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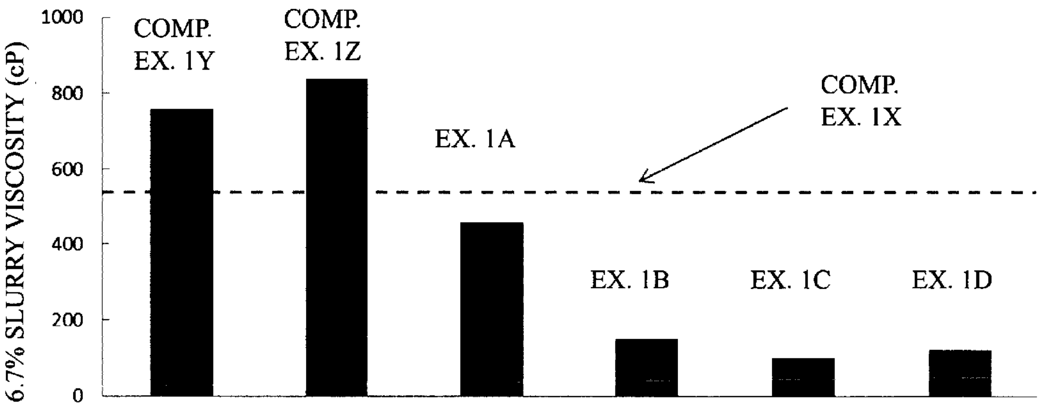
(54) Title: TOBACCO MATERIAL



(57) Abrégé/Abstract:
A tobacco material includes an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 µm or less, wherein the hemicellulose content in the tobacco material is 0.8% by weight or less based on bone-dry tobacco particles.

ABSTRACT

A tobacco material includes an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less, wherein the hemicellulose content in the tobacco material is 0.8% by weight or less based on bone-dry tobacco particles.

DESCRIPTION

TOBACCO MATERIAL

TECHNICAL FIELD

[0001] The present invention relates to a tobacco material and a tobacco product comprising the tobacco material.

BACKGROUND ART

[0002] In the field of smoking articles, smoking articles that meet various preferences are developed by adjusting smoking flavor. As a method of adjusting smoking flavor, a method of dispersing leaf tobacco particles in a dispersion medium and adding the resulting dispersion to tobacco shreds is known as in Patent Literature (PTL) 1, for example. Moreover, PTL 2 discloses a method of improving flavor through heating of a suspension of tobacco particles by utilizing the Maillard reaction or the like (PTL 2, paragraph [0013]). Such tobacco particles are smaller than 40 mesh (PTL 2, paragraph [0024]), in other words, smaller than 400 μm. Meanwhile, a suspension of tobacco particles is also known as a raw material for a reconstituted tobacco sheet, and PTL 3 discloses that a suspension of tobacco particles with 60 to 400 mesh is heated to 80°F to 180°F (26.7°C to 82.2°C) (PTL 3, paragraph [0056]). The particle size of these tobacco particles is 38 to 250 μm.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: WO 2014/185103

PTL 2: Japanese Unexamined Patent Application Publication No. H10-66559

PTL 3: Japanese Unexamined Patent Application Publication No. H06-46817

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] The method of PTL 1 is a useful technique since flavor can be evenly imparted to tobacco shreds and the like. However, in the preparation stage for a tobacco raw material dispersion by mixing a tobacco raw material with solvent, such as water, present inventors found a problem, for example, in which interactions and the like between water and water-soluble components derived from the tobacco raw material increase the viscosity of the dispersion, thereby making spraying of the dispersion difficult. In view of the above, an object of the present invention is to provide a low-viscosity tobacco material in which tobacco particles are dispersed in an aqueous dispersion medium. PTL 1 suggests nothing about an increase in viscosity, and PTL 2 and 3 even lack a disclosure of such particles. Accordingly, the above-mentioned problem is a problem peculiar to the use of fine particles with an average particle size of 30 μm or less and is thus a novel problem found by the present inventors.

SOLUTION TO PROBLEM

[0005] The present inventors have resolved the above-mentioned problem by controlling the amount of hemicellulose to a certain value or less in a tobacco material comprising an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less. Specifically, the above-mentioned problem can be resolved by the following present invention.

