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(54) **APPLICATION OF SPHERICAL CARBON IN FLUE GAS ADSORPTION OF HEAT-NOT-BURN TOBACCO PRODUCT**

(57) Use of spherical carbon in flue gas adsorption of a heat-not-burn tobacco product. The spherical carbon of a particular structural parameter, as well as doping it in a cartridge, is particularly advantageous for improving the content of harmful substances in flue gas due to the

excellent selectivity and specific adsorption effect of a large number of carbonyl compounds produced during the heating of the heat-not-burn tobacco product, and even undesirable adsorption of nicotine is significantly improved.

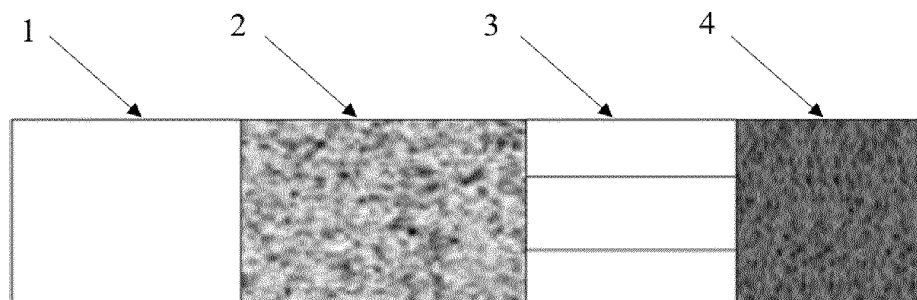


FIG. 1

EP 4 260 715 A1

Description

[0001] The present application claims priority to Patent No. 202011453514.4 entitled "USE OF SPHERICAL CARBON IN FLUE GAS ADSORPTION OF HEAT-NOT-BURN TOBACCO PRODUCT" filed with the China National Intellectual Property Administration on Dec. 11, 2020, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of cigarette smoke adsorption of heat-not-burn tobacco products, and specifically, to use of a spherical carbon in cigarette smoke adsorption of a heat-not-burn tobacco product.

BACKGROUND

[0003] Along with the increasing attention from smokers to health, the appeal for "healthy smoking" is also becoming stronger. In the tobacco industry, compared with traditional cigarettes, novel tobacco products are developing rapidly. Novel tobacco products can be divided into two prominent types: smoky products and smokeless products. The smoky products mainly include e-cigarettes and heat-not-burn (HNB) cigarettes, with the latter divided into a tobacco type and a non-tobacco type. In a cartridge of tobacco-type products, the materials are conventional shag tobaccos, flake tobaccos or reconstituted tobacco stems. In contrast, for the non-tobacco-type products, the principal material in the cartridge is herbal granules, which do not contain nicotine. Aroma beads may be arranged between the material and the mouthpiece and different aroma beads may be provided for different flavors. Tobacco-type heat-not-burn cigarettes retain the tobacco flavor to a greater extent and are more acceptable for the average consumer.

[0004] Compared with the conventional cigarettes, the cigarette cartridge of a heat-not-burn cigarette is only heated, but not burned due to the special temperature of the smoking set, which greatly reduced the release of the harmful and potentially harmful constituents (HPHCs). However, since the tobacco section in the heat-not-burn cigarette cartridge is usually composed of tobacco flakes, reconstituted tobacco, recombined tobacco or herbal particles that contain a large amount of smoke-generating agents, flavorants, essences and the like, and the smoke-generating agents are mainly composed of propylene glycol and glycerol, a large amount of carbonyl compounds are generated during the heating process. Such carbonyl compounds include, but are not limited to, formaldehyde, acetaldehyde, acetone, acrolein, propionaldehyde, crotonaldehyde, 2-butanone, butyraldehyde and the like, which are considered as important HPHCs in cigarette smoke. In particular, the International Agency for Research on Cancer (IARC) lists formaldehyde as a Group I carcinogen; acetaldehyde is listed in Group 2B and possibly has nasal cilium toxicity; and acrolein is cytotoxic. How to effectively reduce the harm is an important orientation for exploring novel tobaccos, particularly the heat-not-burn cigarettes.

SUMMARY

[0005] In order to solve the above-mentioned technical problems, the present disclosure provides use of a spherical carbon in cigarette smoke adsorption of a heat-not-burn tobacco product.

[0006] According to embodiments of the present disclosure, the heat-not-burn tobacco product is selected from at least one of an electrically heated heat-not-burn tobacco product and a carbon-heated heat-not-burn tobacco product. For example, the "cigarette smoke" may be a gas emitted by the heat-not-burn tobacco product under normal pressure, or a gas generated by the tobacco product under a negative pressure (e.g., by inhaling).

[0007] According to embodiments of the present disclosure, the "cigarette smoke" may be gaseous and/or misty in appearance. For example, the "cigarette smoke" is generated by a cartridge in the heat-not-burn tobacco product in a heat-not-burn condition. The mode of heating may be internal heating, external heating or hybrid internal/external heating. The internal heating means that the heating element is surrounded by the cartridge and the heat can be concentrated in a cigarette bin. The external heating means that the cartridge is inserted into a smoking set for heating, and the heat generated by the smoking set is conducted to the surface of the cartridge.

[0008] According to embodiments of the present disclosure, the cartridge may comprise a tobacco or a tobacco-replacing herb. The tobacco may be selected from at least one of a reconstituted tobacco and a recombined tobacco. It will be appreciated by those skilled in the art that the above-mentioned tobaccos may have different components or different amounts of components. The composition of tobacco leaves may be influenced by genetics, agricultural practices, soil and nutrients, weather conditions, plant diseases, leaf location, harvesting and sun-curing procedures. The tobacco-replacing herb is selected from a non-tobacco herb that produces smoke upon low-temperature heating, for example, a herbal product prepared from tea leaves, ginkgo leaves, flowers and other natural herbs.

[0009] According to embodiments of the present disclosure, the tobacco is not specified in its form, and may be in the form of a filament, a sheet, a granule, a powder and the like, for example, in the form of a sheet.

[0010] According to embodiments of the present disclosure, the cartridge may further comprise at least one flavourant and/or other additives. For example, the additive may be selected from at least one of a smoke-generating agent, a colorant and a binder.

[0011] According to embodiments of the present disclosure, the smoke-generating agent comprises propylene glycol and glycerol. For example, in the cartridge, the content of glycerol is 15-70 wt%, preferably 20-60 wt%; for example, in the cartridge, the content of propylene glycol is no more than 2 wt%, preferably no more than 1.5 wt%, and more preferably no more than 1 wt%.

[0012] According to embodiments of the present disclosure, the cigarette smoke comprises or does not comprise nicotine or a salt of nicotine.

[0013] The salt of nicotine may be selected from a salt formed by nicotine and an acid. The acid may be selected from, for example, one, two or more of the following: formic acid, acetic acid, propionic acid, butyric acid, 2-methylbutyric acid, 3-methylbutyrate, valerate, benzoic acid, carbonic acid, citric acid, gallic acid, hydrochloric acid, lactic acid, lauric acid, levulinic acid, malic acid, malonic acid, oxalic acid, oxaloacetic acid, palmitic acid, pyruvic acid, phosphoric acid, salicylic acid, sorbic acid, stearic acid, sulfuric acid, phthalic acid, picric acid, sulfosalicylic acid, tartaric acid, tannic acid, pectic acid, alginic acid, chloroplatinic acid, silicotungstic acid, pyruvic acid, glutamic acid and aspartic acid.

