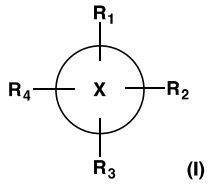
amino acid oxidase and/or 3C-like protease (3CLPro). Certain compounds disclosed herein also exhibited therapeutic effects in an animal model for central nervioius system (CNS) diseases (the MK801 mouse model). Accordingly, the compounds disclosed here are expected to be effective in treating CNS disorders (e.g., those associated with DAAO) and/or for alleviating viral infection caused by coronavirus such as SARS-CoV-2.

Accordingly, the present disclosure provides a compound of formula (I):



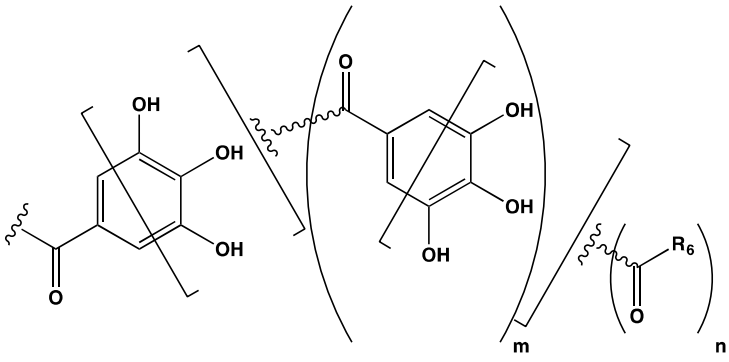
(I)

or a pharmaceutically acceptable salt thereof, wherein:

Ring X is a 3 to 7 membered monocyclic ring, which can be aryl, heteroaryl, cycloalkyl, or cycloheteroalkyl;

at least one of R_1, R_2, R_3, and R_4 is OR_5 or CH_2OR_5 and the other R_1, R_2, R_3, and R_4 each independently are halogen, OH, OR_5, CH_2OR_5, CO_2H, $OC{=}OR_6$, $(C{=}O)R_6$, R_6, C1-10 alkyl, C2-10 alkenyl, C2-10 alkynyl, H, or absent

R_5 is of the formula

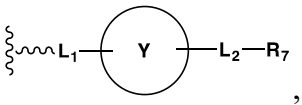


, in which

m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 0, 1, 2, or 3; and

R_6 is of the formula:

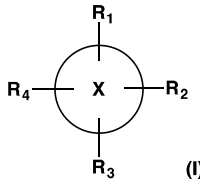


, in which Ring Y is a 3 to 7 membered monocyclic ring, which can be aryl, heteroaryl, cycloalkyl, or cycloheteroalkyl;

Each of L_1 and L_2, independently, is a moiety selected from the group consisting of N, O, S, CH_2, C=O, $C_{2\text{-}10}$ alkyl, $C_{2\text{-}10}$ alkenyl, $C_{2\text{-}10}$ alkynyl, $-(W\text{-}(CH_2)_s)-$, and absent, wherein s is 0, 1, 2, 3, 4, or 5, and W is O, S, or N; and

R_7 is selected from the group consisting of aryl, heteroaryl, aralkyl, $C_{2\text{-}10}$ alkyl, $C_{2\text{-}10}$ alkenyl, $C_{2\text{-}10}$ alkynyl, and H.

In one aspect, the present disclosure provides a compound of formula (I):



(I)

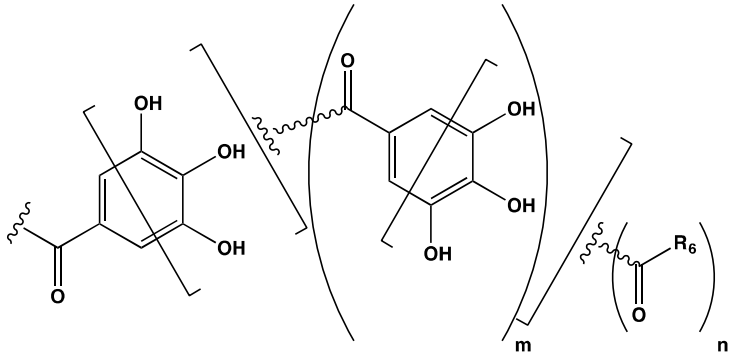
or a pharmaceutically acceptable salt thereof,

wherein:

a) Ring X is a 3 to 7 membered monocyclic ring, which is selected from the group consisting of aryl, heteroaryl, cycloalkyl, and cycloheteroalkyl;

at least one of R_1, R_2, R_3, and R_4 is OR_5 or CH_2OR_5 and the other R_1, R_2, R_3, and R_4 each independently are halogen, OH, OR_5, CH_2OR_5, CO_2H, $OC{=}OR_6$, $(C{=}O)R_6$, R_6, C1-10 alkyl, C2-10 alkenyl, C2-10 alkynyl, H, or absent

R_5 is of the formula

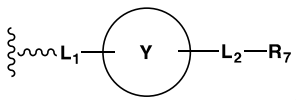


, in which

m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 1, 2, or 3; and

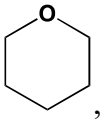
R_6 is of the formula:



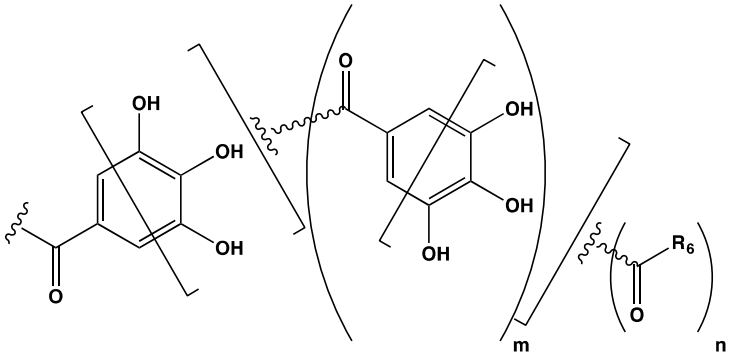
, in which Ring Y is a 3 to 7 membered monocyclic ring, which is selected from the group consisting of aryl, heteroaryl, cycloalkyl, and cycloheteroalkyl;

each of L_1 and L_2, independently, is a moiety selected from the group consisting of N, O, S, CH_2, C=O, $C_{2\text{-}10}$ alkyl, $C_{2\text{-}10}$ alkenyl, $C_{2\text{-}10}$ alkynyl, $-(W-(CH_2)_s)-$, and absent, wherein s is 0, 1, 2, 3, 4, or 5, and W is O, S, or N; and

R_7 is selected from the group consisting of aryl, heteroaryl, aralkyl, $C_{2\text{-}10}$ alkyl, $C_{2\text{-}10}$ alkenyl, $C_{2\text{-}10}$ alkynyl, and H;

b) the X ring is , wherein R_1, R_2, R_3, and R_4 are each OR_5, wherein each of m is 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0;