(1) A tobacco material comprising an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less, where a hemicellulose content in the tobacco material is 0.8% by weight or less based on bone-dry tobacco particles.

(2) The tobacco material according to (1), where a pH is 4.8 or less.

(3) The tobacco material according to (1) or (2), where the aqueous dispersion medium contains an aqueous organic compound.

(4) The tobacco material according to (3), where the aqueous organic compound is selected from the group consisting of monohydric alcohols, polyhydric alcohols, sugar alcohols, sugars, polyhydric alcohol esters, and combinations thereof.

(5) The tobacco material according to any one of (1) to (4), where a water content in the aqueous dispersion medium exceeds 50% by weight.

(6) The tobacco material according to any one of (1) to (5), where a content of the

tobacco particles is 1 to 40% by weight.

(7) The tobacco material according to any one of (1) to (6), where the tobacco particles are particles derived from a tobacco raw material, a fermented tobacco raw material, or a heat-treated tobacco raw material.

(8) The tobacco material according to (7), where a variety of the tobacco raw material is flue-cured, burley, domestic, or oriental.

(9) A production method for the tobacco material according to any one of (1) to (8) comprising: preparing a dispersion containing an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less; and heating the dispersion to 160°C or higher.

(10) The production method according to (9), where the heating is performed under pressure.

(11) A tobacco product comprising the tobacco material according to any one of (1) to (8) above.

(12) The tobacco product according to (11), further comprising a base material, where 0.01 to 5% by weight of the tobacco particles are contained relative to the base material.

(13) A production method for the tobacco product according to (12) comprising adding the tobacco material according to any one of (1) to (8) above to the base material.

ADVANTAGEOUS EFFECTS OF INVENTION

[0006] According to the present invention, it is possible to provide a low-viscosity tobacco material in which tobacco particles are dispersed in an aqueous dispersion medium.

BRIEF DESCRIPTION OF DRAWINGS

[0007] Fig. 1A shows the viscosity of tobacco materials.

Fig. 1B shows the viscosity of tobacco materials.

Fig. 1C shows the viscosity of tobacco materials.

Fig. 2 shows the results of a storage test.

Fig. 3 shows the pH of tobacco materials.

DESCRIPTION OF EMBODIMENTS

[0008] Hereinafter, the present invention will be described in detail. In the present invention, the wording "X to Y" includes the lower and the upper limits of X and Y.

[0009] 1. Tobacco Material

A tobacco material of the present invention comprises an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less.

[0010] (1) Tobacco Particles

Tobacco particles may be derived from a tobacco raw material, a fermented tobacco raw material, or a heat-treated tobacco raw material. The tobacco raw material herein means whole tobacco or parts of tobacco. As such parts, leaves, veins, stems, roots, flowers, and mixtures thereof may be used. The variety of tobacco is not particularly limited, and examples include flue-cured, barley, domestic, and oriental. A tobacco raw material to be used may be in the state of fresh leaves immediately after the harvest without being subjected to drying or the like, leaves that have been subjected to drying treatment after the harvest, or combinations thereof. In addition, tobacco stems and veins, expanded tobacco, and sheet tobacco obtained by processing these tobacco raw materials may also be used. These materials may be used alone or in combination of a plurality of varieties or parts.

[0011] Tobacco particles can be prepared by any suitable method but is preferably prepared by subjecting a tobacco raw material to common drying treatment, then coarse grinding with a common coarse grinder, followed by fine grinding. The drying treatment and coarse grinding may be performed in any publicly known manner, and the average particle size of coarsely ground tobacco particles preferably falls within a range from several hundred micrometers to several millimeters. A method for fine grinding is also not limited, and either method of wet grinding and dry grinding may be employed. The wet grinding can be performed by adding a liquid dispersion medium to coarsely ground tobacco particles, mixing, and processing the resulting mixture in a wet milling machine (MIC-2: from Nara

Machinery Co., Ltd., for example). The milling machine is preferably set to the rotation number of typical 1,100 to 1,300 rpm and milling time of about 5 to 100 minutes. Meanwhile, dry grinding can be performed by processing coarsely ground tobacco particles in a dry fine grinder, such as a jet mill.