[0014] According to embodiments of the present disclosure, the cigarette smoke may further comprise a carbonyl compound. Preferably, the carbonyl compound comprises at least one component selected from: formaldehyde, acetaldehyde, acetone, acrolein, propionaldehyde, crotonaldehyde, butyraldehyde and 2-butanone.

[0015] According to embodiments of the present disclosure, the carbonyl compound is from a cigarette smoke generated by heating the cartridge and/or atomization, preferably from a cigarette smoke generated by heating and/or atomizing the smoke-generating agent.

[0016] According to embodiments of the present disclosure, the cigarette smoke optionally comprises or does not comprise a nitrosamine compound. The nitrosamine compound comprises at least one selected from the following: 4-(*N*-methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), *N*'-nitrosoanabasine (NAB), *N*-nitrosoneonicotinoid (NAT), *N*'-nitrososornicotine (NNN), dimethylnitrosamine (NDMA), nitrosopiperidine (NPiP), *N*-nitrosomethylethylamine (NEMA), *N*-nitrosodiethylamine (NDEA), *N*-nitrosodipropylamine (NDPA), *N*-nitrosopyrrolidine (NPYR) and morpholine (NMOR).

[0017] According to embodiments of the present disclosure, the cigarette smoke may further comprise other components, for example, at least one selected from: 1-hydroxy-2-propanone, 3-hexen-2-one, 4-hydroxy-2-pentanone, furfural, 5-(hydroxymethyl)furfural, 2-oxo-3-cyclopenten-1-acetaldehyde, furfuryl alcohol, 2-hexenal, 1-acetoxy-2-propanone, cyclopentene-1,4-dione, 2-methyl-2-cyclopenten-1-one, 2(3*H*)-furanone, 1,2-cyclopentanedione, 2-hydroxy-3-methyl-2-cyclopenten-1-one, 2,3-dimethyl-2-cyclopenten-1-one, 2,5-dimethyl-4-hydroxy-3(2*H*)-furanone, megastigmatrienone A, megastigmatrienone B, megastigmatrienone C, megastigmatrienone D, norsolanedione, 4,4-dimethyl-2-cyclohexen-1-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-4*H*-pyran-4-one, benzene, cyclohexene, propionic acid, acrylic acid, propylene glycol, 2,2'-ethoxypropane, 2-hydroxyethyl acetate, methyl 2-oxopropanoate, isopropyl benzene, diethylene glycol diacetate, phenol, 2-methylphenol, 3-methylphenol, 4-methylphenol, 2-methoxyphenol, methyl 3-furancarboxylate, catechol, 2,3-dihydrobenzofuran, 1,4-benzenediol, 3-methyl-1,2-benzenediol, 2-methoxy-4-vinylphenol, solanone, isoeugenol, farnesol, diennicotinyl, 2,3-bipyridine, quinic acid, 3-oxo- α -ionol, 4,8-dimethyl-1-nonanol, neophytadiene, hexadecanoic acid, methyl 9,12,15-octadecatrienoate, cholest-5-en-3-ol acetate and stigmasta-5,22-dien-3-ol acetate.

[0018] According to embodiments of the present disclosure, the cigarette smoke may further comprise other components, for example, a compound comprising at least one element selected from: Cr, Ni, Fe, Al, Sn, Pb, Cd, As, Sb, Hg and Cu.

[0019] According to embodiments of the present disclosure, the cigarette smoke may further comprise a particulate and/or an aerogel, and may comprise components such as CO, CO₂ and/or gases in the air.

[0020] According to embodiments of the present disclosure, the spherical carbon is used for selectively adsorbing at least one of the above-mentioned components or substances in the cigarette smoke.

[0021] According to embodiments of the present disclosure, also provided is a spherical carbon, which may be selected from a spherical activated carbon.

[0022] Preferably, the spherical carbon can be used in embodiments or technical schemes in the context of the specification, e.g., the use as described above.

[0023] According to embodiments of the present disclosure, the term "spherical activated carbon" refers to an activated carbon in the shape of a sphere or spheroid, wherein the orthographic projection of the spheroid activated carbon on at least 1 plane is circular, elliptical, or substantially circular or elliptical; preferably the orthographic projection of the spheroid activated carbon on at least 5, e.g., at least 10 planes, is circular, elliptical, or substantially circular or elliptical.

[0024] According to embodiments of the present disclosure, the spherical carbon has a volume of $V = \gamma\pi(d/2)^3$, wherein γ is selected from a number of 1.0 to 2.0, for example, a number of 1.2 to 1.5, e.g., a number of 1.3 to 1.4, preferably 4/3; d is the maximum diameter of the spherical carbon.

[0025] According to embodiments of the present disclosure, in the tobacco product, nicotine and/or the salt of nicotine,

on nicotine basis, may have a weight of 0-24 mg, such as 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0 or 24.0 mg. Preferably, nicotine and/or nicotine salt, on nicotine basis, has a weight greater than 0.

[0026] According to embodiments of the present disclosure, the spherical carbon used for adsorbing the cigarette smoke may have a weight of 1 to 300 mg, for example, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200 or 300 mg. Preferably, the spherical carbon for adsorbing the cigarette smoke has a weight of 10-60 mg.

[0027] According to embodiments of the present disclosure, in the tobacco product, nicotine and/or the salt of nicotine (on nicotine basis) and the spherical carbon may be present in a weight ratio of (0-24):(1-300), for example, (0.05-18):(10-200), e.g., (0.08-12):(15-150), e.g., (0.1-10):(40-100), e.g., (0.1-8):(50-80). As an example, in the tobacco product, nicotine and/or the salt of nicotine (on nicotine basis) and the spherical carbon may have a weight ratio of (0.1-0.4):(40-60).

[0028] According to embodiments of the present disclosure, the spherical carbon has a specific surface area B lower than 1300 m²/g. For example, B is less than 1200 m²/g, e.g., 900 m²/g < B ≤ 1180 m²/g or 950 m²/g < B ≤ 1150 m²/g. For example, B = 980 m²/g, 1000 m²/g, 1020 m²/g, 1040 m²/g, 1050 m²/g, 1070 m²/g, 1080 m²/g, 1100 m²/g, 1120 m²/g, 1128 m²/g, 1130 m²/g, 1135 m²/g, 1140 m²/g or 1141 m²/g. According to embodiments of the present disclosure, the spherical carbon may have an average particle size of 0.2-1.5 mm, for example, 0.2-1.0 mm, e.g., 0.2-0.4 mm, 0.6-0.8 mm, specifically 0.2 mm, 0.4 mm, 0.405 mm, 0.42 mm, 0.45 mm, 0.48 mm, 0.49 mm, 0.50 mm, 0.52 mm, 0.53 mm, 0.55 mm, 0.6 mm, 0.7 mm or 0.8 mm. According to embodiments of the present disclosure, the spherical carbon has an average pore size of 1.5-3.2 nm, for example, 1.55-3.0 nm, e.g., 1.6-2.7 nm. As an example, the average pore size is 1.6245 nm, 1.7 nm, 1.8 nm, 1.9 nm, 2.0 nm, 2.1 nm, 2.2 nm, 2.3 nm, 2.4 nm, 2.5 nm, 2.6 nm or 2.7 nm.