R_5 is of the formula

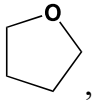


, in which

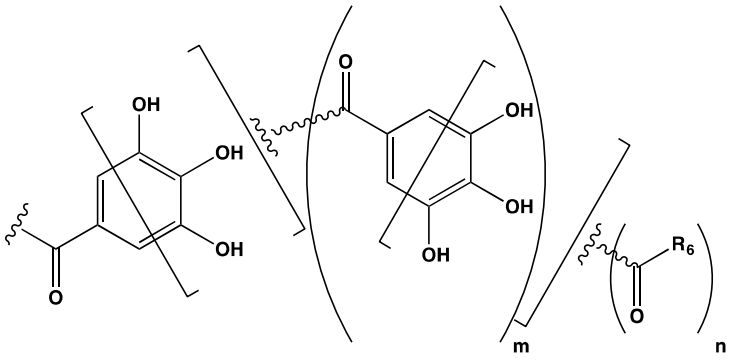
m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 0; and

R_6 is as defined above;

c) X ring is , wherein R_1, R_2, R_3, and R_4 are each OR_5 or CH_2OR_5, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0;

R_5 is of the formula

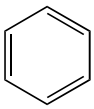


, in which

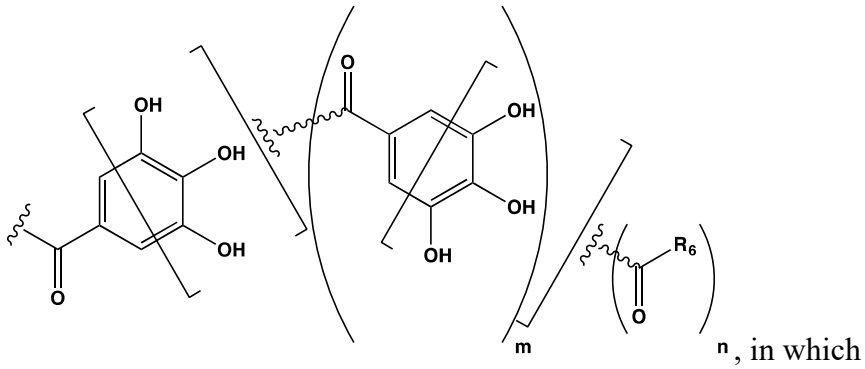
m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 0; and

R_6 is as defined above; or

d) the X ring is , wherein R_1, R_2, R_3, and R_4 are each OH, OR_5, or $(C=O)R_6$, at least one of R_1, R_2, or R_3 and R_4 being $(C=O)R_6$, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0;

R_5 is of the formula

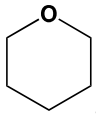


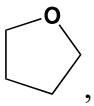
, in which

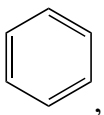
m independently is 1, 2, 3, 4, 5, 6, or 7;

n is 0; and

R_6 is as defined above.

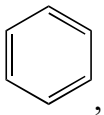
In some examples, the X ring is , R_1, R_2, R_3, and R_4 are each OR_5, each of m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0.

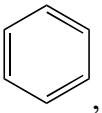
In some examples, the X ring is , R_1, R_2, R_3, and R_4 are each OR_5 or CH_2OR_5, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0.

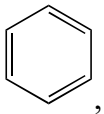
In some examples, the X ring is , R_1, R_2, and R_3 are each OR_5 or $OC=OR_6$, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0 or 1.

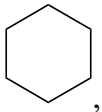
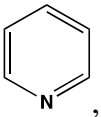
In some examples, at least one of R_1, R_2, or R_3 is $OC=OR_6$.

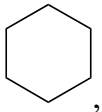
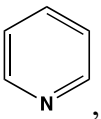
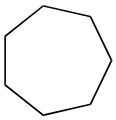
In some examples, the X ring is an aryl, heteroaryl or cycloalkyl ring; R_1, R_2, R_3, and R_4 are each OH, CO_2H, OR_5 or $(C=O)R_6$, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0 or 1.

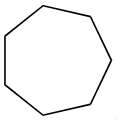
In some examples, the X ring is , R_1, R_2, R_3, and R_4, are each OH, CO_2H, OR_5 or $(C=O)R_6$, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0 or 1.

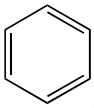
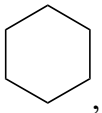
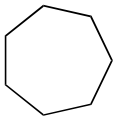
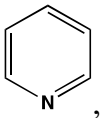
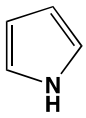
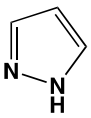
In some examples, the X ring is , R_1, R_2, R_3, and R_4 are each OH, CO_2H, or OR_5, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 1.

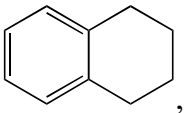
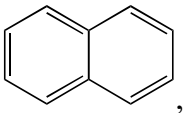
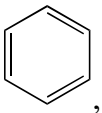
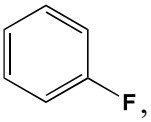
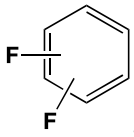
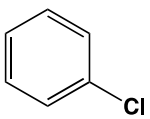
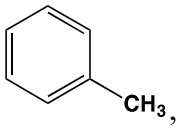
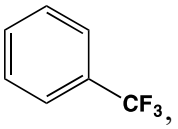
In some examples, the X ring is , R_1, R_2, R_3, and R_4 are each OH, OR_5, or $(C=O)R_6$, at least one of R_1, R_2, or R_3 and R_4 being $(C=O)R_6$, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0.

In some examples, the X ring is , , , , or , R_1 is OR_5, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0 or 1.

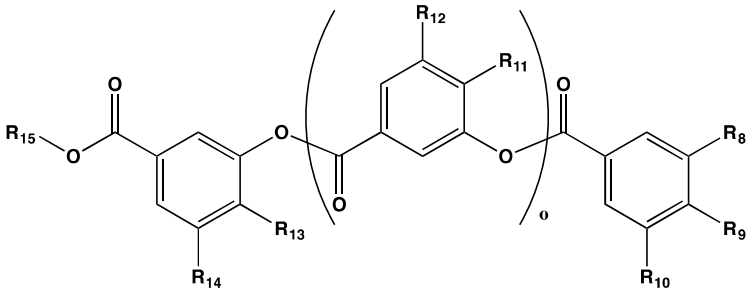
In some examples, the X ring is , , , , or , R_1 is OR_5, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0.

In some examples, the X ring is , or , R_1 is OR_5, m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0.

In some examples, the ring Y is , , , , , ,  or .

In some examples, the R_7 is , , , , , , , , or absent.

In some examples, the compound is of the Formula (II) :



