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(54) Titre : GLUCIDES MEDICAUX POUR TRAITEMENT D'ETATS RESPIRATOIRES
(54) Title: MEDICINAL CARBOHYDRATES FOR TREATMENT OF RESPIRATORY CONDITIONS

(57) **Abrégé/Abstract:**

The present invention relates to a method and compounds of Formula (1) and/or (2) or their pharmaceutically acceptable inorganic or organic salt thereof, and their compositions for treating respiratory conditions including post viral/bacterial infections, acute/chronic bronchitis, COPD, cystic fibrosis, and inflammatory conditions. It has been found by the applicants that the compounds of Formula (1) and/or (2) or their pharmaceutically acceptable inorganic or organic salt thereof could speed up the recovery of the viability of damaged respiratory tract cells by restoring sialylglyco- conjugates on their surface.



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(54) Title: MEDICINAL CARBOHYDRATES FOR TREATMENT OF RESPIRATORY CONDITIONS

(57) Abstract: The present invention relates to a method and compounds of Formula (1) and/or (2) or their pharmaceutically acceptable inorganic or organic salt thereof, and their compositions for treating respiratory conditions including post viral/bacterial infections, acute/chronic bronchitis, COPD, cystic fibrosis, and inflammatory conditions. It has been found by the applicants that the compounds of Formula (1) and/or (2) or their pharmaceutically acceptable inorganic or organic salt thereof could speed up the recovery of the viability of damaged respiratory tract cells by restoring sialylglyco- conjugates on their surface.



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MEDICINAL CARBOHYDRATES FOR TREATMENT OF RESPIRATORY
CONDITIONS

FIELD OF THE INVENTION

5 This invention is related to a novel method and a group of carbohydrates of Formula (1) and/or (2), and their compositions for treating cough and related respiratory conditions including post viral/bacterial infections, acute/chronic bronchitis, COPD, and inflammatory conditions.

BACKGROUND OF THE INVENTION

10

In humans, the respiratory tract, with an area of a football field is the largest surface connecting the body with the outside world required for sufficient exchange of air; meanwhile, it is affected by many physical, chemical, and biological substances in the air to cause disorders including asthma, chronic obstructive pulmonary disease,
15 inflammatory conditions of the lung and respiratory tract. Also, some genetic disorders such as cystic fibrosis are affected by the respiratory tract's connection with the outside world. Viruses and bacteria may enter the body and cause infections in the respiratory tract to occur.

20

Cough is one of the common conditions that needs to be treated. However, the currently available treatments are only limited in symptom relief leaving the body to recover by itself and in many cases the recoveries are sluggish.

25

In Australia, the sale of cough syrup is over \$20 million a year. It is estimated that the worldwide market of cough syrup exceeds \$1 billion per annum.

30

Persistent cough sometimes with period of normality lasting for months or even years is attributed to bronchial asthma, occult reflex, or post viral/bacterial infections and smoking causing the airway to become hypersensitive/hyperreactive. Accordingly
there is a need for an efficient treatment that can assist the body to recover after it
has been affected by many physical, chemical, and biological substances in the air
that can cause disorders in the respiratory system.

The discussion of documents, acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

SUMMARY OF THE INVENTION

The present invention provides in one aspect of the invention a method of promoting restoration of a sialylglycoconjugate on the surface of a damaged respiratory cell of a subject to treat a respiratory condition in the subject, the method including the step of administering to the subject at least one pharmaceutically acceptable compound capable of accelerating sialylglycoconjugate biosynthesis.

In one embodiment, the method provides a recovery of viability of the cell such that the cell is in a better condition for normal biological function to respond to factors which may affect the respiratory surface thereby leading to respiratory conditions such as but not limited to coughs, post viral or bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD), cystic fibrosis and other respiratory inflammatory conditions.

In another embodiment, the present invention provides for the use of a compound selected from the group consisting of compounds of Formula (1) and Formula (2) and their pharmaceutically acceptable salts and derivatives and combinations thereof. The use is for the treatment or prevention of a respiratory condition as herein described.

In other aspects of the invention there are provided compositions and pharmaceutical compositions comprising at least one pharmaceutically acceptable compound capable of accelerating sialylglycoconjugate biosynthesis for use in the treatment and prevention of respiratory conditions.

In yet another aspect of the invention there is provided a method of screening for a compound for the treatment of a respiratory condition, said method comprising:

subjecting a cell having reduced sialylglycoconjugates on a surface of the cell to a test compound; and

measuring recovery of sialylglycoconjugates on the surface of the cell after exposure of the test compound to the cell.

5

Measurement of the recovery of sialylglycoconjugates on the surface of the cell can be determined by a measurement of the viability of the cell.

In yet another aspect of the invention there is provided a method of treating or preventing a respiratory condition in a subject, the method including the step of administering to the subject at least one compound identified by the screening method.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows the biosynthesis pathway of sialylglycoconjugates in living cell.

15

DETAILED DESCRIPTION OF THE INVENTION

From cell biology and molecular biology point of view, the hypersensitivity/hyperreactivity of the damaged respiratory tract may be caused by their damaged cell surface which then will be susceptible to the stimulation of irritants.

For instance, applicants have found that the respiratory tract cells after viral or bacterial infection often lost terminal sialic acids on their surface sialylglycoconjugates. As a consequence, the viability of the "naked" cell was reduced. This then triggered an inflammatory response leading to bronchitis and cough. Without being limited by theory, it is postulated that restoration of the sialic acids on the cell surface may repair the respiratory tract damaged by infection or other physical, chemical, biological factors, to eventually cure the bronchitis, and stop the cough.

Applicants have now shown in this application cell culture experiments conducted in two human respiratory tract cell lines: Small Airways Epithelial Cells (SAEC) and Normal Human Bronchial/Tracheal Epithelial Cells (NHBE). The cells were originally treated with neuraminidases (NAs) from influenza virus or bacteria. The NAs cleave the sialic acids from the cell surface sialylglycoconjugates. As a consequence, the viability of the "naked" cells was reduced. For example, SAEC lost more than 25%

viability when treated with *C. perfringens* NA at a final concentration of 0.01U/ml, or with influenza virus NWS/G70C NA at a final concentration of 0.17µg/well. Similar results were also obtained in the NHBE cell line. After the cells were treated with NA, the cells were washed to remove NA, then incubated with compounds of Formula (1) and/or (2) for 24 hrs. Eventually the cells' viabilities were determined. The results (Examples 7-36) showed that a group of carbohydrates of Formula (1) and/or (2) could help the recovery of the viability of the damaged respiratory tract cells by restoring the sialylglycoconjugates on their surface.

10 Accordingly, the present invention provides in one aspect of the invention a method of promoting restoration of a sialylglycoconjugate on the surface of a damaged respiratory cell of a subject to treat a respiratory condition in the subject, the method including the step of administering to the subject at least one pharmaceutically acceptable compound capable of accelerating sialylglycoconjugate biosynthesis.

15

The present invention provides in another aspect of the invention a method of promoting recovery of cell viability of a damaged respiratory cell of a subject to treat a respiratory condition in the subject, the method including the step of administering to the subject at least one pharmaceutically acceptable compound capable of accelerating sialylglycoconjugate biosynthesis.

20

The promotion of the restoration of a sialylglycoconjugate on the surface of a respiratory cell may also indicate the recovery of the cell to a viable state or recovery of viability such that the cell is in a better condition for normal biological function to respond to factors which may affect the respiratory surface thereby leading to respiratory conditions such as but not limited to coughs, post viral or bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD), cystic fibrosis and other respiratory inflammatory conditions.

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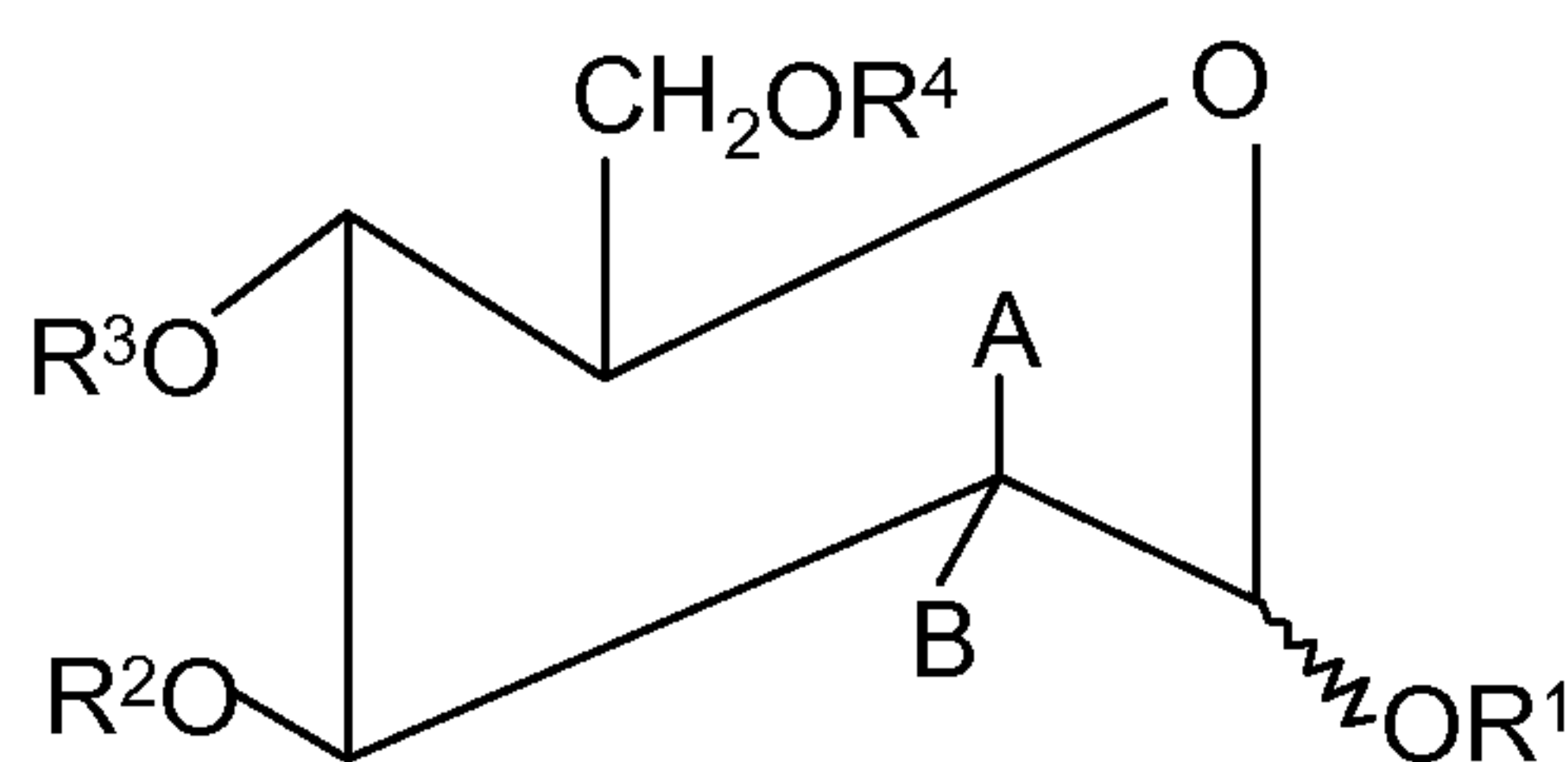
30 In another embodiment, at least one pharmaceutically acceptable compound is selected from the group consisting of carbohydrates capable of participating as intermediates in sialylglycoconjugate biosynthesis, precursors thereof and prodrugs thereof and their pharmaceutically acceptable salts and derivatives and combinations thereof..

The compounds mentioned above may be used orally, by inhalation or injection administration for the treatment of the respiratory conditions selected from the group comprising coughs, post viral or bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD), cystic fibrosis and other respiratory inflammatory conditions..

Throughout the description and claims of this specification, the word “comprise” and variations of the word, such as “comprising” and “comprises”, is not intended to exclude other additives, components, integers or steps.

In another embodiment, the present invention provides for the use of a compound selected from the group consisting of;

compounds of Formula (1):



Formula (1)

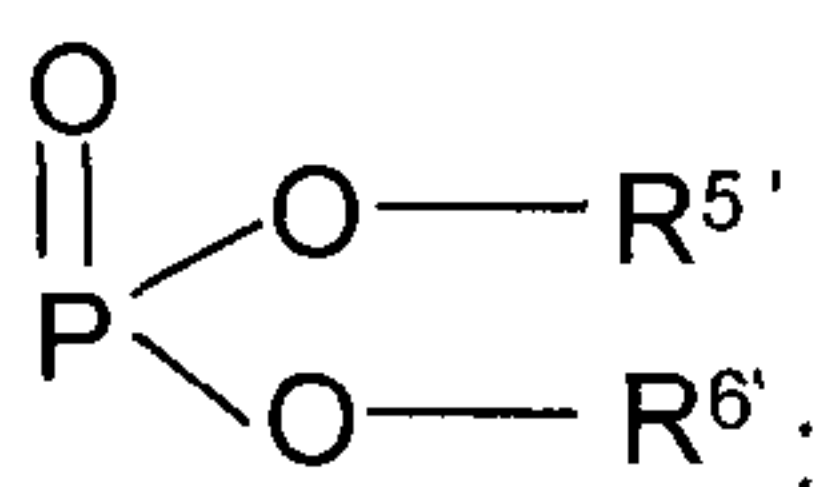
Wherein,

When B=H, A could be NHCOCH₃, NH₂, OH, NH₂·HX or when A=H, B could be NHCOCH₃, NH₂, NH₂·HX, HX could be pharmaceutically suitable inorganic or organic acids, such as hydrochloric acid, sulfuric acid, phosphoric acid, acetic acid, citric acid etc;

R¹, R², R³, R⁴ could be the same or different. They could be H, CH₃, (CH₂)_nCH₃ (n=1~20), CH₂Ph, COCR⁵R⁶R⁷, CO-active esters, such as piva ester, indenyl ester;

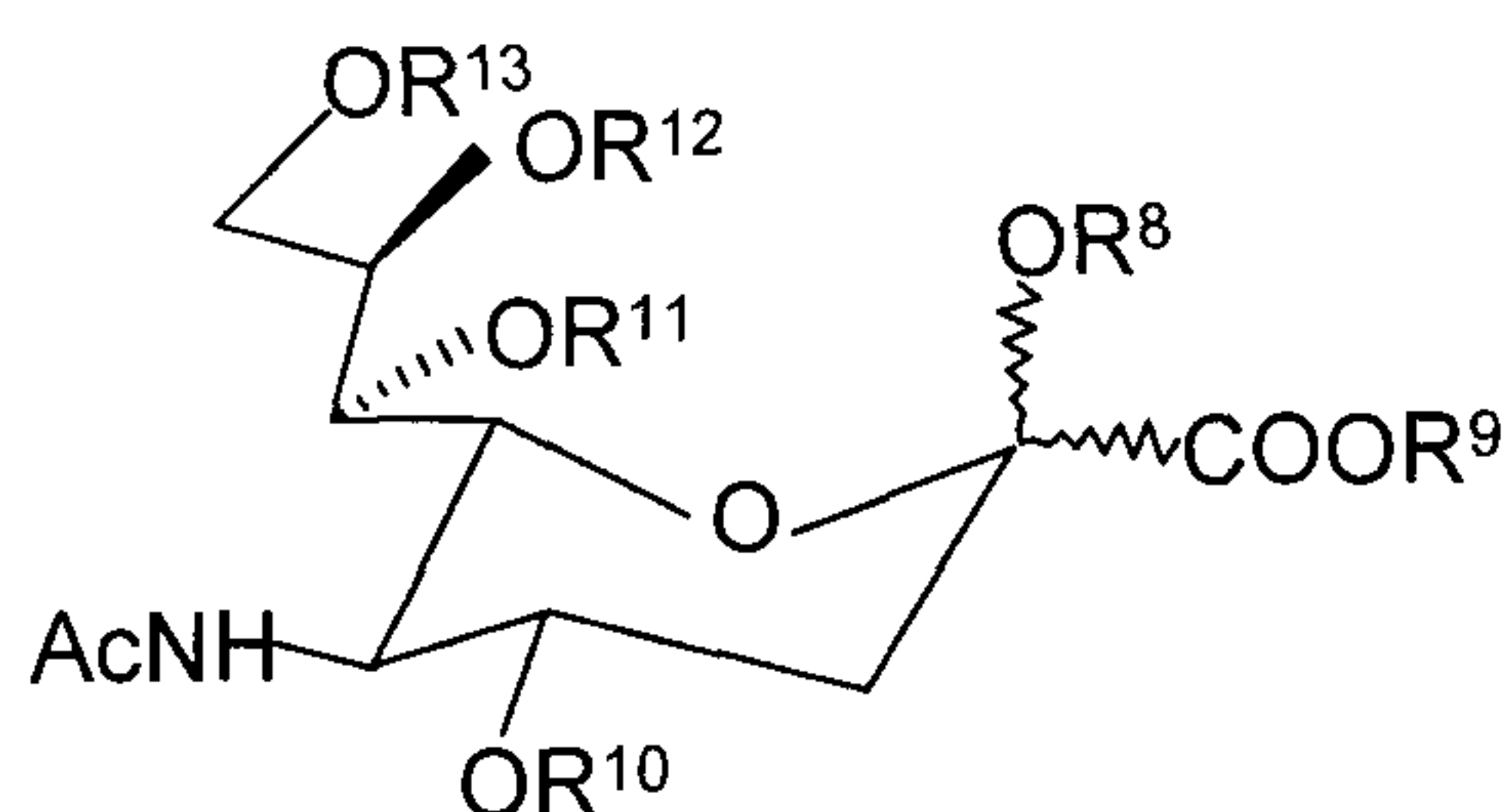
R⁵, R⁶, R⁷ could be the same or different. They could be H, CH₃, (CH₂)_nCH₃ (n=1~20), C₆H₅, CH₂Ph, CH₃CH₂(OCH₂CH₂)_mCH₃ (m=1~200); and