[0029] According to embodiments of the present disclosure, the spherical carbon has an average pore volume of 0.35-0.80 cm³/g, for example, 0.38-0.70 cm³/g, 0.40-0.60 cm³/g. As an example, the average pore volume is 0.45 cm³/g, 0.50 cm³/g, 0.55 cm³/g or 0.60 cm³/g.

[0030] According to embodiments of the present disclosure, the spherical carbon comprises mesopores (pore size between 2-50 nm) and micropores (pore size less than 2 nm). The mesopores have pore volumes of 0.003-0.018 cm³/g. For example, mesopores greater than 2 nm but not greater than 4 nm have a pore volume greater than 0.013 cm³/g but not greater than 0.017 cm³/g, for example, 0.014-0.016 cm³/g. For example, mesopores greater than 4 nm but not greater than 50 nm have a pore volume not less than 0.002 and not less than 0.013 cm³/g, for example, 0.003-0.012 cm³/g. For example, mesopores greater than 4 nm but not greater than 10 nm have a pore volume not less than 0.009 cm³/g and less than 0.013 cm³/g, for example, 0.010-0.012 cm³/g.

[0031] According to embodiments of the present disclosure, the micropores may have a pore volume of ≥ 2000 cm³/g, preferably ≥ 3000 cm³/g, for example, ≥ 4300 cm³/g, e.g., ≥ 4400 cm³/g, ≥ 4500 cm³/g, ≥ 4600 cm³/g, ≥ 4700 cm³/g, ≥ 4800 cm³/g, ≥ 4900 cm³/g, ≥ 5000 cm³/g, ≥ 5100 cm³/g, ≥ 5200 cm³/g, ≥ 5300 cm³/g, ≥ 5400 cm³/g or ≥ 5500 cm³/g.

[0032] According to embodiments of the present disclosure, the spherical carbon may have a compressive strength of 10-100 N, for example, 20-95 N, e.g., 30 N, 40 N, 50 N, 60 N, 70 N, 80 N or 90 N. The compressive strength refers to the maximum pressure value that each spherical carbon can bear.

[0033] According to embodiments of the present disclosure, the spherical carbon may have a cracking rate of less than 10.0%, for example, 0-10.0%, e.g., 0-6.0%, preferably less than 5.0%, e.g., 0-3.0%.

[0034] According to embodiments of the present disclosure, the spherical carbon may have a bulk density of 300-900 g/cm³, preferably 400-800 g/cm³, for example, 450-750 g/cm³, 500-700 g/cm³ or 600-700 g/cm³.

[0035] According to a preferred embodiment of the present disclosure, the spherical carbon is used for cigarette smoke adsorption without modification.

[0036] According to embodiments of the present disclosure, the spherical carbon is used for cigarette smoke adsorption without conjugation or combination with other adsorbents.

[0037] The other adsorbents are adsorbent materials for adsorbing at least one undesired component of the cigarette smoke, but preferably do not comprise any excipient material known to be necessary for the preparation of tobaccos, such as paper for wrapping the tobacco, plug wrap paper and tipping paper of the cartridge and the like. Although they may possess a weak adsorption capacity in certain conditions, such materials will not be used as adsorbent materials by those skilled in the art and should not be included in the scope of the above-mentioned adsorbents for this reason. According to embodiments of the present disclosure, the raw material for preparing the spherical carbon is a spherical polymer, such as a porous spherical polymer or a microporous spherical polymer.

[0038] The present disclosure further provides a method for preparing the spherical carbon, comprising the following steps:

- 1) carbonizing the spherical polymer; and

2) activating the product obtained in Step 1).

[0039] According to the present disclosure, in Step 1), the polymer may be prepared by mixing a monomer and an initiator for a polymerization reaction. As an example, the polymer may be a homopolymer or a copolymer. The homopolymer refers to a polymer prepared by polymerizing one monomer, and the copolymer refers to a polymer prepared by polymerizing two or more monomers.

[0040] According to the present disclosure, the monomer may be selected from compounds having 2-60 carbon atoms and having at least 1 carbon-carbon double bond, for example, a compound having 2-20 carbon atoms and having at least 1 carbon-carbon double bond. For example, the monomer may be selected from one, two or more of the following: ethylene, propylene, isopropene, butene, isobutene, pentene, isopentene, neopentene, hexene, isohexene, neohexene, styrene, methylstyrene, acrylic acid, methacrylic acid, methyl acrylate, methyl methacrylate, butadiene, pentadiene, isopentadiene, isohexadiene, divinylbenzene and diethylene glycol divinyl ether.

[0041] Alternatively, the polymer matrix of the copolymer comprises a structural unit derived from a first monomer having 2-10 carbon atoms and comprising at least one carbon-carbon double bond, and a structural unit derived from a second monomer having 4-15 carbon atoms and comprising at least two carbon-carbon double bonds. Preferably, in the polymer matrix of the copolymer, the structural unit derived from the first monomer constitutes 75% to 98%, preferably 80% to 90%, of the total structural units of the polymer network; the structural unit derived from the second monomer constitutes 25% to 2%, preferably 20% to 10%, of the total structural units of the polymer network.

[0042] According to the present disclosure, the first monomer is selected from one, two or more of styrene, methylstyrene, ethylstyrene, acrylic acid, methacrylic acid, methyl acrylate, methyl methacrylate and a mono-olefin having 2-6 carbon atoms, the mono-olefin having 2-6 carbon atoms being, for example, ethylene, propylene, isopropene, butene, isobutene, pentene, isopentene, neopentene, hexene, isohexene, neohexene and the like.

[0043] According to the present disclosure, the second monomer is selected from one, two or more of butadiene, pentadiene, isopentadiene, isohexadiene, divinylbenzene and diethylene glycol divinyl ether.

[0044] According to the present disclosure, the polymerization reaction may be a suspension polymerization reaction; preferably, the polymerization reaction is performed in the presence of water, a dispersant and a dispersion aid.

[0045] For example, the water, the dispersant and the dispersion aid are present in a weight ratio of (800-1000):(0.5-100):(0.05-10). For example, according to the ratio, based on 1000 g of water, the dispersant may have a weight of 8-80 g and the dispersion aid may have a weight of 0.2-2.4 g.

[0046] When the polymer is a homopolymer, the monomer and the initiator may be present in a weight ratio of 1:(0.003-0.01).

[0047] If present, the first monomer, the second monomer and the initiator may be present in a weight ratio of (0.75-0.98):(0.02-0.25):(0.003-0.01).

[0048] Preferably, the water, the dispersant and the dispersion aid form an aqueous phase, and the monomer of the homopolymer, the first monomer of the copolymer, the second monomer of the copolymer and/or the initiator form an oil phase. The oil phase and the aqueous phase may be present in a weight ratio of 1:(4-6).

[0049] According to the present disclosure, the suspension polymerization reaction may comprise: adding the components into a reaction kettle, introducing compressed air or nitrogen into the reaction kettle, keeping the pressure in the reaction kettle in a positive pressure state with the gauge pressure less than or equal to 0.5 MPa, heating to 80-110 °C, keeping the temperature for 2-24 h, cooling, washing with water, sieving and drying to obtain the spherical polymer.

[0050] In a preferred embodiment, the dispersant is an inorganic dispersant such as a silicate, a carbonate or a phosphate (e.g., disodium hydrogen phosphate dodecahydrate), or a combination thereof; an organic dispersant such as polyvinyl alcohol, gelatin, carboxymethylcellulose or polyacrylate, or a combination thereof; or a combination thereof.