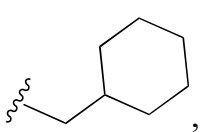
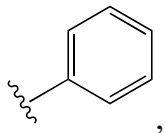
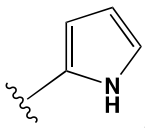
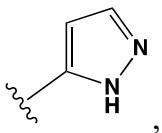
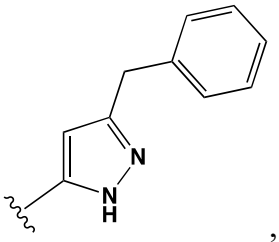
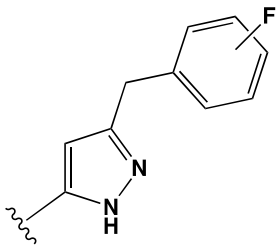
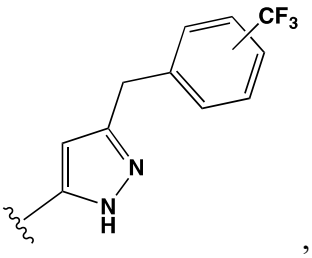
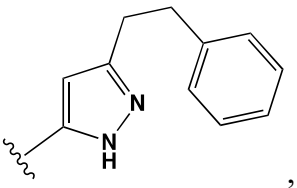
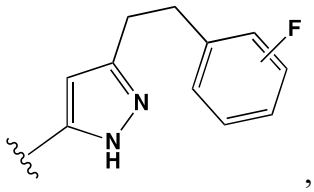
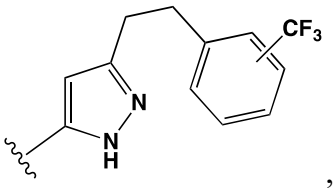
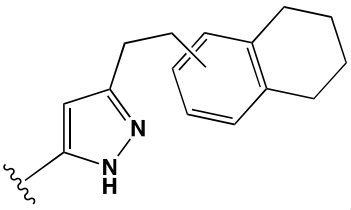
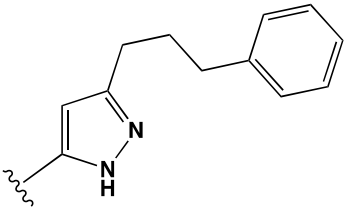
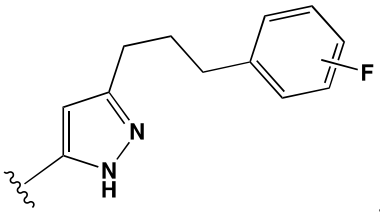
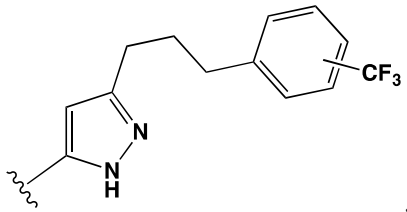
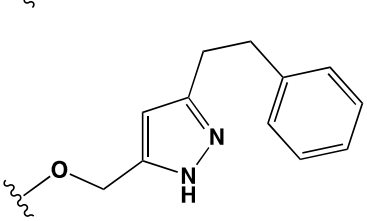
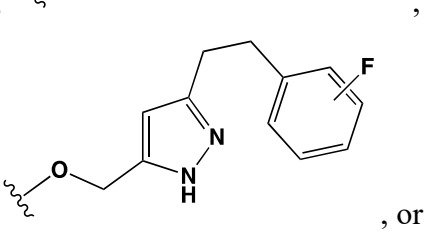
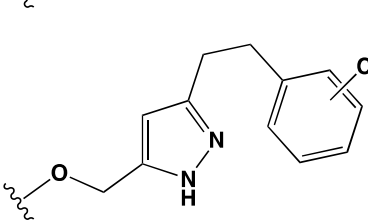
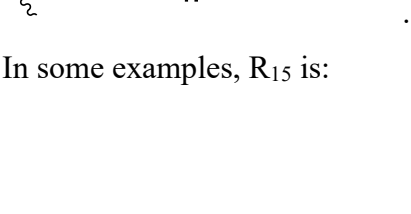
(II), in which

R_9-R_{14} are each independently H, OH, NH_2, halogen, C_{1-3} alkyl, or C_{1-3} alkoxy;

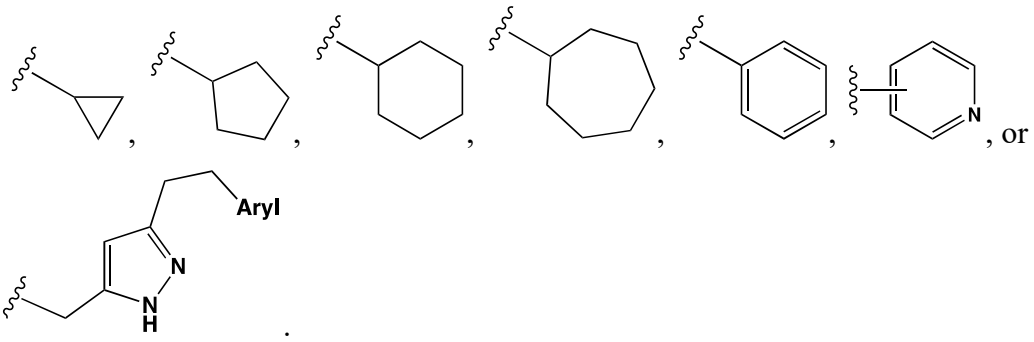
R_8 is H, OH, NH_2, halo, C_{1-3} alkyl, C_{1-3} alkoxy, aryl, heteroaryl, or $O(CO)R_6$; and

R_{15} is H, alkyl, cycloalkyl, aryl, alkylaryl, heteroaryl, or alkylheteroaryl; o is 1, 2, 3, 4, or 5.

In some examples, each of R_9-R_{14} is OH.

In some examples, R_6 is , , , , , , , , , , , , , , , , , , , or .

In some examples, R_{15} is:



In some examples, the compound is selected from the compounds listed in Table 1.

In another aspect, the present disclosure provides a composition comprising any of the compounds disclosed herein and a carrier.

In some examples, the composition is a pharmaceutical composition, a nutraceutical composition, a health food, or a medical food.

The present disclosure also features a method of treating coronavirus infection, comprising administering to a subject in need thereof an effective amount of the compounds or the compositions disclosed herein.

In another aspect, the present disclosure provides a compound as disclosed herein or the composition as disclosed herein for use in treating coronavirus infection.In some examples, the coronavirus virus is selected from the group consisting of SARS-CoV-2, severe acute respiratory syndrome coronavirus (SARS-CoV), middle east respiratory syndrome coronavirus (MERS-CoV), 229E alpha coronavirus, NL63 alpha coronavirus, OC43 beta coronavirus, and HKU1 beta coronavirus.

In some examples, the compound or composition is administered by oral, by injection, by external use, or by inhalation.

In some examples, the composition is placed in a medical device selected from the group consisting of an inhaler, a nebulizer, a nasal spray, and a vaporization aerosol device for administration to the subject.

In some examples, the subject is a human subject.

In some examples, the subject is administered the composition continuously or at a frequency of every five minutes to one time every three months.

In some examples, any of the methods disclosed herein further comprises administering the human subject one or more additional anti-viral agents. In some examples, the one or more additional anti-viral agents comprise a viral entry inhibitor, a viral uncoating inhibitor, a viral reverse transcriptase inhibitor, a viral protein

synthesis inhibitor, a viral protease inhibitor, a viral polymerase inhibitor, a viral integrase inhibitor, an interferon, or the combination thereof.

In some examples, the viral entry inhibitor is selected from the group consisting of maraviroc, enfuvirtide, ibalizumab, fostemsavir, plerixafor, epigallocatechin gallate, vicriviroc, aplaviroc, maraviroc, tromantadine, nitazoxanide, umifenovir, and podofilox.

In some examples, the viral uncoating inhibitor is selected from the group consisting of amantadine, rimantadine, and pleconaril.

In some examples, the viral reverse transcriptase inhibitor is selected from the group consisting of zidovudine, didanosine, zalcitabine, stavudine, lamivudine, abacavir, emtricitabine, entecavir, truvada, nevirapine, raltegravir, and tenofovir disoproxil.

In some examples, the viral protease inhibitor is selected from the group consisting of fosamprenavir, ritonavir, atazanavir, nelfinavir, indinavir, saquinavir, saquinavir, famciclovir, fomivirsen, lopinavir, ribavirin, darunavir, oseltamivir, and tipranavir.

