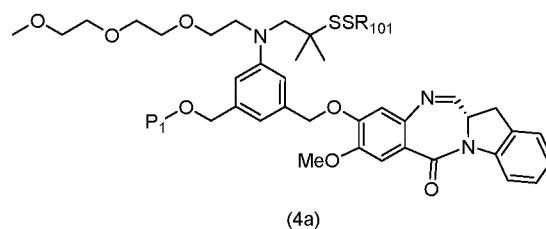


wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a fourth embodiment, the present invention provides a method of preparing a compound of formula (5a),

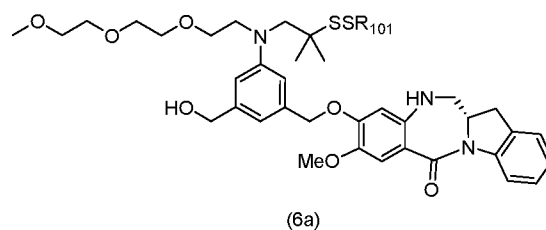


or a salt thereof, said method comprising reacting a compound of formula (4a),



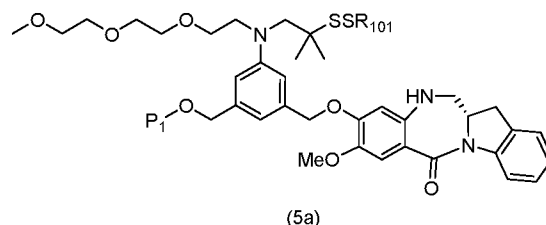
with an imine reducing agent, wherein P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a fifth embodiment, the present invention provides method of preparing a compound of formula (6a),



(6a)

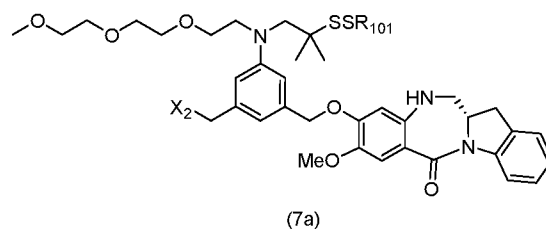
or a salt thereof, said method comprising reacting a compound of formula (5a),



(5a)

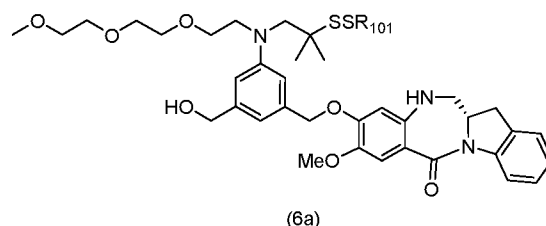
with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a sixth embodiment, the present invention provides a method of preparing a compound of formula (7a),



(7a)

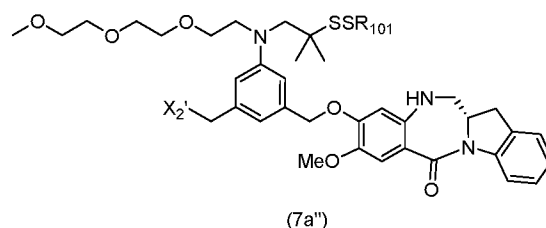
or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the primary alcohol compound of formula (6a),



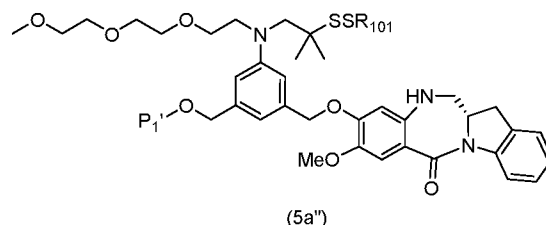
(6a)

wherein X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₂ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a seventh embodiment, the present invention provides a method of preparing a compound of formula (7a'')

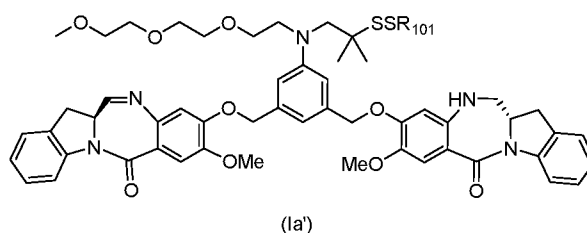


or a salt thereof, said method comprising reacting a compound of formula (5a'')

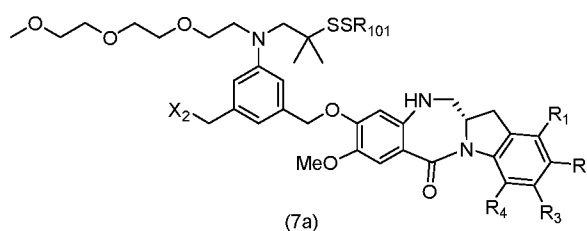


with an alcohol deprotecting reagent and a halogenating reagent, wherein P₁' is an acid labile alcohol protecting group; X₂' is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl..

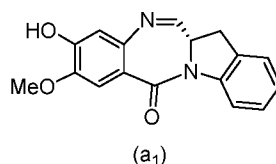
In a eighth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (7a)

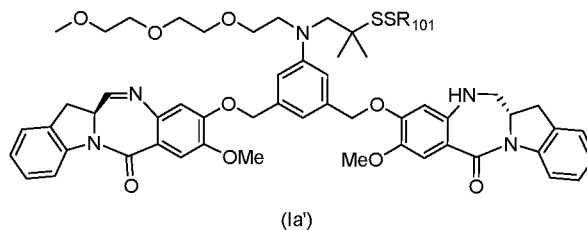


with a monomer compound of the formula (a₁),



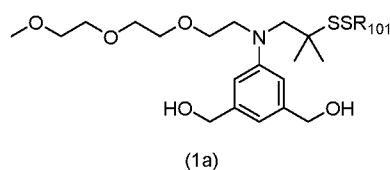
wherein R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl; and, X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₂ is -Br, -I, or a sulfonate ester).

In a ninth embodiment, the present invention provides a method of forming a compound of formula (Ia'),

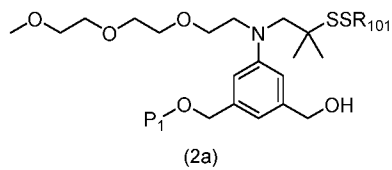


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

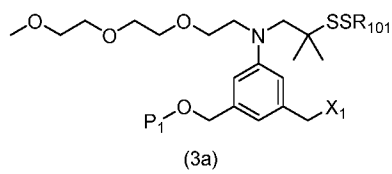
- 5 (1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



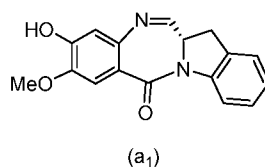
to form a compound of formula (2a),



- 10 (2) reacting the compound of formula (2a) with a halogenating reagent, a sulfonating reagent, or an esterification reagent to form a compound of formula (3a),

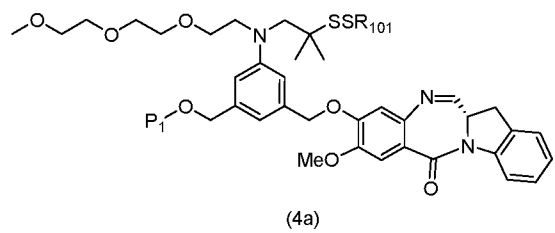


(3) reacting the compound of formula (3a) with a monomer compound of the formula (a₁),

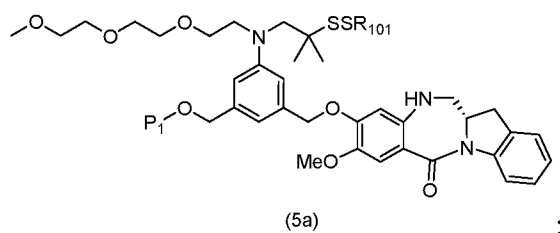


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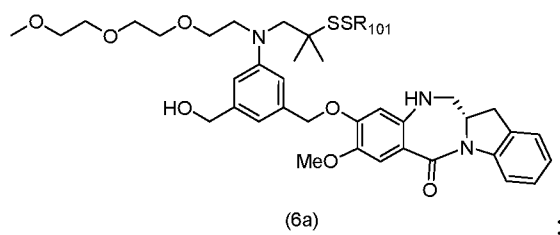
to form a compound of formula (4a),



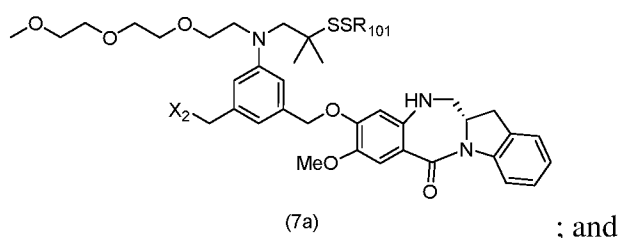
(4) reacting the compound of formula (4a) with an imine reducing agent to form a compound of formula (5a),



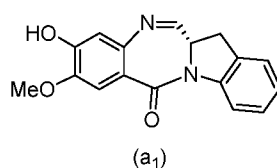
(5) reacting the compound of formula (5a) with an alcohol deprotecting reagent
5 to form a compound of formula (6a),



(6) reacting the compound of formula (6a) with a second halogenating reagent, a second sulfonating reagent or a second esterification reagent to form a compound of formula (7a),

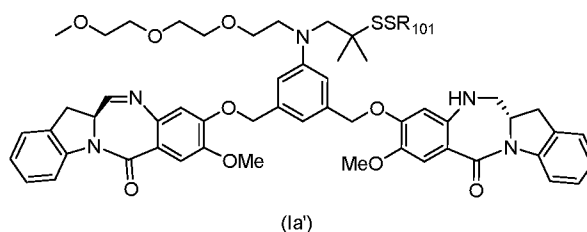


(7) reacting the compound of formula (7a) with a monomer compound of the formula (a₁),



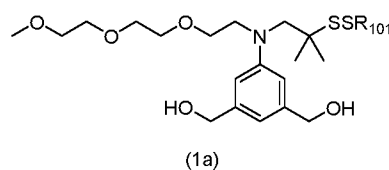
to form the compound of formula (Ia'); wherein P₁ is an alcohol protecting
15 group; X₁ and X₂ are each independently a leaving group selected from the group
consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ and X₂
are each independently -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or
nitropyridyl.

In a tenth embodiment, the present invention provides a method of preparing a
20 compound of formula (Ia'),



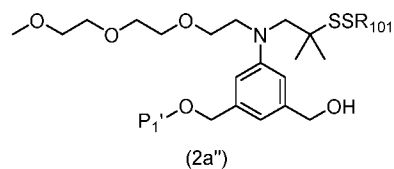
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



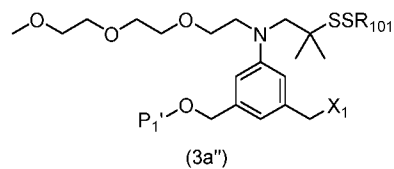
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to form a compound of formula (2a''),



;

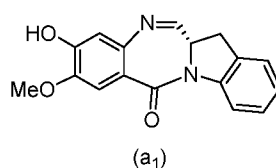
(2) reacting the compound of formula (2a'') with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a''),



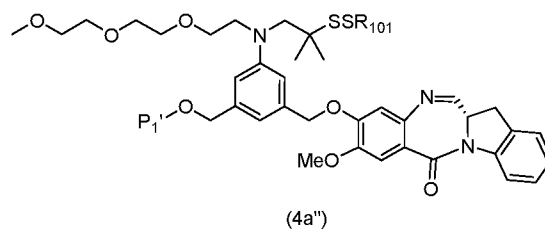
;

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(3) reacting the compound of formula (3a'') with a monomer compound of the formula (a₁),



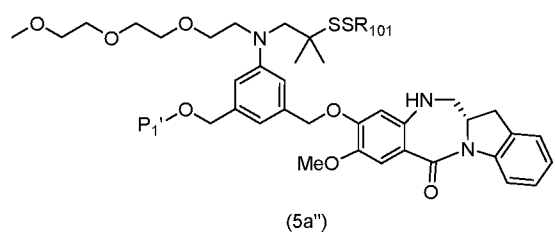
to form a compound of formula (4a''),



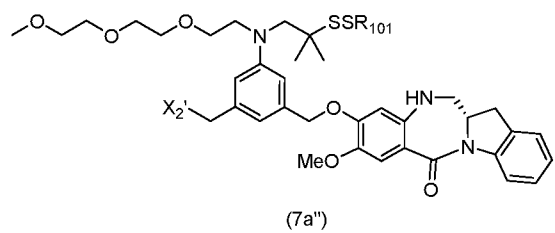
;

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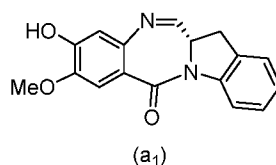
(4) reacting the compound of formula (4a'') with an imine reducing agent to form a compound of formula (5a''),



(5) reacting the compound of formula (5a'') with an alcohol deprotecting reagent and a halogenating reagent to form a compound of formula (7a''),

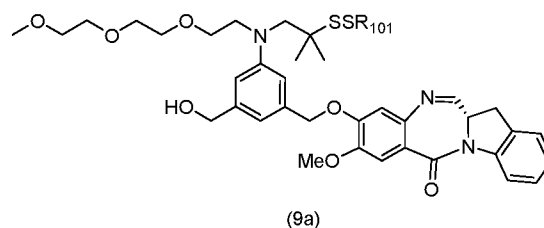


5 (6) reacting a compound of formula (7a'') with a monomer compound of the formula (a₁),

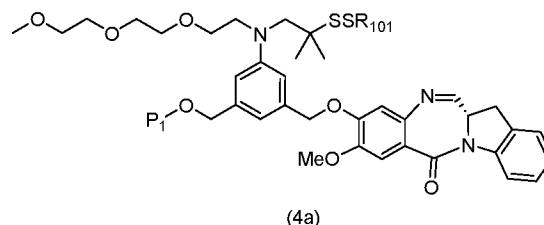


to form the compound of formula (Ia'), wherein X₂' is -Br or -I; and the remaining variables are as described above in the ninth embodiment.

10 In a eleventh embodiment, the present invention provides a method of preparing a compound of formula (9a),

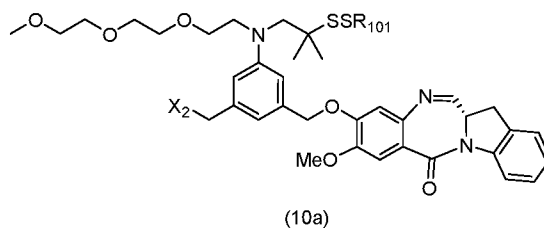


or a salt thereof, said method comprising reacting a compound of formula (4a),



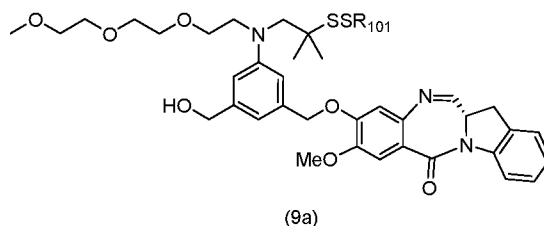
15 with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a twelfth embodiment, the present invention provides a method of preparing a compound of formula (10a),



(10a)

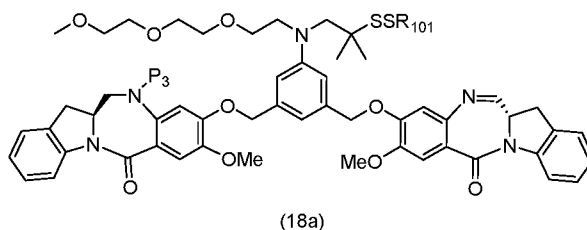
or a salt thereof, said method comprising reacting the compound of formula (9a) with a halogenating reagent, a sulfonating reagent or an esterification reagent,



(9a)

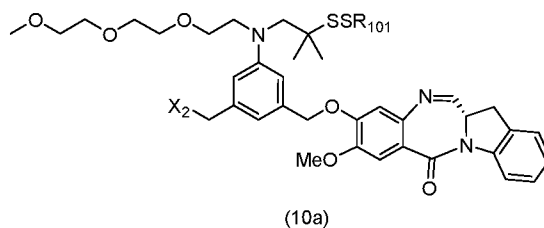
wherein X₂ is -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₂ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a thirteenth embodiment, the present invention provides a method of preparing a compound of formula (18d),



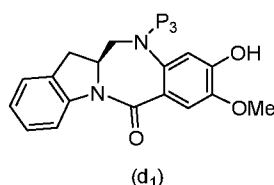
(18a)

or a salt thereof, said method comprising reacting a compound of formula (10a)



(10a)

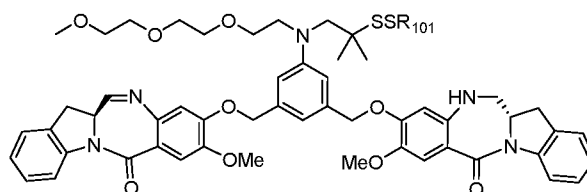
with a monomer compound of the formula (d₁),

(d₁)

wherein X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₂ is -Br, -I, or a sulfonate ester); P₃ is

H or P₂; P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

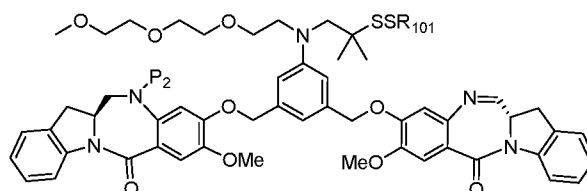
In a fourteenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



(Ia')

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or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (11a),

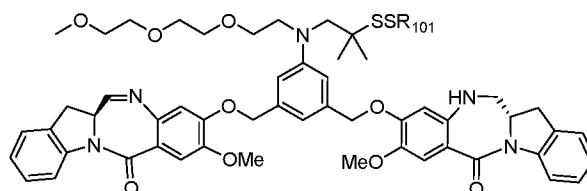


(11a)

with an amine deprotecting reagent, wherein P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

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In a fifteenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

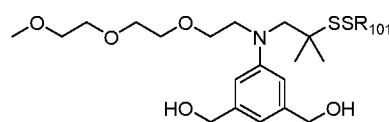


(Ia')

or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

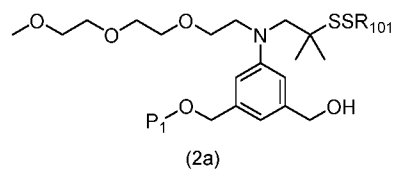
(1) introducing an alcohol protecting group onto one of the primary alcohols of the compound of formula (1a),

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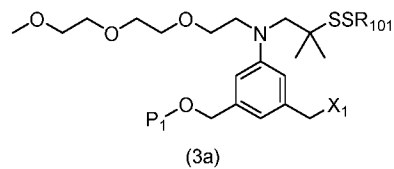


(1a)

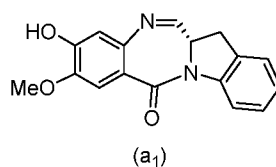
to form a compound of formula (2a),



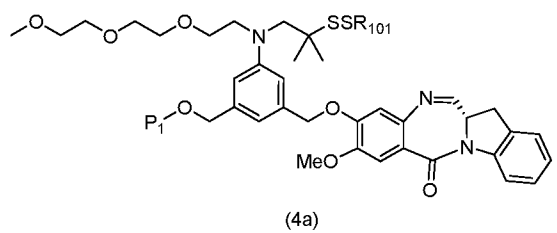
(2) reacting the compound of formula (2a) with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a),



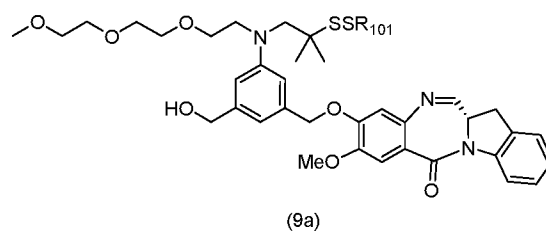
5 (3) reacting the compound of formula (3a) with a monomer compound of the formula (a₁),



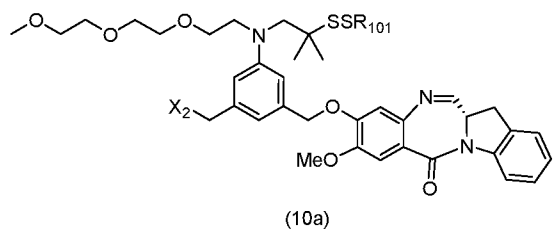
to form a compound of formula (4a),



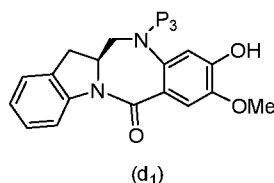
10 (4) reacting the compound of formula (4a) with an alcohol deprotecting reagent to form a compound of formula (9a),



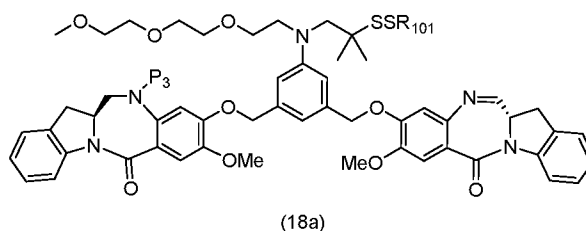
(5) reacting the compound of formula (9a) with a second halogenating reagent, a second sulfonating reagent or a second esterification reagent to form a compound of formula (10a).



(6) reacting the compound of formula (10a) with a monomer compound of the formula (d₁)



to form a compound of formula (18a),



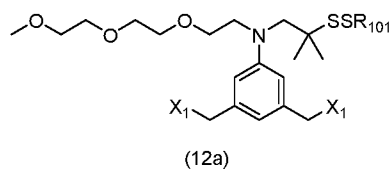
5

; and

(7) when P₃ is an amine protecting group, reacting the compound of formula (18a) to an amine deprotecting reagent to form the compound of formula (1a'), wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

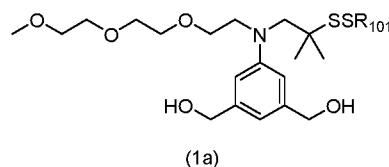
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In a sixteenth embodiment, the present invention provides a method of preparing a compound of formula (12a),



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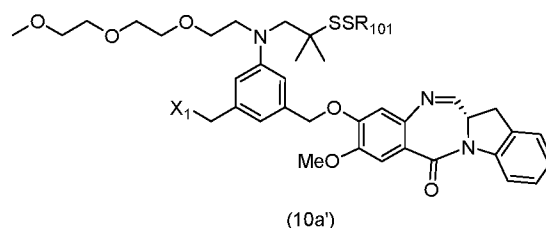
or a salt thereof, said method comprising reacting a compound of formula (1a),



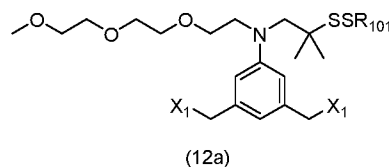
with a halogenating reagent, a sulfonating reagent or an esterification reagent, wherein X₁ is -Br, -I, a sulfonate ester or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

20

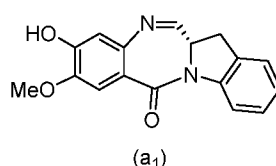
In a seventeenth embodiment, the present invention provides a method of preparing a compound of formula (10a'),



or a salt thereof, said method comprising reacting a compound of formula (12a),



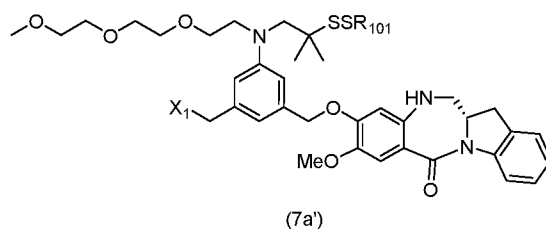
with a monomer compound of the formula (a₁),



5

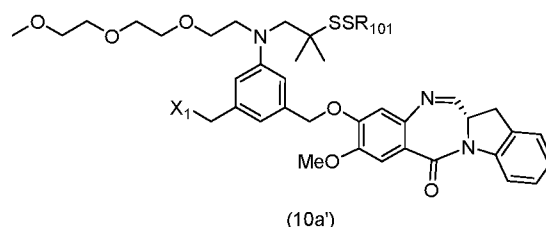
wherein X₁ is -Br, -I, a sulfonate ester or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a eighteenth embodiment, the present invention provides a method of preparing a compound of formula (7a'),



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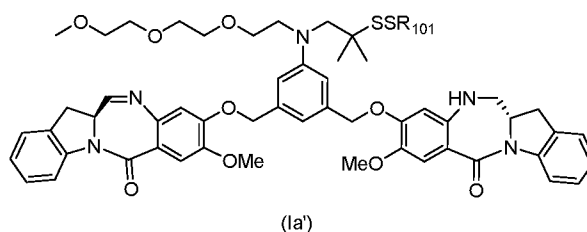
or a salt thereof, said method comprising reacting a compound of formula (10a'),



or a salt thereof, with an imine reducing agent, wherein X₁ is -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

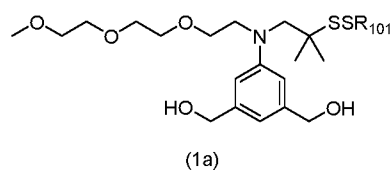
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In a nineteenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



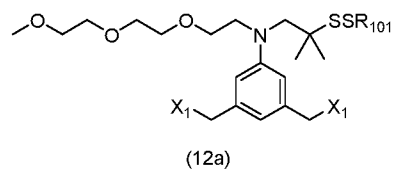
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a compound of formula (1a) with a halogenating reagent, a sulfonating reagent or an esterification reagent,

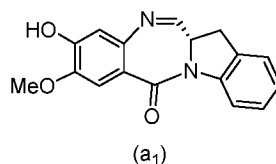


5

to form a compound of formula (12a),

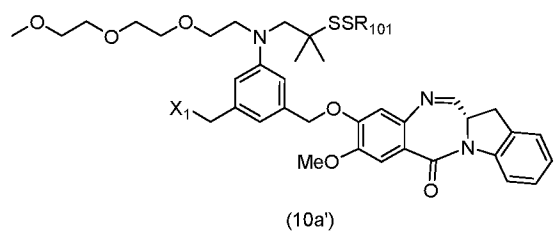


(2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),

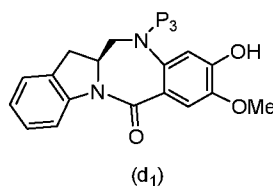


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to form a compound of a formula (10a'),

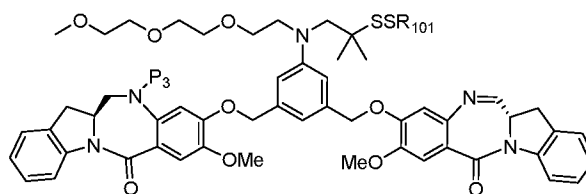


(3) reacting the compound of formula (10a') with a monomer compound of the formula (d₁),



15

to form a compound of formula (18a),

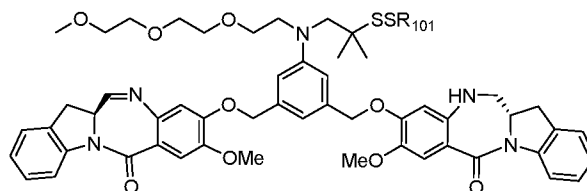


(18a)

; and

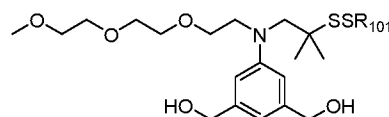
- (4) when P₃ is an amine protecting group, reacting the compound of formula (18a) with an amine deprotecting reagent to form the compound of formula (Ia'), wherein X₁ is -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a twentieth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



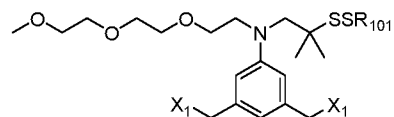
(Ia')

- or a pharmaceutically acceptable salt thereof, said method comprising the steps of:
- (1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



(1a)

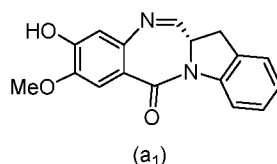
to form a compound of formula (12a),



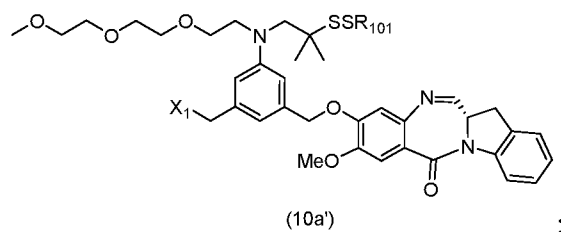
(12a)

;

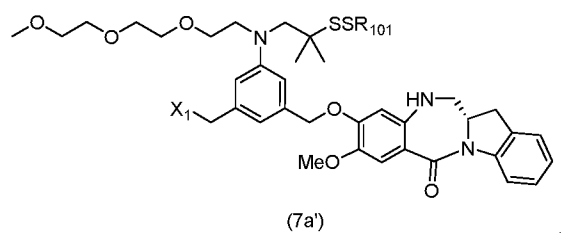
- (2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),



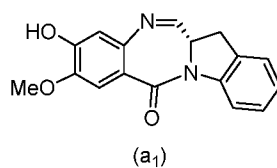
to form a compound of a formula (10a'),



(3) reacting the compound (10a') with an imine reducing reagent to form a
5 compound (7a'),

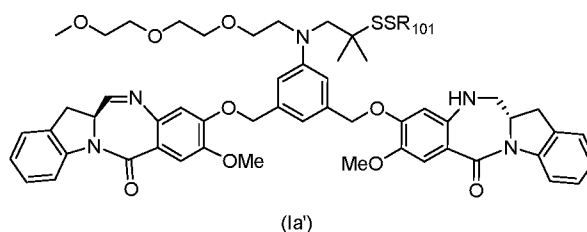


(4) reacting the compound of formula (7a') with a monomer compound of the
formula (a₁),



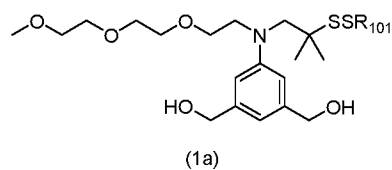
10 to form a compound of formula (Ia'), or a pharmaceutically acceptable salt thereof,
wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -
I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a twenty-first embodiment, the present invention provides a method of
preparing a compound of formula (Ia'),



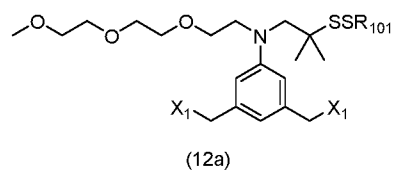
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),

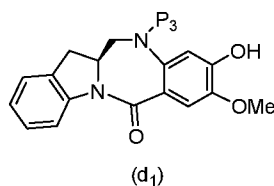


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to form a compound of formula (12a),

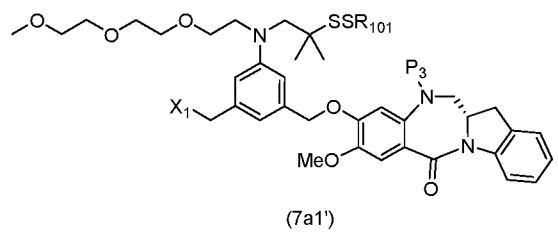


(2) reacting the compound of formula (12a) with a monomer compound of the formula (d₁),

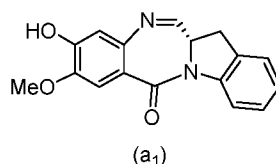


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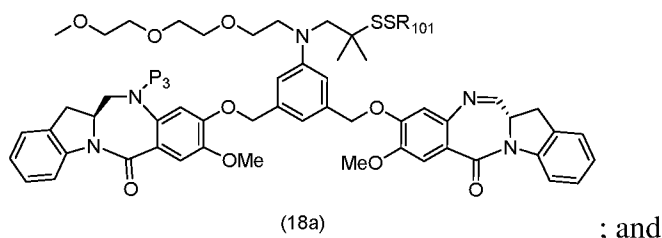
to form a compound of a formula (7a1'),



(3) reacting the compound of formula (7a1') with a monomer compound of the formula (a₁),

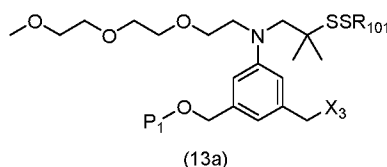


to form a compound of formula (18a),

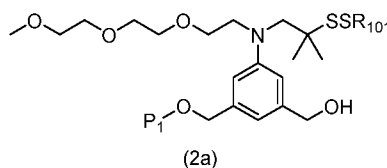


- (4) when P₃ is an amine protecting group, reacting the compound of formula (18a) with an amine deprotecting reagent to form the compound of formula (Ia'); wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a twenty-second embodiment, the present invention provides a method of preparing a compound of formula (13a),

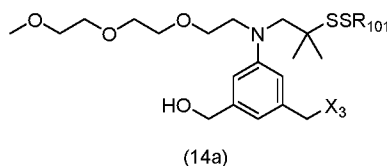


or a salt thereof, said method comprising reacting a chlorinating reagent with a compound of formula (2a),

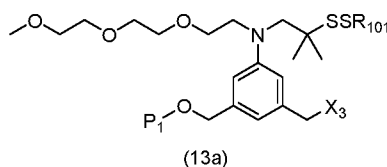


- wherein P₁ is an alcohol protecting group; X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a twenty-third embodiment, the present invention provides a method of preparing a compound of formula (14a),

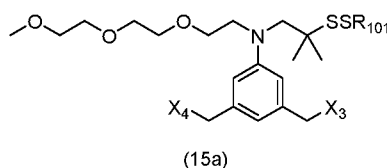


or a salt thereof, said method comprising reacting a compound of formula (13a)

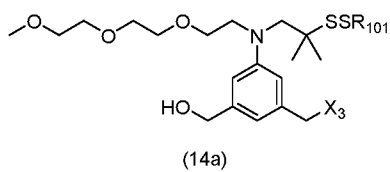


with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

5 In a twenty-fourth embodiment, the present invention provides a method of preparing a compound of formula (15a):



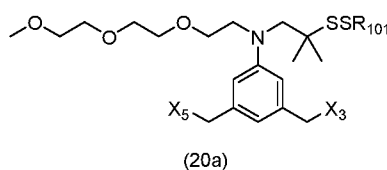
or a salt thereof, said method comprising reacting a sulfonating reagent or an esterification reagent with a compound of formula (14a),



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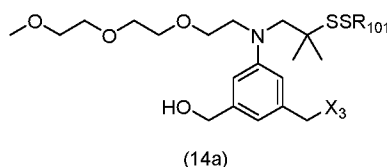
wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, X₄ is a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a twenty-fifth embodiment, the present invention provides a method of preparing a compound of formula (20a):



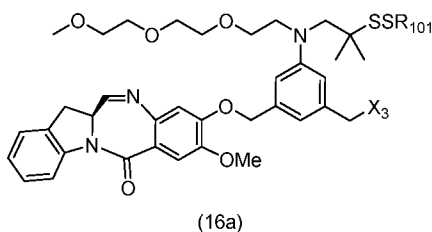
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or a salt thereof, said method comprising reacting a brominating or iodinating reagent with a compound of formula (14a),

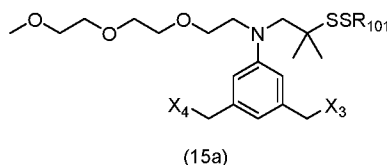


wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

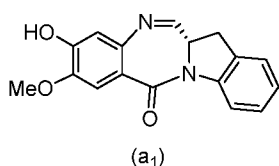
20 In a twenty-sixth embodiment, the present invention provides a method of preparing a compound of formula (16a):



or a salt thereof, said method comprising reacting a compound of formula (15d)

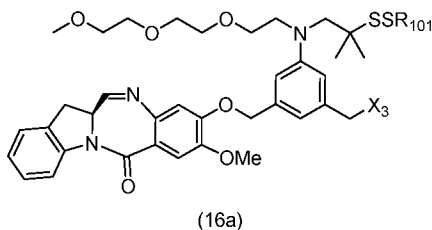


with a monomer compound of formula (a₁),

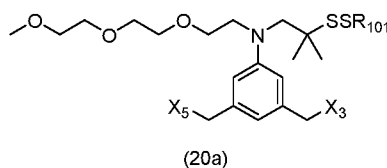


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, X₄ is a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

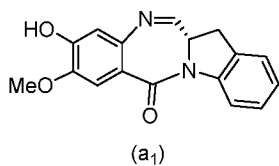
In a twenty-seventh embodiment, the present invention provides a method of preparing a compound of formula (16a),



or a salt thereof, said method comprising reacting a compound of formula (20a)

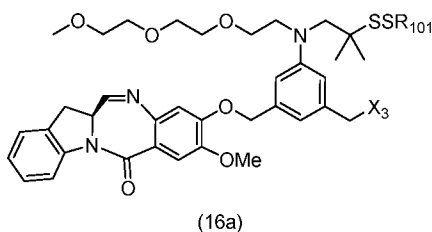


with a monomer compound of formula (a₁),

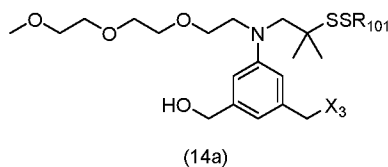


wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

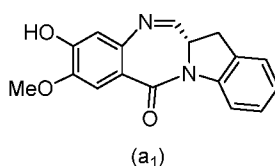
In a twenty-eighth embodiment, the present invention provides a method of preparing a compound of formula (16a),



or a salt thereof, said method comprising reacting a compound of formula (14a)

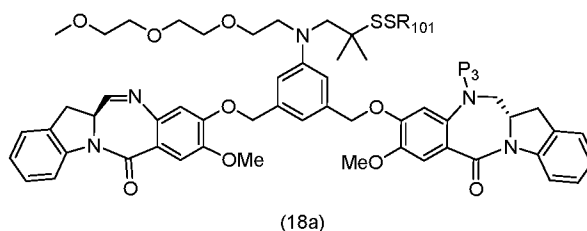


with a monomer compound of formula (a₁),

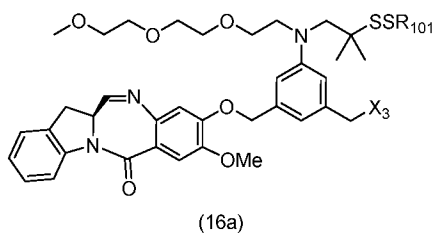


wherein X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

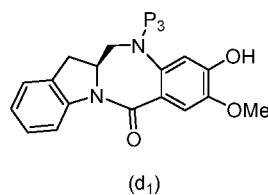
In a twenty-ninth embodiment, the present invention provides a method of preparing a compound of formula (18a):



a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (16a):

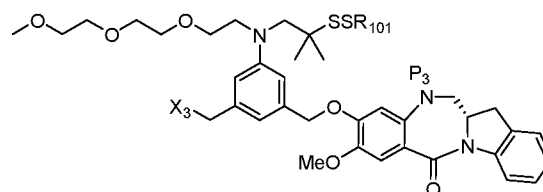


with a reduced monomer of formula (d₁):



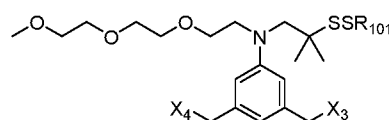
wherein X_3 is $-\text{Cl}$; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

In a thirtieth embodiment, the present invention provides a method for preparing a compound of formula (17a):



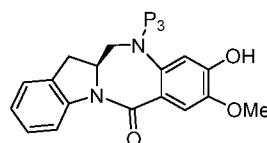
(17a)

or a salt thereof, said method comprising reacting a compound of formula (15a)



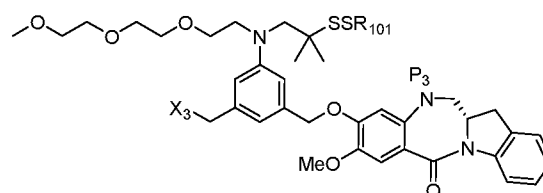
(15a)

with a monomer compound of formula (d_1),

(d₁)

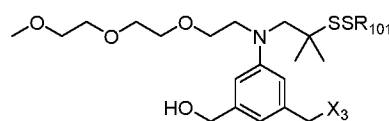
wherein X_3 is $-\text{Cl}$; X_4 is a sulfonate ester or an activated ester (preferably, X_4 is a sulfonate ester); P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

In a thirty-first embodiment, the present invention provides a method of preparing a compound of formula (17a),



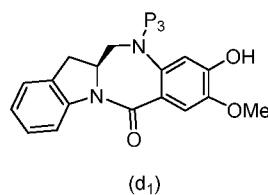
(17a)

or a salt thereof, said method comprising reacting a compound of formula (14a)



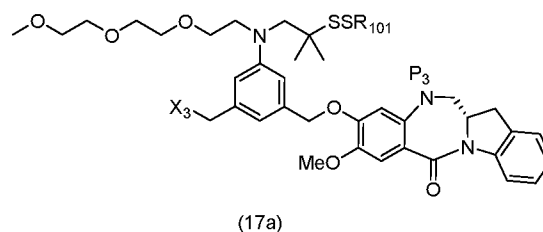
(14a)

with a monomer compound of formula (d_1),

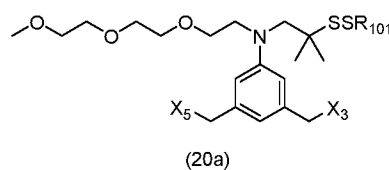


wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

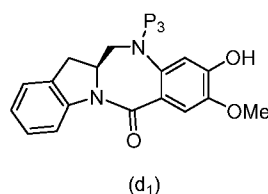
In a thirty-second embodiment, the present invention provides a method of
5 preparing a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (20a)



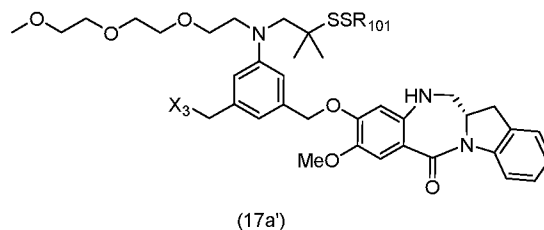
with a monomer compound of formula (d₁),



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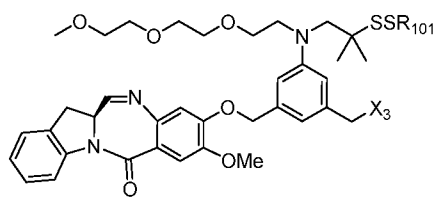
wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a thirty-third embodiment, the present invention provides a method of
preparing a compound of formula (17a'):



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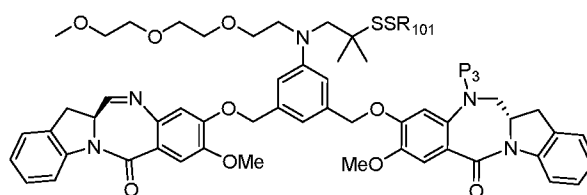
or a salt thereof, said method comprising reacting a compound of formula (16a)



(16a)

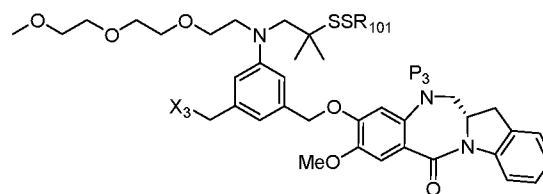
with an imine reducing agent, wherein X_3 is $-\text{Cl}$; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

In a thirty-fourth embodiment, the present invention provides a method of
5 preparing a compound of formula (18a),



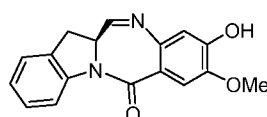
(18a)

or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (17a):



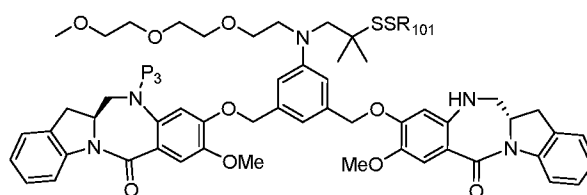
(17a)

10 with a monomer of formula (a_1):

(a₁)

wherein X_3 is $-\text{Cl}$; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

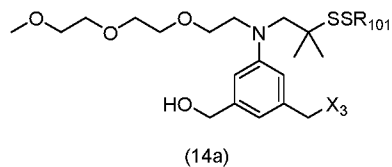
In a thirty-fifth embodiment, the present invention provides a method of
15 preparing a compound of formula (18a),



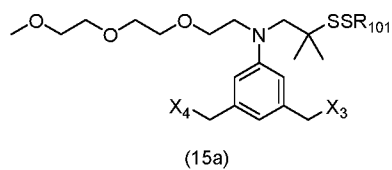
(18a)

or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

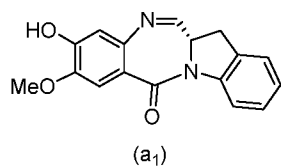


- 5 or a salt thereof, to form a compound of formula (15a):



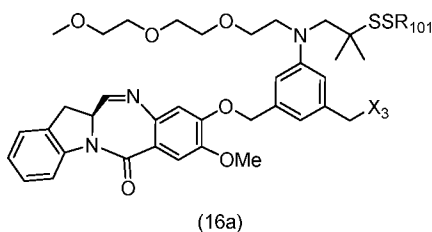
or a salt thereof;

- (2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),



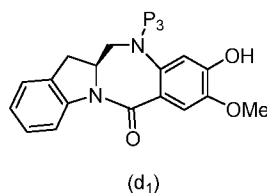
10

to form a compound of formula (16a):



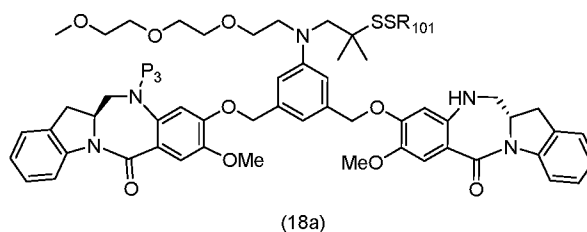
or a salt thereof; and

- (3) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



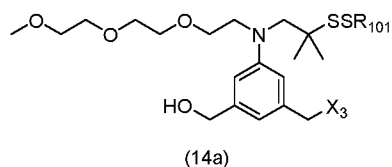
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X_3 is $-Cl$; X_4 is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P_1 is an alcohol protecting group; P_3 is H or an amine protecting group; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

- 5 In a thirty-sixth embodiment, the present invention provides a method of preparing a compound of formula (18a),



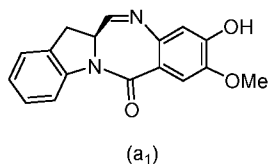
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting the compound of formula (14a):

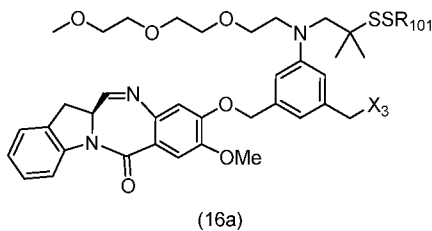


10

or a salt thereof, with a monomer compound of formula (a₁),

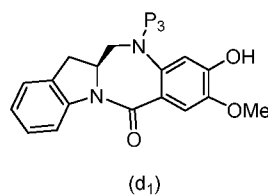


to form a compound of formula (16a):



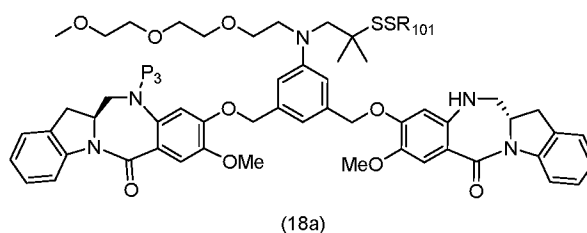
15 or a salt thereof; and

- (2) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



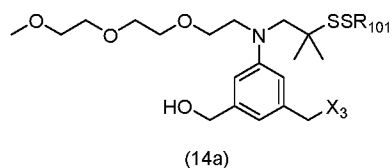
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X_3 is $-\text{Cl}$; P_1 is an alcohol protecting group; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

5 In a thirty-seventh embodiment, the present invention provides a method of preparing a compound of formula (18a),



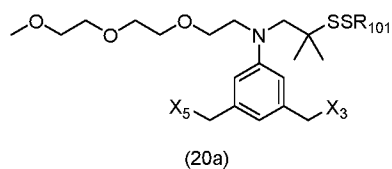
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent with the compound of formula (14a):



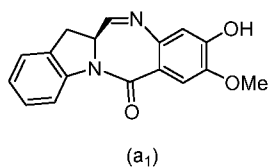
10

or a salt thereof, to form a compound of formula (20a):

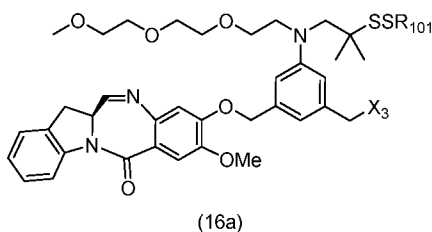


or a salt thereof;

(2) reacting a compound of formula (20a) or a salt thereof with a monomer
15 compound of formula (a₁),

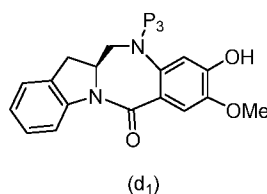


to form a compound of formula (16a):



or a salt thereof; and

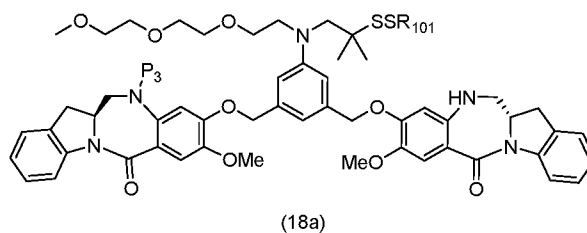
(3) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



5

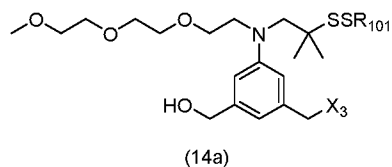
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a thirty-eighth embodiment, the present invention provides a method of preparing a compound of formula (18a),



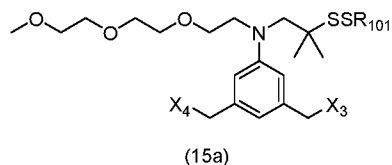
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):



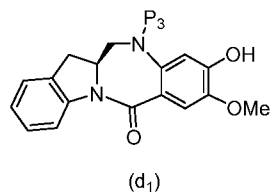
15

or a salt thereof, to form a compound of formula (15a):

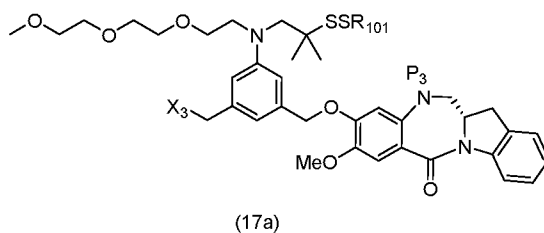


or a salt thereof;

(2) reacting the compound of formula (15a) with a reduced monomer compound of formula (d₁),

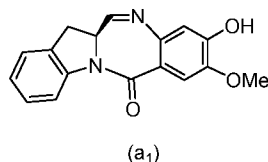


to form a compound of formula (17a):



or a salt thereof; and

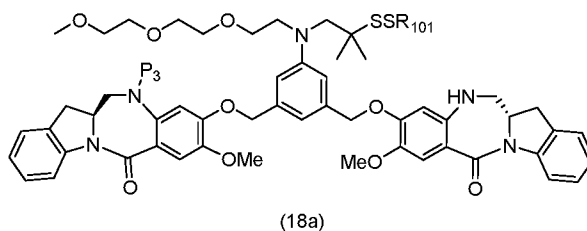
(3) reacting the compound of formula of (17a) with a monomer of formula (a₁):



to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof,

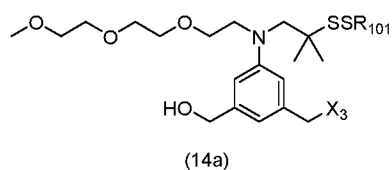
wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

In a thirty-ninth embodiment, the present invention provides method of preparing a compound of formula (18a),

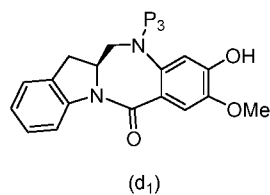


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

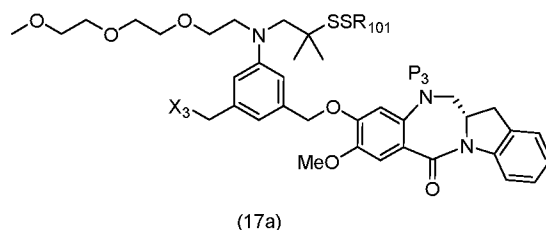
(1) reacting the compound of formula (14a):



or a salt thereof, with a reduced monomer compound of formula (d₁),

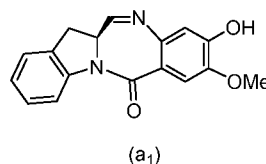


to form a compound of formula (17a):



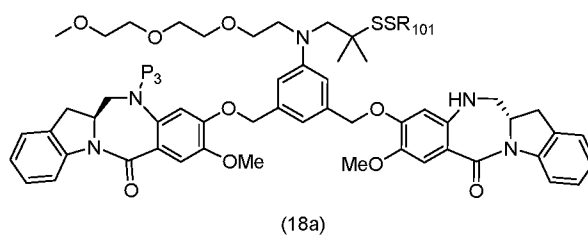
or a salt thereof; and

- 5 (2) reacting the compound of formula of (17a) with a monomer of formula (a₁):



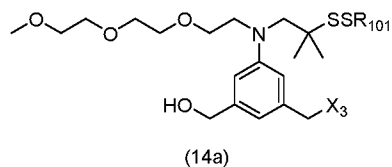
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

- 10 In a fortieth embodiment, the present invention provides a method of preparing a compound of formula (18a),

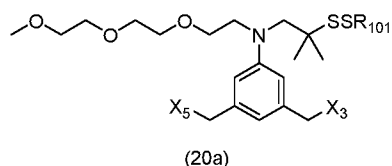


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- 15 (1) reacting a brominating or iodinating reagent with the compound of formula (14a):

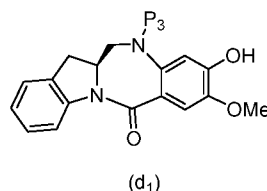


or a salt thereof, to form a compound of formula (20a):



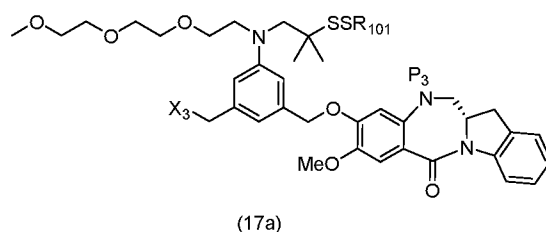
or a salt thereof;

(2) reacting the compound of formula (20a) with a reduced monomer compound of formula (d₁),



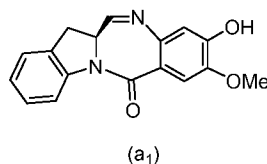
5

to form a compound of formula (17a):



or a salt thereof; and

(3) reacting the compound of formula of (17a) with a monomer of formula (a₁):

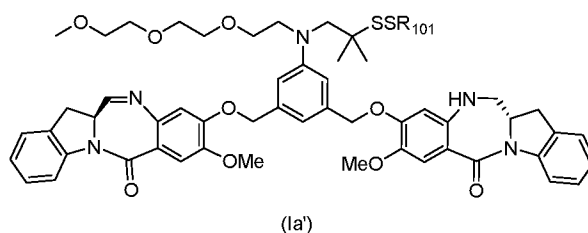


10

to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₅ is -Br or -I; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

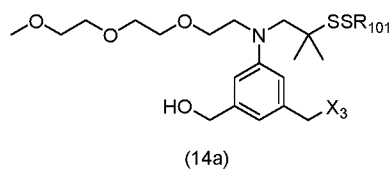
In a forty-first embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

15

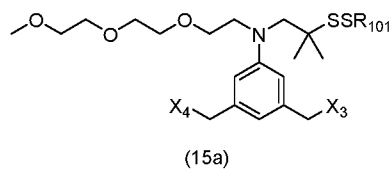


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

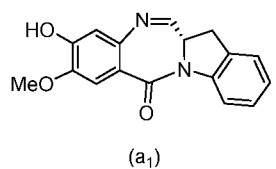


or a salt thereof, to form a compound of formula (15a):

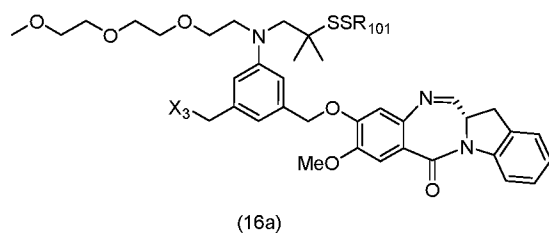


or a salt thereof;

- 5 (2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),

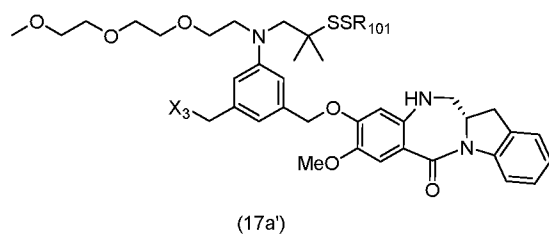


to form a compound of formula (16a):



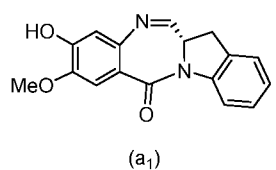
- 10 or a salt thereof;

(3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



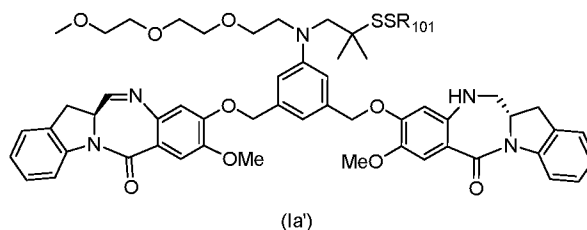
or a salt thereof; and

- 15 (4) reacting the compound of formula (17a') with a monomer of formula (a₁):



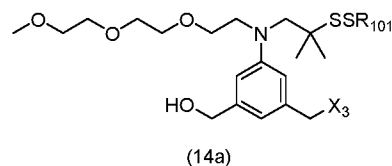
to form the compound of formula (Id'); wherein X_3 is $-Cl$; X_4 is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P_1 is an alcohol protecting group; P_2 is an amine protecting group; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

In a forty-second embodiment, the present invention provides a method of
5 preparing a compound of formula (Ia'),

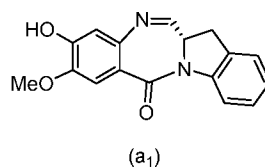


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

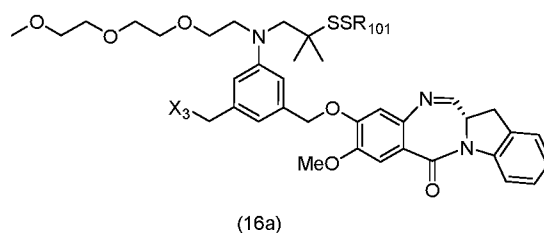
(1) reacting the compound of formula (14a):



10 or a salt thereof, with a monomer compound of formula (a₁),

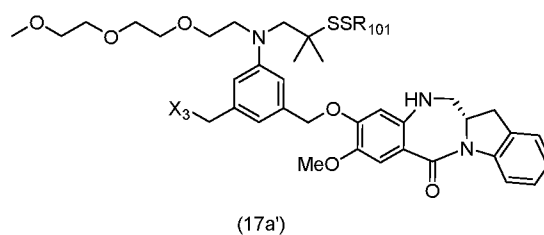


to form a compound of formula (16a):



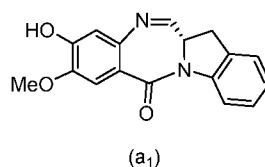
or a salt thereof;

15 (2) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



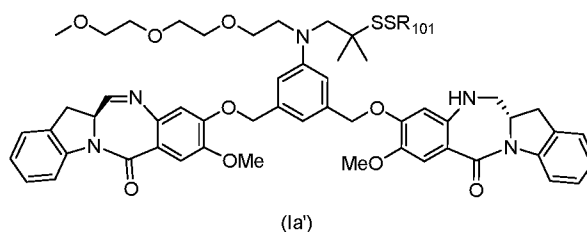
or a salt thereof; and

(3) reacting the compound of formula (17a') with a monomer of formula (a₁):



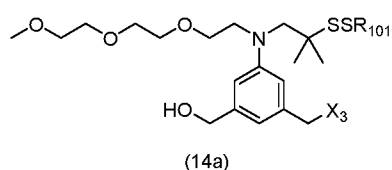
to form the compound of formula (Id'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

5 In a forty-third embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

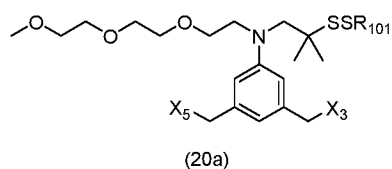


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a brominating or iodinating reagent with the compound of formula
10 (14a):

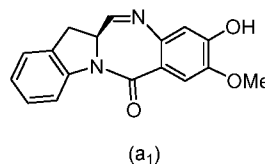


or a salt thereof, to form a compound of formula (20a):

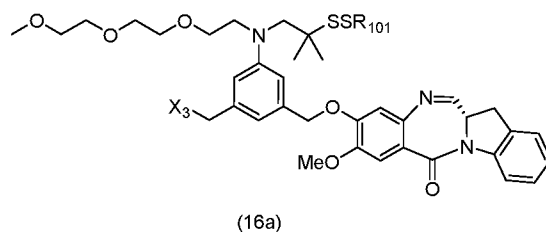


or a salt thereof;

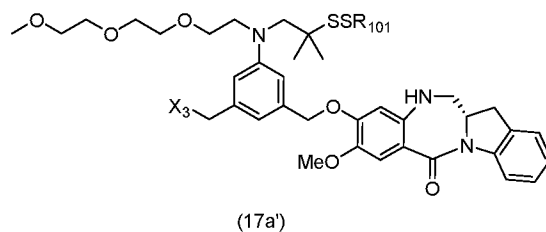
15 (2) reacting a compound of formula (20a) or a salt thereof with a monomer compound of formula (a₁),



to form a compound of formula (16a):

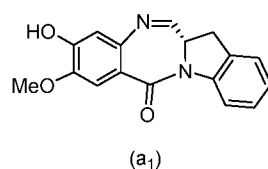


(3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



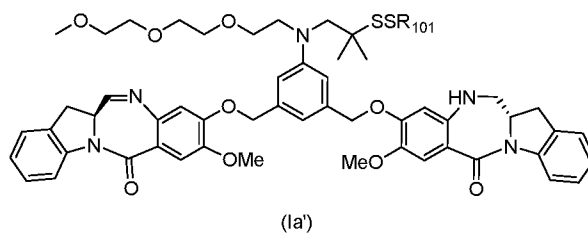
5 or a salt thereof; and

(4) reacting the compound of formula (17a') with a monomer of formula (a₁):



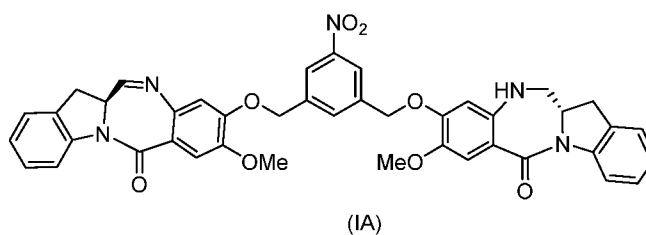
to form the compound of formula (Id'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

10 In a forty-fourth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



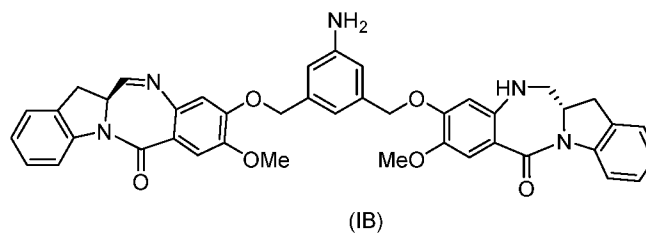
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a compound of formula (IA):



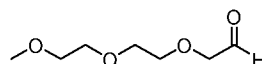
15

with a reducing agent to form a compound of formula (IB):

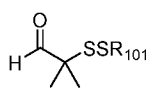


; and

(2) reacting the compound of formula (IB) with a compound of formula (L1a),



and a compound of formula (L1b):



in the presence of a reducing agent to form the compound of formula (Ia'), wherein R₁₀₁ is (C₁-C₃)alkyl.

Also included in the present invention are compounds described in the methods of the present invention.

10 BRIEF DESCRIPTION OF THE FIGURES

FIGs. 1–7 show exemplary schemes for the methods of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to certain embodiments of the invention, examples of which are illustrated in the accompanying structures and formulas. While the invention will be described in conjunction with the enumerated embodiments, it will be understood that they are not intended to limit the invention to those embodiments. On the contrary, the invention is intended to cover all alternatives, modifications, and equivalents which may be included within the scope of the present invention as defined by the claims. One skilled in the art will recognize many methods and materials similar or equivalent to those described herein, which could be used in the practice of the present invention.

It should be understood that any of the embodiments described herein can be combined with one or more other embodiments of the invention, unless explicitly disclaimed or improper. Combination of embodiments are not limited to those specific combinations claimed via the multiple dependent claims.

DEFINITIONS

“**Alkyl**” as used herein refers to a saturated linear or branched-chain monovalent hydrocarbon radical of one to twenty carbon atoms. Examples of alkyl include, but are not limited to, methyl, ethyl, 1-propyl, 2-propyl, 1-butyl, 2-methyl-1-propyl, -
5 $\text{CH}_2\text{CH}(\text{CH}_3)_2$, 2-butyl, 2-methyl-2-propyl, 1-pentyl, 2-pentyl 3-pentyl, 2-methyl-2-butyl, 3-methyl-2-butyl, 3-methyl-1-butyl, 2-methyl-1-butyl, 1-hexyl, 2-hexyl, 3-hexyl, 2-methyl-2-pentyl, 3-methyl-2-pentyl, 4-methyl-2-pentyl, 3-methyl-3-pentyl, 2-methyl-3-pentyl, 2,3-dimethyl-2-butyl, 3,3-dimethyl-2-butyl, 1-heptyl, 1-octyl, and the like. Preferably, the alkyl has one to ten carbon atoms. More preferably, the alkyl has one to
10 four carbon atoms.

“**Aryl**” means a monovalent aromatic hydrocarbon radical of 6-18 carbon atoms derived by the removal of one hydrogen atom from a single carbon atom of a parent aromatic ring system. Some aryl groups are represented in the exemplary structures as “Ar.” Aryl includes bicyclic radicals comprising an aromatic ring fused to a saturated,
15 partially unsaturated ring, or aromatic carbocyclic or heterocyclic ring. Typical aryl groups include, but are not limited to, radicals derived from benzene (phenyl), substituted benzenes, naphthalene, anthracene, indenyl, indanyl, 1,2-dihydronaphthalene, 1,2,3,4-tetrahydronaphthyl, and the like. Preferably, aryl is phenyl group.

The term “**halo**” or “**halogen**” refers to F, Cl, Br or I. In one embodiment, the
20 halogen is Br or I.