[0051] In a preferred embodiment, the dispersion aid is sodium dodecyl sulfate, calcium dodecylbenzene sulfonate, sodium dodecylbenzene sulfonate, calcium petroleum sulfonate, sodium petroleum sulfonate or barium stearate, resorcinol, or a combination thereof.

[0052] In a preferred embodiment, the initiator is an organic peroxide compound, an inorganic peroxide compound or an azo compound, or a combination thereof.

[0053] In a preferred embodiment, the initiator is a diacyl peroxide compound, a dioxane peroxide compound, a peroxyester compound, azobisisobutyronitrile or a persulfate, or a combination thereof.

[0054] Preferably, the polymerization reaction may also be performed in the presence of a porogen. The porogen may be selected from paraffin, magnesium sulfate, sodium carbonate, gelatin or glycerol, or a combination thereof.

[0055] According to the present disclosure, the spherical polymer may have a median particle diameter D_{50} of 0.2-1.5 mm, for example, 0.2-1.0 mm, e.g., 0.2-0.4 mm, 0.6-0.8 mm, specifically 0.2 mm, 0.4 mm, 0.50 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm or 1.2 mm.

[0056] According to the present disclosure, the polymer may be a sulfonated polymer or an unsulfonated polymer. When an unsulfonated polymer is used, the sulfonation may be performed prior to the carbonization step and/or *in situ*

during the carbonization. As an example, the unsulfonated polymer may also be prepared according to known methods or commercially available.

[0057] The sulfonation may be performed using starting materials known in the art, for example, by contacting the unsulfonated polymer with a sulfonating agent. The sulfonating agent may be selected from one or a combination of more of sulfuric acid (e.g., concentrated sulfuric acid), fuming sulfuric acid and SO₃.

[0058] According to the present disclosure, the non-sulfonated spherical polymer and the sulfonating agent may be present in a total weight ratio of 3:1-1:3, for example, 2:1-1:2, e.g., 1:1-1:1.5.

[0059] The temperature of the sulfonation step may vary over a wide range.

[0060] For example, when the sulfonation is performed prior to the carbonization step, the temperature of the sulfonation step may be 30-300 °C, for example, 40-180 °C, 200-280 °C, e.g., 50-160 °C, 240-260 °C.

[0061] Preferably, the sulfonation step may be performed while elevating the temperature within the above-mentioned temperature range. The temperature ramp may be no more than 10 °C/min, for example, no more than 5 °C/min, e.g., no more than 3 °C/min.

[0062] The time of the sulfonation step may be 0.5-12 h, preferably 1-10 h, for example, 1.5-10 h, 1.8-8 h, 2-6 h.

[0063] Preferably, the sulfonation is performed in an inert atmosphere, and the gas in the inert atmosphere may be selected from one or a combination of more of nitrogen, helium and argon.

[0064] According to the present disclosure, the carbonization of Step 1) may be performed in an inert atmosphere or in a mixed atmosphere of an inert atmosphere and oxygen. Generally, the temperature of the carbonization step may be 100-950 °C, for example, 160-900 °C, e.g., 300-850 °C.

[0065] When the sulfonation is performed before the carbonization step, the starting temperature of the carbonization step may be equal to or greater than the ending temperature of the sulfonation temperature.

[0066] Preferably, the carbonization step may be performed while elevating the temperature within the above-mentioned temperature range. The temperature ramp may be no more than 10 °C/min, for example, no more than 5 °C/min, e.g., no more than 3 °C/min.

[0067] Preferably, the carbonization may be performed sequentially in 2 or more temperature ranges, for example, sequentially in 2 to 10 temperature ranges. Preferably, the temperatures of the temperature ranges are different from each other. Alternatively, the carbonization may be performed through gradient temperature ramping.

[0068] Preferably, the carbonization may have the same or different temperature ramping rates and the same or different holding times in different temperature ranges. Preferably, when the carbonization is sequentially performed in 2 or more temperature ranges, the carbonization is first performed in a first temperature range, and is sequentially performed in the next temperature range, for example, a second temperature range. For example, the temperature of the first temperature range may be 100-500 °C, e.g., 160-350 °C. The initial temperature of the second temperature range may be greater than or equal to the maximum temperature of the first temperature range, for example, the temperature of the second temperature range is 350-850 °C, e.g., 400-800 °C.

[0069] Preferably, the carbonization time is 30 min to 20 h, for example, 1-16 h, e.g., 2-12 h. Preferably, when the carbonization is performed in a mixed atmosphere of an inert atmosphere and oxygen, the volume percentage of oxygen in the mixed atmosphere is 1-5%.

[0070] It will be appreciated that the spherical polymer may be subjected to sulfonation either at that temperature or *in situ* during the carbonization.

[0071] According to the present disclosure, the activation of Step 2) may comprise a first activation step performed in an atmosphere comprising water vapor. Preferably, the temperature of the first activation treatment is 700-1300 °C, for example, 800-1200 °C, e.g., 850-950 °C; the time for the first activation step may be 1-40 h, for example, 5-35 h, e.g., 10-30 h.

[0072] Preferably, the atmosphere in the first activation step comprises or consists of water vapor, in particular a water vapor/inert gas (e.g., nitrogen) mixture, preferably a water vapor/nitrogen mixture.

[0073] Preferably, nitrogen and water vapor are present in a volume ratio (flow rate ratio) of 3:1 or greater, for example, 4:1-15:1, preferably 7:1-13:1.

[0074] According to the present disclosure, the atmosphere of the first activation step may be free of other gases, for example, free of carbon oxides (e.g., CO₂), oxygen and ammonia.

[0075] Preferably, the activation may be performed sequentially in 2 or more temperature ranges, for example, sequentially in 2 to 10 temperature ranges. Preferably, the temperatures of the temperature ranges are different from each other. Alternatively, the activation may be performed through gradient temperature ramping.

[0076] Preferably, the activation may have the same or different temperature ramping rates and the same or different holding times in different temperature ranges.

[0077] Preferably, when the first activation is sequentially performed in 2 or more temperature ranges, the activation is first performed in a first temperature range, and is sequentially performed in the next temperature range, for example, a second temperature range. For example, the temperature of the first temperature range may be 20-200 °C. The initial temperature of the second temperature range may be greater than or equal to the maximum temperature of the first

temperature range, for example, the temperature of the second temperature range is 200-550 °C. The initial temperature of a third temperature range may be greater than or equal to the maximum temperature of the second temperature range, for example, the temperature of the third temperature range is 550-900 °C. The initial temperature of a fourth temperature range may be greater than or equal to the maximum temperature of the third range, for example, the temperature of the fourth temperature range is 900-1300 °C, e.g., 900-1100 °C.

[0078] According to the present disclosure, the activation of Step 2) may further comprise a second activation step performed in an atmosphere comprising CO₂. Preferably, the temperature of the second activation step is 700-1300 °C, preferably 800-1200 °C, for example, 900-950 °C; the time of the second activation step is 1-15 h, for example, 3-12 h.

[0079] Preferably, the atmosphere of the second activation step comprises CO₂, for example, CO₂ or a mixture of CO₂ and an inert gas, e.g., a mixture of CO₂ and nitrogen. Preferably, when the second activation atmosphere comprises a mixture of nitrogen and CO₂, nitrogen and CO₂ may be present in a volume ratio (flow rate ratio) of 10:1-1:10, for example, 10:1-2:1, e.g., 8:1-4:1, 3:1-2:1.

