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(54) Title: USE OF MANNURONIC DIACID COMPOSITION IN TREATMENT OF PAIN

(54) 发明名称: 甘露糖醛二酸的组合物在治疗疼痛中的应用

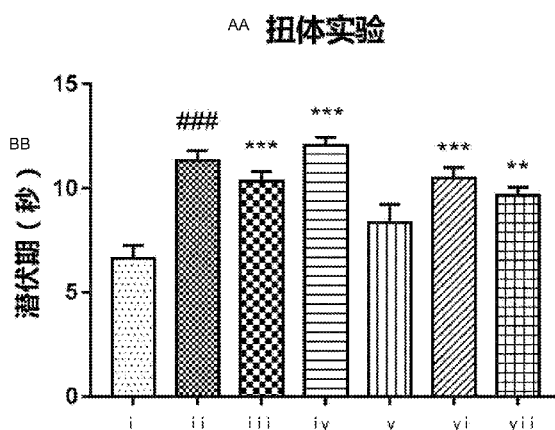


图 4

AA WRITHING TEST
BB LATENT PERIOD (SECONDS)

(57) Abstract: The present invention relates to the use of a mannuronic diacid oligosaccharide composition in the treatment of pain.

(57) 摘要: 本发明涉及一种甘露糖醛二酸寡糖组合物在治疗疼痛方面的应用。

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DESCRIPTION

USE OF MANNURONIC DIACID COMPOSITION IN TREATMENT OF PAIN

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TECHNICAL FIELD

The present invention relates to the use of an optimal composition of mannuronic diacids obtained by a biological activity screening method in the treatment of pain.

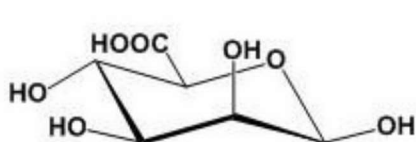
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BACKGROUND OF THE INVENTION

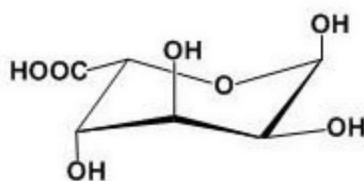
Pain is a complex physiological and psychological activity, which is one of the most common clinical symptoms. Acute pain is often a symptom of other diseases, and chronic pain *per se* is a disease. At present, about 30% of population worldwide suffers from chronic pain. There are at least 100 million patients sufferieng chronic pain in China. Migraine is one of the common headache types in clinical practice. It is characterized by recurrent headaches, with normal intermittent periods. The exact cause of migraine is still unclear. The clinic practice focuses on alleviation of symptoms and preventive treatment during the attack, but there is no ideal treatment drug.

Mannuronic diacids have been paid extensive attention due to their potential medicinal values. Mannuronic diacids are usually prepared by multiple steps with alginic acid as a raw material.

The polysaccharide molecule of the raw material, alginic acid, comprises an M segment formed of D-mannuronic acids linked by β -1,4-glycosidic bonds, a G segment formed of L-guluronic acids linked by α -1,4-glycosidic bonds, and an MG segment formed by hybridization of the two sacchorides. The structural formulae of D-mannuronic acid and L-guluronic acid are shown in the following Formula (I):



M; β -D-mannuronic acid

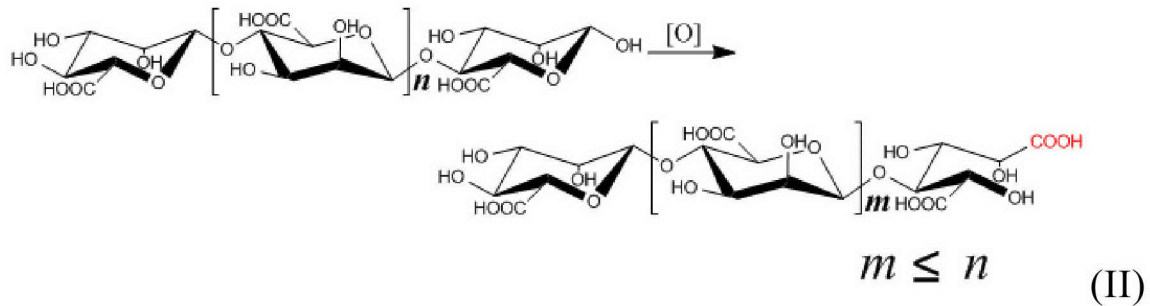


G; α -L-guluronic acid (I)

The M segment and the G segment can be separated from the raw material, alginic acids. A common method can be simply described below: alginic acid is preliminarily degraded to give mixed polysaccharides of polymannuronic acid and polyguluronic acid; then the mixed polysaccharides are subjected to acidic precipitation to remove the polyguluronic acid therein, and further refinement is conducted to obtain a homopolymannuronic acid with a purity of more than 90% (hereinafter also referred to as “M-segment intermediate”). See, e.g., the methods disclosed in Chinese Patent Application No. 98806637.8 and CN02823707.2.

A common preparation method of oligomeric mannuronic acid is as follows: the M-segment intermediate obtained above is subjected to further acidolysis by heating under an acidic condition to obtain a small fragment mannuronic acid polymer having a desired molecular weight range. In addition, the degradation efficiency can be improved by an oxidative degradation method; meanwhile, the reducing end can be oxidized to a ring-opened saccharic diacid, see Chinese Patent Application No. 200580009396.5 (Patent literature 1) filed by Meiyu Geng, *et al.* and US Patent No. 8,835,403 B2 (Patent literature 2) for details. For convenience of description, Patent literatures 1 and 2 are hereinafter collectively referred to as prior documents, which are incorporated herein by reference in their entirety.

The reaction to obtain mannuronic diacid disclosed in prior documents can be represented by the following reaction equation (II), that is, the aldehyde group at position C1 of mannuronic acid at the reducing end of oligomannuronic acid polysaccharide is oxidized to carboxyl group.



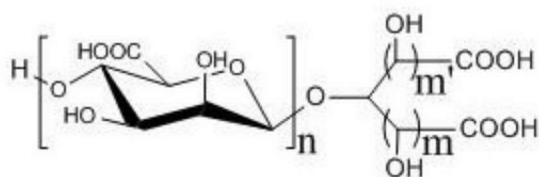
In the above oxidative conversion process, a commonly used oxidant is an alkaline copper sulfate solution, i.e. Fehling's reagent. Prior documents adopt this oxidation method. Specifically, under an alkaline condition, the reaction substrate polymannuronic acid, i.e. the above M-segment intermediate, is added to a copper sulfate solution and reacted in a boiling water bath for 15 minutes to 2 hours. This method uses Cu^{2+} ion as an oxidant to oxidize the aldehyde group, and a brick-red cuprous oxide precipitate is generated in the reaction. This reaction is often used to identify a reducing sugar.

Prior documents disclose that oligomannuronic acids have effects against Alzheimer's disease (AD) and Diabetes Mellitus. The pathogenesis of Alzheimer's disease and type 2 diabetes is closely related to amyloids (β -amyloid and amylin). Amyloid protein aggregates and then produces protein oligomers, which further aggregate to form fibers. These protein aggregates are cytotoxic, induces an oxidative reaction in cells to damage mitochondria, and triggers a cascade reaction such as pain reaction, causing damages to a large number of neurons and β cells, and ultimately leading to onset of Alzheimer's disease and type 2 diabetes. Oligomannuronic acids target amyloid protein and antagonize the cascade reactions induced by the amyloid protein, and therefore have the effects of preventing and treating Alzheimer's disease and type 2 diabetes.

The prior document CN106344595A discloses the application of oligomannuronic acids in the treatment of pain, and also discloses the pharmacodynamic activity of tetrasaccharide-to-decasaccharide mixture in the treatment of pain.

SUMMARY OF THE INVENTION

The invention relates to the use of a mannuronic diacid oligosaccharide composition in the treatment of pain. The applicant has found that the mannuronic diacid oligosaccharide composition with a specific constitution has the effect of treating pain, which comprises mannuronic diacids having Formula (III) or a pharmaceutically acceptable salt thereof:



Formula (III),

wherein n is an integer selected from 1 to 9, m is selected from 0, 1 or 2,

m' is selected from 0 or 1,

and wherein,

the total weight of mannuronic diacids wherein n=1-5 accounts for no less than 60% of the total weight of the composition;

the total weight of mannuronic diacids wherein n=1-2 accounts for less than 60% of the total weight of the composition.

Another aspect of the present invention relates to a method of treating a patient suffering from pain, comprising administering an effective amount of the mannuronic diacid oligosaccharide composition of the present invention to the patient in need thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows mass spectra of disaccharide, trisaccharide and tetrasaccharide in product A.

Figure 2 shows mass spectra of pentasaccharide, hexasaccharide and heptasaccharide in product A.

Figure 3 shows mass spectra of octasaccharide, nonasaccharide and decasaccharide in product A.

Figure 4 shows the effects of oligosaccharide composition, comparative experimental samples and hexasaccharide on the latency of writhing response in mice induced by acetic acid. The samples corresponding to the numbers on the abscissa in the Figure are: i: model group; ii: product A; iii: product B; iv: product C; v: product D; vi: comparative experimental sample; vii: hexasaccharide.