The term “**compound**” or “**cytotoxic compound**,” “**cytotoxic dimer**” and “**cytotoxic dimer compound**” are used interchangeably. They are intended to include compounds for which a structure or formula or any derivative thereof has been disclosed in the present invention or a structure or formula or any derivative thereof that has been
25 incorporated by reference. The term also includes, stereoisomers, geometric isomers, tautomers, solvates, metabolites, salts (*e.g.*, pharmaceutically acceptable salts) and prodrugs, and prodrug salts of a compound of all the formulae disclosed in the present invention. The term also includes any solvates, hydrates, and polymorphs of any of the foregoing. The specific recitation of “stereoisomers,” “geometric isomers,” “tautomers,”
30 “solvates,” “metabolites,” “salt” “prodrug,” “prodrug salt,” “conjugates,” “conjugates salt,” “solvate,” “hydrate,” or “polymorph” in certain aspects of the invention described in this application shall not be interpreted as an intended omission of these forms in other aspects of the invention where the term “compound” is used without recitation of

these other forms.

The term “**precursor**” of a given group refers to any group which may lead to that group by any deprotection, a chemical modification, or a coupling reaction.

The term “**chiral**” refers to molecules which have the property of non-
5 superimposability of the mirror image partner, while the term “achiral” refers to molecules which are superimposable on their mirror image partner.

The term “**stereoisomer**” refers to compounds which have identical chemical constitution and connectivity, but different orientations of their atoms in space that cannot be interconverted by rotation about single bonds.

10 “**Diastereomer**” refers to a stereoisomer with two or more centers of chirality and whose molecules are not mirror images of one another. Diastereomers have different physical properties, *e.g.* melting points, boiling points, spectral properties, and reactivities. Mixtures of diastereomers may separate under high resolution analytical procedures such as crystallization, electrophoresis and chromatography.

15 “**Enantiomers**” refer to two stereoisomers of a compound which are non-superimposable mirror images of one another.

Stereochemical definitions and conventions used herein generally follow S. P. Parker, Ed., McGraw-Hill Dictionary of Chemical Terms (1984) McGraw-Hill Book Company, New York; and Eliel, E. and Wilen, S., “Stereochemistry of Organic
20 Compounds,” John Wiley & Sons, Inc., New York, 1994. The compounds of the invention may contain asymmetric or chiral centers, and therefore exist in different stereoisomeric forms. It is intended that all stereoisomeric forms of the compounds of the invention, including but not limited to, diastereomers, enantiomers and atropisomers, as well as mixtures thereof such as racemic mixtures, form part of the present invention.
25 Many organic compounds exist in optically active forms, *i.e.*, they have the ability to rotate the plane of plane-polarized light. In describing an optically active compound, the prefixes D and L, or R and S, are used to denote the absolute configuration of the molecule about its chiral center(s). The prefixes d and l or (+) and (-) are employed to designate the sign of rotation of plane-polarized light by the compound, with (-) or l
30 meaning that the compound is levorotatory. A compound prefixed with (+) or d is dextrorotatory. For a given chemical structure, these stereoisomers are identical except that they are mirror images of one another. A specific stereoisomer may also be referred to as an enantiomer, and a mixture of such isomers is often called an enantiomeric

mixture. A 50:50 mixture of enantiomers is referred to as a racemic mixture or a racemate, which may occur where there has been no stereoselection or stereospecificity in a chemical reaction or process. The terms “racemic mixture” and “racemate” refer to an equimolar mixture of two enantiomeric species, devoid of optical activity.

5 The term “**tautomer**” or “**tautomeric form**” refers to structural isomers of different energies which are interconvertible via a low energy barrier. For example, proton tautomers (also known as prototropic tautomers) include interconversions via migration of a proton, such as keto-enol and imine-enamine isomerizations. Valence tautomers include interconversions by reorganization of some of the bonding electrons.

10 As used herein, the term “**imine reducing reagent**” refers to a reagent that is capable of reducing an imine functional group to an amine functional group. In certain embodiments, the imine reducing reagent is a hydride reducing reagent. Examples of such imine reducing reagents include, but are not limited to, borohydrides (*e.g.*, sodium borohydride, sodium triacetoxy borohydride, sodium cyanoborohydride, lithium
15 borohydride (LiBH₄), potassium borohydride (KBH₄)), hydrogen gas, and lithium aluminum hydride, ammonium formate, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminium hydride (DIBAL), and sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al). In certain embodiments, the imine reducing reagent is sodium triacetoxy borohydride.

20 The term “**protecting group**” or “**protecting moiety**” refers to a substituent that is commonly employed to block or protect a particular functionality while reacting other functional groups on the compound, a derivative thereof, or a conjugate thereof. For example, an “**amine protecting group**” or an “**amino-protecting moiety**” is a substituent attached to an amino group that blocks or protects the amino functionality in
25 the compound. Such groups are well known in the art (see for example P. Wuts and T. Greene, 2007, Protective Groups in Organic Synthesis, Chapter 7, J. Wiley & Sons, NJ) and exemplified by carbamates such as methyl and ethyl carbamate, Fmoc, substituted ethyl carbamates, carbamates cleaved by 1,6-β-elimination (also termed “**self immolative**”), ureas, amides, peptides, alkyl and aryl derivatives. Suitable amino-
30 protecting groups include, but are not limited to, acetyl, trifluoroacetyl, t-butoxycarbonyl (BOC), benzyloxycarbonyl (CBZ) and 9-fluorenylmethylenoxycarbonyl (Fmoc), 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-

(trimethylsilyl)ethoxycarbonyl, or 2, 2,2,2-trichloroethoxycarbonyl. For a general description of protecting groups and their use, *see* P. G.M. Wuts & T. W. Greene, Protective Groups in Organic Synthesis, John Wiley & Sons, New York, 2007.

An “**alcohol protecting group**” or an “**alcohol-protecting moiety**” is a
5 substituent attached to an alcohol group that blocks or protects the alcohol functionality in the compound. Such groups are well known in the art (see for example, P. Wuts and T. Greene, 2007, Protective Groups in Organic Synthesis, Chapter 2, J. Wiley & Sons, NJ). Suitable alcohol protecting group include, but are not limited to, pivaloyl, methoxymethyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, 3,4-dimethoxybenzyl,
10 2,6-dimethoxybenzyl, diphenylmethyl, benzyloxymethyl, 2,2,2-trichloroethoxycarbonyl, tetrahydrofuranyl, tetrahydropyranyl, benzyl, benzoyl, *para*-phenylbenzoyl, 2,4,6-trimethylbenzoyl, *para*-bromobenzoyl, *para*-nitrobenzoyl, picolinoyl, nicotinoyl, 5-dibenzosuberyl, trityl/triphenylmethyl, or tris(4-*tert*-butylphenyl)methyl and various silyl protecting groups (for example,
15 dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl). In certain embodiments, the alcohol protecting group is sterically hindered. In certain embodiments, the alcohol protecting group is preferably
20 methoxymethyl, tetrahydropyranyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, benzyloxymethyl, or 2,2,2-trichloroethoxycarbonyl. More preferably, the alcohol protecting group is 2,2,2-trichloroethoxycarbonyl. In certain embodiments, the alcohol protecting group is a silyl protecting group, preferably, triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl. More preferably, the alcohol protecting group is *tert*-
25 butyldimethylsilyl.

An “**alcohol protecting reagent**” as used herein refers to a reagent that introduces an alcohol protecting group onto an alcohol group.

An “**acid labile alcohol protecting group**” is an alcohol protecting group that is not stable under acidic condition and releases the alcohol protecting group to form free
30 alcohol. Examples of an acid labile alcohol protecting group include, but are not limited to, acetate, allyl, methoxymethyl, tetrahydrofuranyl, tetrahydropyranyl, 5-dibenzosuberyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, 2-(phenylselenyl)ethyl, trityl/triphenylmethyl, tris(4-*tert*-butylphenyl)methyl, and various silyl protecting group

(for example, dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, or 2-trimethylethylsilyl (TEOC), [2-(trimethylsilyl)ethoxy]methyl). In certain embodiments, the alcohol protecting group is a silyl protecting group, preferably, triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl. More preferably, the alcohol protecting group is *tert*-butyldimethylsilyl.

As used herein, the term “**alcohol deprotecting reagent**” refers to a reagent that is capable of cleaving an alcohol protecting group to form free alcohol. Such reagents are well known in the art (see for example P. Wuts and T. Greene, 2007, Protective Groups in Organic Synthesis, Chapter 2, J. Wiley & Sons, NJ). Examples of such alcohol deprotecting reagents include, but are not limited to, tetra-*n*-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, trifluoroacetic acid, pyridinium *p*-toluenesulfonate, *p*-toluenesulfonic acid (*p*-TsOH), formic acid, periodic acid. In certain embodiments, the alcohol deprotecting reagent is hydrochloric acid or tetra-*n*-butylammonium fluoride (TBAF). In certain embodiments, the alcohol deprotecting agent is hydrogen fluoride-pyridine (HF-pyridine).

As used herein, “**amine deprotecting group**” refers a reagent that is capable of cleaving an amine protecting group to form free amine. Such reagents are well known in the art (see for example P. Wuts and T. Greene, 2007, Protective Groups in Organic Synthesis, Chapter 7, J. Wiley & Sons, NJ). Examples of such amine deprotecting reagents include, but are not limited to, tetra-*n*-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

As used herein, “**alcohol activating agent**” refers a reagent that increases the reactivity of a hydroxyl group thereby making the hydroxyl group a better leaving group. Examples of such alcohol activating agents include *p*-toluenesulfonyl chloride, thionyl chloride, triflic anhydride, mesyl chloride, mesyl anhydride, triphenylphosphine, acyl chloride, 4-dimethylaminopyridine, and others. In certain embodiments, the alcohol activating agent is thionyl chloride. In certain embodiment, the alcohol activating agent is a trialkyl phosphine, triarylphosphine, or triheteroarylphosphine. In a

specific embodiment, the alcohol activating agent is trimethylphosphine, tributylphosphine, tri(o-tolyl)phosphine, tri(m-tolyl)phosphine, tri(p-tolyl)phosphine, tri(2-pyridyl)phosphine, tri(3-pyridyl)phosphine, or tri(4-pyridyl)phosphine. In a more specific embodiment, the alcohol activating agent is triphenylphosphine.

5 The phrase “**pharmaceutically acceptable salt**” as used herein, refers to pharmaceutically acceptable organic or inorganic salts of a compound of the invention. Exemplary salts include, but are not limited, to sulfate, citrate, acetate, oxalate, chloride, bromide, iodide, nitrate, bisulfate, phosphate, acid phosphate, isonicotinate, lactate, salicylate, acid citrate, tartrate, oleate, tannate, pantothenate, bitartrate, ascorbate,
10 succinate, maleate, gentisinate, fumarate, gluconate, glucuronate, saccharate, formate, benzoate, glutamate, methanesulfonate “mesylate,” ethanesulfonate, benzenesulfonate, p-toluenesulfonate, pamoate (*i.e.*, 1,1'-methylene-bis-(2-hydroxy-3-naphthoate)) salts, alkali metal (*e.g.*, sodium and potassium) salts, alkaline earth metal (*e.g.*, magnesium) salts, and ammonium salts. A pharmaceutically acceptable salt may involve the
15 inclusion of another molecule such as an acetate ion, a succinate ion or other counter ion. The counter ion may be any organic or inorganic moiety that stabilizes the charge on the parent compound. Furthermore, a pharmaceutically acceptable salt may have more than one charged atom in its structure. Instances where multiple charged atoms are part of the pharmaceutically acceptable salt can have multiple counter ions. Hence, a
20 pharmaceutically acceptable salt can have one or more charged atoms and/or one or more counter ion.

 If the compound of the invention is a base, the desired pharmaceutically acceptable salt may be prepared by any suitable method available in the art, for example, treatment of the free base with an inorganic acid, such as hydrochloric acid,
25 hydrobromic acid, sulfuric acid, nitric acid, methanesulfonic acid, phosphoric acid and the like, or with an organic acid, such as acetic acid, maleic acid, succinic acid, mandelic acid, fumaric acid, malonic acid, pyruvic acid, oxalic acid, glycolic acid, salicylic acid, a pyranosidyl acid, such as glucuronic acid or galacturonic acid, an alpha hydroxy acid, such as citric acid or tartaric acid, an amino acid, such as aspartic acid or glutamic acid,
30 an aromatic acid, such as benzoic acid or cinnamic acid, a sulfonic acid, such as p-toluenesulfonic acid or ethanesulfonic acid, or the like.

 If the compound of the invention is an acid, the desired pharmaceutically acceptable salt may be prepared by any suitable method, for example, treatment of the

free acid with an inorganic or organic base, such as an amine (primary, secondary or tertiary), an alkali metal hydroxide or alkaline earth metal hydroxide, or the like.

Illustrative examples of suitable salts include, but are not limited to, organic salts derived from amino acids, such as glycine and arginine, ammonia, primary, secondary, and tertiary amines, and cyclic amines, such as piperidine, morpholine and piperazine, and inorganic salts derived from sodium, calcium, potassium, magnesium, manganese, iron, copper, zinc, aluminum and lithium.

The phrase “**pharmaceutically acceptable**” indicates that the substance or composition must be compatible chemically and/or toxicologically, with the other ingredients comprising a formulation, and/or the mammal being treated therewith.

The term “**leaving group**” refers to a group of charged or uncharged moiety that departs during a nucleophilic substitution or displacement. Such leaving groups are well known in the art and include, but not limited to, halogens, esters, alkoxy, hydroxyl, tosylates, triflates, mesylates, nitriles, azide, carbamate, disulfides, thioesters, thioethers and diazonium compounds.

As used herein, the term “**halogenating reagent**” refers to a reagent that converts an alcohol group to a halide group. A “**brominating reagent**” is a reagent that converts an alcohol group to a bromide group. A “**iodinating reagent**” is a reagent that converts an alcohol group to a iodide group. A “**chlorinating reagent**” is a reagent that converts an alcohol group to a chloride group. Exemplary brominating reagents include, but are not limited to, bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, and potassium bromide. Exemplary iodinating reagent include, but are not limited to, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide. Exemplary chlorinating reagent include, but are not limited to, carbon tetrachloride, methanesulfonyl chloride, sulfuryl chloride, thionyl chloride, cyanuric chloride, *N*-chlorosuccinimide, phosphorus(V) oxychloride, phosphorus pentachloride, and phosphorus trichloride. In a specific embodiment, the chlorinating reagent is methanesulfonyl chloride.

As used herein, a “**sulfonating reagent**” refers to a reagent that converts an alcohol group to a sulfonate ester group. Preferably, the sulfonating reagent is a sulfonic anhydride, such as methanesulfonic anhydride, or a sulfonic chloride, such as methanesulfonyl chloride (MsCl).

As used herein, an “**activated ester**” refers to an ester group that is readily

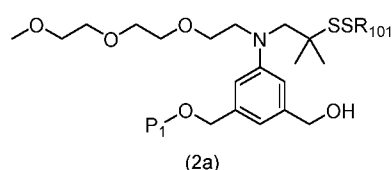
displaced by a hydroxyl or an amine group. Exemplary activated esters include, but are not limited to nitrophenyl (*e.g.*, 2 or 4-nitrophenyl) ester, dinitrophenyl (*e.g.*, 2,4-dinitrophenyl) ester, sulfo-tetrafluorophenyl (*e.g.*, 4-sulfo-2,3,5,6-tetrafluorophenyl) ester, pentafluorophenyl ester, nitropyridyl (*e.g.*, 4-nitropyridyl) ester, trifluoroacetate, and acetate.

As used herein, an “**esterification reagent**” refers to a reagent that converts an alcohol group to an ester group. Exemplary esterification reagent include, but are not limited to, nitrobenzoid acid (*e.g.*, 2 or 4-nitrobenzoic acid), dinitrobenzoid acid (*e.g.*, 2,4-dinitrobenzoic acid), sulfo-tetrafluorobenzoid acid (*e.g.*, 4-sulfo-2,3,5,6-tetrafluorobenzoid acid), pentafluorobenzoid acid, nitropyridine carboxylic acid (*e.g.*, 4-nitro-2-pyridine carboxylic acid, trifluoroacetic acid, and acetic acid, or acyl chloride, acid anhydride or other activated carboxylic acid derivatives thereof.

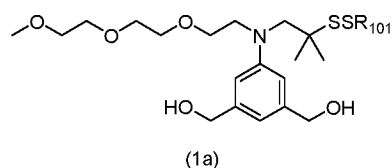
METHODS OF THE PRESENT INVENTION

The present invention provides novel methods for preparing indolinobenzodiazepine dimer compounds that have one imine functionality and one amine functionality. As compared to the methods known in the art, the present methods can produce the desired dimer compounds with higher yield and without the use of HPLC purification.

In a first embodiment, the present invention provides a method of preparing a compound of formula (2a),



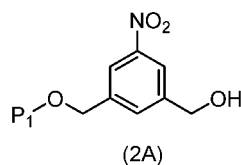
or a salt thereof, said method comprising introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a) by reacting the compound of formula (1a) with an alcohol protecting reagent,



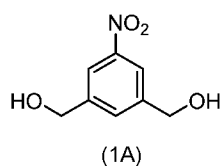
wherein P₁ is the alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the first embodiment is a method of preparing a compound of

formula (2A),



or a salt thereof, comprising introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1A) by reacting the compound of formula
5 (1A) with an alcohol protecting reagent,



wherein P₁ is the alcohol protecting group.

In a specific embodiment, for methods of preparing compound of formula (2a) or (2A) described above the alcohol protecting group is sterically hindered.

10 In another specific embodiment, the alcohol protecting group is pivaloyl, methoxymethyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, 3,4-dimethoxybenzyl, 2,6-dimethoxybenzyl, diphenylmethyl, benzyloxymethyl, 2,2,2-trichloroethoxycarbonyl, tetrahydrofuranyl, tetrahydropyranyl, benzyl, benzoyl, *para*-phenylbenzoyl, 2,4,6-trimethylbenzoyl, *para*-bromobenzoyl, *para*-nitrobenzoyl,
15 picolinoyl, nicotinoyl, 5-dibenzosuberyl, trityl/triphenylmethyl, or tris(4-*tert*-butylphenyl)methyl. Preferably, the alcohol protecting group is methoxymethyl, tetrahydropyranyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, benzyloxymethyl, or 2,2,2-trichloroethoxycarbonyl. Even more preferably, the alcohol protecting group is 2,2,2-trichloroethoxycarbonyl.

20 In another specific embodiment, the alcohol protecting group is a silyl protecting group. For example, the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl. Preferably, the silyl
25 protecting group is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl. More preferably, the silyl protecting group is *tert*-butyldimethylsilyl.

The silyl protecting group can be introduced by reacting the compound of formula (1a) or (1A) with R³-Cl, R³-Br, R³-I or R³-OSO₂CF₃ (collectively the alcohol

protecting reagent) in the presence of a base, wherein R^3 is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl or [2-(trimethylsilyl)ethoxy]methyl. In certain embodiments, the molar ratio of the alcohol protecting reagent to the compound of formula (1a) or (1A) is between 0.8-1.2, between 1 to 5, between 1 to 2, between 1 to 1.5, between 1 to 1.4, between 1 to 1.3, between 1 to 1.2, or between 1 to 1.1. In certain embodiment, less than 2 molar equivalents of the alcohol protecting reagent is used relative to the compound of formula (1a) or (1A). Preferably, 1.5, 1.4, 1.3, 1.2, 1.1 or 1.0 molar equivalent of the alcohol protecting reagent relative to the compound of formula (1a) or (1A) is used.

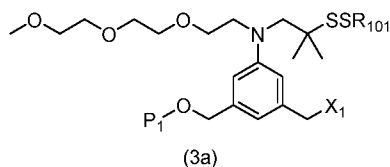
In one embodiment, the base can be a non-nucleophilic base. Examples of non-nucleophilic base include, but are not limited to, imidazole, triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, 1,8-diazabicycloundec-7-ene, or tetramethylpiperidine. Preferably, the non-nucleophilic base is imidazole. Molar excess amount of the base can be used. In certain embodiments, more than 2 molar equivalents of the base (e.g., non-nucleophilic base) are used relative to the compound of formula (1a) or (1A).

In another embodiment, the reaction between the compound of formula (1a) or (1A) and R^3 -Cl, R^3 -Br, R^3 -I or R^3 -OSO₂CF₃ is carried out in the presence of a catalyst that facilitates the introduction of the silyl protecting group. Any suitable catalysts known in the art (see, for example, P. Wuts and T. Greene, 2007, Protective Groups in Organic Synthesis, Chapter 2, J. Wiley & Sons, NJ) can be used in the reaction. Exemplary catalysts include, but are not limited to, 4-dimethylaminopyridine (DMAP), 1,1,3,3-tetramethylguanidine and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU).

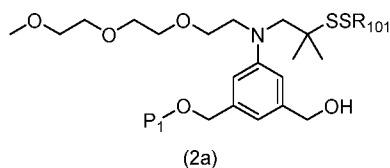
Any suitable organic solvents can be used for the methods of the first embodiment. Exemplary solvents include, but are not limited to, DMF, CH₂Cl₂, dichloroethane, THF, dimethylacetamide, etc. In certain embodiments, DMF is used as the solvent.

In another specific embodiment, the method of preparing the compound of formula (2a) or (2A) comprising reacting the compound of (1a) or (1A) with TBSCl in the presence of a non-nucleophilic base. In one embodiment, the base is imidazole or DIPEA. In a specific embodiment, the base is imidazole. In another specific embodiment, the base is DIPEA.

In a second embodiment, the present invention provides a method of preparing a compound of formula (3a),

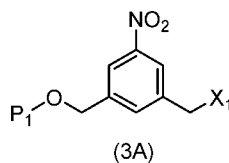


or a salt thereof, said method comprising reacting a halogenating reagent, a
5 sulfonating reagent or an esterification reagent with a compound of formula (2a),

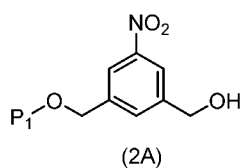


wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the second embodiment is a method of preparing a compound
10 of formula (3A),



or a salt thereof, comprising reacting the compound of formula (2A) with a halogenating reagent, a sulfonating reagent or an esterification reagent,



15 wherein P₁ and R₁₀₀ are as defined in the first embodiment, and X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl a sulfonate ester, and an activated ester.

In a specific embodiment, for methods of preparing compound of formula (3d) or
20 (3A) described above, X₁ is -Br, -I or a sulfonate ester.

In a specific embodiment, for methods of making compound of formula (3a) or (3A) described above, X₁ is mesylate, tosylate, brosylate, or triflate. Preferably, X₁ is mesylate.

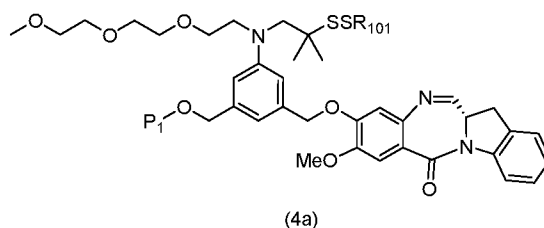
In another specific embodiment, the method of the second embodiment comprises reacting the compound of formula (2a) or (2A) with a halogenating reagent. Exemplary halogenating reagents include, but are not limited to, bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.

In yet another specific embodiment, the method of the second embodiment comprises reacting the compound of formula (2a) or (2A) with a sulfonating reagent. Preferably, the sulfonating reagent is a sulfonic anhydride, such as methanesulfonic anhydride, or a sulfonic chloride, such as methanesulfonyl chloride (MsCl).

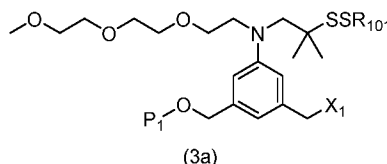
In certain embodiment, the reaction between the compound of formula (2d) or (2A) and the sulfonating reagent can be carried out in the presence of a base. In one embodiment, the base is a non-nucleophilic base. Exemplary non-nucleophilic bases include, but are not limited to, triethylamine, imidazole, triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine. Preferably, the base is triethylamine or diisopropylethylamine.

Any suitable organic solvents can be used in the method of the second embodiment. In one embodiment, the solvent is dichloromethane.

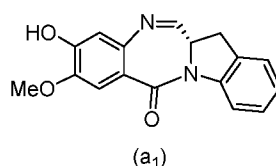
In a third embodiment, the present invention provides a method of preparing a compound of formula (4a),



or a salt thereof, said method comprising reacting a compound of formula (3a)

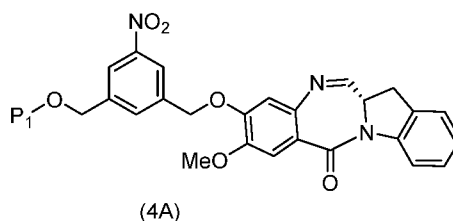


with a monomer compound of the formula (a₁),

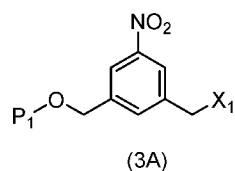


wherein P_1 is an alcohol protecting group; X_1 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester; and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

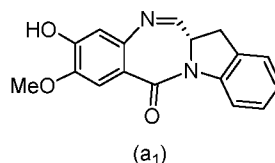
Also provided in the third embodiment is a method of preparing a compound of
5 formula (4A),



or a salt thereof, said method comprising reacting a compound of formula (3A)



with a monomer compound of the formula (a₁),



10

wherein P_1 is an alcohol protecting group; and X_1 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester.

In a specific embodiment, for methods of the third embodiment, X_1 is -Br, -I, or a sulfonate ester.

15 In a specific embodiment, for method of preparing compound of formula (4a) or (4A), the compound of formula (3a) or (3A) is reacted with the monomer compound of formula (a₁) in the presence of a base. Any suitable base can be used. Exemplary bases include, but are not limited to, sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. In one embodiment, the base is
20 potassium carbonate.

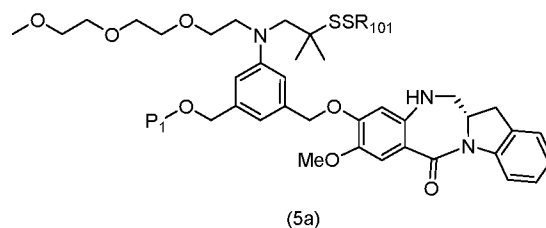
Any suitable solvents can be use in the method of third embodiment. In one embodiment, the solvent is dimethylacetamide (DMA).

In a specific embodiment, the method of preparing compound of formula (4a) or (4A) described above comprises reacting the compound of formula (3a) or (3A) with the

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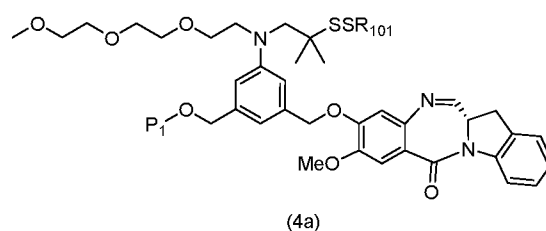
monomer compound (a₁) in the presence of potassium carbonate in DMA. In one embodiment, the reaction is carried out in the presence of potassium iodide.

In a fourth embodiment, the present invention provides a method of preparing a compound of formula (5a),



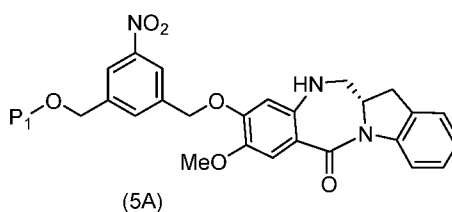
5

or a salt thereof, said method comprising reacting a compound of formula (4a),

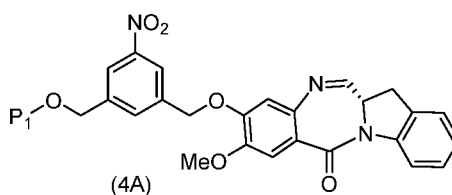


with an imine reducing agent, wherein P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the fourth embodiment is a method of preparing a compound of formula (5A),



or a salt thereof, said method comprising reacting a compound of formula (4A),



with an imine reducing agent, wherein the variables are as described above in the third embodiment.

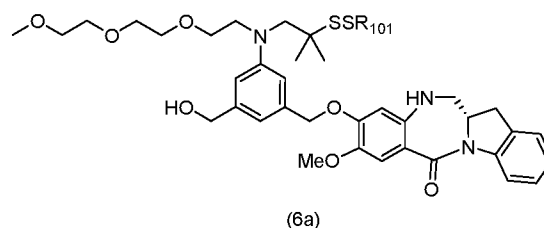
In a specific embodiment, for methods of preparing compound of formula (5a) or (5A) described above, the imine reducing reagent is a hydride reducing reagent.

In another specific embodiment, the imine reducing reagent is sodium borohydride, sodium triacetoxy borohydride, sodium cyanoborohydride, lithium aluminum hydride, hydrogen gas, ammonium formate, borane, 9-

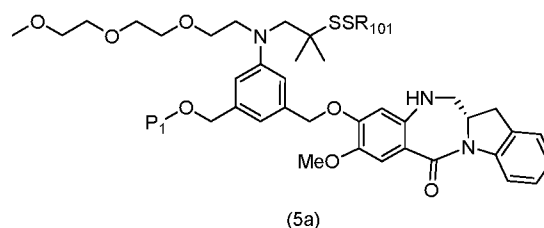
borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminium hydride (DIBAL), lithium borohydride (LiBH_4), potassium borohydride (KBH_4), or sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al). Preferably, the imine reducing reagent is sodium triacetoxy borohydride ($\text{NaBH}(\text{OAc})_3$).

5 Any suitable solvents can be use in the method of fourth embodiment. In one embodiment, the solvent is dichloroethane.

In a fifth embodiment, the present invention provides method of preparing a compound of formula (6a),

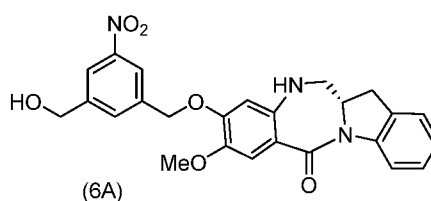


10 or a salt thereof, said method comprising reacting a compound of formula (5a),

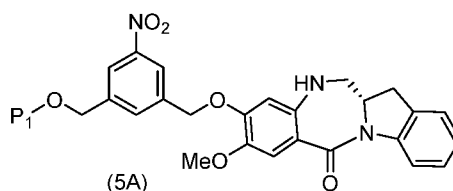


with an alcohol deprotecting reagent, wherein P_1 is an alcohol protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

Also provided in the fifth embodiment is a method of preparing a compound of
15 formula (6A),



or a salt thereof, said method comprising reacting a compound of formula (5A),

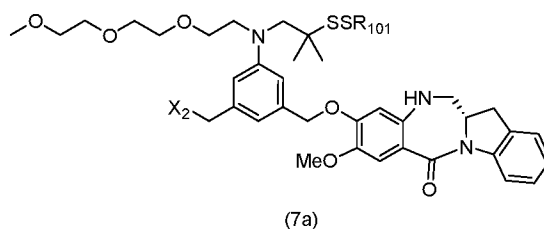


with an alcohol deprotecting reagent, wherein the variables are as described above in the
20 fourth embodiment.

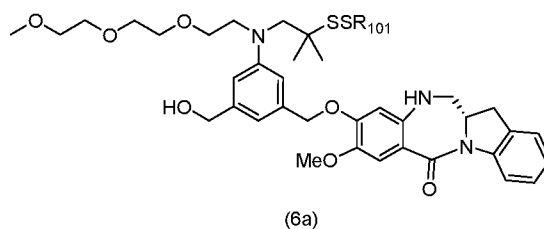
In a specific embodiment, for methods of preparing a compound of formula (6a) or (6A) described above, the alcohol deprotecting reagent is tetra-n-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, trifluoroacetic acid, pyridinium p-toluenesulfonate, p-toluenesulfonic acid (p-TsOH), formic acid, or periodic acid. Preferably, the alcohol deprotecting reagent is hydrochloric acid or tetra-n-butylammonium fluoride. In a more specific embodiment, the alcohol deprotecting reagent is aqueous hydrochloric acid.

Any suitable solvents can be used in the deprotection reaction described above. In one embodiment, the solvent is THF.

In a sixth embodiment, the present invention provides a method of preparing a compound of formula (7a),

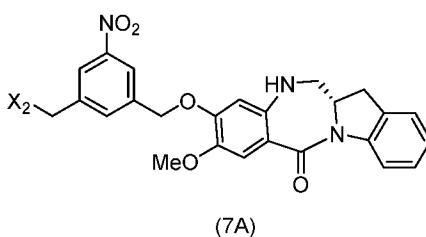


or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the primary alcohol compound of formula (6a),

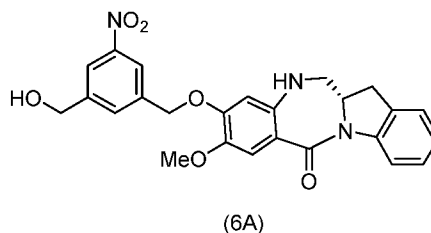


wherein X_2 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester; and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the sixth embodiment is a method of preparing a compound of formula (7A),



or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the primary alcohol compound of formula (6A),



wherein X_2 is $-\text{Br}$, $-\text{I}$, $-\text{Cl}$, a sulfonate ester or an activated ester; and the remaining variables are as described above in the fifth embodiment

In a specific embodiment, for methods of preparing a compound of formula (7d) or (7A), X_2 is $-\text{Br}$, $-\text{I}$ or a sulfonate ester.

In a specific embodiment, for methods of preparing a compound of formula (7a) or (7A), X_2 is mesylate, tosylate, brosylate, or triflate. Preferably, X_2 is mesylate.

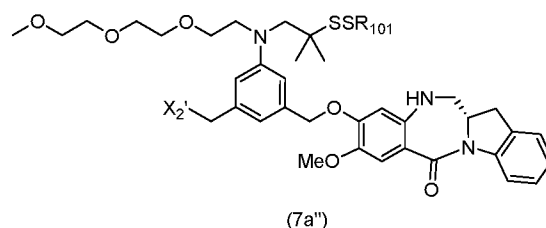
In another specific embodiment, the method of the sixth embodiment comprises reacting the compound of formula (6a) or (6A) with a halogenating reagent. Exemplary halogenating reagent include, but are not limited to, bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.

In yet another specific embodiment, the method of the sixth embodiment comprises reacting the compound of formula (6a) or (6A) with a sulfonating reagent. Preferably, the sulfonating reagent is a sulfonic anhydride, such as methanesulfonic anhydride, or a sulfonic chloride, such as methanesulfonyl chloride (MsCl).

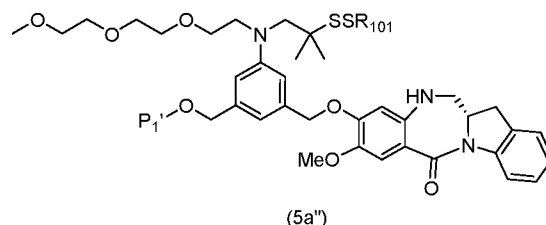
In one embodiment, the reaction between the compound of formula (6a) or (6A) and the sulfonating reagent is carried out in the presence of a base. Preferably, the base is a non-nucleophilic base. Exemplary non-nucleophilic base include, but are not limited to, triethylamine, imidazole, triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine. Preferably, the base is triethylamine or diisopropylethylamine.

Any suitable solvents can be used in the reactions described in the sixth embodiment above. In one embodiment, the solvent is dichloromethane. In another embodiment, the solvent is DMF. In yet another embodiment, the solvent is a mixture of dichloromethane and DMF.

In a seventh embodiment, the present invention provides a method of preparing a compound of formula (7a'')

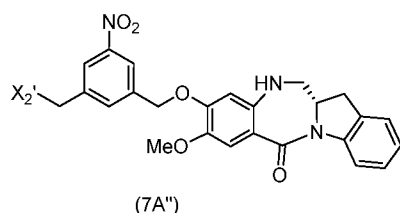


or a salt thereof, said method comprising reacting a compound of formula (5a'')

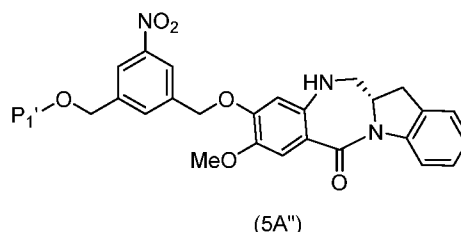


with an alcohol deprotecting reagent and a halogenating reagent, wherein P₁' is an acid labile alcohol protecting group; X₂' is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl..

Also provided in the seventh embodiment is a method of preparing a compound of formula (7A'')



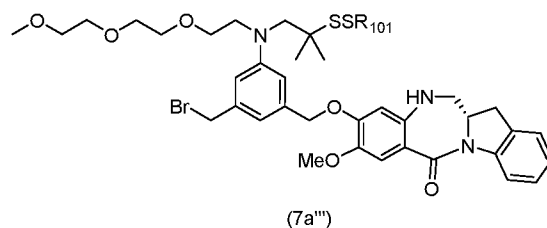
or a salt thereof, said method comprising reacting a compound of formula (5A'')



with an alcohol deprotecting reagent and a halogenating reagent, wherein P₁' is an acid labile alcohol protecting group; X₂' is -Br or -I; and the remaining variables are as described above in the sixth embodiment.

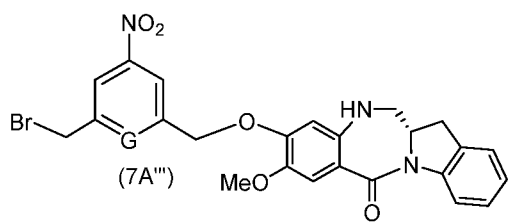
The method of the seventh embodiment combines the alcohol deprotection step described in the fifth embodiment and the halogenation reaction of the resulting alcohol described in the sixth embodiment into one step.

In a specific embodiment, for the method of the seventh embodiment, the compound of formula (7a'') is represented by the following formula:

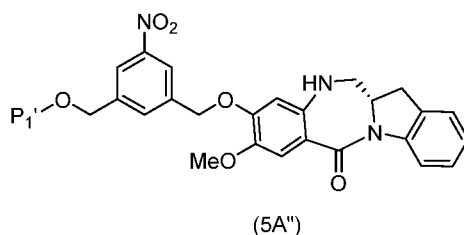


and the method comprising reacting the compound of formula (5a'') with an alcohol deprotecting reagent and a bromination reagent.

In another specific embodiment, for the method of the seventh embodiment, the compound of formula (7A''') is represented by the following formula:



and the method comprising reacting the compound of formula (5A''),



with an alcohol deprotecting reagent and a bromination reagent.

In one embodiment, for the methods described in the seventh embodiment, the acid labile alcohol protecting group is acetate, allyl, methoxymethyl, tetrahydrofuranyl, tetrahydropyranyl, 5-dibenzosuberlyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, 2-(phenylselenyl)ethyl, trityl/triphenylmethyl, or tris(4-tert-butylphenyl)methyl.

In another embodiment, the acid labile alcohol protecting group is a silyl protecting group. Exemplary silyl protecting groups include, but are not limited to, dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl. Preferably, the silyl protecting group is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl. More preferably, the silyl protecting group is *tert*-butyldimethylsilyl.

In one embodiment, the alcohol deprotecting reagent is tetra-*n*-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a

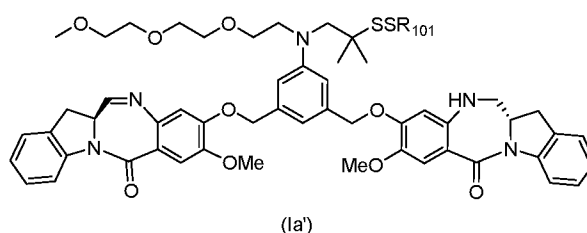
solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, pyridinium p-toluenesulfonate, formic acid, periodic acid, trifluoroacetic acid, or p-toluenesulfonic acid (p-TsOH). Preferably, the alcohol deprotecting reagent is acetic acid.

5 In yet another embodiment, the bromination reagent is HBr.

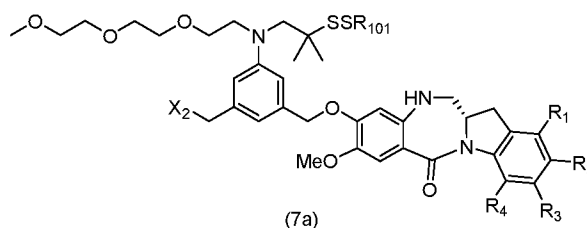
In one specific embodiment, the methods of the seventh embodiment comprises reacting the compound of formula (5a'') with a mixture of acetic acid and HBr to give the compound of formula (7a''').

10 In another specific embodiment, the methods of the seventh embodiment comprises reacting the compound of formula (5A'') with a mixture of acetic acid and HBr to give the compound of formula (7A''')

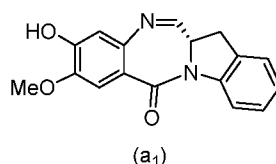
In a eighth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



15 or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (7a)

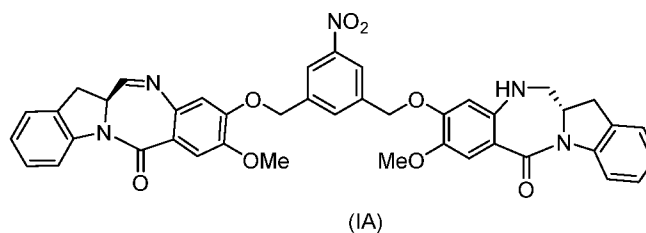


with a monomer compound of the formula (a₁),

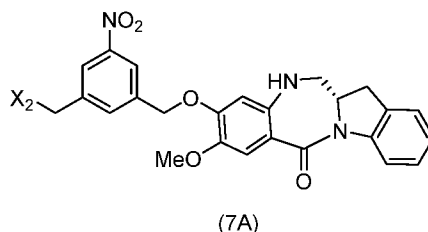


20 wherein R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl; and, X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester.

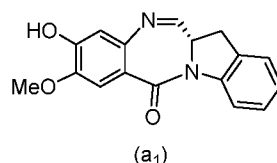
Also provided in the eighth embodiment is a method of preparing a compound of formula (IA),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (7A)



5 with a monomer compound of the formula (a₁),



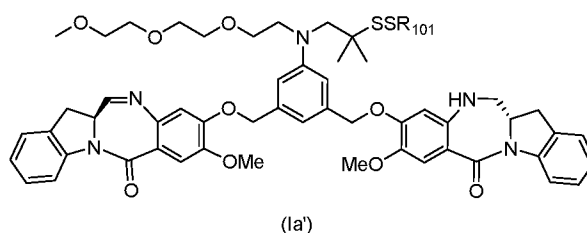
wherein R₁₀₀ is (C₁-C₃)alkoxy; and, X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester.

10 In one embodiment, for methods of the eighth embodiment, X₂ is -Br, -I or a sulfonate ester..

In one embodiment, for methods of the eighth embodiment, the compound of formula (7a) or (7A) is reacted with the monomer compound of formula (a₁) in the presence of a base. Examples of the base include, but are not limited to, sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium
15 hydride. In one embodiment, the base is potassium carbonate.

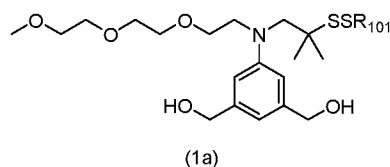
Any suitable solvents can be used in the methods of eighth embodiment described above. In one embodiment, the solvent is DMF. In another embodiment, the solvent is DMA.

20 In a ninth embodiment, the present invention provides a method of forming a compound of formula (Ia'),

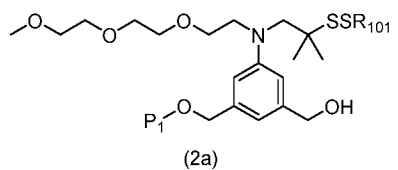


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

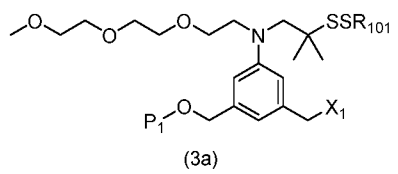
(1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



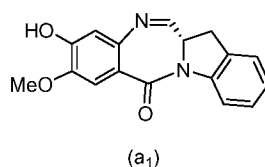
to form a compound of formula (2a),



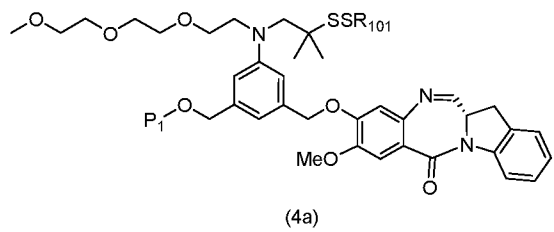
(2) reacting the compound of formula (2a) with a halogenating reagent or a sulfonating reagent or an esterification reagent to form a compound of formula (3a),



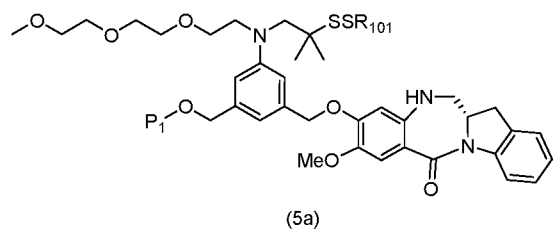
(3) reacting the compound of formula (3a) with a monomer compound of the formula (a₁),



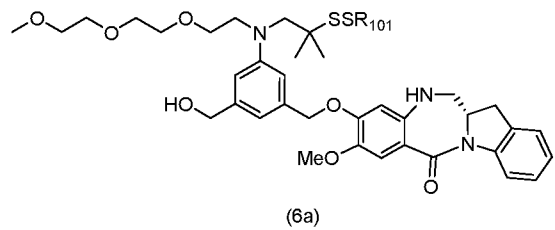
to form a compound of formula (4a),



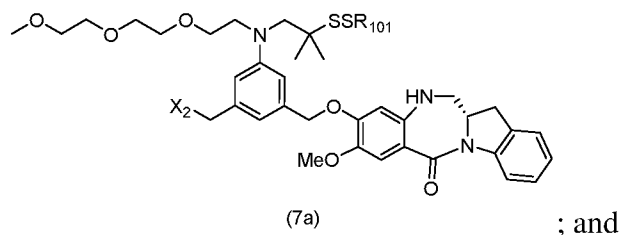
(4) reacting the compound of formula (4a) with an imine reducing agent to form a compound of formula (5a),



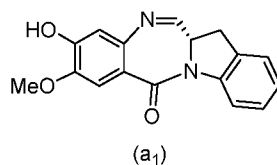
(5) reacting the compound of formula (5a) with an alcohol deprotecting reagent to form a compound of formula (6a),



5 (6) reacting the compound of formula (6a) with a second halogenating reagent, a second sulfonylating reagent or a second esterification reagent to form a compound of formula (7a),

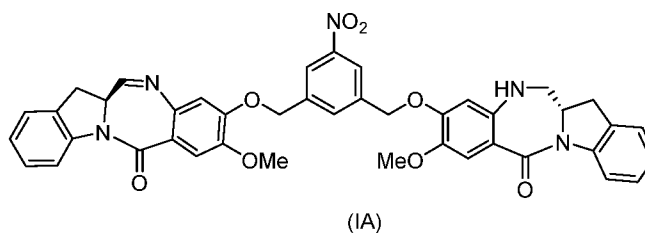


(7) reacting the compound of formula (7a) with a monomer compound of the
10 formula (a₁),



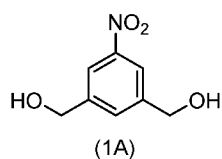
to form the compound of formula (Ia'); wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the ninth embodiment is a method of preparing a compound of formula (IA):



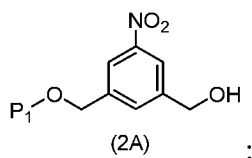
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1A),

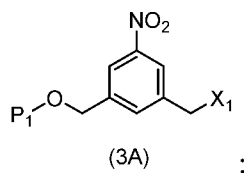


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to form a compound of formula (2A),

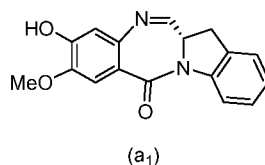


(2) reacting the compound of formula (2A) with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3A),

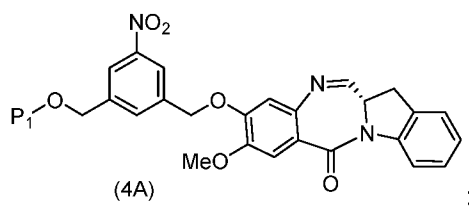


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(3) reacting the compound of formula (3A) with a monomer compound of the formula (a₁),

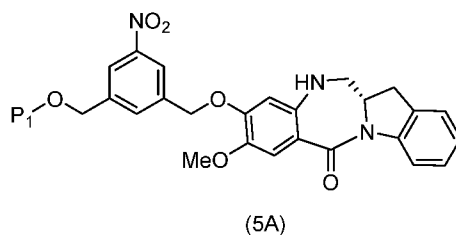


to form a compound of formula (4A),

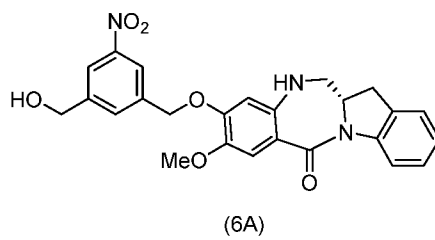


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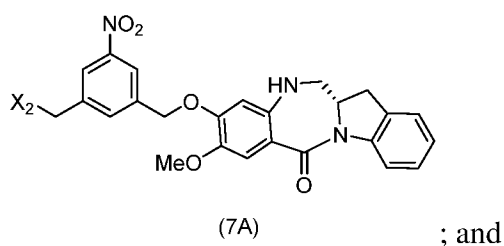
(4) reacting the compound of formula (4A) with an imine reducing agent to form a compound of formula (5A),



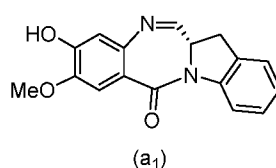
(5) reacting the compound of formula (5A) with an alcohol deprotecting reagent to form a compound of formula (6A),



- 5 (6) reacting a second halogenating reagent, a second sulfonating reagent or an esterification reagent with the compound of formula (6A) to form a compound of formula (7A),



- 10 (7) reacting the compound of formula (7A) with a monomer compound of the formula (a₁),

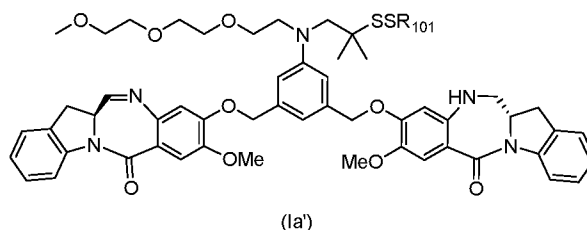


to form the compound of formula (IA), wherein P₁ is an alcohol protecting group; and X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester.

- 15 In one embodiment, for methods of the ninth embodiment, X₁ and X₂ are each independently -Br, -Cl or a sulfonate ester.

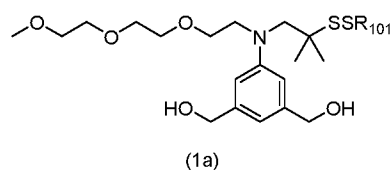
The reaction conditions and reagents for each step in the method of the ninth embodiment are as described in the first, second, third, fourth, fifth, sixth and/or eighth embodiment or any specific embodiments described therein.

In a tenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

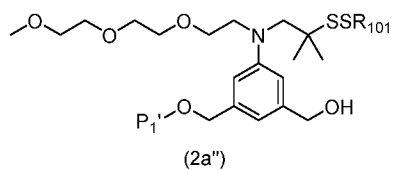


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

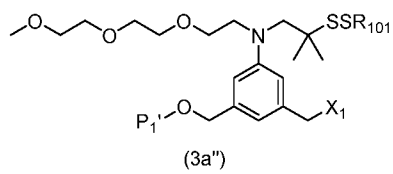
- 5 (1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



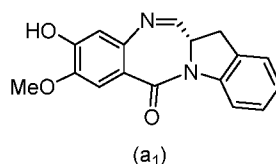
to form a compound of formula (2a''),



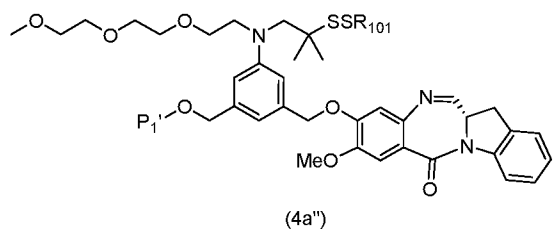
- 10 (2) reacting the compound of formula (2a'') with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a''),



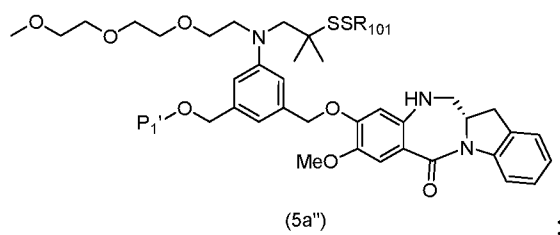
(3) reacting the compound of formula (3a'') with a monomer compound of the formula (a₁),



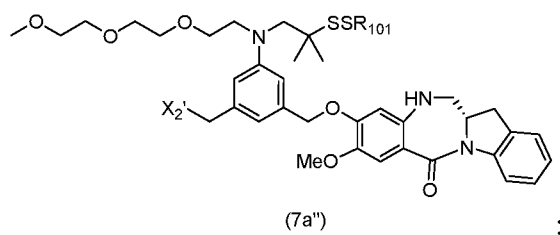
- 15 to form a compound of formula (4a''),



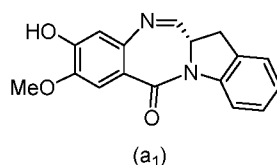
(4) reacting the compound of formula (4a'') with an imine reducing agent to form a compound of formula (5a''),



(5) reacting the compound of formula (5a'') with an alcohol deprotecting reagent and a halogenating reagent to form a compound of formula (7a''),

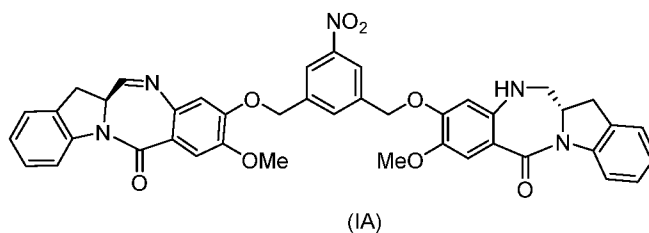


(6) reacting a compound of formula (7a'') with a monomer compound of the formula (a₁),



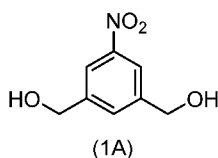
to form the compound of formula (Ia'), wherein X₂' is -Br or -I; and the remaining variables are as described above in the ninth embodiment.

Also provided in the tenth embodiment is a method of preparing a compound of formula (IA):

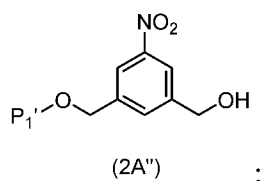


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

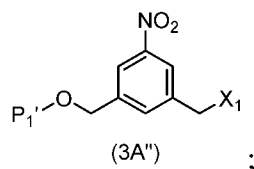
(1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1A),



to form a compound of formula (2A''),

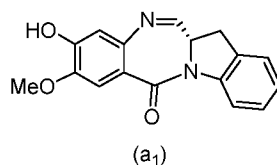


(2) reacting the compound of formula (2A'') with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3A''),

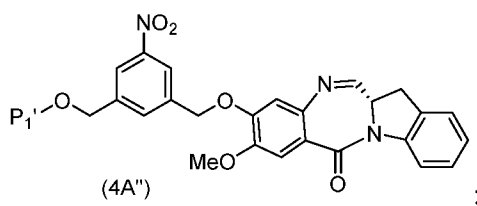


5

(3) reacting the compound of formula (3A'') with a monomer compound of the formula (a₁),

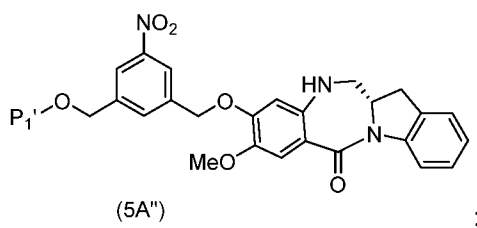


to form a compound of formula (4A''),



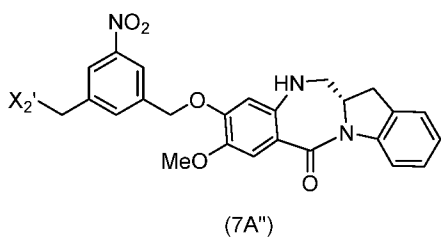
10

(4) reacting the compound of formula (4A'') with an imine reducing agent to form a compound of formula (5A''),

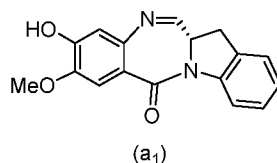


(5) reacting the compound of formula (5A'') with an alcohol deprotecting reagent and a halogenating reagent to form a compound of formula (7A''),

15



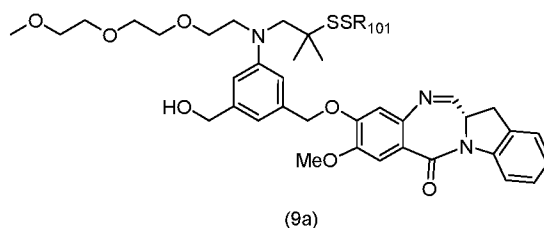
(6) reacting a compound of formula (7A'') with a monomer compound of the formula (a₁),



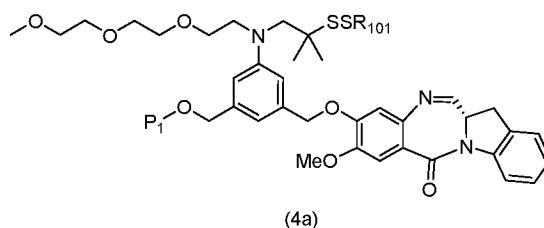
to form the compound of formula (IA), wherein X₂' is -Br or -I; and the remaining
5 variables are as described above in the ninth embodiment.

The conditions and reagents for the methods of tenth embodiment are as described above in the first, second, third, fourth, seventh and/or eighth embodiment(s) and any specific embodiments described therein.

In a eleventh embodiment, the present invention provides a method of preparing
10 a compound of formula (9a),

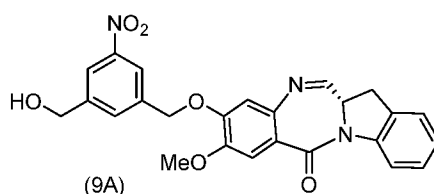


or a salt thereof, said method comprising reacting a compound of formula (4a),

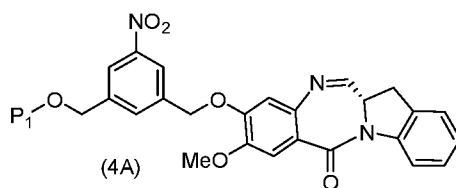


with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; and R₁₀₁
15 is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the eleventh embodiment is a method of preparing a compound of (9A):



or a salt thereof, said method comprising reacting a compound of formula (4A),

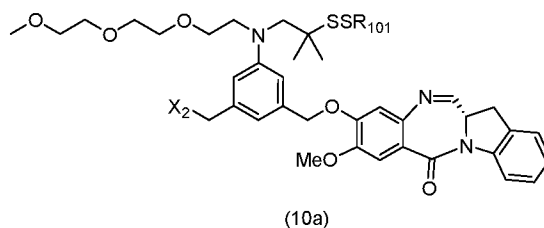


with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group.

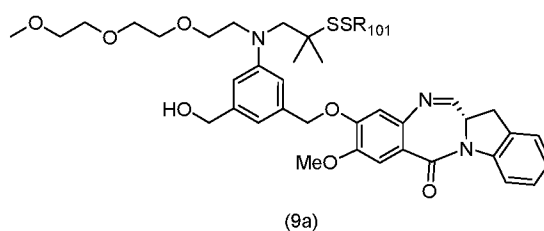
In a specific embodiment, for the methods of the eleventh embodiment, the alcohol deprotecting reagent is tetra-n-butylammonium fluoride,

- 5 tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, pyridinium p-toluensulfonate, formic acid, periodic acid, trifluoroacetic acid, or p-toluenesulfonic acid (p-TsOH). More specifically, the alcohol deprotecting reagent is hydrochloric acid or tetra-n-
- 10 butylammonium fluoride.

In a twelfth embodiment, the present invention provides a method of preparing a compound of formula (10a),

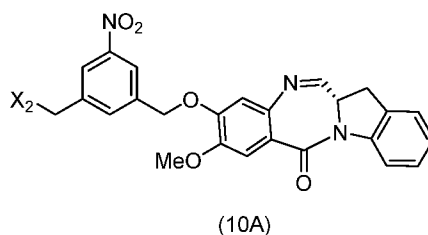


- or a salt thereof, said method comprising reacting the compound of formula (9a) with a
- 15 halogenating reagent, a sulfonating reagent or an esterification reagent,

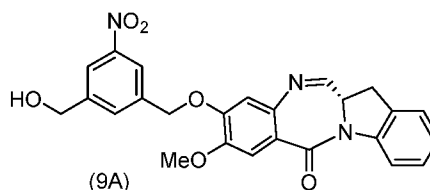


wherein X₂ is -Br, -I, -Cl, a sulfonate ester or an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

- Also provided in the twelfth embodiment is a method of preparing a compound
- 20 of formula (10A):



or a salt thereof, said method comprising reacting the compound of formula (9A) with a halogenating reagent, a sulfonating reagent or an esterification reagent,



5 wherein X_2 is -Br, -I, -Cl, a sulfonate ester or an activated ester.

In a specific embodiment, for the methods of the twelfth embodiment, X_2 is -Br, -I or a sulfonate ester.

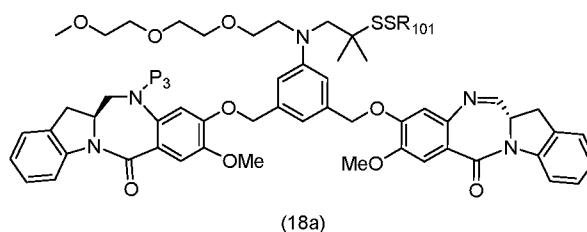
In a specific embodiment, for the methods of the twelfth embodiment, X_2 is mesylate, tosylate, brosylate, or triflate. Preferably, X_2 is mesylate.

10 In another specific embodiment, the method described in the twelfth embodiment comprises reacting the compound of formula (9a) or (9A) with a halogenating reagent. Exemplary halogenating reagent include, but are not limited to, bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.

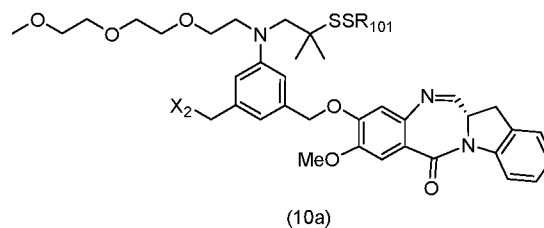
15 In yet another specific embodiment, the method of the twelfth embodiment comprises reacting the compound of formula (9a) or (9A) with a sulfonating reagent. Preferably, the sulfonating reagent is a sulfonic anhydride, such as methanesulfonic anhydride, or a sulfonic chloride, such as methanesulfonyl chloride (MsCl).

20 In one embodiment, the reaction between the compound of formula (9a) or (9A) and the sulfonating reagent is carried out in the presence of a base. Preferably, the base is a non-nucleophilic base. Exemplary non-nucleophilic base include, but are not limited to, triethylamine, imidazole, triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine. Preferably, the base is triethylamine or diisopropylethylamine.

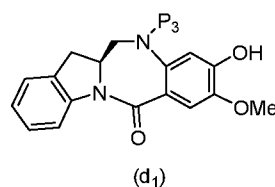
25 In a thirteenth embodiment, the present invention provides a method of preparing a compound of formula (18d),



or a salt thereof, said method comprising reacting a compound of formula (10a)



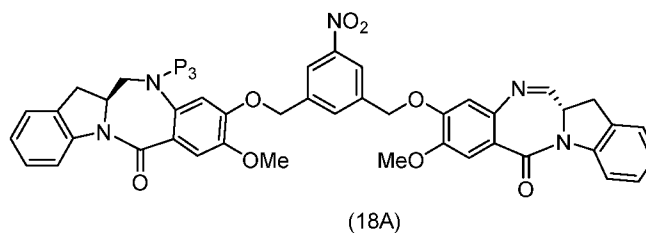
with a monomer compound of the formula (d₁),



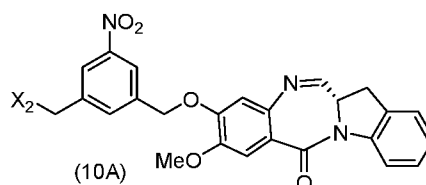
5

wherein X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester; P₃ is H or P₂; P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl. In one embodiment, X₂ is -Br, -I, or a sulfonate ester.

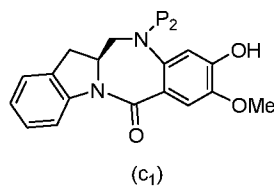
10 Also provided in the thirteenth embodiment is a method of preparing a compound of formula (18A):



or a salt thereof, said method comprising reacting a compound of formula (10A)

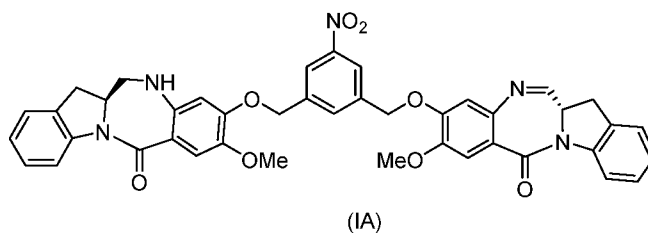
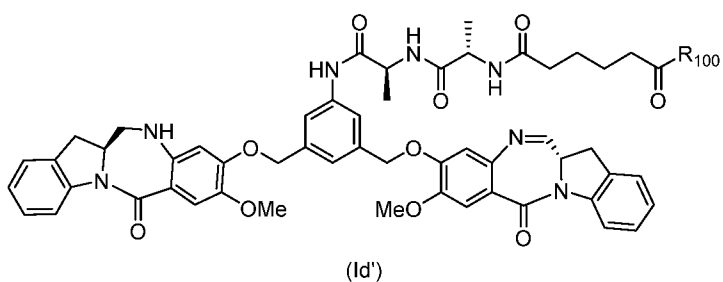


15 with a monomer compound of the formula (d₁),

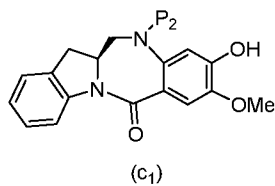


herein X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester or an activated ester; and P₃ is H or P₂; and P₂ is an amine protecting group. In one embodiment, X₂ is -Br, -I, or a sulfonate ester.