[0080] According to the present disclosure, the atmosphere of the second activation step may be free of other gases, for example, free of water vapor.

[0081] According to the present disclosure, the temperature ramping may be a gradient temperature ramping. Alternatively, the temperature may be raised to a certain temperature, kept for 1-900 min, e.g., 30-800 min, and then raised again.

[0082] Preferably, the temperature ramping in the method of the present disclosure may be continuous or intermittent. Preferably, during the activation, the temperature ramping rate is no more than 10 °C/min, for example, no more than 5 °C/min, e.g., no more than 3 °C/min.

[0083] According to embodiments of the present disclosure, the cartridge comprises a composite mouthpiece comprising the spherical carbon. For example, the composite mouthpiece comprises at least one of the following composite units: an empty section comprising the spherical carbon in the middle, and tow sections connected with the two ends of the empty section. The composite unit can play a role in filtering and/or cooling.

[0084] According to embodiments of the present disclosure, the cartridge further comprises a tobacco section, a hollow filter section, a cooling section and/or a solid filter section, for example, the cartridge comprises the tobacco section, the hollow filter section, the cooling section and the solid filter section that are arranged in sequence. Preferably, the cooling section may comprise a phase-change material.

[0085] Alternatively, the cartridge comprises a heating section, a first tobacco section, a second tobacco section and a hollow filter section; for example, the cartridge comprises the heating section, the first tobacco section, the second tobacco section and the hollow filter section that are arranged in sequence. Preferably, the heating section comprises a carbon bar. Preferably, the first tobacco section comprises a vaporization chamber. Preferably, the second tobacco section comprises a condensation chamber.

[0086] According to embodiments of the present disclosure, the composite mouthpiece may be combined with any one, two or more of the above-described sections to form a cartridge.

[0087] According to embodiments of the present disclosure, the hollow filter section and solid filter section comprise a filter medium tow, for example, fibers, cellulose, cellulose acetate, acetate fibers, polypropylene and the like.

[0088] According to a preferred embodiment of the present disclosure, the spherical carbon is used to adsorb cigarette smoke in any one or more of the above-described structural sections in the cartridge.

[0089] The present disclosure further provides a cartridge comprising a spherical carbon, wherein the spherical carbon is defined above.

[0090] According to embodiments of the present disclosure, the cartridge has a structure as described above.

[0091] According to embodiments of the present disclosure, the spherical carbon is dispersed in any one or more of the above-described structural sections in the cartridge. The dispersion is a continuous dispersion or a discontinuous dispersion. For example, the discontinuous dispersion may be uniform dispersion at intervals or non-uniform dispersion of spherical carbon at intervals according to a certain concentration gradient; for example, the continuous dispersion may be an isocratic dispersion or a non-isocratic dispersion. Illustratively, the spherical carbon is present at the greatest concentration near the tobacco portion.

[0092] For example, the spherical carbon and the tow in the filter section are compounded into a carbon spraying tow, which is arranged in the hollow filter section and/or the solid filter section.

[0093] For example, the spherical carbon and the phase-change material are compounded and arranged in the cooling section. The phase-change material is selected from phase-change materials known in the art.

[0094] According to embodiments of the present disclosure, the cartridge may further comprise other adsorbents, catalysts and/or additives suitable for use in the cartridge in addition to the spherical carbon.

[0095] The present disclosure further provides a heat-not-burn tobacco product comprising the spherical carbon and/or the cartridge.

[0096] According to embodiments of the present disclosure, the spherical carbon in the tobacco product may have a weight of 1 to 300 mg, for example, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27,

28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200 or 300 mg. Preferably, the spherical carbon has a weight of about 10-60 mg, for example, 15-30 mg.

[0097] According to embodiments of the present disclosure, the heat-not-burn tobacco product and the cartridge have the meanings as described above.

[0098] According to embodiments of the present disclosure, the heat-not-burn tobacco product further comprises a smoking set for heating the cartridge. The heating may be internal heating, external heating or hybrid internal/external heating. For example, the number of smoking sets is at least 3, preferably 4, 5 or more. For example, the number of cartridges is at least 120, preferably 130, 140 or more. The "smoking" of the heat-not-burn tobacco product generally comprises heating the tobacco in the cartridge and inhaling downstream smoke through the cooling section of the tobacco product via a filter mouthpiece.

[0099] The present disclosure further provides a method for producing the heat-not-burn tobacco product, comprising combining the cartridge with the smoking set.

[0100] The present disclosure further provides a method for adsorbing cigarette smoke, comprising contacting the spherical carbon with the cigarette smoke. In order to avoid the influence of moisture and other volatile substances contained in the spherical carbon on the cigarette smoke adsorption result, the spherical carbon may be pretreated. For example, the spherical carbon is heated, and furthermore, the heating temperature may be 90 °C or greater, preferably 100 °C or greater.

[0101] The present disclosure further provides a method for selectively adsorbing at least one component in a cigarette smoke, comprising contacting the spherical carbon with the cigarette smoke comprising the at least one component.

Beneficial Effects

[0102] The inventors have surprisingly found that not only are the mechanical properties satisfactory when the spherical carbon of the present disclosure is used in heat-not-burn tobacco products, but also the undesirable adsorption of nicotine is significantly improved due to the excellent selective and specific adsorption effect of the large amount of carbonyl compounds produced during heating, which is undoubtedly particularly advantageous for improving the content of HPHCs in the cigarette smoke.

[0103] The spherical carbon used in the present disclosure has stable physical and mechanical properties, and does not require modification or introduce new chemicals, thus ensuring the safety and stability of tobacco products.

BRIEF DESCRIPTION OF THE DRAWING

[0104] FIG. 1 is a schematic view of the structure of the cartridge in Test Example 1.

[0105] Reference numerals: 1-hollow composite mouthpiece, 2-cooling section, 3-hollow filter section and 4-tobacco section.

DETAILED DESCRIPTION

[0106] The technical scheme of the present disclosure will be further illustrated in detail with reference to the following specific examples. It will be appreciated that the following embodiments are merely exemplary illustrations and explanations of the present disclosure, and should not be construed as limiting the protection scope of the present disclosure. All techniques implemented based on the content of the present disclosure described above are included within the protection scope of the present disclosure. Unless otherwise stated, the starting materials and reagents used in the following examples are all commercially available products or can be prepared using known methods.

[0107] The instruments and methodology for measuring the various characteristic parameters of the product in the following examples are as follows:

Average pore size, pore size distribution, total pore volume and specific surface area: BELSORP-min II multi-station automatic specific surface and porosity analyzer.

Cracking rate, particle size distribution and average particle size: Nikon Stereo Microscope SMZ800N.

Bulk density: as per GB/T 30202.1-2013.

Strength: as per GB/T 7702.3-2008.

Cracking rate and compressive strength: using a commercially available instrument YHS229KG.

[0108] Methodology for collecting cigarette smoke: with reference to ISO3308:2000, the smoke produced by a cigarette was collected using a smoking simulator in the following conditions:

Duration of each inhalation	2.0s±0.02s
Volume of each inhalation	35mL±0.3mL
Interval between inhalations	28s±0.5s
Pressure difference	<50hPa
Total number of inhalations	10 inhalations/cigarette

Example 1. Preparation of spherical carbon XH-1

1.1 Preparation of spherical polymer matrix

[0109] 1 kg of water was added into a 40-L glass reactor. 30 g of gelatin, 50 g of disodium hydrogen phosphate dodecahydrate solution and 2.4 g of resorcinol were added, and the mixture was well mixed. The temperature of the mixture was adjusted to 25 °C and the oil phase substances were added with stirring, including: 540 g of divinylbenzene, 150 g of ethylstyrene, 50 g of *tert*-butyl peroxy-2-ethylhexanoate and 11500 g of styrene. The reactor was sealed before clean compressed air was introduced into the reactor. The mixture was quickly stirred to adjust the size of droplets in the reactor and the temperature was raised from 25 °C to 100 °C to polymerize the mixture. The mixture was cooled, washed through a sieve and dried in vacuum at 80 °C. 11132 g of spherical polymer with a smooth surface was obtained.