, R⁴ may be



R^{5'}, R^{6'} could be the same or different. They may be H, or a pharmaceutically suitable inorganic or organic salt, such as, Na, K, Ca, Mg, Zn, NH₃, triethylamine etc., or R^{5'}, R^{6'} could be a pharmaceutically suitable ester, such as (CH₂)_nCH₃ (n=1~20) or
 5 CH₃CH₂(OCH₂CH₂)_mCH₃ (m=1~200) or active ester, such as piva ester, indenyl ester;

and compounds of Formula (2)



Formula (2)

10

Wherein,

R⁸ could be H, CH₃, (CH₂)_nCH₃ (n=1~20), CH₂Ph, COCH₂Ph, CO-active ester, such as piva ester, indenyl ester, COCR¹⁴R¹⁵R¹⁶; wherein R¹⁴, R¹⁵, R¹⁶ could be the same or different. They could be H, CH₃, (CH₂)_nCH₃ (n=1~20), C₆H₅, CH₂Ph,
 15 CH₂CH₂(OCH₂CH₂)_mCH₃ (m=1~200);

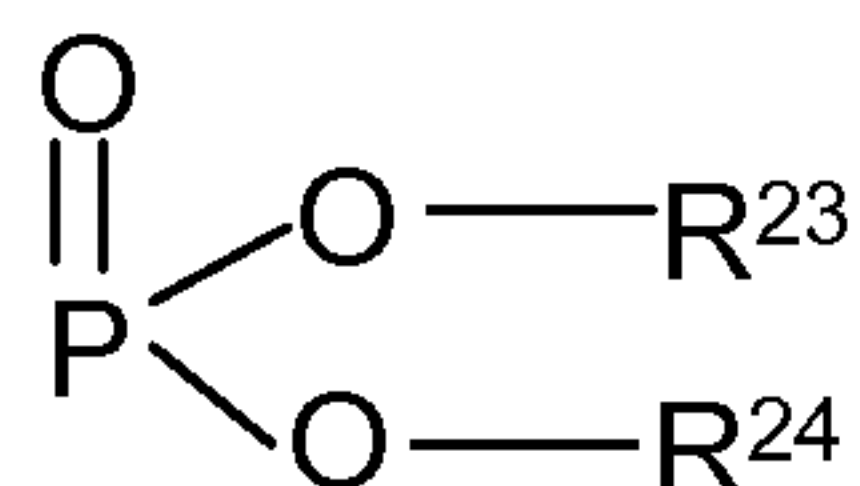
R⁸ may be cytidine, cytidine monophosphate, cytidine diphosphate, cytidine triphosphate, adenosine, adenosine monophosphate, adenosine diphosphate, adenosine triphosphate;

R⁹ may be H, CH₃, pharmaceutically acceptable inorganic or organic salt, such as Na, K, Ca, Mg, Zn, NH₃, triethylamine, etc., or a pharmaceutically suitable active ester, such as piva ester, indenyl ester etc., or CH₂CR¹⁷R¹⁸R¹⁹ wherein R¹⁷, R¹⁸, R¹⁹ may be the same or different. They could be H, CH₃, (CH₂)_nCH₃ (n=1~20), CH₂CH₂(OCH₂CH₂)_mCH₃ (m=1~200), C₆H₅, CH₂Ph;
 20

R¹⁰, R¹¹, R¹², R¹³ could be the same or different. They could be H, CH₃, (CH₂)_nCH₃ (n=1~20), CH₂Ph, active ester, such as piva ester, and COCR²⁰R²¹R²², wherein
 25

R^{21} , R^{22} could be the same or different. They could be H, CH_3 , $(CH_2)_nCH_3$ ($n=1\sim20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1\sim200$);

R^{13} may be



- 5 R^{23} , R^{24} could be the same or different. They could be H, CH_3 , $(CH_2)_nCH_3$ ($n=1\sim20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1\sim200$), CH_2Ph , or active ester, such as piva ester, indenyl ester or $CH_2CR^{25}R^{26}R^{27}$, or pharmaceutically acceptable inorganic or organic salt, such as Na, K, Ca, Mg, Zn, NH_3 , triethylamine etc and R^{25} , R^{26} , R^{27} may be the same or different. They could be H, CH_3 , $(CH_2)_nCH_3$ ($n=1\sim20$), C_6H_5 , CH_2Ph .

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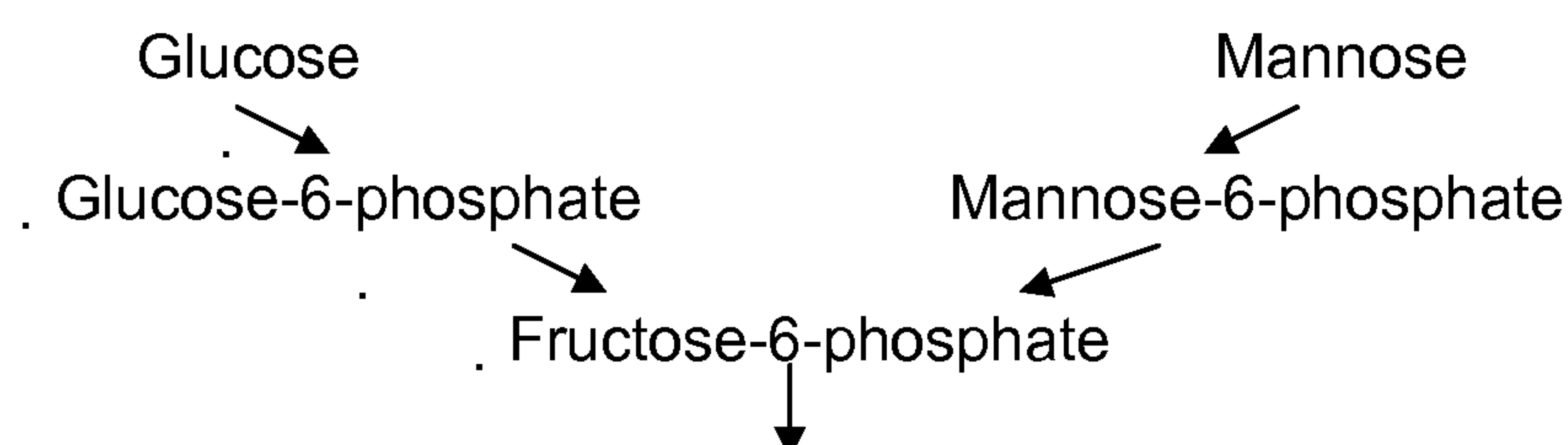
In one embodiment in Formula (1) when $A=NHCOCH_3$, $B=H$, R^1 , R^2 , R^3 , $R^4=H$, the compound is N-acetyl-D-mannosamine. This will be referred to as Compound (1) throughout this specification.

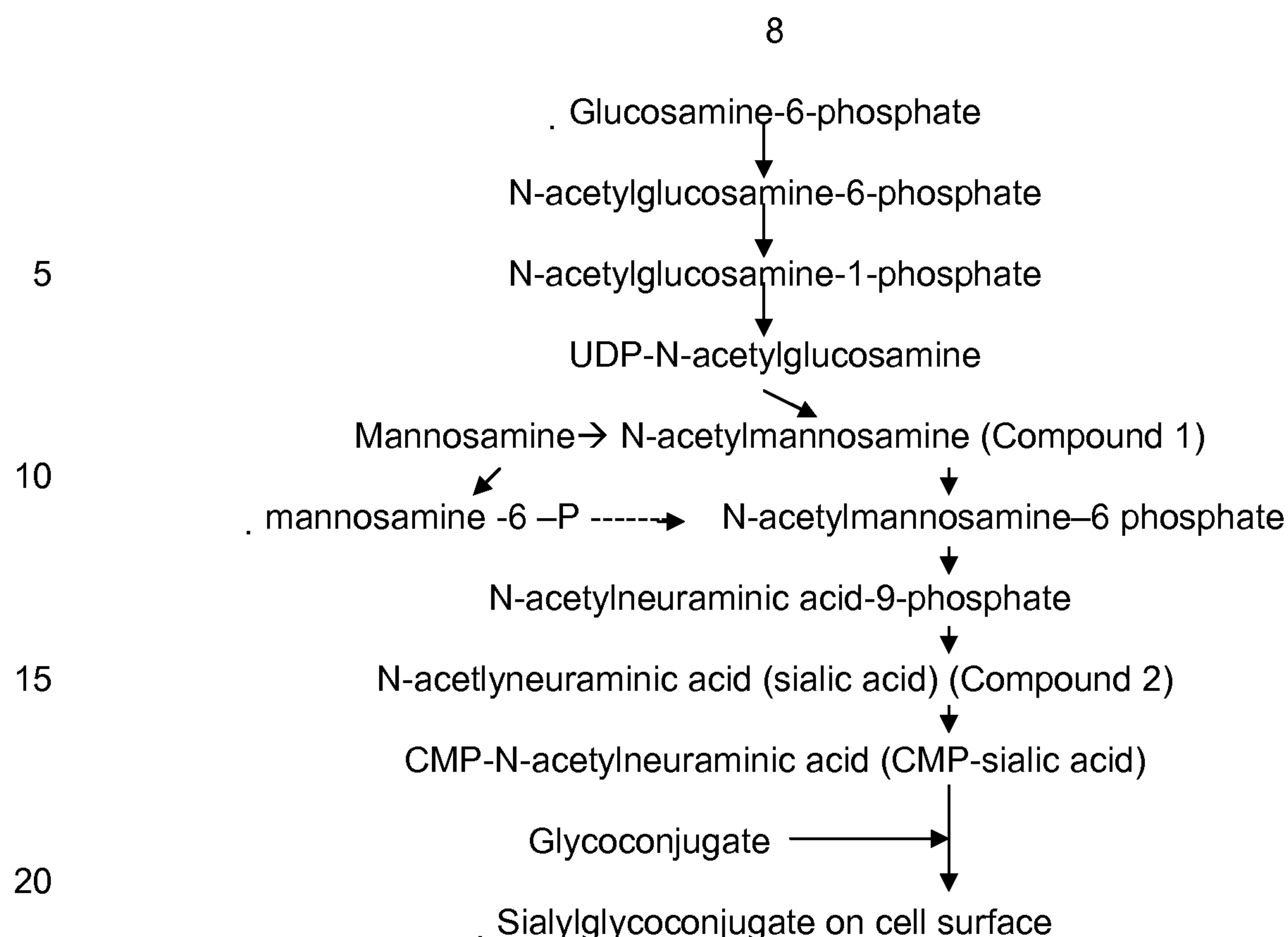
- 15 In another embodiment in Formula (2) when R^8 , R^{10} , R^{11} , R^{12} , $R^{13}=H$, $R^9=Na$, the compound is N-acetylneuraminic acid sodium salt. (Sialic acid sodium salt). This will be referred to as Compound (2) throughout this specification.

20 When R^8 is cytidine monophosphate, and R^9 , R^{10} , R^{11} , R^{12} , $R^{13}=H$, the compound is CMP-sialic acid.

Sialic acids as terminal sugars on the oligosaccharide chains of glycoconjugate on the surface of cell are well suited as molecular determinants of specific biological processes such as cellular adhesion ^[1], formation or masking of recognition determinants^{[2][3]} and stabilization of the structure of glycoproteins^[4]. The biosynthesis pathway of sialylglycoconjugates in living cell is shown below in Figure 1^[5].

30 **Figure 1 - The biosynthesis pathway of sialylglycoconjugates in living cell**





It was reported that N-acetylneuraminic acid, but not lactose, dose-dependently protected against the impairment of the mucocilliary transport^[6]. Furthermore, pre-treatment with repeated administrations (inhalations) of N-acetylneuraminic acid remarkably prevented the inflammatory changes caused by long term exposure of SO₂ in rabbits^[7]. It was also reported that oral administration of N-acetyl-D-mannosamine to mammals was rapidly metabolized into glucose^[8]. It was also reported that methods of administering N-acetylmannosamine or its derivative (to produce sialic acid in patients who are deficient in the sugar molecule) to treat muscular atrophy including hereditary inclusion body myopathy (HIMB) and distal myopathy with rimmed vacuoles (Nonaka myopathy). Certain kidney conditions such as those arising from hyposialytion of kidney membranes may be treated by this method as well^{[8b] [8c]}.

However, none of these treatments related to the use of these intermediates for the treatment of respiratory conditions.

Compounds of Formula (1) and/or (2) have been tested for safety by the applicants. For example, Compounds (1) and (2) were used in a tolerance and subchronic toxicity

study on Balb-C mice (AEC Approval Code: BAM/ B / 2005 /16). The results for the tolerance study showed that both compounds at 5g/Kg for oral dose or 2g/Kg for intraperitoneal dose were well tolerated. In the subchronic toxicity study, the results showed that both compounds at 1g/Kg/day x 30 days for oral dose or 0.5g/Kg/day x 30 days for intraperitoneal dose were non-toxic.

A guinea pig cough model was also established by the applicants. Compounds (1) and (2) were tested in this model. At an oral dose of 500mg/kg/day X 3days, both compounds could restore the respiratory tract damages caused by neuraminidase in guinea pigs. These *in vivo* results are in line with the *in vitro* data. Thus, both the efficacy and safety data support compounds of Formula (1) and/or (2) and particularly compounds (1) and (2) may be useful for medicinal applications.

It has been found by the applicants that the compounds of Formula (1) and/or (2) could speed up the recovery of the viability of damaged respiratory tract cells by restoring sialylglyco- conjugates on their surface.

The compounds of Formula (1) and/or (2) enhance the production of sialylglycoconjugates after entering the cells. Thus, one aspect of this invention relates to the use of compounds of Formula (1) and/or (2), and their pharmaceutically acceptable salts and derivatives and combinations thereof. or their mixtures as active therapeutic agents for the treatment of cough, and related respiratory conditions including post viral/bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD), cystic fibrosis and inflammatory conditions.

Pharmaceutically acceptable compositions of the compounds of Formula (1) and/or (2) and their mixtures may also be formed by combining them with one or more other active ingredients for the treatment of respiratory conditions. For example, choline theophyllinate (bronchodilator), theophylline (bronchodilator), salbutamol and terbutaline sulfate (relief of bronchospasm associated with asthmas and other respiratory conditions), bromhexine (expectorant, mucolytic), codeine, pholcodeine (analgesic, antitussive), clofedanol (antitussive), pentoxyverine (antitussive), dimethoxanate, glaucine (antitussive), promdate, taloximine, acetyl piperacetamide, eucalyptus oil, ammonium chloride, and herbs such as fritillariae cirrhosae (anti-cough

herb). Mucin synthesis inhibitors such as talniflumate, 2-amino-phenyl-acetic acids, or combining with some glucocorticoids such as flunisolide (antiasthmatic), or combining with symptom relief pharmaceutically compatible cough syrups, or combining with phosphodiesterase-4 inhibitor, such as cilomilast (Ariflo) for the
5 treatment of chronic obstructive pulmonary disease (COPD).