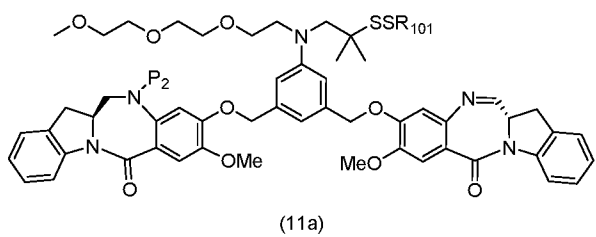
- 5 In a specific embodiment, for methods of the thirteenth embodiment, P₃ is H and the compound of (10a) or (10A) is reacted with the monomer compound of (d₁) to form a compound of (Id') or (IA), respectively:

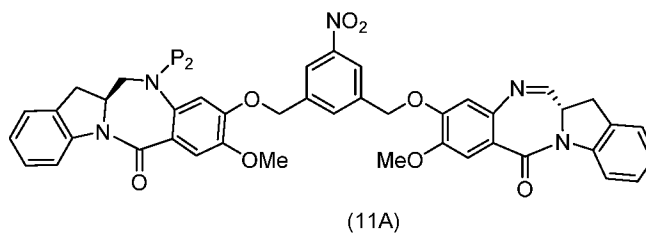


- 10 In another specific embodiment, P₃ is an amine protecting group represented by P₂; the monomer compound is represented by formula (c₁):



and the compound of formula (18a) or (18A) is represented by formula (11a) or (11A), respectively,





Any suitable amine protecting group can be used in the methods of the thirteenth embodiment described above. In one embodiment, the amine protecting group is 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-

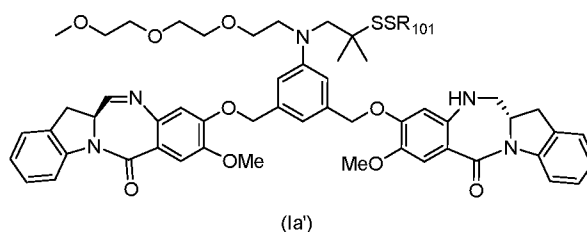
5 (trimethylsilyl)ethoxymethyl, allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, or 2, 2,2,2-trichloroethoxycarbonyl.

In a specific embodiment, the compound of formula (10a) or (10A) is reacted with the monomer compound of formula (d₁) or (c₁) in the presence of a base. Examples of the base include, but are not limited to sodium carbonate, potassium carbonate,

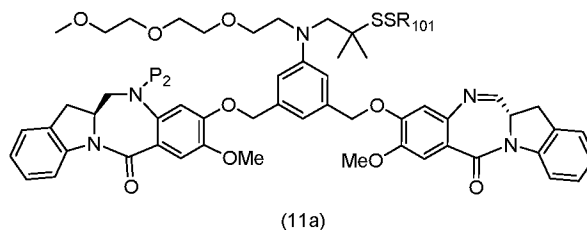
10 cesium carbonate, sodium hydride, or potassium hydride.

Any suitable solvents can be used in the reaction described above. In one embodiment, the solvent is DMF.

In a fourteenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



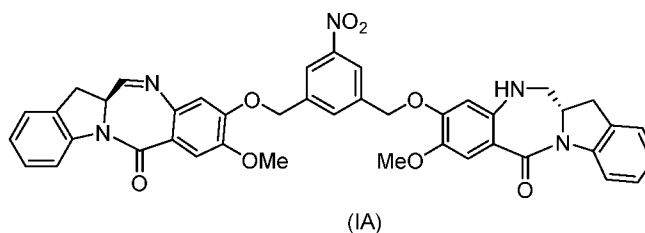
or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (11a),



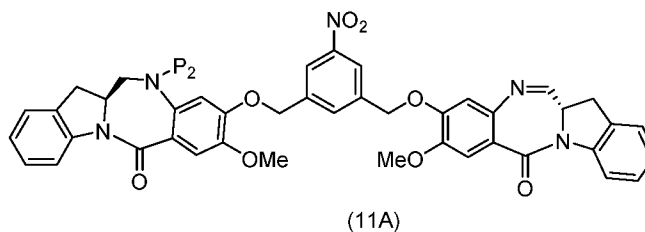
with an amine deprotecting reagent, wherein P₂ is an amine protecting group; and R₁₀₁ is

20 (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the fourteenth embodiment is a method of preparing a compound of formula (IA):



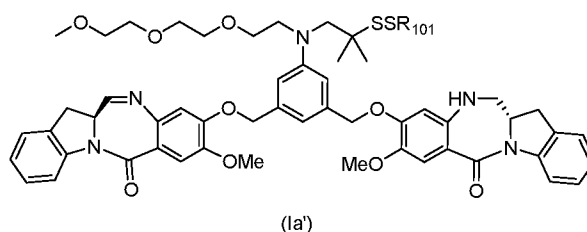
or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (11A),



- 5 with an amine deprotecting reagent, wherein P₂ is an amine protecting group.

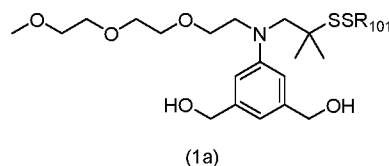
Any suitable amine deprotecting reagent can be used in the method described above. In one embodiment, the amine deprotecting reagent is tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

- 10 In a fifteenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

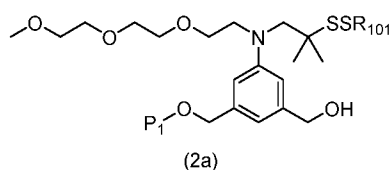


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

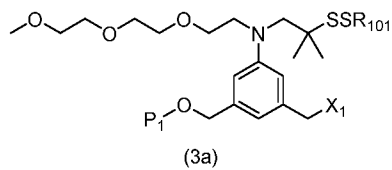
- 15 (1) introducing an alcohol protecting group onto one of the primary alcohols of the compound of formula (1a),



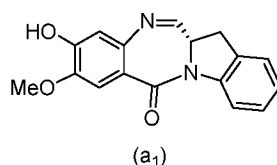
to form a compound of formula (2a),



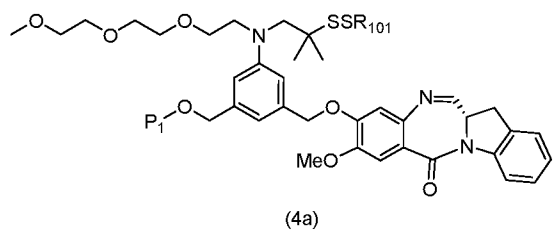
(2) reacting the compound of formula (2a) with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a),



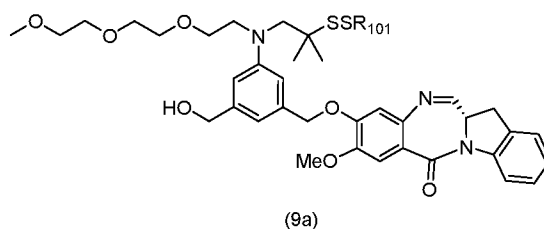
(3) reacting the compound of formula (3a) with a monomer compound of the
5 formula (a₁),



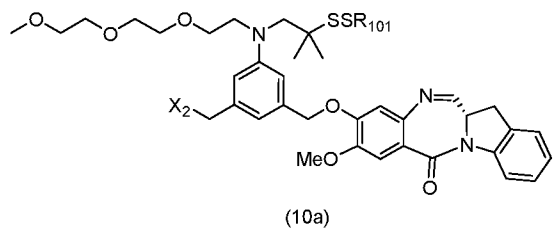
to form a compound of formula (4a),



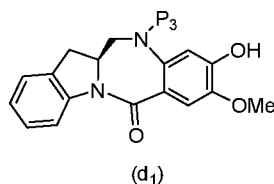
(4) reacting the compound of formula (4a) with an alcohol deprotecting reagent
10 to form a compound of formula (9a),



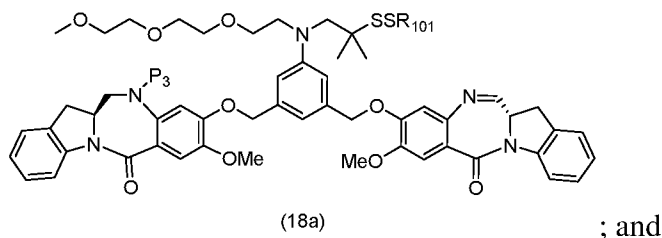
(5) reacting the compound of formula (9a) with a second halogenating reagent, a second sulfonating reagent or a second esterification reagent to form a compound of formula (10a),



(6) reacting the compound of formula (10a) with a monomer compound of the
15 formula (d₁)

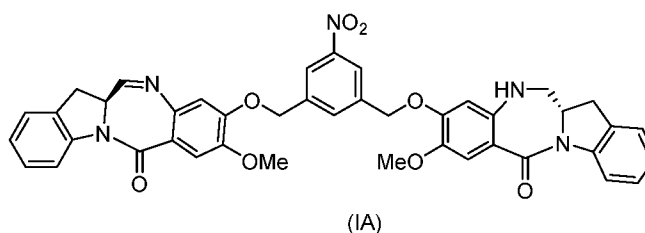


to form a compound of formula (18a),



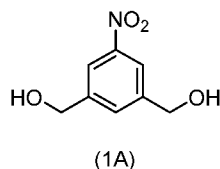
- (7) when P₃ is an amine protecting group, reacting the compound of formula (18a) to an amine deprotecting reagent to form the compound of formula (Ia'), wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also included in the fifteenth embodiment is a method of preparing a compound of formula (IA):

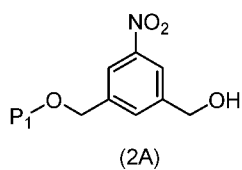


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

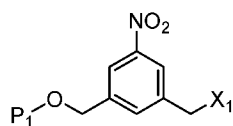
- (1) introducing an alcohol protecting group onto one of the primary alcohols of the compound of formula (1A),



to form a compound of formula (2A),

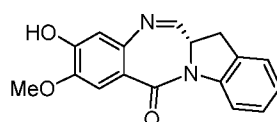


- (2) reacting the compound of formula (2A) with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3A),

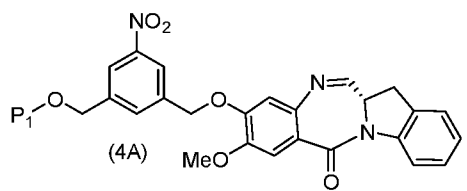


(3A) ;

(3) reacting the compound of formula (3A) with a monomer compound of the formula (a₁),

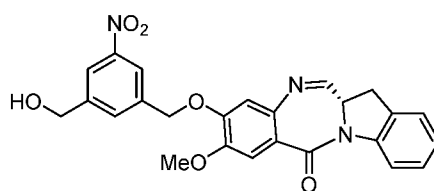
(a₁)

5 to form a compound of formula (4A),



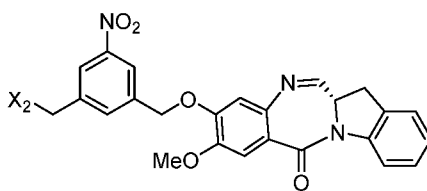
(4A) ;

(4) reacting the compound of formula (4A) with an alcohol deprotecting reagent to form a compound of formula (9A),



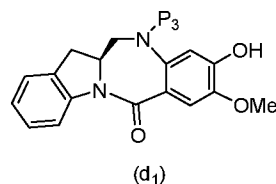
(9A)

10 (5) reacting the compound of formula (9A) with a second halogenating reagent , a second sulfonating reagent or a second esterification reagent to form a compound of formula (10A),

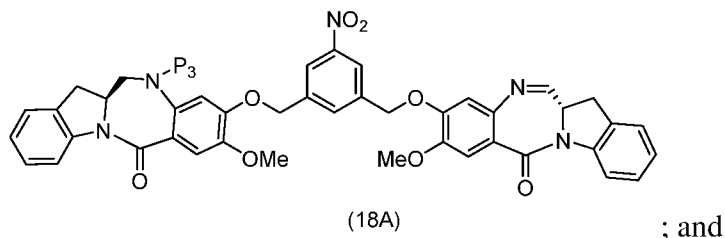


(10A) ;

15 (6) reacting the compound of formula (10A) with a monomer compound of the formula (d₁)



to form a compound of formula (18A),



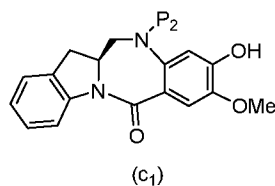
; and

- (7) reacting the compound of formula (18A) to an amine deprotecting reagent to form the compound of formula (IA), wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester; and P₃ is H or an amine protecting group.

In a specific embodiment, for methods of the fifteenth embodiment, X₁ and X₂ are each independently -Br, -I or a sulfonate ester.

- 10 In a specific embodiment, for methods of the fifteenth embodiment, P₃ is H and the compound of (10a) or (10A) is reacted with the monomer compound of (d₁) to form a compound of (Id') or (IA), respectively.

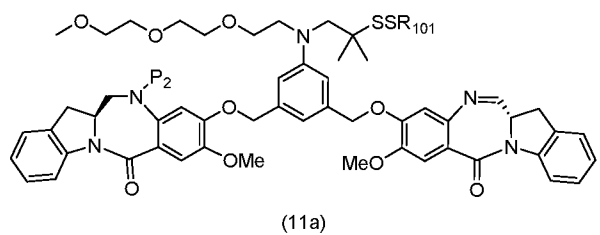
In another specific embodiment, for methods of the fifteenth embodiment, P₃ is P₂; the monomer compound is represented by formula (c₁):



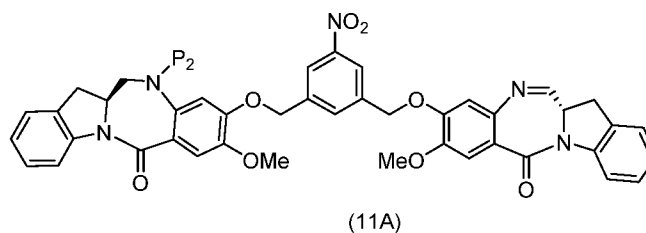
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;

and the compound of formula (18a) or (18A) is represented by formula (11a) or (11A), respectively:



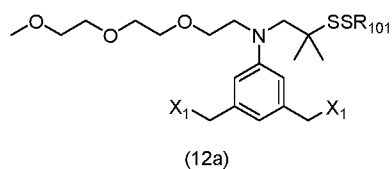
;



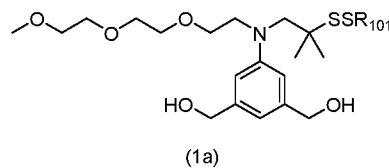
wherein P₂ is an amine protecting group.

The conditions and reagents for the methods of the fifteenth embodiment are as described above in the first, second, third, eleventh, twelfth, thirteenth, and/or
 5 fourteenth, embodiment(s) and any specific embodiments described therein.

In a sixteenth embodiment, the present invention provides a method of preparing a compound of formula (12a),



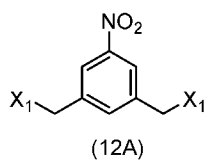
or a salt thereof, said method comprising reacting a compound of formula (1a),



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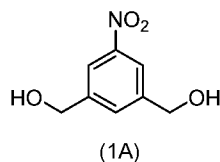
with a halogenating reagent or a sulfonating reagent, wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the sixteenth embodiment is a method of preparing a compound of formula (12A):



15

or a salt thereof, said method comprising reacting a compound of formula (1A),



with a halogenating reagent or a sulfonating reagent, wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester.

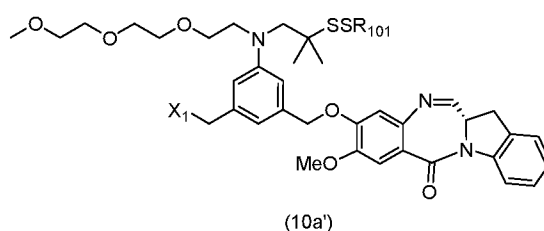
In a specific embodiment, for the methods of the sixteenth embodiment, X_1 is -Br, -I, or a sulfonate ester. In another specific embodiment, X_1 is -Br or -I. In yet another specific embodiment, X_1 is a sulfonate ester, preferably mesylate. In another specific embodiment, X_1 is -Cl.

5 In another specific embodiment, the halogenating reagent reacts with the primary alcohols of the compound of formula (1a) or (1A) in the presence of an alcohol activating agent. In one embodiment, the alcohol activating agent is thionyl chloride. In another specific embodiment, halogenating reagent is lithium bromide, sodium bromide, potassium bromide, potassium iodide, or sodium iodide. In another specific
10 embodiment, the halogenating reagent is carbon tetrachloride/triphenylphosphine, methanesulfonyl (mesyl) chloride/lithium chloride, or methanesulfonyl (mesyl) chloride/pyridine.

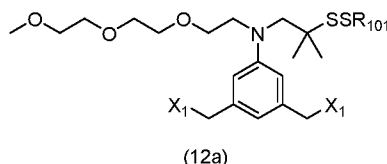
In yet another specific embodiment, the methods of the sixteenth embodiment comprise reacting the compound of formula (1a) or (1A) with LiBr in the presence of
15 thionyl chloride.

Any suitable solvents can be used in the methods of the sixteenth embodiment described above. Exemplary solvents include, but are not limited to, DMF, CH_2Cl_2 , THF, dichloroethane, etc.

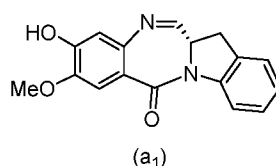
In a seventeenth embodiment, the present invention provides a method of
20 preparing a compound of formula (10a'),



or a salt thereof, said method comprising reacting a compound of formula (12a),



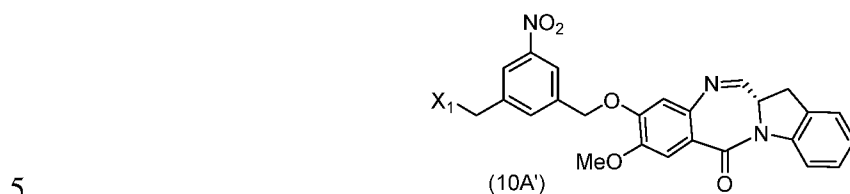
with a monomer compound of the formula (a₁),



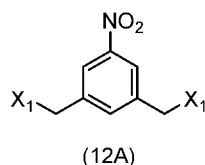
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wherein X_1 is -Br, -I, -Cl, a sulfonate ester or an activated ester; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

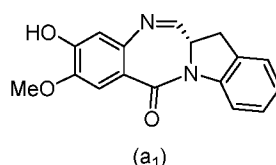
Also provided in the seventeenth embodiment is a method of preparing a compound of formula (10A')



or a salt thereof, said method comprising reacting a compound of formula (12A),

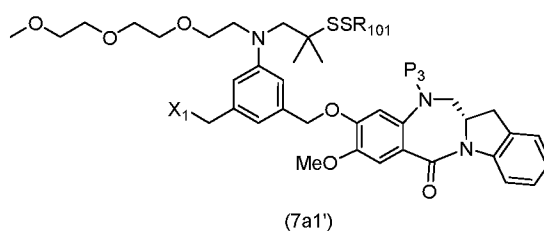


with a monomer compound of the formula (a₁),



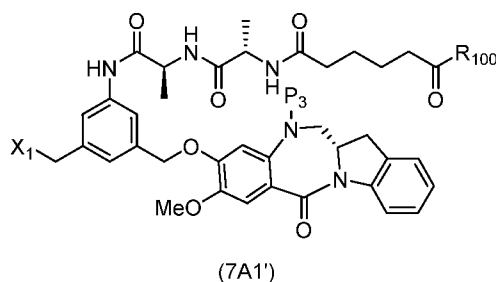
10 wherein X_1 is -Br, -I, -Cl, a sulfonate ester or an activated ester.

Also provided in the seventeenth embodiment is a method of preparing a compound of formula (7a1'),



or a salt thereof, said method comprising reacting a compound of formula (12a) with a
15 monomer compound of formula (d₁), wherein X_1 is -Br, -I, -Cl, a sulfonate ester or an activated ester; P_3 is H or an amine protecting group; and R_{100} is a (C_1-C_3) alkoxy.

Also provided in the seventeenth embodiment is a method of preparing a compound of formula (7A1'),



or a salt thereof, said method comprising reacting a compound of formula (12A) with a monomer compound of formula (d₁), wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester; and P₃ is H or an amine protecting group.

- 5 In a specific embodiment, for formula (7a1') or (7A1'), P₃ is H. In another specific embodiment, P₃ is an amine protecting group as described herein.

 In a specific embodiment, for methods of the seventeenth embodiment, X₁ is -Br, -I, or a sulfonate ester. In another specific embodiment, X₁ is a sulfonate ester. In a more specific embodiment, X₁ is mesylate.

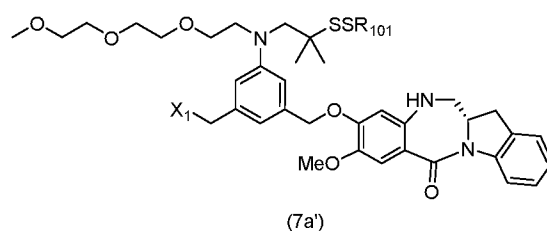
- 10 In a specific embodiment, the compound of formula (12a) or (12A) is reacted with the monomer compound of formula (a₁) in the presence of a base. Examples of suitable base include, but are not limited to, sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. In one embodiment, the base is potassium carbonate.

- 15 In another specific embodiment, the compound of formula (12a) or (12A) is reacted with the monomer compound of formula (d₁) in the presence of a base. Examples of suitable base include, but are not limited to, sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. In one embodiment, the base is potassium carbonate.

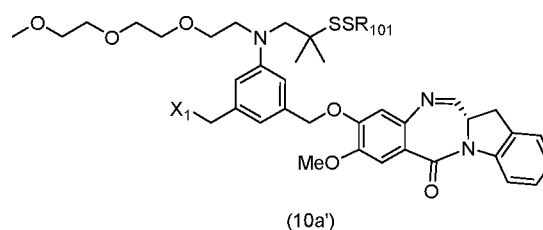
- 20 For the methods of the seventeenth embodiment, any suitable solvents can be used. In one embodiment, the solvent is DMF.

 In another specific embodiment, excess molar equivalent of the compound of formula (12a) or (12A) relative to the monomer compound of formula (a₁) or (d₁) is used in the reaction.

- 25 In a eighteenth embodiment, the present invention provides a method of preparing a compound of formula (7a'),

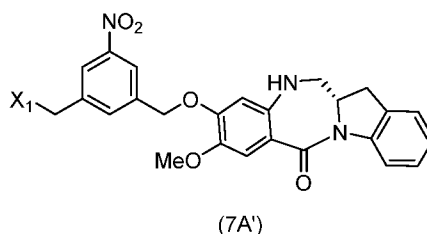


or a salt thereof, said method comprising reacting a compound of formula (10a'),

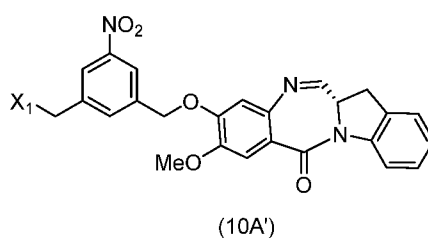


or a salt thereof, with an imine reducing agent, wherein X_1 is -Br, -I, -Cl, a sulfonate ester or an activated ester; and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the eighteenth embodiment is a method of preparing a compound of formula (7A'),



or a salt thereof, said method comprising reacting a compound of formula (10A'),



or a salt thereof, with an imine reducing agent, wherein X_1 is -Br, -I, -Cl, a sulfonate ester or an activated ester.

In a specific embodiment, for methods of the eighteenth embodiment, X_1 is -Br, -I, or a sulfonate ester. In another specific embodiment, X_1 is a sulfonate ester.

Preferably, X_1 is mesylate.

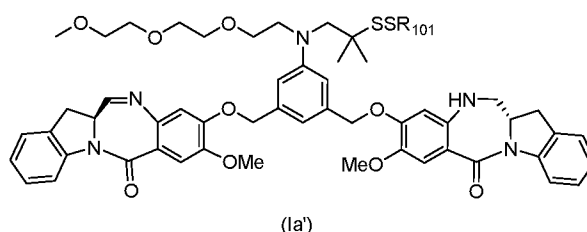
In another specific embodiment, for methods of the eighteenth embodiment, the

imine reducing reagent is a hydride reducing reagent. In a more specific embodiment, the imine reducing reagent is sodium borohydride, sodium triacetoxy borohydride, sodium cyanoborohydride, lithium aluminum hydride, hydrogen gas, ammonium formate, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminum hydride
 5 (DIBAL), lithium borohydride (LiBH_4), potassium borohydride (KBH_4), or sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al). Even more specifically, the imine reducing reagent is sodium triacetoxy borohydride ($\text{NaBH}(\text{OAc})_3$).

Any suitable solvents can be used in the methods of the eighteenth embodiment.

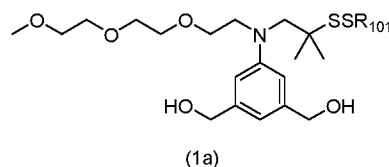
In one embodiment, the solvent is dichloroethane.

10 In a nineteenth embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

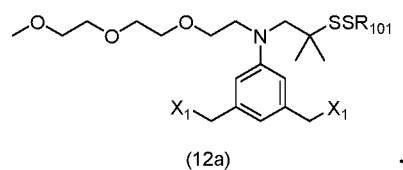


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

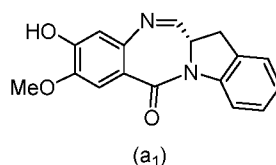
(1) reacting a compound of formula (1a) with a halogenating reagent, a
 15 sulfonating reagent or an esterification reagent,



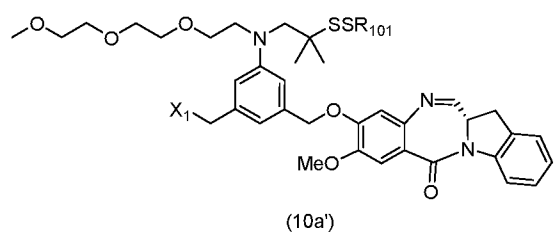
to form a compound of formula (12a),



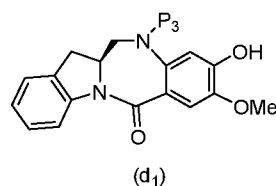
(2) reacting the compound of formula (12a) with a monomer compound of the
 20 formula (a_1),



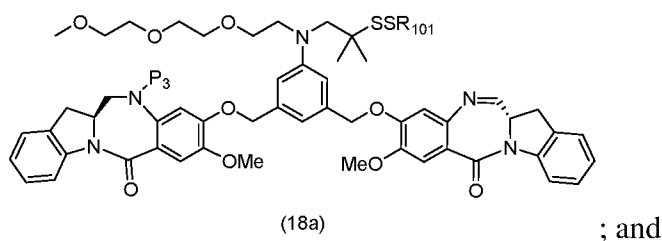
to form a compound of a formula ($\text{10a}'$),



(3) reacting the compound of formula (10a') with a monomer compound of the formula (d₁),

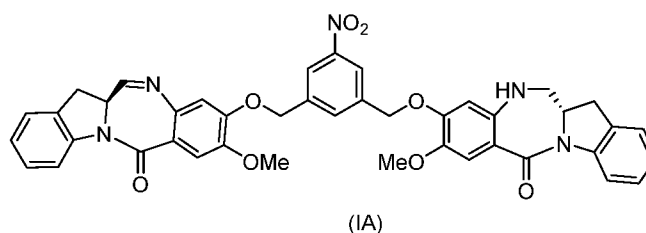


5 to form a compound of formula (18a),



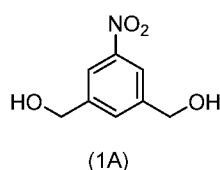
(4) when P₃ is an amine protecting group, reacting the compound of formula (18a) with an amine deprotecting reagent to form the compound of formula (Ia'), wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the nineteenth embodiment is a method of preparing a compound of formula (IA),

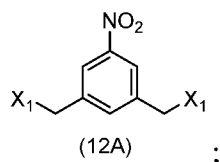


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

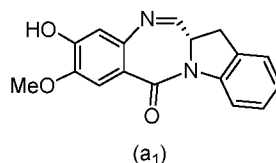
(1) reacting a compound of formula (1A) with a halogenating reagent, a sulfonating reagent or an esterification reagent,



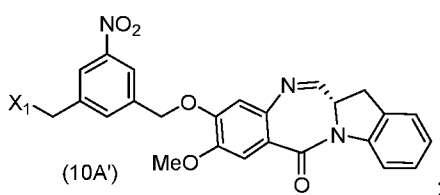
to form a compound of formula (12A),



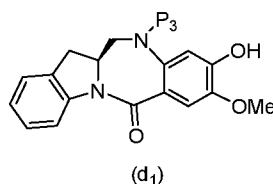
(2) reacting the compound of formula (12A) with a monomer compound of the formula (a₁),



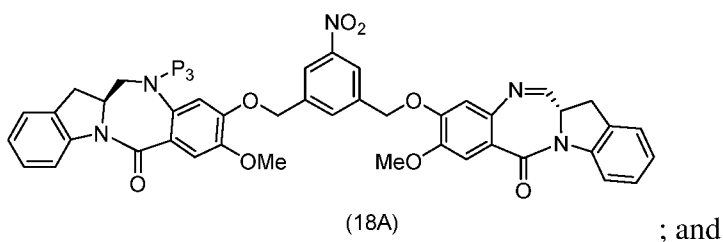
5 to form a compound of a formula (10A'),



(3) reacting the compound of formula (10A') with a monomer compound of the formula (d₁),



10 to form a compound of formula (18A),

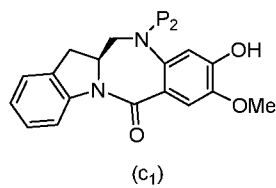


(4) when P₃ is an amine protecting group, reacting the compound of formula (18A) with an amine deprotecting reagent to form the compound of formula (IA), wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester; P₃ is H or an amine protecting group.

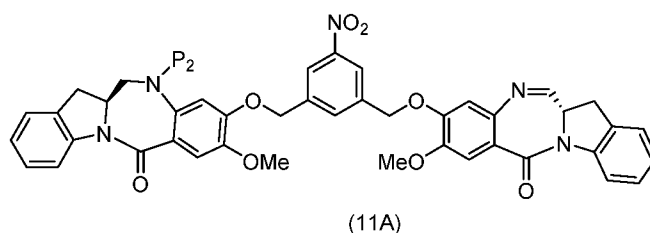
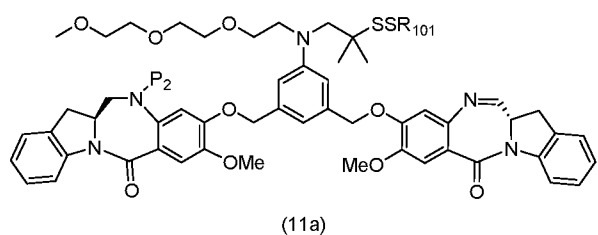
In a specific embodiment, for methods of the nineteenth embodiment, X₁ is -Br, -I, or a sulfonate ester.

In a specific embodiment, for methods of the nineteenth embodiment, P₃ is H and the compound of (10a') or (10A) is reacted with the monomer compound of (d₁) to form a compound of (Ia') or (IA), respectively.

In another specific embodiment, for methods of the nineteenth embodiment, P_3 is P_2 ; the monomer compound is represented by formula (c_1):



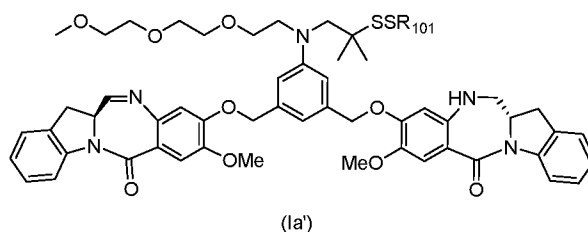
and the compound of formula (18a) or (18A) is represented by formula (11a) or (11A),
5 respectively:



wherein P_2 is an amine protecting group.

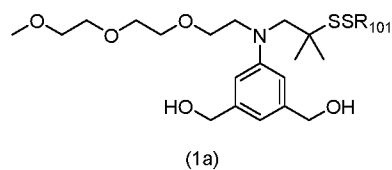
The conditions and reagents for the method of nineteenth embodiment are as
10 described above in the sixteenth, seventeenth, thirteenth and/or fourteenth
embodiment(s) and any specific embodiments described therein.

In a twentieth embodiment, the present invention provides a method of preparing
a compound of formula (Ia'),

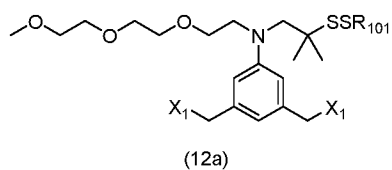


15 or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),

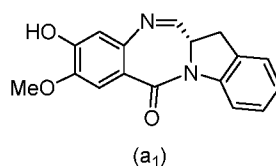


to form a compound of formula (12a),

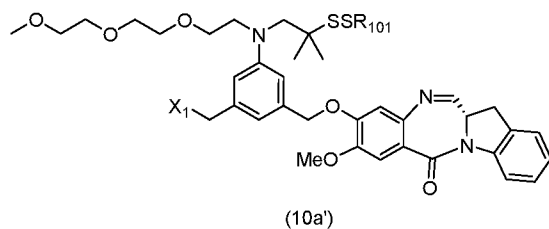


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(2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),

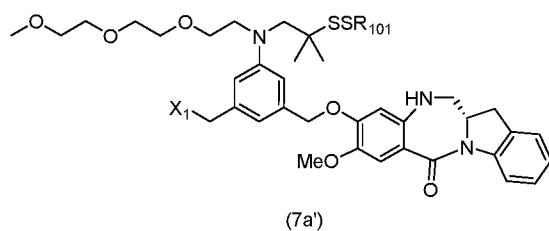


to form a compound of a formula (10a'),



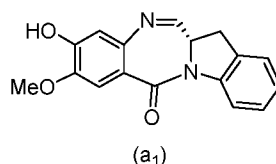
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(3) reacting the compound (10a') with an imine reducing reagent to form a compound (7a'),



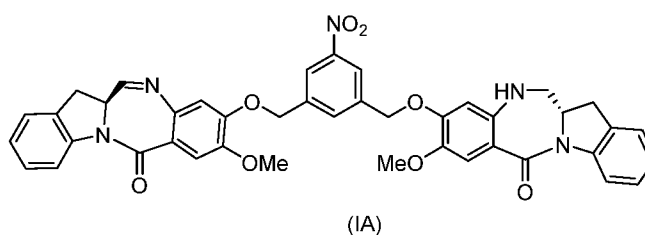
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(4) reacting the compound of formula (7a') with a monomer compound of the formula (a₁),



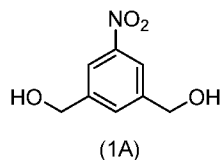
to form a compound of formula (Ia'), or a pharmaceutically acceptable salt thereof, wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

5 Also provided in the twentieth embodiment is a method of preparing a compound of (IA),

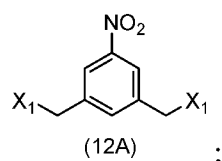


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

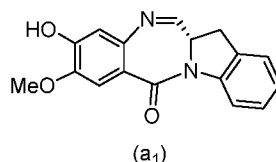
10 (1) reacting a halogenating reagent, a sulfonating reagent or a second esterification reagent with a compound of formula (1A),



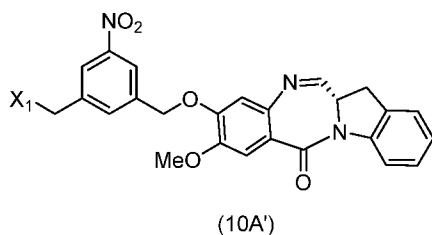
to form a compound of formula (12A),



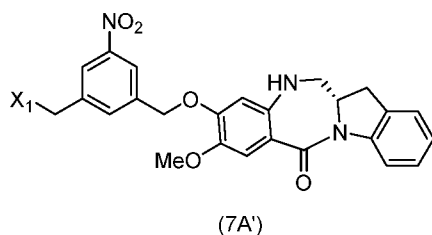
15 (2) reacting the compound of formula (12A) with a monomer compound of the formula (a₁),



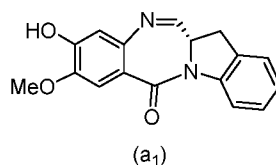
to form a compound of a formula (10A'),



(3) reacting the compound (10A') with an imine reducing reagent to form a compound (7A'),



5 (4) reacting the compound of formula (7A') with a monomer compound of the formula (a₁),

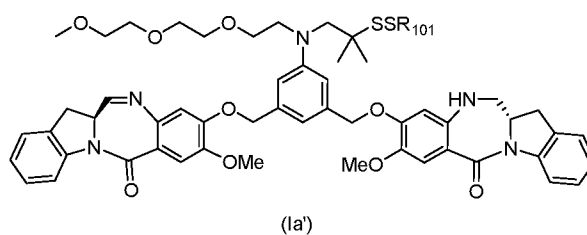


to form a compound of formula (IA'), or a pharmaceutically acceptable salt thereof, wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester.

10 In a specific embodiment, for methods of the twentieth embodiment, X₁ is -Br, -I, or a sulfonate ester.

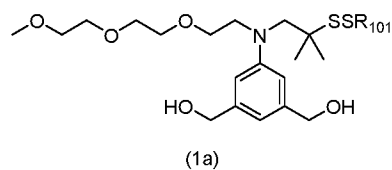
The conditions and reagents for the method of twentieth embodiment are as described above in the sixteenth, seventeenth, eighteenth and/or eighth embodiment(s) and any specific embodiments described therein.

15 In a twenty-first embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

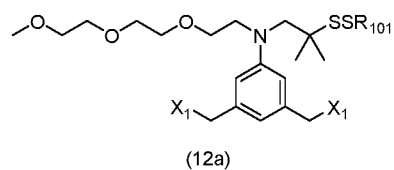


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),

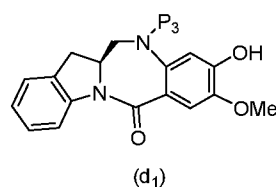


to form a compound of formula (12a),

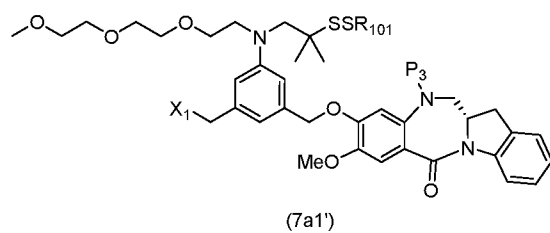


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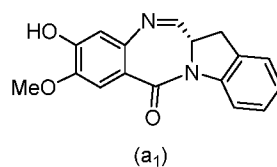
(2) reacting the compound of formula (12a) with a monomer compound of the formula (d₁),



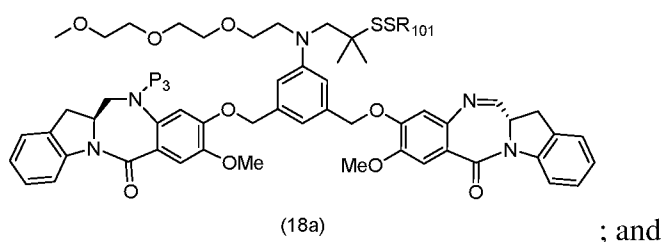
to form a compound of a formula (7a1'),



(3) reacting the compound of formula (7a1') with a monomer compound of the formula (a₁),

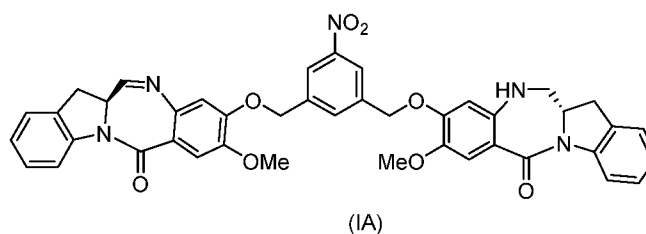


to form a compound of formula (18a),



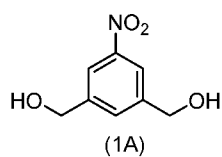
- (4) when P_3 is an amine protecting group, reacting the compound of formula (18a) with an amine deprotecting reagent to form the compound of formula (Ia'); wherein X_1 is $-\text{Br}$, $-\text{I}$, $-\text{Cl}$, a sulfonate ester or an activated ester; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

Also provided in the twenty-first embodiment is a method of preparing a compound of formula (IA),

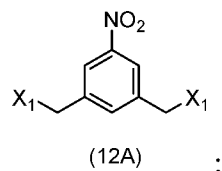


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

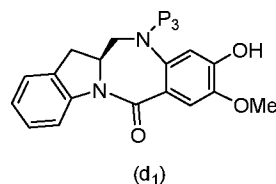
- (1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (IA),



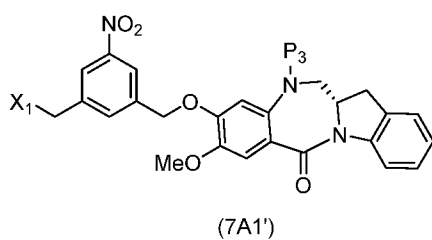
to form a compound of formula (12A),



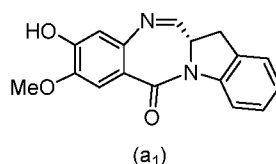
- (2) reacting the compound of formula (12A) with a monomer compound of the formula (d_1),



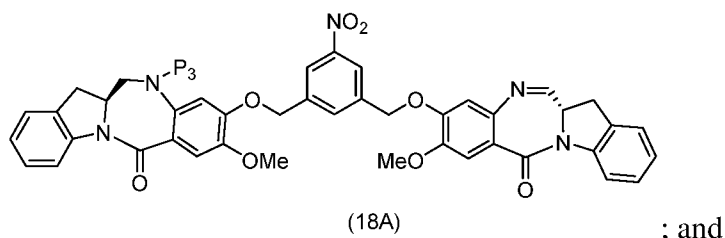
to form a compound of a formula (7A1'),



(3) reacting the compound of formula (7A1') with a monomer compound of the
5 formula (a₁),



to form a compound of formula (18A),



; and

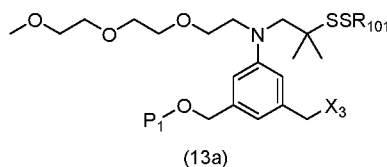
(4) when P₃ is an amine protecting group, reacting the compound of formula
10 (18A) with an amine deprotecting reagent to form the compound of formula (IA);
wherein X₁ is -Br, -I, -Cl, a sulfonate ester or an activated ester; P₃ is H or an amine
protecting group.

In one embodiment, for methods of the twenty-first embodiment, P₃ is H.

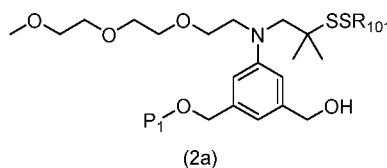
In another embodiment, for methods of the twenty-first embodiment, X₁ is -Br,
15 -Cl or a sulfonate ester.

The conditions and reagents for the methods of twenty-first embodiment are as
described above in the sixteenth, seventeenth, eighteenth, eighth and/or fourteenth
embodiment(s) and any specific embodiments described therein.

In a twenty-second embodiment, the present invention provides a method of preparing a compound of formula (13a),

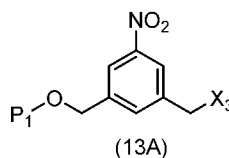


or a salt thereof, said method comprising reacting a chlorinating reagent with a
5 compound of formula (2a),

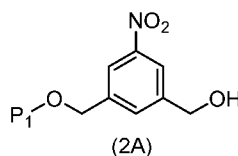


wherein P₁ is an alcohol protecting group; X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the twenty-second embodiment is a method of preparing a
10 compound of formula (13A),



or a salt thereof, said method comprising reacting a chlorinating reagent with a
compound of formula (2A),



15 wherein P₁ is an alcohol protecting group and X₃ is -Cl.

In another specific embodiment, for methods of the twenty-second embodiment, the alcohol protecting group is pivoloxy, methoxymethyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, 3,4-dimethoxybenzyl, 2,6-dimethoxybenzyl, diphenylmethyl, benzyloxymethyl, 2,2,2-trichloroethoxycarbonyl, tetrahydrofuranyl, tetrahydropyranyl, benzyl, benzoyl, *para*-phenylbenzoyl, 2,4,6-trimethylbenzoyl, *para*-bromobenzoyl, *para*-nitrobenzoyl, picolinoyl, nicotinoyl, 5-dibenzosuberonyl, trityl/triphenylmethyl, or tris(4-*tert*-butylphenyl)methyl. Preferably, the alcohol protecting group is
20 methoxymethyl, tetrahydropyranyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl,

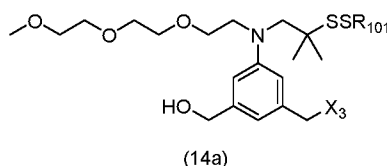
benzyloxymethyl, or 2,2,2-trichloroethoxycarbonyl. Even more preferably, the alcohol protecting group is 2,2,2-trichloroethoxycarbonyl.

In another specific embodiment, the alcohol protecting group is a silyl protecting group. For example, the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl. Preferably, the silyl protecting group is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl. More preferably, the silyl protecting group is *tert*-butyldimethylsilyl.

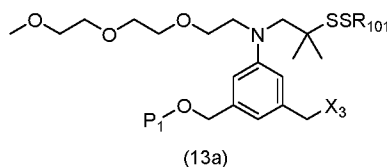
In one embodiment, the base is used. The base can be a non-nucleophilic base. Examples of non-nucleophilic base include, but are not limited to, triethylamine, imidazole, diisopropylethylamine (DIPEA), pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine. Preferably, the non-nucleophilic base is pyridine.

Any suitable organic solvents can be used for the methods of the twenty-second embodiment. Exemplary solvents include, but are not limited to, DMF, CH₂Cl₂, dichloroethane, THF, dimethylacetamide, etc. In certain embodiments, DMF is used as the solvent.

In a twenty-third embodiment, the present invention provides a method of preparing a compound of formula (14a),

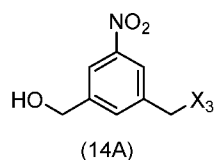


or a salt thereof, said method comprising reacting a compound of formula (13a)

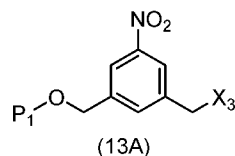


with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the twenty-third embodiment is a method of preparing a compound of formula (14A),



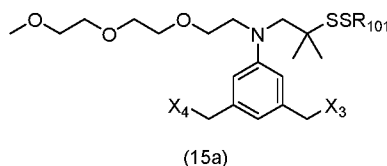
or a salt thereof, said method comprising reacting a compound of formula (13A)



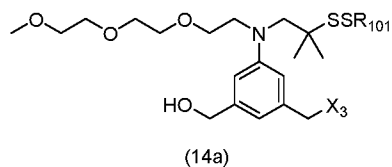
with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; and X₃ is -Cl.

In another specific embodiment, for methods of the twenty-third embodiment, the alcohol deprotecting reagent is tetra-n-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, trifluoroacetic acid, pyridinium p-toluenesulfonate, p-toluenesulfonic acid (p-TsOH), formic acid, or periodic acid. Preferably, the alcohol deprotecting reagent is hydrogen fluoride pyridine.

In a twenty-fourth embodiment, the present invention provides a method of preparing a compound of formula (15a):

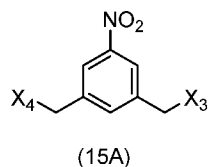


or a salt thereof, said method comprising reacting a sulfonating reagent or an esterification reagent with a compound of formula (14a),

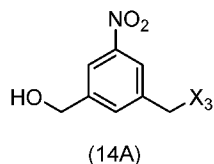


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the twenty-fourth embodiment is a method of preparing a compound of formula (15A),



or a salt thereof, said method comprising reacting a sulfonating reagent or an esterification reagent with a compound of formula (14A),



5 Wherein X₃ is -Cl; and X₄ is a sulfonate ester or an activated ester.

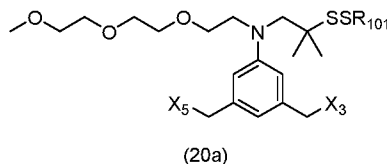
 In a specific embodiment, for methods of the twenty-fourth embodiment, X₄ is a sulfonate ester.

 In another specific embodiment, for methods of the twenty-fourth embodiment, the sulfonating reagent is methanesulfonyl anhydride, methanesulfonyl chloride, p-
10 toluenesulfonyl chloride, 4-bromobenzenesulfonyl chloride, or trifluoromethanesulfonyl anhydride.

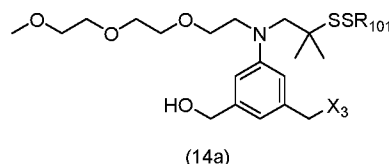
 In another specific embodiment, for methods of the twenty-fourth embodiment, the sulfonate ester is mesylate, tosylate, brosylate, or triflate. Preferably, the sulfonate ester is mesylate.

15 In another embodiment, for methods of the twenty-fourth embodiment, a base is used. The base can be a non-nucleophilic base. Examples of non-nucleophilic base include, but are not limited to, triethylamine, imidazole, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine. Preferably, the non-nucleophilic base is
20 diisopropylethylamine.

 In a twenty-fifth embodiment, the present invention provides a method of preparing a compound of formula (20a):

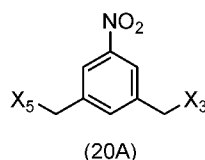


25 or a salt thereof, said method comprising reacting a brominating or iodinating reagent with a compound of formula (14a),



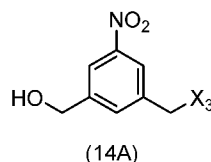
wherein X_3 is $-\text{Cl}$; X_5 is $-\text{Br}$ or $-\text{I}$; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

Also provided in the twenty-fifth embodiment is a method of preparing a compound of formula (20A):



5

or a salt thereof, said method comprising reacting a brominating or iodinating reagent with a compound of formula (14A),



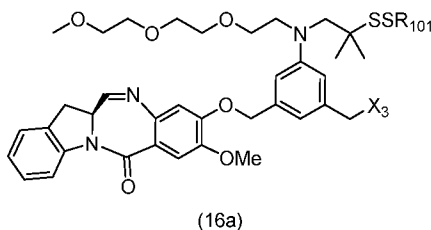
wherein X_3 is $-\text{Cl}$; X_5 is $-\text{Br}$ or $-\text{I}$; and R_{100} is $(\text{C}_1\text{-C}_3)\text{alkoxy}$.

10

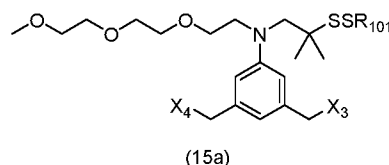
In a specific embodiment, for methods of the twenty-fifth embodiment, the brominating or iodinating reagent is bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.

In a twenty-sixth embodiment, the present invention provides a method of preparing a compound of formula (16a):

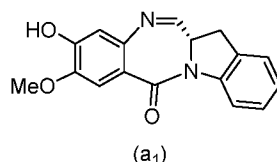
15



or a salt thereof, said method comprising reacting a compound of formula (15d)

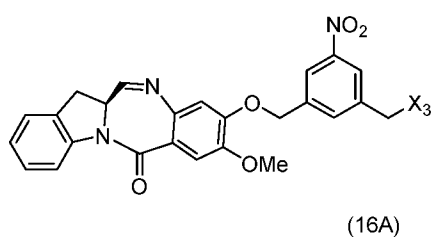


with a monomer compound of formula (a₁),

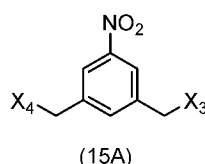


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

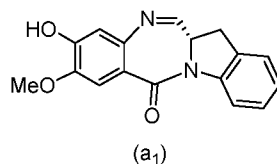
Also provided in the twenty-sixth embodiment is a method of preparing a
5 compound of formula (16A),



or a salt thereof, said method comprising reacting a compound of formula (15A)



with a monomer compound of formula (a₁),



10

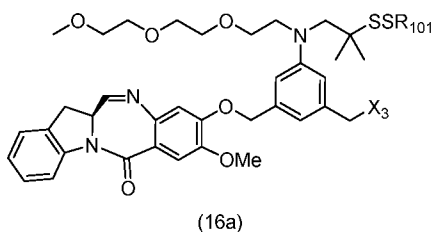
wherein X₃ is -Cl; and X₄ is a sulfonate ester or an activated ester.

In a specific embodiment, for methods of the twenty-sixth embodiment, X₄ is a sulfonate ester.

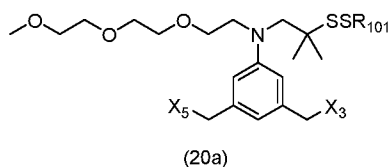
In an embodiment, for methods of the twenty-sixth embodiment, a base is used.
15 In specific embodiment, the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. Preferably, the base is potassium carbonate.

Any suitable organic solvents can be used for the methods of the twenty-sixth embodiment. Exemplary solvents include, but are not limited to, DMF, CH₂Cl₂,
20 dichloroethane, THF, dimethylacetamide, etc. In certain embodiments, dimethylacetamide is used as the solvent.

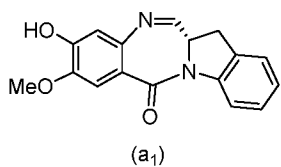
In a twenty-seventh embodiment, the present invention provides a method of preparing a compound of formula (16a),



or a salt thereof, said method comprising reacting a compound of formula (20a)

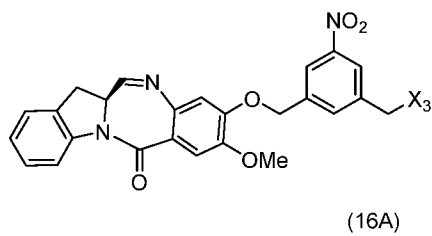


with a monomer compound of formula (a₁),

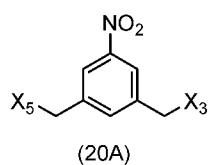


wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

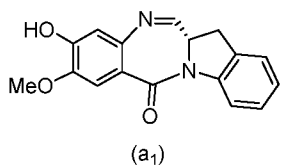
Also provided in the twenty-seventh embodiment is a method of preparing a compound of formula (16A),



or a salt thereof, said method comprising reacting a compound of formula (20A)



with a monomer compound of formula (a₁),

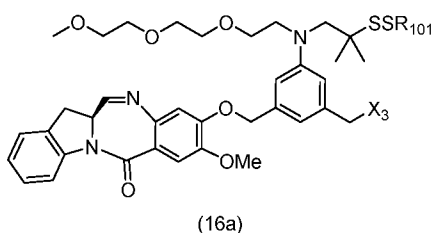


wherein X_3 is $-Cl$ and X_5 is $-Br$ or $-I$.

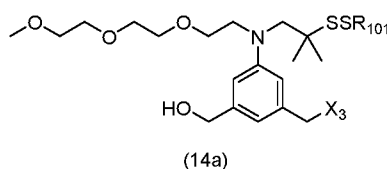
In a specific embodiment, for methods of the twenty-seventh embodiment, the compound of formula (20a) or (20A) is reacted with the monomer compound of formula (a₁) in the presence of a base. Any suitable base can be used. In one embodiment, the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. More specifically, the base is potassium carbonate.

In one embodiment, for methods of the twenty-seventh embodiment, any suitable solvent can be used for the reactions of compounds of formula (20a) or (20A) with the monomer compounds of formula (a₁). In a specific embodiment, the reaction is carried out in a polar aprotic solvent. More specifically, the aprotic solvent is dimethylacetamide.

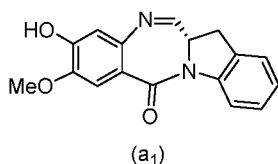
In a twenty-eighth embodiment, the present invention provides a method of preparing a compound of formula (16a),



or a salt thereof, said method comprising reacting a compound of formula (14a)

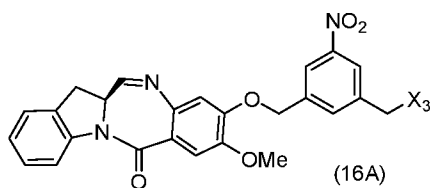


with a monomer compound of formula (a₁),

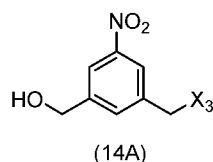


wherein X_3 is $-Cl$; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

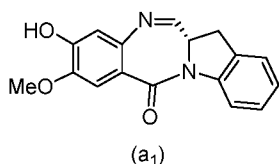
Also included in the twenty-eighth embodiment is a method of preparing a compound of formula (16A),



or a salt thereof, said method comprising reacting a compound of formula (14A)



with a monomer compound of formula (a₁),



wherein X₃ is -Cl.

In a specific embodiment, for methods of the twenty-eighth embodiment, the compound of formula (14a) or (14A) is reacted with a monomer of formula (a₁) in the presence of an alcohol activating agent. In one embodiment, the alcohol activating agent is a trialkyl phosphine, triarylphosphine, or triheteroarylphosphine. In a specific embodiment, the alcohol activating agent is trimethylphosphine, tributylphosphine, tri(o-tolyl)phosphine, tri(m-tolyl)phosphine, tri(p-tolyl)phosphine, tri(2-pyridyl)phosphine, tri(3-pyridyl)phosphine, tri(4-pyridyl)phosphine, or [4-(3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-Heptafluorodecyl)phenyl] diphenylphosphine. In another embodiment, the alcohol activating agent can be a phosphine-like reagents, such as (tributylphosphoranylidene)acetonitrile, (cyanomethylene)tributylphosphorane (CMBP), or (cyanomethylene)trimethylphosphorane (CMMP). In a more specific embodiment, the alcohol activating agent is triphenylphosphine. In one embodiment, the alcohol activating agent can be polymer-bound or polymer-supported, such as polymer-bound or polymer-supported trialkyl phosphine, triarylphosphine (e.g., triphenylphosphine), or triheteroarylphosphine.

In another specific embodiment, for methods of the twenty-eighth embodiment, the compound of formula (14a) or (14A) is reacted with a monomer of formula (a₁) in the presence of an azodicarboxylate. In one embodiment, the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl

azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), ditertbutyl azodicarboxylate (DTAD), 1,6-dimethyl-1,5,7-hexahydro-1,4,6,7-tetrazocin-2,5-dione (DHTD), di-(4-chlorobenzyl)azodicarboxylate (DCAD), azodicarboxylic dimorpholide, N,N,N',N'- tetramethylazodicarboxamide (TMAD), N,N,N',N'-

5 tetraisopropylazodicarboxamide (TIPA), 4,4'-azopyridine, bis (2,2,2-trichloroethyl) azodicarboxylate, o-(tert-Butyldimethylsilyl)-N-tosylhydroxylamine, di-(4-chlorobenzyl)azodicarboxylate, cyclic 1,6-dimethyl-1,5,7-hexahydro-1,4,6,7-tetrazocin-2,5-dione (DHTD), dimethyl acetylenedicarboxylate (DMAD), di-2-methoxyethyl azodicarboxylate, di-(4-chlorobenzyl)azodicarboxylate and bis(4,4,5,5,6,6,7,7,8,8,9,9,9-tridecafluorononyl) azodicarboxylate, . More specifically, the azodicarboxylate is

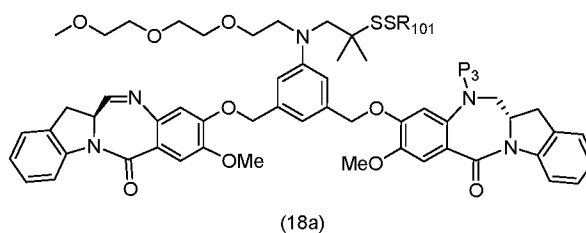
10 DIAD. In one embodiment, the azodicarboxylate is polymer-bound or polymer supported, such as polymer-supported alkylazodicarboxylate (*e.g.* polymer-bound DEAD, DIAD, DTAD or ADDP).

In yet another specific embodiment, for methods of the twenty-eighth

15 embodiment, the compound of formula (14a) or (14A) is reacted with a monomer of formula (a₁) in the presence of triphenylphosphine and an azodicarboxylate. In one embodiment, the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), and ditertbutyl azodicarboxylate (DTAD). More

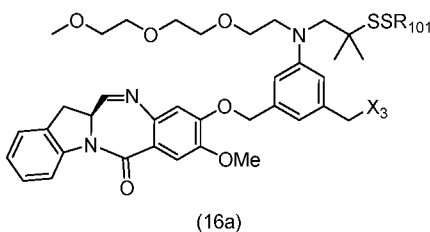
20 specifically, the azodicarboxylate is DIAD.

In a twenty-ninth embodiment, the present invention provides a method of preparing a compound of formula (18a):

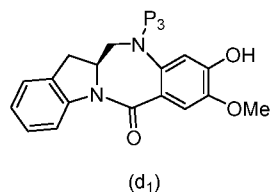


a pharmaceutically acceptable salt thereof, said method comprising reacting a compound

25 of formula of (16a):

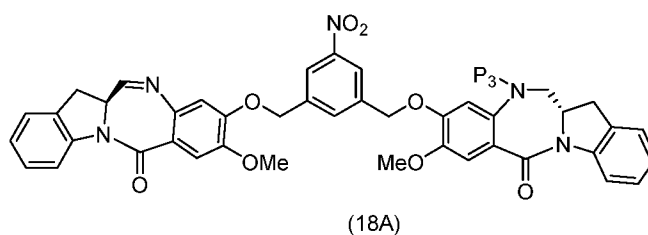


with a reduced monomer of formula (d₁):

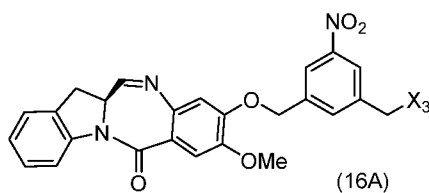


wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

5 Also provided in the twenty-ninth embodiment is a method of preparing a compound of formula (18A),

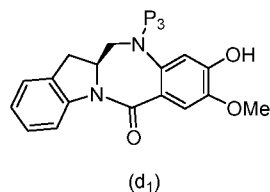


a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (16A):



10

with a reduced monomer of formula (d₁):



wherein X₃ is -Cl; and P₃ is H or an amine protecting group.

15 In one embodiment, for methods of the twenty-ninth embodiment, the reaction between the compound of formula (16a) or (16A) and the reduced monomer of formula (d₁) is carried out in the presence of a base. In specific embodiment, the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. Preferably, the base is potassium carbonate.

Any suitable organic solvents can be used for the methods of the twenty-ninth
20 embodiment. In one embodiment, the solvent is a polar aprotic solvent. Exemplary solvents include, but are not limited to, dimethylformamide (DMF), CH₂Cl₂,

dichloroethane, THF, dimethylacetamide, etc. In certain embodiments, dimethylformamide or dimethylacetamide is used as the solvent.

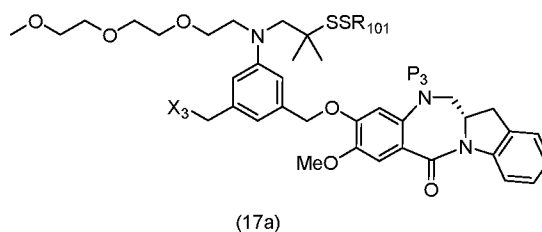
In a specific embodiment of the twenty-ninth embodiment, the compound of formula (16a) or (16A) is reacted with reduced monomer of formula (d₁), wherein P₃ is H, to form a compound of formula (Ia') or (IA), respectively.

In another specific embodiment of the twenty-ninth embodiment, P₃ is an amine protecting group. Any suitable amine protecting group can be used in the method described above. In one embodiment, the amine protecting group is 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, or 2, 2,2,2-trichloroethoxycarbonyl.

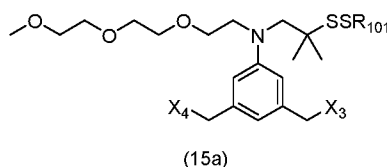
When P₃ is an amine protecting group, the compound of formula (18a) or (18A) is further reacted with an amine deprotecting reagent to form a compound of formula (Ia') or (IA), respectively.

15 Examples of suitable amine deprotecting reagent include, but are not limited to, the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

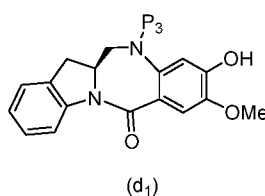
In a thirtieth embodiment, the present invention provides a method for preparing
20 a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (15a)

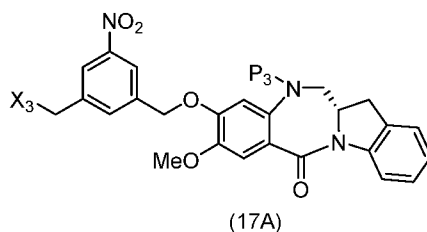


with a monomer compound of formula (d₁),

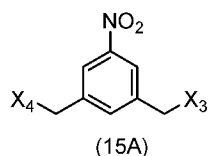


wherein X_3 is $-\text{Cl}$; X_4 is a sulfonate ester or an activated ester; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl. In one embodiment, X_4 is an activated ester.

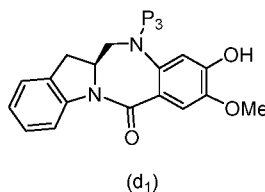
Also included in the thirtieth embodiment is a method of preparing a compound
5 of formula (17A),



or a salt thereof, said method comprising reacting a compound of formula (15A)



with a monomer compound of formula (d_1),



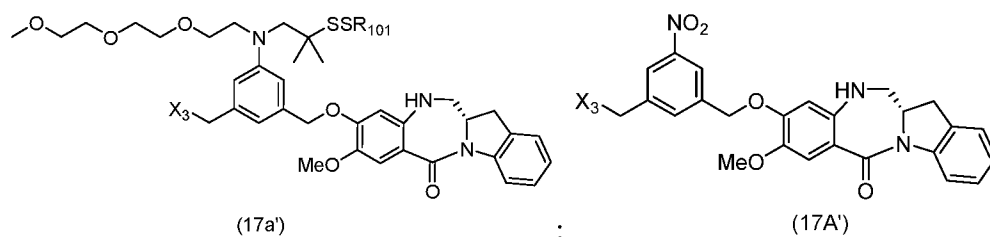
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wherein X_3 is $-\text{Cl}$; X_4 is a sulfonate ester or an activated ester; and P_3 is H or an amine protecting group. In one embodiment, X_4 is an activated ester.

In an embodiment, for methods of the thirtieth embodiment, a base is used. In specific embodiment, the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. Preferably, the base is potassium carbonate.
15

Any suitable organic solvents can be used for the methods of the thirtieth embodiment. Exemplary solvents include, but are not limited to, DMF, CH_2Cl_2 , dichloroethane, THF, dimethylacetamide, etc. In certain embodiments,
20 dimethylacetamide is used as the solvent.

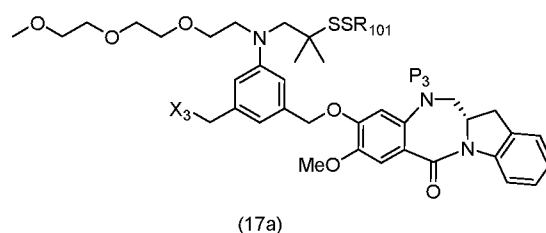
In a specific embodiment of the thirtieth embodiment, P_3 is H and the compound of formula (15a) or (15A) is reacted with the monomer compound of formula (d_1) to form a compound of formula (17a') or (17A'), respectively.



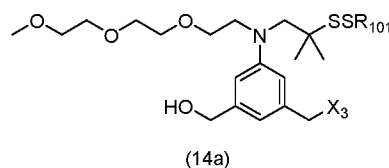
In another specific embodiment of the thirtieth embodiment, P₃ is an amine protecting group and the method further comprises the step of reacting the compound of formula (17a) or (17A) with an amine deprotecting reagent to form a compound of formula (17a') or (17A'), respectively.

Examples of suitable amine deprotecting reagent include, but are not limited to, the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

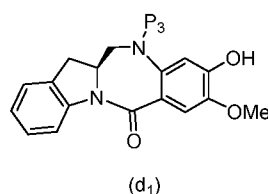
In a thirty-first embodiment, the present invention provides a method of preparing a compound of formula (17a),



or a salt thereof, said method comprising reacting a compound of formula (14a)

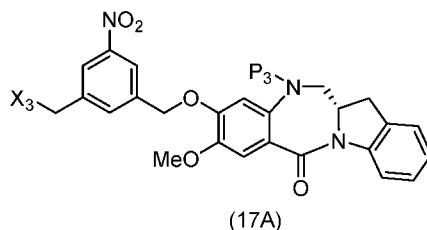


with a monomer compound of formula (d₁),

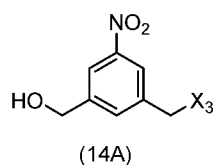


wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also included in the thirty-first embodiment is a method of preparing a compound of formula (17A),

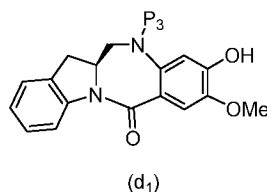


or a salt thereof, said method comprising reacting a compound of formula (14A)



5

with a monomer compound of formula (d₁),



wherein X₃ is -Cl; and P₃ is H or an amine protecting group.