In some examples, the viral polymerase inhibitor is selected from the group consisting of amatoxins, rifamycin, cytarabine, fidaxomicin, tagetitoxin, foscarnet sodium, idoxuridine, penciclovir, sofosbuvir, trifluridine, valacyclovir, valganciclovir, vidarabine, and remdesivir.

In some examples, the viral integrase inhibitor is selected from the group consisting of raltegarvir, elvitegravir, dolutegravir, bictegravir, and cabotegravir.

In some examples, the interferon is selected from the group consisting of type I interferon, type II interferon, type III interferon, and peginterferon alfa-2a.

The present disclosure provides a method of inhibiting D-amino acid oxidase (DAAO) in a subject, comprising administering to a subject in need thereof an effective amount of any of the compounds or the compositions disclosed herein. In some examples, the subject is a human having, suspected of having, or at risk for a central nervous system (CNS) disorder, a metabolic disorder, or pain.

In another aspect, the present disclosure provides a compound as disclosed herein or the composition as disclosed herein for use in treating a central nervous system (CNS) disorder in a subject having the CNS disorder, wherein the CNS disorder is selected from the group consisting of schizophrenia, psychotic disorders, Alzheimer's disease, frontotemporal dementia, vascular dementia, dementia with Lewy bodies, senile dementia, mild cognitive impairment, benign forgetfulness, closed head injury, autistic spectrum disorder, Asperger's disorder, fragile X syndrome, attention deficit hyperactivity disorders, attention deficit disorder, obsessive compulsive disorder, tic disorders, childhood learning disorders, premenstrual syndrome, depression, major depressive disorder, anhedonia, suicidal ideation

and/or behaviors, bipolar disorder, anxiety disorders, panic disorder, post-traumatic stress disorder, chronic mild and unpredictable stress, eating disorders, addiction disorders, personality disorders, Parkinson's disorder, Huntington's disorder, multiple sclerosis, amyotrophic lateral sclerosis, ataxia, Friedreich's ataxia, Tourette's syndrome, nocturnal enuresis, non-epileptic seizures, blepharospasm, Duchenne muscular dystrophy, and stroke.

Exemplary CNS disorders include, but are not limited to, schizophrenia, psychotic disorders, Alzheimer's disease, frontotemporal dementia, vascular dementia, dementia with Lewy bodies, senile dementia, mild cognitive impairment, benign forgetfulness, closed head injury, autistic spectrum disorder, Asperger's disorder, fragile X syndrome, attention deficit hyperactivity disorders, attention deficit disorder, obsessive compulsive disorder, tic disorders, childhood learning disorders, premenstrual syndrome, depression, major depressive disorder, anhedonia, suicidal ideation and/or behaviors, bipolar disorder, anxiety disorders, panic disorder, post-traumatic stress disorder, chronic mild and unpredictable stress, eating disorders, addiction disorders, personality disorders, Parkinson's disorder, Huntington's disorder, multiple sclerosis, amyotrophic lateral sclerosis, ataxia, Friedreich's ataxia,

Tourette's syndrome, nocturnal enuresis, non-epileptic seizures, blepharospasm, Duchenne muscular dystrophy, and stroke.

Exemplary metabolic disorders include, but are not limited to, obesity, hyperlipidemia, hypercholesterolemia, hyperglycemia, hyperinsulinemia, insulin resistance, and diabetes.

Exemplay pain disease include, but are not limited to, psychogenic pain, acute pain, chronic pain, chronic pain syndromes, neuropathic pain, nociceptive pain, and hyperalgesia. For example,

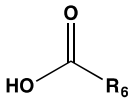
psychogenic pain may be headache, muscle pain, back pain and stomach pain, the neuropathic pain is selected from the group consisting of sciatica, carpal tunnel syndrome, diabetic neuropathy, postherpetic neuralgia, and central pain syndrome, and the nociceptive pain is selected from the group consisting of radicular pain, somatic pain, or visceral pain.

In some examples, the method disclosed herein may further comprise administering to the subject one or more additional pharmaceutical agents (e.g., those disclosed herein) for treating and/or reducing the risk for a CNS disorder.

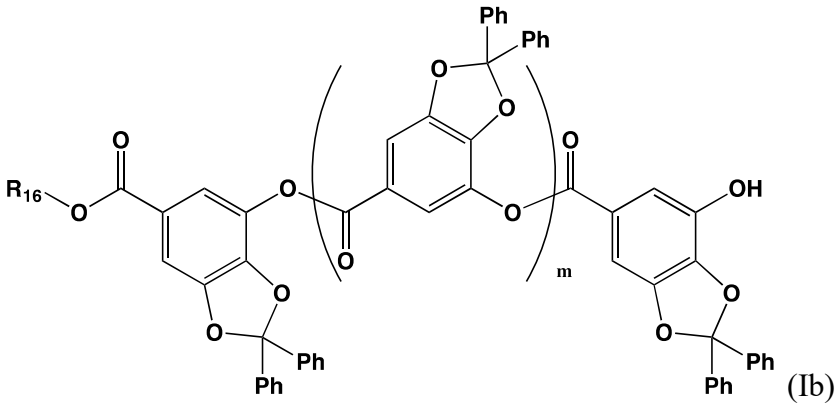
Further, the present disclosure provides methods for preparing the compounds disclosed herein.

In another aspect, the present disclosure provides a method of preparing the compound as disclosed herein,comprising:

(a) providing compounds of formula (Ia) and (Ib)



(Ia),



(Ib)

wherein R_{16} is the group selected from alkyl group, alkylsilyl group, or arylsilyl group;

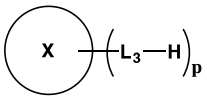
(b) reacting the compound of formula (Ia) with formula (Ib) to produce intermediate I;

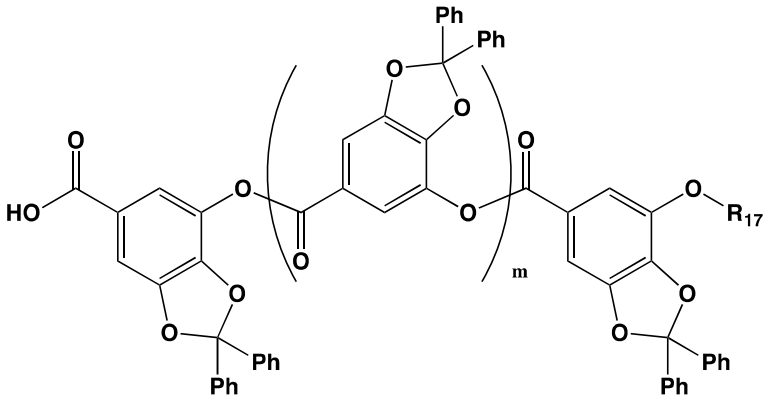
(c) de-protecting the R_{16} group to produce intermediate II; and

(d) de-protecting the cyclic acetal groups and purifying the reaction mixture to obtain a compound as disclosed herein.