Furthermore, pharmaceutically acceptable compositions of the compounds of Formula (1) and/or (2) and their pharmaceutically acceptable salts and derivatives and combinations thereof. and their mixtures may also be formed by combining them
10 with one or more other active ingredients, for example, antiviral agents such as zanamivir and/or oseltamivir (anti-influenza virus agents), pleconaril and/or enviroxime (anti-rhinovirus agents). antimicrobial agents, such as antibiotics, for example, erythromycins, tetracyclines, rifamycins, penicillins, cephalosporins; quinolones, fluoroquinolones; sulfonamides, and trimethoprim; antifungal agents, such
15 as, amphotericins, clotrimazole, econazole, fluconazole, flucytosine, etc.

References to the compounds of Formula (1) and/or (2) herein include the compounds of Formula (1) and/or (2), and their pharmaceutically acceptable derivatives and salts thereof.

20

In a further or alternative embodiment there is provided a method for the treatment or prevention of respiratory conditions including post viral/bacterial infections, acute/chronic bronchitis, COPD, cystic fibrosis and inflammatory conditions in animals including humans comprising administering of an effective amount of the compounds
25 of Formula (1) and/or (2).

There is also provided in a further or alternative aspect the use of the compounds of Formula (1) and/or (2) in the manufacture of a medicament for the treatment of respiratory conditions including post viral/bacterial infections, acute/chronic bronchitis,
30 COPD, cystic fibrosis and inflammatory conditions in animals including humans.

The amount of the compounds of Formula (1) and/or (2) required for use in treatment will vary with the route of administration, the nature of the condition being treated and

the age and condition of the animal (including human patients), and will ultimately be at the discretion of the attendant veterinarian or physician.

5 In general a suitable dose will be in the range of from about 0.1mg to 500mg/kg of body weight per day, preferably in the range of 0.1mg to 50mg/kg/day.

10 In general, the dosage for oral administration would be 1mg/kg/day to 500mg/kg/day, the dose for injection would be 1mg/kg/day to 100 mg/kg/day. The dose for inhalation would be 0.01mg/kg/day to 5mg/kg/day. Preferably, the dose would be 5mg to 50mg/kg for oral or injection administration, two to three times a day for 5 to 10 days; the dose would be 0.1 to 0.5mg/kg for inhalation, one to five times a day for a period of 5 to 10 days.

15 Treatment is preferably commenced after or at the time the cough or related conditions occur and continues until the cough or related conditions ceased. Suitably treatment is given 1 to 4 times daily and continued for 3 to 30 days.

20 The desired dose may be presented in a single dose or as divided doses administered at appropriate intervals, for example as two, three, four or more sub-doses per day.

25 The compounds of Formula (1) and/or (2) are conveniently administered in unit dosage form for example containing 0.1 to 500mg of active ingredient per unit dosage form. As used herein, the term "unit dose" includes not only individually packaged unit doses such as vials but also aliquots dispensed from vials into syringes and compositions for infusion contained in infusion containers.

30 While it is possible that, for use in therapy, the compounds of Formula (1) and/or (2) may be administered as the raw chemical, it is preferable to present the active ingredient as a pharmaceutical formulation.

The invention thus further provides a pharmaceutical formulation including the compounds of Formula (1) and/or (2) or a pharmaceutically acceptable derivative thereof together with one or more pharmaceutically acceptable carriers thereof and,

optionally, other therapeutic and/or prophylactic ingredients. The carrier(s) must be 'acceptable' in the sense of being compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

5 Pharmaceutical formulations include those suitable for oral, rectal, nasal, or parenteral (including intramuscular, intradermal, sub-cutaneous and intravenous) administration or in a form suitable for administration to the gastrointestinal tract, or in a form suitable for administration to the respiratory tract (including the nasal passages) for example by inhalation or insufflation or for intradermal or sub-
10 cutaneous implantation or for transdermal patch. The formulations may, where appropriate, be conveniently presented in discrete dosage units and may be prepared by any of the methods well known in the art of pharmacy. All methods include the step of bringing into association the active compound with liquid carriers or finely divided solid carriers or both and then, if necessary, shaping the product into the
15 desired formulation.

Pharmaceutical formulations suitable for oral administration may be presented as discrete units such as capsules, cachets or tablets each containing a predetermined amount of the active ingredient; as a powder or granules; as a solution, a suspension
20 or as an emulsion. The active ingredient may also be presented as a bolus, electuary or paste. Tablets and capsules for oral administration may contain conventional excipients such as binding agents, fillers, lubricants, disintegrants, or wetting agents. The tablets may be coated according to methods well known in the art. Oral liquid preparations may be in the form of, for example, aqueous or oily suspensions,
25 solutions, emulsions, syrups or elixirs, or may be presented as a dry product for constitution with water or other suitable vehicle before use. Such liquid preparations may contain conventional additives such as suspending agents, emulsifying agents, non-aqueous vehicles (which may include edible oils), or preservatives.

30 The compounds of Formula (1) and/or (2) may also be formulated for parenteral administration (e.g. by injection, for example bolus injection or continuous infusion) and may be presented in unit dose form in ampoules, pre-filled syringes, small volume infusion or in multi-dose containers with an added preservative. The compositions may take such forms as suspensions, solutions, or emulsions in oily or

aqueous vehicles, and may contain formulatory agents such as suspending, stabilising and/or dispersing agents. Alternatively, the active ingredient may be in powder form, obtained by aseptic isolation of sterile solid or by lyophilisation from solution, for constitution with a suitable vehicle, e.g. sterile, pyrogen-free water, before
5 use.

For rectal administration, unit dose suppositories wherein the carrier is a solid are preferred. Suitable carriers include cocoa butter and other materials commonly used in the art, and the suppositories may be conveniently formed by admixture of the
10 active compound with the softened or melted carrier(s) followed by chilling and shaping in moulds.

For administration to the respiratory tract (including intranasal administration) compounds of Formula (1) and/or (2) may be administered by any of the methods and
15 formulations employed in the art for administration to the respiratory tract.

Thus in general the compounds of Formula (1) and/or (2) may be administered in the form of a solution or a suspension or as a dry powder.

20 Solutions and suspensions will preferably be aqueous for example prepared from water alone (for example sterile or pyrogen-free water) or water and a physiologically acceptable co-solvent (for example ethanol, propylene glycol, polyethylene glycols such as PEG 400).

25 Such solutions or suspensions may additionally contain other excipients for example preservatives (such as benzalkonium chloride), solubilising agents/surfactants such as polysorbates (e.g. Tween [®]80, Span [®]80, benzalkonium chloride), buffers, isotonicity-adjusting agents (for example sodium chloride), absorption enhancers and viscosity enhancers. Suspensions may additionally contain suspending agents (for
30 example microcrystalline cellulose, carboxymethyl cellulose sodium).

Solutions or suspensions are applied directly to the nasal cavity by conventional means, for example with a dropper, pipette or spray. The formulations may be provided in single or multidose form. In the latter case a means of dose metering is

desirably provided. In the case of a dropper or pipette this may be achieved by the patient administering an appropriate, predetermined volume of the solution or suspension. In the case of a spray this may be achieved for example by means of a metering atomizing spray pump.

5

An aerosol formulation may also be used for the respiratory tract administration, in which the compounds of Formula (1) and/or (2) are provided in a pressurized pack with a suitable propellant such as a chlorofluorocarbon (CFC) for example dichlorodifluoromethane, trichlorofluoromethane or dichlorotetrafluoroethane, carbon
10 dioxide or other suitable gas. The aerosol may conveniently also contain a surfactant such as lecithin. The dose of drug may be controlled by provision of a metered valve.

Alternatively the compounds of Formula (1) and/or (2) may be provided in the form of a dry powder, for example a powder mix of the compound in a suitable powder base
15 such as lactose, starch, starch derivatives such as hydroxypropylmethyl cellulose and polyvinylpyrrolidone (PVP). Conveniently the powder carrier will form a gel in the nasal cavity. The powder composition may be presented in unit dose form for example in capsules or cartridges of e.g. gelatin or blister packs from which the powder may be administered by means of an inhaler.

20

In formulations intended for administration to the respiratory tract, including intranasal formulations, the compound will generally have a small particle size for example of the order of 5 microns or less. Such a particle size may be obtained by means known in the art, for example by micronisation.

25

When desired, formulations adapted to give sustained release of the active ingredient may be employed.

The compounds of Formula (1) and/or (2) may also be used in combination with other
30 therapeutic agents, for example anti-infective agents, such as antibiotics, antiviral agents, and agents for treatment of respiratory conditions. The invention thus provides in a further aspect a combination comprising the compounds of Formula (1) and/or (2) or a pharmaceutically acceptable derivative thereof together with another therapeutically active agent.

The combinations mentioned above may conveniently be presented for use in the form of a pharmaceutical formulation and thus such formulations comprising a combination as defined above together with a pharmaceutically acceptable carrier
5 therefore comprise a further aspect of the invention.

The individual components of such combinations may be administered either sequentially or simultaneously in separate or combined pharmaceutical formulations.

10 When the compounds of Formula (1) and/or (2) are used with a second therapeutic agent active in therapy, the dose of each compound may either be the same as or differ from that employed when each compound is used alone. Appropriate doses will be readily appreciated by those skilled in the art.

15 The compounds of Formula (1) and/or (2) and their pharmaceutically acceptable derivatives may be prepared by any methods known in the art for the preparation of compounds of analogous structure.

In another aspect of the invention there is provided a method of screening for a
20 compound for the treatment of a respiratory condition, said method comprising:

subjecting a cell having reduced sialylglycoconjugates on a surface of the cell to a test compound; and

measuring recovery of viability of the cell after exposure of the test compound to the cell.

25

Based on the present invention, other compounds may be used to promote the restoration of a sialylglycoconjugate on the surface of a respiratory cell; or to promote recovery of viability of the cell by its ability to accelerate sialylglycoconjugate biosynthesis. Hence the cells restoration to a better condition for normal biological
30 function to respond to factors which may affect the respiratory surface thereby leading to respiratory conditions can be achieved providing the sialylglycoconjugate are restored on the surface of the cell.

This method involves obtaining a cell, preferably a respiratory cell, which has reduced sialylglycoconjugates on a surface. This cell is termed as a “naked cell” which is vulnerable to factors which may affect its ability to function normally.

- 5 The cell may be derived by subjecting a normal cell such as a respiratory cell to a neuraminidase to remove sialic acid from the sialylglycoconjugates on the surface of the cell. This cell is then measured by the ability of a test compound to restore the sialylglycoconjugates on the surface. The test compound may restore the sialylglycoconjugates by accelerating sialylglycoconjugate biosynthesis or by other
10 means that result in the restoration of the sialylglycoconjugates on the surface of the cell.

The ability to restore the sialylglycoconjugates on the surface of the cells may be measured by the restoration of viability of the cell. The viability of the cell may be
15 measured by any means available to the skilled addressee. However, it may be determined by the cells ability for cellular proliferation. This can be measured by the use of standard cell proliferation kits such as but not limited to Cell Proliferation ELISA kit to measure BrdU incorporated into newly synthesized DNA of replicating cells or by the use of [³H]-thymidine-based cell proliferation assays.

20 The ability may also be measured by determining the number of sialylglycoconjugates restored on the cell as a consequence of exposure of the cell to the test compound. This can be measured by means available to the skilled addressee such as, but not limited to the use of antibodies to the sialylglycoconjugates.

25 In yet another embodiment there is provided a method of treating or preventing a respiratory condition in a subject, the method including the step of administering to the subject at least one compound identified by the screening method.

30 Finally, the invention as hereinbefore described is susceptible to variations, modifications and/or additions other than those specifically described and it is understood that the invention includes all such variations, modifications and/or additions which may be made it is to be understood that various other modifications and/or additions which fall within the scope of the description as hereinbefore

described. The following examples are for illustrative purposes only and should not be construed as a limitation of the invention.

EXAMPLES

5 General methods used in the Examples

• NMR was recorded on Bruker Avance™ 300, Xwin-NMR version 3.5 on DPX 300A.

• MS was recorded on Mass Spectrometer Waters Micromass™ ZMD using an ESI (electrospray ionisation probe). The system was run using Water Mass
10 Lynx™ NT software.

• Flash column chromatography was performed on silica gel 60 F₂₄₅ (E. Merck).

• Thin Layer Chromatography (TLC) was performed on silica gel precoated plates (E. Merck).

15 • HPLC was run on Waters Alliance™ 2690 separation module, detected by Waters dual wavelength 2487 UV detector, the software was Waters Millenium 32.

• Cell culture and cell viability assay

20 ○ Method 1

Cells used: Small Airway Epithelial Cells (SAEC)

Media: SAGM Bullet kit (SABM + growth supplement)

And/or

Cells used: Normal Human Bronchial Epithelial Cells (NHBE)

25 *Media:* BEGM Bullet kit (BEBM + growth supplement)

Experimental details:

Cryopreserved cells (1x10⁶ cells in 1ml) were thawed and cultured on 175cm² petri-dish in complete media. The media is removed the next day and replaced with fresh media. The cells are cultured for about 5-6 days to obtain 70-80% confluency.

30 During the growing phase, the media is changed every second day.

When the appropriate confluency is obtained, the media is removed. The monolayer of cells is rinsed with 1x PBS. Following the removal of the PBS, 2ml of trypsin+EDTA

is added. The cells are gently rocked at room temperature for 2 min. The cells are harvested with 1x PBS, centrifuged at 200g for 10min. The pellet was resuspended to 5×10^4 /ml. In a 96-well plate, the cells were aliquoted in 100 μ l/well (approx. 5000 cells/well). The cells are incubated at 37°C for 24h.

5

Bacterial neuraminidase (from *Clostridium perfringens*), 10 μ l was added to each well to a final concentration of 0.0IU/ml for SAEC and 0.008u/ml for NHBE. The cells were then incubated for 6h at 37°C.

10 Centrifugation of the plate was carried out at 1000rpm for 10 min, the media aspirated and 200 μ l of fresh media added. The plate was centrifuged again, the media replaced with 100 μ l of fresh media.

Compounds for test were made up at 6x of the desired concentration; 20 μ l of the
15 compound was added to each well in triplicate. The cells were then incubated at 37°C for 24h.

The cells were labeled overnight (approx. 16h) at 37°C with 10 μ l of BrdU label (Cell Proliferation ELISA kit —Roche).

20

Labeling medium was removed and the cells were fixed and denatured for 30 min at room temperature with Fixing solution supplied by the manufacturer.

Following removal of the fixing solution, 100 μ l of anti-BrdU-POD (at the appropriate
25 concentration as suggested by the manufacturer) was added to each well. The plate was incubated at room temperature for 90 min.

The antibody conjugate was removed and the wells washed three times with 200 μ l of Washing solution (supplied). After removal of the washing solution, 100 μ l of the
30 Substrate solution (supplied) was added; and incubated at room temperature for 30 min. The reaction was stopped with the addition of 50 μ l of 1M H₂SO₄. Absorbance of the samples was measured at 450nm (reference wavelength of 690nm).

Small Airway Epithelial Cells (SAEC) treated with 0.01U/ml neuraminidase (NA) from *Clostridium perfringens*.

	Cell viability (mean $\pm$ SEM, n=20)
Control (normal cell)	100%
Control treated with NA	72.82% $\pm$ 7.26

- 5 Normal Human Bronchial Epithelial Cells (NHBE) treated with 0.008U/ml neuraminidase (NA) from *Clostridium perfringens*.

	Cell viability (mean $\pm$ SEM, n=20)
Control (normal cell)	100%
Control treated with NA	73.30% $\pm$ 7.12

- 10 The cell viability assay normally gave an operational deviation of $\pm$ 10%. Therefore, only the results showed the cell viability $\geq$ 120% against that of control (treated with neuraminidase) are considered as significant. It is indicated that the compounds with positive results could restore the cell viability within 48 hrs. Among the compounds of Formula (1) and/or (2) the most active compounds with low cytotoxicity were N-acetylmannosamine (Compound 1) and N-acetylneuraminic acid (Compound 2).