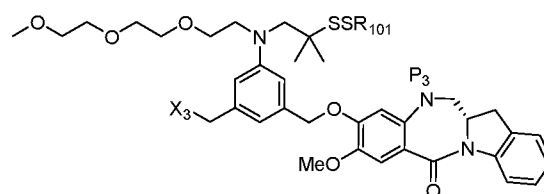
In a specific embodiment, for methods of the thirty-first embodiment, the compound of formula (14a) or (14A) is reacted with a monomer of formula (d₁) in the presence of an alcohol activating agent. In one embodiment, the alcohol activating agent is a trialkyl phosphine, triarylphosphine, or triheteroarylphosphine. In a specific embodiment, the alcohol activating agent is trimethylphosphine, tributylphosphine, tri(o-tolyl)phosphine, tri(m-tolyl)phosphine, tri(p-tolyl)phosphine, tri(2-pyridyl)phosphine, tri(3-pyridyl)phosphine, tri(4-pyridyl)phosphine, or [4-(3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptafluorodecyl)phenyl]diphenylphosphine. In another embodiment, the alcohol activating agent can be a phosphine-like reagent, such as (tributylphosphoranylidene)acetonitrile, (cyanomethylene)tributylphosphorane (CMBP), or (cyanomethylene)trimethylphosphorane (CMMP). In a more specific embodiment, the alcohol activating agent is triphenylphosphine. In one embodiment, the alcohol activating agent can be polymer-bound or polymer-supported, such as polymer-

bound or polymer-supported trialkyl phosphine, triarylphosphine (e.g., triphenylphosphine), or triheteroarylphosphine.

In another specific embodiment, for methods of the thirty-first embodiment, the compound of formula (14a) or (14A) is reacted with a monomer of formula (d₁) in the presence of an azodicarboxylate. In one embodiment, the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), ditertbutyl azodicarboxylate (DTAD), 1,6-dimethyl-1,5,7-hexahydro-1,4,6,7-tetrazocin-2,5-dione (DHTD), di-(4-chlorobenzyl)azodicarboxylate (DCAD), azodicarboxylic dimorpholide, N,N,N',N'- tetramethylazodicarboxamide (TMAD), N,N,N',N'- tetraisopropylazodicarboxamide (TIPA), 4,4'-azopyridine, bis (2,2,2-trichloroethyl) azodicarboxylate, o-(tert-Butyldimethylsilyl)-N-tosylhydroxylamine, di-(4-chlorobenzyl)azodicarboxylate, cyclic 1,6-dimethyl-1,5,7-hexahydro-1,4,6,7-tetrazocin-2,5-dione (DHTD), dimethyl acetylenedicarboxylate (DMAD), di-2-methoxyethyl azodicarboxylate, di-(4-chlorobenzyl)azodicarboxylate and bis(4,4,5,5,6,6,7,7,8,8,9,9,9-tridecafluorononyl) azodicarboxylate, . More specifically, the azodicarboxylate is DIAD. In one embodiment, the azodicarboxylate is polymer-bound or polymer supported, such as polymer-supported alkylazodicarboxylate (e.g. polymer-bound DEAD, DIAD, DTAD or ADDP).

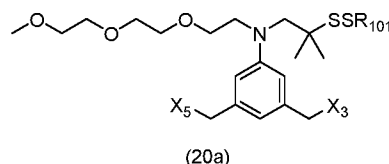
In yet another specific embodiment, for methods of the thirty-first embodiment, the compound of formula (14a) or (14A) is reacted with a monomer of formula (d₁) in the presence of triphenylphosphine and an azodicarboxylate. In one embodiment, the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), and ditertbutyl azodicarboxylate (DTAD). More specifically, the azodicarboxylate is DIAD.

In a thirty-second embodiment, the present invention provides a method of preparing a compound of formula (17a):

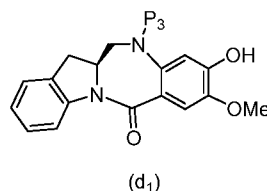


(17a)

or a salt thereof, said method comprising reacting a compound of formula (20a)

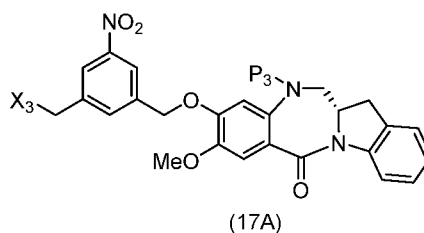


with a monomer compound of formula (d₁),

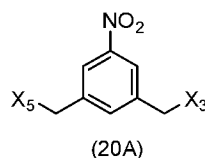


wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

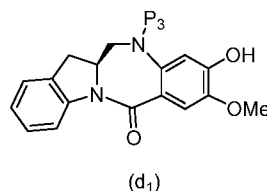
Also provided in the thirty-second embodiment is a method of preparing a compound of formula (17A):



or a salt thereof, said method comprising reacting a compound of formula (20A)



with a monomer compound of formula (d₁),

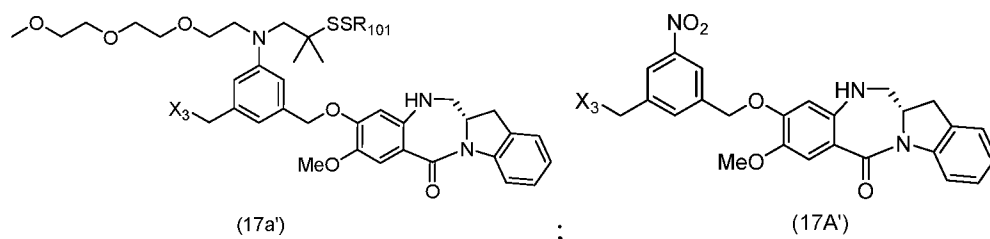


wherein X₃ is -Cl; X₅ is -Br or -I; and P₃ is H or an amine protecting group.

In one embodiment, for methods of the thirty-second embodiment, the compound of formula (20a) or (20A) is reacted with the monomer compound of formula (d₁) in the presence of a base. Any suitable base can be used. In one embodiment, the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride. More specifically, the base is potassium carbonate.

In another embodiment, for methods of the thirty-second embodiment, any suitable solvent can be used for the reactions of compounds of formula (20a) or (20A) with the monomer compounds of formula (d₁). In a specific embodiment, the reaction is carried out in a polar aprotic solvent. More specifically, the aprotic solvent is dimethylacetamide.

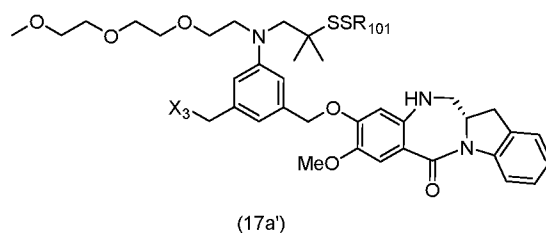
In a specific embodiment of the thirty-second embodiment, P₃ is H and the compound of formula (20a) or (20A) is reacted with the monomer compound of formula (d₁) to form a compound of formula (17a') or (17A'), respectively.



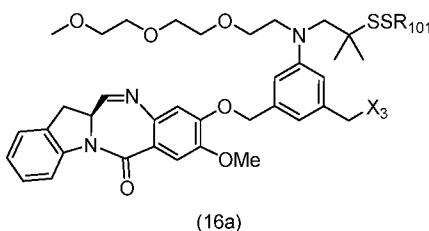
In another specific embodiment of the thirty-second embodiment, P₃ is an amine protecting group, the method further comprises the step of reacting the compound of formula (17a) or (17A) with an amine deprotecting reagent to form a compound of formula (17a') or (17A'), respectively.

Examples of suitable amine deprotecting reagent include, but are not limited to, the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

In a thirty-third embodiment, the present invention provides a method of preparing a compound of formula (17a'):

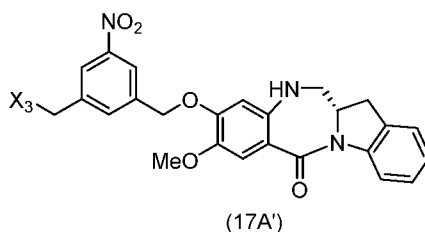


or a salt thereof, said method comprising reacting a compound of formula (16a)



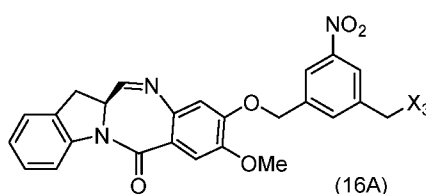
with an imine reducing agent, wherein X_3 is $-\text{Cl}$; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

Also included in the thirty-third embodiment is a method of preparing a compound of formula (17A'):



5

or a salt thereof, said method comprising reacting a compound of formula (16A)

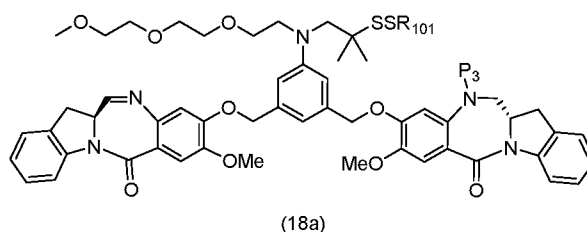


with an imine reducing agent, wherein X_3 is $-\text{Cl}$.

In one specific embodiment, for methods of the thirty-third embodiment, the imine reducing agent is a hydride reducing agent. Examples of suitable hydride reducing agents include, but are not limited to, sodium borohydride, sodium triacetoxy borohydride, sodium cyanoborohydride, lithium aluminum hydride, hydrogen gas, ammonium formate, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminum hydride (DIBAL), lithium borohydride (LiBH_4), potassium borohydride (KBH_4), or sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al). In one particular embodiment, the hydride reducing agent is sodium triacetoxy borohydride ($\text{NaBH}(\text{OAc})_3$).

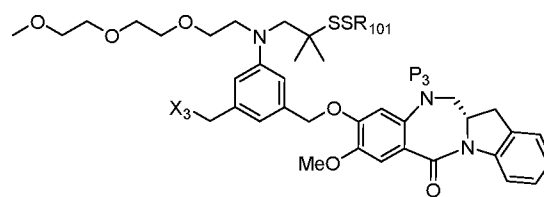
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In a thirty-fourth embodiment, the present invention provides a method of preparing a compound of formula (18a),



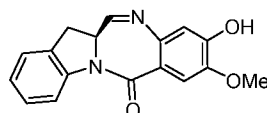
20

or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (17a):



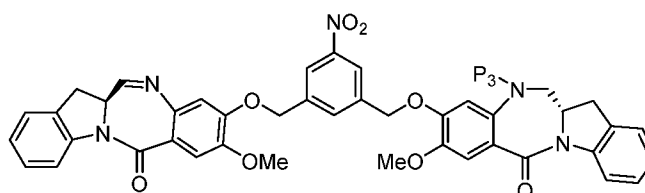
(17a)

with a monomer of formula (a₁):

(a₁)

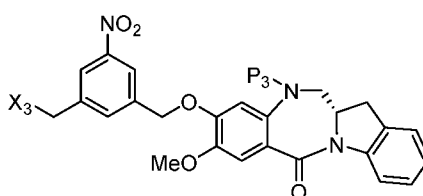
wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the thirty-fourth embodiment is a method of preparing a compound of formula (18A),



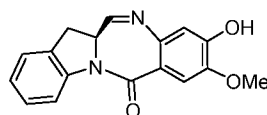
(18A)

or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (17A):



(17A)

with a monomer of formula (a₁):

(a₁)

wherein X₃ is -Cl; and P₃ is H or an amine protecting group.

In one embodiment, for methods of the thirty-fourth embodiment, the reaction between the compound of formula (17a) or (17A) and the monomer of formula (a₁) is carried out in the presence of a base. In specific embodiment, the base is sodium

carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassiumhydride. Preferably, the base is potassium carbonate.

Any suitable organic solvents can be used for the methods of the thirty-fourth embodiment. In one embodiment, the solvent is a polar aprotic solvent. Exemplary solvents include, but are not limited to, dimethylformamide (DMF), CH₂Cl₂, dichloroethane, THF, dimethylacetamide, etc. In certain embodiments, dimethylformamide or dimethylacetamide is used as the solvent.

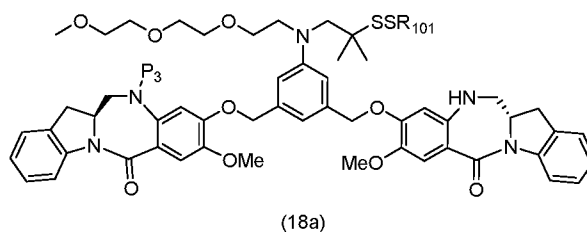
In a specific embodiment of the thirty-fourth embodiment, the compound of formula (17a) or (17A) is reacted with the monomer of formula (a₁), wherein P₃ is H, to form a compound of formula (Ia') or (IA), respectively.

In another specific embodiment of the thirty-fourth embodiment, P₃ is an amine protecting group. Any suitable amine protecting group can be used in the method described above. In one embodiment, the amine protecting group is 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, or 2, 2,2,2-trichloroethoxycarbonyl.

When P₃ is an amine protecting group, the compound of formula (18a) or (18A) is further reacted with an amine deprotecting reagent to form a compound of formula (Ia') or (IA), respectively.

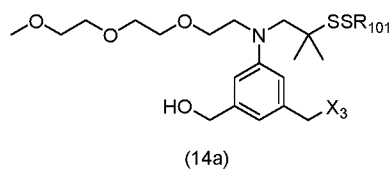
20 Examples of suitable amine deprotecting reagent include, but are not limited to, the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

In a thirty-fifth embodiment, the present invention provides a method of
25 preparing a compound of formula (18a),

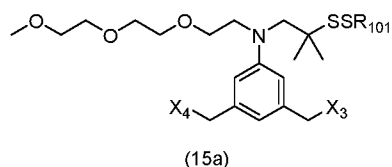


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

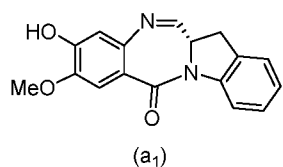


or a salt thereof, to form a compound of formula (15a):

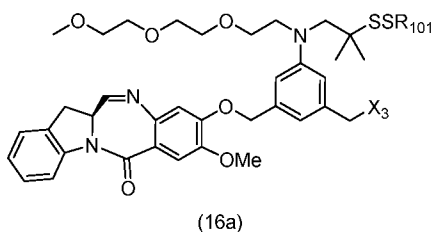


or a salt thereof;

- 5 (2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),

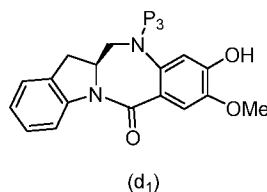


to form a compound of formula (16a):



- 10 or a salt thereof; and

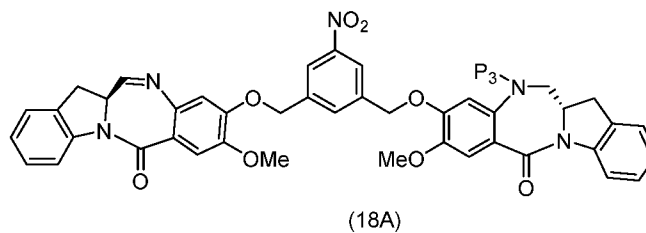
- (3) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof,

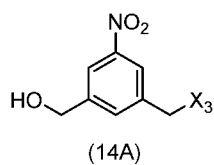
- 15 wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl. In one embodiment, X₄ is a sulfonate ester.

Also included in the thirty-fifth embodiment is a method of preparing a compound of formula (18A),

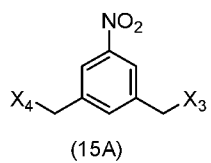


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- 5 (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14A):

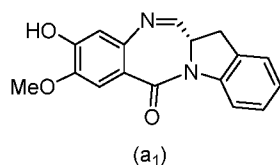


or a salt thereof, to form a compound of formula (15A):

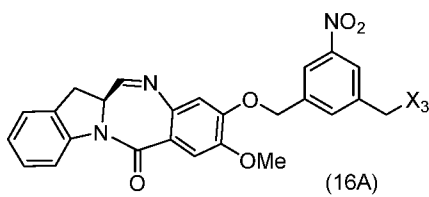


- 10 or a salt thereof;

(2) reacting the compound of formula (15A) with a monomer compound of formula (a₁),



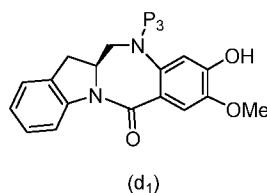
to form a compound of formula (16A):



- 15

or a salt thereof; and

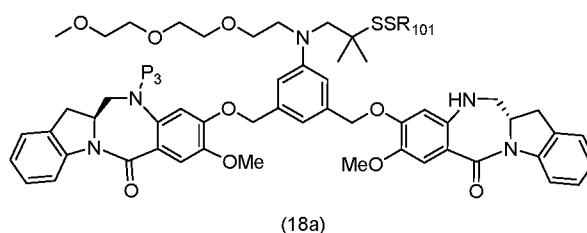
(3) reacting the compound of formula of (16A) with a reduced monomer of formula (d₁):



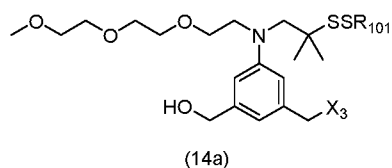
to form a compound of formula (18A), or a pharmaceutically acceptable salt thereof,
 5 wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; P₁ is an alcohol protecting group; and P₃ is H or an amine protecting group. In one embodiment, X₄ is a sulfonate ester.

The conditions and reagents for the method of thirty-fifth embodiment are as described above in the twenty-fourth, twenty-sixth and/or twenty-ninth embodiment(s)
 10 and any specific embodiments described therein.

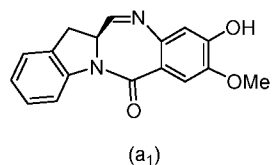
In a thirty-sixth embodiment, the present invention provides a method of preparing a compound of formula (18a),



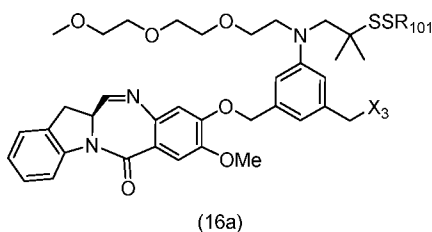
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:
 15 (1) reacting the compound of formula (14a):



or a salt thereof, with a monomer compound of formula (a₁),

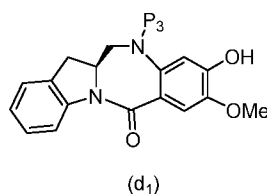


to form a compound of formula (16a):



or a salt thereof; and

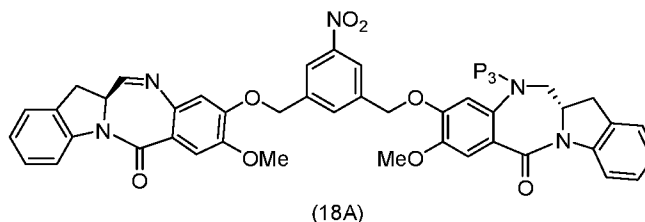
(2) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



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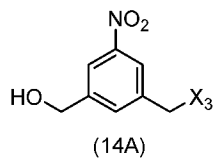
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the thirty-sixth embodiment is a method of preparing a
10 compound of formula (18A),

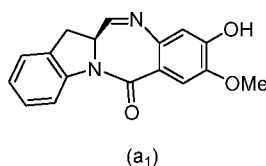


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

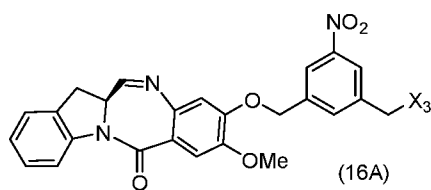
(1) reacting the compound of formula (14A):



15 or a salt thereof, with a monomer compound of formula (a₁),

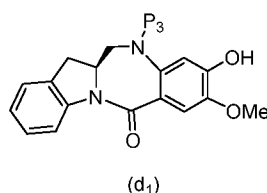


to form a compound of formula (16A):



or a salt thereof; and

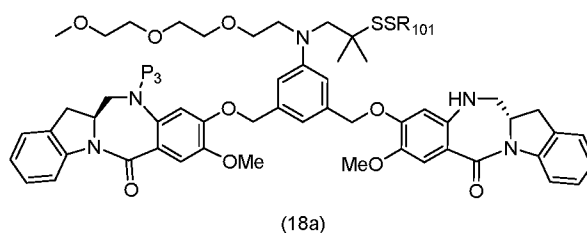
- (2) reacting the compound of formula of (16A) with a reduced monomer of
5 formula (d₁):



to form a compound of formula (18A), or a pharmaceutically acceptable salt thereof,
wherein X₃ is -Cl; P₁ is an alcohol protecting group; and P₃ is H or an amine protecting
group.

- 10 The conditions and reagents for the method of thirty-sixth embodiment are as
described above in the twenty-eighth, and/or twenty-ninth embodiment(s) and any
specific embodiments described therein.

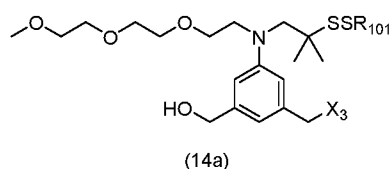
In a thirty-seventh embodiment, the present invention provides a method of
preparing a compound of formula (18a),



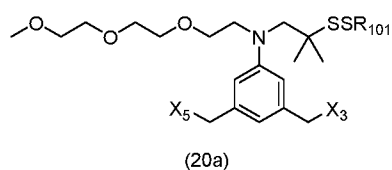
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or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a halogenating reagent with the compound of formula (14a):

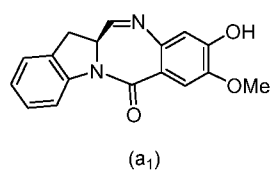


or a salt thereof, to form a compound of formula (20a):

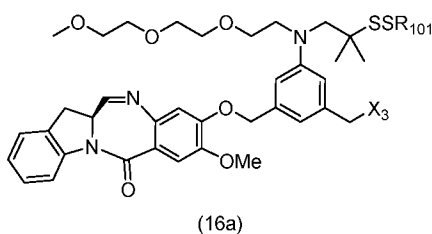


or a salt thereof;

- (2) reacting a compound of formula (20a) or a salt thereof with a monomer
5 compound of formula (a₁),

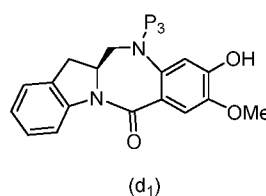


to form a compound of formula (16a):



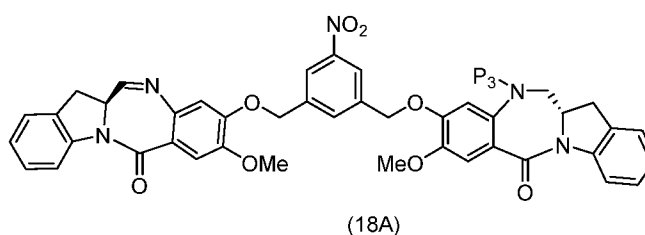
or a salt thereof; and

- (3) reacting the compound of formula of (16a) with a reduced monomer of
10 formula (d₁):



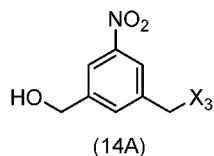
- to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof,
wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-
15 C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the thirty-seventh embodiment is a method of preparing a
compound of formula (18A),

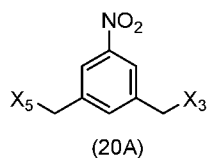


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent with the compound of formula (14A):

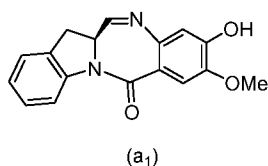


or a salt thereof, to form a compound of formula (20A):

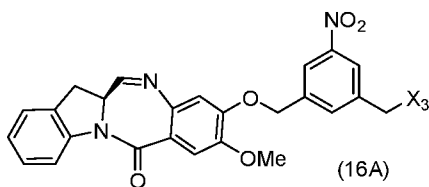


or a salt thereof;

(2) reacting a compound of formula (20A) or a salt thereof with a monomer compound of formula (a₁),

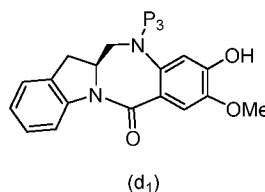


to form a compound of formula (16A):



or a salt thereof; and

(3) reacting the compound of formula of (16A) with a reduced monomer of formula (d₁):



to form a compound of formula (18A), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₅ is -Br or -I; and P₃ is H or an amine protecting group.

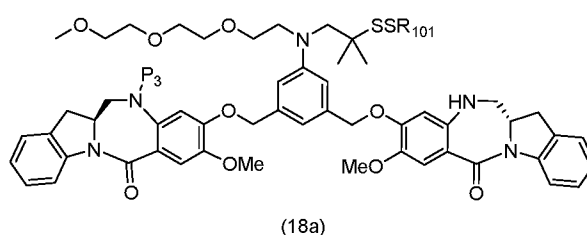
The conditions and reagents for the method of thirty-seventh embodiment are as described above in the twenty-fifth, twenty-seventh, and/or twenty-ninth embodiment(s)

and any specific embodiments described therein.

In a specific embodiment, for the methods of the thirty-fifth, thirty-sixth and thirty-seventh embodiments, P_3 is H, the compound of formula (16a) or (16A) is reacted with reduced monomer of formula (d_1) to form a compound of formula (Ia') or (IA) respectively.

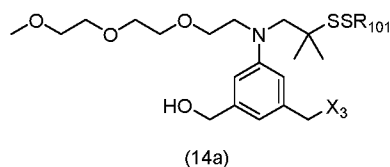
- 5 In another specific embodiment, for the methods of thirty-fifth, thirty-sixth and thirty-seventh embodiments, P_3 is an amine protecting group and the methods further comprise reacting the compound of formula (18a) or (18A) with an amine deprotecting reagent to form a compound of formula (Id') or (IA) respectively.

10 In a thirty-eighth embodiment, the present invention provides a method of preparing a compound of formula (18a),



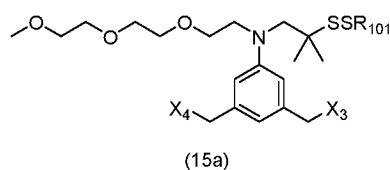
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):



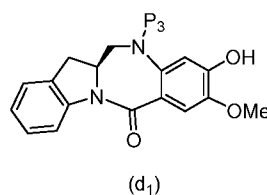
15

or a salt thereof, to form a compound of formula (15a):

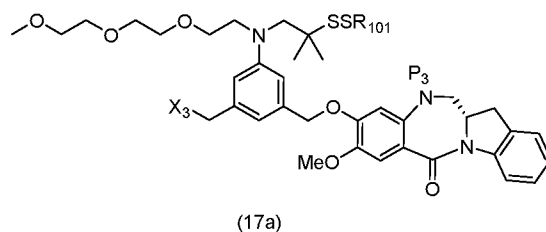


or a salt thereof;

- 20 (2) reacting the compound of formula (15a) with a reduced monomer compound of formula (d_1),

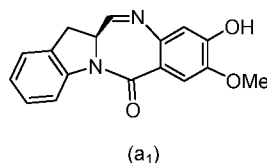


to form a compound of formula (17a):



or a salt thereof; and

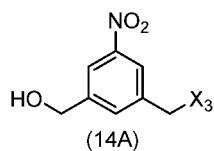
(3) reacting the compound of formula of (17a) with a monomer of formula (a₁):



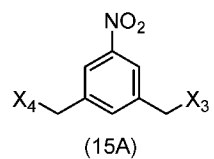
- 5 to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl. In one embodiment, X₄ is a sulfonate ester.

Also provided in the thirty-eighth embodiment is a method of preparing a
10 compound of formula (18A),

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14A):



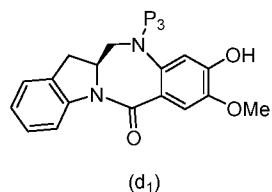
or a salt thereof, to form a compound of formula (15A):



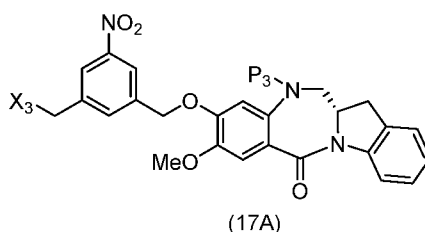
15

or a salt thereof;

(2) reacting the compound of formula (15A) with a reduced monomer compound of formula (d₁),

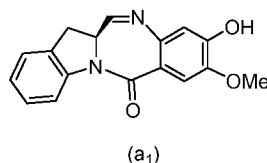


20 to form a compound of formula (17A):



or a salt thereof; and

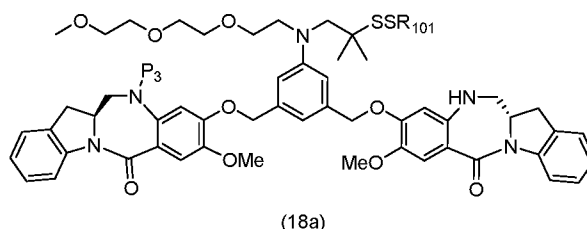
(3) reacting the compound of formula of (17A) with a monomer of formula (a₁):



- 5 to form a compound of formula (18A), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; P₁ is an alcohol protecting group; and P₃ is H or an amine protecting group. In one embodiment, X₄ is a sulfonate ester.

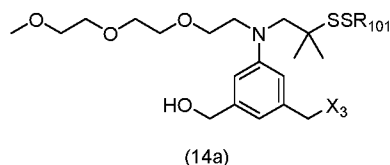
The conditions and reagents for the method of thirty-eighth embodiment are as described above in the twenty-fifth, thirtieth and/or thirty-fourth embodiment(s) and any specific embodiments described therein.

In a thirty-ninth embodiment, the present invention provides method of preparing a compound of formula (18a),

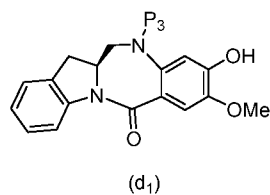


- 15 or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

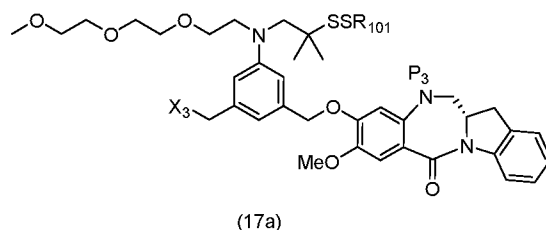
(1) reacting the compound of formula (14a):



or a salt thereof, with a reduced monomer compound of formula (d₁),

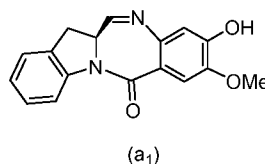


to form a compound of formula (17a):



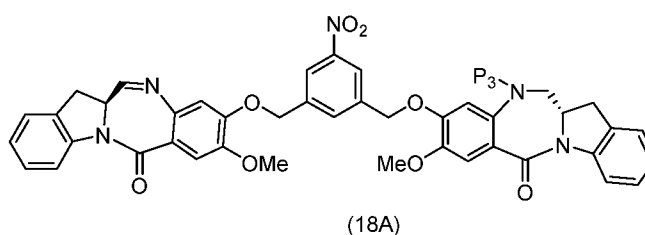
or a salt thereof; and

- 5 (2) reacting the compound of formula of (17a) with a monomer of formula (a₁):



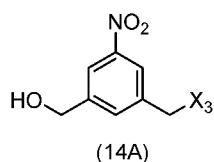
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

- 10 Also provided in the thirty-ninth embodiment is a method of preparing a compound of formula (18A),



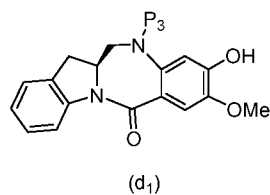
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting the compound of formula (14A):

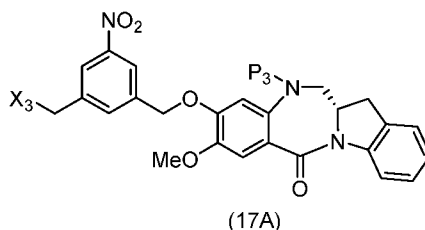


- 15

or a salt thereof, with a reduced monomer compound of formula (d₁),

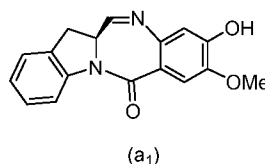


to form a compound of formula (17A):



or a salt thereof; and

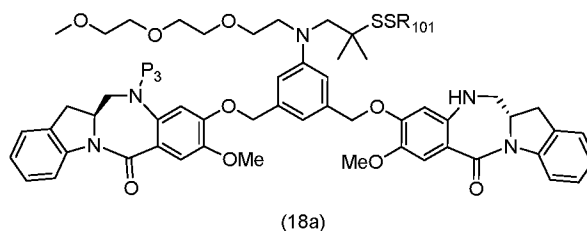
- 5 (2) reacting the compound of formula of (17A) with a monomer of formula (a₁):



to form a compound of formula (18A), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; P₁ is an alcohol protecting group; and P₃ is H or an amine protecting group.

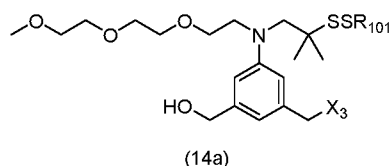
- 10 The conditions and reagents for the method of thirty-ninth embodiment are as described above in the thirty-first and/or thirty-fourth embodiment(s) and any specific embodiments described therein.

In a fortieth embodiment, the present invention provides a method of preparing a compound of formula (18a),

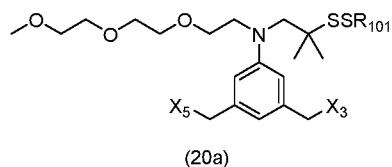


- 15 or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a brominating or iodinating reagent with the compound of formula (14a):

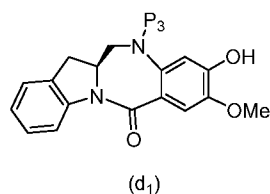


or a salt thereof, to form a compound of formula (20a):

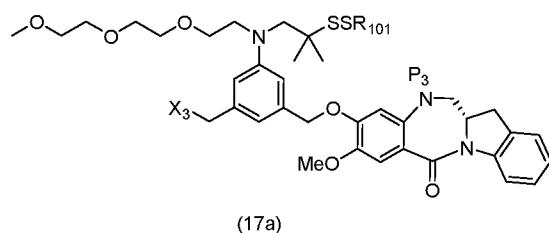


or a salt thereof;

- 5 (2) reacting the compound of formula (20a) with a reduced monomer compound of formula (d₁),

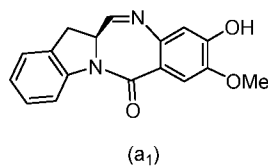


to form a compound of formula (17a):



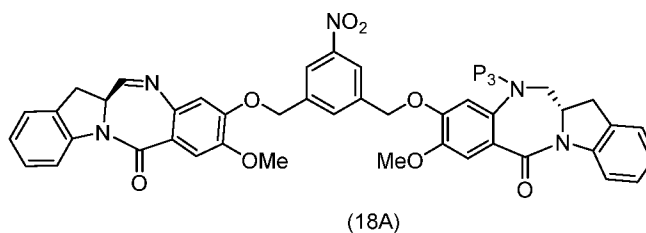
- 10 or a salt thereof; and

- (3) reacting the compound of formula of (17a) with a monomer of formula (a₁):



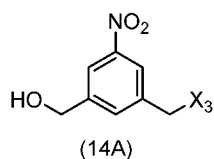
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof,
wherein X₃ is -Cl; X₅ is -Br or -I; P₁ is an alcohol protecting group; P₃ is H or an amine
15 protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the fortieth embodiment is a method of preparing a compound of formula (18A),



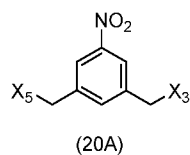
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a brominating or iodinating reagent with the compound of formula (14A):



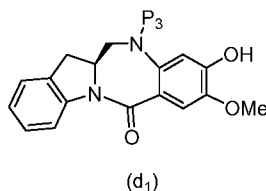
5

or a salt thereof, to form a compound of formula (20A):

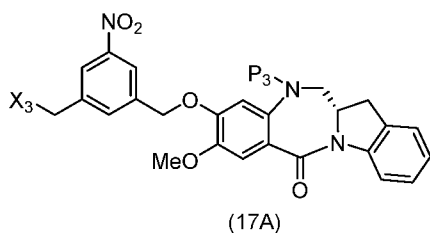


or a salt thereof;

(2) reacting the compound of formula (20A) with a reduced monomer compound of formula (d₁),

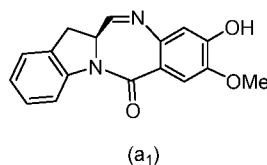


to form a compound of formula (17A):



or a salt thereof; and

(3) reacting the compound of formula of (17A) with a monomer of formula (a₁):



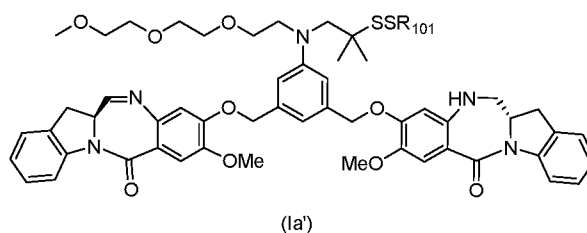
to form a compound of formula (18A), or a pharmaceutically acceptable salt thereof, wherein X_3 is $-\text{Cl}$; X_5 is $-\text{Br}$ or $-\text{I}$; P_1 is an alcohol protecting group; and P_3 is H or an amine protecting group.

The conditions and reagents for the method of fortieth embodiment are as described above in the twenty-fifth, thirty-second and/or thirty-fourth embodiment(s) and any specific embodiments described therein.

In a specific embodiment, for the methods of the thirty-eighth, thirty-ninth and fortieth embodiments, P_3 is H, the compound of formula (17a) or (17A) is reacted with the monomer of formula (a₁) to form a compound of formula (Ia') or (IA) respectively.

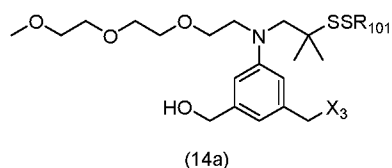
In another specific embodiment, for the methods of thirty-eighth, thirty-ninth and fortieth embodiments, P_3 is an amine protecting group and the methods further comprise reacting the compound of formula (18a) or (18A) with an amine deprotecting reagent to form a compound of formula (Id') or (IA) respectively.

In a forty-first embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



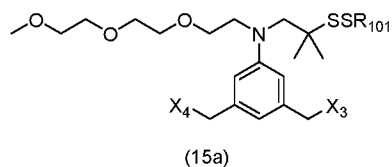
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):



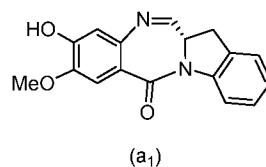
20

or a salt thereof, to form a compound of formula (15a):

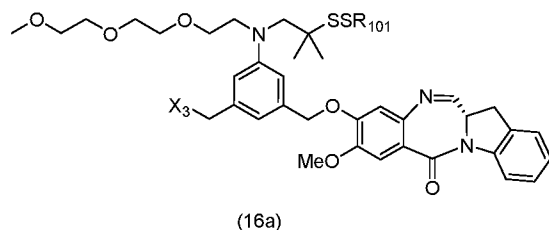


or a salt thereof;

(2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),

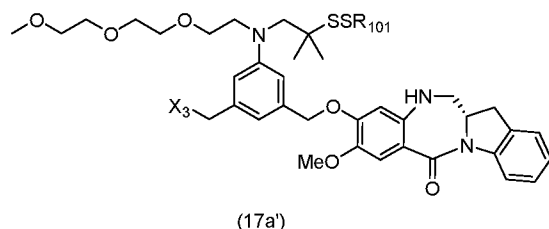


to form a compound of formula (16a):



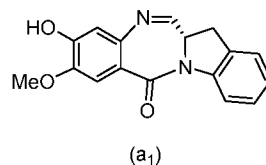
or a salt thereof;

- 5 (3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



or a salt thereof; and

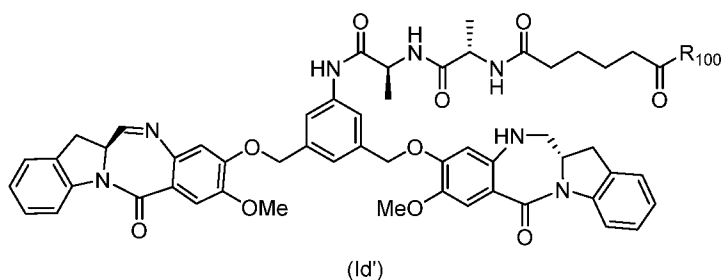
- (4) reacting the compound of formula (17a') with a monomer of formula (a₁):



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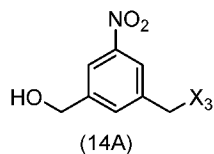
to form the compound of formula (Id'); wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester; P₁ is an alcohol protecting group; P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl. In one embodiment, X₄ is a sulfonate ester.

- Also provided in the forty-first embodiment is a method of preparing a
15 compound of formula (IA),

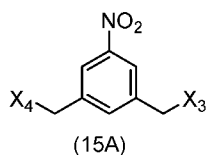


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14A):

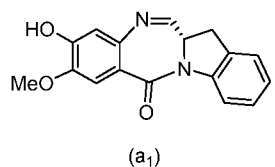


or a salt thereof, to form a compound of formula (15A):

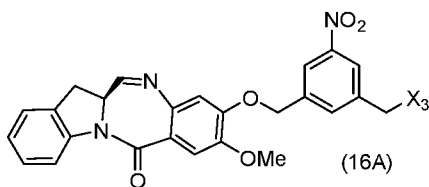


or a salt thereof;

(2) reacting the compound of formula (15A) with a monomer compound of formula (a₁),

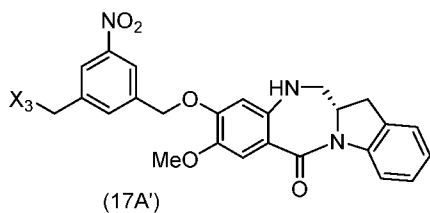


to form a compound of formula (16d):



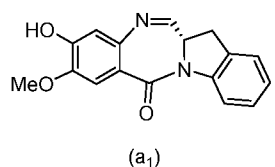
or a salt thereof;

(3) reacting the compound of formula (16A) with an imine reducing agent to form a compound of formula (17A'):



or a salt thereof; and

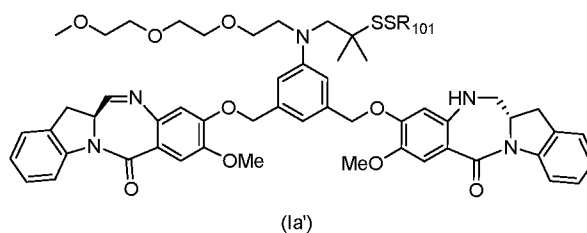
(4) reacting the compound of formula (17A') with a monomer of formula (a₁):



to form the compound of formula (IA); wherein X_3 is $-\text{Cl}$; X_4 is a sulfonate ester or an activated ester; P_1 is an alcohol protecting group; and P_2 is an amine protecting group. In one embodiment, X_4 is a sulfonate ester.

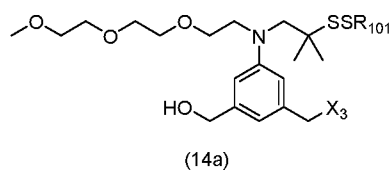
The conditions and reagents for the method of forty-first embodiment are as described above in the twenty-fourth, twenty-sixth and/or thirty-fourth embodiment(s) and any specific embodiments described therein.

In a forty-second embodiment, the present invention provides a method of preparing a compound of formula (Ia'),

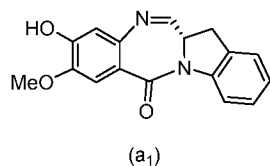


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

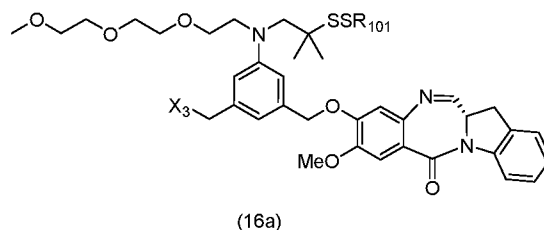
(1) reacting the compound of formula (14a):



or a salt thereof, with a monomer compound of formula (a₁),

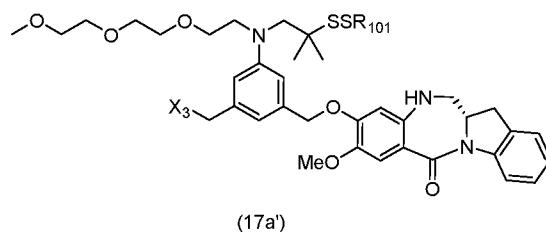


to form a compound of formula (16a):



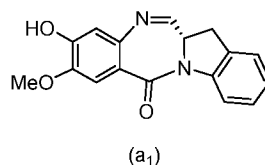
or a salt thereof;

(2) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



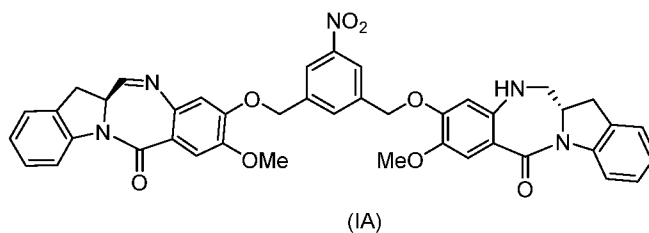
or a salt thereof; and

(3) reacting the compound of formula (17a') with a monomer of formula (a₁):



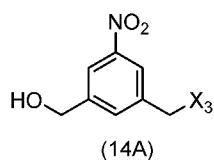
5 to form the compound of formula (Id'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the forty-second embodiment is a method of preparing a compound of formula (IA),

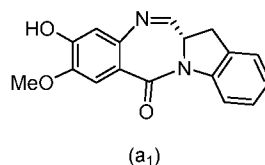


10 or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

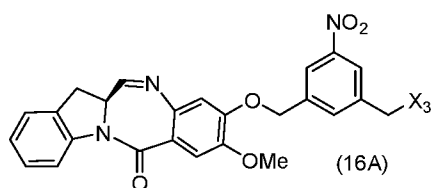
(1) reacting the compound of formula (14A):



or a salt thereof, with a monomer compound of formula (a₁),

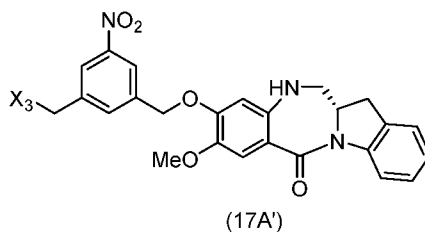


15 to form a compound of formula (16A):



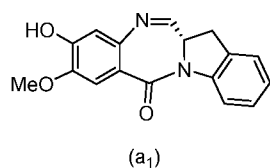
or a salt thereof;

(2) reacting the compound of formula (16A) with an imine reducing agent to form a compound of formula (17A'):



5 or a salt thereof; and

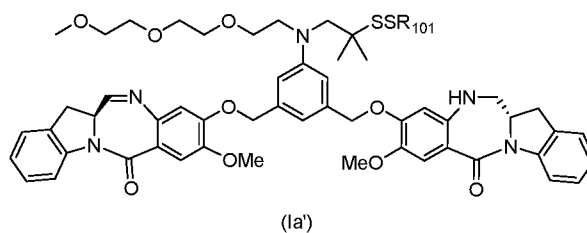
(3) reacting the compound of formula (17A') with a monomer of formula (a₁):



to form the compound of formula (IA); wherein X₃ is -Cl; and P₁ is an alcohol protecting group.

10 The conditions and reagents for the method of forty-second embodiment are as described above in the twenty-eighth, thirty-third and/or thirty-fourth embodiment(s) and any specific embodiments described therein.

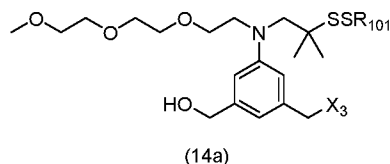
In a forty-third embodiment, the present invention provides a method of preparing a compound of formula (Ia'),



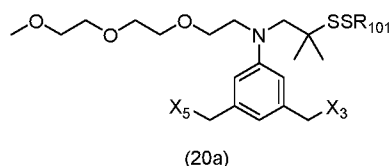
15

or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent with the compound of formula (14a):

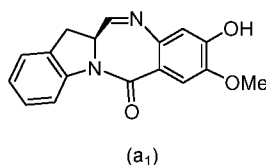


or a salt thereof, to form a compound of formula (20a):

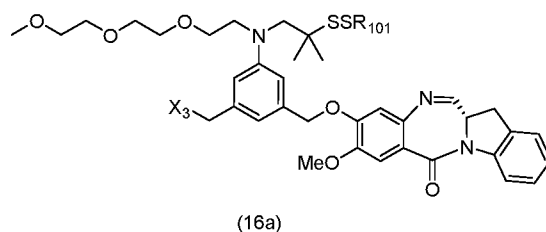


or a salt thereof;

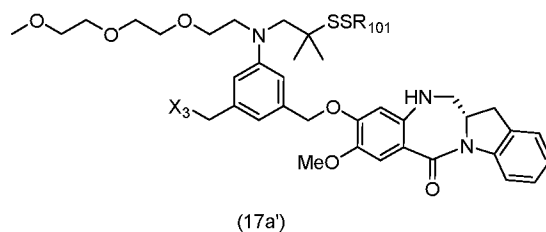
(2) reacting a compound of formula (20a) or a salt thereof with a monomer compound of formula (a₁),



to form a compound of formula (16a):

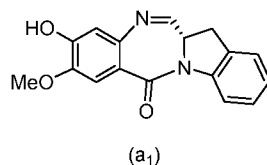


(3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



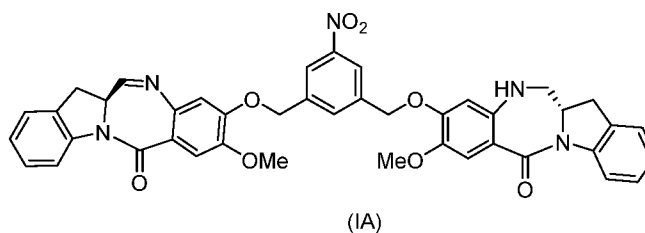
or a salt thereof; and

(4) reacting the compound of formula (17a') with a monomer of formula (a₁):



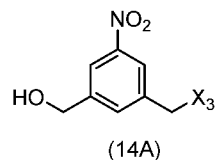
to form the compound of formula (Id'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

Also provided in the forty-third embodiment is a method of preparing a compound of formula (IA),

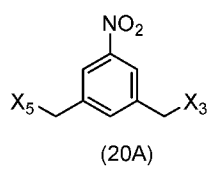


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a halogenating reagent with the compound of formula (14A):

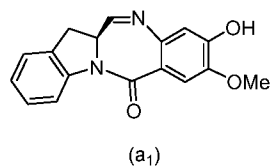


5 or a salt thereof, to form a compound of formula (20d):



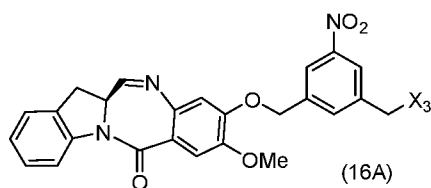
or a salt thereof;

(2) reacting a compound of formula (20A) or a salt thereof with a monomer compound of formula (a₁),

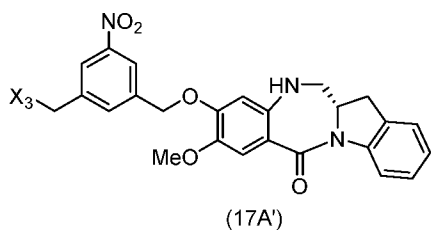


10

to form a compound of formula (16A):



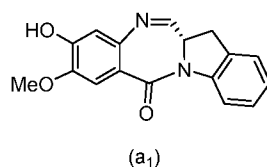
(3) reacting the compound of formula (16A) with an imine reducing agent to form a compound of formula (17A'):



15

or a salt thereof; and

(4) reacting the compound of formula (17A') with a monomer of formula (a₁):

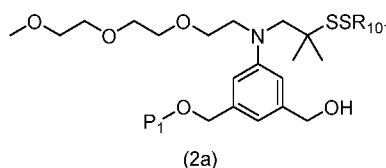


to form the compound of formula (IA); wherein X_3 is $-Cl$; and P_1 is an alcohol protecting group.

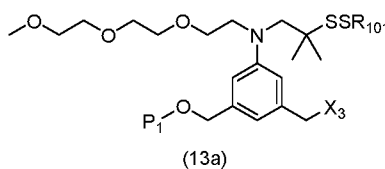
5 The conditions and reagents for the method of the forty-third embodiment are as described above in the twenty-fifth, twenty-seventh, thirty-third and/or thirty-fourth embodiment(s) and any specific embodiments described therein.

In one embodiment, for methods of the thirty-fifth, thirty-sixth, thirty-seventh, thirty-eighth, thirty-ninth, fortieth, forty-first, forty-second and forty-third embodiments
10 described above, the compound (14a) of a salt thereof is prepared a method comprising the following steps:

(1) reacting a chlorinating reagent with a compound of formula (2a),



to form a compound a compound of formula (13a),

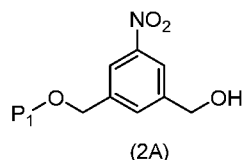


or a salt thereof; and

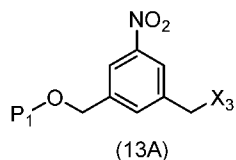
(2) reacting the compound of formula (13a) with an alcohol deprotecting reagent to form the compound of formula (14a) or a salt thereof.

In another embodiment, for methods of the thirty-fifth, thirty-sixth, thirty-
 20 seventh, thirty-eighth, thirty-ninth, fortieth, forty-first, forty-second and forty-third
 embodiments described above, the compound (14A) of a salt thereof is prepared a
 method comprising the following steps:

(1) reacting a chlorinating reagent with a compound of formula (2A),



to form a compound a compound of formula (13A),



or a salt thereof; and

- 5 (2) reacting the compound of formula (13A) with an alcohol deprotecting reagent to form the compound of formula (14A) or a salt thereof.

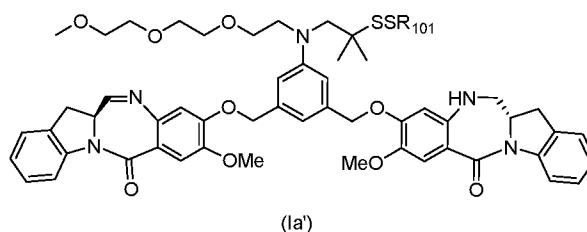
The conditions and reagents for the method of preparing compound of formula (14d) or (14A) above are as described above in the twenty-second and/or twenty-third embodiment(s) and any specific embodiments described therein.

- 10 In another embodiment, for the methods described above, the compound of formula (2a) is prepared by reacting a compound of formula (1a) with an alcohol protecting reagent.

- In another embodiment, for the methods described above, the compound of formula (2A) is prepared by reacting a compound of formula (1A) with an alcohol
15 protecting reagent.

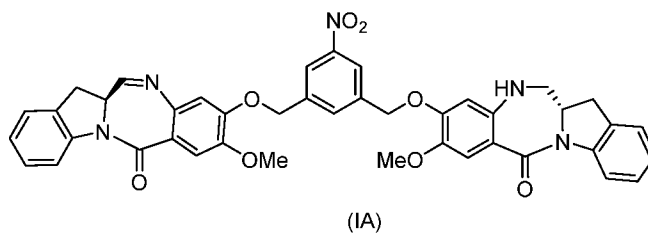
The conditions and reagents for the method of preparing compound of formula (2a) or (2A) above are as described above in the first embodiment and any specific embodiments described therein.

- In a forty-fourth embodiment, the present invention provides a method of
20 preparing a compound of formula (Ia'),

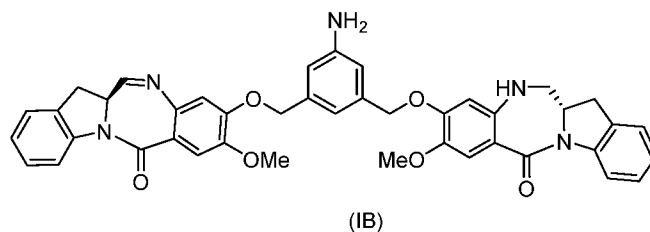


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a compound of formula (IA):



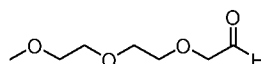
with a reducing agent to form a compound of formula (IB):



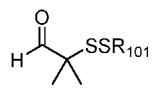
; and

(2) reacting the compound of formula (IB) with a compound of formula (L1a),

5

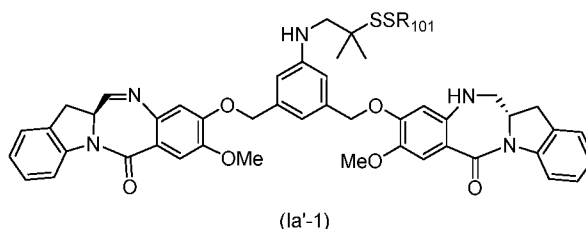


and a compound of formula (L1b):



in the presence of a reducing agent to form the compound of formula (Ia'), wherein R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

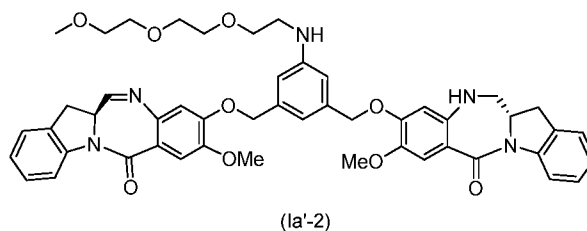
10 In one embodiment, for the method of forty-fourth embodiment, the compound of formula (IB) is reacted with a compound of formula (L1b) in the presence of a reducing agent to form a compound of (Ia'-1):



15 or a salt thereof, followed by reacting the compound of (Ia'-1) with the compound of formula (L1a) in the presence of a reducing agent to form the compound of formula (Ia').

In another embodiment, for the method of forty-fourth embodiment, the compound of formula (IB) is reacted with a compound of formula (L1a) in the presence

of a reducing agent to form a compound of (Ia'-2)



or a salt thereof, followed by reacting the compound of formula (Ia'-2) with the compound of formula (L1b) in the presence of a reducing agent to form the compound of formula (Ia').

In a specific embodiment, for methods of forth-fourth embodiment, the reducing agent in step (2) is selected from the group consisting of: sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, hydrogen gas, ammonium formate, titanium isopropoxide, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), lithium borohydride (LiBH₄), potassium borohydride (KBH₄), titanium isopropoxide, and stannous chloride. Preferably, the reducing agent is sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, or potassium borohydride. Even more preferably, the reducing agent is sodium borohydride.

Any reducing reagent that can convert a nitro (-NO₂) group to an amine (-NH₂) group can be used in step (1). In one embodiment, the reducing reagent is selected from the group consisting of: hydrogen gas, sodium hydrosulfite, sodium sulfide, stannous chloride, titanium (II) chloride, zinc, iron and samarium iodide. In a specific embodiment, the reducing reagent is Fe/NH₄Cl or Zn/NH₄Cl.

In one embodiment, for methods described above, R₁₀₁ is methyl.


The method of the present invention can also be any combination of the methods described above (*e.g.*, methods in the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth, sixteenth, seventeenth, eighteenth, nineteenth, twentieth, twenty-first, twenty-second, twenty-third, twenty-fourth, twenty-fifth, twenty-sixth, twenty-seventh, twenty-eighth, twenty-ninth, thirtieth, thirty-first, thirty-second, thirty-third, thirty-fourth, thirty-fifth, thirty-sixth, thirty-seventh, thirty-eighth, thirty-ninth, fortieth, forty-first, forty-second, forty-third and forty-fourth embodiment). For example, the combination of the methods of the first and second embodiments, the combination of methods of the first, second, and third embodiments, the combination of the methods of the fourth and fifth embodiments, the

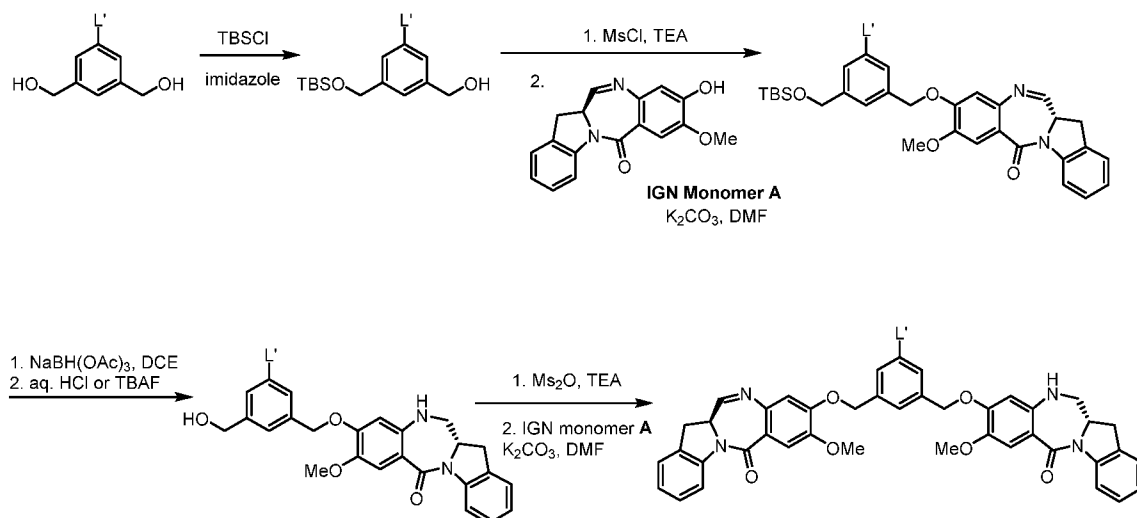
combination of the methods of the fourth, fifth and sixth embodiments, the combination of the methods of the sixth and eighth embodiments, the combination of the methods of thirteenth and fourteenth embodiments, the combination of the methods of thirteenth, fourteenth and fifteenth embodiments, and the combination of the methods of the
5 seventeenth and eighteenth embodiments are also included in the present invention. The variable definitions described in any of the specific embodiments below also apply to any combination of methods described above.

The reactions described herein in the methods of the present invention can be carried out in any suitable solvent(s). In one embodiment, the solvent is an organic solvent. Exemplary organic solvents include, but are not limited to, dichloromethane, 10 dichloroethane, DMF, DMA, acetone, acetonitrile, THF, DMSO, ethyl acetate etc., or a combination thereof.

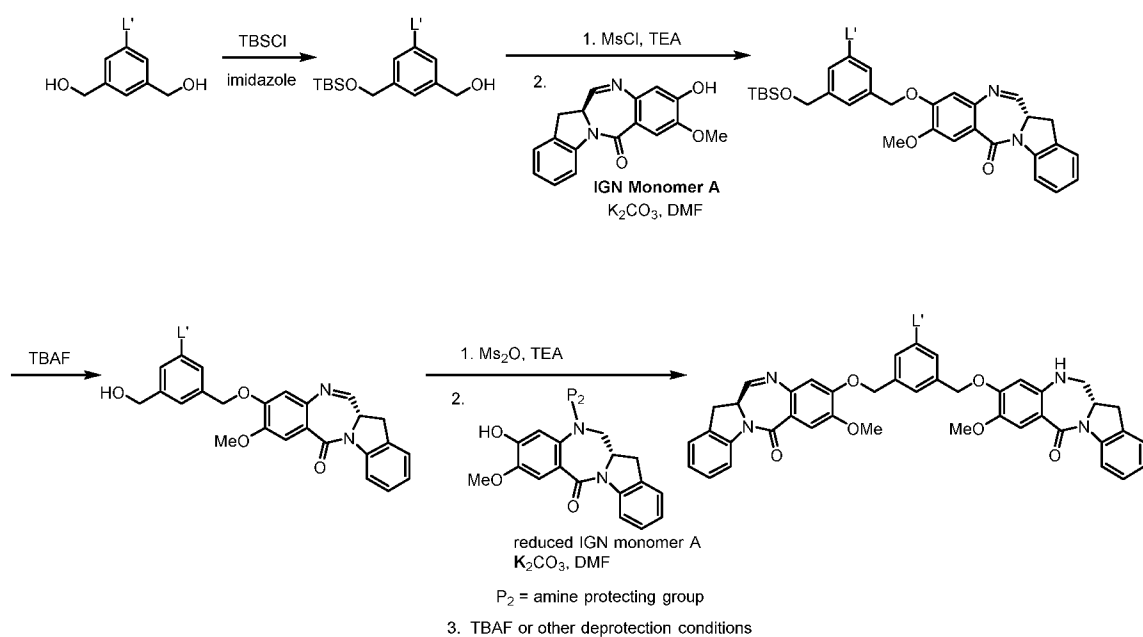
The reactions described herein in the methods of the present invention can be carried out at any suitable temperature. In one embodiment, the reaction can be carried out at room temperature. In another embodiment, the reaction can be carried out at a low temperature, such as 0°C. In yet another embodiment, the reaction can be carried out at an elevated temperature, such as about 40°C, about 50 °C etc.

In certain embodiment, the indolinobenzodiazepine dimer compound of formula (Id') and (IA) can be prepared according to Schemes 1 –10 shown below, wherein L' is

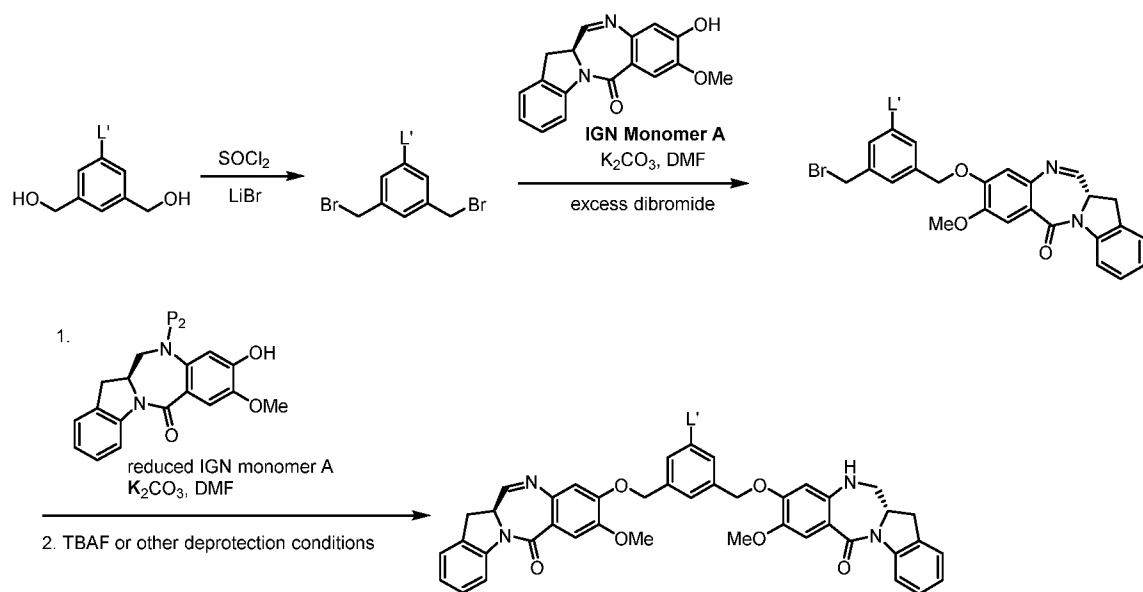
20  for formula (Id'); and $-\text{NO}_2$ for formula (IA). In one embodiment, R_{101} is Me.