The preparation method disclosed herein may comprise:

(a) providing compounds of formula (Ic) and (Id)


(Ic),


(Id)

wherein p = 1, 2, 3, or 4; each of L_3, independently, is a moiety selected from the group consisting of NH, O, S, -((CH_2)$_s$-W)-, or absent; R_{17} is the group selected from benzyl group, allyl group, ethoxylmethyl group, methoxylmethyl group, ethoxylethyl group, alkyl silyl group, or aryl silyl group;

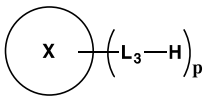
(b) reacting the compound of formula (Ic) with formula (Id), to allow conjugation of formula (Id) to one or more of L_3 of the formula (Ic), thereby producing intermediate III;

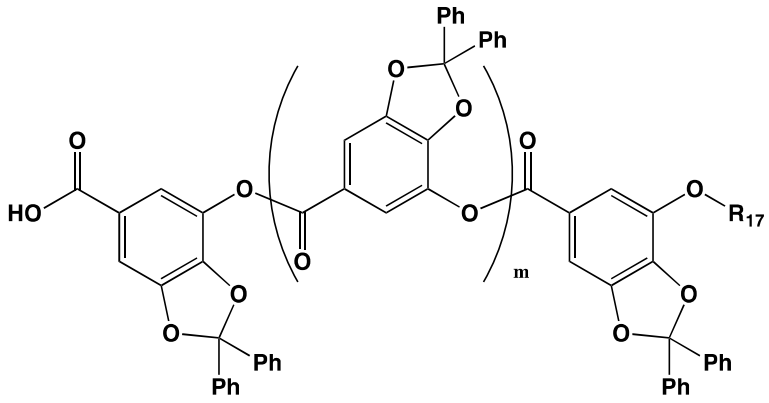
(c) de-protecting the R_{17} group to produce intermediate IV; and

(d) de-protecting the cyclic acetal groups and purifying the reaction mixture to obtain a compound disclosed herein.

In another aspect, the present disclosure provides a method of preparing the compound as disclosed herein, comprising:

(a) providing compounds of formula (Ic) and (Id)


(Ic),


(Id)

wherein p = 1, 2, 3, or 4; each of L_3, independently, is a moiety selected from the group consisting of NH, O, S, -((CH_2)$_s$-W)-, or absent; R_{17} is the group selected from benzyl group, allyl group, ethoxylmethyl group, methoxylmethyl group, ethoxylethyl group, alkyl silyl

group, or aryl silyl group;

(b) reacting the compound of formula (Ic) with formula (Id), to allow conjugation of formula (Id) to one or more of L_3 of the formula (Ic), thereby producing intermediate III;

(c) de-protecting the R_{17} group to produce intermediate IV;

(d) de-protecting the cyclic acetal groups and purifying the reaction mixture to obtain the compound of claim 1; and

(e) reacting the intermediate IV with formula (Ia) to produce intermediate VI.

Any of the preparation methods disclosed herein may further comprise the following step after step (c)

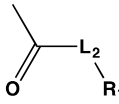
(f) reacting the intermediate II with formula (Ic) and allowing conjugation of the intermediate II to one or more L_3 of the formula (Ic) to produce intermediate V.

In some examples, the method further comprises the following step after step (c):

(e) reacting the intermediate IV with formula (Ia) to produce intermediate VI.

Further, the present disclosure provides a method of preparing the compound (Ia), comprising:

(a) providing compound of formula (Ie);



(Ie);

(b) reacting the compound of formula (Ie) with strong organic base under -78°C to 0°C to produce intermediate VII;

(c) reacting the first intermediate VII with alkyl group protected oxalic acid to produce intermediate VIII;

(d) reacting the second intermediate VIII with a cycloling reagent to produce intermediate IX; and,

(e) de-protecting the alkyl group of the protected oxalic acid to obtain the formula (Ia).

In some examples, the strong organic base in step (b) is alkali alkoxide, alkyl lithium, lithium alkylamide, lithium alkylsilylamide.

In some examples, the cycloling reagent in step (d) is hydrazine, hydrazine hydrate, hydroxyl amine, or any acceptable salts of which thereof.

In some examples, L_1, L_2, and L_3, independently, is a moiety selected from the group consisting of N, O, S, CH_2, C_2H_4, C_3H_6, OCH_2, OC_2H_4, OC_3H_6, NCH_3, NC_2H_5, and C=O.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram showing the effect of compound 66 on locomotion in MK-801 treated mice.

Figure 2 is a diagram showing the effects of compound 66 on pre-pulse inhibition in MK-801 treated mice.

Figure 3 is a diagram showing the effect of compound 74 on locomotion in MK-801 treated mice.

Figure 4 is a diagram showing the effects of compound 74 on pre-pulse inhibition in MK-801 treated mice.

Figure 5 is a diagram showing the effect of compound 121 on locomotion in MK-801 treated mice.

Figure 6 is a diagram showing the effects of compound 121 on pre-pulse inhibition in MK-801 treated mice.

Figure 7 is a diagram showing the effect of compound 138 on locomotion in MK-801 treated mice.

Figure 8 is a diagram showing the effects of compound 138 on pre-pulse inhibition in MK-801 treated mice.

DETAILED DESCRIPTION

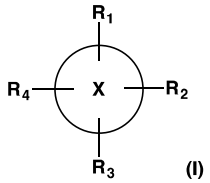
DEFINITIONS

Definitions of specific functional groups and chemical terms are described in more detail below. The chemical elements are identified in accordance with the Periodic Table of the Elements, CAS version, *Handbook of Chemistry and Physics*, 75th Ed., inside cover, and

CLAIMS

What Is Claimed Is:

1. A compound of formula (I):



(I)

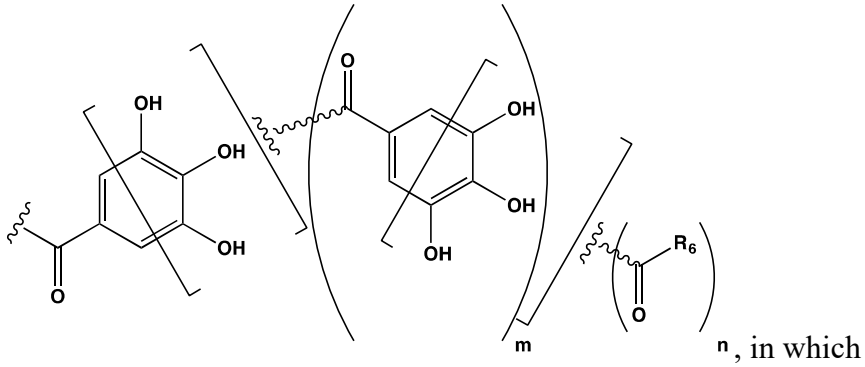
or a pharmaceutically acceptable salt thereof,

wherein:

a) Ring X is a 3 to 7 membered monocyclic ring, which is selected from the group consisting of aryl, heteroaryl, cycloalkyl, and cycloheteroalkyl;

at least one of R_1, R_2, R_3, and R_4 is OR_5 or CH_2OR_5 and the other R_1, R_2, R_3, and R_4 each independently are halogen, OH, OR_5, CH_2OR_5, CO_2H, $OC{=}OR_6$, $(C{=}O)R_6$, R_6, C1-10 alkyl, C2-10 alkenyl, C2-10 alkynyl, H, or absent

R_5 is of the formula

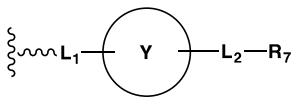


, in which

m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 1, 2, or 3; and

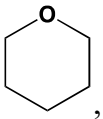
R_6 is of the formula:



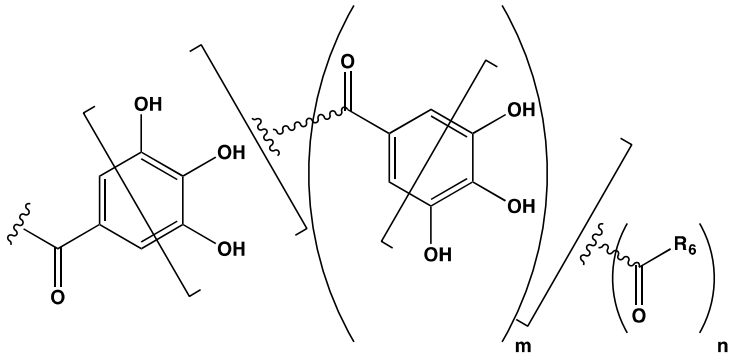
, in which Ring Y is a 3 to 7 membered monocyclic ring, which is selected from the group consisting of aryl, heteroaryl, cycloalkyl, and cycloheteroalkyl;

each of L_1 and L_2, independently, is a moiety selected from the group consisting of N, O, S, CH_2, C=O, $C_{2\text{-}10}$ alkyl, $C_{2\text{-}10}$ alkenyl, $C_{2\text{-}10}$ alkynyl, $-(W-(CH_2)_s)-$, and absent, wherein s is 0, 1, 2, 3, 4, or 5, and W is O, S, or N; and

R_7 is selected from the group consisting of aryl, heteroaryl, aralkyl, C_{2-10} alkyl, C_{2-10} alkenyl, C_{2-10} alkynyl, and H;

b) the X ring is , wherein R_1, R_2, R_3, and R_4 are each OR_5, wherein each of m is 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0;

R_5 is of the formula

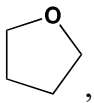


, in which

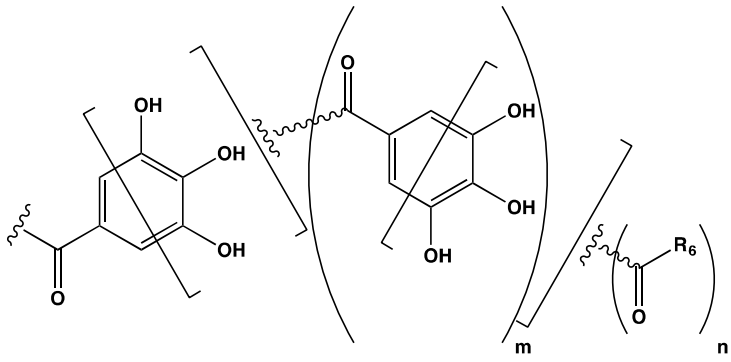
m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 0; and

R_6 is as defined above;

c) X ring is , wherein R_1, R_2, R_3, and R_4 are each OR_5 or CH_2OR_5, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0;

R_5 is of the formula

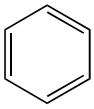


, in which

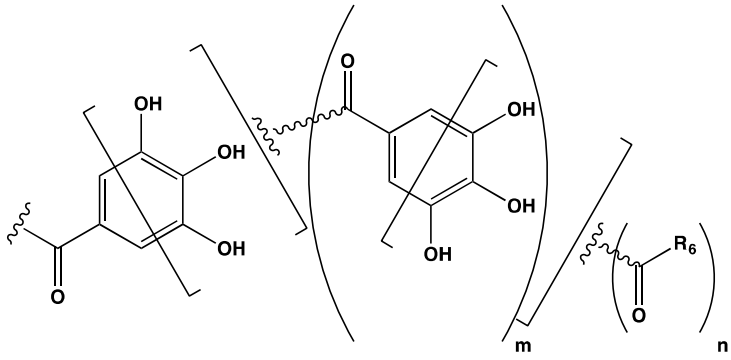
m independently is 1, 2, 3, 4, 5, 6, or 7;

n independently is 0; and

R_6 is as defined above; or

d) the X ring is , wherein R_1, R_2, R_3, and R_4 are each OH, OR_5, or $(C=O)R_6$, at least one of R_1, R_2, or R_3 and R_4 being $(C=O)R_6$, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0;

R_5 is of the formula

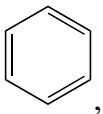


, in which

m independently is 1, 2, 3, 4, 5, 6, or 7;

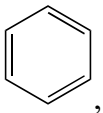
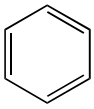
n is 0; and

R_6 is as defined above.

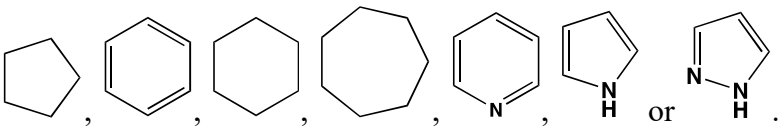
2. The compound of claim 1, wherein the X ring is , wherein R_1, R_2, and R_3 are each OR_5 or $OC=OR_6$, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0 or 1.

3. The compound of claim 2, wherein at least one of R_1, R_2, or R_3 is $OC=OR_6$.

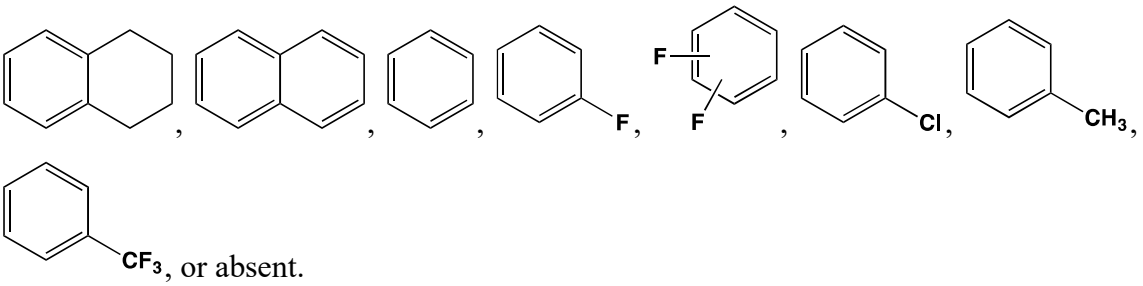
4. The compound of claim 1, wherein the X ring is an aryl, heteroaryl or cycloalkyl ring; wherein R_1, R_2, R_3, and R_4 are each OH, CO_2H, OR_5 or $(C=O)R_6$, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and n is 0 or 1.

5. The compound of claim 4, wherein the X ring is , wherein R_1, R_2, R_3, and R_4, are each OH, CO_2H, OR_5 or $(C=O)R_6$, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 0 or 1 or wherein the X ring is , wherein R_1, R_2, R_3, and R_4 are each OH, CO_2H, or OR_5, wherein m is 0, 1, 2, 3, 4, 5, 6, or 7, and wherein n is 1.