15

- Method 2

Cells used: Small Airway Epithelial Cells (SAEC)

Media: SAGM Bullet kit (SABM + growth supplement)

And/or

Cells used: Normal Human Bronchial Epithelial Cells (NHBE)

Media: BEGM Bullet kit (BEBM + growth supplement)

Experimental details:

5 Cryopreserved cells (1×10^6 cell in 1 ml) were thawed and cultured on 175cm^2 petri-dish in complete media. The media was removed the next day and replaced with fresh media. The cells were cultured for about 5-6 days to obtain 70-80% confluency. During the growing phase, the media was changed every second day.

10 When the appropriate confluency was obtained, the media was removed. The monolayer of cells was rinsed with $1 \times$ PBS. Following the removal of the PBS, 2ml of trypsin+EDTA was added. The cells were gently rocked at room temperature for 2 min. The cells were harvested with $1 \times$ PBS, centrifuged at 200g for 10 min. The pellet was resuspended to $5 \times 10^4/\text{ml}$. In a 96-well plate, the cells were aliquoted in 100 μl /well (approx. 5000 cells/well). The cells were incubated at 37°C for 24h.

15 Viral neuraminidase (from influenza virus NWS/G70C), 10 μl was added to each well to a final concentration of 0.017 $\mu\text{g}/\text{ml}$. The cells were then incubated for 6h at 37°C .

20 Centrifugation of the plate was carried out at 1000rpm for 10 min, the media aspirated and 200 μl of fresh media added. The plate was centrifuged again, the media replaced with 100 μl of fresh media.

25 Compounds for test were made up at 6x of the desired concentration; 20 μl of the compound is added to each well in triplicate. The cells are then incubated at 37°C for 24h.

The cells are labeled overnight (approx. 16h) at 37°C with 10 μl of BrdU label (Cell Proliferation ELISA kit — Roche).

30 Labeling media was removed and the cells are fixed and denatured for 30 min at room temperature with Fixing solution supplied by the manufacturer.

Following removal of the fixing solution 100 μl of anti-BrdU-POD (at the appropriate concentration as suggested by the manufacturer) was added to each well. The plate

is incubated at room temperature for 90 min.

The antibody conjugate was removed and the wells washed three times with 200µl of Washing solution (supplied). After removal of the washing solution, 100µl of the Substrate solution (supplied) was added and incubated at room temperature for 30 min. The reaction was stopped with the addition of 50µl of 1M H₂SO₄. Absorbance of the samples was measured at 450nm (reference wavelength of 690nm).

Example 1. Preparation of N-acetyl-D-mannosamine (1).

10 [Compound (1), formula (1), B=H, A=NHCOCH₃, R¹=R²=R³=R⁴=H]

1 g. of N-acetyl-D-glucosamine obtained by hydrolysis of chitin, was dissolved in 3ml. of water, then adjusted to pH>11 by using 30% NaOH solution. The mixture was allowed to stand at 20°C~40°C for 48 hrs. The resulting solution was neutralized to pH 6.5~7.0 with 5N H₂SO₄, then evaporated under reduced pressure to dryness. The solid was refluxed in ethanol for 10 min., cooled to room temperature, and filtered. The filtrate was vacuum evaporated to dryness to afford a white solid which contains 85% N-acetyl-D-mannosamine and 15% N-acetyl-D-glucosamine, determined by ¹H-nmr. This solid was fractionally recrystallized from ethanol/isopropanol/EA to afford the title compound as a white solid (125mg, 62.5% based on 20% conversion rate of N-acetyl-D-mannosamine). The unreacted N-acetyl-D-glucosamine (0.8g) could be reused for next batch of reaction.

¹H-nmr (D₂O) δ (ppm)

5.15 (d, 0.7H), 3.85~3.32 (m, 6.3H), 1.99 (s, 3H).

25 MS 222 (M+1)

Example 2. Preparation of N-acetyl-neuraminic acid Sodium Salt (2).

[Compound (2), Formula (2), R⁸=R¹⁰=R¹¹=R¹²=R¹³=H, R⁹=Na]

To a pH 7.0~7.5 solution of N-acetylmannosamine (2.7g, 12.2 mmole) and sodium pyruvate (2.7g, 24.5mmole) in water (15ml) was added a dialysis bag (cut off MW of 20,000) containing N-acetylneuraminate lyase [EC 4.1.3.3] (25 units) in a reaction mixture of N-acetylmannosamine (0.54g) and sodium pyruvate (0.54g) in water (3ml) at pH 7.0-7.5. The reaction mixture was shaken at 60 r.p.m. at 30°C for 5 days. The enzyme bag was removed and reused for new batch of reaction. The reaction mixture

was diluted with water (15ml), then passed through a column of Amberlite™ IRA-400 (HCOO⁻ form) (150ml). The resin was then washed with water (300ml), eluted with 0.5M HCOOH solution. The eluate was collected and vacuum evaporated to dryness. The residue was dissolved in water (2ml) then diluted with glacial acetic acid (10ml) at 4°C overnight, filtered the crystals, washed with EtOH, dried to afford N-acetylneuraminic acid as white crystalline powder (1.5g, 39.8%).

¹H-nmr (D₂O) δ (ppm)

4.00 (m, 1H), 3.97 (m, 1H), 3.87 (d, 1H), 3.77 (dd, 1H), 3.67 (m, 1H), 3.55 (dd, 1H), 3.48 (d, 1H), 2.24 (dd, 1H, J=13.2 Hz, 5.1Hz), 1.98 (s, 3H), 1.83 (dd, 1H, J=13.2 Hz, 11.5 Hz).

MS 310 (M+1)

N-acetylneuraminic acid (1g, 3.23 mmol) was dissolved in water (20ml), then stirred with NaHCO₃ (0.26g, 3.09mmol to pH 6~6.5), after freez-dried to afford the title product as white powder (1.05g, 98%).

Example 3. Preparation of ethyl N-acetyl-neuramate (3).

To a suspension of N-acetyl-neuraminic acid (1g, 3.23mmole) in anhydrous ethanol (75ml) was added 1.5ml acetyl chloride. The mixture was sealed and stirred at room temperature for 16 hrs. to form a clear solution. The resulting solution was vacuum evaporated to dryness. The white solid was washed with ethyl acetate and vacuum dried to afford the title compound as a white solid (1g, 91.7%).

¹H-nmr (D₂O) δ (ppm)

4.27 (q, 2H), 4.04 (m, 2H), 3.91 (d, 1H), 3.78 (dd, 1H), 3.68 (dd, 1H), 3.57 (dd, 1H), 3.52 (d, 1H), 2.28 (dd, 1H), 2.01 (s, 3H), 1.88 (dd, 1H), 1.28 (t, 3H).

MS 338 (M+1), 360 (M+23)

Example 4. Preparation of ethyl 5-acetamido-4,7,8,9,-tetra-o-acetyl-3,5-dideoxy-β-D-glycero-D-galacto-2-nonulopyranosonate (ethyl 5-acetamido-4,7,8,9-tetra-o-acetyl-neuramate) (4).

To an agitated solution of acetic anhydride (0.72g) and aqueous 60% perchloric acid (5μl) at 40°C. was added in portion over 30mins ethyl 5-acetamido-neuramate

(230mg, 0.68mmol). The resulting mixture was stirred at 40°C. for 2 hrs. Then it was cooled to room temperature, diluted with cold water (10ml), saturated with ammonium sulfate, extracted with ethyl acetate (40ml x 3). The organic extracts were combined and washed with saturated NaHCO₃ solution and water successively. The organic layer was dried over MgSO₄, and evaporated in vacuo to dryness. The residue was dissolved in ethyl acetate, diluted with hexane to give the title compound as a white crystal (223mg, 65%).

¹H-nmr (CDCl₃) δ(ppm)

5.71 (m, 1H), 5.36 (dd, 1H, J=1.5Hz, 5.6Hz), 5.25 (ddd, 1H, J=2.4Hz, 7.5Hz), 5.22 (ddd, 1H, J=11.4Hz, 5.4Hz, 9.5Hz), 4.51 (dd, 1H, J=12.4Hz), 4.47 (d, 1H, J=0.8Hz), 4.21~4.13 (m, 4H), 4.03 (dd, 1H), 2.26 (ddd, 1H, 12.8Hz), 2.19 (dd, 1H), 2.15, 2.11, 2.03, 2.02, and 1.91 (5s, 15H), 1.29 (t, 3H, J=7.2Hz).

MS 506 (M+1)

Example 5. Preparation of cytidine -5'-monophospho-5-acetamido-3,5,-dideoxy-β-D-glycero-D-galacto-2-nonulopyranosonic acid (CMP-sialic acid) (5).

N-acetylneuraminic acid (100mg, 0.32mmole), and cytidine-5'-triphosphate sodium salt (156.3mg, 0.32mmole) were dissolved in 32ml of Tris-HCl buffer (100mM, pH8.8) containing MgCl₂ (20mM). To this solution was added CMP-Neu5Ac synthetase (5mg, from N. meningitidis). The reaction mixture was incubated at 37°C for 2~3 hrs. while monitored by TLC (silica gel, EtOH:1M NH₄HCO₃=7:3). The reaction mixture was diluted with methanol (50ml) and filtered off. The filtrate was evaporated under reduced pressure to dryness. The residue was chromatographed on Bio Gel P-2 resin (50ml) to afford the title compound after freeze-dried as a white crystalline powder (147mg, 75%).

HPLC analysis:

- C-18 column.

- Mobile phase: buffer A (0.1M potassium phosphate buffer. Supplemented with 8mM tetra-butylammonium hydrogensulfate, pH5.3) and buffer B (70% buffer A plus 30% methanol, pH 5.9)

- Gradient condition:

100% buffer A for 2.5min, 0~40% buffer B for 7.5 min, 40~100% buffer B for 1min, 100% buffer B for 4 min, 100~0% buffer B for 1 min, followed by an equilibration phase of 100% buffer A for 4 min.

- Flow rate: 1ml/min.

5 • U.V. detection at 270nm

¹H-nmr (D₂O) δ(ppm)

7.87 (d, 1H, J=7.6 Hz), 6.25 (d, 1H, J=7.6 Hz), 5.91 (d, 1H, J=4.4Hz), 4.26~4.20 (m, 2H), 4.17~4.10 (m, 3H), 4.09~3.98 (m, 2H), 3.90~3.80 (m, 3H), 3.59~3.40 (m, 2H), 2.42 (dd, 1H, J=4.8, 13.2 Hz), 1.98 (s, 3H), 1.60 (dt, 1H, J=5.6, 12.6 Hz).

10 MS 635 (M²⁺+Na⁺)

Example 6. Preparation of ethyl 5-acetamido-8,9-O-isopropylidene-neuramate (6).

To a solution of ethyl 5-acetamido-neuramate (150mg, 0.445mmole) in anhydrous DMF (2ml) was added 2,2-dimethoxypropane (1ml, 8mmole) and Amberlyst 15 (50mg). The mixture was stirred at 60°C for 7 hrs, then cooled to room temperature and filtered. The filtrate was evaporated under reduced pressure to dryness. TLC (silica gel, EA/MeOH=10:4) indicated the completion of the reaction. The residue was redissolved in EA/MeOH=10/1 (1ml), then flash column chromatographed. The required fractions were combined and evaporated in vacuo to dryness to afford the title compound as a white form (135mg, 75%).

¹H-nmr (D₂O) δ(ppm)

4.28~4.23 (m, 2H), 4.23~4.11 (m, 2H), 4.08~3.92 (m, 2H), 3.96~3.52 (m, 3H), 2.31 (dd, 1/3H), 2.23 (dd, 2/3H), 1.99 (s, 3H), 1.82 (dd, 2/3H), 1.70 (dd, 1/3H), 1.36 (s, 3H), 1.32 (s, 3H), 1.25 (t, 3H).

MS 428 (M+Na)

Example 7: Activity of compound (1) on recovery of the viability of Small Airways Epithelial Cells (SAEC)

Compound (1) [Formula (1), B=H, A=NHCOCH₃, R¹=R²=R³=R⁴=H]

	Cell viability (mean ±SEM, n=3)
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Control (treated with neuraminidase)	100%
Compound (1) 50µg/ml	171% ± 6.33
12.5µg/ml	175% ± 2.33
3.1µg/ml	146% ± 7.10
0.77µg/ml	139% ± 3.46
0.19µg/ml	157% ± 4.47

Example 8: Activity of compound (1) on recovery of the viability of Normal Human Bronchial/Tracheal Epithelial Cells (NHBE)

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (1) 50µg/ml	125% ± 3.20
12.5µg/ml	124% ± 2.21
3.1µg/ml	120% ± 0.79
0.77µg/ml	119% ± 2.23
0.19µg/ml	116% ± 1.42

5 Example 9. Activity of compound (2) on recovery of the viability of SAEC

Compound (2) [Formula (2), $R^8=R^{10}=R^{11}=R^{12}=R^{13}=H$, $R^9=Na$]

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (2) 50µg/ml	129% ± 3.96
12.5µg/ml	127% ± 2.51
3.1µg/ml	115% ± 1.56

0.77µg/ml	130% ± 2.18
0.19µg/ml	129% ± 3.22
0.05µg/ml	138% ± 0.50
0.012µg/ml	140% ± 2.15
0.003µg/ml	124% ± 1.91

Example 10: Activity of compound (2) on recovery of the viability of the NHBE

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (2)	
50µg/ml	137% ± 1.00
12.5µg/ml	127% ± 4.02
3.1µg/ml	117% ± 3.22
0.77µg/ml	117% ± 0.68
0.19µg/ml	126% ± 0.21

Example 11. Activity of compound (3) on recovery of the viability of SAEC

5 Compound (3) [Formula (2), $R^8=R^{10}=R^{11}=R^{12}=R^{13}=H$, $R^9=C_2H_5$]

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (3)	
50µg/ml	104% ± 1.66
12.5µg/ml	107% ± 0.41
3.1µg/ml	109% ± 1.41
0.77µg/ml	103% ± 3.43

0.05µg/ml	104% ± 1.46
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Example 12: Activity of compound (3) on recovery of the viability of NHBE

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (3) 50µg/ml	106% ± 1.35
12.5µg/ml	100% ± 0.88
3.1µg/ml	113% ± 0.84
0.77µg/ml	111% ± 4.73
0.19µg/ml	114% ± 5.14
0.05µg/ml	130% ± 5.19
0.012µg/ml	130% ± 6.11
0.003µg/ml	154% ± 4.91

Example 13: Activity of compound (4) on recovery of the viability of SAEC

5 Compound (4) [Formula (2), $R^8=H$, $R^9=C_2H_5$, $R^{10}=R^{11}=R^{12}=R^{13}=CH_3CO$]

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (4) 50µg/ml	99% ± 4.00
12.5µg/ml	97% ± 3.00
3.1µg/ml	100% ± 1.80
0.77µg/ml	115% ± 4.40
0.19µg/ml	121% ± 1.80
0.05µg/ml	106% ± 6.09

0.012µg/ml	116% ± 0.10
0.003µg/ml	110% ± 1.09

Example 14: Activity of compound (4) on recovery of viability of NHBE

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (4) 50µg/ml	110% ± 1.02
12.5µg/ml	117% ± 0.29
3.1µg/ml	111% ± 4.54
0.77µg/ml	110% ± 3.77
0.19µg/ml	125% ± 1.46
0.05µg/ml	115% ± 5.22
0.012µg/ml	113% ± 6.85
0.003µg/ml	83% ± 0.88

5 Example 15: Activity of compound (5) on recovery of the viability of SAEC

Compound (5) [formula (2), R⁸=cytidine monophosphate, R⁹=R¹⁰=R¹¹=R¹²=R¹³=H]

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (5) 50µg/ml	116% ± 5.30
12.5µg/ml	108% ± 1.20
3.1µg/ml	141% ± 1.70
0.77µg/ml	141% ± 1.09
0.19µg/ml	145% ± 4.89

Example 16: Activity of compound (5) on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (5) 50 μ g/ml	116% $\pm$ 0.93
12.5 μ g/ml	109% $\pm$ 3.60
3.1 μ g/ml	112% $\pm$ 2.59
0.77 μ g/ml	109% $\pm$ 1.92
0.19 μ g/ml	89% $\pm$ 0.79

Example 17: Activity of compound (6) on recovery of the viability of SAEC

Compound (6) [formula (2), R⁸=H, R⁹=C₂H₅, R¹⁰=R¹¹=H, R¹² and R¹³= >C (CH₃)₂]