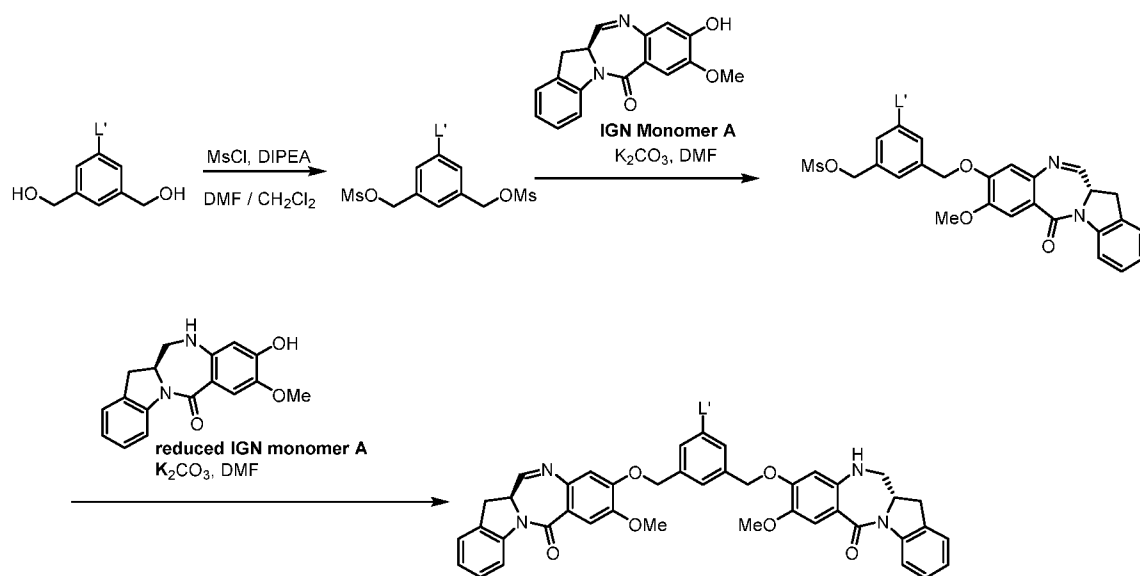
Scheme 1



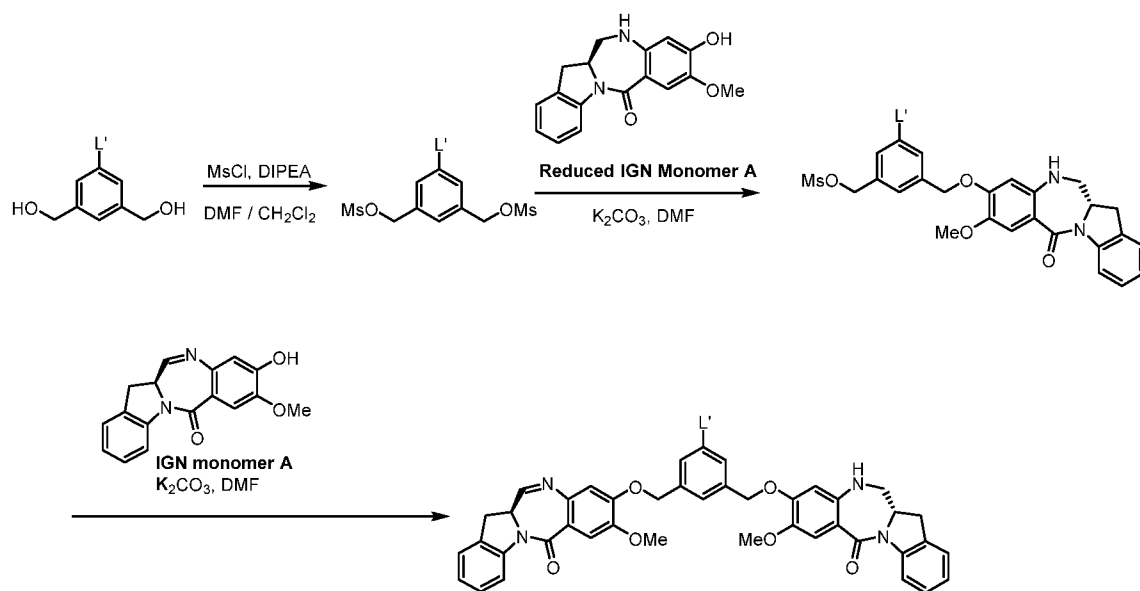
Scheme 2



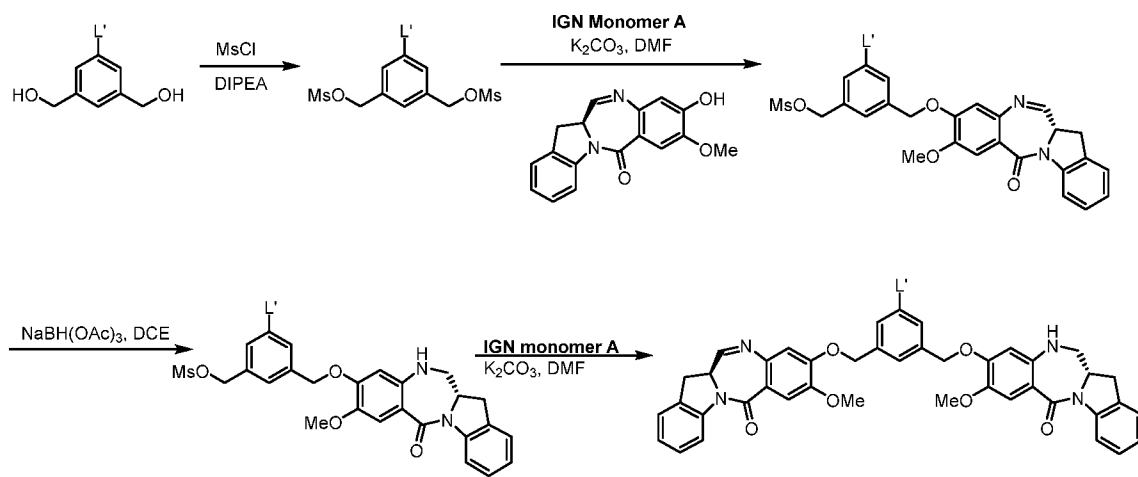
Scheme 3



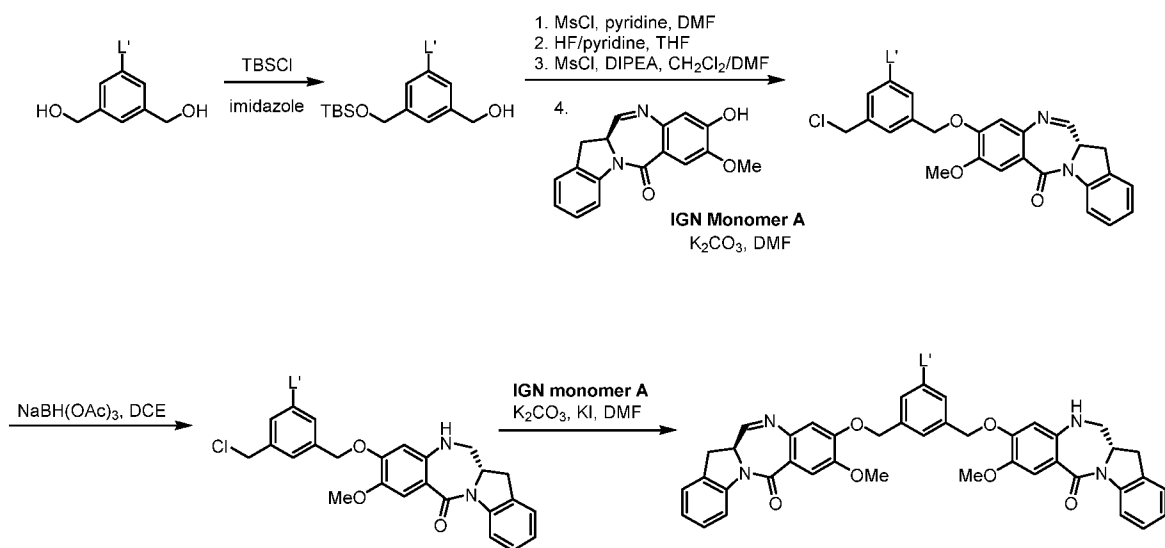
Scheme 4



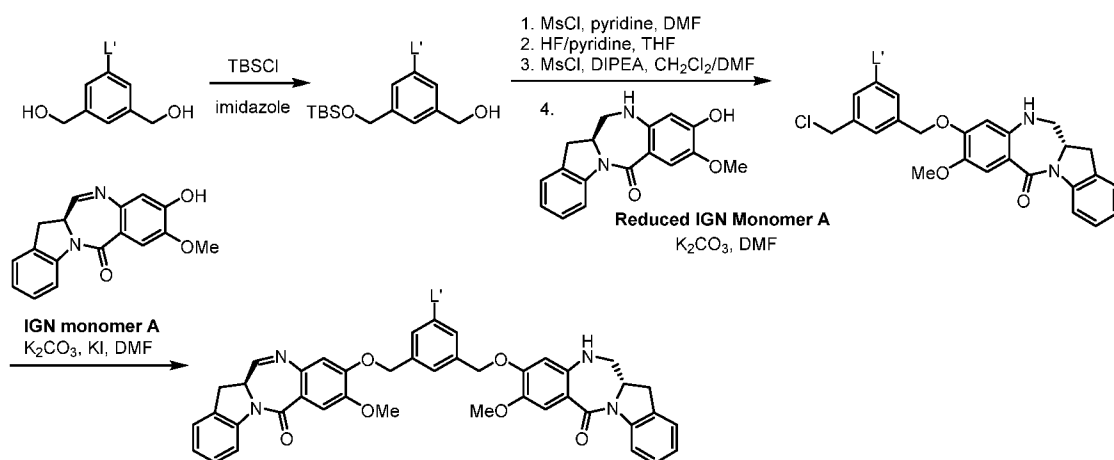
Scheme 5



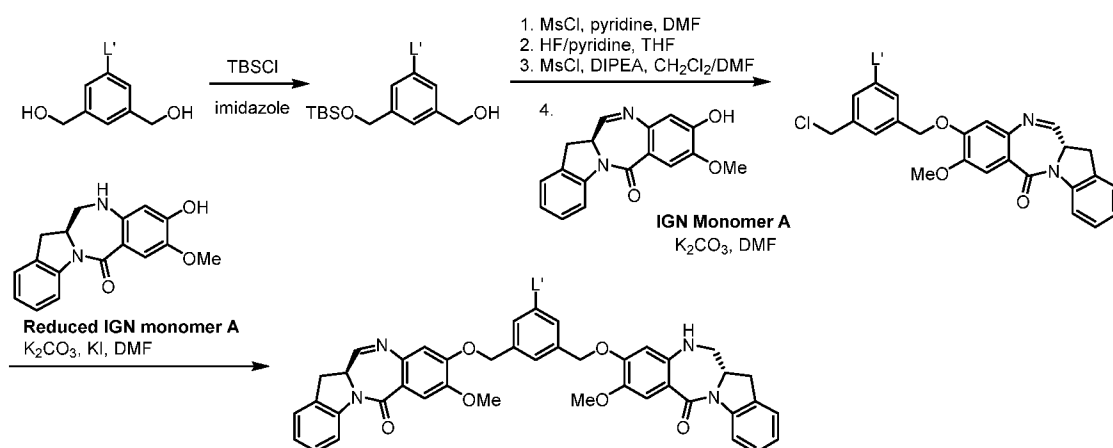
Scheme 6



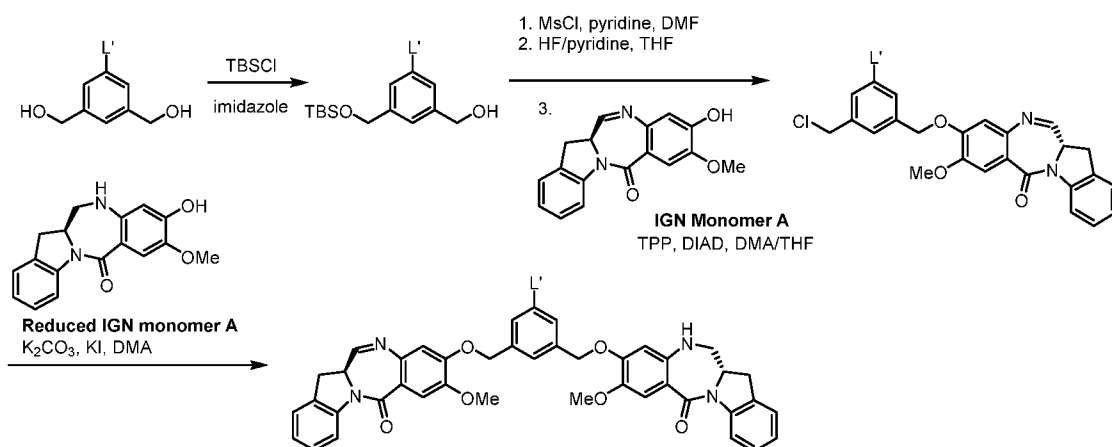
Scheme 7



Scheme 8

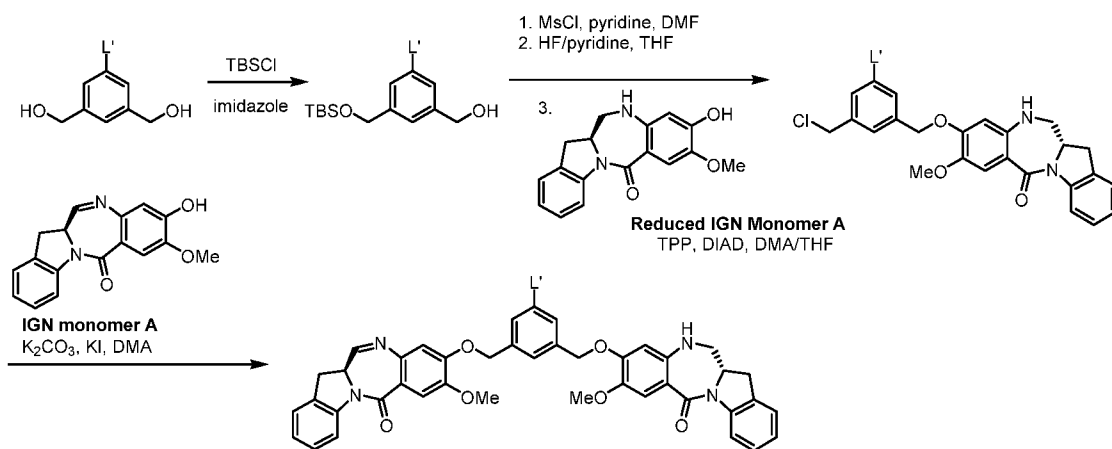


Scheme 9

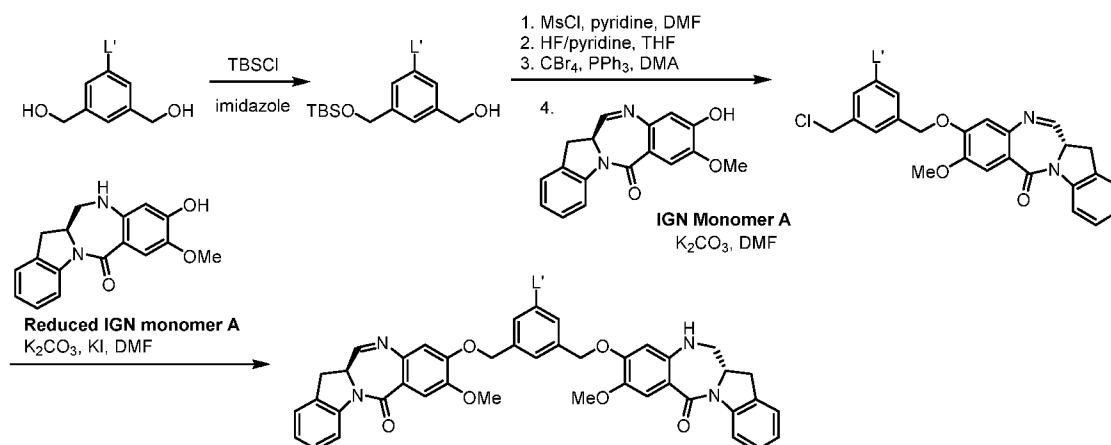


Scheme 10

5



Scheme 11



Scheme 12

COMPOUNDS OF THE INVENTION

The present invention also provides novel compounds described herein. In certain embodiments, the compounds of the present invention are compounds of formulas (1a), (1A), (2a), (2A), (2a''), (2A''), (3a), (3A), (3a''), (3A''), (4a), (4A), (4a''), (4A''), (5a), (5A), (5a''), (5A''), (6a), (6A), (7a), (7A), (7a'), (7A'), (7a1'), (7A1'), (7a''), (7A''), (7a'''), (7A'''), (9a), (9A), (10a), (10A), (10a'), (10A'), (11a), (11A), (12a), (12A), (13a), (13A), (14a), (14A), (15a), (15A), (16a), (16A), (17a), (17A), (17a'), (17A'), (18a), (18A), (20a), (20A), (c₁), (d₁), (Ia'), (IA), and (IB), wherein the variables are as described above.

In a 1st specific embodiment, for compound of formula (1a), (2a), (2a''), (3a), (3a''), (4a), (4a''), (5a), (5a''), (6a), (7a), (7a'), (7a1'), (7a''), (7a'''), (9a), (10a), (10a'), (11a), (12a), (13a), (14a), (15a), (16a), (17a), (17a'), (18a), (20a), or (Ia'), R₁₀₁ is -Me.

In a 2nd specific embodiment, for compound of formula (2a), (3a), (4a), (5a), (13a), (2A), (3A), (4A), (5A), (13A), P₁ is a silyl protecting group; and the remaining variables are as described in first to forty-fourth embodiments or the 1st specific embodiment above. More specifically, the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, tert-butylsilyl, tert-butylsilyl, tert-butylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl. Even more specifically, the silyl protecting group is triethylsilyl, triisopropylsilyl, or tert-butylsilyl. In another even more specific embodiment, the silyl protecting group is tert-butylsilyl.

In a 3rd specific embodiment, for compound of formula (3a), (3a''), (7a'), (7a1'), (12a), (10a'), (3A), (3A''), (7A'), (7A1'), (12A), or (10A'), X₁ is a sulfonate ester; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st or 2nd specific embodiment. More specifically, the sulfonate ester is mesylate, tosylate, brosylate, or triflate. Even more specifically, the sulfonate ester is mesylate.

In a 4th specific embodiment, for compound of formula (3a), (3a''), (7a'), (7a1'), (12a), (10a'), (3A), (3A''), (7A'), (7A1'), (12A), or (10A'), X₁ is -Br or -I; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st or 2nd specific embodiment. More specifically, X₁ is -Br.

In a 5th specific embodiment, for compound of formula (7a), (10a), (7A), or (10A), X₂ is a sulfonate ester; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st specific embodiment. More specifically, the sulfonate ester is mesylate, tosylate, brosylate, or triflate. Even more specifically, the sulfonate ester is mesylate.

In a 6th specific embodiment, for compound of (7a'') or (7A''), X₂' is -Br or -I, and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st specific embodiment.

In a 7th specific embodiment, for the compound of formula (2a''), (3a''), (4a''), (5a''), (2A''), (3A''), (4A''), or (5A''), P₁' is acetate, allyl, methoxymethyl, tetrahydrofuranyl, tetrahydropyranyl, 5-dibenzosuberyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, 2-(phenylselenyl)ethyl, trityl/triphenylmethyl, or tris(4-*tert*-butylphenyl)methyl; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st, 3rd, or 4th specific embodiment. In another specific embodiment, P₁' is a silyl protecting group; the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st, 3rd, or 4th specific embodiment. In a more specific embodiment, P₁' is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl. Even more specifically, P₁' is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl. In another more specific embodiment, P₁' is *tert*-butyldimethylsilyl.

In a 8th specific embodiment, for the compound of formula (13a), (14a), (15a), (16a), (17a), (17a'), (20a), (13A), (14A), (15A), (16A), (17A), (17A'), or (20A), X₃ is chlorine; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st or 2nd specific embodiment.

5 In a 9th specific embodiment, for the compound of formula (15a) or (15A), X₄ is a sulfonate ester; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st or 8th specific embodiment. More specifically, the sulfonate ester is mesylate, tosylate, brosylate, or triflate. Even more specifically, the sulfonate ester is mesylate.

10 In a 10th specific embodiment, for the compound of formula (c₁), (11a) or (11A), P₂ is an amine protecting group selected from 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, and allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, and 2,2,2-trichloroethoxycarbonyl; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st specific embodiment.

15 In a 11th specific embodiment, for the compound of formula (d₁), (7a1'), (17a), (18a), (7A1'), (17A) or (18A), P₃ is H or an amine protecting group selected from 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, and allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, or 2,2,2-trichloroethoxycarbonyl; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st or 8th specific embodiment.

20 In a 12th specific embodiment, for the compound of (20a) or (20A), X₅ is -Br; and the remaining variables are as described above in the first to forty-fourth embodiments or in the 1st or 8th specific embodiment.

All references cited herein and in the examples that follow are expressly incorporated by reference in their entireties.

EXAMPLES

The invention will now be illustrated by reference to non-limiting examples.

30 Unless otherwise stated, all percents, ratios, parts, *etc.* are by weight. All reagents were purchased from the Aldrich Chemical Co., New Jersey, or other commercial sources. Nuclear Magnetic Resonance (¹H NMR) spectra were acquired on a Bruker 400 MHz instrument. Mass spectra were acquired on a Bruker Daltonics Esquire 3000 instrument

and LCMS were acquired on an Agilent 1260 Infinity LC with an Agilent 6120 single quadrupole MS using electrospray ionization and UPLC were acquired on a Waters, Acquity system with a single quadrupole MS ZsprayTM (column: Acquity BEH C18, 2.1 x 50 mm, 1.7 μ m, method: 2.5 min, flow rate 0.8 mL/min, solvent A: water, solvent B:

5 MeCN, 5 to 95% of MeCN over 2.0 min and 95% MeCN for 0.5 min).

The following solvents, reagents, protecting groups, moieties and other designations may be referred to by their abbreviations in parenthesis:

Me = methyl; Et = ethyl; Pr = propyl; *i*-Pr = isopropyl; Bu = butyl; *t*-Bu = tert-butyl; Ph = phenyl, and Ac = acetyl

10 AcOH or HOAc = acetic acid

ACN or CH₃CN = acetonitrile

Ala = alanine

Ar = argon

aq = aqueous

15 Bn = benzyl

Boc or BOC = tert-butoxycarbonyl

CBr₄ = carbontetrabromide

Cbz or Z = benzyloxycarbonyl

DCM or CH₂Cl₂ = dichloromethane

20 DCE = 1,2-dichloroethane

DMAP = 4-dimethylaminopyridine

DI water = deionized water

DIBAL = diisobutylaluminum hydride

DIEA or DIPEA = N,N-diisopropylethylamine

25 DMA = N,N-dimethylacetamide

DMF = N,N-dimethylformamide

DMSO = dimethyl sulfoxide

DTT = dithiothreitol

EDC = 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide

30 EEDQ = N-Ethoxycarbonyl-2-ethoxy-1,2-dihydroquinoline

ESI or ES = electrospray ionization

EtOAc = ethylacetate

Gly = glycine

- g = grams
h = hour
HATU = N,N,N',N'-tetramethyl-O-(7-azabenzotriazol-1-yl)uronium hexaphosphate
HPLC = high-performance liquid chromatography
- 5 HOBt or HOBT = 1-hydroxybenzotriazole
LAH = lithium aluminum hydride
LC = liquid chromatography
LCMS = liquid chromatography mass spectrometry
min = minutes
- 10 mg = milligrams
mL = milliliters
mmol = millimoles
μg = micrograms
μL = microliters
- 15 μmol = micromoles
Me = methyl
MeOH = methanol
MeI = methyl iodide
MS = mass spectrometry
- 20 MsCl = methanesulfonyl chloride (mesyl chloride)
Ms₂O = methanesulfonic anhydride
MTBE = Methyl *tert*-butyl ether
NaBH(OAc)₃ = sodium triacetoxyborohydride
NHS = N-hydroxysuccinamide
- 25 NMR = nuclear magnetic resonance spectroscopy
PPh₃ = triphenylphosphine
PTLC = preparative thin layer chromatography
rac = racemic mixture
R_f = retardation factor
- 30 RPHPLC or RP-HPLC = reverse phase high-performance liquid chromatography
RT or *rt* = room temperature (ambient, about 25 °C)
sat or sat'd = saturated
STAB = sodium triacetoxyborohydride (NaBH(OAc)₃)

TBSCl or TBDMSCl = *tert*-butyldimethylsilyl chloride

TBS = *tert*-butyldimethylsilyl

TCEP·HCl = *tris*(2-carboxyethyl)phosphine hydrochloride salt

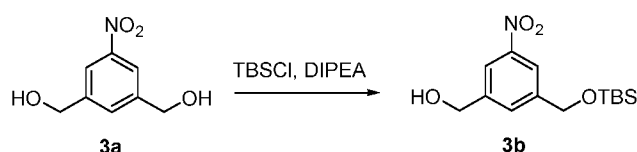
TEA = triethylamine (Et₃N)

5 TFA = trifluoroacetic acid

THF = tetrahydrofuran

TLC = thin layer chromatography

Example 1.

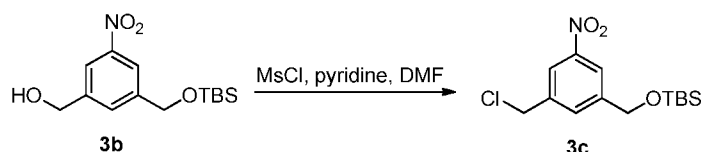


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To a solution of (5-nitro-1,3-phenylene)dimethanol **3a** (4.0 g, 21.84 mmol) in DCM (40 mL) and DMF (5 mL) was added DIPEA (3.86 mL, 21.84 mmol, 1.0 equiv.) followed by TBSCl (3.29 g, 21.84 mmol, 1.0 equiv.) as a solution in DMF (5 mL). The reaction was stirred at 0 °C for 1 h.. The reaction was quenched with sat. ammonium chloride (20 mL) and the layers were separated. The aqueous layer was extracted with DCM (2 x 20 mL) and the combined organic layers were washed with water (2 x 50 mL), brine, dried over magnesium sulfate, filtered and solvent was removed in vacuo to give a crude yellow oil. The crude product was purified by silica gel chromatography (DCM/MeOH) to give desired product **3b** (3.69 g, 12.41 mmol, 57% yield). UPLCMS (2.5 min method) = 1.96 min. Mass observed (ESI⁺): 298.5 (M+H)⁺.

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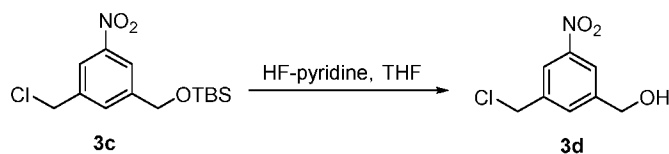
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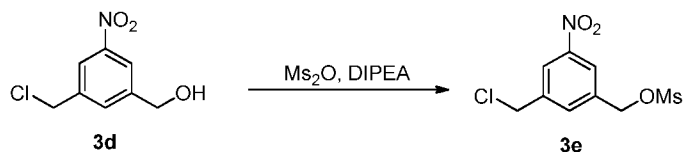
To a solution of **3b** (2.0 g, 6.72 mmol) in DMF (50 mL) was added pyridine (1.6 mL, 20.17 mmol, 3.0 equiv.) followed by methanesulfonyl chloride (1.1 mL, 13.45 mmol, 2.0 equiv.) at 0 °C. The reaction was warmed to rt and was stirred for 3 h. The reaction was quenched with sat. sodium bicarbonate (20 mL) and the layers were separated. The aqueous layer was extracted with EtOAc (3 x 30 mL). The combined organic layers were washed with water (2 x 100 mL), brine (100 mL), dried over magnesium sulfate and filtered. The solvent removed in vacuo and the crude material **3c**

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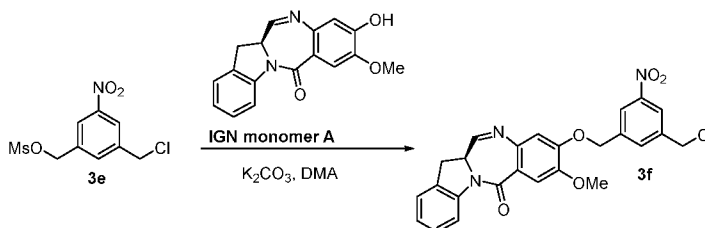
(2.0g, 6.7 mmol, 94% yield) was carried crude onto the next step. UPLCMS (2.5 min method) = 2.22 min. Mass observed (ESI⁺): 316.7 (M+H)⁺.



To a solution of **3c** (2.0 g, 6.33 mmol) in THF (38.9 mL) was added DIPEA (5.5 mL, 31.6 mmol, 5.0 equiv.) followed by HF-pyridine (2.7 mL, 19.0 mmol, 3.0 equiv.) and the reaction was stirred at room temperature for 2 h. The reaction was then quenched with sat. sodium bicarbonate (100 mL). The layers were separated and then the aqueous layer was extracted with EtOAc (3 x 20 mL). The combined organic layers were then washed with water (30 mL), brine (30 mL), dried over magnesium sulfate and filtered. The excess of solvent was removed in vacuo to give desired product **3d** (1.1g, 5.46 mmol, 86% yield). UPLCMS (2.5 min method) = 1.31 min. Mass observed (ESI⁺): 202.4 (M+H)⁺.

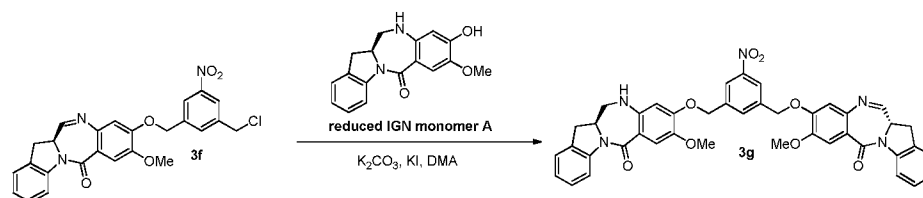


To a solution of **3d** (1.0 g, 4.96 mmol) in DCM (10 mL) was added DIPEA (2.6 mL, 14.9 mmol, 3.0 equiv.) at 0 °C then a solution of methanesulfonyl anhydride (1.1 g, 6.45 mmol, 1.3 equiv.) in DCM was added to the reaction mixture. The reaction was stirred for 1 h. The reaction was quenched with water (10 mL) and the layers were separated and the aqueous layer was extracted with DCM (2 x 20 mL). The combined organic layers were washed with sat. sodium bicarbonate (10 mL), brine (20 mL), dried over magnesium sulfate and filtered. The solvent was removed in vacuo and the crude material **3e** (1.3 g, 4.65 mmol, 94% yield) was used in the next step without further purification. UPLCMS (2.5 min method) = 1.51 min. Mass observed (ESI⁺): 280.6 (M+H)⁺.



To a solution of **3e** (0.4 g, 1.43 mmol) and potassium carbonate (0.6 g, 4.29 mmol, 3.0 equiv.) in DMA (13.4 mL) was added a solution of **IGN monomer A** (0.46 g, 1.57 mmol, 1.1 equiv.) in DMA (2 mL) at room temperature and the reaction was stirred for 5 h. The reaction was quenched with water (30 mL), the layers were separated and the aqueous layer was extracted with EtOAc (3 x 30 mL). The combined organic layers were washed with water (30 mL), brine (30 mL), dried over magnesium sulfate and the solvent was removed in vacuo. The crude oil was purified over silica gel chromatography using DCM / MeOH to give compound **3f** (0.37g, 0.77 mmol, 54% yield). UPLCMS (2.5 min method) = 1.69 min. Mass observed (ESI⁺): 478.3 (M+H)⁺.

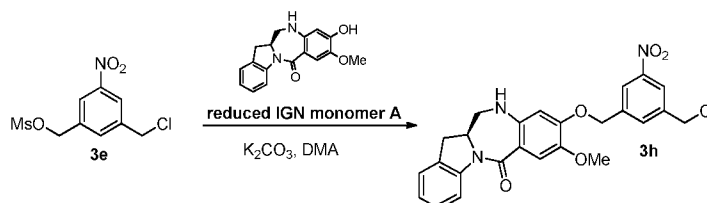
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To a solution of **3f** (0.11 g, 0.23 mmol) in DMA (3.0 mL) was added potassium carbonate (0.095 g, 0.69 mmol, 3.0 equiv.), followed by potassium iodide (0.02 g, 0.11 mmol, 0.5 equiv.). A solution of **reduced IGN monomer A** (0.07 g, 0.25 mmol, 1.1 equiv.) in DMA (1 mL) was added. The reaction was then gently heated at 35 °C for 5 h. The reaction was quenched with water, and the solid was filtered off. The solid was redissolved in DCM/MeOH (20:1), washed with water, dried with magnesium sulfate, filtered and concentrated. The crude residue (0.13 g) was purified by RPHPLC (ACN/H₂O) to give **3g** (0.063 g, 0.085 mmol, 36% yield). UPLCMS (2.5 min method) = 1.79 min. Mass observed (ESI⁺): 738.3 (M+H)⁺. ¹H NMR (400 MHz, DMSO-*d*₆, reported as a mixture of water adducts) ¹H NMR (400 MHz, DMSO-*d*₆): δ 8.43 – 8.36 (m, 2H), 8.27 (d, *J* = 8.1 Hz, 1H), 8.13 – 8.02 (m, 2H), 7.44 – 7.14 (m, 6H), 7.14 – 6.99 (m, 2H), 6.79 (s, 0.5H), 6.56 (s, 0.5H), 6.50 (d, *J* = 2.2 Hz, 1H), 6.39 (d, *J* = 6.9 Hz, 1H), 6.17 (d, *J* = 6.8 Hz, 0.5H), 5.69 (s, 0.5H), 5.59 (d, *J* = 5.7 Hz, 0.5H), 5.47 – 5.27 (m, 4H), 5.03 (t, *J* = 6.1 Hz, 0.5H), 4.77 (dd, *J* = 9.1, 6.8 Hz, 0.5H), 4.61 (dt, *J* = 9.7, 5.1 Hz, 0.15H), 4.50 – 4.39 (m, 0.5H), 4.27 (dd, *J* = 10.9, 4.2 Hz, 0.5H), 4.16 (td, *J* = 9.6, 2.9 Hz, 0.5H), 3.95 (s, 0.5H), 3.89 – 3.76 (m, 6H), 3.76 – 3.44 (m, 4H), 3.20 – 3.08 (m, 1H), 2.96 (dd, *J* = 17.0, 4.4 Hz, 1H).

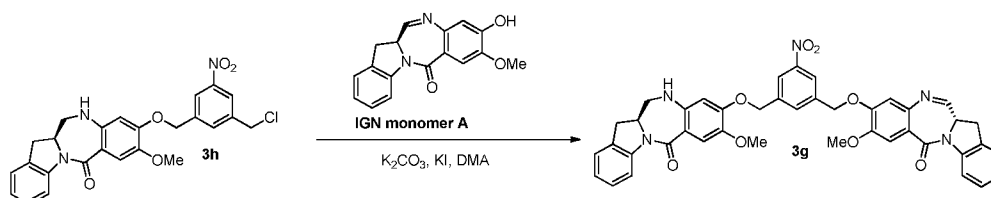
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Example 2.



5 To a solution of **3e** (0.45 g, 1.61 mmol) in DMA (15.1 mL) was added potassium carbonate (0.67 g, 4.83 mmol, 3.0 equiv.) followed by a solution of **reduced IGN monomer A** (0.5 g, 1.69 mmol, 1.1 equiv.) in DMA (2 mL). The reaction was stirred at room temperature for 5h.. The reaction was quenched with water (30 mL) and the mixture was stirred for 10 min. The solid was filtered and then dissolved in
 10 DCM/MeOH (9/1, 30 mL) and washed with brine (20 mL). The organic layer was separated and dried over magnesium sulfate, filtered and the solvent removed in vacuo. The crude material was purified by silica gel chromatography using Hexane/EtOAc to give compound **3h** (0.28 g, 0.58 mmol, 36% yield) as colorless oil. UPLCMS (2.5 min method) = 1.82 min. Mass observed (ESI⁺): 480.3 (M+H)⁺.

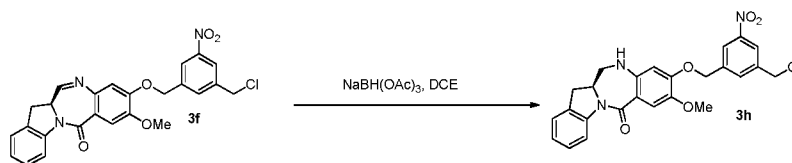
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To a solution of **3h** (0.27 g, 0.56 mmol) in DMA (10 mL) was added potassium carbonate (0.16 g, 1.12 mmol, 2.0 equiv.) followed by potassium iodide (0.05 g, 0.28
 20 mmol, 0.05 equiv.). A solution of **IGN monomer A** (0.18 g, 0.62 mmol, 1.1 equiv.) in DMA (2 mL) was added to the reaction mixture at room temperature. The reaction was then stirred at 40 °C for 3h. The reaction was quenched with water (20 mL) and the solid was filtered off and washed with water. The crude yellow solid was dissolved in DCM/MeOH (9/1, 30 mL) and then washed with water (10 mL), dried over magnesium
 25 sulfate and filtered. The solvent was removed in vacuo to give a crude yellow solid. The crude product was purified by silica gel chromatography using DCM/MeOH (0% to 5% MeOH/DCM) to give the product **3g** as a yellow powder (0.35 g, 0.48 mmol, 86%

yield). UPLCMS (2.5 min method) = 1.79 min (2.5 min method). Mass observed (ESI⁺): 738.4 (M+H)⁺.

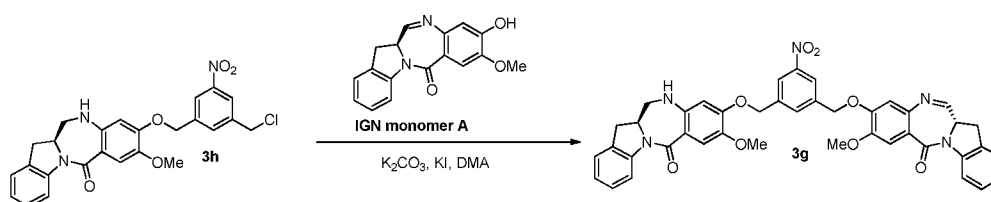
Example 3.



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To a solution of **3f** (0.15 g, 0.31 mmol) in DCE (2 mL) was added sodium triacetoxyborohydride (0.067 g, 0.31 mmol, 1.0 equiv.) and the reaction was stirred at room temperature for 1 h. The reaction was quenched with sat. ammonium chloride (1 mL) and then the layers were separated. The aqueous layer was extracted with DCM (3 x 10 mL) and the combined organic layers were washed with brine (20 mL), dried over magnesium sulfate, filtered and the solvent removed in vacuo. The crude brown oil was purified by silica gel chromatography to give desired product **3h** (0.08 g, 0.16 mmol, 52% yield). UPLCMS (2.5 min method) = 1.80 min. Mass observed (ESI⁺): 480.5 (M+H)⁺.

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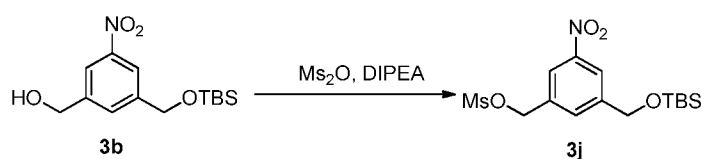


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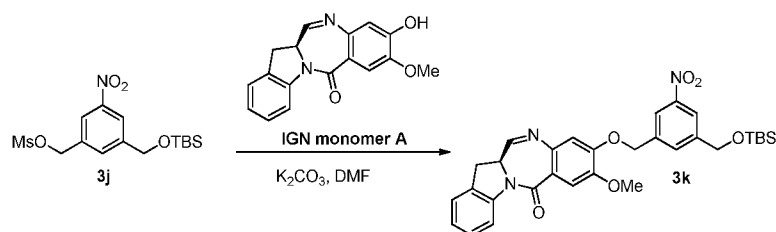
To a solution of **3h** (0.07g, 0.16 mmol) in DMA (2 mL) was added potassium carbonate (0.07 g, 0.47 mmol, 3.0 equiv.) followed by potassium iodide (0.013 g, 0.08 mmol, 0.05 equiv.) and then a solution of **IGN monomer A** (0.05 g, 0.17 mmol, 1.1 equiv.) in DMA (0.5 mL) was added. The reaction was stirred at room temperature for 12h.. Water (20 mL) was added to the mixture and the mixture was stirred for 10 min at which point the solid was filtered. The solid was solubilized in DCM (10 mL) and then washed with brine (10 mL). The organic layer was dried over magnesium sulfate and filtered. The solvent was removed to obtain a yellow oil (0.09 g, 0.12 mmol, 80% yield). UPLCMS (2.5 min method) = 1.79 min (2.5 min method). Mass observed (ESI⁺): 738.5 (M+H)⁺.

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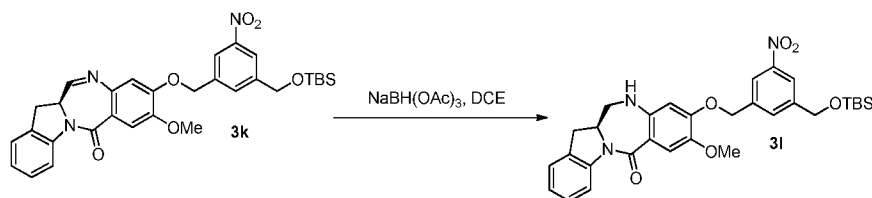
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Example 4.

To a solution of **3b** (1.00 g, 3.4 mmol) in DCM (33 mL) was added DIPEA (1.781 mL, 10.09 mmol, 3.0 equiv.), followed by a solution of methanesulfonic anhydride (0.703 g, 4.03 mmol, 1.2 equiv.) at 0 °C. The reaction was stirred for 1 h. The solvent was evaporated to give the crude product **3j** (1.2 g, 3.2 mmol, 95% yield) which was used in the next step without further purification. UPLCMS (2.5 min method) = 2.04 min. Mass observed (ESI⁺): 376.5 (M+H)⁺.

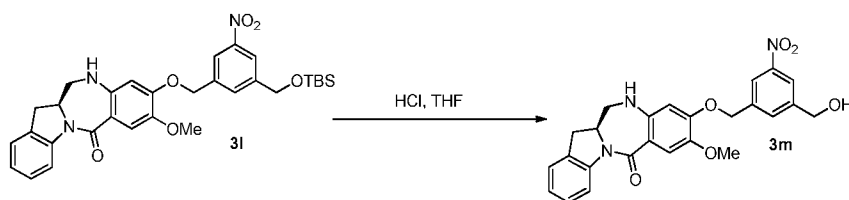


To a solution of **3j** (1.24 g, 3.30 mmol) in DMF (26 mL) was added potassium carbonate (0.91 g, 6.60 mmol, 2.0 equiv.) followed by **IGN monomer A** (0.97 g, 3.30 mmol, 1.0 equiv.) at room temperature for 12 h. The reaction was quenched with water (60 mL) and the solid was filtered off and then dissolved in DCM/MeOH (20/1, 20 mL). The organic layer was washed with brine, dried over magnesium sulfate and filtered. The solvent was removed in vacuo and the crude material was purified over silica gel chromatography to give the desired product **3k** (1.3 g, 2.27 mmol, 69% yield). UPLCMS (2.5 min method) = 2.12 min (2.5 min method). Mass observed (ESI⁺): 574.4 (M+H)⁺.

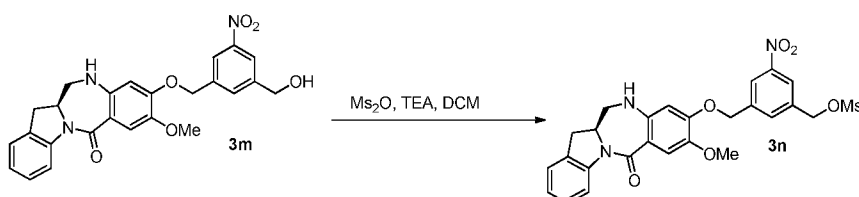


3k (0.63 g, 1.1 mmol) was dissolved in anhydrous DCE (11 mL). Sodium triacetoxyborohydride (0.70 g, 3.3 mmol, 3.0 equiv.) was added and the reaction mixture was stirred for 1 h at room temperature. The mixture was quenched with sat. ammonium chloride (10 mL). The layers were separated and the aqueous layer was extracted with DCM (2 x 20 mL). The combined organic layers were washed with brine (20 mL), dried over anhydrous magnesium sulfate, filtered and concentrated to obtain **3l** (0.58 g, 1.0

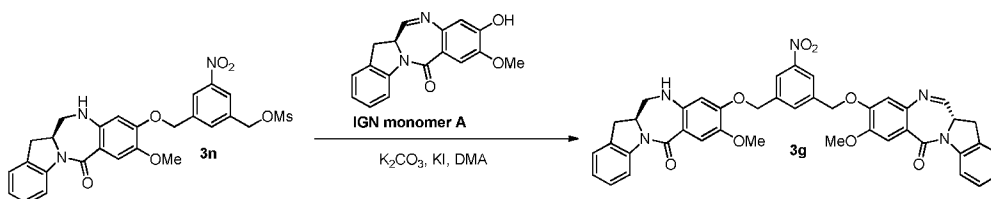
mmol, 92% yield). UPLCMS (8.0 min method) = 7.797 min (8.0 min method). Mass observed (ESI⁺): 576.3 (M+H)⁺.



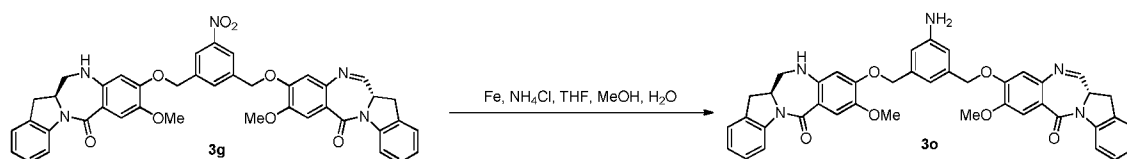
- 5 A solution of **3l** (0.58 g, 1.0 mmol) was dissolved in anhydrous THF (5 mL) and 5 M aqueous hydrochloride acid solution (2.01 mL, 10.07 mmol) was added. The mixture was stirred at room temperature for 2 h. The reaction was quenched with sat. sodium bicarbonate (5 mL) and the layers were separated and the aqueous layer was extracted with DCM (2 x 10 mL). The combined organic layers were washed with brine
10 (20 mL), dried over magnesium sulfate and concentrated to give a bright orange solid. The resulting solid was purified by silica gel chromatography (DCM/MeOH) to give compound **3m** (0.33 g, 0.71 mmol, 71% yield). UPLCMS (8.0 min method) = 5.166 min. Mass observed (ESI⁺): 462.1 (M+H)⁺.



- 15 **3m** (0.1 g, 0.22 mmol) was dissolved in anhydrous DCM (1.5 mL) and anhydrous DMF (0.7 mL). The reaction was cooled to 0 °C and triethylamine (0.12 mL, 0.88 mmol) and methanesulfonyl anhydride (0.08 g, 0.44 mmol) were added. The reaction was stirred at 0 °C for 1 h. The reaction mixture was diluted with ethyl acetate (20 mL), washed with water (2 x 20 mL), dried over magnesium sulfate, filtered and
20 concentrated. The compound was initially purified by silica gel chromatography (DCM/EtOAc) followed by additional purification by RPPHPLC (MeCN/water) to give the desired product **3n** (0.041 g, 0.076 mmol, 34% yield). Mass observed (ESI⁺): 540.3 (M+H)⁺.

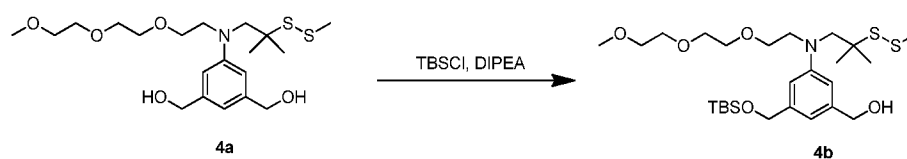


Compound **3n** (0.041 g, 0.076 mmol) and **IGN monomer A** (0.027 g, 0.091 mmol) were dissolved in anhydrous DMA (0.5 mL). Potassium carbonate (0.012 g, 0.091 mmol) and potassium iodide (0.006 g, 0.038 mmol) were added and the mixture stirred for 12 h. . Water (5 mL) was added to the reaction mixture. The solid was filtered off and then redissolved in DCM (20 mL) and washed with water (10 mL). After drying over magnesium sulfate, filtration and concentration, the solid was purified by RPHPLC (ACN/H₂O) to give **3g** (0.012 g, 0.016 mmol, 21% yield). UPLCMS (2.5 min method) = 1.79 min. Mass observed (ESI⁺): 738.5 (M+H)⁺.



Compound **3g** (0.017 g, 0.023 mmol) was dissolved in anhydrous THF (1 mL), anhydrous MeOH (0.5 mL) and water (0.1 mL). Ammonium chloride (0.012 g, 0.23 mmol, 10.0 equiv.) and iron (0.006 g, 0.115 mmol, 5.0 equiv.) were added. The mixture was stirred at 60 °C for 2 h.. The reaction mixture was cooled to room temp, filtered through Celite and rinsed with 20% MeOH/DCM (10 mL). The filtrate was concentrated and the crude product was purified by silica gel chromatography (DCM/MeOH) to give compound **3o** as a white solid (0.012 g, 0.018 mmol, 76% yield). UPLCMS (2.5 min method) = 1.84 min. Mass observed (ESI⁺): 708.5 (M+H)⁺. ¹H NMR (400 MHz, DMSO-*d*₆, reported as a mixture of water adducts, T = 330K): δ 8.26 (d, *J* = 7.9 Hz, 1H), 8.17 (d, *J* = 7.8 Hz, 1H), 8.03 (d, *J* = 4.5 Hz, 1H), 7.49 (s, 1H), 7.42 – 7.33 (m, 2H), 7.36 – 7.08 (m, 4H), 7.09 – 6.95 (m, 2H), 6.76 – 6.64 (m, 3H), 6.47 (s, 1H), 6.15 (d, *J* = 6.5 Hz, 1H), 5.11 (m, 2H), 4.98 (m, 2H), 4.58 (dt, *J* = 9.9, 4.7 Hz, 1H), 4.47 – 4.36 (m, 1H), 3.87 (m, 1H), 3.76 (s, 3H). 3.71 – 3.46 (m, 4H), 3.39 – 3.28 (m, 1H), 2.93 (dd, *J* = 16.8, 4.7 Hz, 1H).

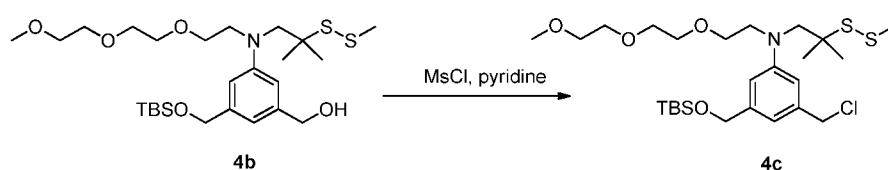
Example 5.



To a solution of **4a** (5.6 g, 12.9 mmol, 1.0 equiv.) in DCM (83 mL) was added DIPEA (6.77 mL, 38.7 mmol, 3.0 equiv.) followed by a solution of TBS-Cl (2.336 g,

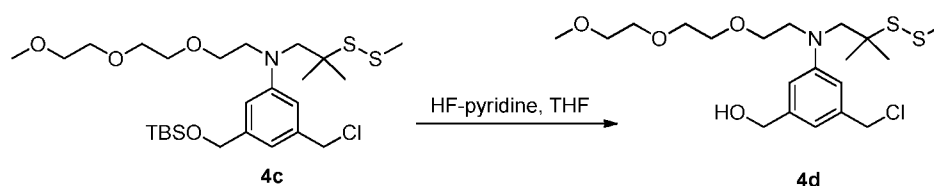
15.50 mmol, 1.2 equiv.) in DCM (10 mL) at 0 °C. The reaction was stirred at room temperature for 3h. The reaction was quenched with sat. ammonium chloride (30 mL) and the layers were separated. The aqueous solution was extracted with DCM (2 x 30 mL) and the combined organic layers were washed with water (2 x 50 mL), brine (50 mL), dried over magnesium sulfate, filtered and the solvent removed in vacuo to give crude yellow oil. The crude product was purified by silica gel chromatography (Hexane/EtOAc) to give the desired product **4b** (3.0 g, 5.48 mmol, 43% yield). UPLCMS (2.5 min method) = 2.29 min. Mass observed (ESI⁺): 549.0 (M+H)⁺.

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To a solution of **4b** (3.00 g, 5.48 mmol, 1.0 equiv.) in DMF (30 mL) was added pyridine (1.33 mL, 16.4 mmol, 3.0 equiv.) followed by a solution of methanesulfonyl chloride (0.64 mL, 8.21 mmol, 1.5 equiv.) at 0 °C. The reaction was stirred for 1 h and was quenched with sat. sodium bicarbonate (30 mL), and diluted with EtOAc (40 mL). The layers were separated and the aqueous layer was extracted with EtOAc (2 x 30 mL). The combined organic layers were washed with water (2 x 40 mL), brine (40 mL), dried over magnesium sulfate, filtered and the solvent was removed in vacuo to give crude product **4c** (2.5 g, 4.41 mmol, 81% yield). UPLCMS (10.0 min method) = 8.23 min. Mass observed (ESI⁺): 567.6 (M+H)⁺.

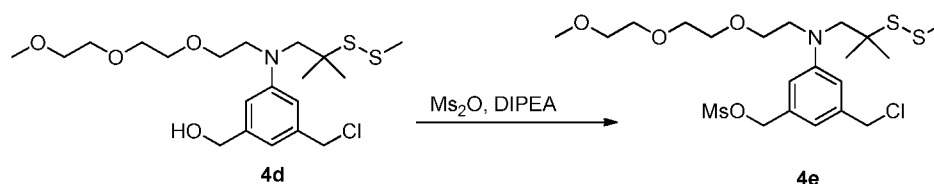
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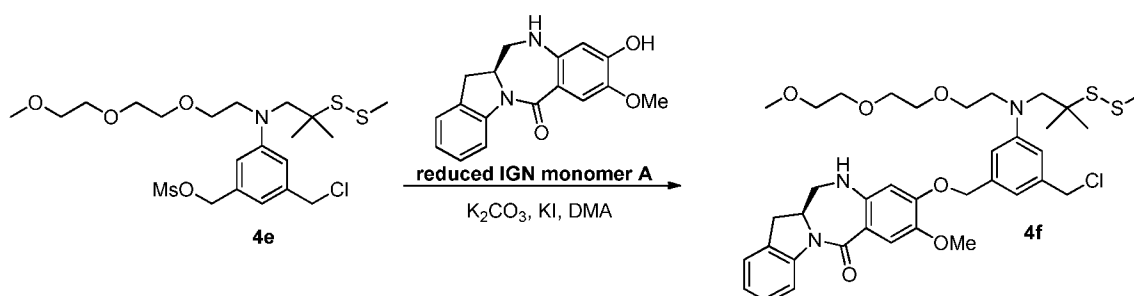
To a solution of **4c** (2.5 g, 4.41 mmol, 1.0 equiv.) in THF (43 mL) was added DIPEA (2.46 mL, 14.1 mmol, 4.0 equiv.), followed by HF-pyridine (1.48 mL, 10.6 mmol, 3.0 equiv.) and the reaction was stirred at room temperature for 2 h. The reaction was quenched with sat. sodium bicarbonate (100 mL) and the layers were separated. The aqueous layer was extracted with EtOAc (3 x 20 mL) and the combined organic layers were washed with water (30 mL), brine (30 mL) dried over magnesium sulfate and filtered. The solvent was removed in vacuo to give desired product **4d** (0.9 g, 2.0

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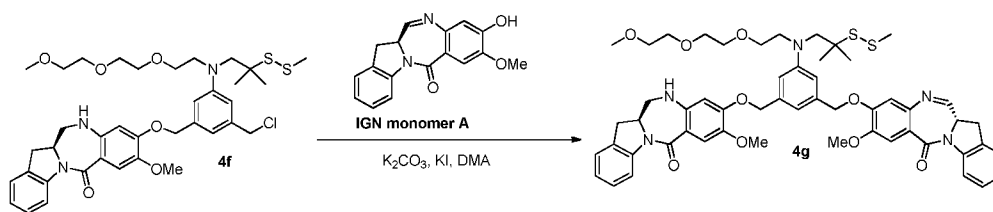
mmol, 56% yield). UPLCMS (10.0 min method) = 5.20 min. Mass observed (ESI⁺): 435.4 (M+H)⁺.



To a solution of **4d** (0.9 g, 2.0 mmol, 1.0 equiv.) in DCM (10 mL) was added DIPEA (0.69 mL, 3.98 mmol, 2.0 equiv.) at 0 °C, followed by a solution of methanesulfonyl anhydride (0.52 g, 2.99 mmol, 1.5 equiv.) in DCM (2 mL). The reaction was stirred for 1 h. The reaction was quenched with water (10 mL), the layers were separated and the aqueous layer was extracted with DCM (2 x 20 mL). The combined organic layers were washed with sat. sodium bicarbonate (10 mL), brine (20 mL), dried over magnesium sulfate and filtered. The solvent was removed in vacuo and the crude material **4e** (1.0 g, 1.88 mmol, 95% yield) was used in the next step without further purification. UPLCMS (10 min method) = 5.7 min. Mass observed (ESI⁺): 531.4 (M+H)⁺.

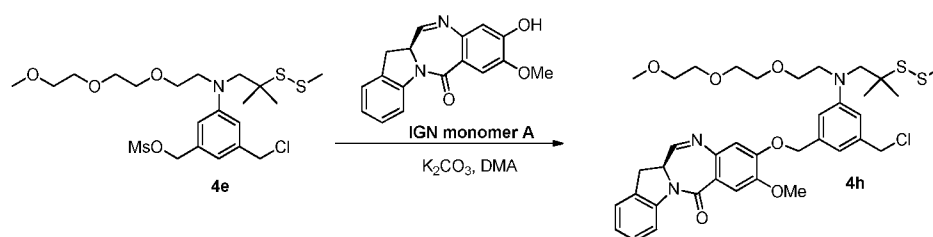


To a solution of **4e** (0.21 g, 0.39 mmol, 1.0 equiv.) in DMA (2.0 mL) was added potassium carbonate (0.16 g, 1.19 mmol, 3.0 equiv.) followed by a solution of **reduced IGN monomer A** (0.12 g, 0.41 mmol, 1.05 equiv.) in DMA (1 mL). The reaction was stirred at room temperature for 5h. The reaction was quenched with water (30 mL) and the mixture stirred for 10 min. The solid was filtered and was dissolved in DCM/MeOH (9/1, 30 mL) and washed with brine (20 mL). The organic layer was separated and dried over magnesium sulfate, filtered and the solvent removed in vacuo. The crude material was purified by silica gel chromatography (Hexane/EtOAc) to give the desired product **4f** (0.11 g, 0.15 mmol, 38% yield) as colorless oil. UPLCMS (10 min method) = 6.55 min. Mass observed (ESI⁺): 730.9 (M+H)⁺.



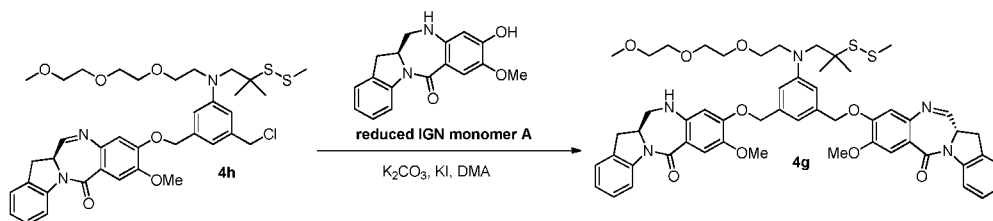
A solution of **4f** (0.11 g, 0.15 mmol, 1.0 equiv.) and **IGN monomer A** (0.053 g, 0.18 mmol) were dissolved in anhydrous DMA (1.0 mL). Potassium carbonate (0.041 g, 0.30 mmol) and potassium iodide (0.025 g, 0.15 mmol) were added. The mixture was stirred for 4 h at 40 °C. Water (5 mL) was added to the reaction mixture and the solid was filtered off and then redissolved in DCM (20 mL) and washed with water (10 mL). The organic layer was dried over magnesium sulfate, filtration and concentrated. The crude solid was purified by silica gel chromatography (Hexane/EtOAc) to give **4g** (0.099 g, 0.10 mmol, 66% yield). UPLCMS (10 min method) = 6.38 min. Mass observed (ESI⁺): 988.7 (M+H)⁺. ¹H NMR (400 MHz, DMSO-*d*₆): δ 8.22 (d, *J* = 7.9 Hz, 1H), 8.12 (d, *J* = 8.1 Hz, 1H), 8.03 (d, *J* = 4.5 Hz, 1H), 7.38 – 7.25 (m, 2H), 7.24 (t, *J* = 7.9 Hz, 2H), 7.24 – 7.06 (m, 2H), 7.11 – 6.94 (m, 1H), 6.98 (s, 1H), 6.91 (d, *J* = 15.2 Hz, 2H), 6.79 (s, 1H), 6.45 (s, 1H), 6.32 (d, *J* = 6.8 Hz, 1H), 5.18 (q, *J* = 12.3 Hz, 2H), 5.01 (m, 2H), 4.54 (dt, *J* = 9.7, 5.2 Hz, 1H), 4.37 (dt, *J* = 10.6, 5.4 Hz, 1H), 3.87 (s, 3H), 3.71 (s, 3H), 3.60 (m, 6H), 3.57 – 3.50 (m, 2H), 3.47 (qd, *J* = 4.3, 1.0 Hz, 4H), 3.47 (s, 3H), 3.42 – 3.33 (m, 2H), 3.32 – 3.16 (m, 2H), 3.21 (s, 3H), 2.97 – 2.85 (m, 1H), 2.44 (s, 3H), 1.30 (s, 6H).

Example 6.



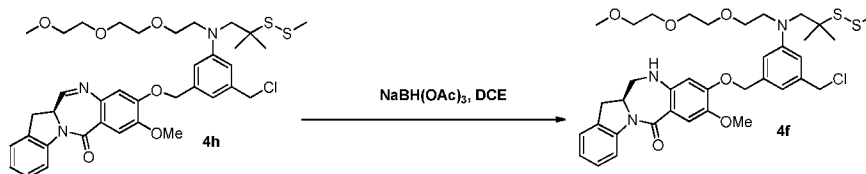
To a solution of **4e** (0.52 g, 0.98 mmol, 1.0 equiv.) and potassium carbonate (0.41 g, 2.94 mmol, 3.0 equiv.) in DMA (10 ml) was added a solution of **IGN monomer A** (0.30 g, 1.03 mmol, 1.05 equiv.) in DMA (2 mL) at room temperature and the reaction was stirred for 5h. The reaction was quenched with water (30 mL), the layers were separated and the aqueous layer extracted with EtOAc (3 x 30 mL). The combined organic layers were washed with water (30 mL), brine (30 mL), dried over magnesium sulfate and excess of solvent removed in vacuo. The crude oil was purified by silica gel

chromatography (Hexane/EtOAc) to give desired product **4h** (0.35 g, 0.48 mmol, 49% yield). UPLCMS (10 min method) = 6.19 min. Mass observed (ESI⁺): 728.7 (M+H)⁺.

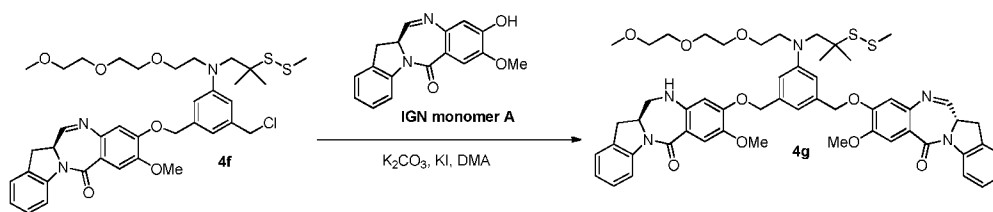


To a solution of **4h** (0.18 g, 0.25 mmol, 1.0 equiv.) in DMA (5.0 mL) was added
 5 potassium carbonate (0.10 g, 0.74 mmol, 3.0 equiv.) followed by potassium iodide (0.04 g, 0.2 mmol, 1.0 equiv.). A solution of **reduced IGN monomer A** (0.08 g, 0.27 mmol, 1.1 equiv.) in DMA (1 mL) was added and the reaction was then heated at 40 °C for 5h. The reaction was quenched with water, and then solid was filtered off. The solid was redissolved in DCM/MeOH (20:1), washed with water, dried over magnesium sulfate,
 10 filtered and concentrated. The crude residue was purified by silica gel chromatography (Hexane/EtOAc) to give **4g** (0.05 g, 0.05 mmol, 21% yield). UPLCMS (10 min method) = 6.39 min. Mass observed (ESI⁺): 989.0 (M+H)⁺.

Example 7.

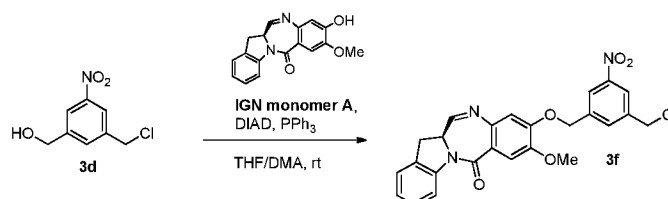


Compound **4h** (0.17 g, 0.24 mmol, 1.0 equiv.) was dissolved in anhydrous DCE
 (3 mL) and sodium triacetoxyborohydride (0.10 g, 0.48 mmol, 3.0 equiv.) was added at
 room temperature. The reaction mixture was stirred for 1 h. The mixture was quenched
 with sat. ammonium chloride (10 mL). The layers were separated and the aqueous layer
 20 extracted with DCM (2 x 20 mL). The combined organic layers were washed with brine
 (20 mL), dried over anhydrous magnesium sulfate, filtered and concentrated to obtain **4f**
 (0.13 g, 0.18 mmol, 77% yield) which was used in the next step without further
 purification. UPLCMS (2.5 min method) = 2.13 min. Mass observed (ESI⁺): 731.2
 (M+H)⁺.