1.2 Sulfonation and carbonization

[0110] The polymer obtained in Step 1.1 was mixed with concentrated sulfuric acid (98% concentration) in a mass ratio of 2:3. The mixture was then transferred into an acid-resistant rotary tube furnace with a nitrogen atmosphere and subjected to thermal treatments with a nitrogen flow rate kept at 10-20 Nm³/h as follows:

heating from 30 °C to 50 °C at a ramping rate of 5 °C/min;
 heating to 160 °C at a ramping rate of 3 °C/min;
 keeping at 160 °C for 360 min;
 heating to 350 °C at a ramping rate of 1 °C/min;
 keeping at 350 °C for 120 min;
 heating to 800 °C at a ramping rate of 1 °C/min; and cooling to obtain a carbonized product.

1.3 Activation

[0111] 5 kg of the carbonized product obtained in Step 1.2 was added into a rotary tube furnace with a nitrogen atmosphere and subjected to thermal treatments with a nitrogen flow rate kept at 2-5 m³/h as follows:

heating from 20 °C to 200 °C at a ramping rate of 4 °C/min;
 heating to 550 °C at a ramping rate of 3 °C/min;
 heating to 900 °C at a ramping rate of 1 °C/min;
 keeping at 900 °C, introducing water vapor at 850 °C at a rate of 25 kg/h, and
 keeping for 720 min; and cooling to obtain a spherical carbon.

[0112] The obtained product was sieved to give spherical carbon XH-1 with particle sizes of 0.20-0.40 mm, an average pore size of 2.14 nm, an average specific surface area of 1115 m²/g, an average pore volume of 0.5966 cm³/g, an average compressive strength of 25.94 N, an average bulk density of 612 g/L, a cracking rate of 0 and a strength of 98.84%.

Example 2. Preparation of spherical carbon XH-2

[0113] Spherical carbon XH-2 was prepared according to Example 1, except that the stirring speed for preparing polymer matrix was adjusted to increase the particle sizes of the polymer matrix and spherical carbon.

[0114] The prepared spherical carbon was sieved to give spherical carbon XH-2 with particle sizes of 0.60-0.80 mm, an average pore size of 2.26 nm, an average specific surface area of 1037 m²/g, an average pore volume of 0.5854 cm³/g, an average compressive strength of 94.45 N, an average bulk density of 686 g/L, a cracking rate of 0 and a strength of 99.57%.

Example 3. Preparation of spherical carbon DH

[0115] Spherical carbon DH was prepared according to Example 1, except that the method for preparing the spherical polymer matrix is as follows:

3 L of water was added into a 10-L glass reactor and heated to 25 °C. 10 g of gelatin, 16 g of disodium hydrogen phosphate dodecahydrate and 0.8 g of resorcinol were added with stirring, and the mixture was stirred homogeneously. 120 g of divinylbenzene, 30 g of ethylstyrene, 20 g of dibenzoyl peroxide, 1800 g of styrene and 1200 g of isododecane were mixed by stirring to form an oil phase, and the oil phase was added to the above-described mixture with stirring. The reactor was sealed before clean compressed air was introduced into the reactor. The mixture was quickly stirred to adjust the size of droplets in the reactor and the temperature was gradually raised to 95 °C. After keeping the temperature for 12 h, the mixture was cooled, filtered through a 32- μ m mesh screen, washed and then dried in vacuum at 80 °C. 1704 g of spherical polymer with a smooth surface was obtained.

[0116] Subsequently, the sulfonation, carbonization and activation steps were performed according to the conditions in Example 1. The obtained spherical carbon was sieved to give spherical carbon DH with particle sizes of 0.60-0.80 mm, an average pore size of 2.2578 nm, an average specific surface area of 1037 m²/g, an average pore volume of 0.5854 cm³/g, an average compressive strength of 94.45 N, an average bulk density of 686 g/L, a cracking rate of 0 and a strength of 99.57%.

Test Example 1. Cigarette smoke adsorption test of heat-not-burn cartridges I and II

[0117] The cartridge was formed by combining the composite mouthpiece 1 and at least one section of the hollow filter section, the cooling section, the solid filter section or the tobacco section (tobacco flakes, reconstituted tobacco or recombined tobacco) together.

[0118] Specifically, the cartridge, as shown in FIG. 1, was formed by connecting and combining the hollow composite mouthpiece 1, the cooling section 2, the hollow filter section 3 and the tobacco section 4.

[0119] The structure of the hollow composite mouthpiece 1 is as follows: the middle is an empty section comprising the spherical carbon, and the two ends are tow sections formed by low-resistance tows. The preparation of the hollow composite mouthpiece is as follows: The tows were cut into uniform small segments and the outer package was plug wrap paper. The small segments of tows were fixed on the plug wrap paper at cavity intervals of about 6 mm by adjusting the speed of the forming machine. The spherical carbons were uniformly added into the cavity intervals, and the hollow composite mouthpiece was obtained by rolling.

[0120] Cartridges I and II were prepared according to different loading amounts and particle sizes of the spherical carbon. In cartridge I, the loading amount of the spherical carbon was 15 mg, and spherical carbon XH-1 with a particle size range of 0.2-0.4 mm prepared in Example 1 was selected; in cartridge II, the loading amount of the spherical carbon was 30 mg, and spherical carbon DH with a particle size range of 0.6-0.8 mm prepared in Example 3 was selected. The coconut shell activated carbon used in the manufacture of commercially available "HaoRiZi" cigarette of Shenzhen Tobacco Industry Inc., in Comparative Example 1 (wherein the average pore size of the coconut shell activated carbon is 1.7268 nm, the specific surface area is 983 m²/g, and the pore volume is 0.4244 cm³/g). The addition amounts of the coconut shell activated carbon in the Comparative Example were 15 mg and 30 mg.

[0121] The cartridges were placed into heat-not-burn smoking sets for heating. The number of heat-not-burn smoking sets was at least 3, and the number of cartridges was at least 120.

[0122] The cartridges were heated by smoking sets. The generated cigarette smoke was collected and analyzed as per criteria YC/T 254-2008 or European Union TPD, for HPHCs including, but not limited to, formaldehyde, acetaldehyde, acetone, acrolein, propionaldehyde, crotonaldehyde, 2-butanone, butyraldehyde and other aldehyde and ketone substances. The test showed that the contents of HPHCs in cigarette smokes of the heat-not-burn tobacco products containing the activated carbon provided by the Examples were significantly lower than those in the smoke of Comparative Example 1. Particularly, the contents of the carbonyl compounds generated in the heating process of the smoke-generating agent were significantly reduced, suggesting that the spherical carbon prepared by the Examples achieves superior selective and specific adsorption effect on the carbonyl compounds.