Figure 5 shows the effects of oligosaccharide composition, comparative experimental samples and hexasaccharide on the number of times of writhing response in mice induced by acetic acid; wherein the symbols on the abscissa are the same as those in Figure 4.

Figure 6 shows the effects of oligosaccharide composition, comparative experimental samples and hexasaccharide on the number of times of head scratching in migraine rats induced by nitroglycerin. The samples corresponding to the numbers on the abscissa in the Figure are: i: control group; ii: model group; iii: product A; iv: product B; v: product C; vi: product D; vii: comparative experimental sample; viii: hexasaccharide.

Figure 7 shows the effects of oligosaccharide composition, comparative experimental samples and hexasaccharides on the number of c-fos positive cells in caudal part (*nucleus caudalis*) of the spinal trigeminal nucleus in migraine rats induced by electrical stimulation of the trigeminal ganglia; wherein the symbols on the abscissa are the same as those in Figure 6.

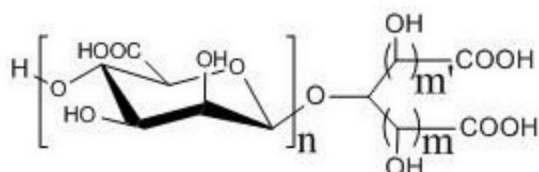
DETAILED DESCRIPTION OF THE INVENTION

Various aspects of the present invention will be described in detail below, but the present invention is not limited to these specific embodiments. Those skilled in the art can make some modifications and adjustments to the present invention according to the the substantial disclosure below, and these adjustments are also within the scope of the present invention.

The present invention relates to the use of the mannuronic diacid oligosaccharide composition in the treatment of pain. The present invention

also relates to a method of treating pain, comprising administering an effective amount of the mannuronic diacid oligosaccharide composition of the present invention to a patient in need thereof.

The mannuronic diacid oligosaccharide composition of the present invention has a specific composition, comprising mannuronic diacids having Formula (III) or a pharmaceutically acceptable salt thereof:



Formula (III),

wherein n is an integer selected from 1 to 9, m is selected from 0, 1 or 2, m' is selected from 0 or 1,

and wherein,

the total weight of mannuronic diacids wherein n=1-5 accounts for no less than 60% of the total weight of the composition;

the total weight of mannuronic diacids wherein n=1-2 accounts for less than 60% of the total weight of the composition.

The mannuronic diacid oligosaccharide composition of the present invention is a mixture of mannuronic diacids with different polymerization degrees, and the main components thereof are mannuronic diacid oligosaccharides with a polymerization degree of 2 to 10. The most active saccharides in mannuronic diacids are tetrasaccharide to decasaccharide, especially hexasaccharide. However, the inventors currently find that adding a certain proportion of less active disaccharide and trisaccharide to the most active tetrasaccharide to decasaccharide does not reduce the biological activity and even increases the activity under the identical administration dosage in mass. Without being bound by any theory, it is speculated that this may be due to the synergistic effect of the small molecular weight disaccharide to trisaccharide when mixed with other oligosaccharides although they cannot work alone. However, when the proportion of disaccharide to trisaccharide is

too high, the overall activity of the composition would be reduced. Therefore, the proportion of disaccharide and trisaccharide in the composition must be controlled within a certain range.

In the actual preparation process, a large amount of disaccharide to trisaccharide will be produced in the oxidative degradation reaction, and usually will be removed from the product after separation in order to avoid affecting the pharmaceutical effect of the product due to its low activity. However, based on the above findings of the inventors, it is not required to separate and remove disaccharide to trisaccharide in the oxidative degradation products, and it is only required to control the conditions of the oxidative degradation reaction to control the proportion of disaccharide to trisaccharide within a certain range. The activity of the resulted composition can reach or even be better than that of the composition disclosed in the prior applications. Moreover, since disaccharide and trisaccharide are not considered as impurities to be removed, the product yield is also significantly higher than that disclosed in the prior applications. Thus, it greatly reduces the production cost, reduces the waste discharge, thereby being easier to realize in the actual production, and being easier to realize industrial large-scale production.

According to a preferred embodiment, in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacids with $m+m'=1$ or 2 is no less than 50% of the total weight of the composition, preferably 60%-90%, more preferably 70%-90%. In particular, in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacids with $m+m'=1$ is no less than 10% of the total weight of the composition, preferably 30-40%. In another preferred embodiment, in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacids with $m+m'=2$ is no less than 10% of the total weight of the composition, preferably 30-50%.

According to a preferred embodiment, in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacid

oligosaccharide wherein n=1-5 accounts for 80-95% of the total weight of the composition.

According to a preferred embodiment, in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacid oligosaccharide wherein n=1-2 accounts for 10-50% of the total weight of the composition, preferably 25-50%.

According to a preferred embodiment, in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacid oligosaccharide wherein n=1-3 accounts for 20-70% of the total weight of the composition.

According to a preferred embodiment, in the mannuronic diacid oligosaccharide composition, the proportion of the total weight of mannuronic diacids wherein n=1-3 to the total weight of mannuronic diacids wherein n=4-7 is between 1.0 and 3.5, preferably between 1.0 and 3.0.

According to a preferred embodiment, in the mannuronic diacid oligosaccharide composition, the weight percentage content of mannuronic diacids with each of the polymerization degrees in the above composition is: disaccharide 5-25%, trisaccharide 15-30%, tetrasaccharide 15-28%, pentasaccharide 5-25%, hexasaccharide 2-20%, heptasaccharide 2-20%, octasaccharide 2-20%, nonasaccharide 2-20%, decasaccharide 2-20%. In particular, in the composition, the weight percentage content of oligosaccharides in the above composition is: disaccharide 5-25%, trisaccharide 15-30%, tetrasaccharide 15-28%, pentasaccharide 10-20%, hexasaccharide 5-15%, heptasaccharide 3-10%, octasaccharide 2-5%, nonasaccharide 1-5%, decasaccharide 1-5%. More preferably, in the composition, the weight percentage content of oligosaccharides in the above composition is: disaccharide 10-20%, trisaccharide 18-30%, tetrasaccharide 15-28%, pentasaccharide 15-20%, hexasaccharide 5-10%, heptasaccharide 3-5%, octasaccharide 2-5%, nonaccharide 1-3%, decasaccharide 1-3%.

In the mannuronic diacid oligosaccharide composition of the present invention, the pharmaceutically acceptable salt can be sodium salt or potassium salt.

The inventors of the present application have found that, when the oligosaccharides of different polymerization degree are complexed according to certain proportions, a high-activity oligosaccharide composition can be obtained, of which the activity is higher than that of the most active hexasaccharide. In particular, the composition added with a certain proportion of disaccharide and trisaccharide has higher activity than the composition without disaccharide and trisaccharide. The proportion of each oligosaccharide in the high-activity oligosaccharide composition can have the following proportion:

The total weight of mannuronic diacids wherein $n=1-5$ in the composition accounts for no less than 60% of the total weight of the composition, preferably 80-95%. The total weight of mannuronic diacids wherein $n=1-2$ accounts for less than 60% of the total weight of the composition, preferably 10-50%, more preferably 25-50%. The total weight of mannuronic diacid oligosaccharide wherein $n=1-3$ accounts for 20-70% of the total weight of the composition. The ratio of the total weight of the mannuronic diacid oligosaccharide wherein $n=1-3$ to the total weight of the mannuronic diacid oligosaccharide wherein $n=4-7$ is between 1.0 and 3.5, preferably between 1.0 and 3.0.

The medicament for the treatment of pain of the present invention comprises a mannuronic diacid oligosaccharide composition, which comprises mannuronic diacids having Formula (III) or pharmaceutically acceptable salts thereof, and one or more pharmaceutically acceptable carriers. The medicament of the present invention can be in the form of tablets, hard capsules, soft capsules, enteric capsules, microcapsules, granules, syrups, injections, granules, emulsions, suspensions, solutions and sustained-release formulation for oral or non-oral administration.