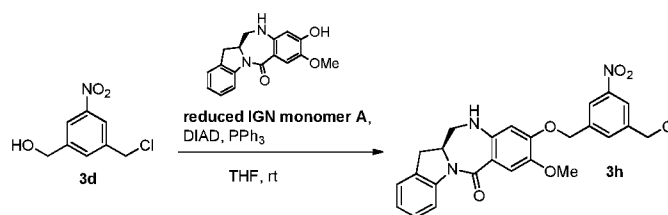
Compound **4f** (0.19 g, 0.26 mmol, 1.0 equiv.) and **IGN monomer A** (0.084 g, 0.28 mmol, 1.1 equiv.) were dissolved in anhydrous DMA (4.0 mL). Potassium carbonate (0.11 g, 0.78 mmol, 3.0 equiv.) and potassium iodide (0.043 g, 0.26 mmol, 1.0 equiv.) were added. The mixture was stirred for 4 h at 40 °C. Water (5 mL) was added to the reaction mixture. The solid was filtered off and was redissolved in DCM (20 mL) and washed with water (10 mL). After drying over magnesium sulfate, filtration and concentration, the solid was purified by silica gel chromatography (Hexane/EtOAc) to give **4g** (0.065 g, 0.06 mmol, 25% yield). UPLCMS (10 min method) = 6.38 min. Mass observed (ESI⁺): 988.7 (M+H)⁺.

Example 8.



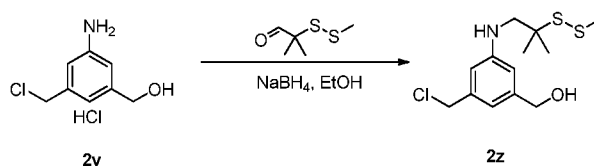
Compound **3d** (0.03 g, 0.149 mmol, 1.0 equiv.) and **IGN monomer A** (0.046 g, 0.156 mmol, 1.05 equiv.) were dissolved in THF (1.5 mL) and DMF (0.3 mL). Triphenylphosphine was added (0.047 g, 0.179 mmol, 1.2 equiv.), followed by a slow addition of DIAD (0.032 mL, 0.164 mmol, 1.1 equiv.). The reaction was stirred at rt under argon for 12 h. The reaction mixture was concentrated and water (~2 mL) was added to triturate the product. The precipitate was filtered and the remaining solid was washed with water. The crude residue was purified by silica gel chromatography (hexane/EtOAc) to give compound **3f** as a white yellow solid (0.013 g, 0.027 mmol, 18% yield). UPLCMS (2.5 min method) = 1.80 min. Mass observed (ESI⁺) = 478.4 (M+H)⁺.

Example 9.

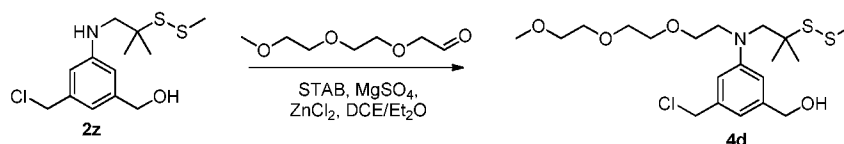


Compound **3d** (0.03 g, 0.149 mmol, 1.0 equiv.) and **reduced IGN monomer A** (0.046 g, 0.156 mmol, 1.05 equiv.) were dissolved in THF (1.5 mL). Triphenylphosphine was added (0.047 g, 0.179 mmol, 1.2 equiv.), followed by a slow addition of DIAD (0.032 mL, 0.164 mmol, 1.1 equiv.). The reaction was stirred at rt under argon for 2 h. The reaction mixture was concentrated and coevaporated with toluene (2 x). The crude residue was purified by silica gel chromatography (hexane/EtOAc) to give compound **3h** as a orange yellow solid (0.055 g, 0.115 mmol, 77% yield). UPLCMS (2.5 min method) = 1.90 min. Mass observed (ESI⁺) = 480.5 (M+H)⁺.

Example 10.



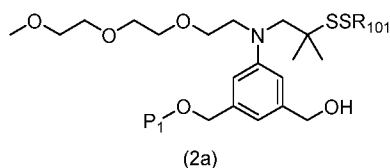
To a solution of compound **2y** (1.0 g, 5.83 mmol, 1.1 equiv.) in ethanol (26.5 mL) was added 2-(methylthio)isobutyraldehyde (0.838 g, 5.30 mmol, 1.0 equiv.) at room temperature with continuous stirring. The mixture was cooled to 0 °C and sodium borohydride (0.24 g, 6.36 mmol, 1.2 equiv.) was added in one portion and the reaction was allowed to stir at this temperature for 1 h. After 1 h, the reaction was quenched with sat. ammonium chloride (20 mL) and extracted with dichloromethane (3 X 50 mL). The combined organic layers were washed with brine (10 mL) and dried over sodium sulfate and filtered. The solvent was removed in vacuo and the crude residue was purified via silica gel column chromatography (dichloromethane:methanol) to give **2z** (0.181 g, 0.593 mmol, 11% yield). LCMS (8 min method) = 5.86 min. Mass observed (ESI⁺): 306.1 (M+H)⁺.



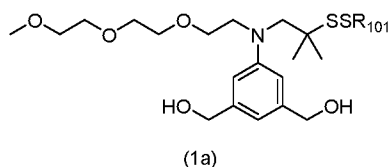
To a solution of compound **2z** (0.089 g, 0.292 mmol, 1.0 equiv.) in 1,2-dichloroethane (0.972 mL) was added 2-(2-(2-methoxyethoxy)ethoxy)acetaldehyde (0.057 g, 0.35 mmol, 1.2 equiv.) and magnesium sulfate (0.053 g, 0.437 mmol, 1.5 equiv.) at room temperature with continuous stirring. The mixture was cooled to 0 °C
5 and a 1M solution of zinc chloride in diethyl ether (0.146 mL, 0.146 mmol, 0.5 equiv.) was added followed by the addition of sodium triacetoxyborohydride. The reaction was allowed to warm to room temperature, while stirring, over a 2h period. The reaction was quenched with sat. ammonium chloride (5 mL) and extracted with dichloromethane (3 X 10 mL). The combined organic layers were washed with brine (5 mL) and dried over
10 sodium sulfate and filtered. The solvent was removed in vacuo and the crude residue was purified via ptlc (dichloromethane:methanol) to give **4d** (0.014 g, 0.032 mmol, 11% yield). LCMS (8 min method) = 5.96 min. Mass observed (ESI+): 452.1 (M+H)⁺.

CLAIMS

1. A method of preparing a compound of formula (2a),



- 5 or a salt thereof, said method comprising introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a) by reacting the compound of formula (1a) with an alcohol protecting reagent,

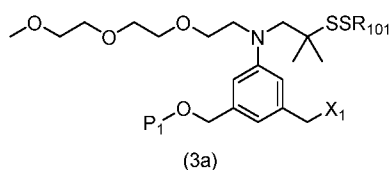


wherein P₁ is the alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

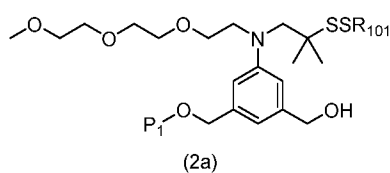
- 10 2. The method of claim 1, wherein the alcohol protecting group is sterically hindered.
3. The method of claim 1, wherein the alcohol protecting group is pivaloyl, methoxymethyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, 3,4-dimethoxybenzyl, 2,6-dimethoxybenzyl, diphenylmethyl, benzyloxymethyl, 15 2,2,2-trichloroethoxycarbonyl, tetrahydrofuranyl, tetrahydropyranyl, benzyl, benzoyl, *para*-phenylbenzoyl, 2,4,6-trimethylbenzoyl, *para*-bromobenzoyl, *para*-nitrobenzoyl, picolinoyl, nicotinoyl, 5-dibenzosuberyl, trityl/triphenylmethyl, or tris(4-*tert*-butylphenyl)methyl.
4. The method of claim 3, wherein the alcohol protecting group is methoxymethyl, 20 tetrahydropyranyl, 2-methoxyethoxymethyl, *p*-methoxybenzyl, benzyloxymethyl, or 2,2,2-trichloroethoxycarbonyl.
5. The method of claim 4, wherein the alcohol protecting group is 2,2,2-trichloroethoxycarbonyl.

6. The method of claim 1, wherein the alcohol protecting group is a silyl protecting group.
7. The method of claim 6, wherein the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl,
5 triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl.
8. The method of claim 7, wherein the silyl protecting group is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl.
- 10 9. The method of claim 8, wherein the silyl protecting group is *tert*-butyldimethylsilyl.
10. The method of any one of claims 6-9, wherein the silyl protecting group is introduced by reacting the compound of formula (1a) with R^3 -Cl, R^3 -Br, R^3 -I or R^3 -OSO₂CF₃ in the presence of a base, wherein R^3 is dimethylisopropylsilyl,
15 diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, or *tert*-butyldiphenylsilyl.
11. The method of claim 10, wherein the base is a non-nucleophilic base.
12. The method of claim 11, wherein the non-nucleophilic base is imidazole,
20 triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, 1,8-diazabicycloundec-7-ene, or tetramethylpiperidine.
13. The method of claim 11, wherein the non-nucleophilic base is imidazole.
14. The method of any one of claims 11-13, wherein the reaction is carried out in the presence of a catalyst.
- 25 15. The method of claim 14, wherein the catalyst is 4-dimethylaminopyridine (DMAP), 1,1,3,3-tetramethylguanidine or 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU).

16. The method of any one of claims 1-15, wherein 0.8-1.2, 1-5, 1-2, 1-1.5 or 1-1.2 molar equivalents of the alcohol protecting reagent are used relative to the compound of formula (1a).
17. The method of any one of claims 11-16, wherein more than 2 molar equivalents of the non-nucleophilic base are used relative to the compound of formula (1a).
18. A method of preparing a compound of formula (3a),



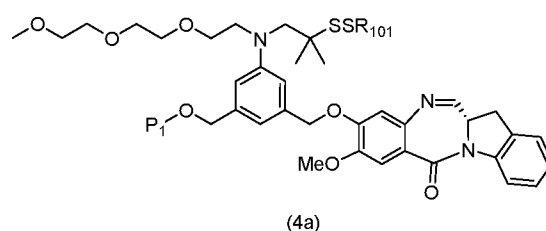
or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (2a),



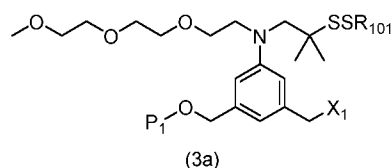
wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

19. The method of claim 18, wherein the sulfonate ester represented by X₁ is mesylate, tosylate, brosylate, or triflate.
20. The method of claim 18, wherein the sulfonate ester represented by X₁ is mesylate.
21. The method of any one of claims 18-20, wherein the method comprising reacting the compound of formula (2a) with a sulfonating reagent in the presence of a non-nucleophilic base.

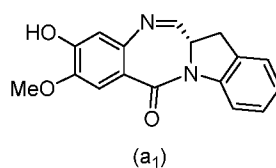
22. The method of claim 21, wherein the non-nucleophilic base is triethylamine, imidazole, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine .
23. The method of claim 22, wherein the non-nucleophilic base is triethylamine or diisopropylethylamine.
24. The method of any one of claims 21-23, wherein the sulfonating reagent is methanesulfonic anhydride or methanesulfonyl chloride (MsCl).
25. The method of claim 18, wherein the method comprising reacting a halogenating reagent with the compound of formula (2a) and the halogenating reagent is bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.
26. A method of preparing a compound of formula (4a),



- or a salt thereof, said method comprising reacting a compound of formula (3a)



with a monomer compound of the formula (a₁),



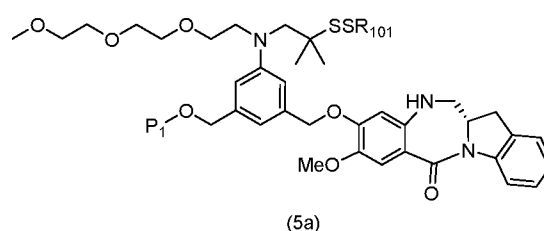
wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester

(preferably, X_1 is -Br, -I, or a sulfonate ester); and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

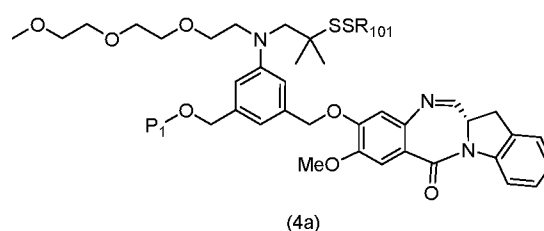
27. The method of claim 26, wherein the compound of formula (3a) is reacted with the monomer compound of formula (a₁) in the presence of a base.

5 28. The method of claim 27, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.

29. A method of preparing a compound of formula (5a),



or a salt thereof, said method comprising reacting a compound of formula (4a),



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with an imine reducing agent, wherein P_1 is an alcohol protecting group; and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

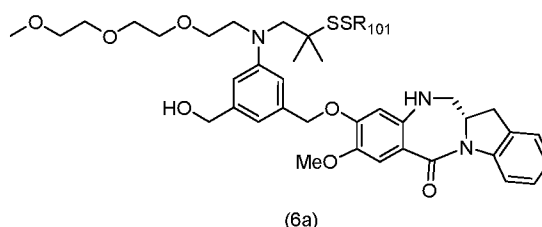
30. The method of claim 29, wherein the imine reducing reagent is a hydride reducing reagent.

15 31. The method of claim 29, wherein the imine reducing reagent is sodium borohydride, sodium triacetoxy borohydride, sodium cyanoborohydride, lithium aluminum hydride, hydrogen gas, ammonium formate, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminium hydride (DIBAL), lithium borohydride (LiBH₄), potassium borohydride (KBH₄), or sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al).

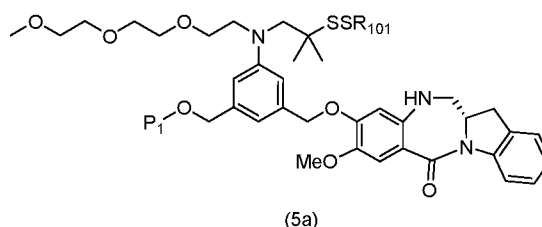
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32. The method of claim 29, wherein the imine reducing reagent is sodium triacetoxy borohydride ($\text{NaBH}(\text{OAc})_3$).

33. A method of preparing a compound of formula (6a),



5 or a salt thereof, said method comprising reacting a compound of formula (5a),

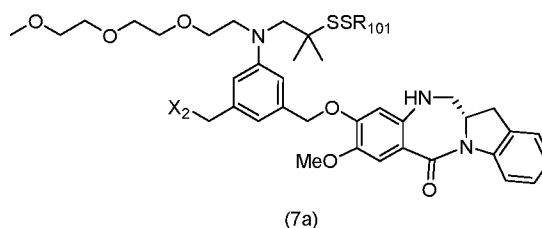


with an alcohol deprotecting reagent, wherein P_1 is an alcohol protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)$ alkyl, pyridyl, or nitropyridyl.

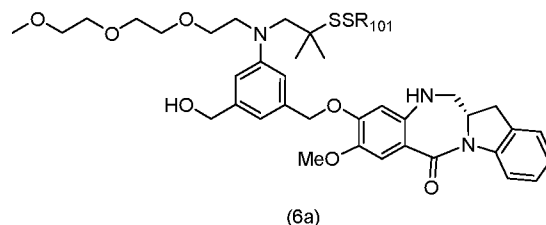
34. The method of claim 33, wherein the alcohol deprotecting reagent is tetra-n-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, trifluoroacetic acid, pyridinium p-toluenesulfonate, p-toluenesulfonic acid (p-TsOH), formic acid, periodic acid.

35. The method of claim 33, wherein the alcohol deprotecting reagent is hydrochloric acid or tetra-n-butylammonium fluoride.

36. A method of preparing a compound of formula (7a),



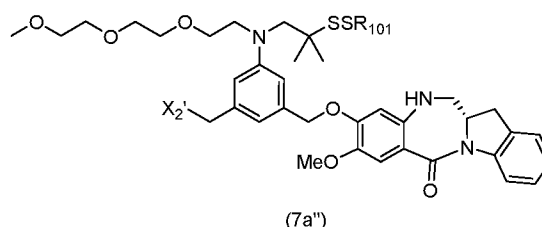
or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the primary alcohol compound of formula (6a),



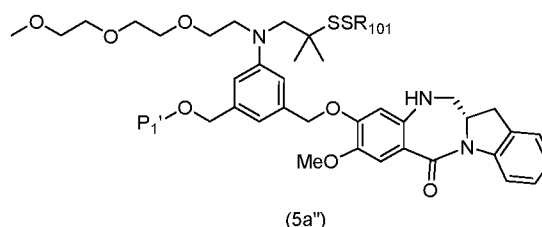
- 5 wherein X_2 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X_2 is -Br, -I, a sulfonate ester); and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.
37. The method of claim 36, wherein the sulfonate ester represented by X_2 is mesylate, tosylate, brosylate, or triflate.
- 10 38. The method of claim 37, wherein the sulfonate ester represented by X_2 is mesylate.
39. The method of any one of claims 36-38, wherein the method comprising reacting the compound of formula (6a) with the sulfonating reagent in the presence of a non-nucleophilic base.
- 15 40. The method of claim 39, wherein the non-nucleophilic base is triethylamine, imidazole, triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine.
41. The method of claim 39, wherein the non-nucleophilic base is triethylamine or diisopropylethylamine.
- 20 42. The method of any one of claims 36-41, wherein the sulfonating reagent is methanesulfonic anhydride or methanesulfonyl chloride (MsCl).
43. The method of claim 36, wherein the method comprising reacting the compound of formula (6) with a halogenating reagent, wherein the halogenating reagent is bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide,

potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.

44. A method of preparing a compound of formula (7a''),

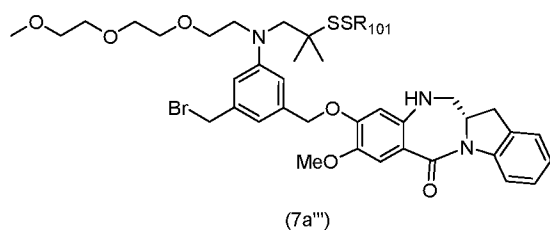


- 5 or a salt thereof, said method comprising reacting a compound of formula (5a'')



with an alcohol deprotecting reagent and a halogenating reagent, wherein P₁' is an acid labile alcohol protecting group; X₂' is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

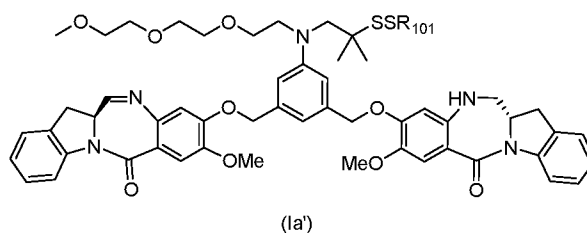
- 10 45. The method of claim 44, wherein the compound of formula (7a''') is represented by the following:



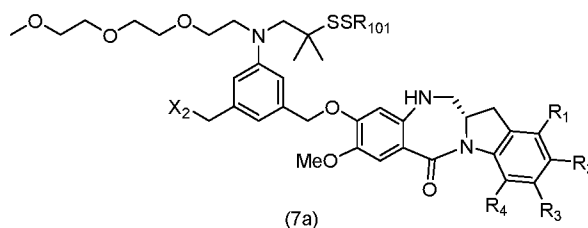
and the method comprising reacting the compound of formula (5a'') with an alcohol deprotecting reagent and a bromination reagent.

- 15 46. The method of claim 44 or 45, wherein the acid labile alcohol protecting group is acetate, allyl, methoxymethyl, tetrahydrofuranyl, tetrahydropyranyl, 5-dibenzosuberonyl, 1-ethoxyethyl, 1-methyl-1-methoxyethyl, 2-(phenylselenenyl)ethyl, trityl/triphenylmethyl, or tris(4-*tert*-butylphenyl)methyl.

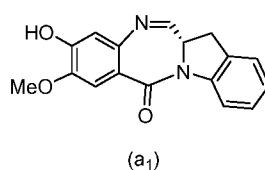
47. The method of claim 46, wherein the acid labile alcohol protecting group is a silyl protecting group.
48. The method of claim 47, wherein the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl.
49. The method of claim 47, wherein the silyl protecting group is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl.
50. The method of claim 47, wherein the silyl protecting group is *tert*-butyldimethylsilyl.
51. The method of any one of claims 44-50, wherein the alcohol deprotecting reagent is tetra-*n*-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, pyridinium *p*-toluenesulfonate, formic acid, periodic acid, trifluoroacetic acid, or *p*-toluenesulfonic acid (*p*-TsOH).
52. The method of claim 51, wherein the alcohol deprotecting reagent is acetic acid.
53. The method of any one of claims 44-52, wherein the bromination reagent is HBr.
54. The method of any one of claims 44-50, wherein the compound of formula (5a') is reacted with a mixture of acetic acid and HBr.
55. A method of preparing a compound of formula (Ia'),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (7a),



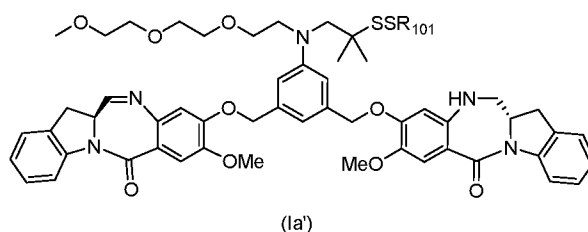
with a monomer compound of the formula (a₁),



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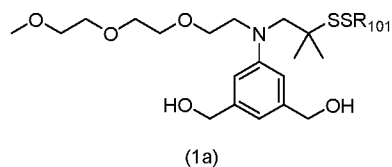
wherein R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl; and, X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester (preferably, X₂ is -Br, -I, or a sulfonate ester).

56. The method of claim 55, wherein the compound of formula (7a) is reacted with the monomer compound of formula (a₁) in the presence of a base.
57. The method of claim 56, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
58. A method of preparing a compound of formula (Ia'),

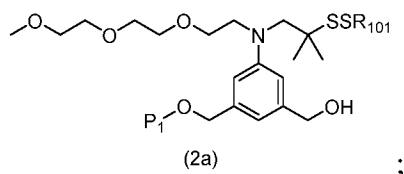


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

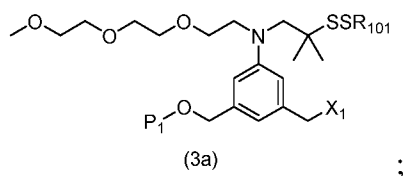
(1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



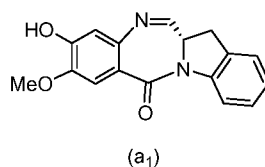
to form a compound of formula (2a),



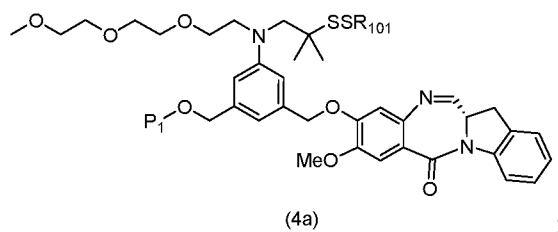
5 (2) reacting the compound of formula (2a) with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a),



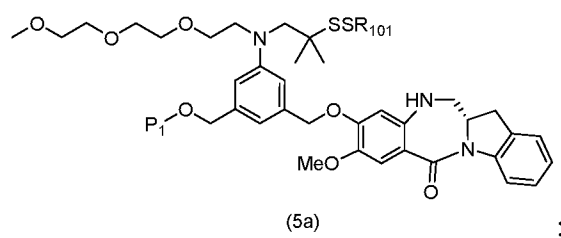
(3) reacting the compound of formula (3a) with a monomer compound of the formula (a₁),



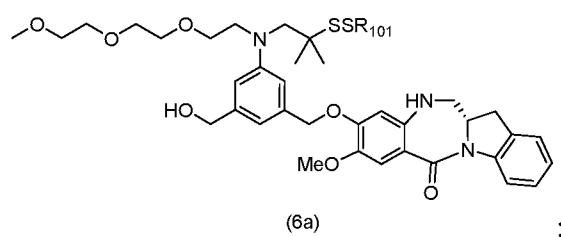
to form a compound of formula (4a),



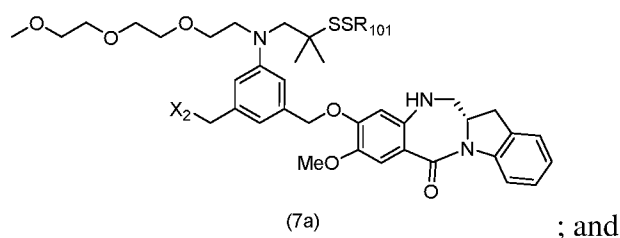
(4) reacting the compound of formula (4a) with an imine reducing agent to form a compound of formula (5a),



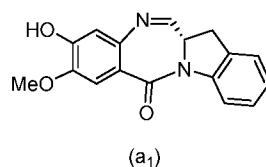
(5) reacting the compound of formula (5a) with an alcohol deprotecting reagent to form a compound of formula (6a),



5 (6) reacting the compound of formula (6a) with a second halogenating reagent, a second sulfonating reagent or a second esterification reagent to form a compound of formula (7a),

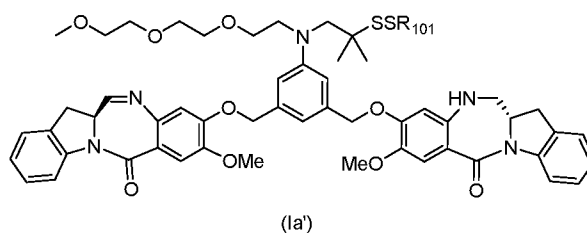


10 (7) reacting the compound of formula (7a) with a monomer compound of the formula (a₁),



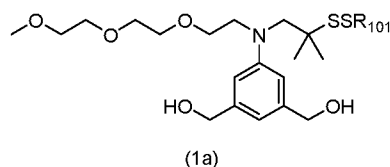
to form the compound of formula (I'); wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester (preferably, X₁ and X₂ are each independently -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

59. A method of forming a compound of formula (Ia'),

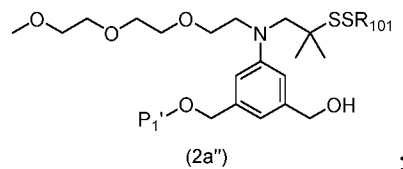


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

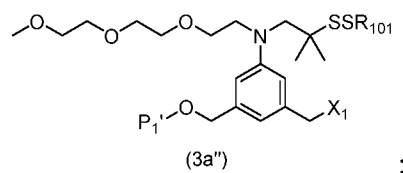
- 5 (1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



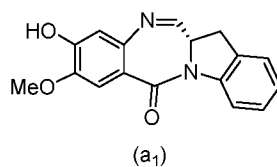
to form a compound of formula (2a''),



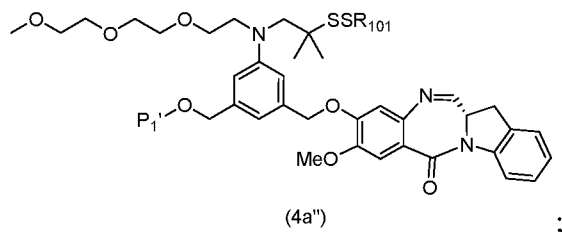
- 10 (2) reacting the compound of formula (2a'') with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a''),



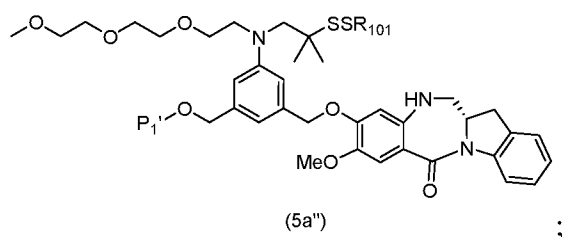
- 15 (3) reacting the compound of formula (3a'') with a monomer compound of the formula (a₁),



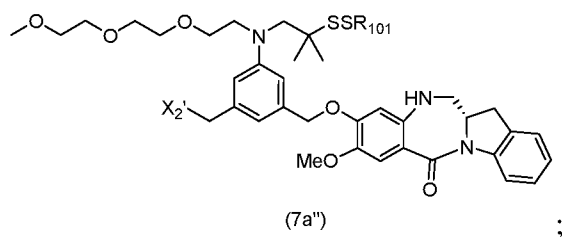
to form a compound of formula (4a''),



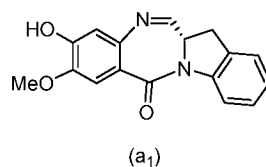
(4) reacting the compound of formula (4a'') with an imine reducing agent to form a compound of formula (5a''),



(5) reacting the compound of formula (5a'') with an alcohol deprotecting reagent and a halogenating reagent to form a compound of formula (7a''),

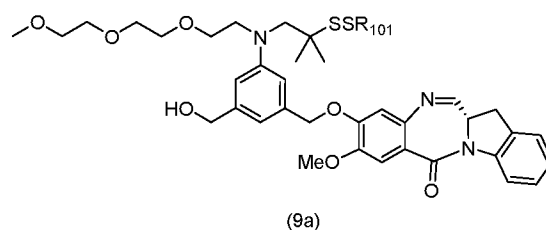


(6) reacting a compound of formula (7a'') with a monomer compound of the formula (a₁),

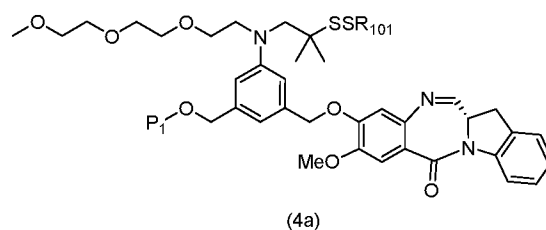


to form the compound of formula (Ia'), wherein P_1' is an acid labile alcohol protecting group; X_1 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester (preferably, -Br, -I, a sulfonate ester); X_2' is -Br or -I; and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

- 5 60. A method of preparing a compound of formula (9a),



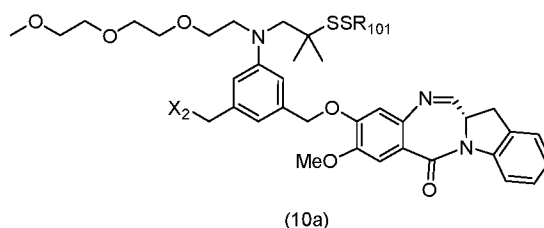
or a salt thereof, said method comprising reacting a compound of formula (4a),



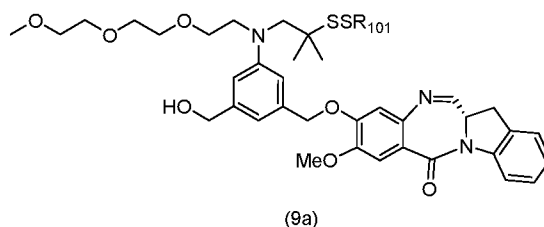
- 10 with an alcohol deprotecting reagent; wherein P_1 is an alcohol protecting group; and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

61. The method of claim 60, wherein the alcohol deprotecting reagent is tetra-n-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, pyridinium p-toluenesulfonate, formic acid, periodic acid, trifluoroacetic acid, or p-toluenesulfonic acid (p-TsOH).
62. The method of claim 60, wherein the alcohol deprotecting reagent is hydrochloric acid or tetra-n-butylammonium fluoride.

63. A method of preparing a compound of formula (10a),



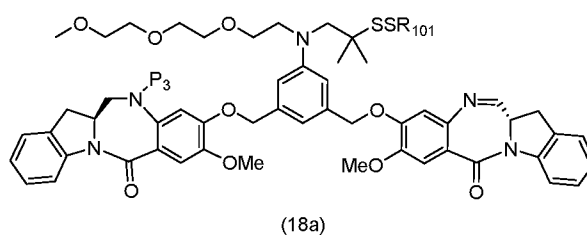
or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the compound of formula (9a),



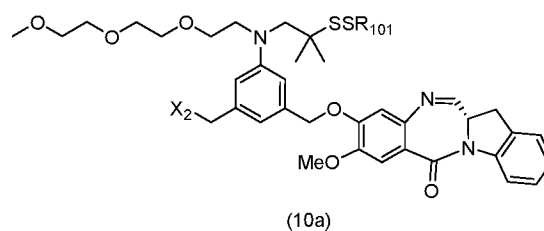
wherein X_2 is a leaving group selected from the group consisting of -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X_2 is -Br, -I, or a sulfonate ester); and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

64. The method of claim 63, wherein the sulfonate ester represented by X_2 is mesylate, tosylate, brosylate, or triflate.
65. The method of claim 63, wherein the sulfonate ester represented by X_2 is mesylate.
66. The method of any one of claims 63-65, wherein the method comprising reacting the compound of formula (6a) with the sulfonating reagent in the presence of a non-nucleophilic base.
67. The method of claim 66, wherein the non-nucleophilic base is triethylamine, imidazole, triethylamine, diisopropylethylamine, pyridine, 2,6-lutidine, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine.
68. The method of claim 66, wherein the non-nucleophilic base is triethylamine or diisopropylethylamine.

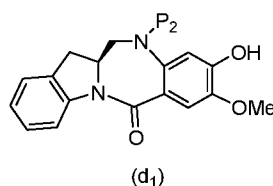
69. The method of any one of claims 63-68, wherein the sulfonating reagent is methanesulfonic anhydride or methanesulfonyl chloride.
70. The method of claim 63, wherein the method comprising reacting the compound of formula (6a) with a halogenating reagent and the halogenating reagent is
5 bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.
71. A method of preparing a compound of formula (18a),



- 10 or a salt thereof, said method comprising reacting a compound of formula (10a)

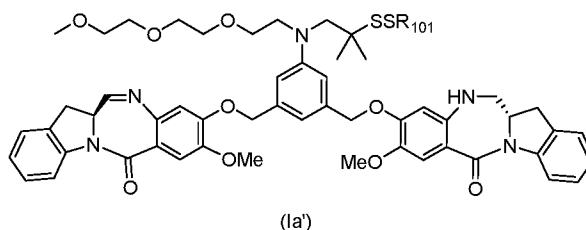


with a monomer compound of the formula (d₁),

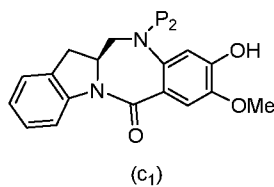


wherein X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl,
a sulfonate ester, and an activated ester (preferably, X₂ is -Br, -I, or a sulfonate
ester); P₃ is H or P₂; P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl,
pyridyl, or nitropyridyl.

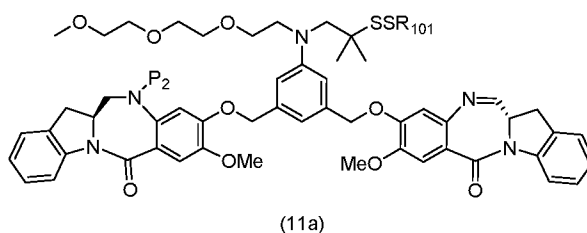
72. The method of claim 71, wherein P_3 is H and the compound of (10a) is reacted with the monomer compound of (d_1) to form a compound of (1a'):



73. The method of claim 71, wherein P_3 is P_2 ; the monomer compound is represented by formula (c_1):

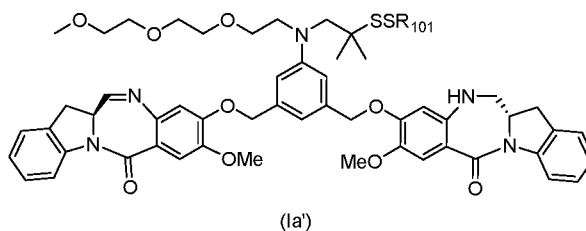


and the compound of formula (18a) is represented by formula (11a),

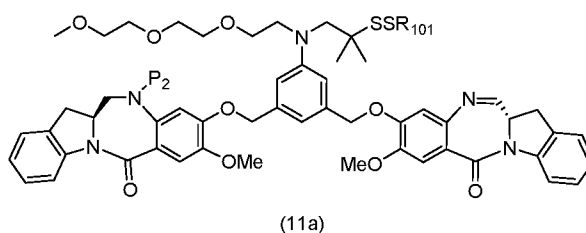


74. The method of claim 71, 72 or 73, wherein the compound of formula (11a) is reacted with the monomer compound of formula (c_1) in the presence of a base.
75. The method of claim 74, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
76. The method of any one of claims 71-75, wherein the amine protecting group is 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, or 2, 2,2,2-trichloroethoxycarbonyl.

77. A method of preparing a compound of formula (Ia'),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (11a),

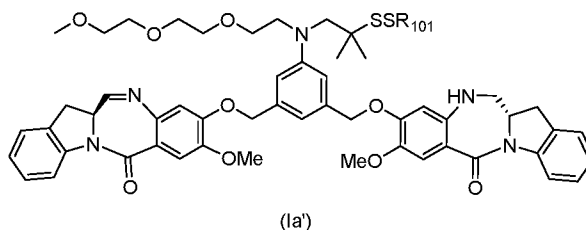


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with an amine deprotecting reagent; wherein P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

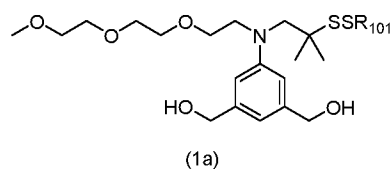
78. The method of claim 77, wherein the amine deprotecting reagent is tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

79. A method of preparing a compound of formula (Ia'),

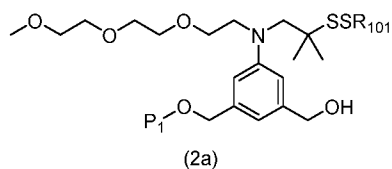


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- 15 (1) introducing an alcohol protecting group onto one of the primary alcohols of
the compound of formula (1a),

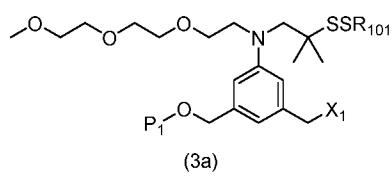


to form a compound of formula (2a),

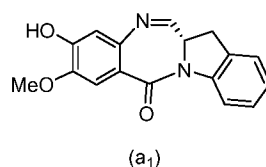


(2) reacting a halogenating reagent, a sulfonating reagent or an esterification

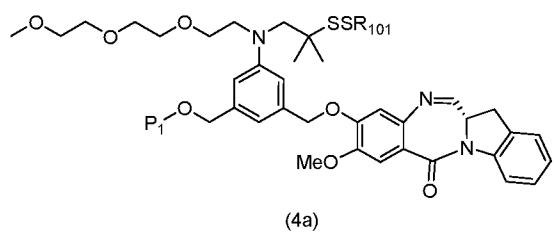
5 reagent with the compound of formula (2a) to form a compound of formula (3a),



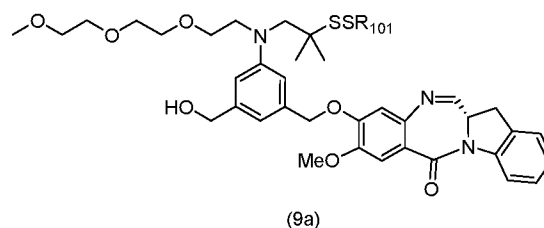
(3) reacting the compound of formula (3a) with a monomer compound of the formula (a₁),



10 to form a compound of formula (4a),

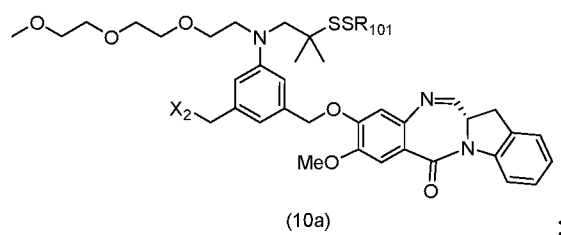


(4) reacting the compound of formula (4a) with an alcohol deprotecting reagent to form a compound of formula (9a),

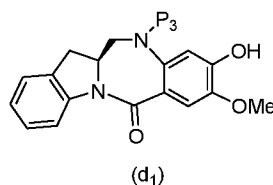


15 (5) reacting a second halogenating reagent, a second sulfonating reagent or a second esterification reagent with the compound of formula (9a) to form a

compound of formula (10a),

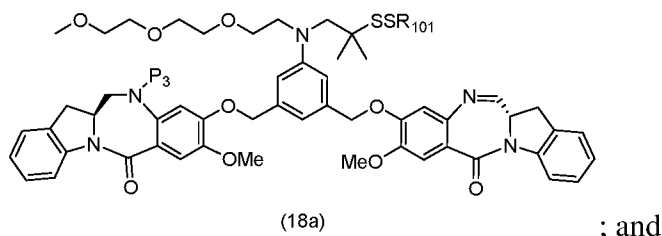


(6) reacting the compound of formula (10a) with a monomer compound of the formula (d₁)



5

to form a compound of formula (18a),

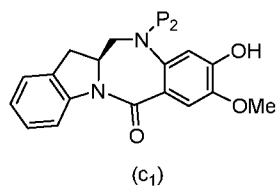


(7) reacting the compound of formula (11a) to an amine deprotecting reagent to form the compound of formula (Ia');;

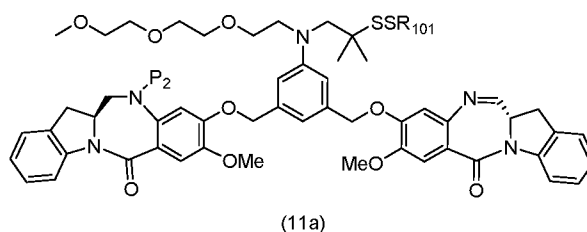
10 wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, -Br, -I, a sulfonate ester); P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

80. The method of claim 79, wherein P₃ is H and the compound of (10a) is reacted
15 with the monomer compound of (d₁) to form a compound of (Ia').

81. The method of claim 80, wherein P₃ is P₂; the monomer compound is represented by formula (c₁):

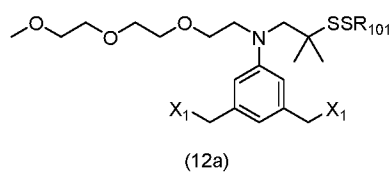


and the compound of formula (18a) is represented by formula (11a),

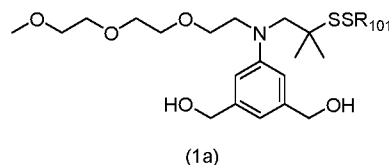


wherein P_2 is an amine protecting group.

82. A method of preparing a compound of formula (12a),



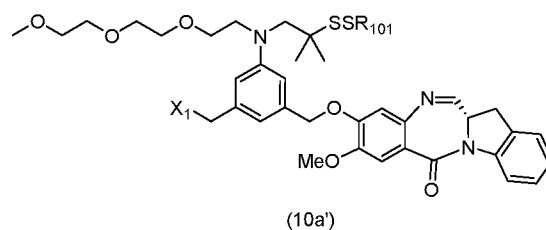
- 5 or a salt thereof, said method comprising reacting a compound of formula (1a),



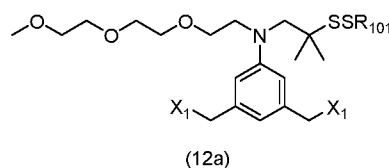
with a halogenating reagent, a sulfonating reagent or an esterification reagent, wherein X_1 is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X_1 is -Br, -I, or a sulfonate ester); and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

- 10 83. The method of claim 82, wherein X_1 is -Br or -I.
84. The method of claim 82 or 83, wherein the halogenating reagent reacts with the primary alcohols of the compound of formula (1a) in the presence of an alcohol activating agent.
85. The method of claim 84, wherein the alcohol activating agent is thionyl chloride.
- 15 86. The method of any one of claims 82-85, wherein the halogenating reagent is lithium bromide, sodium bromide, potassium bromide, potassium iodide, or sodium iodide.

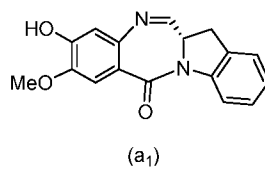
87. A method of preparing a compound of formula (10a'),



or a salt thereof, said method comprising reacting a compound of formula (12a),



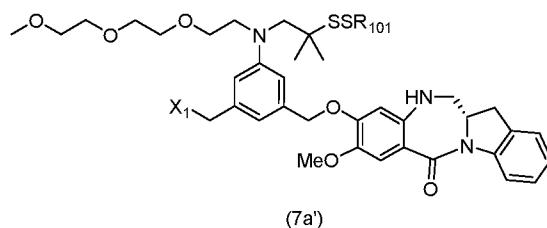
- 5 with a monomer compound of the formula (a₁),



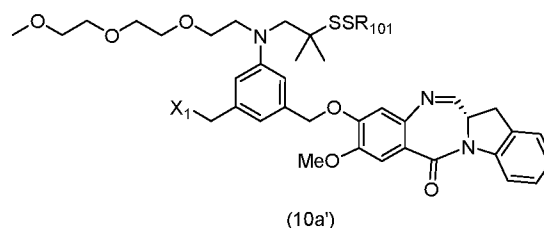
wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

88. The method of claim 87, wherein the compound of formula (12a) is reacted with
10 the monomer compound of formula (a₁) in the presence of a base.
89. The method of claim 88, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
90. The method of any one of claims 87-89, wherein excess molar equivalent of the
15 compound of formula (12a) relative to the monomer compound of formula (a₁) is used.

91. A method of preparing a compound of formula (7a'),

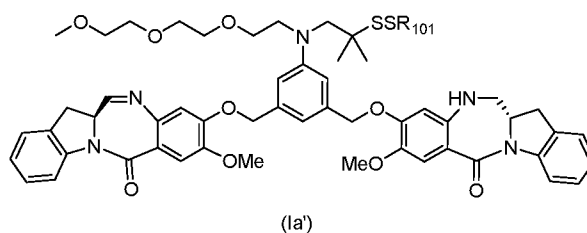


or a salt thereof, said method comprising reacting a compound of formula (10a'),



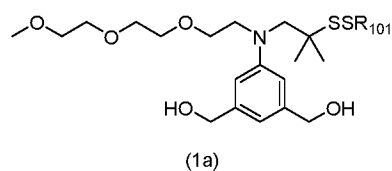
- 5 or a salt thereof, with an imine reducing agent, wherein X_1 is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X_1 is -Br, -I, a sulfonate ester); and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.
92. The method of claim 91, wherein the imine reducing reagent is a hydride reducing reagent.
- 10 93. The method of claim 91, wherein the imine reducing reagent is sodium borohydride, sodium triacetoxy borohydride, sodium cyanoborohydride, lithium aluminum hydride, hydrogen gas, ammonium formate, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminium hydride (DIBAL), lithium borohydride ($LiBH_4$), potassium borohydride (KBH_4), or sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al).
- 15 94. The method of claim 91, wherein the imine reducing reagent is sodium triacetoxy borohydride ($NaBH(OAc)_3$).
95. The method of any one of claims 91-94, wherein X_1 is mesylate.

96. A method of preparing a compound of formula (Ia'),

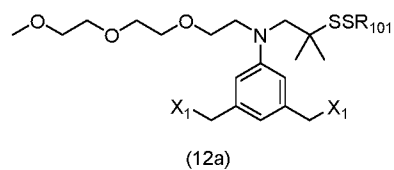


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

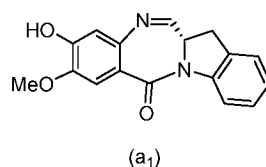
5 (1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



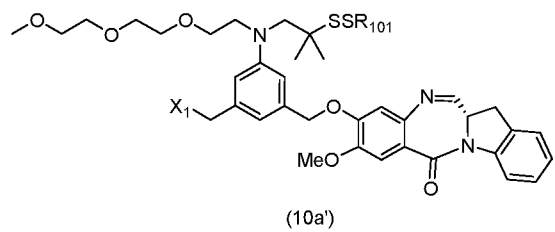
to form a compound of formula (12a),



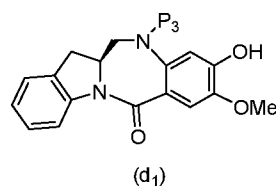
10 (2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),



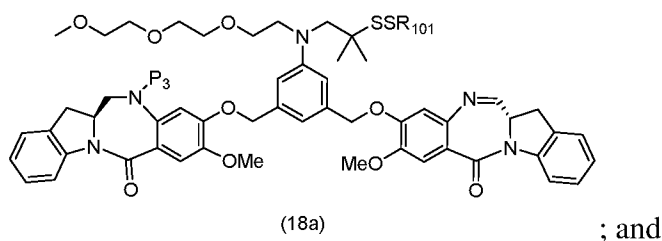
to form a compound of formula (10a'),



15 (3) reacting the compound of formula (10a') with a monomer compound of the formula (d₁),

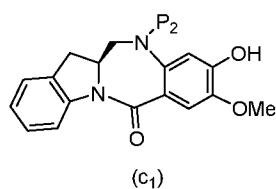


to form a compound of formula (18a),

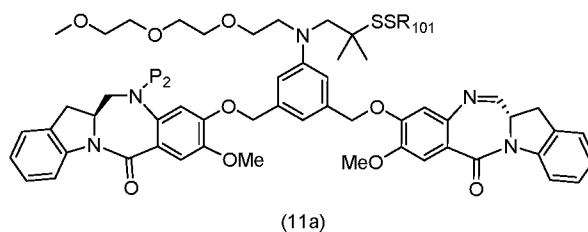


- (4) when P₃ is an amine protecting group, reacting the compound of formula (18a) with an amine deprotecting reagent to form the compound of formula (Ia'); wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

97. The method of claim 96, wherein P₃ is H and the compound of (10a') is reacted with the monomer compound of (d₁) to form a compound of (Ia').
98. The method of claim 96, wherein P₃ is P₂; the monomer compound is represented by formula (c₁):

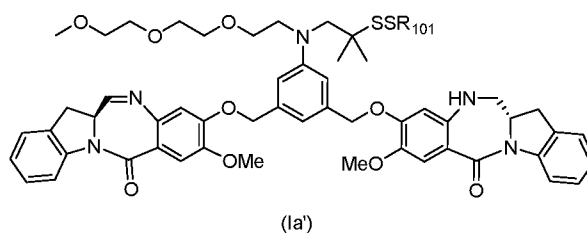


and the compound of formula (18a) is represented by formula (11a),



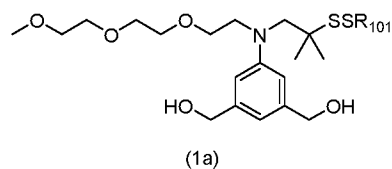
wherein P₂ is an amine protecting group.

99. A method of preparing a compound of formula (Ia'),

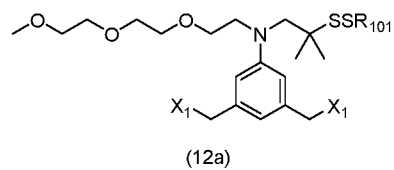


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

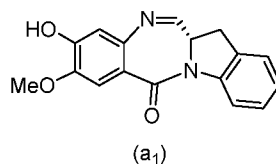
- 5 (1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



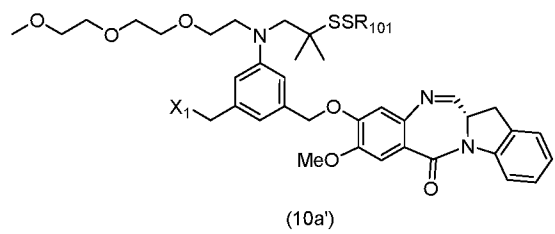
to form a compound of formula (12a),



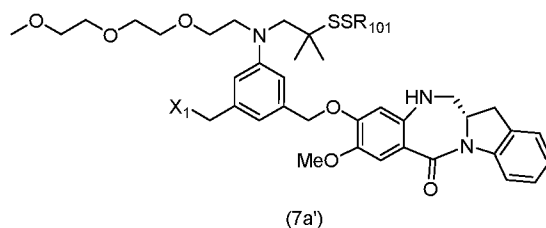
- 10 (2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),



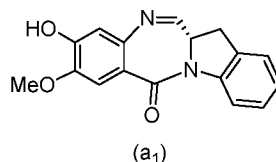
to form a compound of a formula (10a'),



- 15 (3) reacting the compound (10a') with an imine reducing reagent to form a compound (7a'),



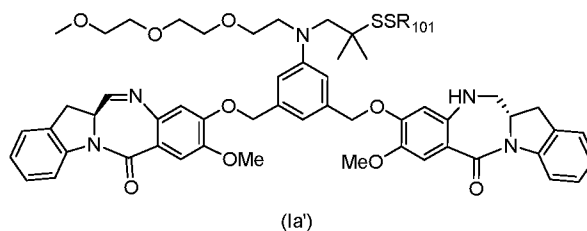
(4) reacting the compound of formula (7a') with a monomer compound of the formula (a₁),



5 to form a compound of formula (Ia'), or a pharmaceutically acceptable salt thereof, wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

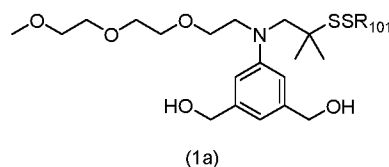
100. The method of claim 99, wherein X₁ is mesylate.

10 101. A method of preparing a compound of formula (Ia'),

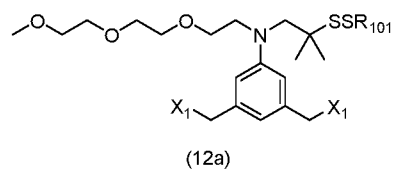


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

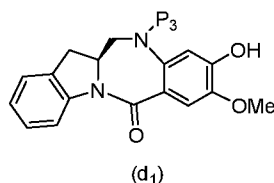
(1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



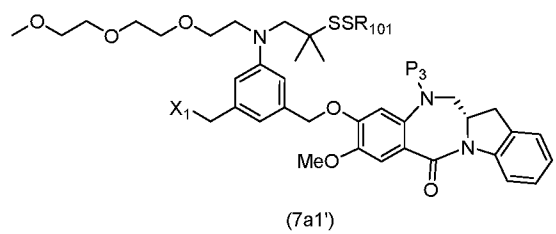
to form a compound of formula (12a),



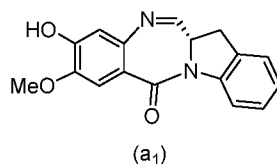
(2) reacting the compound of formula (12d) with a monomer compound of the formula (d₁),



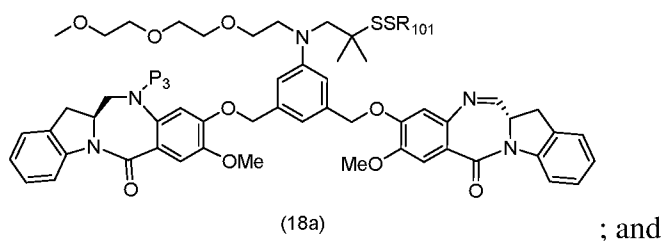
5 to form a compound of a formula (7a1'),



(3) reacting the compound of formula (7a1') with a monomer compound of the formula (a₁),



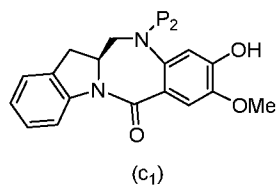
10 to form a compound of formula (18a),



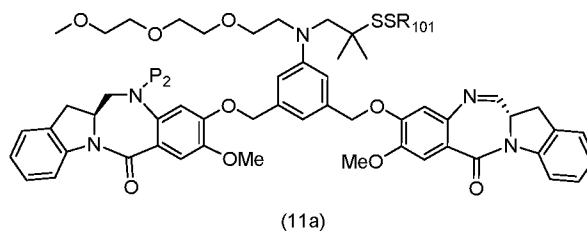
(4) when P₃ is an amine protecting group, reacting the compound of formula (18d) with an amine deprotecting reagent to form the compound of formula (Id'); wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

102. The method of claim 101, wherein P₃ is H and the compound of (10a') is reacted with the monomer compound of (d₁) to form a compound of (Ia').

103. The method of claim 101, wherein P_3 is P_2 ; the monomer compound is represented by formula (c₁):



and the compound of formula (18a) is represented by formula (11a),

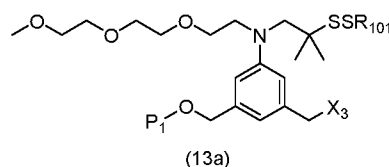


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wherein P_2 is an amine protecting group.

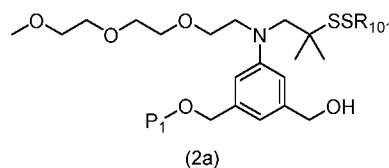
104. The method of any one of claims 101-103, wherein X_1 is mesylate.

105. A method of preparing a compound of formula (13a),



10

or a salt thereof, said method comprising reacting a chlorinating reagent with a compound of formula (2a),



wherein P_1 is an alcohol protecting group; X_3 is $-Cl$; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

15

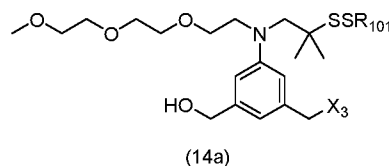
106. The method of claim 105, wherein the alcohol protecting group is a silyl protecting group.

107. The method of claim 106, wherein the silyl protecting group is the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl,

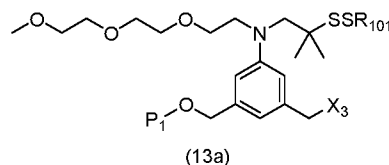
dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl.

108. The method of claim 107, wherein the silyl protecting group is triethylsilyl,
5 triisopropylsilyl, or *tert*-butyldimethylsilyl.
109. The method of claim 108, wherein the silyl protecting group is *tert*-butyldimethylsilyl.
110. The method of any one of claims 105-109, wherein the chlorinating reagent is
10 selected from the group consisting of carbon tetrachloride, methanesulfonyl chloride, sulfuryl chloride, thionyl chloride, cyanuric chloride, *N*-chlorosuccinimide, phosphorus(V) oxychloride, phosphorus pentachloride, and phosphorus trichloride.
111. The method of claim 110, wherein the chlorinating reagent is methanesulfonyl chloride.
- 15 112. The method of any one of claims 105-111, wherein the chlorinating reagent is reacted with a compound of formula (2a) in the presence of a non-nucleophilic base.
113. The method of claim 112, wherein the non-nucleophilic base is triethylamine, imidazole, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide,
20 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine .
114. The method of claim 113, wherein the non-nucleophilic base is pyridine.
115. The method of any one of claims 105-114, wherein the chlorinating reagent is reacted with a compound of formula (2a) in a polar aprotic solvent.
116. The method of claim 115, wherein the polar aprotic solvent is *N,N*-
25 dimethylformamide or dimethylacetamide.

117. A method of preparing a compound of formula (14a),



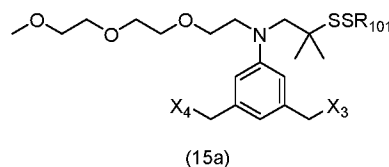
or a salt thereof, said method comprising reacting a compound of formula (13a)



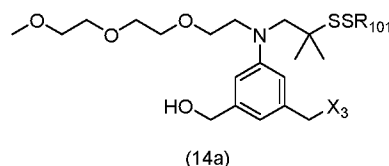
- 5 with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group;
X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.
118. The method of claim 117, wherein the alcohol protecting group is a silyl protecting group.
119. The method of claim 118, wherein the silyl protecting group is the silyl
10 protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl.
120. The method of claim 119, wherein the silyl protecting group is triethylsilyl,
15 triisopropylsilyl, or *tert*-butyldimethylsilyl.
121. The method of claim 120, wherein the silyl protecting group is *tert*-butyldimethylsilyl.
122. The method of any one of claims 117-121, wherein the alcohol deprotecting reagent is tetra-*n*-butylammonium fluoride, tris(dimethylamino)sulfonium
20 difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, trifluoroacetic acid, pyridinium *p*-toluenesulfonate, *p*-toluenesulfonic acid (*p*-TsOH), formic acid, periodic acid.

123. The method of claim 122, wherein the alcohol deprotecting agent is hydrogen fluoride pyridine.

124. A method of preparing a compound of formula (15a):



5 or a salt thereof, said method comprising reacting a sulfonating reagent or an esterification reagent with a compound of formula (14a),



wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

10 125. The method of claim 124, wherein the sulfonating reagent is methanesulfonyl anhydride, methanesulfonyl chloride, p-toluenesulfonyl chloride, 4-bromobenzenesulfonyl chloride, or trifluoromethanesulfonyl anhydride.

126. The method of claim 125, wherein the sulfonate ester represented by X₁ is mesylate, tosylate, brosylate, or triflate.

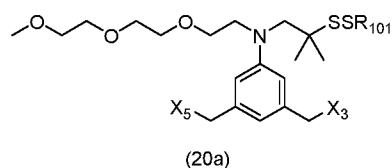
15 127. The method of claim 126, wherein the sulfonate ester represented by X₁ is mesylate.

128. The method of any one of claims 124–127, wherein the sulfonate ester is reacted with a compound of formula (14a) in the presence of a non-nucleophilic base.

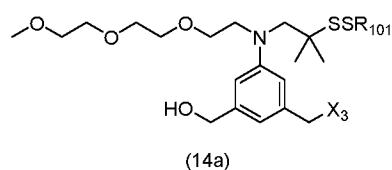
129. The method of claim 128, wherein the non-nucleophilic base is triethylamine, imidazole, diisopropylethylamine, pyridine, 2,6-lutidine, dimethylformamide, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU), or tetramethylpiperidine.

130. The method of claim 129, wherein the amine base is diisopropylethylamine.

131. A method of preparing a compound of formula (20a):



or a salt thereof, said method comprising reacting a brominating or iodinating reagent with a compound of formula (14a),



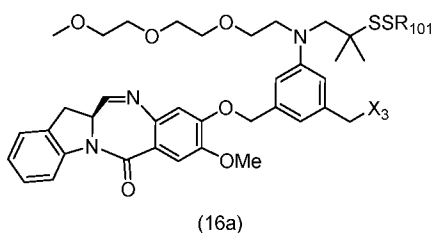
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wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

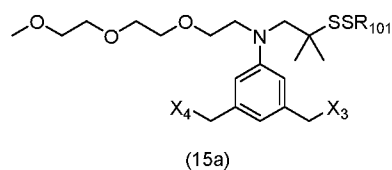
132. The method of claim 131, wherein the brominating or halogenating reagent is bromine, hydrobromic acid, carbon tetrabromide, phosphorus tribromide, potassium bromide, hydroiodic acid, iodine, carbon tetraiodide, phosphorus triiodide, sodium iodide, or potassium iodide.

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133. A method of preparing a compound of formula (16a):

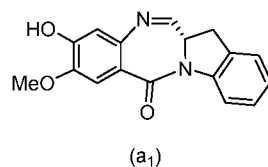


or a salt thereof, said method comprising reacting a compound of formula (15a)



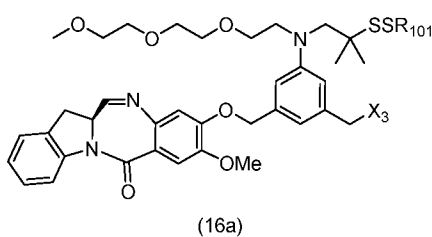
15

with a monomer compound of formula (a₁),

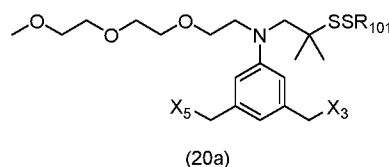


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

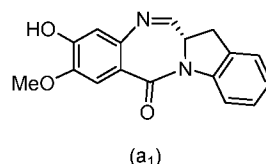
134. The method of claim 133, wherein the compound of formula (15a) is reacted with a monomer compound of formula (a₁) in the presence of a base.
135. The method of claim 134, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
136. The method of claim 135, wherein the base is potassium carbonate.
137. The method of any one of claims 133–136, wherein the compound of formula (15a) is reacted with a monomer compound of formula (a₁) in the presence of a polar aprotic solvent.
138. The method of claim 137, wherein the polar aprotic solvent is dimethylacetamide.
139. A method of preparing a compound of formula (16a):



or a salt thereof, said method comprising reacting a compound of formula (20a)

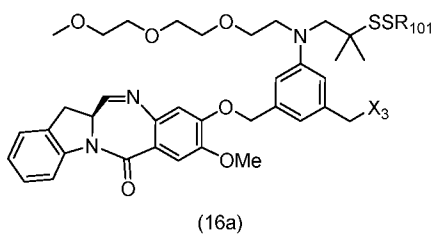


with a monomer compound of formula (a₁),

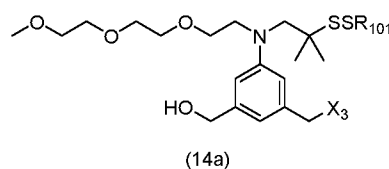


wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

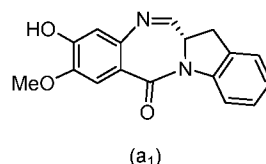
140. The method of claim 139, wherein the compound of formula (20a) is reacted
5 with a monomer compound of formula (a₁) in the presence of a base.
141. The method of claim 140, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
142. The method of claim 141, wherein the base is potassium carbonate.
143. The method of any one of claims 139–142, wherein the compound of formula
10 (20a) is reacted with a monomer compound of formula (a₁) in the presence of a polar aprotic solvent.
144. The method of claim 143, wherein the polar aprotic solvent is dimethylacetamide.
145. A method of preparing a compound of formula (16a):



or a salt thereof, said method comprising reacting a compound of formula (14a)

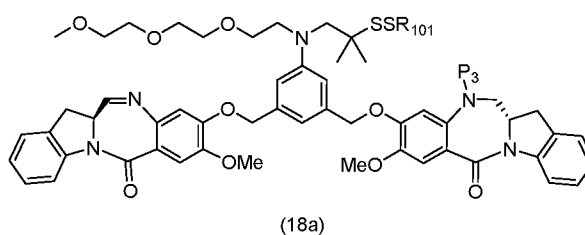


with a monomer compound of formula (a₁),

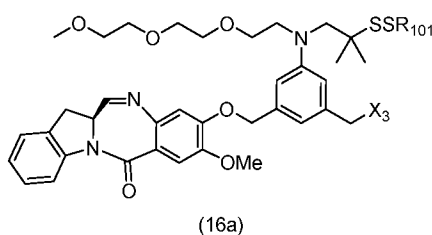


wherein X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

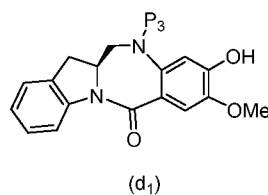
146. The method of claim 145, wherein the compound of formula (14a) is reacted with a monomer of formula (a₁) in the presence of an alcohol activating agent.
- 5 147. The method of claim 146, wherein the alcohol activating agent is triphenylphosphine.
148. The method of any one of claims 145–147, wherein the compound of formula (14a) is reacted with a monomer of formula (a₁) in the presence of an azodicarboxylate.
- 10 149. The method of claim 148, wherein the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), and di-tert-butyl azodicarboxylate (DTAD).
150. A method of preparing a compound of formula (18a):



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (16a):

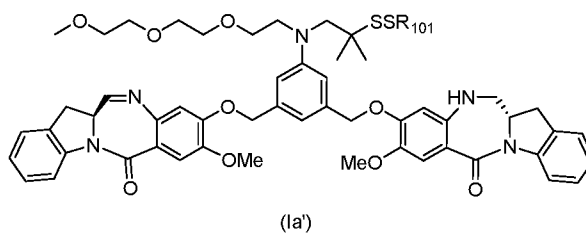


with a reduced monomer of formula (d₁):



wherein X₃ is –Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

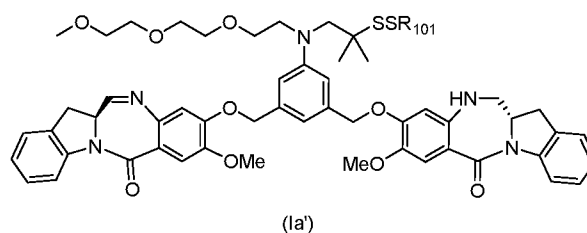
151. The method of claim 150, wherein the compound of formula (16a) is reacted with a monomer compound of formula (d₁) in the presence of a base.
152. The method of claim 151, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
153. The method of claim 152, wherein the base is potassium carbonate.
154. The method of any one of claims 150–153, wherein the compound of formula (16a) is reacted with a monomer compound of formula (d₁) in the presence of a polar aprotic solvent.
155. The method of claim 154, wherein the polar aprotic solvent is dimethylacetamide or dimethylacetamide.
156. The method of any one of claims 150–155, wherein the compound of formula (16a) is reacted with reduced monomer of formula (d₁), wherein P₃ is H, to form a compound of formula (Ia’):



157. The method of any one of claims 150-155, wherein P₃ is an amine protecting group.
158. The method of claim 157, wherein the amine protecting group is selected from the group consisting of 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, and allyloxycarbonyl, 9-

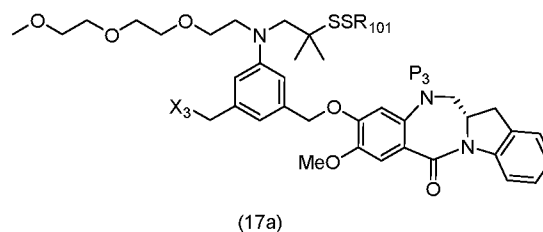
fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, and 2, 2,2,2-trichloroethoxycarbonyl.