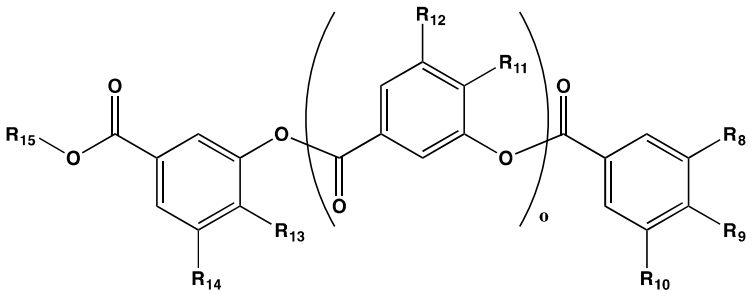
6. The compound of any one of claims 1, 2, 4, and 5 , wherein the ring Y is ,



7. The compound of any one of claims 1, 2, 4, 5, and 6, wherein the R_7 is



8. The compound of claim 1, wherein the compound is of the Formula (II):



(II), in which

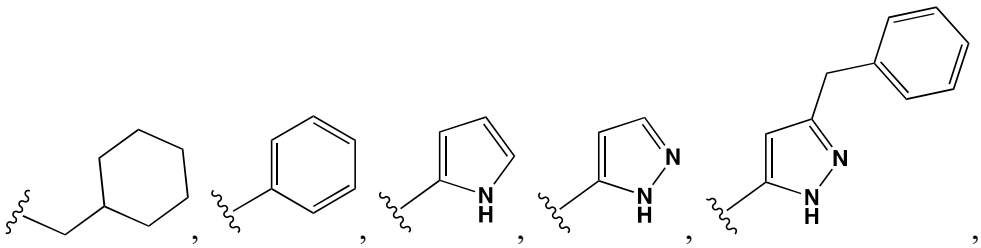
R_9-R_{14} are each independently H, OH, NH_2, halogen, C_{1-3} alkyl, or C_{1-3} alkoxy;

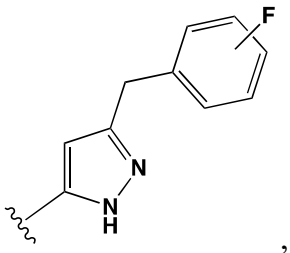
R_8 is H, NH_2, halogen, C_{1-3} alkyl, C_{1-3} alkoxy, aryl, heteroaryl, or $O(CO)R_6$; and

R_{15} is H, alkyl, cycloalkyl, aryl, alkylaryl, heteroaryl, or alkylheteroaryl; o is 1, 2, 3, 4, or 5.

9. The compound of claim 9, wherein each of R_9-R_{14} is OH.

10. The compound of any one of claims 1, 2, 4, 5, 6, and 9 wherein R_6 is





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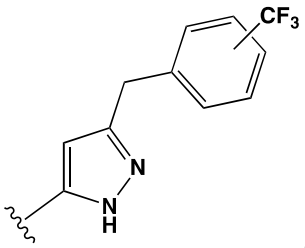

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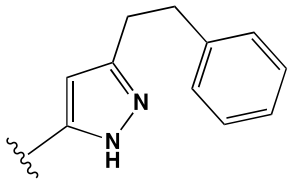

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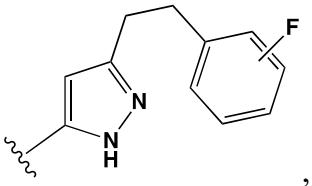

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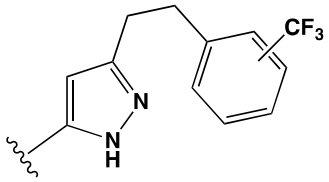

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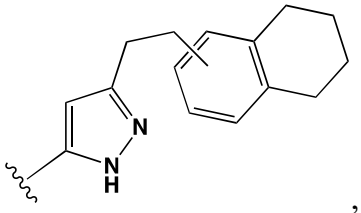

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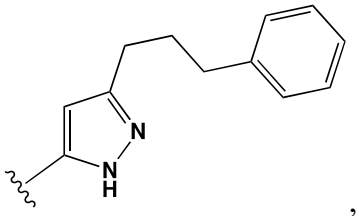

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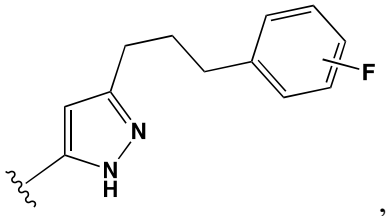

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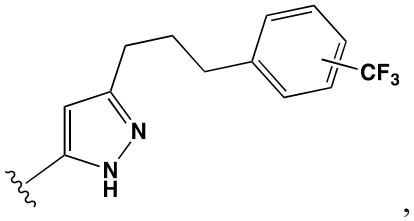

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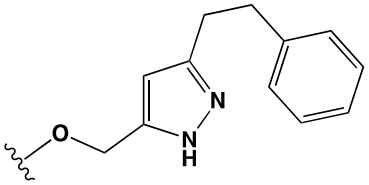

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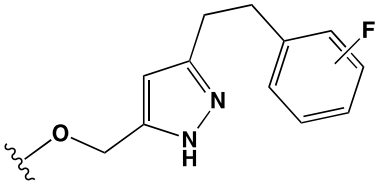

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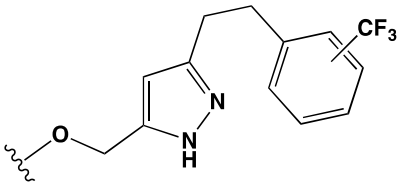

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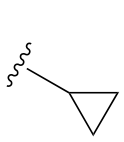
11. The compound of any one of claims 9-10, wherein R_{15} is selected from the group consisting of: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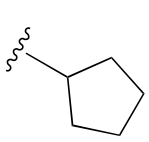
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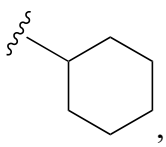
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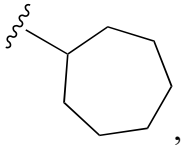
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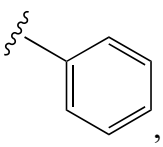
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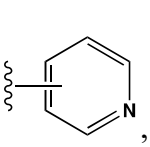
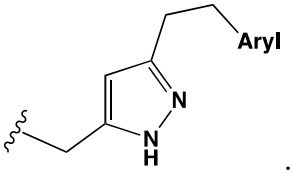


, and


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12. The compound of claim 1, which is selected from the compounds listed in Table 1.

13. A composition, comprising the compound of any one of claims 1-12 and a carrier.

14. The composition of claim 13, wherein the composition is a pharmaceutical composition, a nutraceutical composition, a health food, or a medical food.

15. A compound of any one of claims 1-12 or the composition of claim 13 or claim 14 for use in treating coronavirus infection.

16. The compound or the composition for use of claim 15, wherein the coronavirus virus is selected from the group consisting of SARS-CoV-2, severe acute respiratory syndrome coronavirus (SARS-CoV), middle east respiratory syndrome coronavirus (MERS-CoV), 229E alpha coronavirus, NL63 alpha coronavirus, OC43 beta coronavirus, and HKU1 beta coronavirus.

17. The compound or the composition for use of claim 16, wherein the compound or composition is to be administered by oral, by injection, by external use, or by inhalation; wherein the composition is placed in a medical device selected from the group consisting of an inhaler, a nebulizer, a nasal spray, and a vaporization aerosol device for administration to the subject; or wherein the subject is to be administered the composition continuously or at a frequency of every five minutes to one time every three months.