[0012] The thus-obtained tobacco particles have an average particle size of 30 μm or less and preferably 20 μm or less. By having such average particle sizes, clogging of a nozzle is less likely to occur during spraying of a dispersion; and tobacco particles are readily and uniformly dispersed in the tobacco material. Accordingly, smoking flavor can be evenly imparted to smoking articles. The lower limit of the average particle size of tobacco particles is 5 μm or more in one embodiment and 8 μm or more in another embodiment. The average particle size of tobacco particles is adjustable by grinding conditions. For example, the average particle size can be increased by shortening the time for fine grinding, reducing the viscosity of a dispersion medium, and so forth.

[0013] The average particle size of the present invention can be determined by a laser diffraction/scattering method. Specifically, the average particle size of the present invention is measured by using a laser diffraction particle size analyzer (SALD-2100 nano particle size analyzer from Shimadzu Corporation) at a diffractive index of 1.60 to 0.101.

[0014] (2) Aqueous Dispersion Media

An aqueous dispersion medium herein refers to a liquid medium containing water. The aqueous dispersion medium may be water alone or may contain a specific organic compound. The organic compound is preferably water soluble, and such an aqueous organic compound is preferably selected from the group consisting of monohydric alcohols, polyhydric alcohols, sugar alcohols, sugars, polyhydric alcohol esters, and combinations thereof. When the organic compound is insoluble in water, the organic compound can be dissolved in an aqueous dispersion medium by using in combination with an amphiphilic organic compound, such as methanol.

[0015] Examples of the monohydric alcohols include monohydric C_1 to C_6 aliphatic alcohols, such as methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, 2-methyl-

1-propanol, 2,2-dimethylethanol, and cyclohexanol; monohydric alcohols having an aromatic substituent, such as benzyl alcohol; other monohydric alcohols having one or more halogen elements; and monohydric alcohols having one or more ether linkages.

[0016] A polyhydric alcohol is a generic term for compounds having two or more hydroxy groups in a molecule. Examples of the polyhydric alcohols include, but are not limited to, glycerol and propylene glycol.

Examples of the sugar alcohols include sorbitol, maltitol, xylitol, erythritol, lactitol, sorbitan, xylose, arabinose, mannose, and trehalose.

Examples of the sugars include lactose, table sugar, coupling sugar, glucose, enzyme-converted syrup, acid-converted syrup, maltose syrup, maltose, high-fructose corn syrup, fructose, hydrogenated maltose, hydrogenated starch syrup, and honey.

Examples of the polyhydric alcohol esters include fatty acid polyhydric alcohol esters, such as fatty acid triglycerides.

[0017] The aqueous dispersion medium can be used as a medium for wet grinding of tobacco. In this case, a tobacco material of the present invention can be prepared simultaneously with fine grinding. On this occasion, a mixed solvent of water and glycerol is preferably employed since the average particle size of tobacco particles is readily adjusted to a desirable range. When tobacco particles are obtained by dry fine grinding, a tobacco material of the present invention can be prepared by mixing finely ground tobacco particles with an aqueous medium.

[0018] A mixing ratio of water and the organic compound is not limited, and any suitable mixing ratio may be employed particularly when a mixed solvent of water and glycerol is used. However, in view of handling properties, safety, and the like, a water content in the aqueous dispersion medium is preferably more than 50% by weight, more preferably 80% by weight or more, and further preferably 90% by weight or more.

[0019] (3) Hemicellulose

Hemicellulose is a polysaccharide contained in plant cell walls. A tobacco material of the present invention contains 0.8% by weight or less of hemicellulose based on bone-dry tobacco particles. Hemicellulose readily interacts with water, thereby increasing the viscosity of the tobacco material. However, the present invention exhibits a low viscosity due to a reduced amount of hemicellulose and thus exerts an effect of facilitating spraying onto a base material, such as tobacco shreds. In this view, the amount of hemicellulose is preferably 0.5% by weight or less based on bone-dry tobacco particles. The lower limit of the amount of hemicellulose is not limited but is preferably 0% by weight or is preferably 0.1% by weight or more.