The pharmaceutically acceptable carrier of the present invention refers to a pharmaceutically acceptable carrier known to those skilled in the art. The pharmaceutically acceptable carrier of the present invention includes, but is not limited to, fillers, wetting agents, binders, disintegrants, lubricants, adhesive, 5 glidants, taste masking agents, surfactants, preservatives, etc. Fillers include, but are not limited to lactose, microcrystalline cellulose, starch, saccharide powder, dextrin, mannitol, calcium sulfate, etc. Wetting agents and binders include, but are not limited to sodium carboxymethylcellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, gelatin, sucrose, 10 polyvinylpyrrolidone, etc. Disintegrants include, but are not limited to sodium carboxymethyl starch, crosslinked polyvinylpyrrolidone, crosslinked sodium carboxymethyl cellulose, low substituted hydroxypropyl cellulose, etc. Lubricants include, but are not limited to, magnesium stearate, silica gel micropowder, talc, hydrogenated vegetable oil, polyethylene glycol, 15 magnesium lauryl sulfate, etc. Adhesive includes, but are not limited to, Arabic gum, alginic acid, calcium carboxymethylcellulose, sodium carboxymethylcellulose, glucose binders, dextrans, dextrose, ethyl cellulose, gelatin, liquid glucose, guar gum, hydroxyethylcellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, magnesium aluminum silicate, 20 maltodextrin, methylcellulose, polymethacrylates, polyvinylpyrrolidone, pregelatinized starch, sodium alginate, sorbitol, starch, syrup, and tragacanth gum. Glidants include, but are not limited to colloidal silica, powdered cellulose, magnesium trisilicate, silica and talc. Taste masking agents include, but are not limited to, aspartame, stevioside, fructose, glucose, syrup, honey, 25 xylitol, mannitol, lactose, sorbitol, maltitol, and glycyrrhizin. Surfactants include, but are not limited to Tween -80 and poloxamer. Preservatives include, but are not limited to, parabens, sodium benzoate, potassium sorbate, etc.

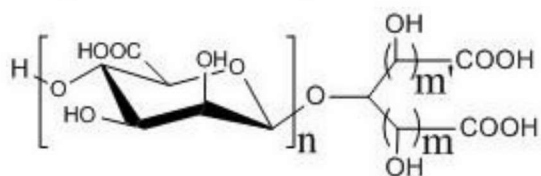
Pain mentioned in the present invention includes various pains, including acute pain, chronic pain, neuropathic pain, postoperative pain, chronic low back 30 pain, cluster headache, herpetic neuralgia, phantom limb pain, central pain,

toothache, opioid-resistant pain, visceral pain, surgical pain, bone injury pain, fatigue and pain during childbirth, pain caused by burns including sunburn, postpartum pain, migraine, angina, and genitourinary tract related pain (including cystitis), vascular pain, trigeminal neuralgia, intercostal neuralgia, surgical incision pain, chronic fasciitis pain, heel pain, muscle pain, bone pain, joint pain, cancer pain, non-cancerous pain etc.

As used herein, the term “treatment” generally refers to achieving a desired pharmacological and/or physiological effect. This effect can be preventive according to the complete or partial prevention of the disease or its symptoms; and/or can be therapeutic according to partial or complete stabilization or cure of the disease and/or side effects due to the disease. As used herein, “treatment” covers any treatment of a patient’s disease, including: (a) prevention of diseases or symptoms occurring in patients who are susceptible to disease or symptoms but have not yet been diagnosed with the disease; (b) inhibiting the symptoms of the disease, i.e. preventing its development; or (c) relieving the symptoms of the disease, i.e. causing the disease or the deterioration of the symptoms.

Mannuronic diacid oligosaccharide composition

The mannuronic diacid oligosaccharide composition for the treatment of pain of the present invention comprises mannuronic diacids having Formula (III) or a pharmaceutically acceptable salt thereof:



Formula (III),

wherein n is an integer selected from 1 to 9, m is selected from 0, 1 or 2, m' is selected from 0 or 1, and wherein,

the total weight of mannuronic diacids wherein $n=1-5$ accounts for no less than 60% of the total weight of the composition;

the total weight of mannuronic diacids wherein $n=1-2$ accounts for less than 60% of the total weight of the composition.

5 In an exemplary embodiment, the preparation method of the mannuronic diacid oligosaccharide composition for the treatment of pain comprises the following steps:

(1) Preparation of the mannuronic diacids products:

Preparation of M segment intermediate. As described above, the raw
10 material M-segment intermediate used in the present invention can be prepared by a method known in the prior art, e.g., the methods disclosed in Chinese Patent Application No. 98806637.8 and CN02823707.2. A common method can be simply described below: alginic acid is preliminarily degraded to give mixed polysaccharides of polymannuronic acid and polyguluronic acid; then the
15 mixed polysaccharides are subjected to acidic precipitation to remove the polyguluronic acid therein, and further refinement is conducted to obtain a homopolymannuronic acid with a purity of more than 90%, i.e., an M-segment intermediate.

Ozone oxidative degradation. The M-segment intermediate is dissolved in
20 an appropriate amount of water and stirred at room temperature or under heating condition. With continuous introduction of ozone, the reaction starts. The pH value of the reaction can be adjusted to 3-13, preferably 4-10, more preferably 6-8 by dropwise adding dilute hydrochloric acid or dilute NaOH solution. The temperature is preferably 0-70°C, more preferably 10-45°C. After
25 completion of the reaction, the introduction of ozone is stopped and the pH is adjusted to neutral.

Membrane separation and purification. The reaction product obtained above is formulated into a solution at a concentration of about 10% and separated by a molecular cut-off membrane to remove degradation products
30 below monosaccharide. The retentate is collected. The MWCO of the

molecular cut-off membrane used is 1000 Da - 3000 Da, preferably 2000 Da. The collected liquid is concentrated on a rotary evaporator and dried under vacuum to obtain an oligomannuronic diacid mixture. After analysis, it is found that these products are all compositions of oligosaccharide from disaccharide to deca-
5 deca-
1-3 are the examples of the preparation method.

(2) Preparation of oligosaccharides with a single polymerization degree

The oligosaccharide mixture obtained in step (1) is dissolved to a concentration of about 10%, separated on a P6 gel chromatographic column, and subjected to ultraviolet detection to collect each effluent component. The
10 components having the same polymerization degree are combined. Nine components of disaccharide to deca-
11 gel column chromatography, concentrated by rotary evaporator, and dried in vacuum. A specific purification and preparation process is shown in example 4.

15 The operations such as column chromatography, desalting and drying are known to those skilled in the art.

(3) Activity comparison of oligosaccharide compositions

The oligosaccharide composition of the present invention is compared with the purified hexasaccharide for the pharmacological activity. The results
20 show that the oligosaccharide composition of the present invention is better than the most active hexasaccharide in the oligosaccharides with single polymerization degree, while the activity of the composition comprising a higher amount of disaccharide and trisaccharide is slightly lower than that of hexasaccharide. Accordingly, it can be seen that single oligosaccharides can
25 play a synergistic effect after being combined. When the proportion of disaccharide to hexasaccharide in the composition is no less than 60%, and the proportion of disaccharide to trisaccharide is less than 60%, the activity of the composition is the highest. However, when the proportion of disaccharide to trisaccharide is more than 60%, the activity of the composition would also
30 decrease.

Animal model and evaluation of pharmacodynamic activity

1. Animal model for anti-pain pharmacodynamic evaluation—a mouse pain model induced by acetic acid

5 Kunming mice, half of them male and half female, weighing 18-22 g, were randomly divided into groups: blank control group, model group, and dosing group, wherein there were 10 mice in each group. From the day of grouping, the blank control group was given intragastrically 20 ml/kg distilled water once a day for 7 consecutive days, and the other groups were dosed
10 intragastrically with corresponding drugs once a day for 7 consecutive days. One hour after the last administration, the mice in each group were intraperitoneally injected with 0.2 ml of 0.6% acetic acid solution, and the latency of writhing (the time from the injection of acetic acid to the occurrence of writhing response) and the number of times of writhing in mice within 20
15 minutes after the injection of acetic acid were recorded.

The injection of chemicals such as acetic acid solution into the abdominal cavity of mice can stimulate the peritoneum of mice and cause intermittent persistent pain, which is manifested by recessed abdomen, front wall of abdomen being close to the bottom of the cage, crooked buttocks and extension
20 of hind limbs, showing a special posture called a writhing response. The latency of writhing (the time from the injection of acetic acid to the occurrence of writhing response) and the number of times of writhing within a certain period of time can represent the severity of pain. The shorter the the latency of writhing is and the more the number of times of writhing is, the more severe
25 the pain is.

2. Animal model for anti-pain pharmacodynamic evaluation—a migraine rat model induced by nitroglycerin

SD male rats, weighing 180-220g, were randomly divided into groups: blank control group, model group, and dosing group, wherein there were 8 rats
30 in each group. The administration was started on the day of grouping. The

blank control group and the model group were given intragastrically distilled water once a day for 28 consecutive days, and the other groups were dosed intragastrically with the corresponding drugs once a day for 28 consecutive days. 30 minutes after the last administration, animals except the blank control group were given saline, and the other groups were injected subcutaneously with 10 mg/kg of nitroglycerin into the right shoulder to establish the model. The time of the appearance and duration of ear redness in rats after modeling, and the number of times of head-scratching within 30-45 minutes after modeling were observed. The content of 5-HT in brain tissue was determined by fluorescence spectrophotometry, and measured at Ex356nm/Em 483nm wavelength. The result is shown in ng/g brain weight.

Migraine is a dysfunction of blood vessels and nerves due to the interaction of blood vessels and nerve mechanisms. Nitroglycerin can cause the hypersensitivity of trigeminal nerve fibers and cause migraine by expanding the blood vessels of the meninges, forming neurogenic inflammation and activating the functions of hypothalamus, brainstem and spinal cord neurons. The nitroglycerin model is an animal model established in 1995 and has now become a classic animal migraine model. According to the pathogenic mechanism of nitroglycerin, the detection of the time of ear redness caused by vasodilation, the number of times of head scratching caused by pain and the content of serotonin (5-HT) (a pain sensitive factor in brain tissue) were used to assess the severity of migraine. The longer the ear redness lasts, the more times the head scratching and the higher the 5-HT content, the more severe the migraine is.