Test Example 2. Cigarette smoke adsorption test of heat-not-burn cartridge III

[0123] In this example, the structure of cartridge III was basically the same as that of Test Example 1, except that: the tobacco section 4 was filled with commercially available tea-flavored tobacco flakes, and the inhalation section was covered with silicone sheets having uniformly distributed small pores and was loaded with 30 mg of spherical carbon XH-2 of Example 2. The cartridge of Comparative Example 2 was a cartridge that did not contain spherical carbon or other activated carbon, also referred to as a "blank cartridge".

[0124] Cartridge III and the cartridge of Comparative Example 2 were heated in the same conditions using smoking

sets. The generated cigarette smokes inhaled by a smoking machine were introduced through an impingement bottle containing acidic 2,4-DNPH (2,4-dinitrophenylhydrazine) solution as per CORESTA RECOMMENDED METHOD N^o74, where the carbonyl compounds in the cigarette smoke were absorbed by the solution. The solution of the carbonyl compounds collected was analyzed by high performance liquid chromatography equipped with an ultraviolet detector (HPLC-UV) to detect the contents of aldehydes and ketones, and the test results are shown in the following table:

Item	Content (μg)	
	Comparative Example 2 (blank)	Cartridge III
Acetaldehyde	28.29	8.39
Butyraldehyde	1.9	1.21
Propionaldehyde	3.11	2.96
2-Butanone	2.01	1.02
Acetone	3.94	Undetectable

[0125] The results show that the adsorption of cartridge III led to contents of HPHCs in the cigarette smoke of heat-not-burn tobaccos significantly lower than those of the blank cartridge and significantly reduced contents of aldehyde and ketone compounds; particularly, the adsorption rate (the adsorption amount of cartridge III/the content of Comparative Example 2 × 100%) of acetone was up to 100%, and the adsorption rate of acetaldehyde exceeded 70%, indicating that the spherical carbon prepared in the Examples achieves superior selective and specific adsorption effect on the carbonyl compounds in the cigarette smoke.

[0126] The embodiments of the present disclosure have been described above. However, the present disclosure is not limited to the embodiments described above. Any modification, equivalent, improvement and the like made without departing from the spirit and principle of the present disclosure shall fall within the protection scope of the present disclosure.

Claims

1. Use of a spherical carbon in cigarette smoke adsorption of a heat-not-burn tobacco product.
2. The use according to claim 1, wherein the heat-not-burn tobacco product is selected from at least one of an electrically heated heat-not-burn tobacco product and a carbon-heated heat-not-burn tobacco product;

preferably, the "cigarette smoke" is a gas emitted by the heat-not-burn tobacco product under normal pressure, or a gas generated by the tobacco product under a negative pressure;

preferably, the "cigarette smoke" is gaseous and/or misty in appearance;

preferably, the "cigarette smoke" is generated by a cartridge of the heat-not-burn tobacco product in a heat-not-burn condition; preferably, the mode of heating is internal heating, external heating or hybrid internal/external heating; the internal heating means that a heating element is surrounded by the cartridge and the heat can be concentrated in a cigarette bin; the external heating means that the cartridge is inserted into a smoking set for heating, and the heat generated by the smoking set is conducted to a surface of the cartridge.

3. The use according to claim 2, wherein the cartridge comprises a tobacco or a tobacco-replacing herb;

preferably, the tobacco is selected from at least one of a reconstituted tobacco and a recombined tobacco;

preferably, the tobacco-replacing herb is selected from a non-tobacco herb that produces smoke upon low-temperature heating;

preferably, the tobacco is in the form of a filament, a sheet, a granule or a powder;

preferably, the cartridge further comprises at least one flavourant and/or other additives; for example, the additive is selected from at least one of a smoke-generating agent, a colorant and a binder;

preferably, the smoke-generating agent comprises propylene glycol and glycerol; for example, in the cartridge, the content of glycerol is 15-70 wt%; for example, in the cartridge, the content of propylene glycol is no more than 2 wt%.

4. The use according to any of claims 1-3, wherein the cigarette smoke comprises or does not comprise nicotine or a salt of nicotine;

preferably, the cigarette smoke further comprises a carbonyl compound; preferably, the carbonyl compound comprises at least one component selected from: formaldehyde, acetaldehyde, acetone, acrolein, propionaldehyde, crotonaldehyde, butyraldehyde and 2-butanone;

preferably, the carbonyl compound is from a cigarette smoke generated by heating the cartridge and/or atomization, preferably from a cigarette smoke generated by heating and/or atomizing the smoke-generating agent; preferably, the cigarette smoke optionally comprises or does not comprise a nitrosamine compound;

preferably, the cigarette smoke further comprises other components, for example, at least one selected from: 1-hydroxy-2-propanone, 3-hexen-2-one, 4-hydroxy-2-pentanone, furfural, 5-(hydroxymethyl)furfural, 2-oxo-3-cyclopenten-1-acetaldehyde, furfuryl alcohol, 2-hexenal, 1-acetoxy-2-propanone, cyclopentene-1,4-dione, 2-methyl-2-cyclopenten-1-one, 2(3*H*)-furanone, 1,2-cyclopentanedione, 2-hydroxy-3-methyl-2-cyclopenten-1-one, 2,3-dimethyl-2-cyclopenten-1-one, 2,5-dimethyl-4-hydroxy-3(2*H*)-furanone, megastigmatrienone A, megastigmatrienone B, megastigmatrienone C, megastigmatrienone D, norsolanedione, 4,4-dimethyl-2-cyclohexen-1-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-4*H*-pyran-4-one, benzene, cyclohexene, propionic acid, acrylic acid, propylene glycol, 2,2'-ethoxypropane, 2-hydroxyethyl acetate, methyl 2-oxopropanoate, isopropyl benzene, diethylene glycol diacetate, phenol, 2-methylphenol, 3-methylphenol, 4-methylphenol, 2-methoxyphenol, methyl 3-furancarboxylate, catechol, 2,3-dihydrobenzofuran, 1,4-benzenediol, 3-methyl-1,2-benzenediol, 2-methoxy-4-vinylphenol, solanone, isoeugenol, farnesol, diennicotinyl, 2,3-bipyridine, quinic acid, 3-oxo- α -ionol, 4,8-dimethyl-1-nonanol, neophytadiene, hexadecanoic acid, methyl 9,12,15-octadecatrienoate, cholest-5-en-3-ol acetate and stigmasta-5,22-dien-3-ol acetate;

preferably, the cigarette smoke further comprises other components, for example, a compound comprising at least one element selected from: Cr, Ni, Fe, Al, Sn, Pb, Cd, As, Sb, Hg and Cu;

preferably, the cigarette smoke further comprises a particulate and/or an aerogel, and may comprise components such as CO, CO₂ and/or gases in the air;

preferably, the spherical carbon is used for selectively adsorbing at least one of the above components or substances in the cigarette smoke.