[0020] The concentration of cellulose in a tobacco material of the present invention is not limited but, in view of viscosity, is preferably 12% by weight or less, more preferably 10.5% by weight or less, further preferably 10% by weight or less, and particularly preferably 9% by weight or less based on bone-dry tobacco particles.

[0021] (4) Characteristics

In a tobacco material of the present invention, tobacco particles with an average particle size of 30 μm or less are dispersed in an aqueous dispersion medium. The amount of tobacco particles in the tobacco material is preferably 1 to 40% by weight in a bone-dry state. When the amount of tobacco particles falls within this range, a tobacco material of the present invention is a slurry with an appropriate viscosity, is easily applied to a base material by using a spraying apparatus, and makes uniform application possible.

[0022] Moreover, a tobacco material of the present invention has a pH of preferably 4.8 or less and more preferably 4.6 or less. A tobacco material obtained by the method of PTL 1 had a problem in which microorganisms proliferate due to increased water activity. Meanwhile, a tobacco material of the present invention with the above-mentioned pH ranges is also characterized by suppressed proliferation of microorganisms and capability of maintaining the quality. The pH of a tobacco material can be determined by measuring a hydrogen ion concentration in the tobacco material by using a pH meter.

[0023] The viscosity of a tobacco material of the present invention at 20°C and a tobacco particle concentration of 16.7% by weight is preferably 10 to 500 cP and more preferably 10 to 200 cP. The viscosity is measured with a B-type viscometer.

[0024] (5) Additives

A tobacco material of the present invention may contain various additives. Examples of the additives include food ingredients for designing flavor, such as spearmint leaves, peppermint leaves, green tea and other tea leaves, coffee, cocoa, cardamom, menthol, and sugar; polysaccharide thickeners for enhancing dispersibility through viscosity adjustment, such as glucans and pectin; food additives, such as various emulsifiers; glues, such as carboxymethyl cellulose (CMC); and curing agents for enhancing handling properties after addition to tobacco. The timing of adding such additives is not limited, and additives may be added before fine grinding of a tobacco raw material and finely ground together or may be added to a tobacco material. The proportions of additives may also be set suitably. However, when additives are contained, the total amount of tobacco particles and a dispersion medium in a tobacco material of the present invention is preferably 90% by weight or more and more preferably 95% by weight or more based on the total amount of the tobacco material.

[0025] 2. Production Method for Tobacco Material of the Present Invention

A tobacco material of the present invention is preferably produced by a method comprising: preparing a dispersion containing an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less, as in the foregoing; and heating the dispersion to 160°C or higher. By heating the dispersion to 160°C or higher, it is possible to decompose substances, such as hemicellulose, that cause thickening through interactions with water and to reduce the amounts thereof. In this view, the heating temperature is preferably higher than 150°C and more preferably 160°C or higher. Meanwhile, an excessively high temperature causes degradation of active components. Accordingly, the upper limit of the heating temperature is preferably 200°C or lower, more preferably 190°C or lower, and further preferably 180°C or lower. Heating is preferably performed under pressure by using an apparatus, such as a pressure cooker. The pressure is preferably 1.8 MPa or higher. A tobacco material of the present invention produced under these conditions also exerts an effect of remarkably suppressing proliferation of microorganisms.

[0026] 3. Tobacco Products

A tobacco product can be obtained by adding a tobacco material of the present invention to a base material. A base material herein refers to a tobacco body or auxiliary members of smokable tobacco. Examples of the tobacco body include tobacco immediately after the harvest, dried tobacco, flavor-added tobacco, tobacco shreds, and cigarettes. Examples of the auxiliary members include cigarette paper, filters, and tipping paper. Examples of the method of adding a tobacco material to a base material include, but are not particularly limited to, dropwise addition, spraying, coating, and impregnation.

[0027] When a tobacco material of the present invention is added to a cigarette, the tobacco material may be added to cigarette components, such as tobacco shreds, cigarette paper, filter, and tipping paper. The tobacco material may be added to one segment or two or more segments, such as both tobacco shreds and tipping paper. Moreover, by adding tobacco materials obtained from different types of tobacco to different locations on cigarette paper, it is also possible to provide different smoking flavors during smoking of a tobacco product, such as a cigarette. When a tobacco material is added to a filter of a cigarette, the filter may also be impregnated with the tobacco material.