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3. Animal model for anti-pain pharmacodynamic evaluation—a migraine rat model induced by electrical stimulation of the trigeminal ganglion

SD rats, 5 months old, male, weighing 200-240 g, were randomly divided into groups: blank control group, sham operation group, model group, dosing group, wherein there were 10 rats in each group.

30

Each group was given corresponding drugs orally, and the blank control group, sham operation group, and model group were given distilled water orally. After continuous administration for 10 days, all rats except the blank control group were anesthetized by intraperitoneal injection of 350 mg/kg chloral hydrate. The rats were fixed on a stereotaxic apparatus, and a median incision was made on the top of the head. The skin and muscle were cut layer by layer to expose the skull at the middle of the sagittal suture. A dental drill was used to create a hole 3 mm back and 3 mm aside from the bregma, followed by inserting the electrode into the trigeminal ganglion (the depth from the dura is 9.5mm). Anesthesia was continued after the surgery. All operations were performed under sterile conditions. The stimulation electrodes were debugged. The electrical stimulation parameters were 200 ms cycle, 10 v amplitude, and 5 ms wave width for 10 minutes stimulation. In the sham operation group, only the electrodes were inserted but no stimulation was given. 50 mg/kg Evans Blue was injected into the right femoral vein 7 minutes before stimulation, followed by perfusion and fixation within 20 minutes after stimulation.

Five minutes after the end of stimulation, the left ventricle was perfused for 2 minutes. Craniotomy was performed, and the whole brain was taken out, fixed for determining the c-fos in the pathological section by immunohistochemical. The electrode position was also determined, and the dura at the electrode insertion site and the corresponding site of the other cerebral hemisphere were separated, followed by washing with deionized water, spreading it flat on a glass slide, drying at 37°C for 15 minutes, and fixing with 70% glycerol. The fluorescence intensity of the designated area on the stimulating side and the control side is detected under a confocal microscope with the excitation wavelength of 647 nm and the emission wavelength of 680 nm. The ratio of the fluorescence intensity of the stimulation side/control side is calculated to indicate the plasma protein extravasation (PPE). Continuous frozen coronal sections of the whole brain with a slice thickness of 10 µm were prepared, and the c-fos positive cells were labeled immunohistochemical

fluorescence. 5 fields were randomly selected under a confocal microscope to determine the number of positive cells on the experimental side and the control side in caudal part of the spinal trigeminal nucleus, and then the average of the 5 fields was taken as the average number of positive cells.

5 The activation of the trigeminal neurovascular system is a key part in the production of pain in migraine patients, and the neuroinflammation of the meninges plays an important role in the production and maintenance of migraine pain. When the trigeminal nerve distributed in the dura mater is stimulated, it releases vasoactive substances, causing meningeal vasodilation, 10 extravasation of plasma components, degranulation of mast cells and activation of platelets, resulting in migraine. In addition, the neurotransmitter released after pain stimulation binds to the corresponding receptors on the cell membrane. Under the action of the second messenger, the c-fos mRNA gene is expressed, translated and synthesized in the nucleus into c-fos protein, resulting 15 in long-term physiological effects on the body. Therefore, during the occurrence of migraine, the number of cells expressing c-fos mRNA and c-fos protein in the spinal tract nucleus and raphe magnus of the trigeminal nerve increases. Therefore, the degree of migraine can be reflected by measuring the amount of serum protein exuded from the dura of migraine animals and the number of 20 c-fos positive cells in caudal part (nucleus caudalis) of the spinal trigeminal nucleus. The lower the number of cells, the less severe the migraine is.

Advantages of the present invention are further illustrated in the following nonlimiting examples. However, the specific materials and amounts thereof as well as other experimental conditions used in the examples should not be 25 construed as limiting the present invention. Unless otherwise specified, the parts, proportions, percentages, and the like in the present invention are all calculated by mass.

EXAMPLE

30

Example 1:

Step 1): Preparation of a mannuronic diacid oligosaccharide mixture

An M-segment intermediate was prepared by the method disclosed in prior patents. The specific operations are briefly described below: 5 kg of sodium alginate was formulated into a solution of about 10%, and the pH was adjusted to about 3.0 by adding dilute hydrochloric acid. The solution was heated to 80 °C, and stirred. It was allowed to react for 10 hr before the heating was stopped. After cooling to room temperature, the pH was adjusted to 9.0 by adding NaOH, and further adjusted to 2.85 by adding dilute hydrochloric acid. The solution was centrifuged at 5000 rpm for 10 min. The supernatant was collected, and adjusted to pH 1.0 by adding HCl. After centrifugation, the precipitate was collected, concentrated on a rotary evaporator, and dried under vacuum to give 1500 g of the M-segment intermediate. 500 g of the M-segment intermediate was weighed, and dissolved in distilled water to prepare a solution in a volume of 5 L. The solution was adjusted to pH 6.5 with NaOH, and heated in a water bath to control the reaction temperature at 75 °C. The gas flow rate at the outlet of an oxygen cylinder and the power of an ozone generator were adjusted such that ozone was fed into the reaction solution at a mass concentration flow rate of 8 g/hr. After 4 hr of reaction, the feeding of ozone was stopped, and a suitable amount of water was added to adjust the concentration of the solution to about 10%. The solution was filtered through an ultrafiltration membrane with a molecular weight cut-off of 2,000 Da to collect a retentate. The collected liquid was concentrated on a rotary evaporator and dried under vacuum to obtain 350 g of mannuronic diacid product A.

Step 2): Analysis of proportions and structures of oligosaccharides with various polymerization degrees in mannuronic diacid product A

100 mg of the above dried mannuronic diacid product A was accurately weighed, dissolved in water to a concentration of 10 mg/mL, and passed through a 0.22 µm filter membrane to obtain a test sample solution. The proportions of oligosaccharides with different polymerization degrees in the

composition were determined by Superdex peptide molecular exclusion chromatography (GE Co.) in combination with multi-angle laser light scattering (MALS, Wyatt Co.). The experimental conditions were as follows:

Chromatographic column: Superdex peptide 10/300G1

5 Mobile phase: 0.1 mol/L NaCl

Injection volume: 10 μ L

Flow rate: 0.3 mL/min

Test results: from disaccharide to decasaccharide were represented by dp2-dp10, respectively, dp2 was 19%, dp3 was 25%, dp4 was 22%, dp5 was
10 13%, dp6 was 9%, dp7 was 6%, dp8 was 3%, dp9 was 2% and dp10 was 1%.

Step 3): LC-MS analysis of structures of oligosaccharides with various polymerization degrees in mannuronic diacid product A

Experimental conditions:

Chromatographic column: Superdex peptide 10/300G1

15 Mobile phase: 20% methanol + 80% 80 mmol/L NH₄Ac

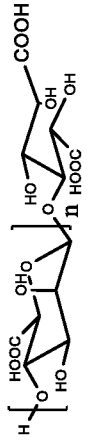
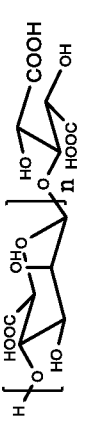
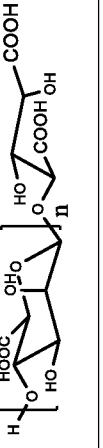
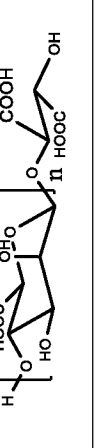
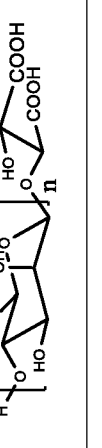

Flow rate: 0.1 mL/ min

Column temperature: 25°C \pm 0.8 °C.

Mass spectrometry conditions: Agilent 6540 QTOF; ion source: ESI collision voltage 120 V; negative ion mode. The width of the acquired signal
20 (m/z) was 100-1000.

The mass spectra of oligosaccharides with various polymerization degrees are shown in Figures 1-3. Various signal peaks in the mass spectra were assigned, confirming the molecular structure of all oligosaccharides in product A, i.e., the structure shown in General Formula (III). See Table 1 below for the
25 signal assignments and the structures corresponding to the signals.