5. The use according to any of claims 1-4, wherein the spherical carbon is selected from a spherical activated carbon;

preferably, the spherical carbon for adsorbing the cigarette smoke has a weight of 1-300 mg, preferably 10-60 mg;

preferably, the spherical carbon has a specific surface area B lower than 1300 m²/g;

preferably, the spherical carbon has an average particle size of 0.2-1.5 mm;

preferably, the spherical carbon has an average pore size of 1.5-3.2 nm;

preferably, the spherical carbon has an average pore volume of 0.35-0.5 cm³/g;

preferably, the spherical carbon comprises mesopores (pore size between 2-50 nm) and micropores (pore size less than 2 nm); wherein, the mesopores have pore volumes of 0.003-0.018 cm³/g;

preferably, the micropores have a pore volume ≥ 4300 cm³/g;

preferably, the spherical carbon has a compressive strength of 10-100 N;

preferably, the spherical carbon has a cracking rate less than 10.0%;

preferably, the spherical carbon has a bulk density of 300-900 g/cm³;

preferably, the spherical carbon is used for cigarette smoke adsorption without modification;

preferably, the spherical carbon is used for cigarette smoke adsorption without conjugation or combination with other adsorbents;

preferably, the raw material for preparing the spherical carbon is a spherical polymer, such as a porous spherical polymer or a microporous spherical polymer;

preferably, the method for preparing the spherical carbon comprises:

- 1) carbonizing the spherical polymer; and
- 2) activating the product obtained in Step 1).

6. The use according to any of claims 2-5, wherein the cartridge comprises a composite mouthpiece comprising the spherical carbon; for example, the composite mouthpiece comprises at least one of the following composite units: an empty section comprising the spherical carbon in the middle, and two sections connected with the two ends of the empty section;

preferably, the cartridge further comprises a tobacco section, a hollow filter section, a cooling section and/or a

solid filter section, for example, the cartridge comprises the tobacco section, the hollow filter section, the cooling section and the solid filter section that are arranged in sequence; preferably, the cooling section may comprise a phase-change material;

alternatively, the cartridge comprises a heating section, a first tobacco section, a second tobacco section and a hollow filter section, for example, the cartridge comprises the heating section, the first tobacco section, the second tobacco section and the hollow filter section that are arranged in sequence; preferably, the heating section comprises a carbon bar; preferably, the first tobacco section comprises a vaporization chamber; preferably, the second tobacco section comprises a condensation chamber;

preferably, the composite mouthpiece may be combined with any one, two or more of the above sections to form a cartridge;

preferably, the hollow filter section and solid filter section comprise a filter medium tow;

preferably, the spherical carbon is used to adsorb cigarette smoke in any one or more of the above-described structural sections of the cartridge.

7. A cartridge, comprising a spherical carbon, wherein the spherical carbon is defined in claim 5;

preferably, the cartridge has a structure described in claim 3 or 6;

preferably, the cartridge may further comprise other adsorbents, catalysts and/or additives suitable for use in the cartridge in addition to the spherical carbon.

8. A heat-not-burn tobacco product, comprising the spherical carbon and/or the cartridge;

preferably, the weight of the spherical carbon in the tobacco product is 1-300 mg;

preferably, the heat-not-burn tobacco product further comprises a smoking set for heating the cartridge.

9. A method for producing the heat-not-burn tobacco product according to claim 8, comprising combining the cartridge with the smoking set.

10. A method for adsorbing cigarette smoke, comprising contacting the spherical carbon described in claim 5 with the cigarette smoke described in any of claims 1-4; preferably, a method for selectively adsorbing at least one component of a cigarette smoke, comprising contacting the spherical carbon described in claim 5 with the cigarette smoke comprising at least one component described in any of claims 1 to 4.

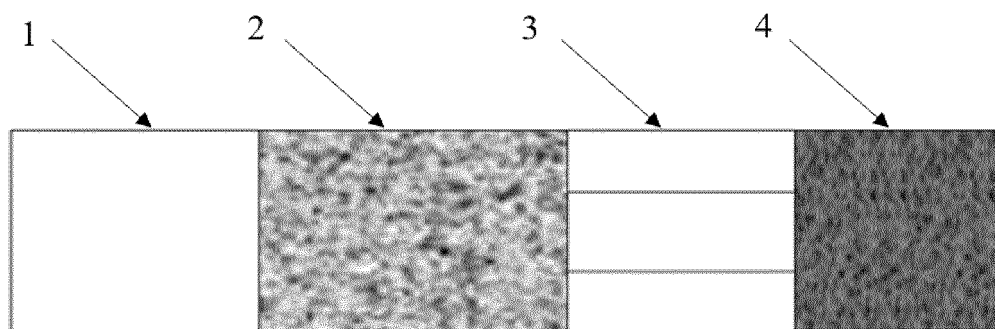


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2021/137474

A. CLASSIFICATION OF SUBJECT MATTER A24F 13/06(2006.01)i; A24D 3/04(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC																					
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A24F, A24D Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																					
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPABSC; CNTXT; ENTXTC; 超星科技数字图书馆; 环球绿地新材料, 球, 活性炭, 活性炭, 烟草, 烟弹, 加热不燃烧, 吸附, 过滤, 球状聚合物, spher+, bead+, activated carbon, tobacco, cigarette, adsorb+, filter, poly+																					
C. DOCUMENTS CONSIDERED TO BE RELEVANT																					
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>CN 1630475 A (PHILIP MORRIS PRODUCTS S. A.) 22 June 2005 (2005-06-22) description page 5 paragraph 2, page 6 lines 14-17, page 10 paragraph 2 from the bottom, page 17 table 2, page 18 paragraph 1, claims 26, 30, 31, 36</td> <td>1-10</td> </tr> <tr> <td>X</td> <td>CN 110432552 A (PUWEI SIXIN BEIJING TECHNOLOGY CO., LTD. et al.) 12 November 2019 (2019-11-12) specific embodiments</td> <td>1-10</td> </tr> <tr> <td>X</td> <td>US 2006180164 A1 (PHILIP MORRIS USA INC.) 17 August 2006 (2006-08-17) specific embodiments</td> <td>1-10</td> </tr> <tr> <td>PX</td> <td>CN 112841708 A (SHENZHEN GLOBAL GREENLAND NEW MATERIALS CO., LTD. et al.) 28 May 2021 (2021-05-28) description paragraphs [0007]-[0043], [0095]-[0111]</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>CN 108383117 A (SHENZHEN GLOBAL GREENLAND NEW MATERIALS CO., LTD.) 10 August 2018 (2018-08-10) claims</td> <td>1-10</td> </tr> <tr> <td>A</td> <td>CN 210203372 U (SHENZHEN CHAOYUE ELECTRONIC CIGARETTE CO., LTD.) 31 March 2020 (2020-03-31) specific embodiments</td> <td>1-10</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	CN 1630475 A (PHILIP MORRIS PRODUCTS S. A.) 22 June 2005 (2005-06-22) description page 5 paragraph 2, page 6 lines 14-17, page 10 paragraph 2 from the bottom, page 17 table 2, page 18 paragraph 1, claims 26, 30, 31, 36	1-10	X	CN 110432552 A (PUWEI SIXIN BEIJING TECHNOLOGY CO., LTD. et al.) 12 November 2019 (2019-11-12) specific embodiments	1-10	X	US 2006180164 A1 (PHILIP MORRIS USA INC.) 17 August 2006 (2006-08-17) specific embodiments	1-10	PX	CN 112841708 A (SHENZHEN GLOBAL GREENLAND NEW MATERIALS CO., LTD. et al.) 28 May 2021 (2021-05-28) description paragraphs [0007]-[0043], [0095]-[0111]	1-10	A	CN 108383117 A (SHENZHEN GLOBAL GREENLAND NEW MATERIALS CO., LTD.) 10 August 2018 (2018-08-10) claims	1-10	A	CN 210203372 U (SHENZHEN CHAOYUE ELECTRONIC CIGARETTE CO., LTD.) 31 March 2020 (2020-03-31) specific embodiments	1-10
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2021/137474

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