159. The method of claim 157 or 158, wherein the compound of formula (18a) is further reacted with an amine deprotecting reagent to form a compound of formula (Ia'):

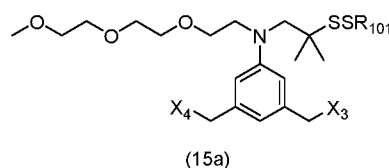


160. The method of claim 159, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

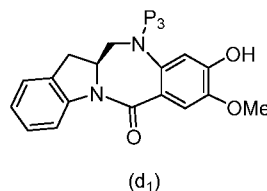
161. A method of preparing a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (15a)

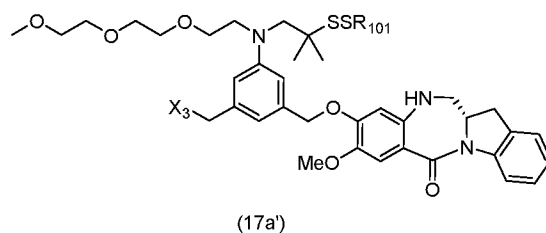


with a monomer compound of formula (d₁),

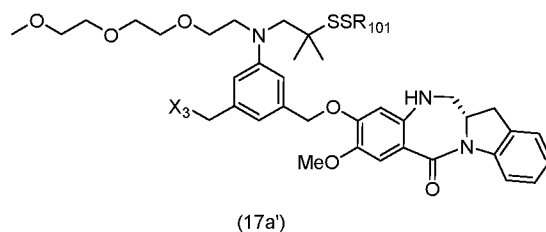


wherein X_3 is $-Cl$; X_4 is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P_3 is H or an amine protecting group; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

162. The method of claim 161, wherein the compound of formula (15a) is reacted
5 with a monomer compound of formula (d_1) in the presence of a base.
163. The method of claim 162, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
164. The method of claim 163, wherein the base is potassium carbonate.
165. The method of any one of claims 161–164, wherein the compound of formula
10 (15a) is reacted with a monomer compound of formula (d_1) in the presence of a polar aprotic solvent.
166. The method of claim 165, wherein the polar aprotic solvent is dimethylacetamide.
167. The method of any one of claims 161–166, wherein the compound of formula
15 (15a) is reacted with the monomer compound of formula (d_1) , wherein P_3 is H, to form a compound of formula $(17a')$:

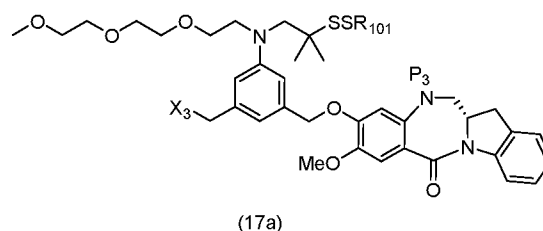


168. The method of any one of claims 161–166, wherein P_3 is an amine protecting group.
- 20 169. The method of claim 168, further comprising the step of reacting the compound of formula (17a) with an amine deprotecting reagent to form a compound of formula $(17a')$:

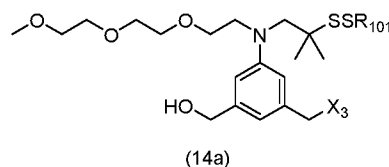


170. The method of claim 169, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, acetic acid, or trifluoroacetic acid.

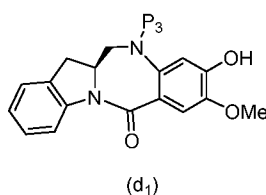
171. A method of preparing a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (14a)



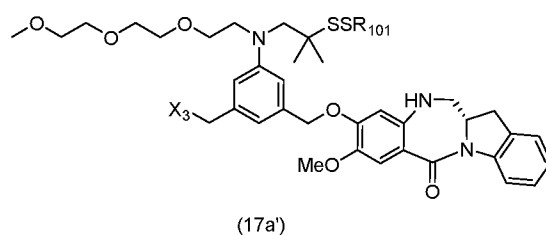
- with a monomer compound of formula (d₁),



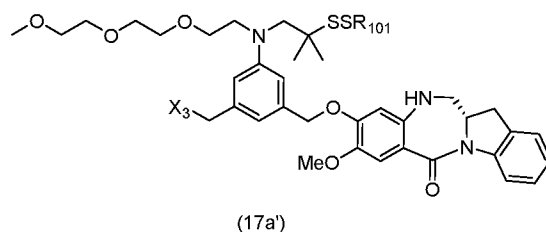
wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

172. The method of claim 171, wherein the compound of formula (14a) is reacted with a monomer of formula (d₁) in the presence of an alcohol activating agent.

173. The method of claim 172, wherein the alcohol activating agent is triphenylphosphine.
174. The method of any one of claims 171–173, wherein the compound of formula (14a) is reacted with a monomer of formula (d₁) in the presence of an azodicarboxylate.
175. The method of claim 174, wherein the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), and ditertbutyl azodicarboxylate (DTAD).
176. The method of any one of claims 171–175, wherein the compound of formula (15a) is reacted with the monomer compound of formula (d₁), wherein P₃ is H, to form a compound of formula (17a'):



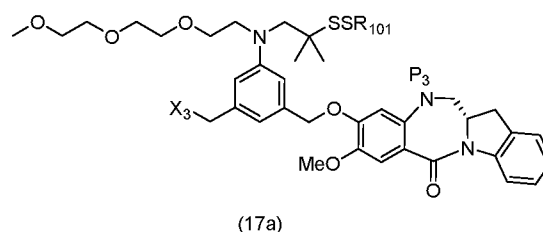
177. The method of any one of claims 171–175, wherein P₃ is an amine protecting group.
178. The method of claim 177, further comprising the step of reacting the compound of formula (17a) with an amine deprotecting reagent to form a compound of formula (17a'):



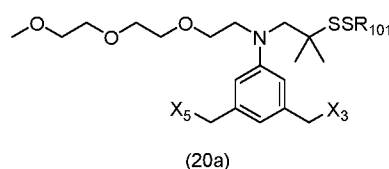
179. The method of claim 178, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid,

hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

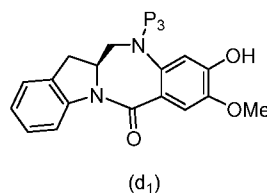
180. A method of preparing a compound of formula (17a):



5 or a salt thereof, said method comprising reacting a compound of formula (20a)



with a monomer compound of formula (d₁),



10 wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

181. The method of claim 180, wherein the compound of formula (20a) is reacted with a monomer compound of formula (d₁) in the presence of a base.

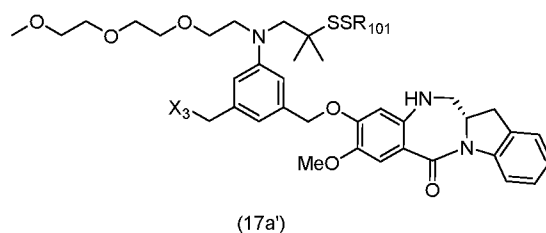
182. The method of claim 181, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.

15 183. The method of claim 182, wherein the base is potassium carbonate.

184. The method of any one of claims 180–183, wherein the compound of formula (20a) is reacted with a monomer compound of formula (d₁) in the presence of a polar aprotic solvent.

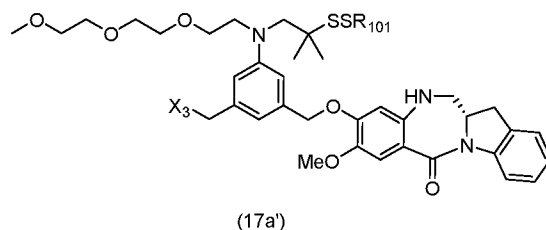
185. The method of claim 184, wherein the polar aprotic solvent is dimethylacetamide.

186. The method of any one of claims 180–185, wherein the compound of formula (20a) is reacted with the monomer compound of formula (d₁), wherein P₃ is H, to form a compound of formula (17a'):



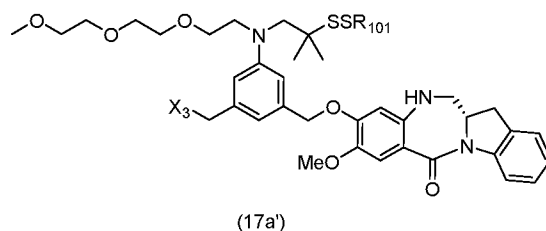
187. The method of any one of claims 180–185, wherein P₃ is an amine protecting group.

188. The method of claim 187, further comprising the step of reacting the compound of formula (17a) with an amine deprotecting reagent to form a compound of formula (17a'):

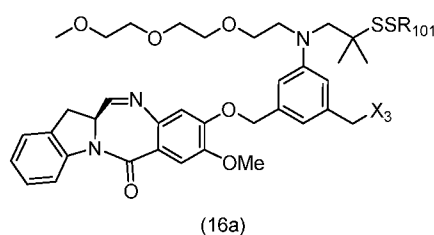


189. The method of claim 188, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.

190. A method of preparing a compound of formula (17a'):

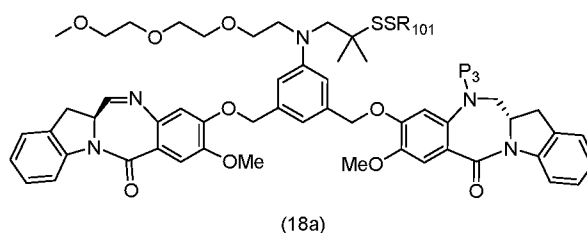


or a salt thereof, said method comprising reacting a compound of formula (16a),

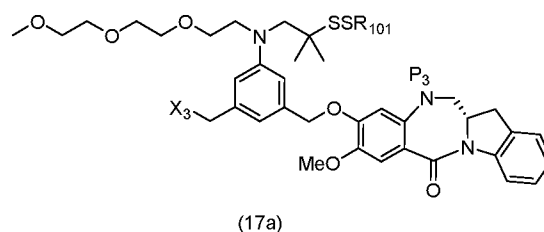


with an imine reducing agent, wherein X_3 is $-Cl$; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

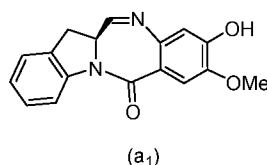
- 5 191. The method of claim 190, wherein the imine reducing reagent is a hydride reducing reagent.
192. The method of claim 191, wherein the imine reducing reagent is sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, lithium aluminum hydride, hydrogen gas, ammonium formate, borane, 9-
- 10 borabicyclo[3.3.1]nonane (9-BBN), diisobutylaluminium hydride (DIBAL), lithium borohydride ($LiBH_4$), potassium borohydride (KBH_4), or sodium bis(2-methoxyethoxy)aluminumhydride (Red-Al) .
193. The method of claim 192, wherein the imine reducing reagent is sodium triacetoxo borohydride ($NaBH(OAc)_3$).
- 15 194. A method of preparing a compound of formula (18a),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (17a):

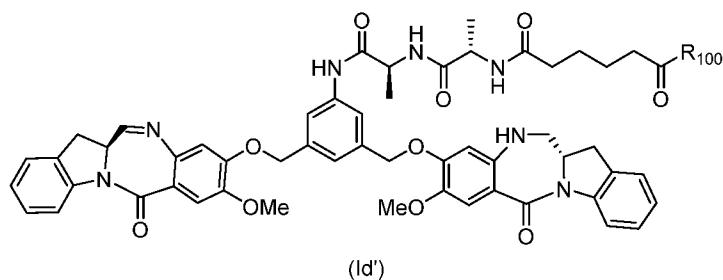


with a monomer of formula (a₁):

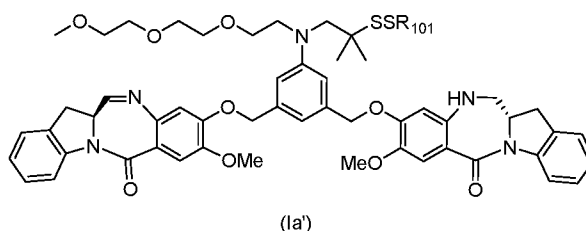


5 wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

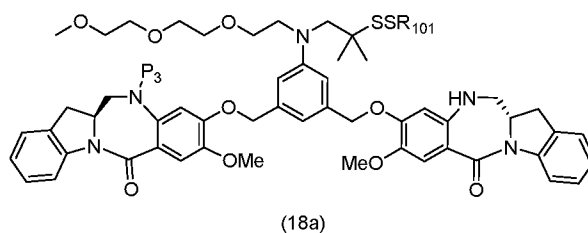
195. The method of claim 194, wherein the compound of formula (17a) is reacted with a monomer compound of formula (d₁) in the presence of a base.
196. The method of claim 195, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
- 10 197. The method of claim 196, wherein the base is potassium carbonate.
198. The method of any one of claims 194-197, wherein the compound of formula (17a) is reacted with a monomer compound of formula (a₁) in the presence of a polar aprotic solvent.
199. The method of claim 198, wherein the polar aprotic solvent is
15 dimethylformamide or dimethylacetamide.
200. The method of any one of claims 194-199, wherein the compound of formula (17a) is reacted with reduced monomer of formula (d₁), wherein P₃ is H, to form a compound of formula (Id'):



201. The method of any one of claims 177-182, wherein P₃ is an amine protecting group.
202. The method of claim 201, wherein the amine protecting group is selected from the group consisting of 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, and allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, and 2, 2,2,2-trichloroethoxycarbonyl.
203. The method of claim 201 or 202, wherein the compound of formula (18d) is further reacted with an amine deprotecting reagent to form a compound of formula (Id'):

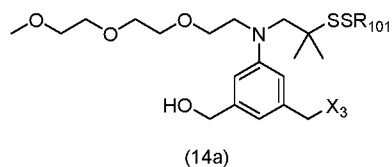


204. The method of claim 203, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.
205. A method of preparing a compound of formula (18a),

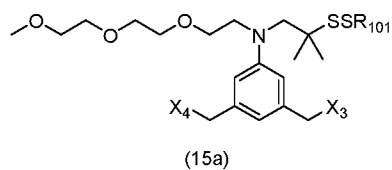


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

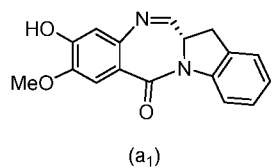


or a salt thereof, to form a compound of formula (15a):

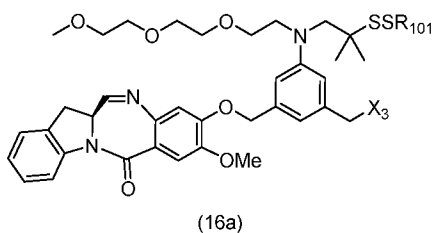


or a salt thereof;

(2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),

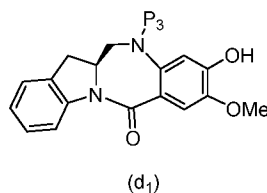


to form a compound of formula (16a):



or a salt thereof; and

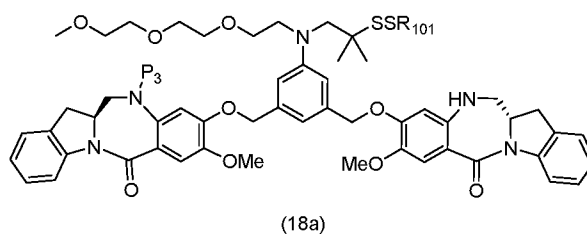
(3) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester

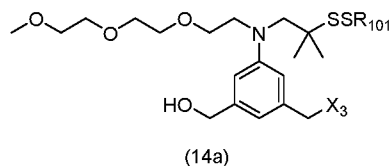
(preferably, a sulfonate ester); P_1 is an alcohol protecting group; P_3 is H or an amine protecting group; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

206. A method of preparing a compound of formula (18a),

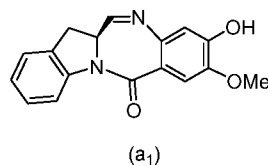


5 or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting the compound of formula (14a):

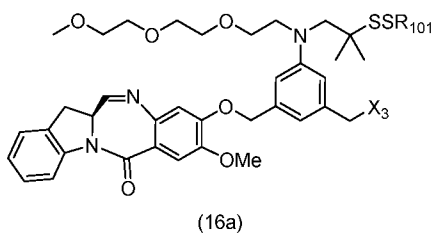


or a salt thereof, with a monomer compound of formula (a₁),



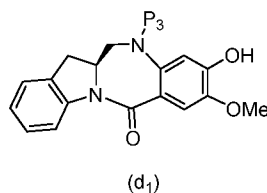
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in the presence of an alcohol activating agent to form a compound of formula (16a):



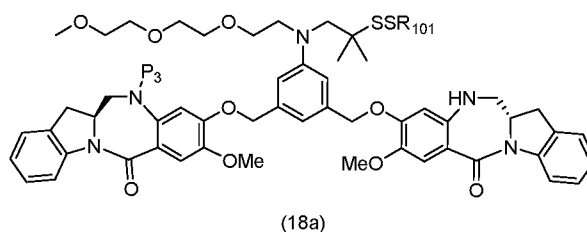
or a salt thereof; and

15 (2) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



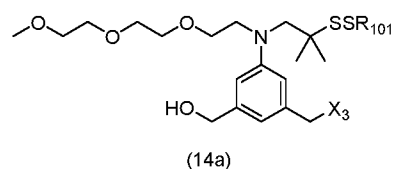
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X_3 is $-Cl$; P_1 is an alcohol protecting group; P_3 is H or an amine protecting group; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

207. A method of preparing a compound of formula (18a),

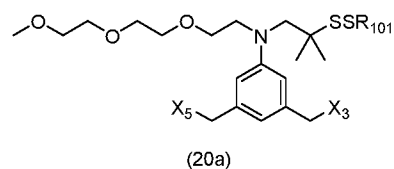


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a brominating or iodinating reagent with the compound of formula (14a):

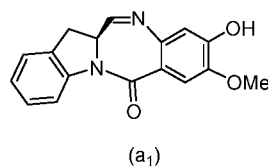


or a salt thereof, to form a compound of formula (20a):

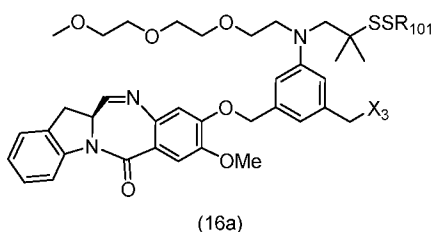


or a salt thereof;

(4) reacting a compound of formula (20a) or a salt thereof with a monomer compound of formula (a₁),

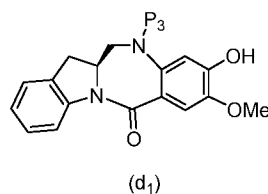


to form a compound of formula (16a):



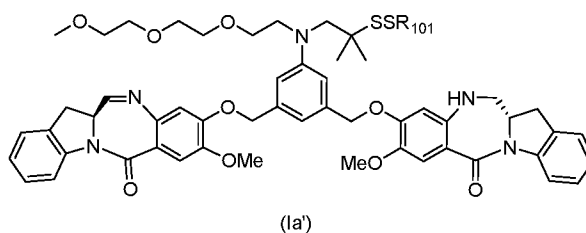
or a salt thereof; and

(5) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



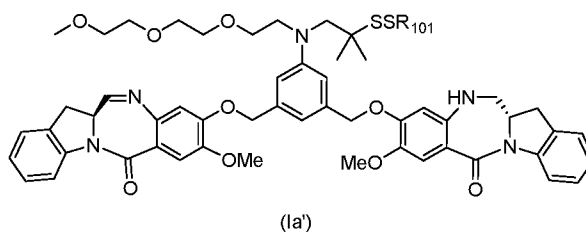
5 to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

208. The method of claim 205, 206, or 207, wherein the compound of formula (16a) is reacted with reduced monomer of formula (d₁), wherein P₃ is H, to form a
10 compound of formula (Ia'):

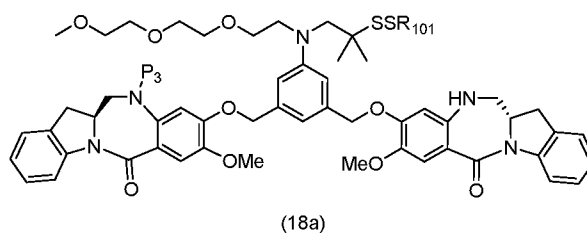


209. The method of claim 205, 206, or 207, wherein P₃ is an amine protecting group.

210. The method of claim 209, wherein the compound of formula (18a) is further reacted with an amine deprotecting reagent to form a compound of formula (Ia'):

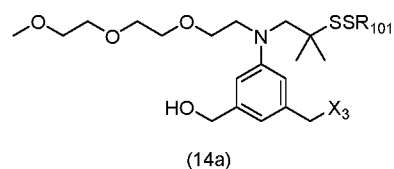


211. A method of preparing a compound of formula (18a),

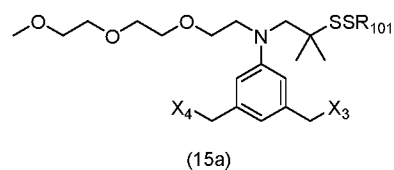


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- 5 (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

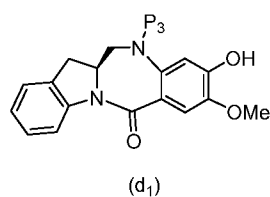


or a salt thereof, to form a compound of formula (15a):

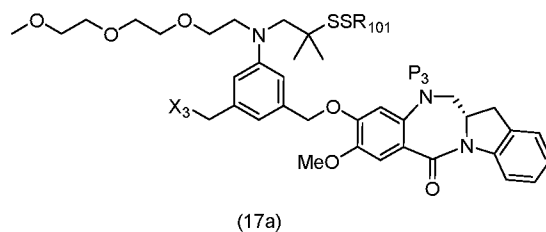


10 or a salt thereof;

- (2) reacting the compound of formula (15a) with a reduced monomer compound of formula (d₁),



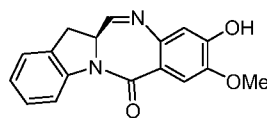
to form a compound of formula (17a):



15

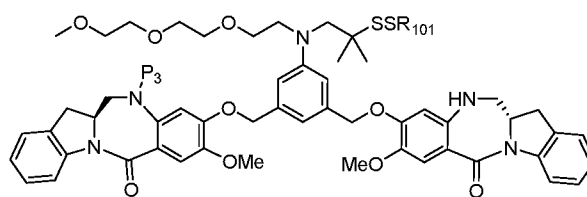
or a salt thereof; and

- (3) reacting the compound of formula of (17a) with a monomer of formula (a₁):

(a₁)

to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

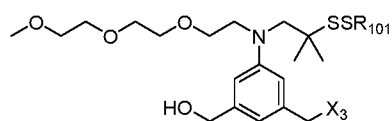
212. A method of preparing a compound of formula (18a),



(18a)

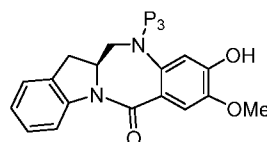
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting the compound of formula (14a):

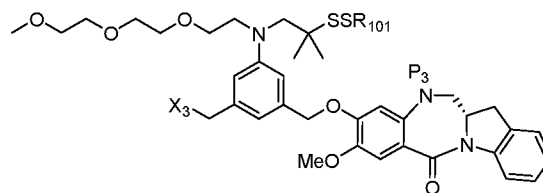


(14a)

or a salt thereof, with a reduced monomer compound of formula (d₁),

(d₁)

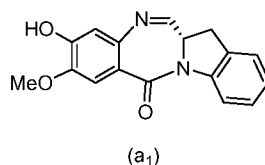
in the presence of an alcohol activating agent to form a compound of formula (17a):



(17a)

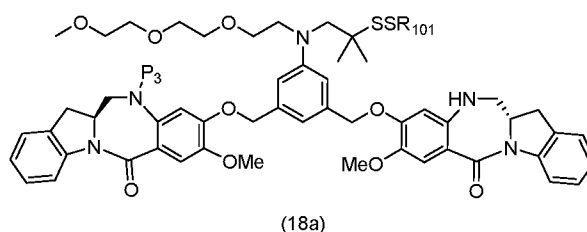
or a salt thereof; and

(2) reacting the compound of formula of (17a) with a monomer of formula (a₁):



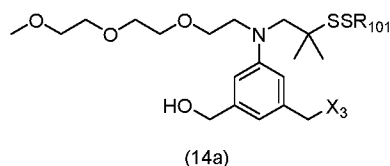
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

213. A method of preparing a compound of formula (18a),

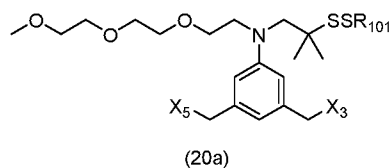


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a brominating or iodinating reagent with the compound of formula (14a):

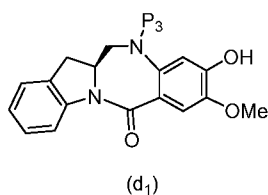


or a salt thereof, to form a compound of formula (20a):

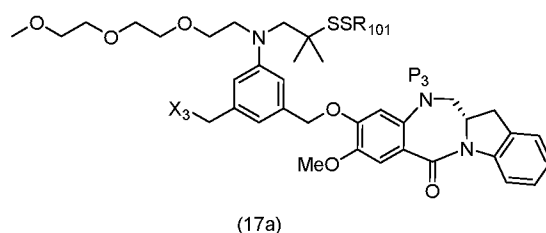


or a salt thereof;

(2) reacting the compound of formula (20a) with a reduced monomer compound of formula (d₁),

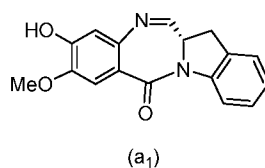


to form a compound of formula (17a):



or a salt thereof; and

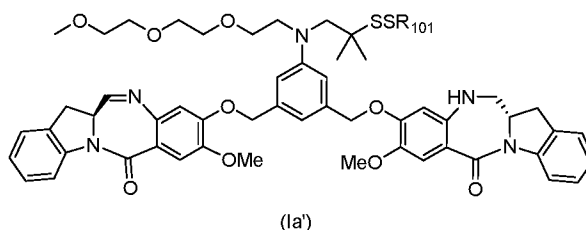
(3) reacting the compound of formula of (17a) with a monomer of formula (a₁):



5

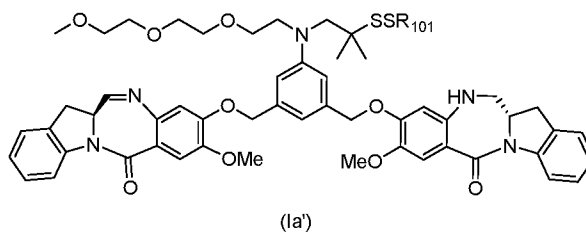
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₅ is -Br or -I; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

- 10 214. The method of claim 211, 212, or 213, wherein the compound of formula (16a) is reacted with reduced monomer of formula (d₁), wherein P₃ is H, to form a compound of formula (Ia'):

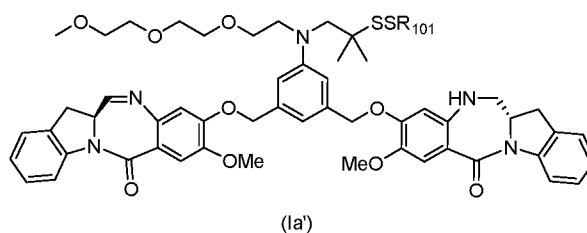


215. The method of claim 211, 212, or 213, wherein P₃ is an amine protecting group.

- 15 216. The method of claim 215, wherein the compound of formula (18a) is further reacted with an amine deprotecting reagent to form a compound of formula (Ia'):

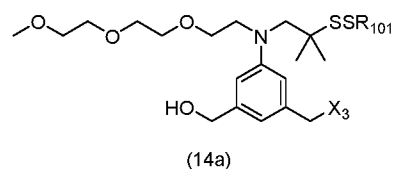


217. A method of preparing a compound of formula (Ia'),

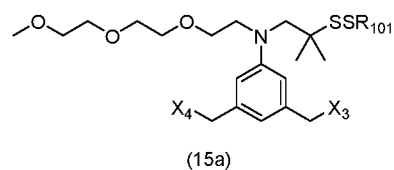


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- 5 (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

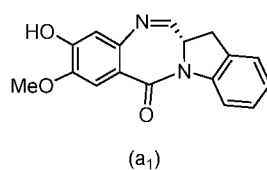


or a salt thereof, to form a compound of formula (15a):

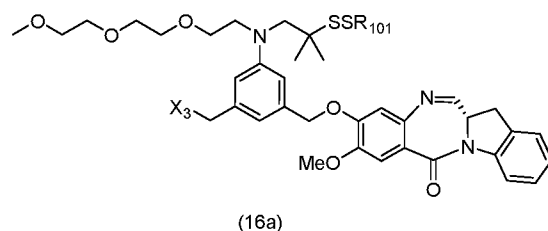


10 or a salt thereof;

- (2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),



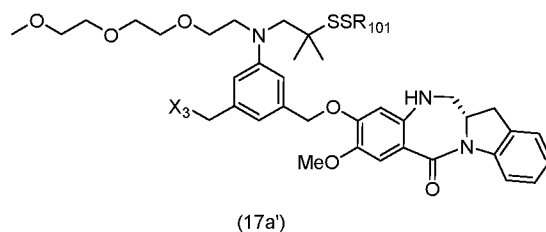
to form a compound of formula (16a):



15

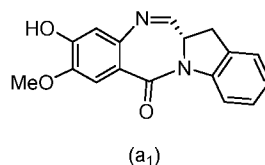
or a salt thereof;

- (3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



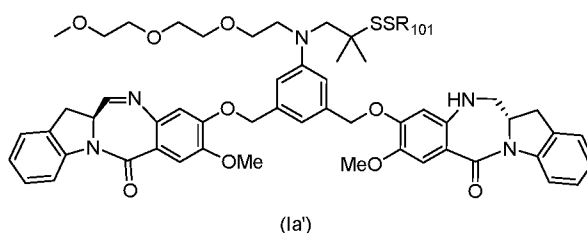
or a salt thereof; and

(4) reacting the compound of formula (17a') with a monomer of formula (a₁):



5 to form the compound of formula (Ia'); wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₁ is an alcohol protecting group; P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

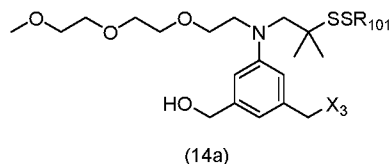
218. A method of preparing a compound of formula (Ia'),



10

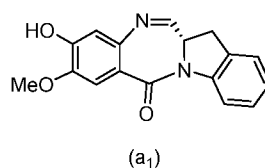
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting the compound of formula (14a):

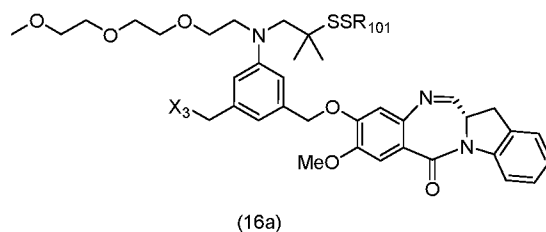


15

or a salt thereof, with a monomer compound of formula (a₁),

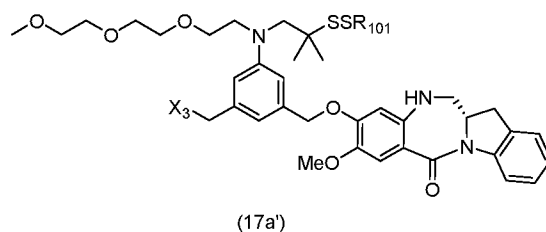


in the presence of an alcohol activating agent to form a compound of formula (16a):



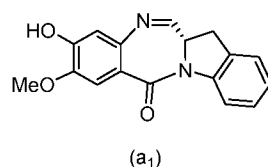
or a salt thereof;

(2) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



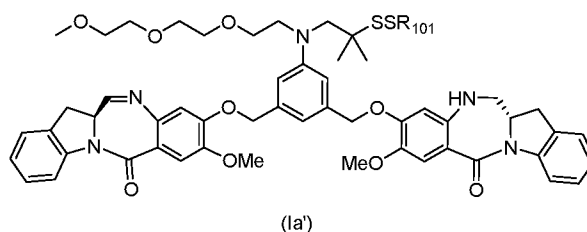
or a salt thereof; and

(3) reacting the compound of formula (17a') with a monomer of formula (a₁):



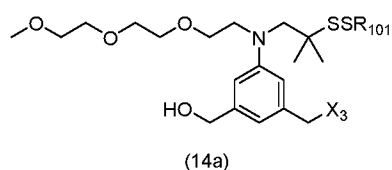
to form the compound of formula (Ia'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

219. A method of preparing a compound of formula (Ia'),

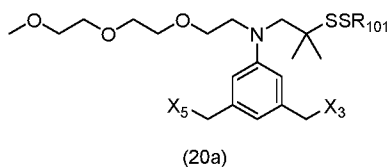


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a brominating or iodinating reagent with the compound of formula (14a):

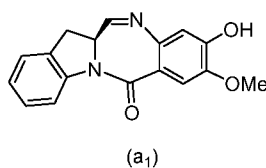


or a salt thereof, to form a compound of formula (20a):

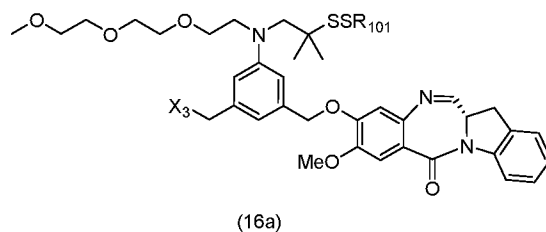


or a salt thereof;

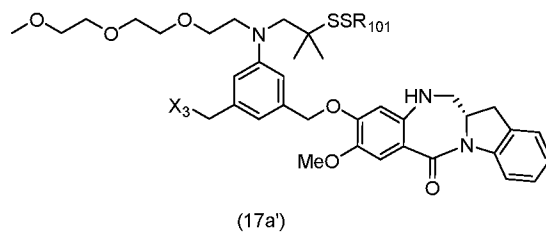
(2) reacting a compound of formula (20a) or a salt thereof with a monomer compound of formula (a₁),



to form a compound of formula (16a):

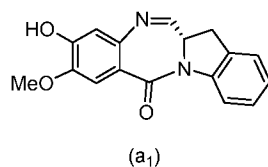


(3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



or a salt thereof; and

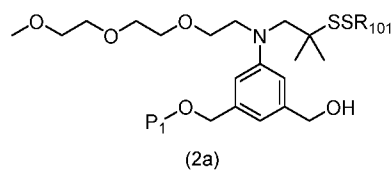
(4) reacting the compound of formula (17d') with a monomer of formula (a₁):



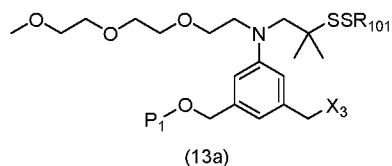
to form the compound of formula (Id'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

220. The method of any one of claims 205-219, wherein the compound of formula (14a) or a salt thereof is prepared a method comprising the following steps:

(1) reacting a chlorinating reagent with a compound of formula (2a),



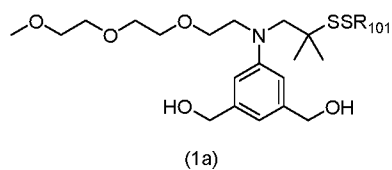
to form a compound a compound of formula (13a),



5 or a salt thereof;

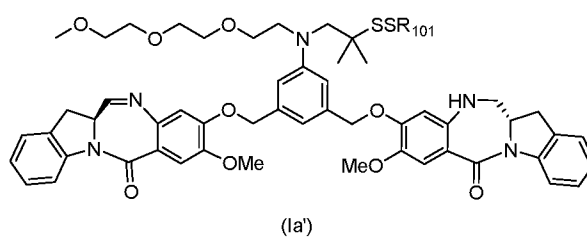
(2) reacting the compound of formula (13a) with an alcohol deprotecting reagent to form the compound of formula (14a) or a salt thereof.

221. The method of claim 220, wherein the compound of formula (2a) is prepared by reacting a compound of formula (1a) with an alcohol protecting reagent



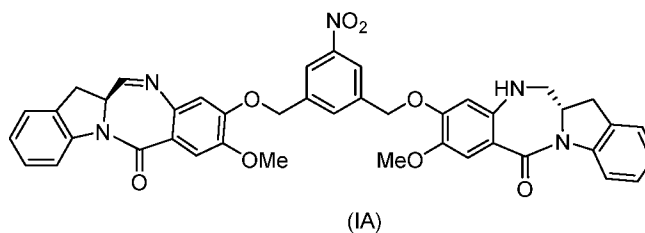
10

222. A method of preparing a compound of formula (Ia'),

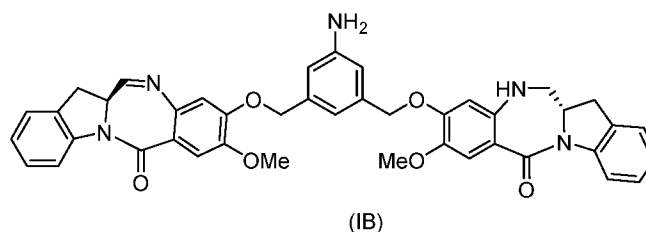


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

15 (1) reacting a compound of formula (IA):

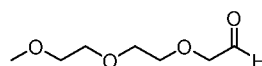


with a reducing agent to form a compound of formula (IB):

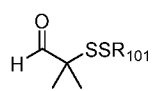


; and

(2) reacting the compound of formula (IB) with a compound of formula (L1a),

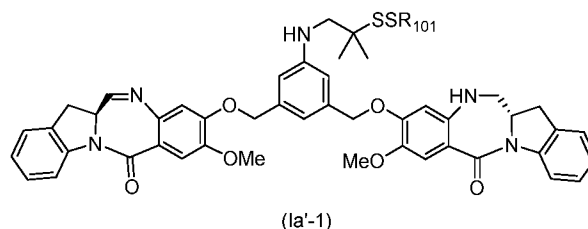


5 and a compound of formula (L1b):



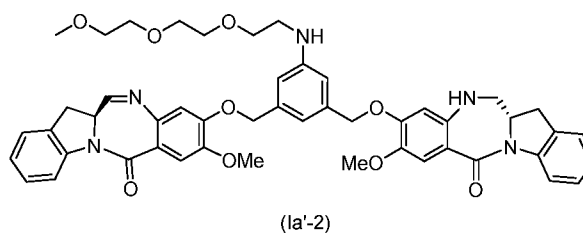
in the presence of a reducing agent to form the compound of formula (Ia'),
wherein R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

223. The method of claim 222, wherein the compound of formula (IB) is reacted with
10 a compound of formula (L1b) in the presence of a reducing agent to form a
compound of (Ia'-1):



or a salt thereof, followed by reacting the compound of (Ia'-1) with the
compound of formula (L1a) in the presence of a reducing agent to form the
15 compound of formula (Ia').

224. The method of claim 222, wherein the compound of formula (IB) is reacted with
a compound of formula (L1a) in the presence of a reducing agent to form a
compound of (Ia'-2)



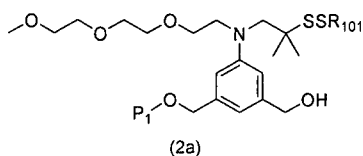
or a salt thereof, followed by reacting the compound of formula (Ia'-2) with the compound of formula (L1b) in the presence of a reducing agent to form the compound of formula (Ia').

225. The method of any one of claims 222-224, wherein the reducing agent in step (2)
5 is selected from the group consisting of: sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, hydrogen gas, ammonium formate, titanium isopropoxide, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), lithium borohydride (LiBH_4), potassium borohydride (KBH_4), titanium isopropoxide, and stannous chloride.
- 10 226. The method of claim 224, wherein the reducing agent is sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, or potassium borohydride.
227. The method of claim 226, wherein the reducing agent is sodium borohydride.
228. The method of any one of claims 222-227, wherein the reducing agent in step (1)
15 is selected from the group consisting of: hydrogen gas, sodium hydrosulfite, sodium sulfide, stannous chloride, titanium (II) chloride, zinc, iron and samarium iodide.
229. The method of claim 228, wherein the reducing agent in step (1) is $\text{Fe}/\text{NH}_4\text{Cl}$ or $\text{Zn}/\text{NH}_4\text{Cl}$.
- 20 230. The method of any one of claims 1-229, wherein R_{101} is methyl.

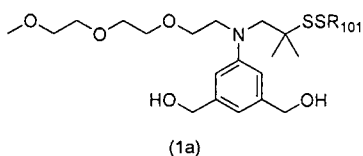
AMENDED CLAIMS
received by the International Bureau on 16 November 2016 (16.11.2016)

We claim:

1. A method of preparing a compound of formula (2a),

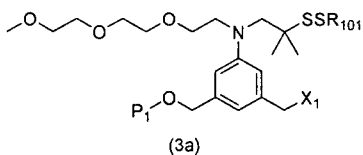


or a salt thereof, said method comprising introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a) by reacting the compound of formula (1a) with an alcohol protecting reagent,

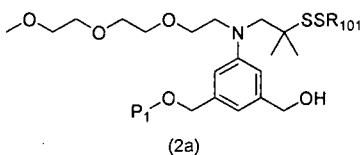


wherein P₁ is the alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

2. A method of preparing a compound of formula (3a),

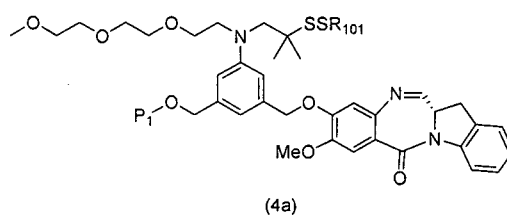


or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (2a),

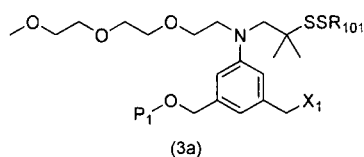


wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

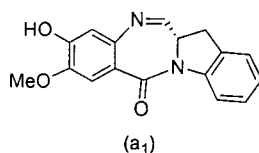
3. A method of preparing a compound of formula (4a),



or a salt thereof, said method comprising reacting a compound of formula (3a)

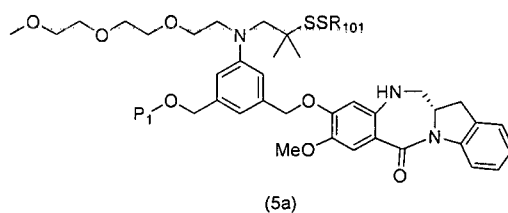


with a monomer compound of the formula (a₁),

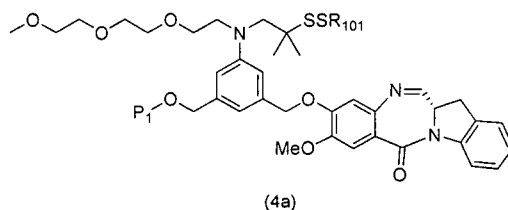


wherein P₁ is an alcohol protecting group; X₁ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

4. A method of preparing a compound of formula (5a),

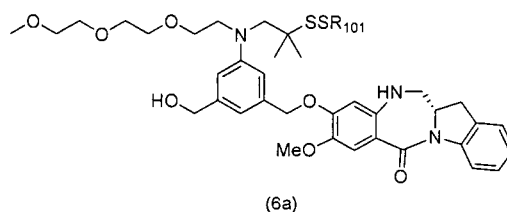


or a salt thereof, said method comprising reacting a compound of formula (4a),

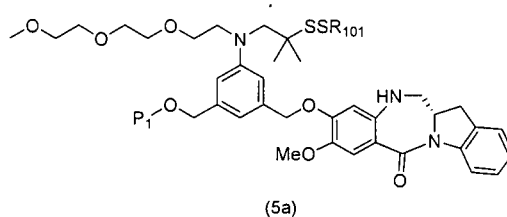


with an imine reducing agent, wherein P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

5. A method of preparing a compound of formula (6a),

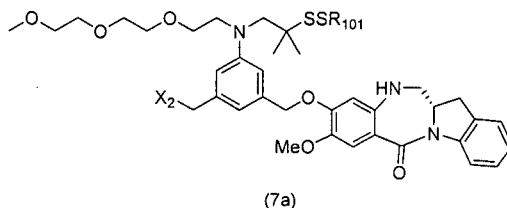


or a salt thereof, said method comprising reacting a compound of formula (5a),

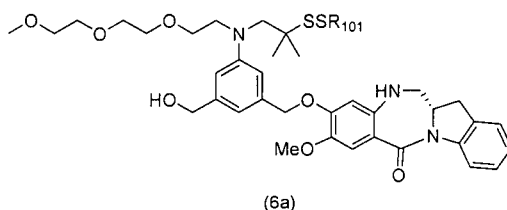


with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

6. A method of preparing a compound of formula (7a),

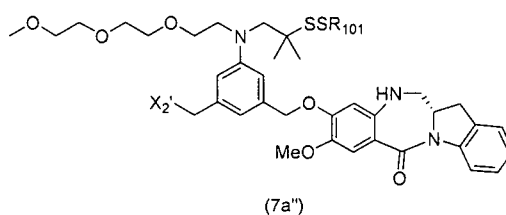


or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the primary alcohol compound of formula (6a),

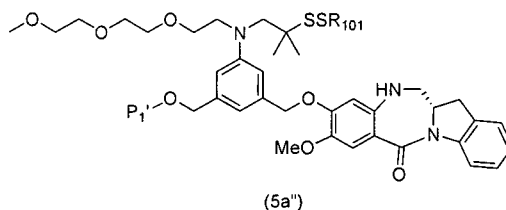


wherein X₂ is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X₂ is -Br, -I, a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

7. A method of preparing a compound of formula (7a''),

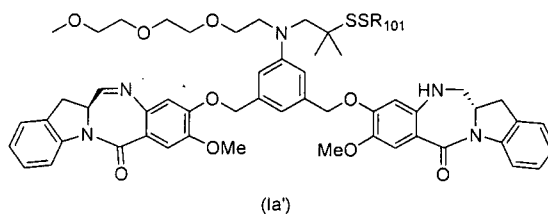


or a salt thereof, said method comprising reacting a compound of formula (5a'')

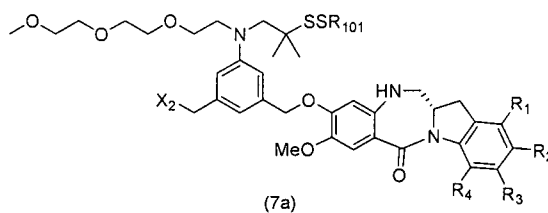


with an alcohol deprotecting reagent and a halogenating reagent, wherein P_1' is an acid labile alcohol protecting group; X_2' is $-Br$ or $-I$; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

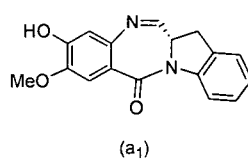
8. A method of preparing a compound of formula (Ia'),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (7a),

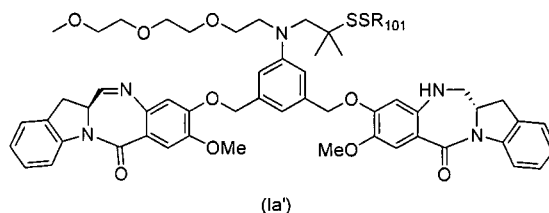


with a monomer compound of the formula (a₁),



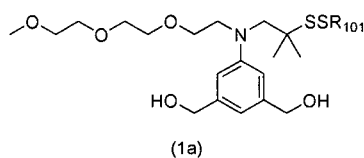
wherein R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl; and, X_2 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester (preferably, X_2 is -Br, -I, or a sulfonate ester).

9. A method of preparing a compound of formula (1a'),

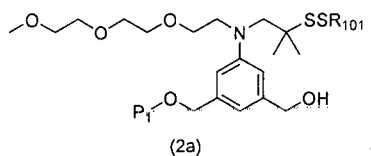


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

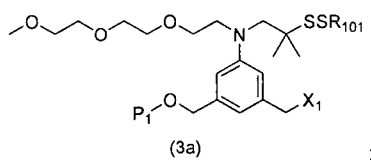
- (1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (1a),



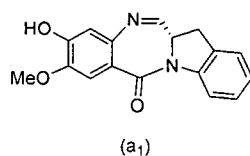
to form a compound of formula (2a),



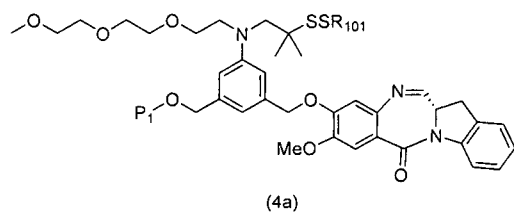
- (2) reacting the compound of formula (2a) with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a),



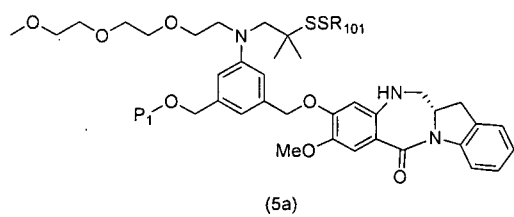
- (3) reacting the compound of formula (3a) with a monomer compound of the formula (a1),



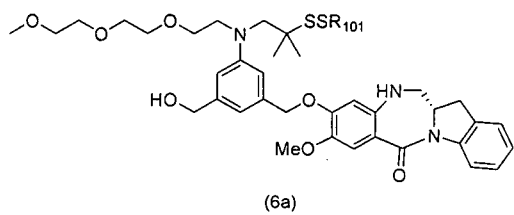
to form a compound of formula (4a),



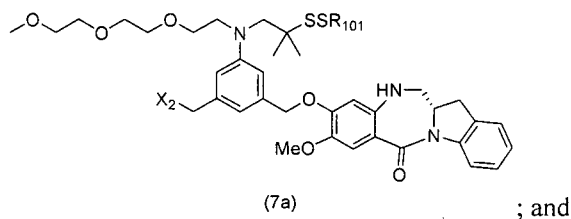
(4) reacting the compound of formula (4a) with an imine reducing agent to form a compound of formula (5a),



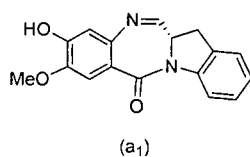
(5) reacting the compound of formula (5a) with an alcohol deprotecting reagent to form a compound of formula (6a),



(6) reacting the compound of formula (6a) with a second halogenating reagent, a second sulfonating reagent or a second esterification reagent to form a compound of formula (7a),

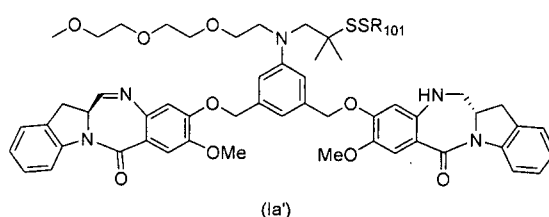


(7) reacting the compound of formula (7a) with a monomer compound of the formula (a₁),



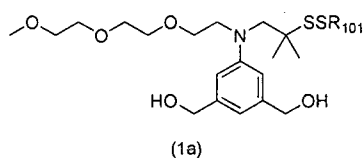
to form the compound of formula (I'); wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester (preferably, X₁ and X₂ are each independently -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

10. A method of forming a compound of formula (Ia'),

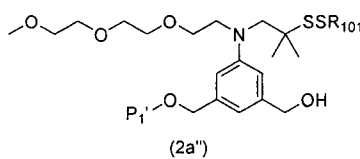


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

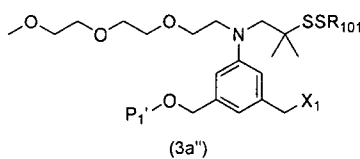
- (1) introducing an alcohol protecting group onto one of the primary alcohols of a compound of formula (Ia),



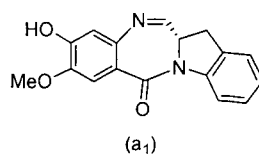
to form a compound of formula (2a''),



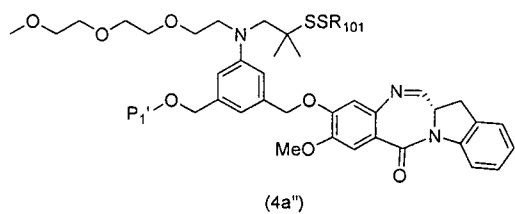
- (2) reacting the compound of formula (2a'') with a halogenating reagent, a sulfonating reagent or an esterification reagent to form a compound of formula (3a''),



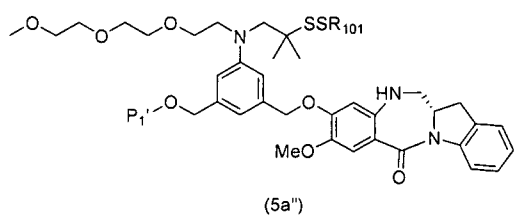
(3) reacting the compound of formula (3a'') with a monomer compound of the formula (a₁),



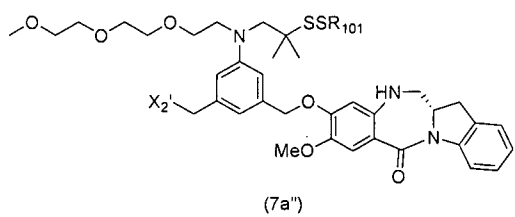
to form a compound of formula (4a''),



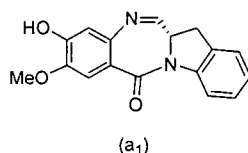
(4) reacting the compound of formula (4a'') with an imine reducing agent to form a compound of formula (5a''),



(5) reacting the compound of formula (5a'') with an alcohol deprotecting reagent and a halogenating reagent to form a compound of formula (7a''),

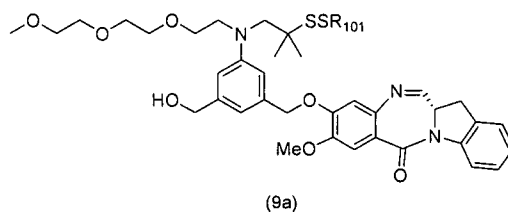


(6) reacting a compound of formula (7a'') with a monomer compound of the formula (a₁),

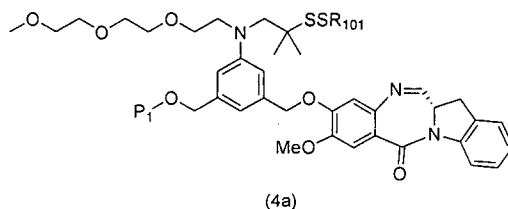


to form the compound of formula (1a'), wherein P_1' is an acid labile alcohol protecting group; X_1 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester and an activated ester (preferably, -Br, -I, a sulfonate ester); X_2' is -Br or -I; and R_{101} is (C_1 - C_3)alkyl, pyridyl, or nitropyridyl.

11. A method of preparing a compound of formula (9a),

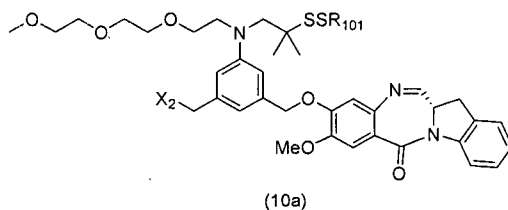


or a salt thereof, said method comprising reacting a compound of formula (4a),

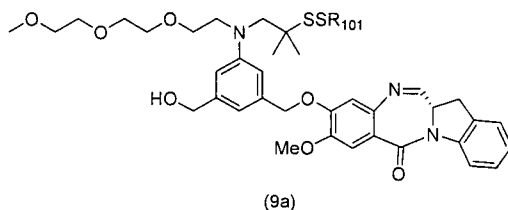


with an alcohol deprotecting reagent; wherein P_1 is an alcohol protecting group; and R_{101} is (C_1 - C_3)alkyl, pyridyl, or nitropyridyl.

12. A method of preparing a compound of formula (10a),

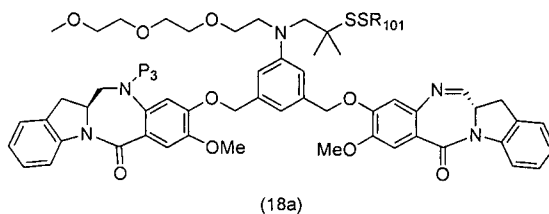


or a salt thereof, said method comprising reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the compound of formula (9a),

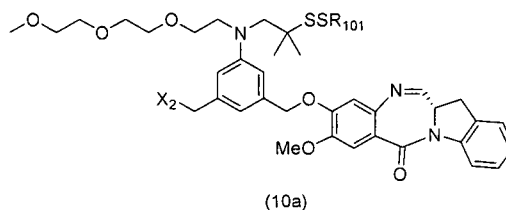


wherein X_2 is a leaving group selected from the group consisting of -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X_2 is -Br, -I, or a sulfonate ester); and R_{101} is (C_1 - C_3)alkyl, pyridyl, or nitropyridyl.

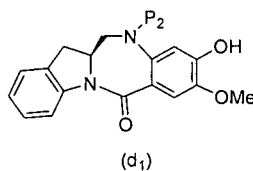
13. A method of preparing a compound of formula (18a),



or a salt thereof, said method comprising reacting a compound of formula (10a)

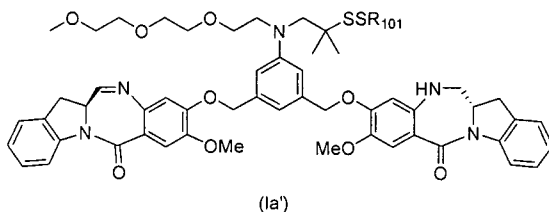


with a monomer compound of the formula (d₁),

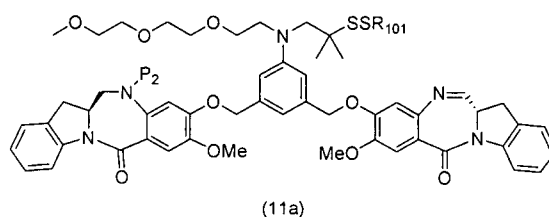


wherein X_2 is a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, X_2 is -Br, -I, or a sulfonate ester); P_3 is H or P_2 ; P_2 is an amine protecting group; and R_{101} is (C_1 - C_3)alkyl, pyridyl, or nitropyridyl.

14. A method of preparing a compound of formula (1a'),

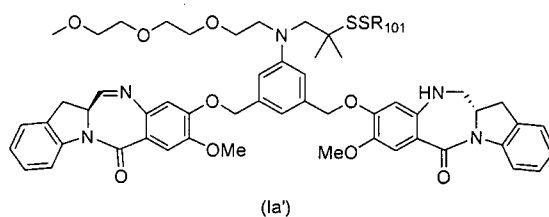


or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula (11a),



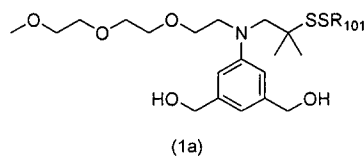
with an amine deprotecting reagent; wherein P_2 is an amine protecting group; and R_{101} is (C_1 - C_3)alkyl, pyridyl, or nitropyridyl.