Table 1: six diacid structures in oligosaccharides with different polymerization degrees in product A and their mass-to-charge ratios in mass spectra

No.	Molecular structure	Molecular Formula	Mass-to-Charge Ratio (m/z)								
			n=1 [M-1] ⁻	n=2 [M-1] ⁻	n=3 [M-1] ⁻	n=4 [M-1] ⁻	n=5 [M-1] ⁻	n=6 [M-1] ⁻	n=7 [M-2] ²⁻	n=8 [M-2] ²⁻	n=9 [M-2] ²⁻
1		$(C_6H_8O_6)_n C_6H_{10}O_8$ n=1-9	385	561	737	913	1089	1265	720	808	896
2		$(C_6H_8O_6)_n C_5H_8O_7$ n=1-9	355	531	707	883	1059	1235	705	793	881
3		$(C_6H_8O_6)_n C_5H_8O_7$ n=1-9	355	531	707	883	1059	1235	705	793	881
4		$(C_6H_8O_6)_n C_4H_6O_6$ n=1-9	325	501	677	853	1029	1205	690	778	866
5		$(C_6H_8O_6)_n C_4H_6O_6$ n=1-9	325	501	677	853	1029	1205	690	778	866
6		$(C_6H_8O_6)_n C_3H_4O_5$ n=1-9	295	471	647	823	999	1175	675	763	851

It was found from the above mass spectrometric structural analysis that the mannuronic acid at the reducing end of the sugar chain in product A was oxidized to a saccharic diacid structure (see General Formula III for the structure), which could be a mannaric diacid structure comprising 6 carbon atoms ($m+m'=3$) with a content of about 10%~30%, or a decarboxylation product of mannaric diacid, i.e., a saccharic diacid comprising 5 carbons ($m+m'=2$) (30~50%) and a saccharide diacid with 4 carbons ($m+m'=1$) (30%~40%).

Example 2:

100 g of the M-segment intermediate in example 1 was weighed, and dissolved in distilled water to prepare a solution with a volume of 0.8 L. The solution was adjusted to pH 4.0 with NaOH, and the reaction was carried out at room temperature (25°C). The gas flow rate at the outlet of an oxygen cylinder and the power of an ozone generator were adjusted such that ozone was fed into the reaction solution at a mass concentration flow rate of 1 g/hr. After 10 hr of reaction, the feeding of ozone was stopped, and a suitable amount of water was added to adjust the concentration of the solution to about 15%. The solution was filtered through an ultrafiltration membrane with a molecular weight cut-off of 1,000 Da to collect a retentate. The collected liquid was concentrated on a rotary evaporator and dried under vacuum to obtain 80 g of mannuronic diacid product B.

The proportions of oligosaccharides components with various polymerization degrees in B were determined by Superdex peptide molecular exclusion chromatography (GE Co.) in combination with multi-angle laser light scattering (MALS, Wyatt Co.). The measurement method was the same as the relevant part in example 1. Test results: from disaccharide to decasaccharide were represented by dp2-dp10, respectively, dp2 was 20%, dp3 was 25%, dp4 was 19%, dp5 was 12%, dp6 was 9%, dp7 was 5%, dp8 was 5%, dp9 was 3% and dp10 was 2%.

Example 3:

100 g of the M-segment intermediate of example 1 was weighed, dissolved in distilled water to prepare a solution with a volume of 1.5 L. The solution was adjusted to pH 9.0 with NaOH, and the reaction was carried out in a water bath at 45 °C. The gas flow rate at the outlet of an oxygen cylinder and the power of an ozone generator were adjusted such that ozone was fed into the reaction solution at a mass concentration flow rate of 3 g/hr. After 2 hr of reaction, the feeding of ozone was stopped, and a suitable amount of water was added to adjust the concentration of the solution to about 5%. The solution was filtered through an ultrafiltration membrane with a molecular weight cut-off of 3,000 Da to collect a retentate. The collected liquid was concentrated on a rotary evaporator and dried under vacuum to obtain 60 g of mannuronic diacid product C.

The proportions of oligosaccharides with various polymerization degrees in C were determined by Superdex peptide molecular exclusion chromatography (GE Co.) in combination with multi-angle laser light scattering (MALS, Wyatt Co.). The measurement method was the same as the relevant part in example 1. Test results: from disaccharide to decasaccharide were represented by dp2-dp10, respectively, dp2 was 8%, dp3 was 20%, dp4 was 28%, dp5 was 19%, dp6 was 13%, dp7 was 6%, dp8 was 3%, dp9 was 2%, and dp10 was 1%.

Example 4:

Preparation of mannuronic diacid oligosaccharide with single polymerization degree, which was as follows:

1. Sample preparation: 300 g of mannuronic diacid product A prepared in example 1 was weighed, dissolved in water, prepared into 1000 mL of concentrated solution, and placed in a refrigerator at 4 °C for use. For each use,

50 mL was taken out and was 1:2 diluted with water, and then suction filtered through a 0.22 μm ultrafiltration membrane.

2. Chromatographic separation conditions: The chromatograph was AKTA pure 150 (purchased from GE Co.) equipped with a UV detector and an automatic collector. Separation chromatographic column: 1.2 kg of BioGel P6 (purchased from Bio-Rad Co.) was mixed with deionized water, vacuum degassed, manually filled into a glass column (inner diameter: 10 cm), rinsed with 10 column volumes of pure water. The chromatographic column bed was stable and the height was 1.0 m. Then, the mobile phase was changed to a 0.02 M NaCl solution, and after equilibration with 10 column volumes, sample loading was initiated.

3. Sample loading and separation: The flow rate of the pump was set at 1 mL/min. After 100 mL of the sample solution was pumped to the top of the column through the chromatograph's own pump, it was switched to the mobile phase and eluted at a flow rate of 5 mL/min. After outflow of the dead water volume, automatic collection was initiated and 50 mL was collected per tube.

4. The sample loading was repeated, and after 20 repetitions of preparation, the same fractions were combined, concentrated on a rotary evaporator, and lyophilized to obtain a total of 9 oligosaccharides with single polymerization degree from disaccharide to decasaccharide.

Example 5

A pharmacological activity evaluation was conducted between the compositions and hexasaccharide to examine the synergistic effect of the oligosaccharides with different polymerization degrees in the compositions and the range of proportions of the oligosaccharides.

Sample preparation:

(1) Composition product D:

The mannuronic diacid oligosaccharides with single polymerization degree as prepared in example 4 were accurately weighed from disaccharide to

decasaccharide by the polymerization degree. The weight of each saccharide taken out was as follows: 3.0 g of disaccharide, 3.0 g of trisaccharide, 1.5 g of tetrasaccharide, 1.5 g of pentasaccharide, 0.4 g of hexasaccharide, 0.2 g of heptasaccharide, 0.2 g of octasaccharide, 0.1 g of nonasaccharide, and 0.1 g of deca-
5 deca-saccharide. They were uniformly mixed to obtain 10 g of composition product D.

(2) Preparation of comparative experimental samples

A tetrasaccharide-to-decasaccharide containing mixture was prepared by
10 referring to the methods disclosed in examples 1 and 2 of the prior patent document CN106344592A.

1g of sodium polymannuronate (weight average molecular weight 8235Da, provided by Shanghai Green Valley Pharmaceutical Co., Ltd.) was weighed and added with appropriate amount of distilled water to prepare 1% (weight percent)
15 aqueous solution of sodium polymannuronate. The pH value of the 1% aqueous solution of sodium polymannuronate was adjusted to 4 with hydrochloric acid, and then the aqueous solution was placed in an autoclave. The reaction was subjected to heating at 110°C for 4 hours. The reacted solution was removed from the autoclave and allowed to cool. After cooling, the pH value of the
20 reacted solution was adjusted with NaOH solution to obtain neutral liquid. Under the condition of stirring, the neutral liquid was slowly added into ethanol with a volume of 4 times the volume of the liquid. The alcohol precipitation was carried out, and the solution was left to stand overnight. The solid substance obtained by alcohol precipitation was filtered and separated, and the
25 absolute ethanol was used to wash the solid substance obtained from filtering and separation during the filtering and separation process. Finally a white filter cake was produced. The filter cake was filtered in an oven at 60°C to obtain crude alginate oligosaccharide.

5g of crude alginate oligosaccharide was prepared into a 5% (weight
30 percentage) aqueous solution. The fresh oxidant copper hydroxide was

prepared by adding 25 ml of 5% (weight percent) copper sulfate solution to 50 ml of 10% (weight percent) sodium hydroxide solution and mixing immediately. The fresh oxidant copper hydroxide was immediately added to 40 ml of the above 5% (weight percent) alginate oligosaccharide solution, while heated in a boiling water bath until no more brick red precipitates were produced. The reaction system was centrifuged to remove the precipitate to obtain the supernatant. A little supernatant was added to the oxidant again to check whether there was still brick red precipitate produced. If brick red precipitate was still produced, all the supernatants obtained from the centrifugation would continue to react with other part of the oxidant until it was checked that no brick red precipitates were produced. The final reaction system was centrifuged to obtain the supernatant. 4 times the volume of 95% ethanol was added to the supernatant for alcohol precipitation, and the solution was allowed to stand overnight. The solid substance given by alcohol precipitation was filtered and separated, and the solid substance was washed with absolute ethanol. The obtained solid substance was placed in an oven at 60°C and dried to give the crude alginate oligosaccharide represented by Formula (II).