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (6) 50 μ g/ml	119% $\pm$ 3.17
12.5 μ g/ml	125% $\pm$ 1.13
3.1 μ g/ml	123% $\pm$ 5.02
0.77 μ g/ml	135% $\pm$ 3.27
0.19 μ g/ml	140% $\pm$ 1.92

5

Example 18. Activity of compound (6) on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (6) 50 μ g/ml	90% $\pm$ 8.36
12.5 μ g/ml	99% $\pm$ 3.17
3.1 μ g/ml	121% $\pm$ 2.10
0.77 μ g/ml	128% $\pm$ 3.60

0.19µg/ml	133% ± 0.88
0.05µg/ml	127% ± 1.81
0.012µg/ml	122% ± 3.33
0.003µg/ml	141% ± 4.70

Example 19: Activity of compound (7) on recovery of the viability of SAECCompound (7) [Formula (1), B=H, A=NHCOCH₃, R¹=R²=R³=R⁴=COCH₃]

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (7) 50µg/ml	73% ± 2.18
12.5µg/ml	134% ± 0.81
3.1µg/ml	103% ± 1.14
0.77µg/ml	112% ± 1.29
0.19µg/ml	105% ± 2.01
0.05µg/ml	128% ± 1.98
0.012µg/ml	105% ± 1.83
0.003µg/ml	102% ± 0.62

5 Example 20: Activity of compound (7) on recovery of the viability of NHBE

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (7) 50µg/ml	54% ± 0.98
12.5µg/ml	117% ± 4.12
3.1µg/ml	98% ± 5.65
0.77µg/ml	99% ± 1.93
0.19µg/ml	100% ± 0.66
0.05µg/ml	104% ± 5.85
0.012µg/ml	103% ± 4.70

0.003µg/ml	85% ± 2.71
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Example 21. Activity of compound (8) on recovery of the viability of SAECCompound (8) [Formula (1), B=H, A=NHCOCH₃, R¹=H, R²=R³=R⁴=COCH₃]

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (8) 50µg/ml	91% ± 3.36
12.5µg/ml	104% ± 1.95
3.1 µg/ml	109% ± 2.79
0.77µg/ml	103% ± 3.21
0.19µg/ml	115% ± 3.52
0.05µg/ml	109% ± 1.16
0.012µg/ml	Not determined
0.003µg/ml	125% ± 8.51

5 Example 22: Activity of compound (8) on recovery of the viability of NHBE

	Cell viability (mean ± SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (8) 50µg/ml	42% ± 1.55
12.5µg/ml	81% ± 0.60
3.1µg/ml	111% ± 2.44
0.77µg/ml	133% ± 2.09
0.19µg/ml	96% ± 1.21
0.05µg/ml	93% ± 1.38
0.012µg/ml	118% ± 3.19
0.003µg/ml	129% ± 1.70

Example 23: Activity of compound (9) on recovery of the viability of SAECCompound (9) [Formula (1), A=H, B=NHCOCH₃, R¹=R²=R³=R⁴=H]

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (9) 50 μ g/ml	122% $\pm$ 3.21
12.5 μ g/ml	119% $\pm$ 3.04
3.1 μ g/ml	115% $\pm$ 3.17
0.77 μ g/ml	120% $\pm$ 3.14
0.19 μ g/ml	121% $\pm$ 2.42

Example 24. Activity of compound (9) on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (9) 50 μ g/ml	106% $\pm$ 2.52
12.5 μ g/ml	106% $\pm$ 3.49
3.1 μ g/ml	108% $\pm$ 3.24
0.77 μ g/ml	107% $\pm$ 1.26
0.19 μ g/ml	107% $\pm$ 3.41

Example 25. Activity of D-glucose on recovery of the viability of SAEC

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
D-Glucose 50 μ g/ml	94% $\pm$ 3.04
12.5 μ g/ml	103% $\pm$ 1.05
3.1 μ g/ml	101% $\pm$ 2.30

Example 26: Activity of D-glucose on recovery of the viability of NHBE

	Cell viability
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	(mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
D-Glucose 50 μ g/ml	106% $\pm$ 2.76
12.5 μ g/ml	104% $\pm$ 2.13
3.1 μ g/ml	107% $\pm$ 3.05
0.77 μ g/ml	99% $\pm$ 3.15
0.19 μ g/ml	104% $\pm$ 2.96

Example 27. Activity of compound (1) at high concentration on recovery of the viability of SAEC

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (1) 5mg/ml	118% $\pm$ 2.15
1.25mg/ml	121% $\pm$ 3.02
312.5 μ g/ml	115% $\pm$ 1.51
78.1 μ g/ml	127% $\pm$ 2.30

5 Example 28: Activity of compound (1) at high concentration on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (1) 5mg/ml	116% $\pm$ 2.11
1.25mg/ml	125% $\pm$ 2.02
312.5 μ g/ml	131% $\pm$ 3.04
78.1 μ g/ml	128% $\pm$ 1.85

Example 29: Activity of compound (2) at high concentration on recovery of the viability of SAEC

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (2) 5mg/ml	129% $\pm$ 1.76
1.25mg/ml	115% $\pm$ 1.38
312 μ g/ml	118% $\pm$ 1.95
78.1 μ g/ml	135% $\pm$ 2.06

Example 30: Activity of compound (2) at high concentration on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (2) 5mg/ml	122% $\pm$ 2.05
1.25mg/ml	129% $\pm$ 3.13
312.5 μ g/ml	118% $\pm$ 2.17
78.1 μ g/ml	107% $\pm$ 1.38

5 Example 31: Activity of compound (9) at high concentration on recovery of the viability of SAEC

	Cell viability (mean $\pm$ SEM, n=3)
Control (treatment with neuraminidase)	100%
Compound (9) 5mg/ml	83% $\pm$ 2.85
1.25mg/ml	96% $\pm$ 3.16
312.5 μ g/ml	90% $\pm$ 3.28
78.1 μ g/ml	100% $\pm$ 2.92

Example 32: Activity of compound (9) at high concentration on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Compound (9) 5mg/ml	76% $\pm$ 2.71
1.25mg/ml	96% $\pm$ 2.42
312.5 μ g/ml	95% $\pm$ 2.85
78.1 μ g/ml	125% $\pm$ 3.23

Example 33: Activity of a mixture of compound (1) (85%) and compound (9) (15%) at high concentration on recovery of the viability of SAEC

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Mixture of compound (1) and (9) 5mg/ml	88% $\pm$ 1.82
1.25mg/ml	91% $\pm$ 2.03
312.5 μ g/ml	87% $\pm$ 2.52
78.1 μ g/ml	94% $\pm$ 1.91

5 **Example 34: Activity of a mixture of compound (1) (85%) and compound (9) (15%) at high concentration on recovery of the viability of NHBE**

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Mixture of compound (1) and (9) 5mg/ml	89% $\pm$ 2.31
1.25mg/ml	107% $\pm$ 2.48
312.5 μ g/ml	105% $\pm$ 2.02
78.1 μ g/ml	95% $\pm$ 3.12

Example 35: Activity of a mixture of compound (1) (85%) and compound (9) (15%) on recovery of the viability of SAEC

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Mixture of compound (1) and (9) 50 μ g/ml	101% $\pm$ 3.41
12.5 μ g/ml	107% $\pm$ 3.91
3.1 μ g/ml	121% $\pm$ 4.82
0.77 μ g/ml	120% $\pm$ 4.11
0.19 μ g/ml	115% $\pm$ 4.02
0.05 μ g/ml	113% $\pm$ 4.30
0.01 μ g/ml	107% $\pm$ 4.12
0.003 μ g/ml	108% $\pm$ 4.20

5

Example 36. Activity of a mixture of compound (1) (85%) and compound (9) (15%) on recovery of the viability of NHBE

	Cell viability (mean $\pm$ SEM, n=3)
Control (treated with neuraminidase)	100%
Mixture of compound (1) and (9) 50 μ g/ml	121% $\pm$ 2.05
12.5 μ g/ml	109% $\pm$ 1.98
3.1 μ g/ml	115% $\pm$ 1.76

Example 37. Cough experiments on guinea pigs^{[9][10]}

10 Male guinea pigs were housed in pens and have access to water and food *ad libitum*. This study was approved by Bio21 Institute Animal Ethics Committee.

Twenty four Conscious male Hartley guineapigs (500~550g) were divided into A, B, C three groups (8 animals for each group), and pretreated with either 5 units/ml solution of neuraminidase (Sigma N2133, lyophilized powder, Type X, 150~400 units/mg protein) in water (group B and C) or saline alone (Group A) via an aerosol for 5 minutes on day one. Then, on day one, two and three, the guineapigs were either orally administered with 500 mg/kg of compound (1) (Group C), or water alone (Group A and B). On day four, all the animals were challenged with 0.5M citric acid solution (nebulised, 10 minutes exposure). The cough frequency, times to the 1st, 2nd and third cough, and times to the 1st nose rubs were then recorded over a period of 15 minutes. The results indicated a trend that compound (1) helped to restore the damages caused by neuraminidase.

	Cough frequency (in 15 minutes)
Group A (Saline only, as control)	13 ± 2.5
Group B (treated with neuraminidase, as negative control)	19 ± 2.5
Group C (firstly treated with neuraminidase, then with compound (1) for 3 days)	16 ± 2.2

	Time (seconds) to the 1st cough 2nd cough 3rd cough
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Group A (water only, as control)	87 ± 10	157 ± 23	200 ± 25
Group B (treated with neuraminidase, as negative control)	70 ± 11	109 ± 6	150 ± 20
Group C (firstly treated with neuraminidase, Then treated with compound (1) for 3 days)	85 ± 15	137 ± 31	220 ± 10

	Time (second) to the 1st nose rubs
Group A (water only, as control)	50 ± 4.3
Group B (treated with neuraminidase, as negative control)	27.7 ± 3.6
Group C (firstly treated with neuraminidase, then treated with compound (1) for 3 days)	49 ± 6.5

Using compound (2) instead of compound (1) by the same experimental protocol, the similar results were obtained.

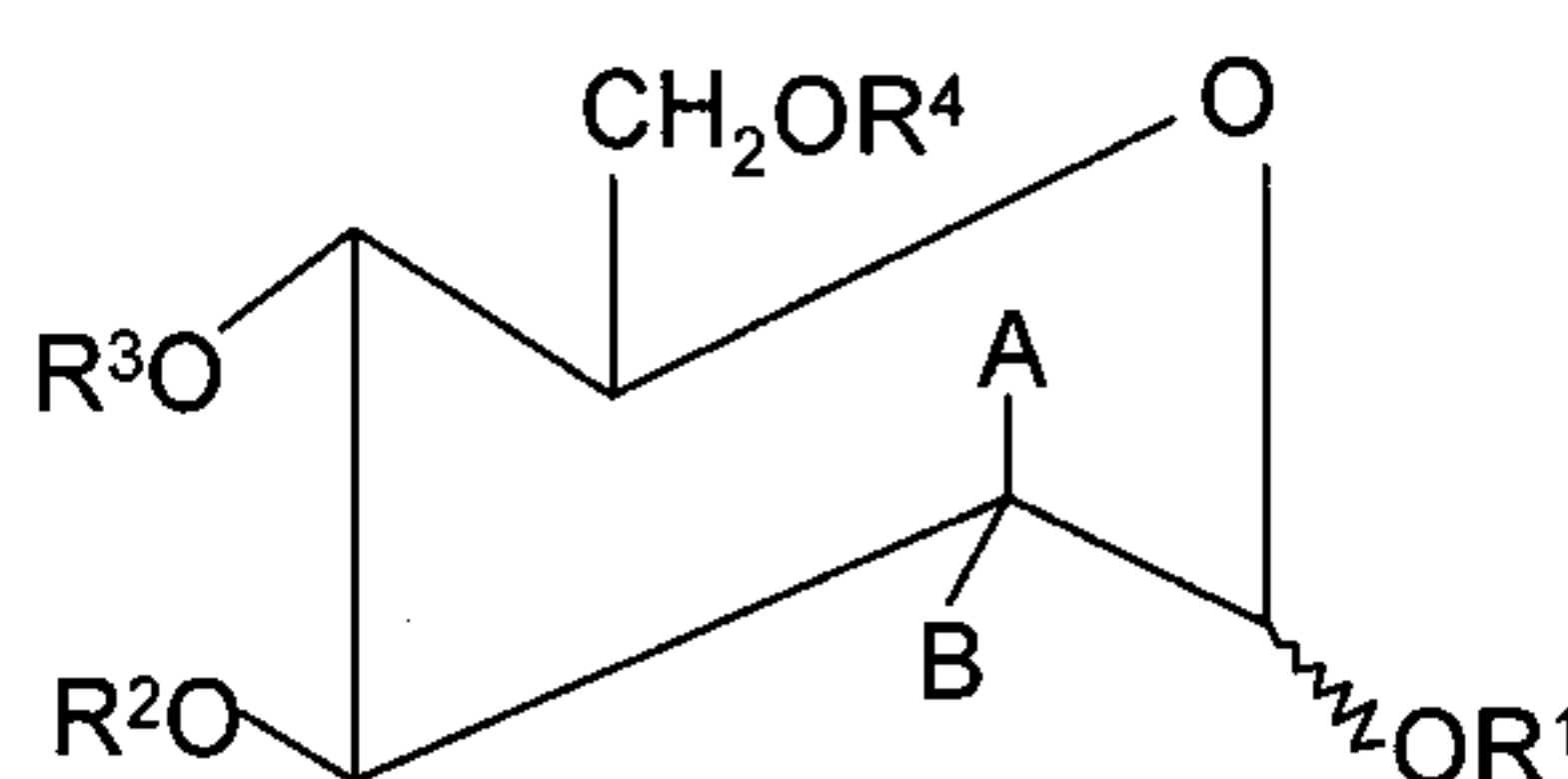
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- 25 The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

CLAIMS

1. A composition for promoting recovery of cell viability of a damaged respiratory cell, said composition comprising at least one pharmaceutically acceptable compound
 5 and a pharmaceutically acceptable carrier, adjuvant, or vehicle, wherein the at least one pharmaceutically acceptable compound is selected from the group consisting of compounds of Formula (1) and compounds of Formula (2) wherein Formula (1) has the formula:



10

Formula (1)

wherein,

R^1 , R^2 , R^3 , are the same or different and are each independently selected from the group consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), CH_2Ph , and $\text{COCR}^5\text{R}^6\text{R}^7$; ;

- 15 R^5 , R^6 , R^7 are the same or different and are each independently selected from the group consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), C_6H_5 , CH_2Ph , and $\text{CH}_3\text{CH}_2(\text{OCH}_2\text{CH}_2)_m\text{CH}_3$ ($m=1-200$);