18. The compound or the composition for use of claim 16 or claim 17, wherein the subject is a human subject.

19. The compound or the composition for use of any one of claims 16 -18, wherein the human subject is subjected to treatment by one or more additional anti-viral agents; wherein the one or more additional anti-viral agents comprise a viral entry inhibitor, a viral uncoating inhibitor, a viral reverse transcriptase inhibitor, a viral protein synthesis inhibitor, a viral protease inhibitor, a viral polymerase inhibitor, a viral integrase inhibitor, an interferon, or the combination thereof.

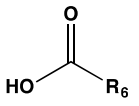
20. The compound or the composition for use of claim 19, wherein the viral entry inhibitor is selected from the group consisting of maraviroc, enfuvirtide, ibalizumab, fostemsavir, plerixafor, epigallocatechin gallate, vicriviroc, aplaviroc, maraviroc, tromantadine, nitazoxanide, umifenovir, and podofilox; wherein the viral uncoating inhibitor is selected from the group consisting of amantadine, rimantadine, and pleconaril; wherein the viral reverse transcriptase inhibitor is selected from the group consisting of zidovudine, didanosine, zalcitabine, stavudine, lamivudine, abacavir, emtricitabine, entecavir, truvada, nevirapine, raltegravir, and tenofovir disoproxil;, wherein the viral protease inhibitor is selected from the group consisting of fosamprenavir, ritonavir, atazanavir, nelfinavir, indinavir, saquinavir, saquinavir, famciclovir, fomivirsen, lopinavir, ribavirin, darunavir, oseltamivir, and tipranavir; wherein the viral polymerase inhibitor is selected from the group consisting of amatoxins, rifamycin, cytarabine, fidaxomicin, tagetitoxin, foscarnet sodium, idoxuridine, penciclovir, sofosbuvir, trifluridine, valacyclovir, valganciclovir, vidarabine, and remdesivir; wherein the viral integrase inhibitor is selected from the group consisting of raltegarvir, elvitegravir, dolutegravir, bictegravir, and cabotegravir, or wherein the interferon is selected from the group consisting of type I interferon, type II interferon, type III interferon, and peginterferon alfa-2a.

21. A compound of any one of claims 1-12 or the composition of claim 13 or claim 14 for use in treating a central nervous system (CNS) disorder in a subject having the CNS disorder, wherein the CNS disorder is selected from the group consisting of schizophrenia, psychotic disorders, Alzheimer's disease, frontotemporal dementia, vascular dementia, dementia with Lewy bodies, senile dementia, mild cognitive impairment, benign forgetfulness, closed head injury, autistic spectrum disorder, Asperger's disorder, fragile X syndrome, attention deficit hyperactivity disorders, attention deficit disorder, obsessive compulsive disorder, tic disorders, childhood learning disorders, premenstrual syndrome, depression, major depressive disorder, anhedonia, suicidal ideation and/or behaviors, bipolar disorder, anxiety disorders, panic disorder, post-traumatic stress disorder, chronic mild and unpredictable stress, eating disorders, addiction disorders, personality disorders, Parkinson's disorder, Huntington's disorder, multiple sclerosis, amyotrophic lateral sclerosis, ataxia, Friedreich's ataxia, Tourette's syndrome, nocturnal enuresis, non-epileptic seizures, blepharospasm, Duchenne muscular dystrophy, and stroke.

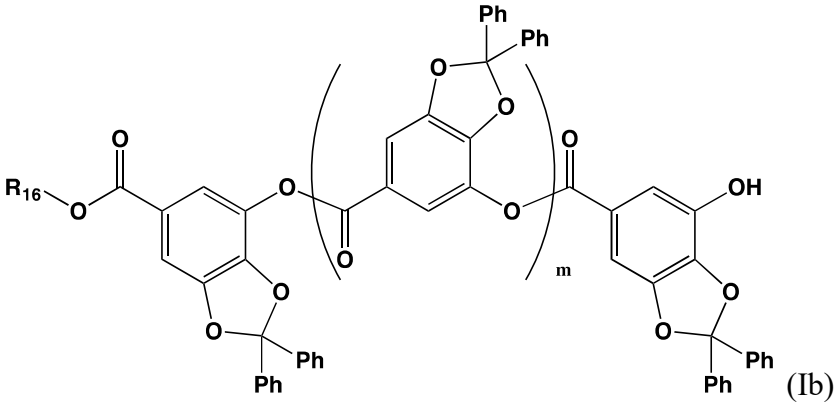
22. The compound or the composition for use of claim 21, wherein the human subject is subjected to treatment by one or more additional pharmaceutical agents for treating and/or reducing the risk for a CNS disorder.

23. A method of preparing the compound of claim 1, comprising:

(a) providing compounds of formula (Ia) and (Ib)



(Ia),



(Ib)

wherein R_{16} is the group selected from alkyl group, alkylsilyl group, or arylsilyl group;

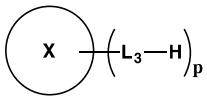
(b) reacting the compound of formula (Ia) with formula (Ib) to produce intermediate I;

(c) de-protecting the R_{16} group to produce intermediate II; and

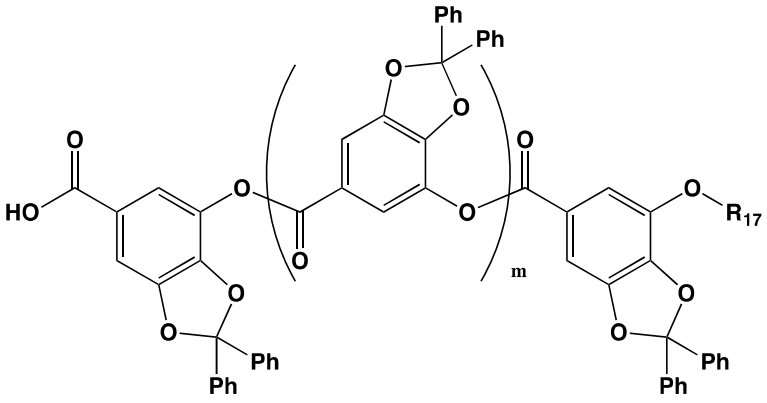
(d) de-protecting the cyclic acetal groups and purifying the reaction mixture to obtain the compound of claim 1.

24. A method of preparing the compound of claim 1, comprising:

(a) providing compounds of formula (Ic) and (Id)



(Ic),



(Id)

wherein p = 1, 2, 3, or 4; each of L_3, independently, is a moiety selected from the group consisting of NH, O, S, -($(CH_2)_s$-W)-, or absent; R_{17} is the group selected from benzyl group, allyl group, ethoxylmethyl group, methoxylmethyl group, ethoxylethyl group, alkyl silyl group, or aryl silyl group;

(b) reacting the compound of formula (Ic) with formula (Id), to allow conjugation of formula (Id) to one or more of L_3 of the formula (Ic), thereby producing intermediate III;

(c) de-protecting the R_{17} group to produce intermediate IV;

(d) de-protecting the cyclic acetal groups and purifying the reaction mixture to obtain the compound of claim 1; and

(e) reacting the intermediate IV with formula (Ia) to produce intermediate VI.

25. The method of claim 24, further comprising, after step (c),

(f) reacting the intermediate II with formula (Ic) and allowing conjugation of the intermediate II to one or more L_3 of the formula (Ic) to produce intermediate V.