1g of the crude alginate oligosaccharide was prepared into a 10% (weight percent) aqueous solution, and alcohol precipitation was carried out again by using a 95% ethanol solution. The precipitate obtained by alcohol precipitation again was filtered and separated, followed by optionally washing with absolute ethanol. The precipitate was separated and dried to obtain a solid substance. The solid substance was prepared into a 5% (weight percentage) aqueous solution. The aqueous solution was filtered with a 3 μm pore size membrane and the filtrate was collected. The filtrate was eluted and separated on a molecular exclusion chromatography Bio-Gel-P6 gel column (1.6 x 180 cm, available from Bio-Rad Company). The eluent as mobile phase was 0.2 mol L⁻¹ NH₄HCO₃. Eluate from the column chromatography was sequentially collected by a plurality of 5 ml test tubes, and then the saccharide content of the eluate in each test tube was detected by using a sulfuric acid-carbazole method.

According to the detection results, eluates containing alginate oligosaccharide components with different molecular weights were respectively collected. Eluates containing alginate oligosaccharide components with different molecular weights were respectively concentrated under reduced pressure and lyophilized. Component 1 was discarded, and alginate oligosaccharide components 2-12 were obtained, as shown in Formula (II) (n has a value of 0-10 respectively) with different molecular weights, and alginate oligosaccharide eluate shown in Formula (II) with n=2-8 was collected, combined and dried. Alginate oligosaccharide mixture (tetrasaccharide to decasaccharide mixture) shown in Formula (II) with n=2-8 was produced as a comparative experimental sample.

The proportion of oligosaccharide components with various polymerization degrees in comparative experimental samples was detected by using Superdex peptide (GE Co.) molecular exclusion chromatography combined with multi-angle laser scattering (MALS, Wyatt). The determination method is the same as the relevant part in example 1. Test results: tetrasaccharide to decasaccharide is represented by dp4-dp10, which is 10% dp4, 12% dp5, 13% dp6, 14% dp7, 15% dp8, 19% dp9 and 17% dp10, respectively.

Products A, B and C respectively prepared in examples 1, 2 and 3, product D in this example and oligosaccharide proportions in the comparative experimental samples are shown in Table 2 below.

Table 2: percentages of oligosaccharides in mannuronic diacid oligosaccharides composition products and comparative experimental samples

Proportion Composition	Disacch aride	Trisacch aride	Tetrasac charide	Pentasa ccharide	Hexasac charide	Heptasa ccharide	Octasac charide	Nonasa ccharide	Decasac charide
A	19%	25%	22%	13%	9%	6%	3%	2%	1%
B	20%	25%	19%	12%	9%	5%	5%	3%	2%
C	8%	20%	28%	19%	13%	6%	3%	2%	1%
D	30%	30%	15%	15%	4%	2%	2%	1%	1%
Comparative samples	0	0	10%	12%	13%	14%	15%	19%	17%

10 g of each of the above four samples A, B, C and D was taken out. The pharmacological activities of these compositions, hexose (6T) and comparative experimental samples were compared according to the method described in
5 “animal model for anti-pain pharmacodynamic evaluation”.

1. Pain mouse model induced by acetic acid

In the experiment, compared with the blank control group, the latency of writhing of the model group was significantly shorter and the number of times of writhing was significantly increased, indicating that the evaluation model
10 was successfully established. Compared with the model group, the latency of writhing of each dosing group was significantly prolonged, and the number of times of writhing was significantly reduced. See Figures 4 and 5.

2. Migraine rat model induced by nitroglycerin

The rats developed ear redness about 3 minutes after subcutaneous
15 injection of nitroglycerin, which lasted for about 2.5 hours. The number of times of head scratching within the 30-45 minutes after modeling in the model group was significantly more than that of the blank control group. Compared with the model group, the dosing group showed a significant delay in the appearance of the ear redness, shortened duration time of the ear redness, and
20 decreased number of times of head scratching within the 30-45 minute period. See Figure 6.

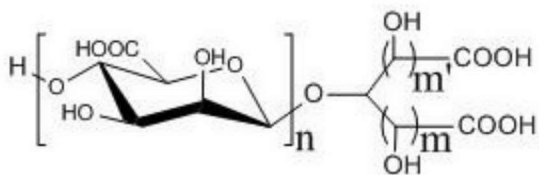
3. Migraine model induced by electrical stimulation of the trigeminal ganglion

Electrical stimulation of the rat trigeminal ganglion obviously caused
25 dural serum protein exudation. Compared with the blank control group and the sham operation group, the PPE rate was significantly increased, and the number of c-fos expression positive cells was significantly increased in the model group. Compared with the model group, the PPE rate was significantly reduced and the number of c-fos expression positive cells was significantly reduced in
30 dosing group. See Figure 7.

The experimental results showed that the pharmacodynamic activity of products A, B and C are all better than the comparative experimental samples, and are better than the most active hexasaccharide with single polymerization degree. However, the activity of product D is weaker than hexasaccharide, 5 indicating that the proportion of oligosaccharides in the composition is important, and adding a certain proportion of disaccharide and trisaccharide has synergistic effect. However, when the proportion of disaccharide and trisaccharide is too high, the activity of the composition would be reduced.

CLAIMS

1. Use of a mannuronic diacid oligosaccharide composition in the manufacture of a medicament for the treatment of pain; wherein the mannuronic diacid oligosaccharide composition comprises mannuronic diacids having Formula (III) or a pharmaceutically acceptable salt thereof:



Formula (III),

wherein n is an integer selected from 1 to 9, m is selected from 0, 1 or 2, m' is selected from 0 or 1,

and wherein,

the total weight of mannuronic diacids wherein $n=1-5$ accounts for no less than 60% of the total weight of the composition;

the total weight of mannuronic diacids wherein $n=1-2$ accounts for less than 60% of the total weight of the composition.

2. The use of claim 1, wherein the pain is acute pain, chronic pain, neuropathic pain, postoperative pain, chronic low back pain, cluster headache, herpetic neuralgia, phantom limb pain, central pain, toothache, opioid-resistant pain, visceral pain, surgical pain, bone injury pain, fatigue and pain during childbirth, pain caused by burns including sunburn, postpartum pain, migraine, angina, and genitourinary tract related pain (including cystitis), vascular pain, trigeminal neuralgia, intercostal neuralgia, surgical incision pain, chronic fasciitis pain, heel pain, muscle pain, bone pain, joint pain, cancer pain, non-cancerous pain.

3. The use of claim 1, wherein in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacids wherein $n=1-2$ accounts for 10-50%, preferably 25-50%, of the total weight of the composition.

4. The use of claim 1, wherein in the mannuronic diacid oligosaccharide composition, the ratio of the total weight of mannuronic diacids wherein $n=1-3$ to the total weight of mannuronic diacids wherein $n=4-7$ is between 1.0 and 3.5.

5. The use of claim 1, wherein in the mannuronic diacid oligosaccharide composition, the total weight of mannuronic diacids with $m+m'=1$ or 2 is no less than 50% of the total weight of the composition, preferably 60%-90%, more preferably 70%-90%.

6. The use of claim 5, wherein the total weight of mannuronic diacids with $m+m'=1$ is no less than 10% of the total weight of the composition, preferably 30-40%.

7. The use of claim 5, wherein the total weight of mannuronic diacids with $m+m'=2$ is no less than 10% of the total weight of the composition, preferably 30-50%.

8. The use of claim 1, wherein the total weight of mannuronic diacids wherein $n=1-5$ accounts for 80-95% of the total weight of the composition.

9. The use of claim 1, wherein the total weight of mannuronic diacids wherein $n=1-3$ accounts for 20-70% of the total weight of the composition.

10. The use of claim 4, wherein the ratio of the total weight of mannuronic diacids wherein $n=1-3$ to the total weight of mannuronic diacids wherein $n=4-7$ is between 1.0 and 3.0.

11. The use of any one of claims 1 to 9, wherein the weight percentage content of mannuronic diacids with each of polymerization degrees in the composition is: disaccharide 5-25%, trisaccharide 15-30%, tetrasaccharide 15-28%, pentasaccharide 5-25%, hexasaccharide 2-20%, heptasaccharide 2-20%, octasaccharide 2-20%, nonasaccharide 2-20%, decasaccharide 2-20%.

12. The use of claim 11, wherein the weight percentage content of mannuronic diacids with each of polymerization degrees in the composition is: disaccharide 5-25%, trisaccharide 15-30%, tetrasaccharide 15-28%, pentasaccharide 10-20%, hexasaccharide 5-15%, heptsaccharide 3-10%,
5 octasaccharide 2-5%, nonasaccharide 1-5%, decasaccharide 1-5%.

13. The use of claim 12, wherein the weight percentage content of mannuronic diacids with each of polymerization degrees in the composition is: disaccharide 10-20%, trisaccharide 18-30%, tetrasaccharide 15-28%, pentasaccharide 15-20%, hexasaccharide 5-10%, heptsaccharide 3-5%,
10 octasaccharide 2-5%, nonaccharide 1-3%, decasaccharide 1-3%.

14. The use of any one of claims 1-13, wherein the pharmaceutically acceptable salt is sodium salt or potassium salt.

15. A method of treating a patient suffering from pain, comprising administering an effective amount of the mannuronic diacid oligosaccharide
15 composition of claim 1-14 to a patient in need thereof.