R^4 is the same or different to R^1 , R^2 , R^3 and is selected from the group

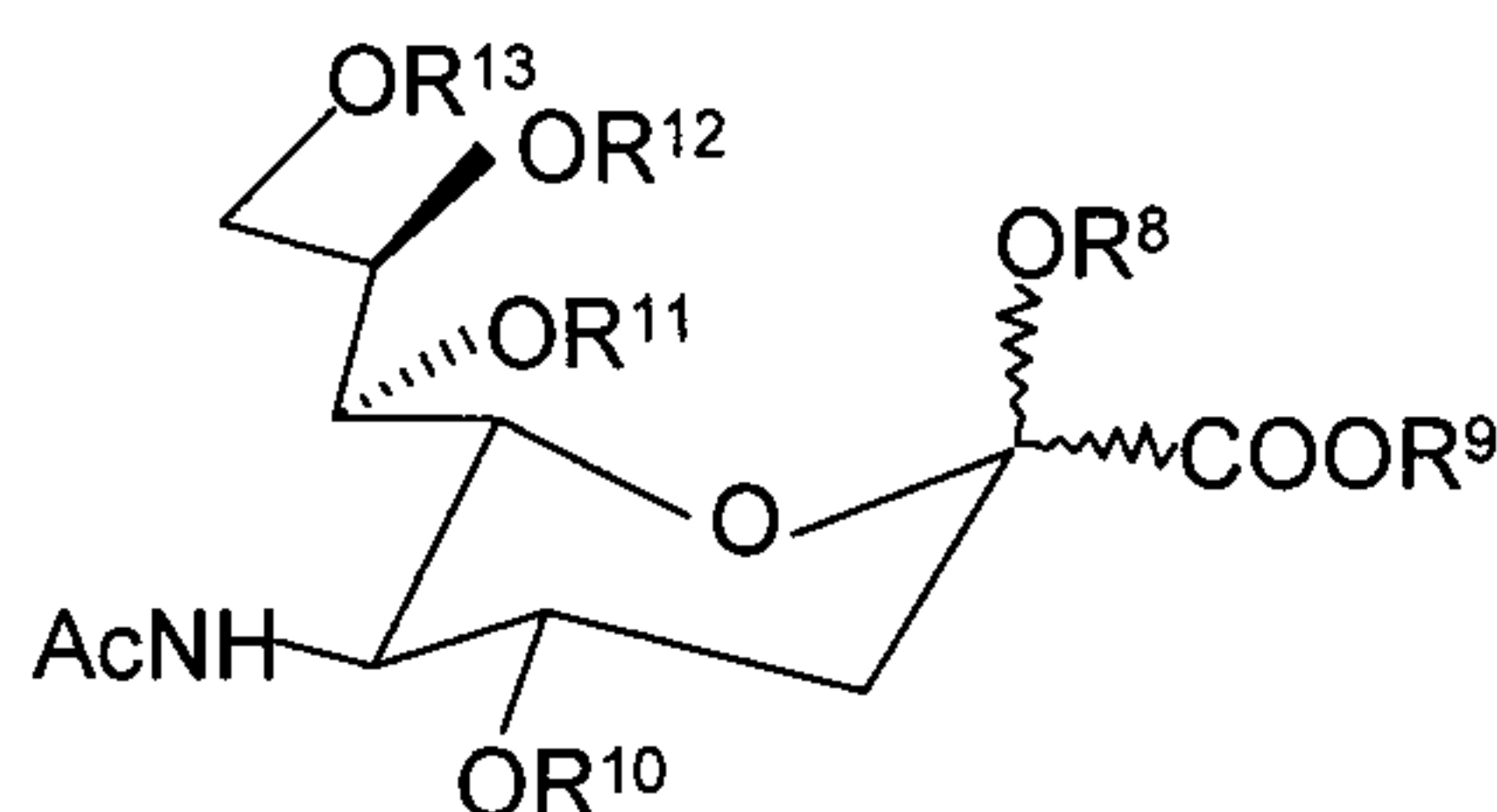
consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), CH_2Ph , $\text{COCR}^5\text{R}^6\text{R}^7$, and $\begin{array}{c} \text{O} \\ \parallel \\ \text{P} \begin{array}{l} \diagup \text{O} - \text{R}^{5'} \\ \diagdown \text{O} - \text{R}^{6'} \end{array} \end{array}$;

- 20 $R^{5'}$, $R^{6'}$ are the same or different and are each independently selected from the group consisting of H or a pharmaceutically acceptable inorganic or organic salt, and a pharmaceutically acceptable ester;

when B is H, then A is selected from the group consisting of NHCOCH_3 , NH_2 , and $\text{NH}_2 \cdot \text{HX}$;

- 25 wherein HX represents a pharmaceutically acceptable inorganic or organic acid; and

wherein Formula (2) has the formula



Formula (2)

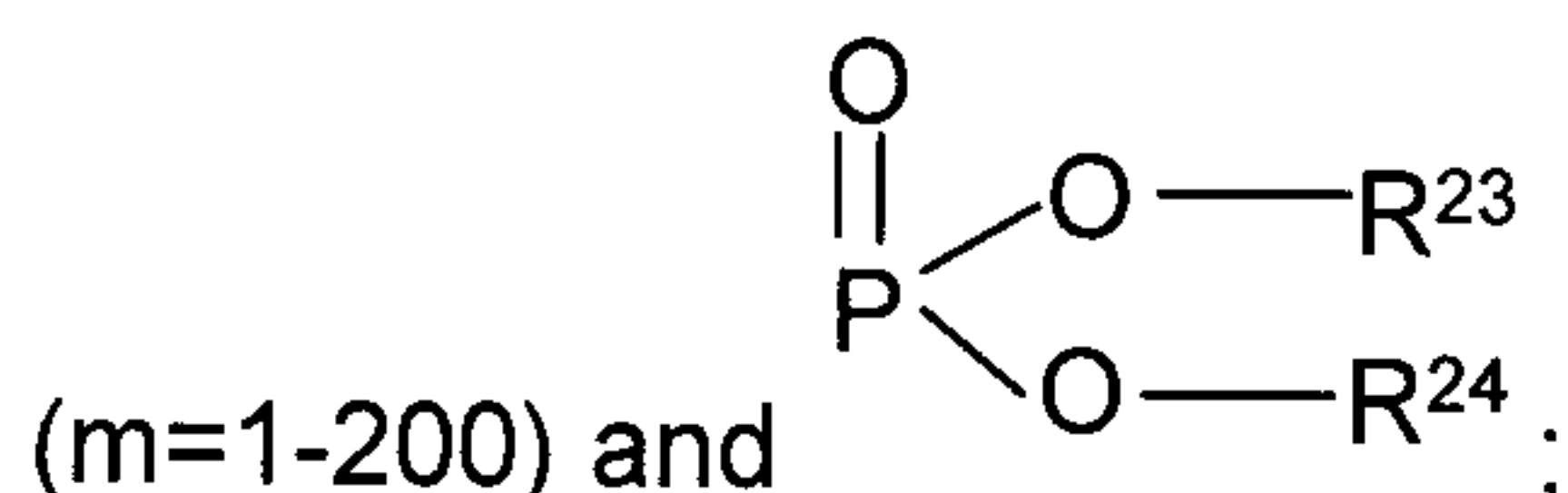
wherein,

R^8 is selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , $COCH_2Ph$, and $COCR^{14}R^{15}R^{16}$; wherein R^{14} , R^{15} , R^{16} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$); cytidine, cytidine monophosphate, cytidine diphosphate, cytidine triphosphate, adenosine, adenosine monophosphate, adenosine diphosphate, and adenosine triphosphate;

R^9 is selected from the group consisting of H, CH_3 , pharmaceutically acceptable inorganic or organic salt, a pharmaceutically acceptable ester, and $CH_2CR^{17}R^{18}R^{19}$ wherein R^{17} , R^{18} , R^{19} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$), C_6H_5 , and CH_2Ph ;

R^{10} , R^{11} , R^{12} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , and $COCR^{20}R^{21}R^{22}$ wherein R^{21} , R^{22} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , and $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$);

R^{13} is the same or different to R^{10} , R^{11} , R^{12} and is selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , and $COCR^{20}R^{21}R^{22}$ wherein R^{21} , R^{22} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$

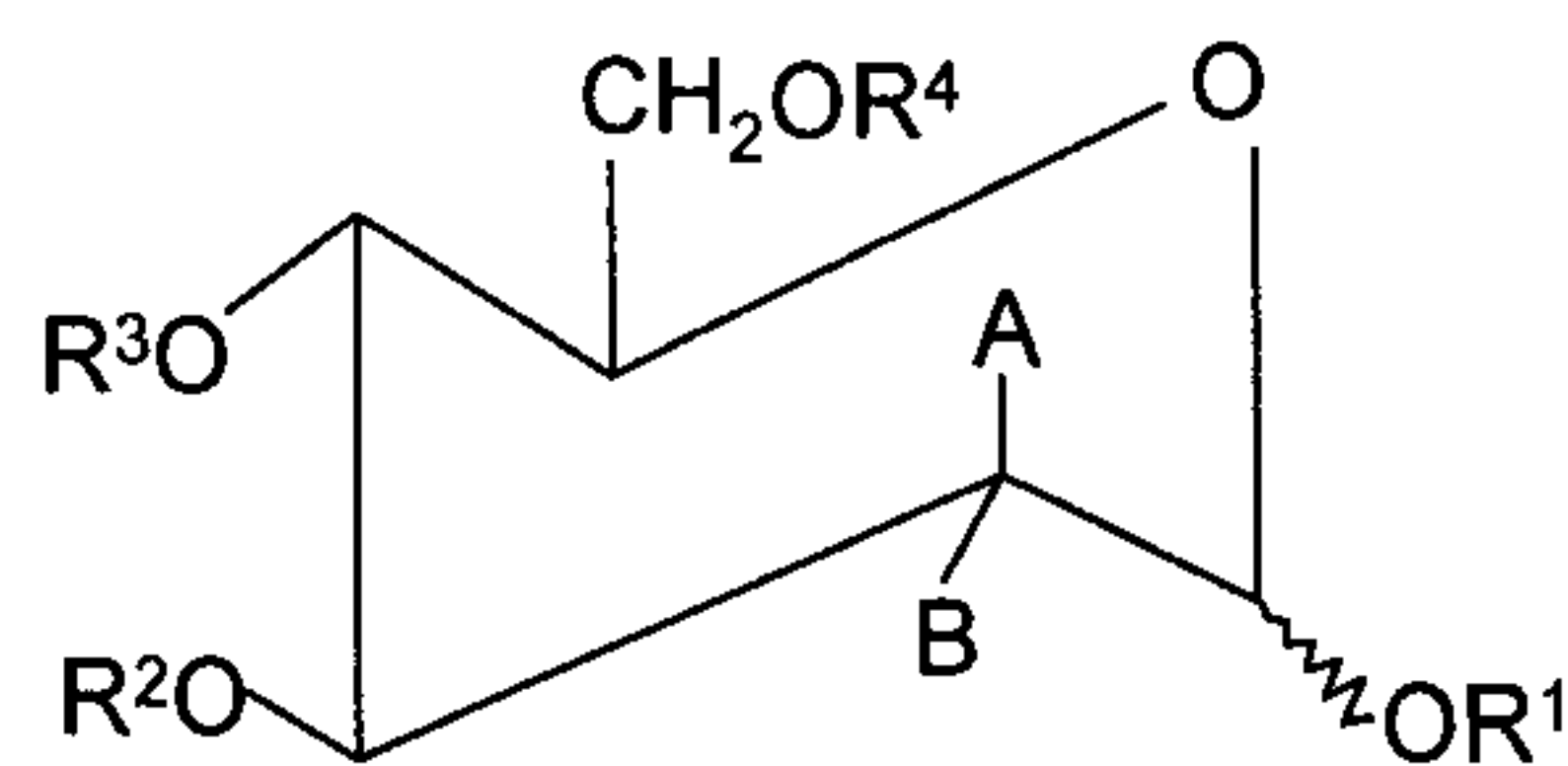


R^{23} , R^{24} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$),

CH₂Ph, CH₂CR²⁵R²⁶R²⁷, and pharmaceutically acceptable inorganic or organic salt; and R²⁵, R²⁶, R²⁷ are the same or different and are each independently selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), and C₆H₅, CH₂Ph.

- 5 2. The composition according to claim 1 wherein the at least one pharmaceutically acceptable compound is selected from the group consisting of N-acetylmannosamine, N-acetylneuraminic acid, CMP-sialic acid, and combinations thereof.
- 10 3. The composition according to claim 1 or 2 wherein the pharmaceutically acceptable compound is selected from the group consisting of:
 - a compound of Formula (1), in which B is H, A is NHCOCH₃, and each of R¹, R², R³, and R⁴ is H;
 - a compound of Formula (2), in which each of R⁸, R¹⁰, R¹¹, R¹², and R¹³ is H, and
 - 15 R⁹ is Na;
 - a compound of Formula (2), in which each of R⁸, R¹⁰, R¹¹, R¹², and R¹³ is H, and R⁹ is C₂H₅;
 - a compound of Formula (2), in which R⁸ is H, R⁹ is C₂H₅, and each of R¹⁰, R¹¹, R¹², and R¹³ is CH₃CO;
 - 20 a compound of Formula (2), in which R⁸ is cytidine monophosphate, and each of R⁹, R¹⁰, R¹¹, R¹², and R¹³ is H; and
 - a compound of Formula (2), in which each of R⁸, R¹⁰, and R¹¹ is H, R⁹ is C₂H₅ and R¹² and R¹³, together, are C(CH₃)₂.
- 25 4. A pharmaceutical composition for treating or preventing a respiratory condition resulting from a damaged respiratory cell in a subject, wherein the composition includes at least one pharmaceutically acceptable compound and a pharmaceutically acceptable carrier, adjuvant, or vehicle wherein the at least one pharmaceutically acceptable compound is selected from the group consisting of compounds of Formula
- 30 (1) and compounds of Formula (2),
 wherein Formula (1) has the formula:

43



Formula (1)

wherein,

5 R^1 , R^2 , R^3 , are the same or different and are each independently selected from the group consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), CH_2Ph , $\text{COCR}^5\text{R}^6\text{R}^7$;

R^5 , R^6 , R^7 are the same or different and are each independently selected from the group consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), C_6H_5 , CH_2Ph , and $\text{CH}_3\text{CH}_2(\text{OCH}_2\text{CH}_2)_m\text{CH}_3$ ($m=1-200$);

R^4 is the same or different to R^1 , R^2 , R^3 and is selected from the group

10 consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), CH_2Ph , $\text{COCR}^5\text{R}^6\text{R}^7$, and $\begin{array}{c} \text{O} \\ || \\ \text{P} \begin{array}{l} \diagup \text{O} - \text{R}^{5'} \\ \diagdown \text{O} - \text{R}^{6'} \end{array} \end{array}$;

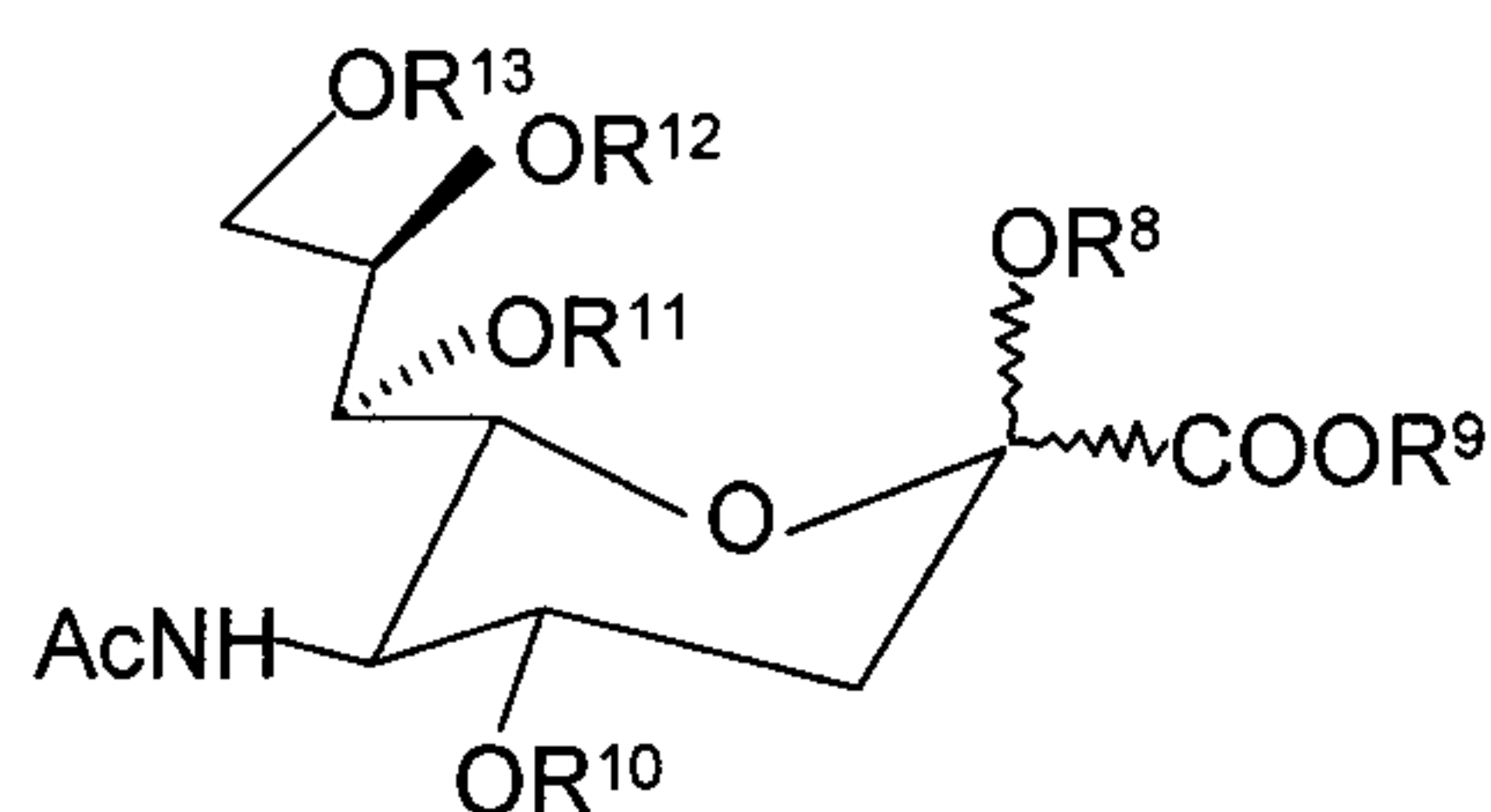
$R^{5'}$, $R^{6'}$ are the same or different and are each independently selected from the group consisting of H or a pharmaceutically acceptable inorganic or organic salt, and a pharmaceutically acceptable ester;