15. A method of preparing a compound of formula (Ia'),

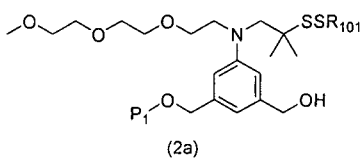


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

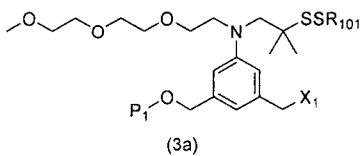
- (1) introducing an alcohol protecting group onto one of the primary alcohols of the compound of formula (1a),



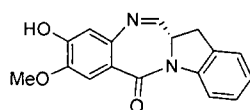
to form a compound of formula (2a),



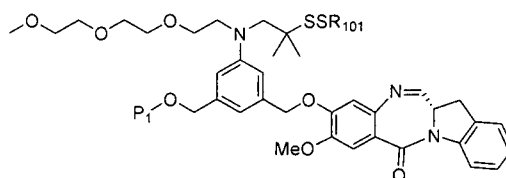
- (2) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with the compound of formula (2a) to form a compound of formula (3a),



- (3) reacting the compound of formula (3a) with a monomer compound of the formula (a₁),

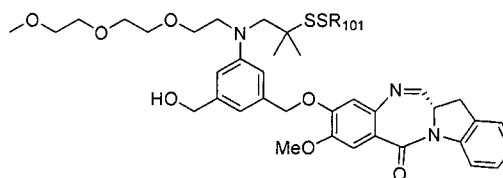
(a₁)

to form a compound of formula (4a),



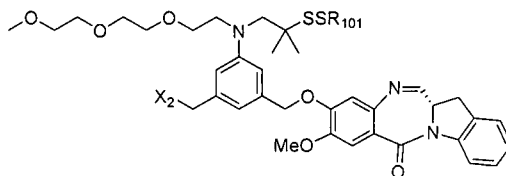
(4a)

(4) reacting the compound of formula (4a) with an alcohol deprotecting reagent to form a compound of formula (9a),



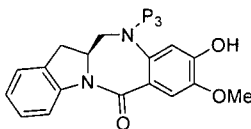
(9a)

(5) reacting a second halogenating reagent, a second sulfonating reagent or a second esterification reagent with the compound of formula (9a) to form a compound of formula (10a),

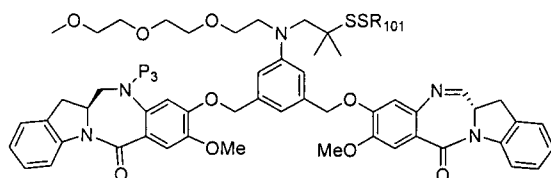


(10a)

(6) reacting the compound of formula (10a) with a monomer compound of the formula (d₁)

(d₁)

to form a compound of formula (18a),



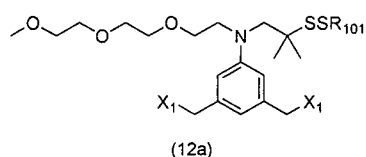
(18a)

; and

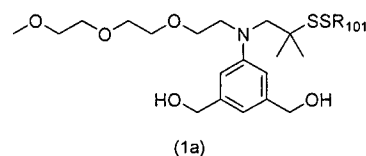
(7) reacting the compound of formula (11a) to an amine deprotecting reagent to form the compound of formula (1a');

wherein P₁ is an alcohol protecting group; X₁ and X₂ are each independently a leaving group selected from the group consisting of: -Br, -I, -Cl, a sulfonate ester, and an activated ester (preferably, -Br, -I, a sulfonate ester); P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

16. A method of preparing a compound of formula (12a),

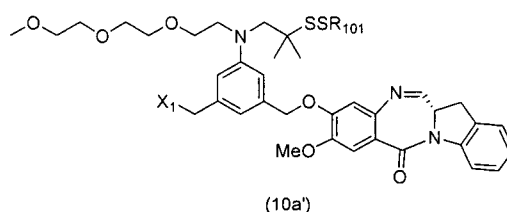


or a salt thereof, said method comprising reacting a compound of formula (1a),

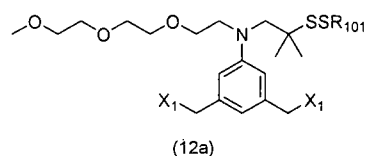


with a halogenating reagent, a sulfonating reagent or an esterification reagent, wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

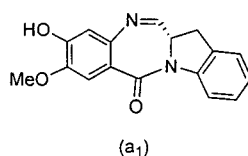
17. A method of preparing a compound of formula (10a'),



or a salt thereof, said method comprising reacting a compound of formula (12a),

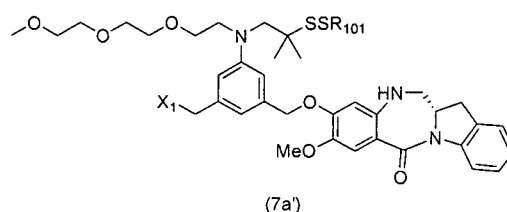


with a monomer compound of the formula (a₁),

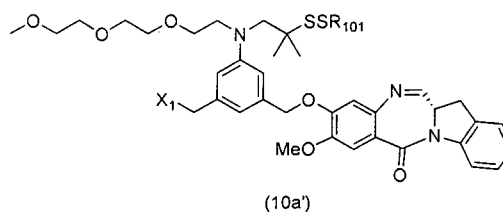


wherein X_1 is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X_1 is -Br, -I, or a sulfonate ester); and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

18. A method of preparing a compound of formula (7a'),

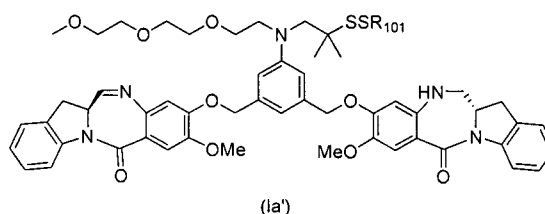


or a salt thereof, said method comprising reacting a compound of formula (10a'),



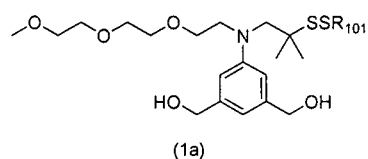
or a salt thereof, with an imine reducing agent, wherein X_1 is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X_1 is -Br, -I, a sulfonate ester); and R_{101} is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

19. A method of preparing a compound of formula (1a'),

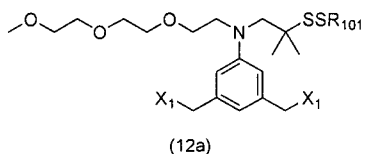


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

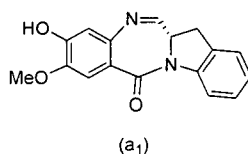
- (1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



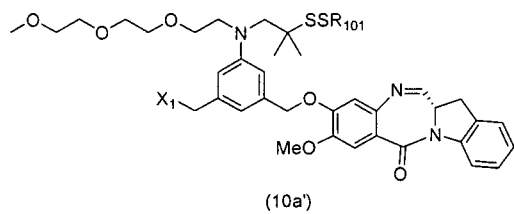
to form a compound of formula (12a),



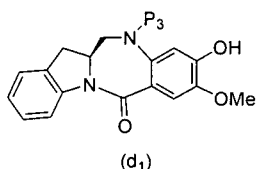
(2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),



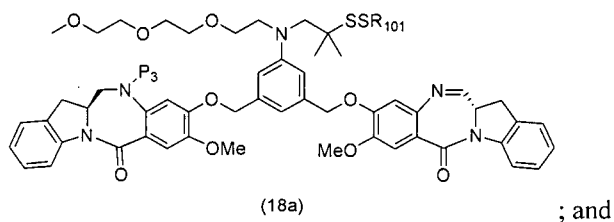
to form a compound of a formula (10a'),



(3) reacting the compound of formula (10a') with a monomer compound of the formula (d₁),

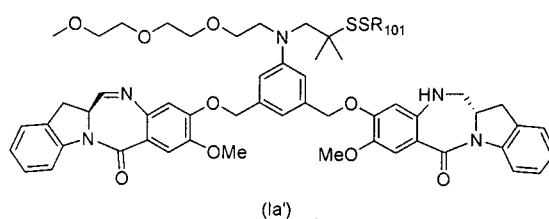


to form a compound of formula (18a),



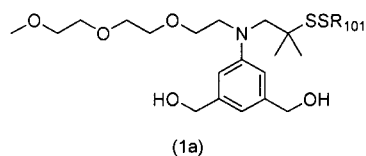
(4) when P₃ is an amine protecting group, reacting the compound of formula (18a) with an amine deprotecting reagent to form the compound of formula (Ia'); wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

20. A method of preparing a compound of formula (Ia'),

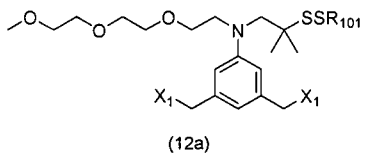


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

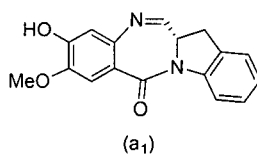
(1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



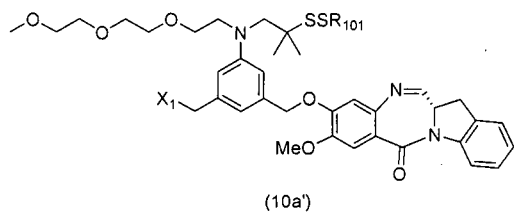
to form a compound of formula (12a),



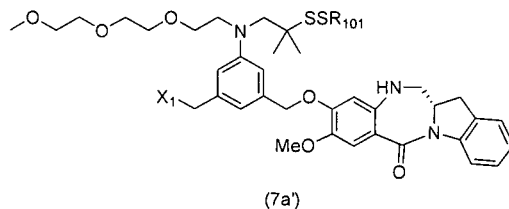
(2) reacting the compound of formula (12a) with a monomer compound of the formula (a₁),



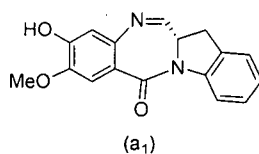
to form a compound of a formula (10a'),



(3) reacting the compound (10a') with an imine reducing reagent to form a compound (7a'),

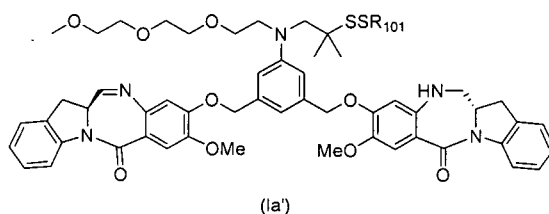


(4) reacting the compound of formula (7a') with a monomer compound of the formula (a₁),



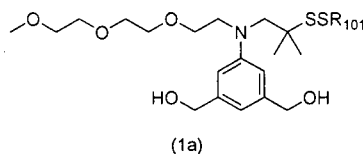
to form a compound of formula (Ia'), or a pharmaceutically acceptable salt thereof, wherein X₁ is -Br, -I, -Cl, a sulfonate ester, or an activated ester (preferably, X₁ is -Br, -I, or a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

21. A method of preparing a compound of formula (Ia'),

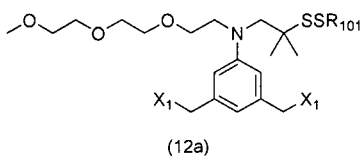


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

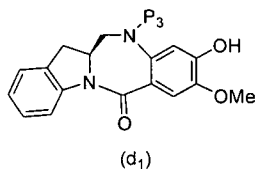
(1) reacting a halogenating reagent, a sulfonating reagent or an esterification reagent with a compound of formula (1a),



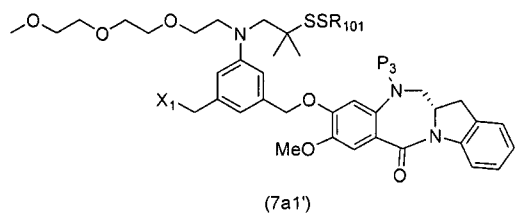
to form a compound of formula (12a),



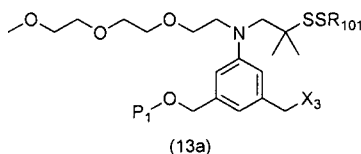
(2) reacting the compound of formula (12d) with a monomer compound of the formula (d₁),



to form a compound of a formula (7a1'),

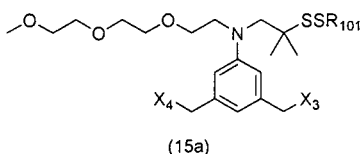


or a salt thereof, said method comprising reacting a compound of formula (13a)

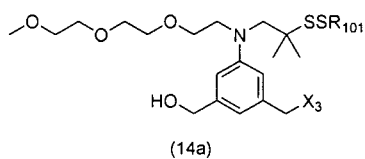


with an alcohol deprotecting reagent, wherein P₁ is an alcohol protecting group; X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

24. The method of claim 23, wherein the alcohol protecting group is a silyl protecting group.
25. The method of claim 24, wherein the silyl protecting group is the silyl protecting group is dimethylisopropylsilyl, diethylisopropylsilyl, dimethylhexylsilyl, trimethylsilyl, triisopropylsilyl, tribenzylsilyl, triphenylsilyl, 2-norbornyldimethylsilyl, *tert*-butyldimethylsilyl, *tert*-butyldiphenylsilyl, 2-trimethylethylsilyl (TEOC), or [2-(trimethylsilyl)ethoxy]methyl.
26. The method of claim 25, wherein the silyl protecting group is triethylsilyl, triisopropylsilyl, or *tert*-butyldimethylsilyl.
27. The method of claim 26, wherein the silyl protecting group is *tert*-butyldimethylsilyl.
28. The method of any one of claims 23-27, wherein the alcohol deprotecting reagent is tetra-*n*-butylammonium fluoride, tris(dimethylamino)sulfonium difluorotrimethylsilicate, hydrogen fluoride or a solvate thereof, hydrogen fluoride pyridine, silicon tetrafluoride, hexafluorosilicic acid, cesium fluoride, hydrochloric acid, acetic acid, trifluoroacetic acid, pyridinium *p*-toluenesulfonate, *p*-toluenesulfonic acid (*p*-TsOH), formic acid, periodic acid.
29. The method of claim 28, wherein the alcohol deprotecting agent is hydrogen fluoride pyridine.
30. A method of preparing a compound of formula (15a):

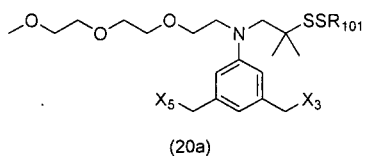


or a salt thereof, said method comprising reacting a sulfonating reagent or an esterification reagent with a compound of formula (14a),

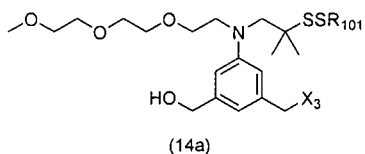


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

31. A method of preparing a compound of formula (20a):

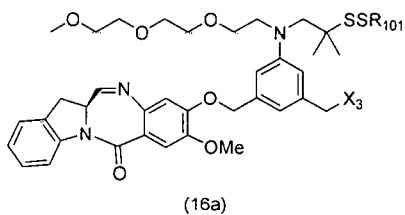


or a salt thereof, said method comprising reacting a brominating or iodinating reagent with a compound of formula (14a),

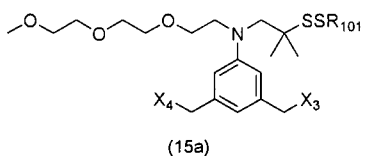


wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

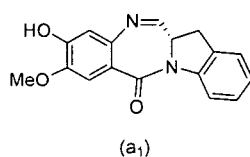
32. A method of preparing a compound of formula (16a):



or a salt thereof, said method comprising reacting a compound of formula (15a)

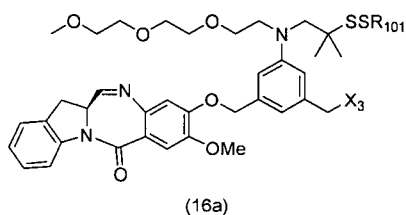


with a monomer compound of formula (a₁),

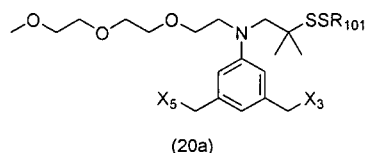


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

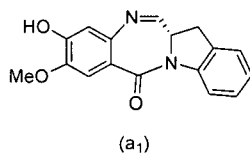
33. A method of preparing a compound of formula (16a):



or a salt thereof, said method comprising reacting a compound of formula (20a)

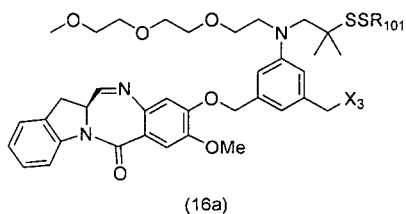


with a monomer compound of formula (a₁),

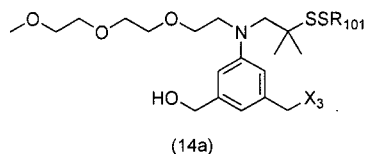


wherein X₃ is -Cl; X₅ is -Br or -I; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

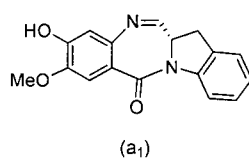
34. A method of preparing a compound of formula (16a):



or a salt thereof, said method comprising reacting a compound of formula (14a)

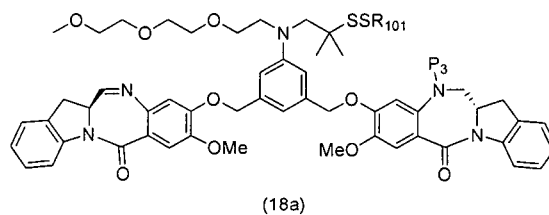


with a monomer compound of formula (a₁),

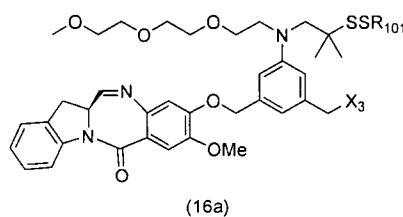


wherein X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

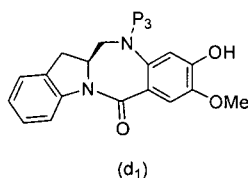
35. A method of preparing a compound of formula (18a):



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (16a):

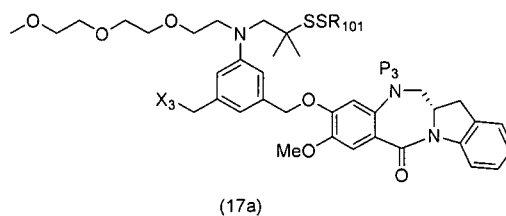


with a reduced monomer of formula (d₁):

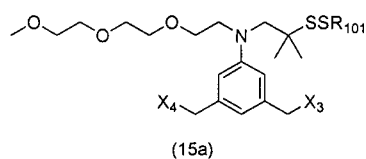


wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

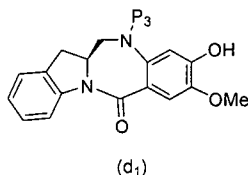
36. A method of preparing a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (15a)

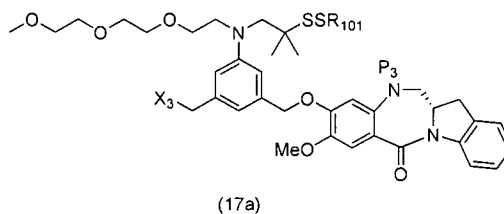


with a monomer compound of formula (d₁),

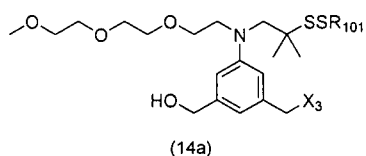


wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

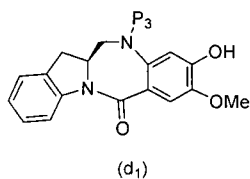
37. A method of preparing a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (14a)



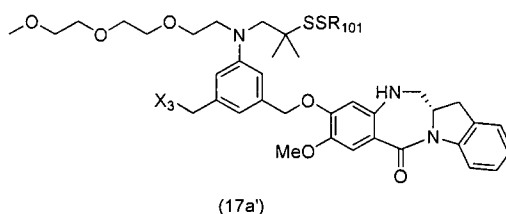
with a monomer compound of formula (d₁),



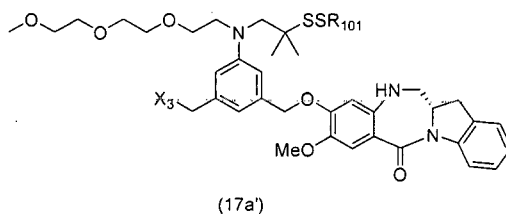
wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

38. The method of claim 37, wherein the compound of formula (14a) is reacted with a monomer of formula (d₁) in the presence of an alcohol activating agent.

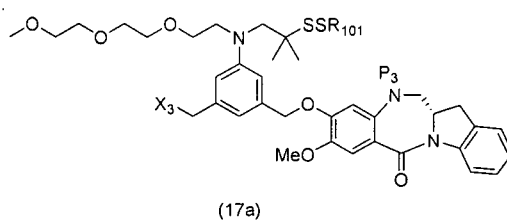
39. The method of claim 38, wherein the alcohol activating agent is triphenylphosphine.
40. The method of any one of claims 37-39, wherein the compound of formula (14a) is reacted with a monomer of formula (d₁) in the presence of an azodicarboxylate.
41. The method of claim 40, wherein the azodicarboxylate is selected from the group consisting of: diethyl azodicarboxylate (DEAD), diisopropyl azodicarboxylate (DIAD), 1,1'-(azodicarbonyl)dipiperidine (ADDP), and ditertbutyl azodicarboxylate (DTAD).
42. The method of any one of claims 37-41, wherein the compound of formula (14a) is reacted with the monomer compound of formula (d₁), wherein P₃ is H, to form a compound of formula (17a'):



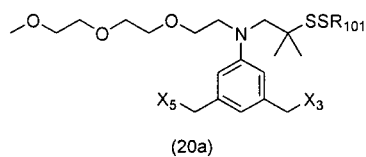
43. The method of any one of claims 37-41, wherein P₃ is an amine protecting group.
44. The method of claim 43, further comprising the step of reacting the compound of formula (17a) with an amine deprotecting reagent to form a compound of formula (17a'):



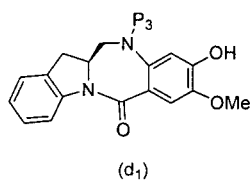
45. The method of claim 44, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.
46. A method of preparing a compound of formula (17a):



or a salt thereof, said method comprising reacting a compound of formula (20a)

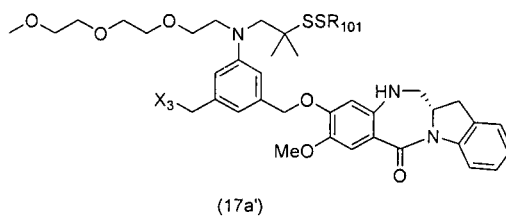


with a monomer compound of formula (d₁),

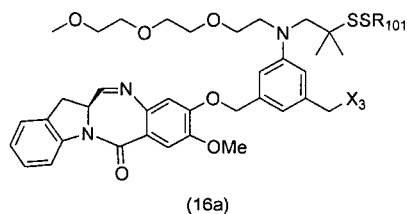


wherein X₃ is -Cl; X₅ is -Br or -I; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

47. A method of preparing a compound of formula (17a'):

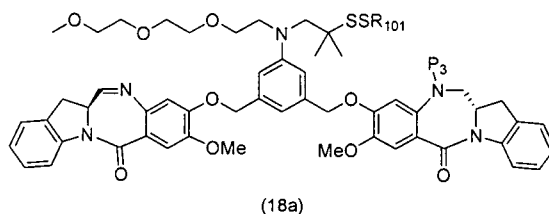


or a salt thereof, said method comprising reacting a compound of formula (16a),

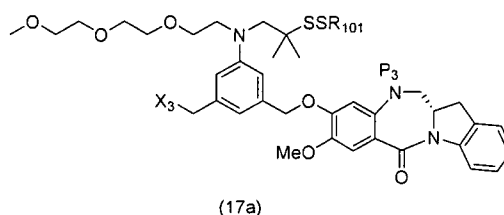


with an imine reducing agent, wherein X₃ is -Cl; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

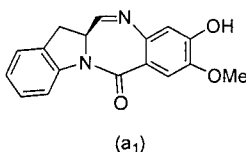
48. A method of preparing a compound of formula (18a),



or a pharmaceutically acceptable salt thereof, said method comprising reacting a compound of formula of (17a):



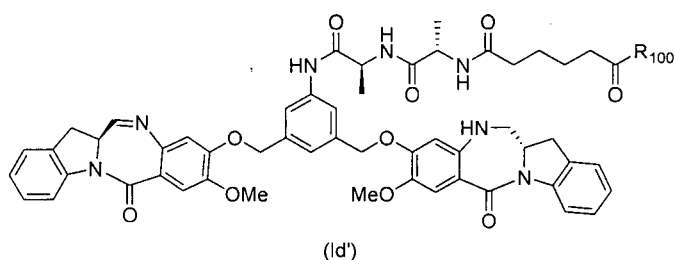
with a monomer of formula (a₁):



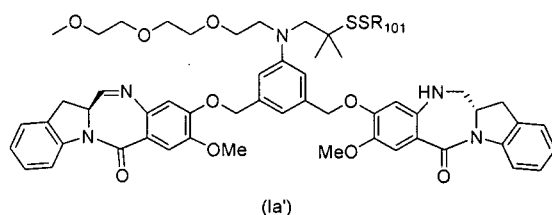
wherein X₃ is -Cl; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

49. The method of claim 48, wherein the compound of formula (17a) is reacted with a monomer compound of formula (a₁) in the presence of a base.
50. The method of claim 49, wherein the base is sodium carbonate, potassium carbonate, cesium carbonate, sodium hydride, or potassium hydride.
51. The method of claim 50, wherein the base is potassium carbonate.
52. The method of any one of claims 48-51, wherein the compound of formula (17a) is reacted with a monomer compound of formula (a₁) in the presence of a polar aprotic solvent.
53. The method of claim 52, wherein the polar aprotic solvent is dimethylformamide or dimethylacetamide.
54. The method of any one of claims 48-53, wherein the compound of formula (17a) is reacted

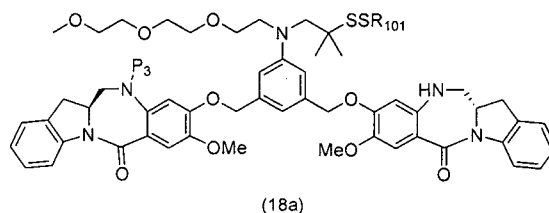
with monomer of formula (a₁), wherein P₃ is H, to form a compound of formula (Id'):



55. The method of any one of claims 48-53, wherein P₃ is an amine protecting group.
56. The method of claim 55, wherein the amine protecting group is selected from the group consisting of 2-trimethylsilylethyl, (2-phenyl-2-trimethylsilyl)ethyl, triisopropylsiloxy, 2-(trimethylsilyl)ethoxymethyl, and allyloxycarbonyl, 9-fluorenylmethoxycarbonyl, 2-(trimethylsilyl)ethoxycarbonyl, and 2, 2,2,2-trichloroethoxycarbonyl.
57. The method of claim 55 or 56, wherein the compound of formula (18d) is further reacted with an amine deprotecting reagent to form a compound of formula (Id'):

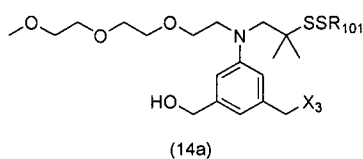


58. The method of claim 57, wherein the amine deprotecting reagent is selected from the group consisting of tetra-n-butylammonium fluoride, acetic acid, hydrogen fluoride pyridine, cesium fluoride, piperidine, morpholine, or trifluoroacetic acid.
59. A method of preparing a compound of formula (18a),

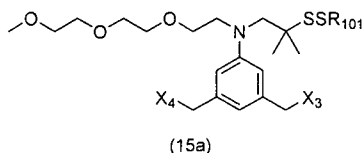


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

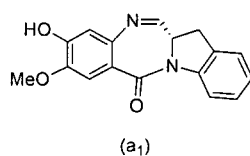


or a salt thereof, to form a compound of formula (15a):

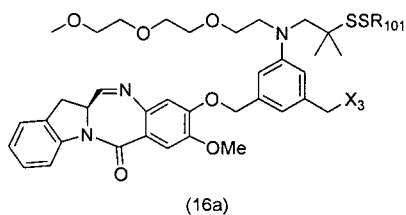


or a salt thereof;

(2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),

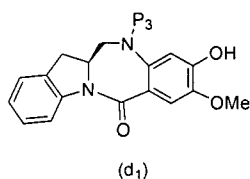


to form a compound of formula (16a):



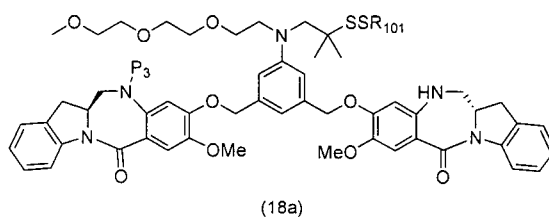
or a salt thereof; and

(3) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



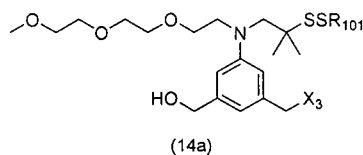
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

60. A method of preparing a compound of formula (18a),

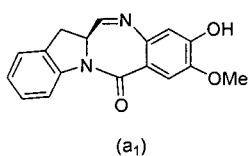


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

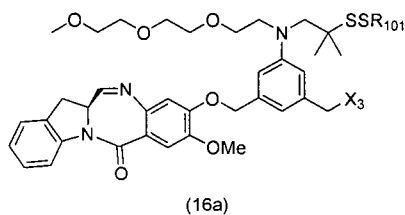
(1) reacting the compound of formula (14a):



or a salt thereof, with a monomer compound of formula (a₁),

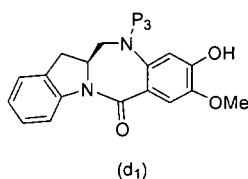


in the presence of an alcohol activating agent to form a compound of formula (16a):



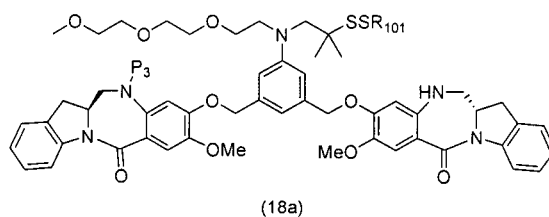
or a salt thereof; and

(2) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



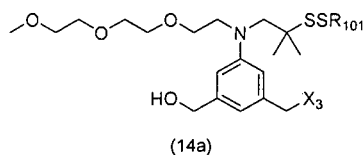
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

61. A method of preparing a compound of formula (18a),

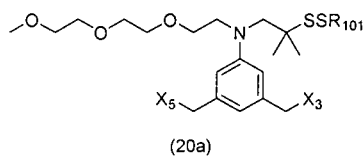


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

(1) reacting a brominating or iodinating reagent with the compound of formula (14a):

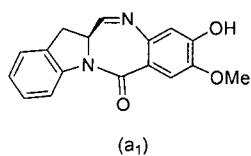


or a salt thereof, to form a compound of formula (20a):

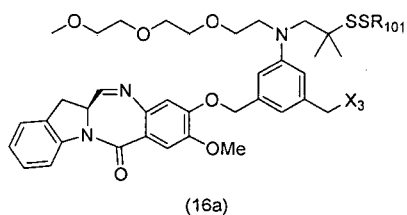


or a salt thereof;

(4) reacting a compound of formula (20a) or a salt thereof with a monomer compound of formula (a₁),

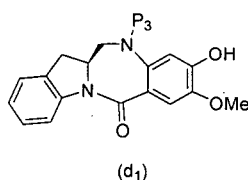


to form a compound of formula (16a):



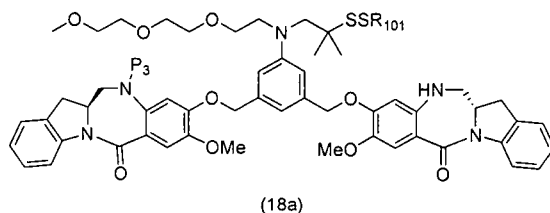
or a salt thereof; and

(5) reacting the compound of formula of (16a) with a reduced monomer of formula (d₁):



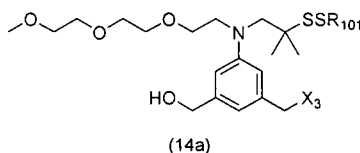
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X_3 is $-\text{Cl}$; X_5 is $-\text{Br}$ or $-\text{I}$; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{--}\text{C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

62. A method of preparing a compound of formula (18a),

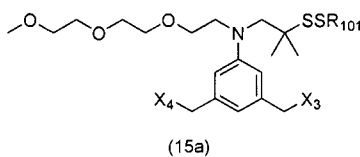


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

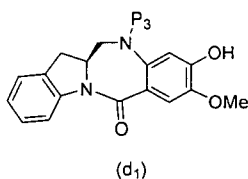


or a salt thereof, to form a compound of formula (15a):

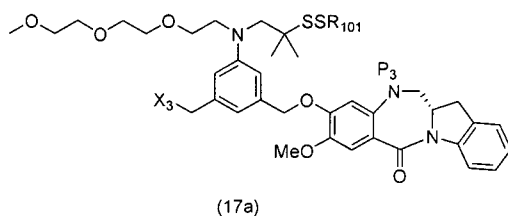


or a salt thereof;

- (2) reacting the compound of formula (15a) with a reduced monomer compound of formula (d₁),

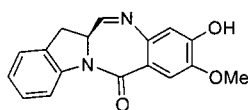


to form a compound of formula (17a):



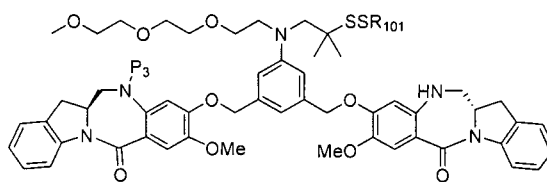
or a salt thereof; and

- (3) reacting the compound of formula of (17a) with a monomer of formula (a₁):

(a₁)

to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

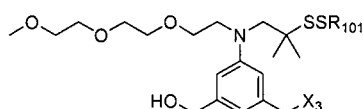
63. A method of preparing a compound of formula (18a),



(18a)

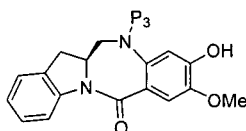
or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting the compound of formula (14a):

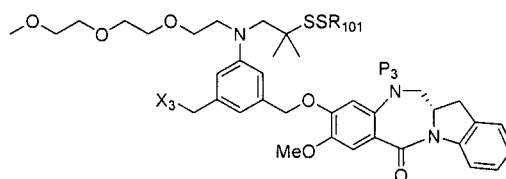


(14a)

or a salt thereof, with a reduced monomer compound of formula (d₁),

(d₁)

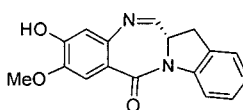
in the presence of an alcohol activating agent to form a compound of formula (17a):



(17a)

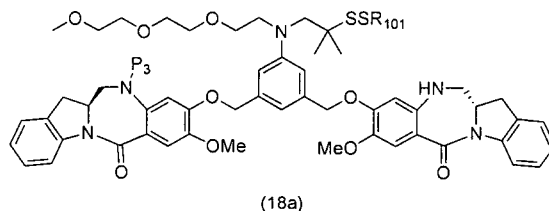
or a salt thereof; and

- (2) reacting the compound of formula (17a) with a monomer of formula (a₁):

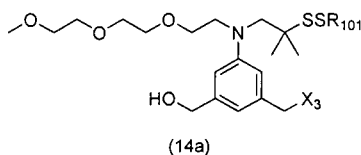
(a₁)

to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X_3 is $-\text{Cl}$; P_1 is an alcohol protecting group; P_3 is H or an amine protecting group; and R_{101} is $(\text{C}_1\text{-C}_3)\text{alkyl}$, pyridyl, or nitropyridyl.

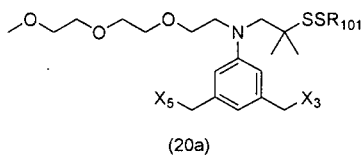
64. A method of preparing a compound of formula (18a),



or a pharmaceutically acceptable salt thereof, said method comprising the steps of:
(1) reacting a brominating or iodinating reagent with the compound of formula (14a):

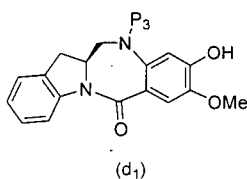


or a salt thereof, to form a compound of formula (20a):

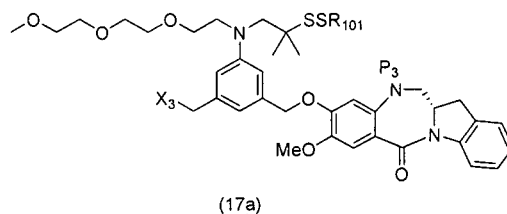


or a salt thereof;

- (2) reacting the compound of formula (20a) with a reduced monomer compound of formula (d₁),

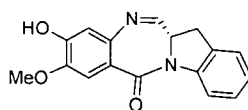


to form a compound of formula (17a):



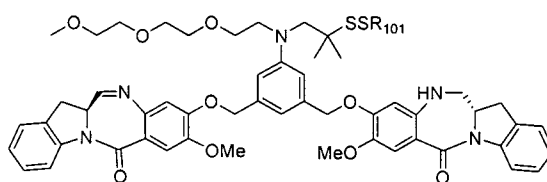
or a salt thereof; and

- (3) reacting the compound of formula (17a) with a monomer of formula (a₁):

(a₁)

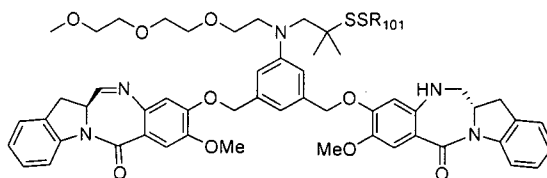
to form a compound of formula (18a), or a pharmaceutically acceptable salt thereof, wherein X₃ is -Cl; X₅ is -Br or -I; P₁ is an alcohol protecting group; P₃ is H or an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

65. The method of claim 62, 63, or 64, wherein the compound of formula (17a) is reacted with monomer of formula (a₁), wherein P₃ is H, to form a compound of formula (Ia'):



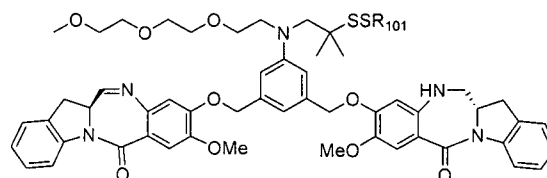
(Ia')

66. The method of claim 62, 63, or 64, wherein P₃ is an amine protecting group.
67. The method of claim 66, wherein the compound of formula (18a) is further reacted with an amine deprotecting reagent to form a compound of formula (Ia'):



(Ia')

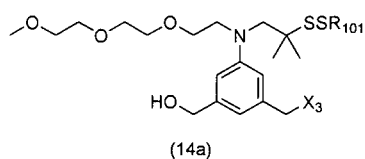
68. A method of preparing a compound of formula (Ia'),



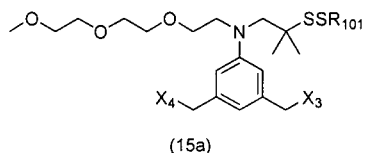
(Ia')

or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a sulfonating reagent or an esterification reagent with the compound of formula (14a):

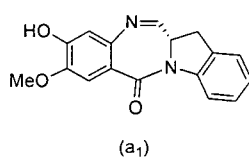


or a salt thereof, to form a compound of formula (15a):

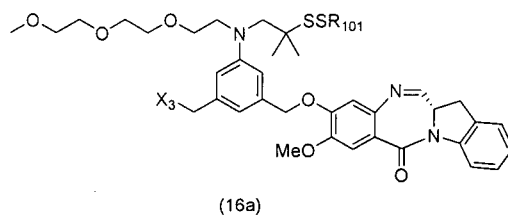


or a salt thereof;

(2) reacting the compound of formula (15a) with a monomer compound of formula (a₁),

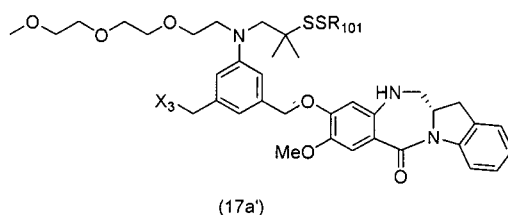


to form a compound of formula (16a):



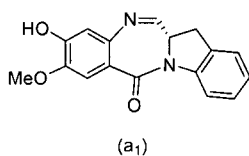
or a salt thereof;

(3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



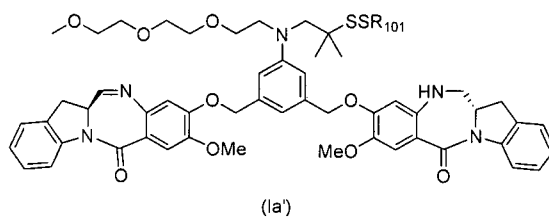
or a salt thereof; and

(4) reacting the compound of formula (17a') with a monomer of formula (a₁):



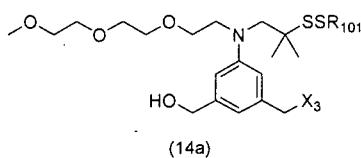
to form the compound of formula (1a'); wherein X₃ is -Cl; X₄ is a sulfonate ester or an activated ester (preferably, a sulfonate ester); P₁ is an alcohol protecting group; P₂ is an amine protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

69. A method of preparing a compound of formula (Ia'),

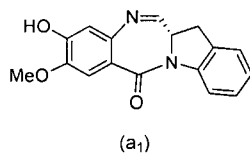


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

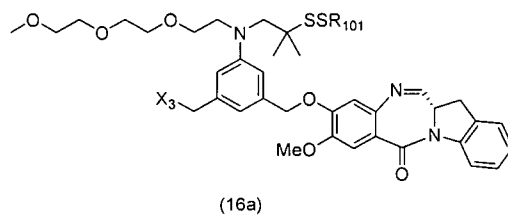
(1) reacting the compound of formula (14a):



or a salt thereof, with a monomer compound of formula (a₁),

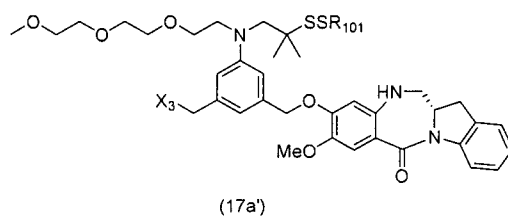


in the presence of an alcohol activating agent to form a compound of formula (16a):



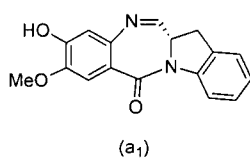
or a salt thereof;

(2) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



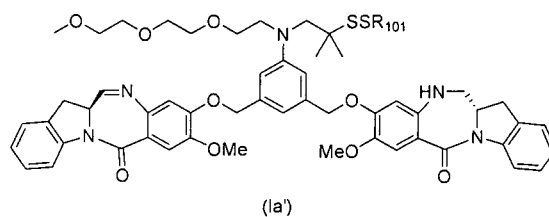
or a salt thereof; and

(3) reacting the compound of formula (17a') with a monomer of formula (a₁):



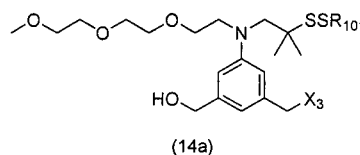
to form the compound of formula (Ia'); wherein X_3 is $-Cl$; P_1 is an alcohol protecting group; and R_{101} is (C_1-C_3) alkyl, pyridyl, or nitropyridyl.

70. A method of preparing a compound of formula (Ia'),

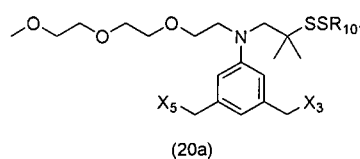


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a brominating or iodinating reagent with the compound of formula (14a):

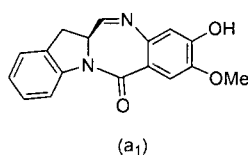


or a salt thereof, to form a compound of formula (20a):

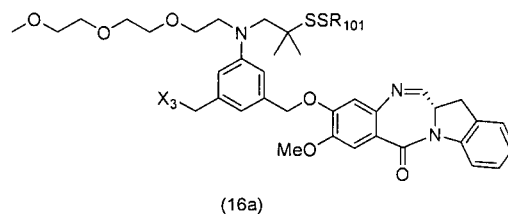


or a salt thereof;

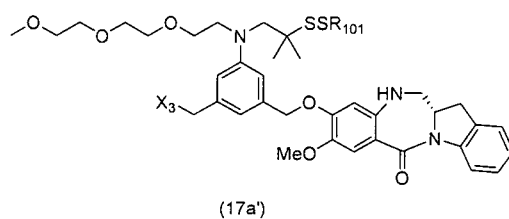
- (2) reacting a compound of formula (20a) or a salt thereof with a monomer compound of formula (a₁),



to form a compound of formula (16a):

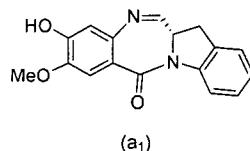


- (3) reacting the compound of formula (16a) with an imine reducing agent to form a compound of formula (17a'):



or a salt thereof; and

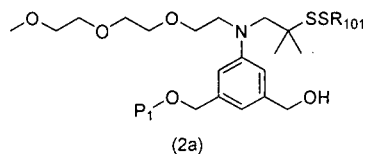
(4) reacting the compound of formula (17d') with a monomer of formula (a₁):



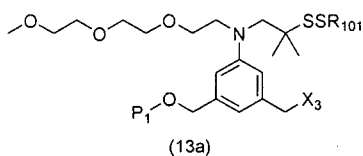
to form the compound of formula (Id'); wherein X₃ is -Cl; P₁ is an alcohol protecting group; and R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

71. The method of any one of claims 59-70, wherein the compound of formula (14a) or a salt thereof is prepared a method comprising the following steps:

(1) reacting a chlorinating reagent with a compound of formula (2a),



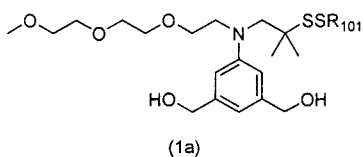
to form a compound a compound of formula (13a),



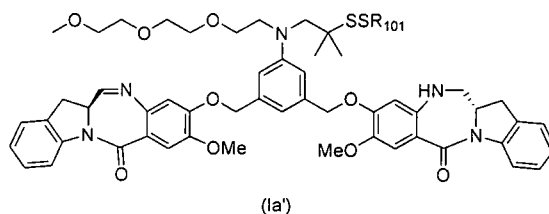
or a salt thereof;

(2) reacting the compound of formula (13a) with an alcohol deprotecting reagent to form the compound of formula (14a) or a salt thereof.

72. The method of claim 71, wherein the compound of formula (2a) is prepared by reacting a compound of formula (1a) with an alcohol protecting reagent

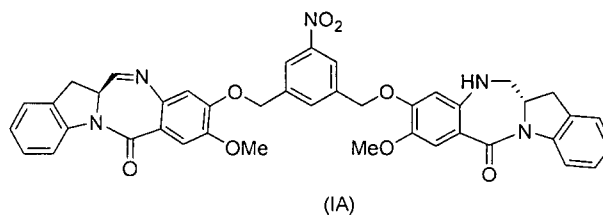


73. A method of preparing a compound of formula (Ia'),

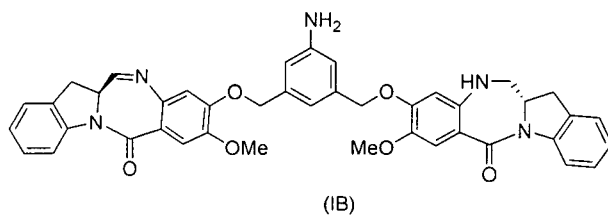


or a pharmaceutically acceptable salt thereof, said method comprising the steps of:

- (1) reacting a compound of formula (IA):

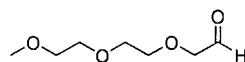


with a reducing agent to form a compound of formula (IB):

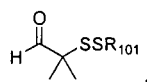


; and

- (2) reacting the compound of formula (IB) with a compound of formula (L1a),

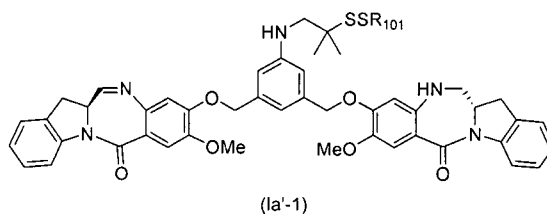


and a compound of formula (L1b):



in the presence of a reducing agent to form the compound of formula (Ia'), wherein R₁₀₁ is (C₁-C₃)alkyl, pyridyl, or nitropyridyl.

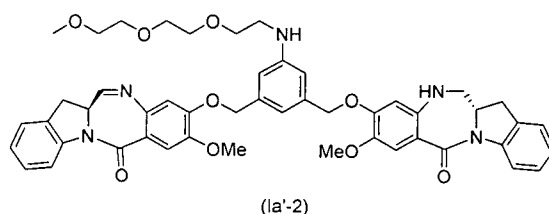
74. The method of claim 73, wherein the compound of formula (IB) is reacted with a compound of formula (L1b) in the presence of a reducing agent to form a compound of (Ia'-1):



or a salt thereof, followed by reacting the compound of (Ia'-1) with the compound of formula

(L1a) in the presence of a reducing agent to form the compound of formula (Ia').

75. The method of claim 73, wherein the compound of formula (IB) is reacted with a compound of formula (L1a) in the presence of a reducing agent to form a compound of (Ia'-2)



or a salt thereof, followed by reacting the compound of formula (Ia'-2) with the compound of formula (L1b) in the presence of a reducing agent to form the compound of formula (Ia').

76. The method of any one of claims 73-75, wherein the reducing agent in step (2) is selected from the group consisting of: sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, hydrogen gas, ammonium formate, titanium isopropoxide, borane, 9-borabicyclo[3.3.1]nonane (9-BBN), lithium borohydride (LiBH_4), potassium borohydride (KBH_4), titanium isopropoxide, and stannous chloride.
77. The method of claim 75, wherein the reducing agent is sodium borohydride, sodium triacetoxo borohydride, sodium cyanoborohydride, or potassium borohydride.
78. The method of claim 77, wherein the reducing agent is sodium borohydride.
79. The method of any one of claims 73-78, wherein the reducing agent in step (1) is selected from the group consisting of: hydrogen gas, sodium hydrosulfite, sodium sulfide, stannous chloride, titanium (II) chloride, zinc, iron and samarium iodide.
80. The method of claim 79, wherein the reducing agent in step (1) is $\text{Fe}/\text{NH}_4\text{Cl}$ or $\text{Zn}/\text{NH}_4\text{Cl}$.
81. The method of any one of claims 1-80, wherein R_{101} is methyl.

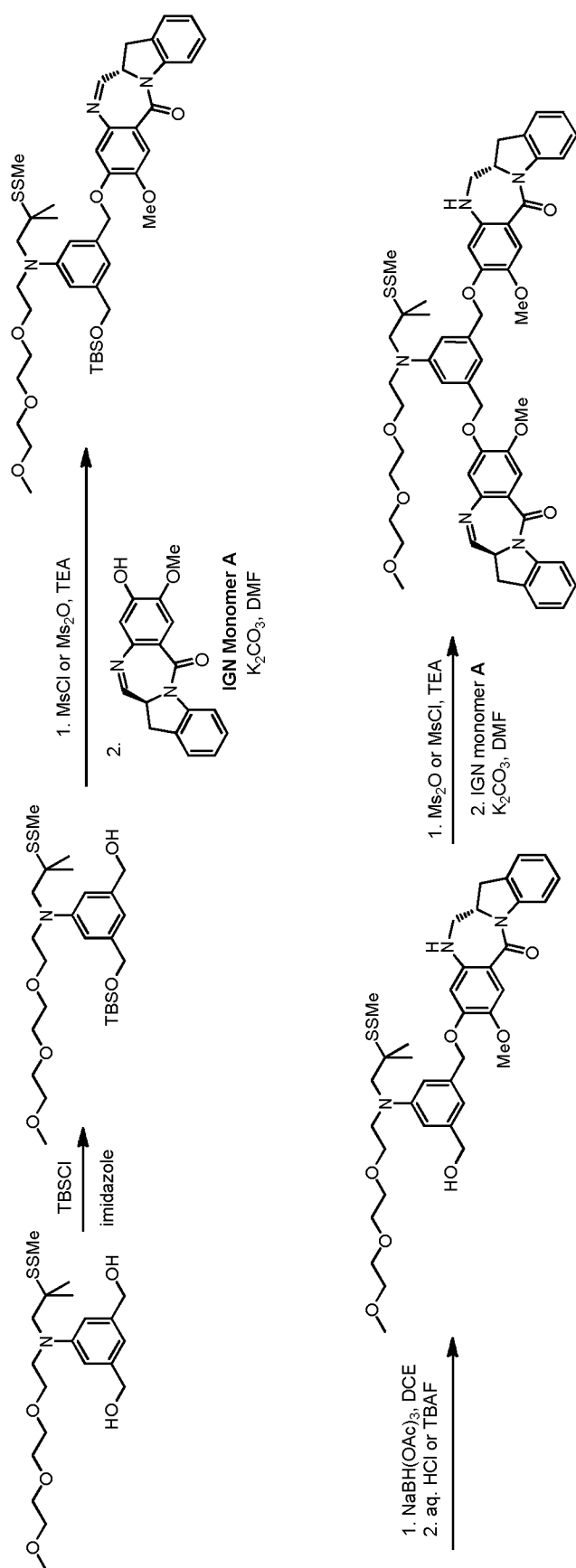


FIG. 1

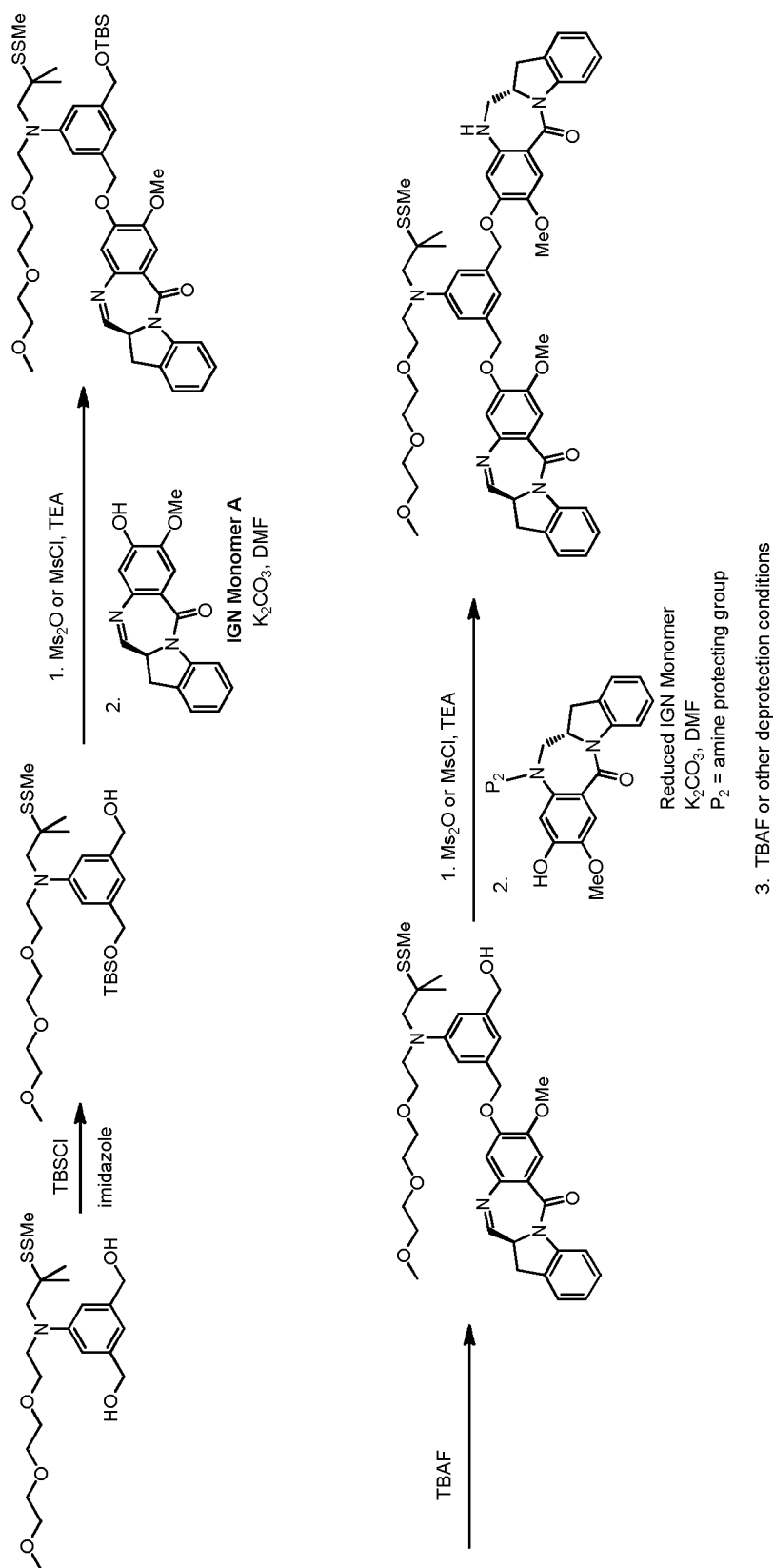


FIG. 2

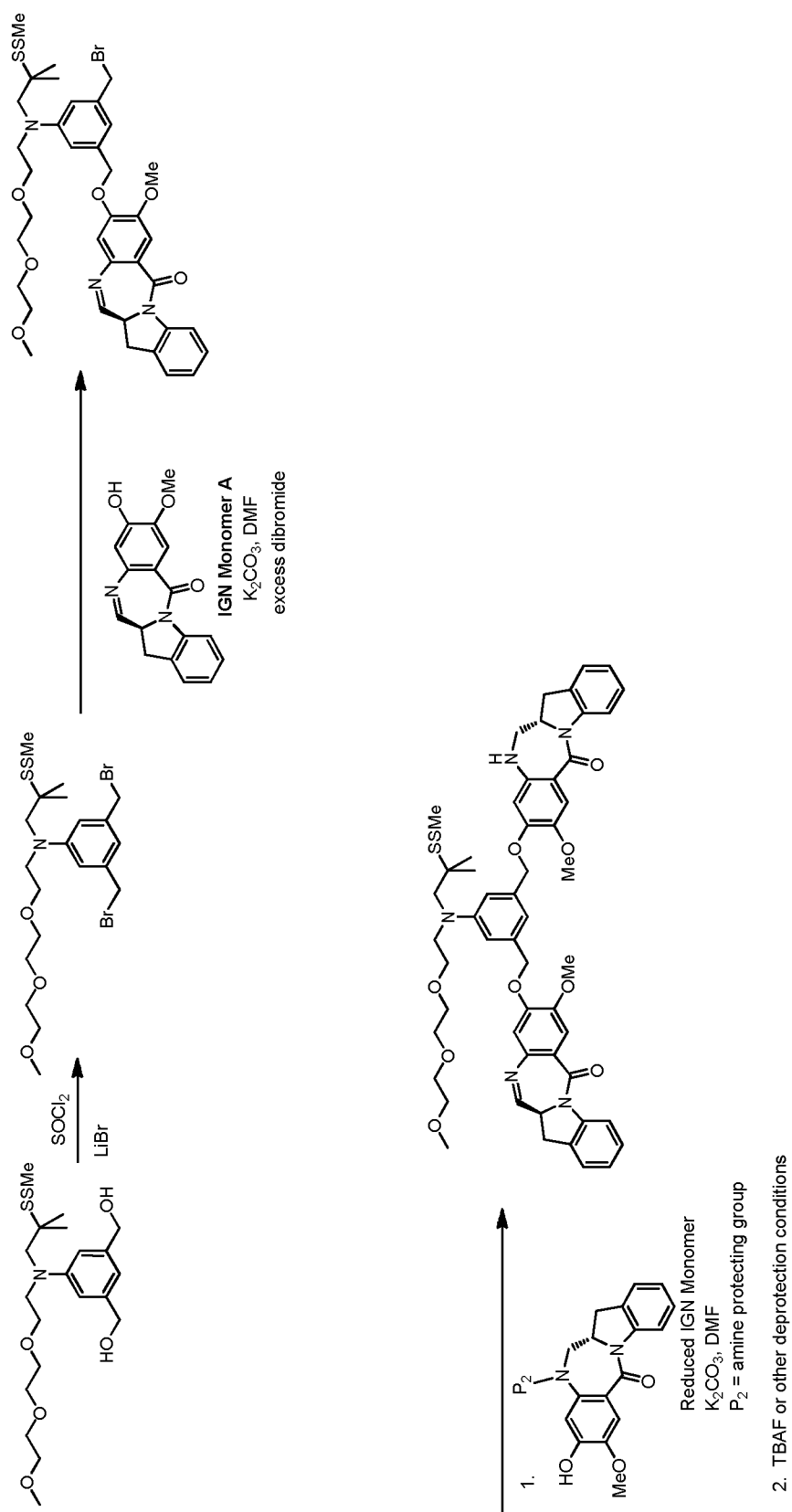


FIG. 3

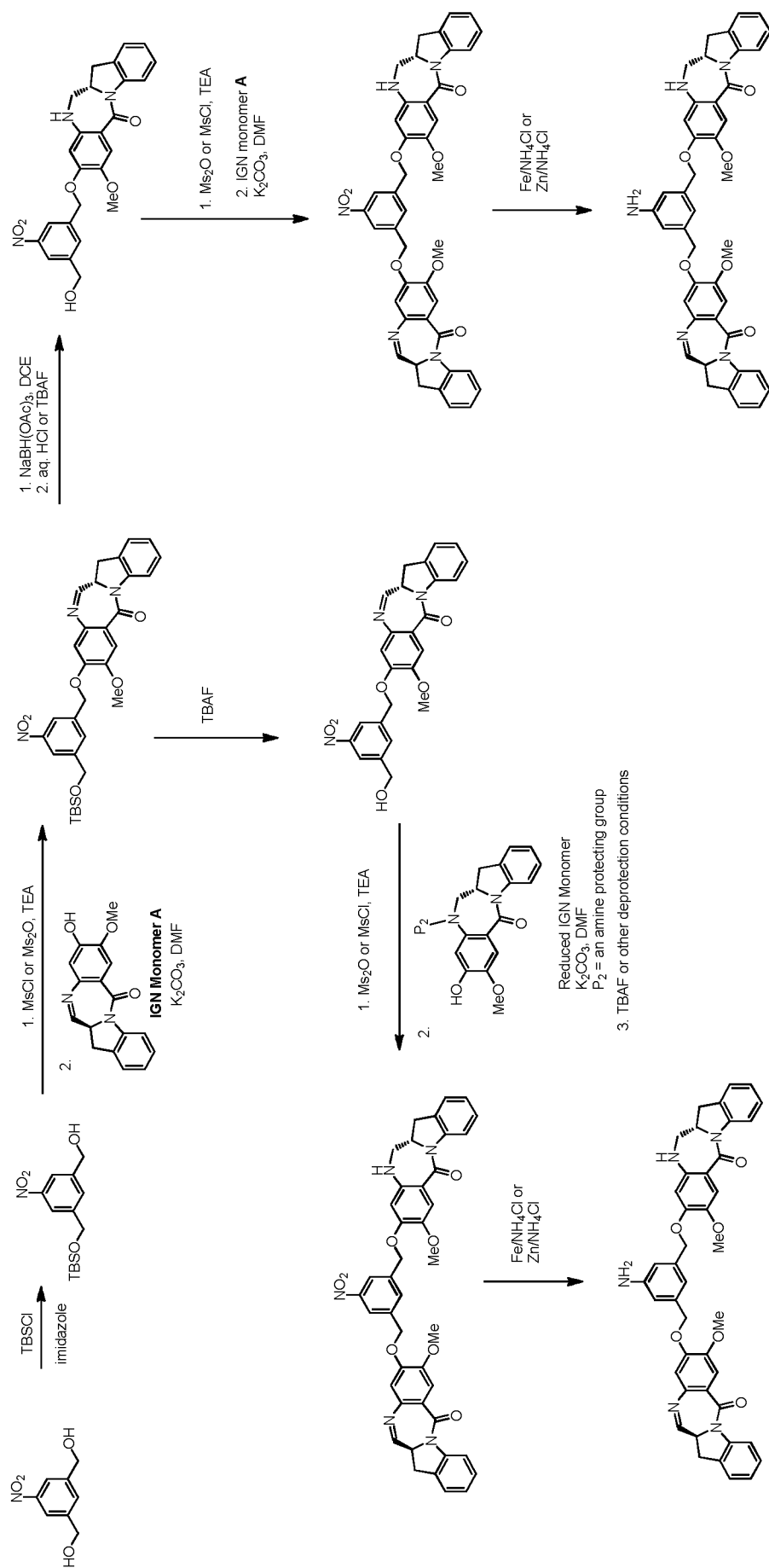


FIG. 4

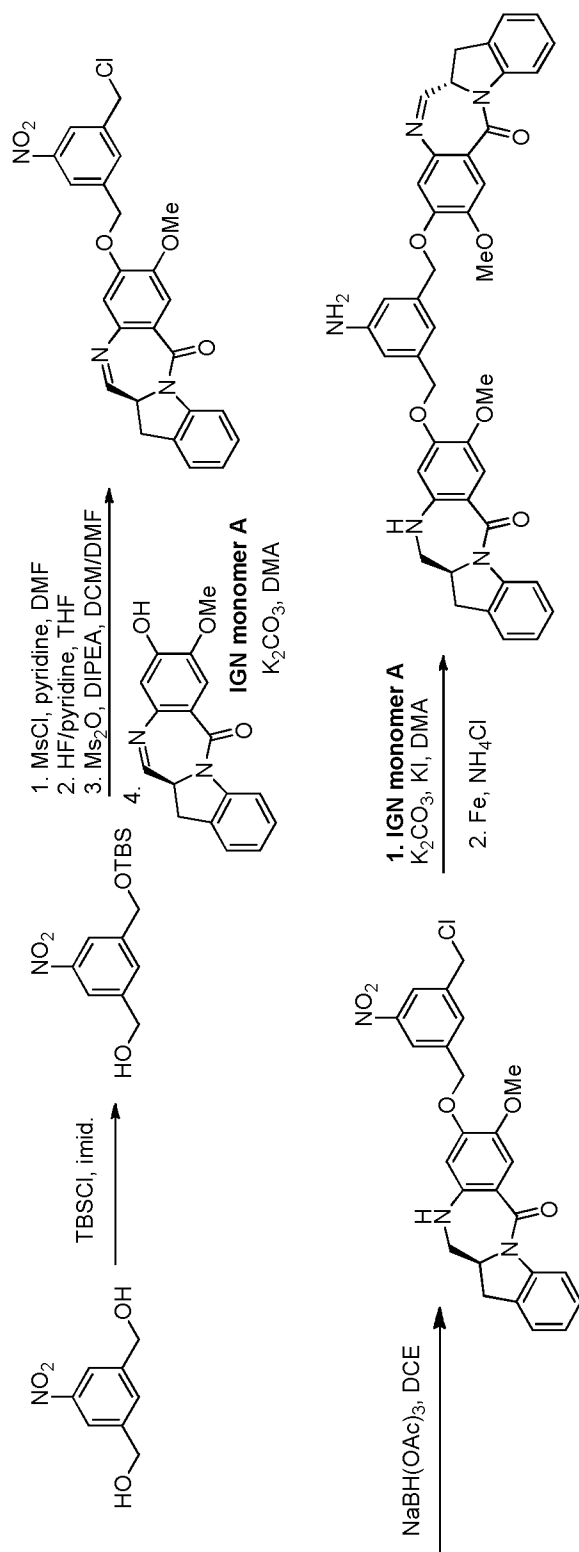


FIG. 5

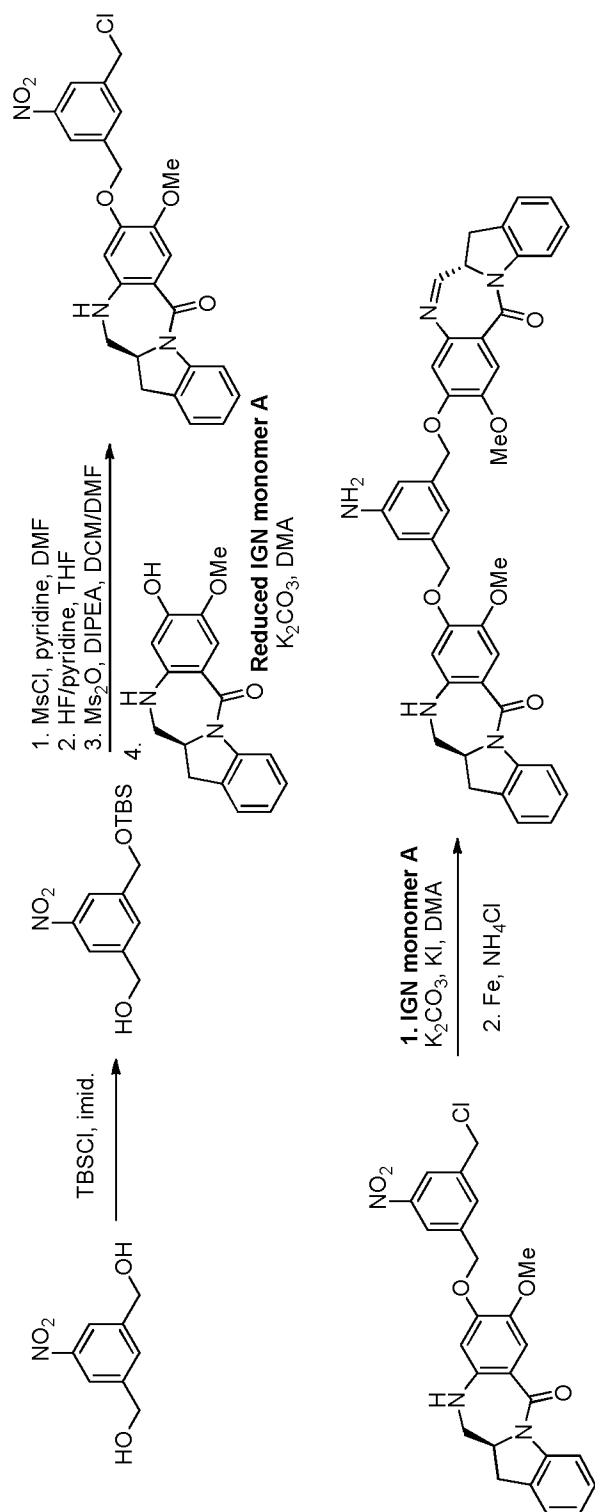


FIG. 6

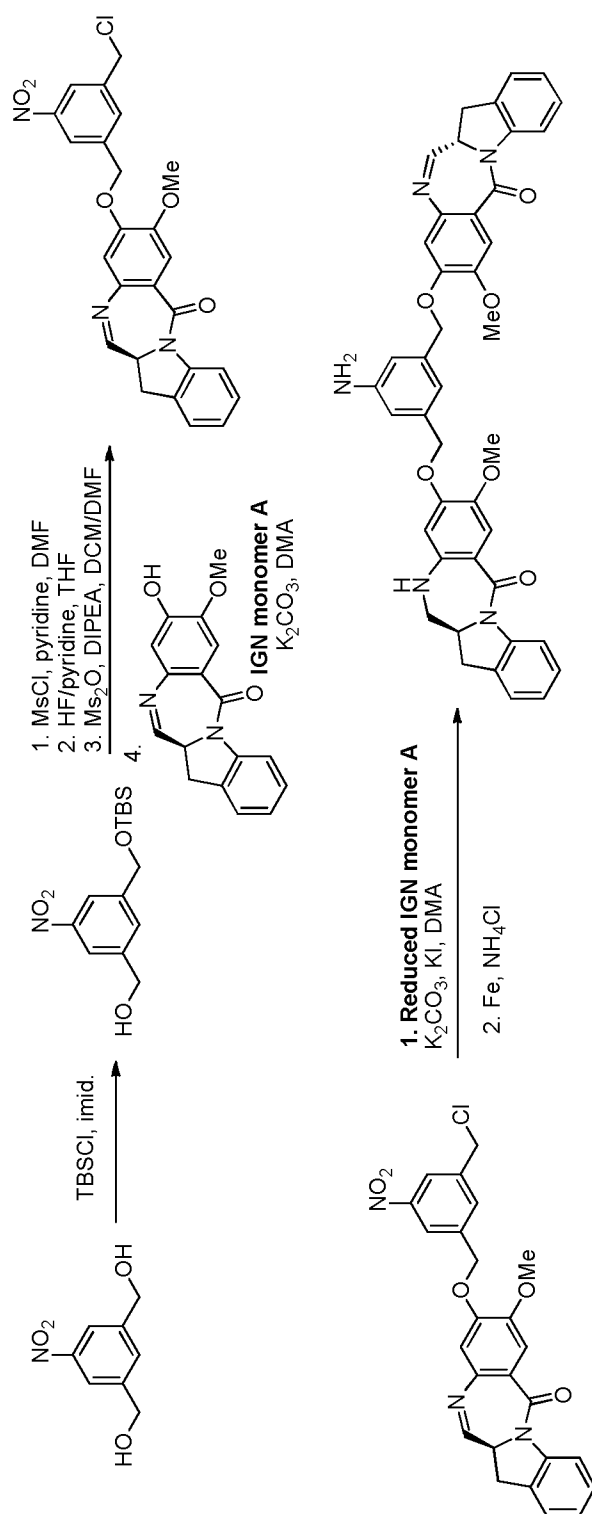


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/043402

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07D487/04
ADD.

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

B. FIELDS SEARCHED

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

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/128868 A1 (IMMUNOGEN INC [US]; LI WEI [US]; MILLER MICHAEL [US]; FISHKIN NATHAN []) 27 September 2012 (2012-09-27) cited in the application examples 1-2; compound 1b -----	1-230
A,P	WO 2016/036794 A1 (IMMUNOGEN INC [US]) 10 March 2016 (2016-03-10) claim 79 -----	1-230



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

14 September 2016

Date of mailing of the international search report

21/09/2016

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
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Fax: (+31-70) 340-3016

Authorized officer

Gettins, Marc

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/043402

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2012128868	A1	27-09-2012	
		AU 2012217719 A1	18-04-2013
		AU 2012231640 A1	02-05-2013
		AU 2016200752 A1	25-02-2016
		CA 2824864 A1	27-09-2012
		CA 2825919 A1	23-08-2012
		CN 103687623 A	26-03-2014
		CN 103702686 A	02-04-2014
		DK 2675479 T3	11-04-2016
		EP 2675479 A1	25-12-2013
		EP 2675480 A1	25-12-2013
		EP 2675481 A1	25-12-2013
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摘要

本發明涉及製備吡啶並苯並二氮雜~~草~~二聚體化合物及其合成前體的新型方法。