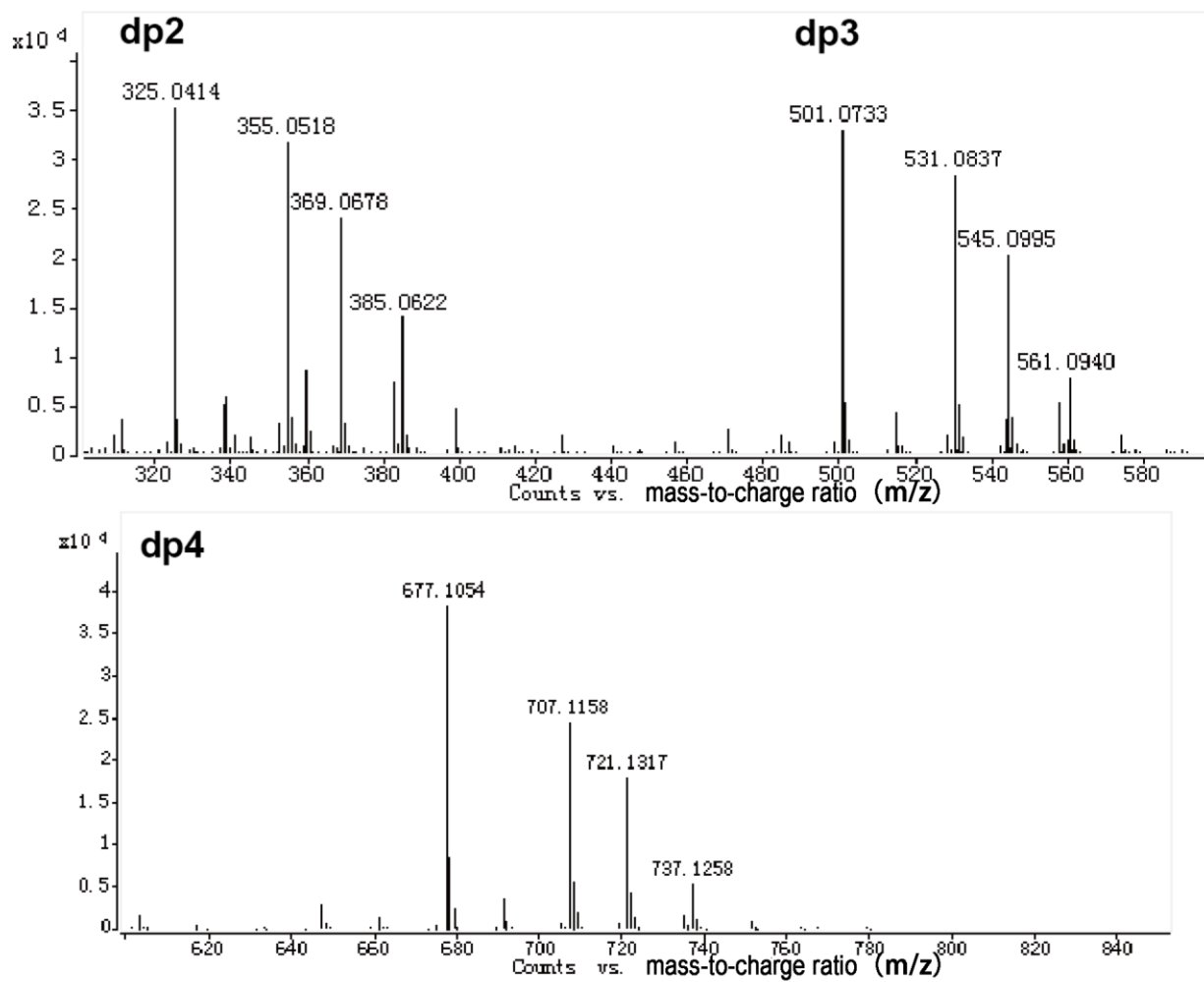


Fig. 1

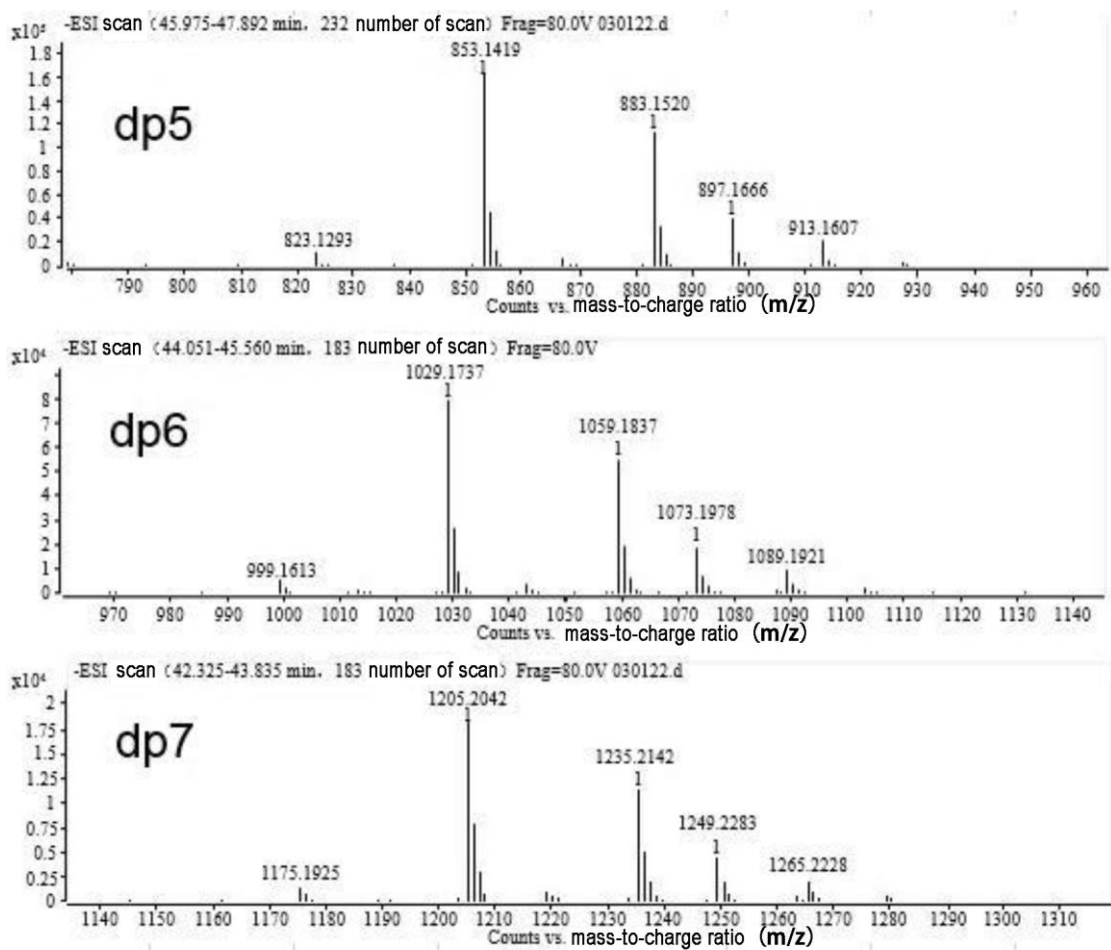


Fig. 2

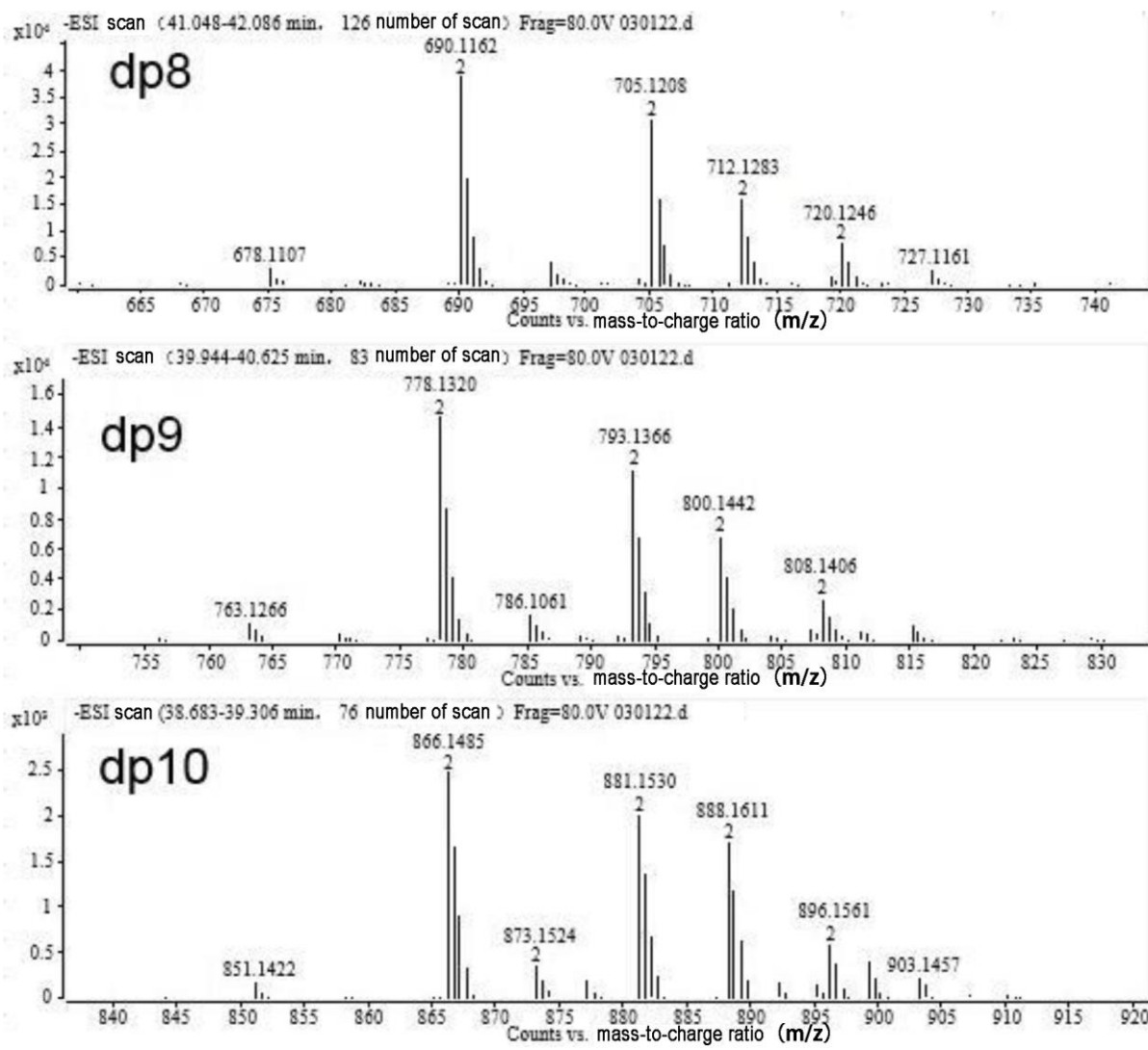


Fig. 3

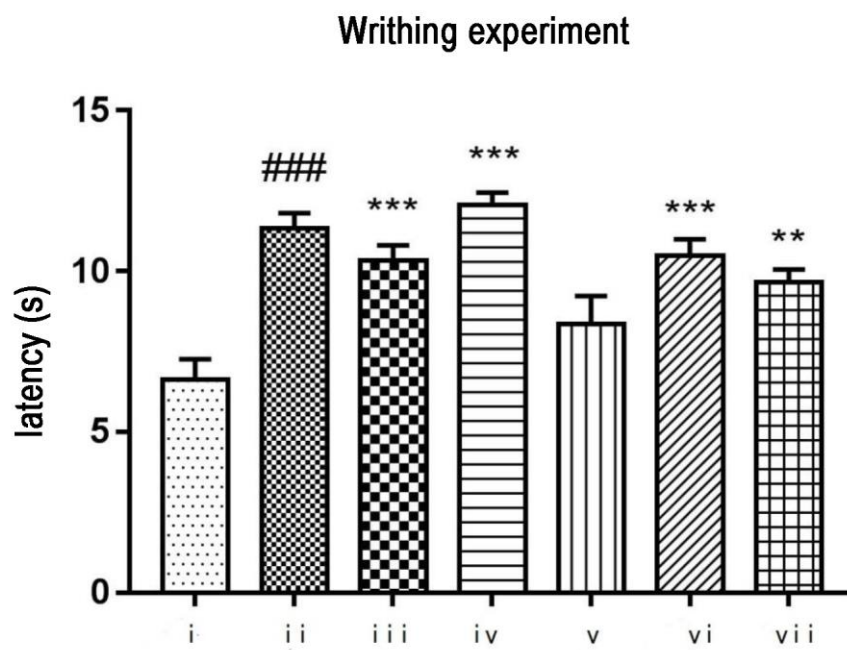