15 when B is H, then A is selected from the group consisting of NHCOCH_3 , NH_2 , and $\text{NH}_2\cdot\text{HX}$;

wherein HX represents a pharmaceutically acceptable inorganic or organic acid;

and

wherein Formula (2) has the formula



Formula (2)

20

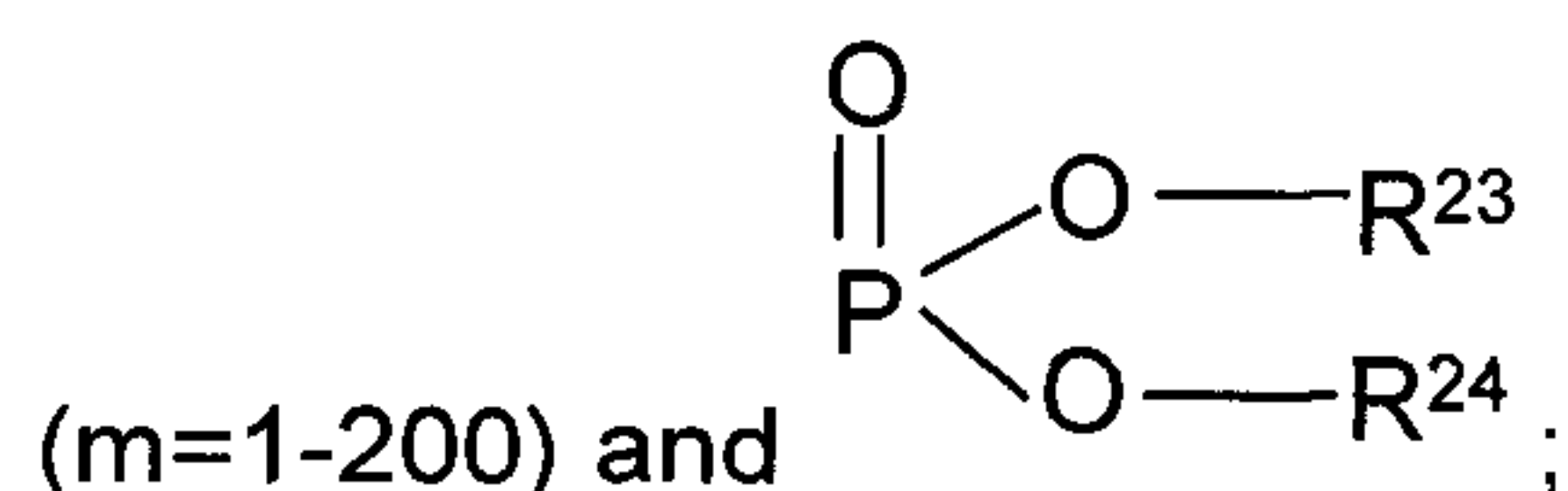
wherein,

R⁸ is selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), CH₂Ph, COCH₂Ph, and COCR¹⁴R¹⁵R¹⁶; wherein R¹⁴, R¹⁵, R¹⁶ are the same or different and are each independently selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), C₆H₅, CH₂Ph, CH₂CH₂(OCH₂CH₂)_mCH₃ (m=1-200); cytidine, cytidine
5 monophosphate, cytidine diphosphate, cytidine triphosphate, adenosine, adenosine monophosphate, adenosine diphosphate, and adenosine triphosphate;

R⁹ is selected from the group consisting of H, CH₃, pharmaceutically acceptable inorganic or organic salt, a pharmaceutically acceptable ester and CH₂CR¹⁷R¹⁸R¹⁹ wherein R¹⁷, R¹⁸, R¹⁹ are the same or different and are each independently selected
10 from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), CH₂CH₂(OCH₂CH₂)_mCH₃ (m=1-200), C₆H₅, and CH₂Ph;

R¹⁰, R¹¹, R¹² are the same or different and are each independently selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), CH₂Ph, and COCR²⁰R²¹R²² wherein R²¹, R²² are the same or different and are each independently selected from
15 the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), C₆H₅, CH₂Ph, and CH₂CH₂(OCH₂CH₂)_mCH₃ (m=1-200);

R¹³ is the same or different to R¹⁰, R¹¹, R¹² and is selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), CH₂Ph, and COCR²⁰R²¹R²² wherein R²¹, R²² are the same or different and are each independently selected from the group
20 consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), C₆H₅, CH₂Ph, CH₂CH₂(OCH₂CH₂)_mCH₃



R²³, R²⁴ are the same or different and are each independently selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), CH₂CH₂(OCH₂CH₂)_mCH₃ (m=1-200), CH₂Ph, , CH₂CR²⁵R²⁶R²⁷, and pharmaceutically acceptable inorganic or organic salt;
25 and R²⁵, R²⁶, R²⁷ are the same or different and are each independently selected from the group consisting of H, CH₃, (CH₂)_nCH₃ (n=1-20), and C₆H₅, CH₂Ph

wherein the respiratory condition is selected from the group consisting of coughs, post viral or bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD) and cystic fibrosis.

5. The pharmaceutical composition according to claim 4 wherein the at least one pharmaceutically acceptable compound is selected from the group consisting of N-acetylmannosamine, N-acetylneuraminic acid, CMP-sialic acid, and combinations thereof.

5

6. The pharmaceutical composition according to claim 4 or 5 wherein the pharmaceutically acceptable compound is selected from the group consisting of:

a compound of Formula (1), in which B is H, A is NHCOCH_3 , and each of R^1 , R^2 , R^3 , and R^4 is H;

10 a compound of Formula (2), in which each of R^8 , R^{10} , R^{11} , R^{12} , and R^{13} is H, and R^9 is Na;

a compound of Formula (2), in which each of R^8 , R^{10} , R^{11} , R^{12} , and R^{13} is H, and R^9 is C_2H_5 ;

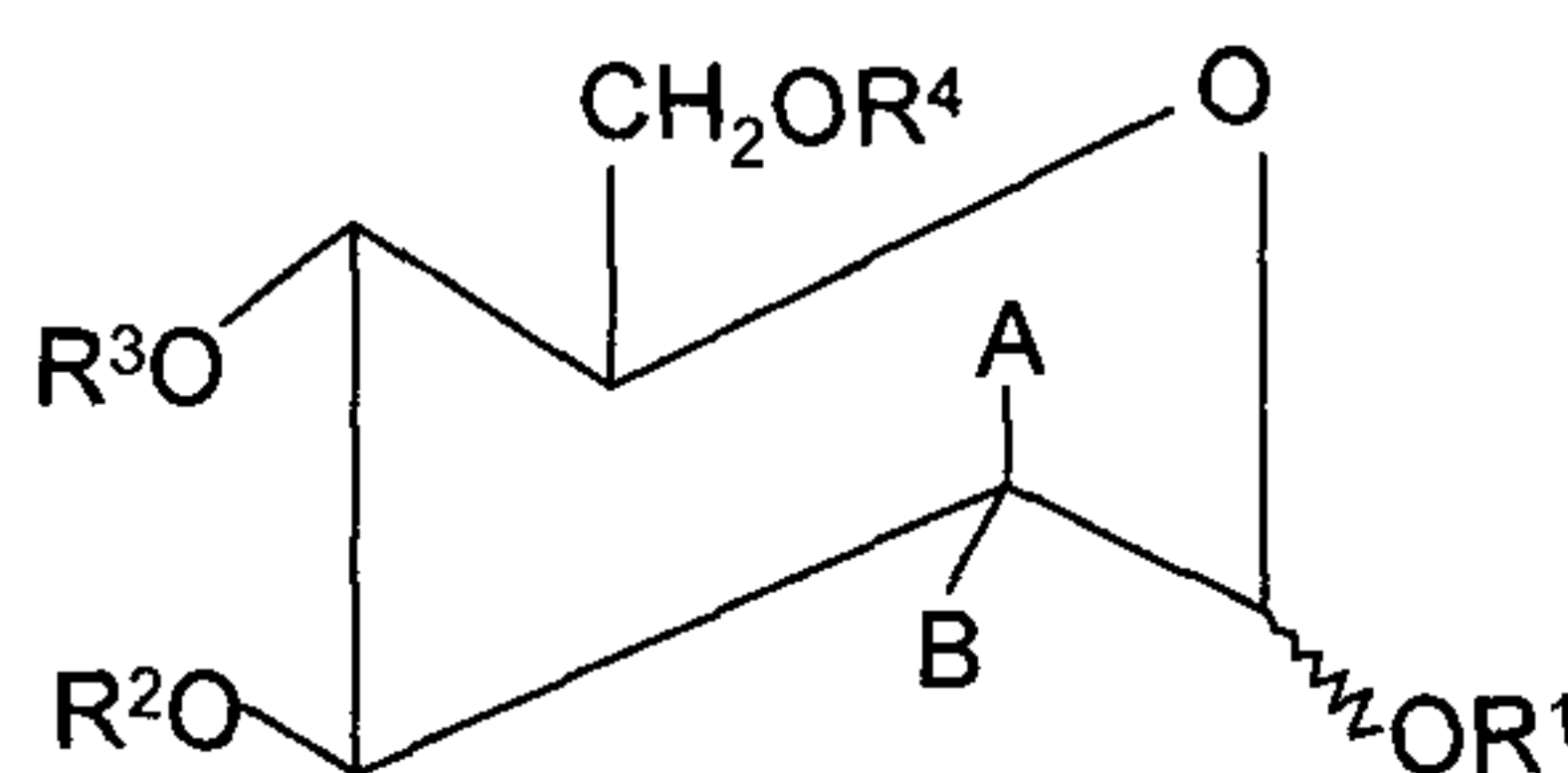
15 a compound of Formula (2), in which R^8 is H, R^9 is C_2H_5 , and each of R^{10} , R^{11} , R^{12} , and R^{13} is CH_3CO ;

a compound of Formula (2), in which R^8 is cytidine monophosphate, and each of R^9 , R^{10} , R^{11} , R^{12} , and R^{13} is H; and

a compound of Formula (2), in which each of R^8 , R^{10} , and R^{11} is H, R^9 is C_2H_5 and R^{12} and R^{13} , together, are $\text{C}(\text{CH}_3)_2$.

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7. A use of at least one pharmaceutically acceptable compound selected from the group consisting of compounds of Formula (1) and compounds of Formula (2) wherein Formula (1) has the formula:



Formula (1)

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wherein,

R^1 , R^2 , R^3 , are the same or different and are each independently selected from the group consisting of H, CH_3 , $(\text{CH}_2)_n\text{CH}_3$ ($n=1-20$), CH_2Ph , and $\text{COCR}^5\text{R}^6\text{R}^7$;

R^5 , R^6 , R^7 are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , and $CH_3CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$);

R^4 is the same or different to R^1 , R^2 , R^3 and is selected from the group

5 consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , $COCR^5R^6R^7$, and

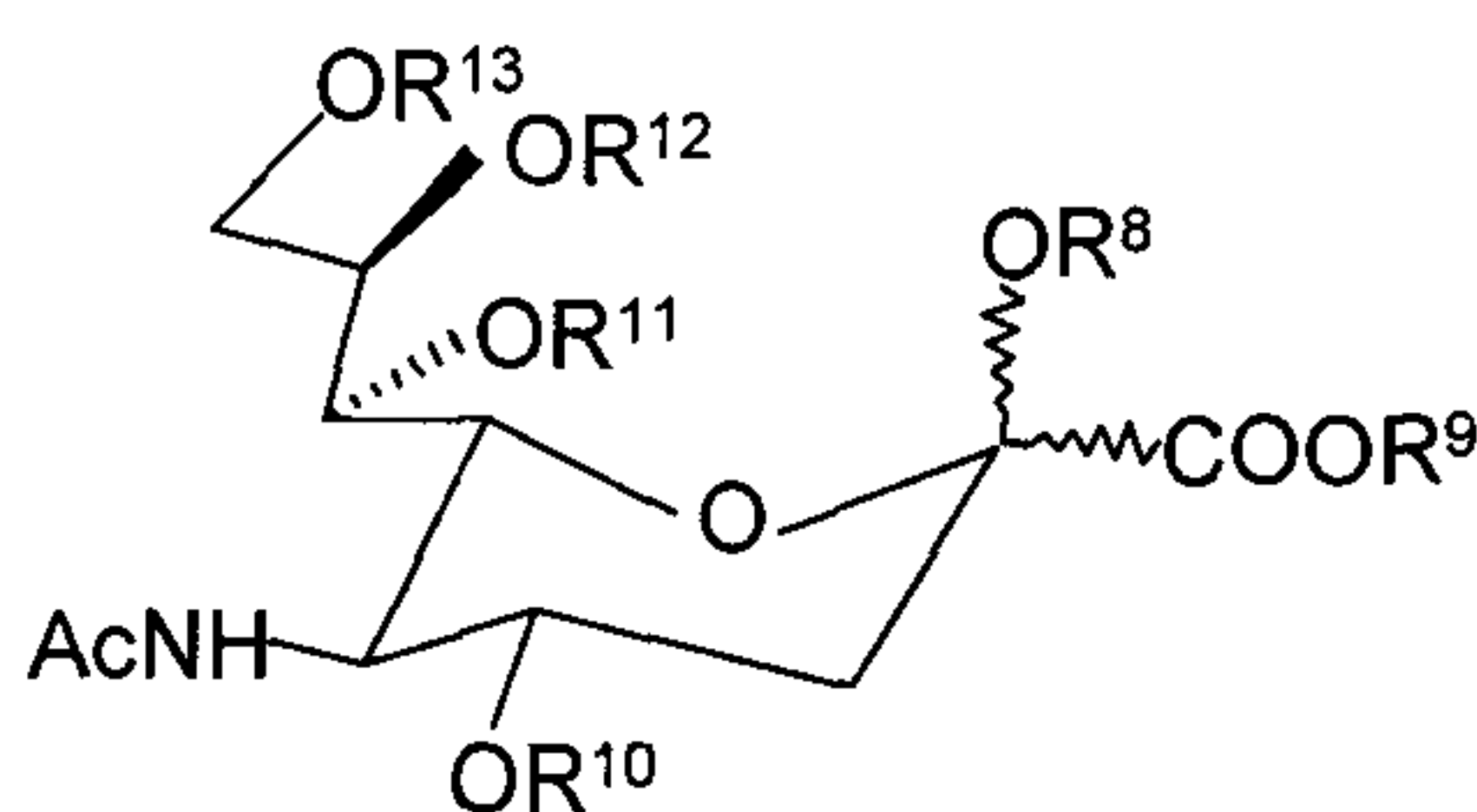
R^5' , R^6' are the same or different and are each independently selected from the group consisting of H or a pharmaceutically acceptable inorganic or organic salt, and a pharmaceutically acceptable ester;