Fig. 4

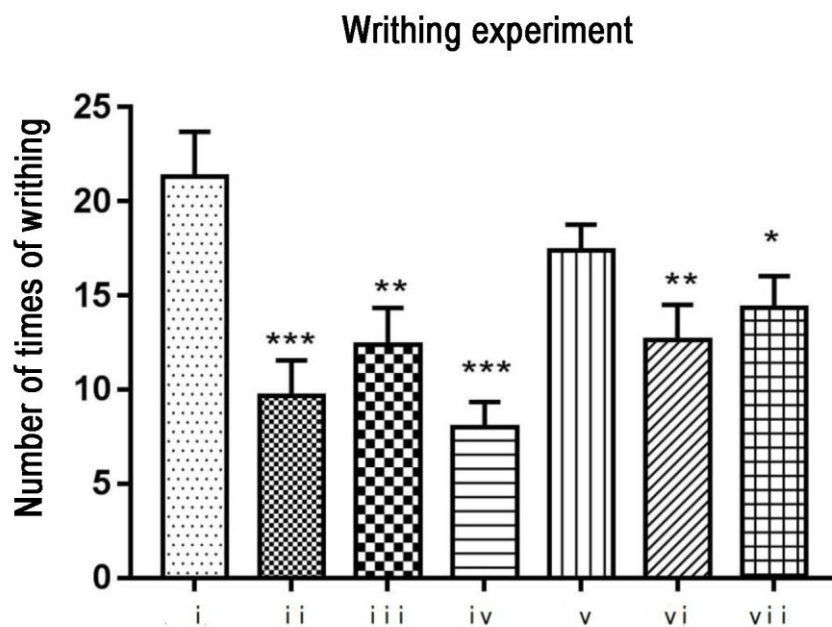


Fig. 5

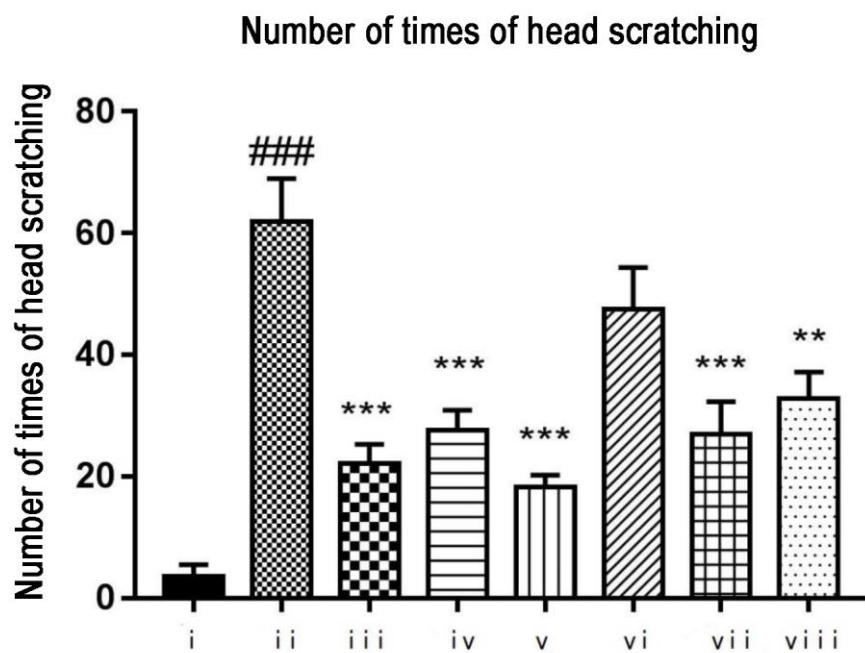


Fig. 6

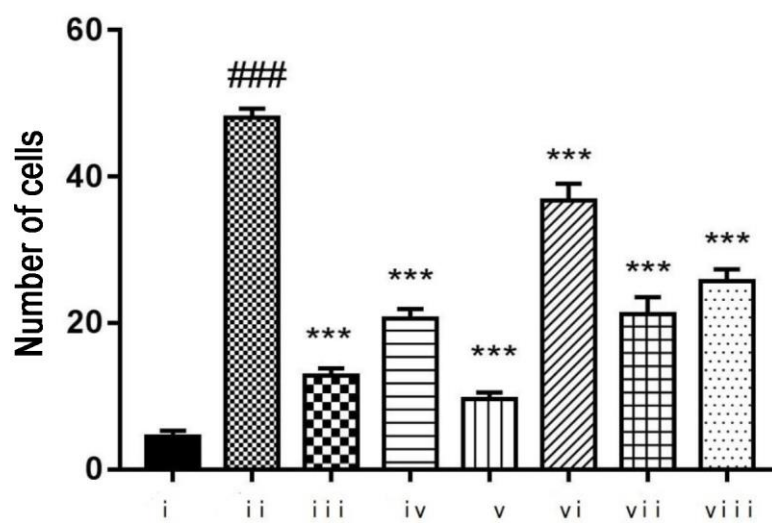


Fig. 7