10 when B is H, then A is selected from the group consisting of $NHCOCH_3$, NH_2 , and $NH_2 \cdot HX$;

wherein HX represents a pharmaceutically inorganic or organic acid;

and

wherein Formula (2) has the formula



15 Formula (2)

wherein,

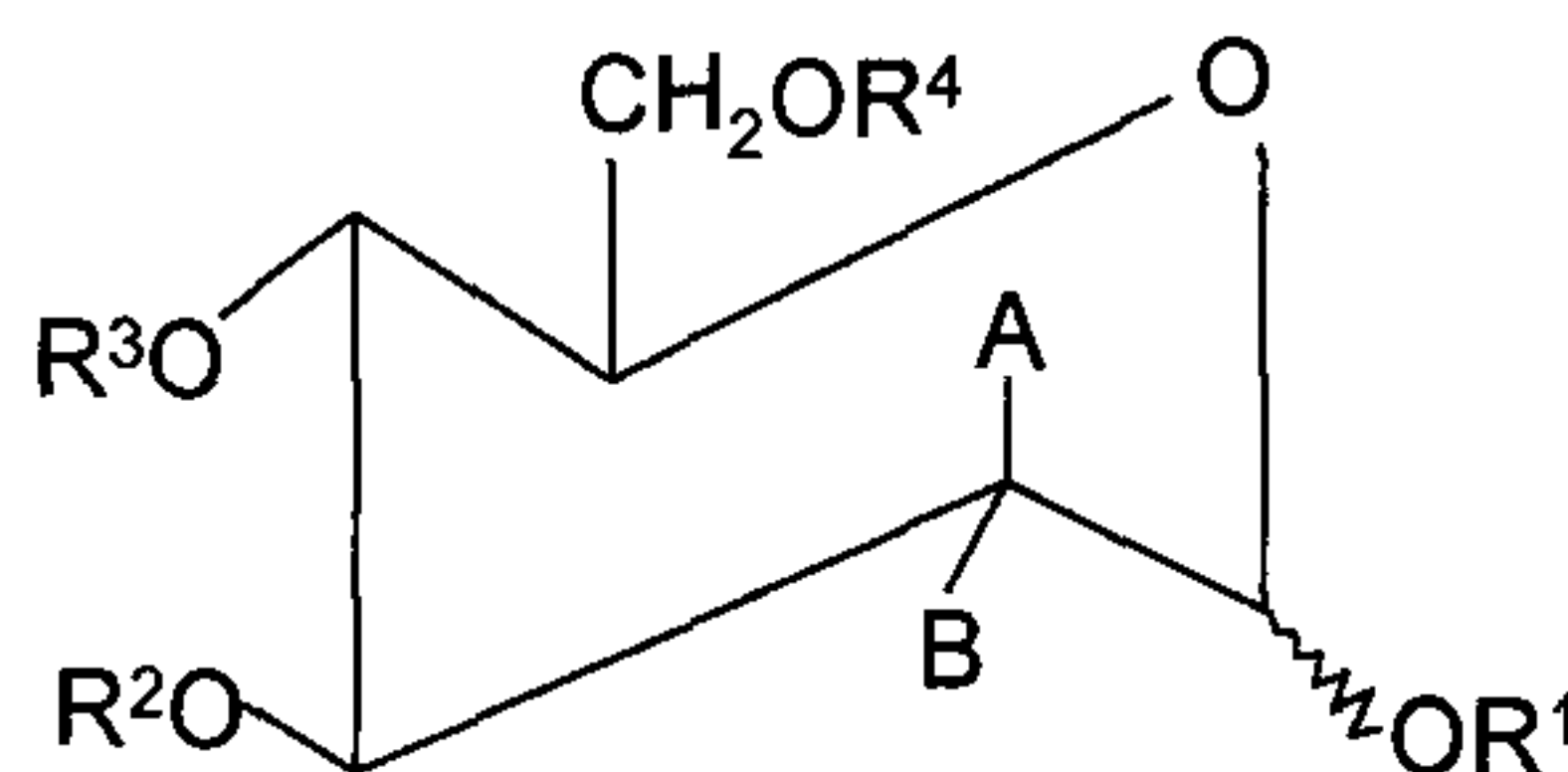
R^8 is selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , $COCH_2Ph$, and $COCR^{14}R^{15}R^{16}$; wherein R^{14} , R^{15} , R^{16} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$); cytidine, cytidine monophosphate, cytidine diphosphate, cytidine triphosphate, adenosine, adenosine monophosphate, adenosine diphosphate, and adenosine triphosphate;

R^9 is selected from the group consisting of H, CH_3 , pharmaceutically acceptable inorganic or organic salt, a pharmaceutically acceptable ester and $CH_2CR^{17}R^{18}R^{19}$ wherein R^{17} , R^{18} , R^{19} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$), C_6H_5 , and CH_2Ph ;

R^{13} is the same or different to R^{10} , R^{11} , R^{12} and is selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , and $COCR^{20}R^{21}R^{22}$ wherein R^{21} , R^{22} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$

R^{23} , R^{24} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$), CH_2Ph , $CH_2CR^{25}R^{26}R^{27}$, and pharmaceutically acceptable inorganic or organic salt; and R^{25} , R^{26} , R^{27} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), and C_6H_5 , CH_2Ph in the preparation of a medicament for the treatment or prevention of a respiratory condition resulting from a damaged respiratory cell said condition selected from the group consisting of coughs, post viral or bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD) and cystic fibrosis.

8. A use of at least one pharmaceutically acceptable compound selected from the group consisting of compounds of Formula (1) and compounds of Formula (2) wherein Formula (1) has the formula:



25

wherein,

R^1 , R^2 , R^3 , are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , and $COCR^5R^6R^7$;

R^5 , R^6 , R^7 are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , and $CH_3CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$);

R^4 is the same or different to R^1 , R^2 , R^3 and is selected from the group

consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , $COCR^5R^6R^7$, and $\begin{array}{c} O \\ || \\ P \begin{array}{l} \diagup O-R^{5'} \\ \diagdown O-R^{6'} \end{array} \end{array}$;

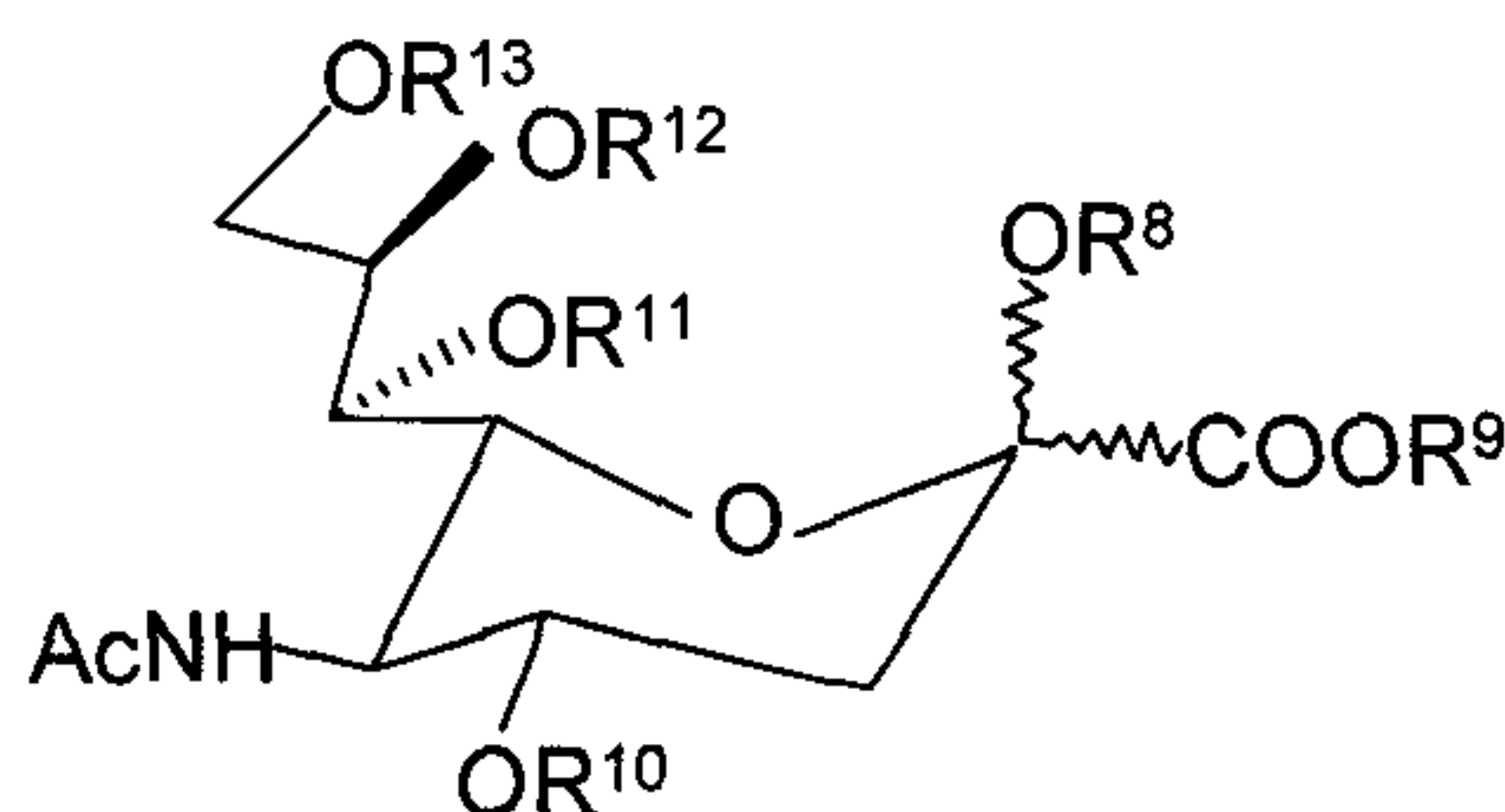
$R^{5'}$, $R^{6'}$ are the same or different and are each independently selected from the group consisting of H or a pharmaceutically acceptable inorganic or organic salt, and a pharmaceutically acceptable ester;

when B is H, then A is selected from the group consisting of $NHCOCH_3$, NH_2 , and $NH_2 \cdot HX$;

wherein HX represents a pharmaceutically inorganic or organic acid;

and

wherein Formula (2) has the formula



Formula (2)

wherein,

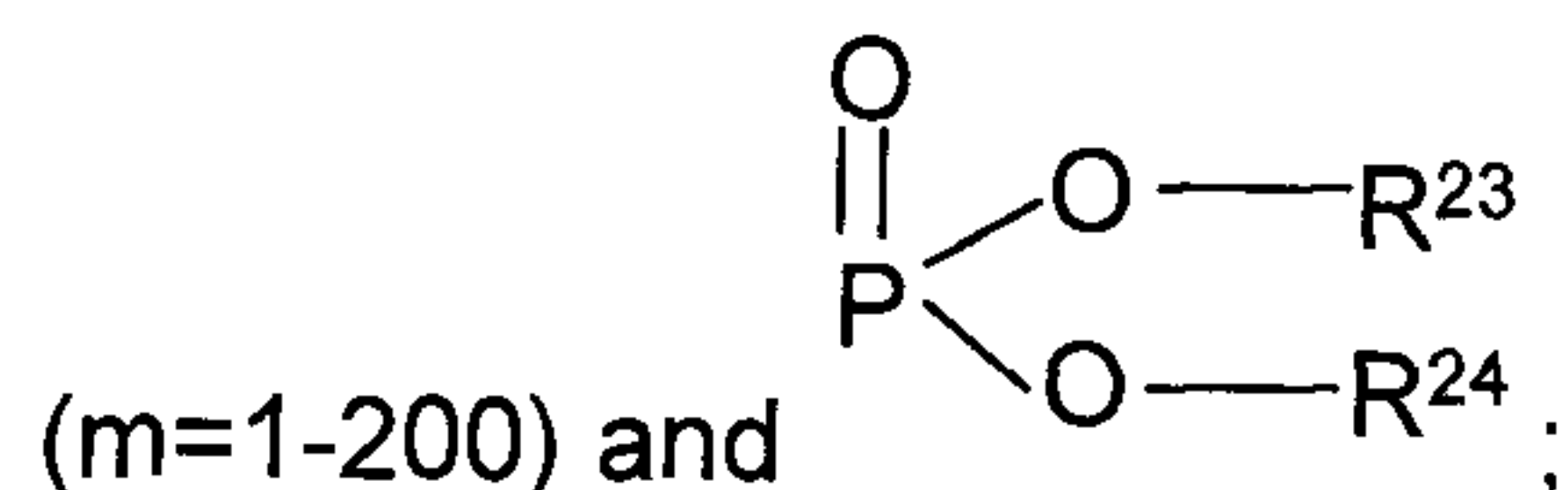
R^8 is selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , $COCH_2Ph$, and $COCR^{14}R^{15}R^{16}$; wherein R^{14} , R^{15} , R^{16} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$); cytidine, cytidine monophosphate, cytidine diphosphate, cytidine triphosphate, adenosine, adenosine monophosphate, adenosine diphosphate, and adenosine triphosphate;

R^9 is selected from the group consisting of H, CH_3 , pharmaceutically acceptable inorganic or organic salt, a pharmaceutically acceptable ester and $CH_2CR^{17}R^{18}R^{19}$

wherein R^{17} , R^{18} , R^{19} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$), C_6H_5 , and CH_2Ph ;

R^{10} , R^{11} , R^{12} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , and $COCR^{20}R^{21}R^{22}$ wherein R^{21} , R^{22} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , and $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$);

R^{13} is the same or different to R^{10} , R^{11} , R^{12} and is selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), CH_2Ph , and $COCR^{20}R^{21}R^{22}$ wherein R^{21} , R^{22} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), C_6H_5 , CH_2Ph , $CH_2CH_2(OCH_2CH_2)_mCH_3$



R^{23} , R^{24} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), $CH_2CH_2(OCH_2CH_2)_mCH_3$ ($m=1-200$), CH_2Ph , $CH_2CR^{25}R^{26}R^{27}$, and pharmaceutically acceptable inorganic or organic salt; and R^{25} , R^{26} , R^{27} are the same or different and are each independently selected from the group consisting of H, CH_3 , $(CH_2)_nCH_3$ ($n=1-20$), and C_6H_5 , CH_2Ph for the treatment or prevention of a respiratory condition resulting from a damaged respiratory cell said condition selected from the group consisting of coughs, post viral or bacterial infections, acute/chronic bronchitis, chronic obstructive pulmonary disease (COPD) and cystic fibrosis.

9. The use according to claim 7 or 8 wherein the at least one pharmaceutically acceptable compound is selected from the group consisting of N-acetylmannosamine, N-acetylneuraminic acid, CMP-sialic acid, and combinations thereof.

10. The use according to claim 7 or 8 wherein the pharmaceutically acceptable compound is selected from the group consisting of:

30 a compound of Formula (1), in which B is H, A is $NHCOCH_3$, and each of R^1 , R^2 , R^3 , and R^4 is H;

a compound of Formula (2), in which each of R^8 , R^{10} , R^{11} , R^{12} , and R^{13} is H, and R^9 is Na;

a compound of Formula (2), in which each of R^8 , R^{10} , R^{11} , R^{12} , and R^{13} is H, and R^9 is C_2H_5 ;

5 a compound of Formula (2), in which R^8 is H, R^9 is C_2H_5 , and each of R^{10} , R^{11} , R^{12} , and R^{13} is CH_3CO ;

a compound of Formula (2), in which R^8 is cytidine monophosphate, and each of R^9 , R^{10} , R^{11} , R^{12} , and R^{13} is H; and

10 a compound of Formula (2), in which each of R^8 , R^{10} , and R^{11} is H, R^9 is C_2H_5 and R^{12} and R^{13} , together, are $C(CH_3)_2$.

11. The use according to any one of claims 7 to 10 wherein the pharmaceutically acceptable compound is suitable for administration in the range from 0.1 mg to 500 mg/kg of body weight per day.

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12. The use according to claim 11 wherein the pharmaceutically acceptable compound is suitable for administration in the range from 0.1 mg to 50 mg/kg/day.

13. The use according to any one of claims 7 to 11 wherein the pharmaceutically acceptable compound is suitable for administration orally in the range from 1 mg/kg/day to 500 mg/kg/day.

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14. The use according to claim 13 wherein the pharmaceutically acceptable compound is suitable for administration in the range of from 5 mg to 50 mg/kg, two or three times a day for 5 to 10 days.

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15. The use according to any one of claims 7 to 11 wherein the pharmaceutically acceptable compound is suitable for administration by injection in the range from 1 mg/kg/day to 100mg/kg/day.

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16. The use according to claim 15, wherein the compound is suitable for administration in the range from 5 mg to 50 mg/kg, two or three times a day for 5 to 10 days.

17. The use according to any one claims 7 to 10 wherein the pharmaceutically acceptable compound is suitable for administration by inhalation in the range from 0.01 mg/kg/day to 5 mg/kg/day.

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18. The use according to claim 17 wherein the pharmaceutically acceptable compound is suitable for administration in the range from 0.1 to 0.5 mg/kg/day, one to five times a day for 5 to 10 days.