[0028] When a tobacco material of the present invention is added to tobacco shreds, the amount of tobacco particles contained in the tobacco material is preferably set to 0.01 to 5% by weight based on the weight of the tobacco shreds in view of efficiency in imparting smoking flavor. When tobacco with strong flavor is used for a tobacco material, the above-mentioned proportion may be reduced to 0.01 to 0.1% by weight, for example.

EXAMPLES

[0029] [Example 1]

Tobacco particles with an average particle size of 30 μm were prepared as in the following by using a leaf tobacco raw material (Brazilian flue-cured raw material).

The leaf tobacco raw material was coarsely ground to 10 mm or less by using a cutter mill from Tokyo Atomizer M. F. G. Co., Ltd. Subsequently, the coarsely ground leaf tobacco raw material was coarsely ground further to an average particle size of 100 μm or less by using a CONDUX impact mill from NETZSCH Group and then finely ground by using a CSM impact classifier mill from NETZSCH Group to yield tobacco particles with an average particle size of 30 μm or less.

[0030] The resulting tobacco particles were mixed with sterile water to obtain a slurry in which the tobacco particles were suspended in water. The content of the tobacco particles (bone dry) in the slurry was 16.7% by weight. The slurry was sealed in four reaction vessels and subjected to high-temperature high-pressure treatment under the following respective conditions to produce tobacco materials of the present invention. The suspended state of the tobacco particles did not change even after the high-temperature high-pressure treatment.

A: 160°C-10 min
B: 180°C-10 min
C: 180°C-30 min
D: 180°C-60 min

[0031] The viscosity of each slurry after the treatment was measured at 20°C by using a B-type viscometer (rotor No. 1, rotation number of 0.3 to 100 rpm).

[0032] Further, cellulose and hemicellulose contents were measured for the tobacco materials (slurries) of the present invention as in the following.

1) A slurry was washed with water and subjected to centrifugation (8,000 rpm, 10 min) to collect a settled residue. This procedure was repeated twice.

2) The collected residue was rinsed with ethanol and subjected to centrifugation (8,000 rpm, 10 min) to collect a settled residue. This procedure was repeated twice.

3) The resulting residue was dried in a constant-temperature apparatus (100°C-2 hrs).

4) The dried residue was weighed, and quantification of cellulose and hemicellulose by the Van Soest method was outsourced to Japan Food Research Laboratories to obtain cellulose and hemicellulose contents based on the weight of bone-dry tobacco particles.

[0033] [Example 2]

A tobacco material of the present invention was produced and evaluated in the same manner as Example 1 except for changing the content of tobacco particles (bone dry) to 14.3% by weight and performing only high-temperature high-pressure treatment D above.

[0034] [Example 3]

A tobacco material of the present invention was produced and evaluated in the same manner as Example 1 except for changing the content of tobacco particles (bone dry) to 20.0% by weight and performing only high-temperature high-pressure treatment D above.

[0035] [Comparative Example 1]

A tobacco material for comparison was produced and evaluated in the same manner as Example 1 except for changing the high-temperature high-pressure treatment to the following.

X: None

Y: 150°C -5 min

Z: 150°C-15 min

[0036] [Comparative Examples 2 and 3]

Tobacco materials for comparison were produced and evaluated in the same manner as Examples 2 and 3, respectively, except for omitting the high-temperature high-pressure treatment.

These results are shown in Figs. 1 and 2 as well as Tables 1 and 2.

[0037] [Table 1]

Table 1 The amount of hemicellulose for Examples and Comparative Examples (weight %)

		Ex. 1	Ex. 2	Ex. 3	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
A	160°C-10 min	0.0	-	-	-	-	-
B	180°C-10 min	0.0	-	-	-	-	-
C	180°C-30 min	0.0	-	-	-	-	-
D	180°C-60 min	0.0	0.0	0.0	-	-	-
Y	150°C -5 min	-	-	-	1.4	-	-
Z	150°C-15 min	-	-	-	0.9	-	-
X	None	-	-	-	2.7	2.7	2.7

[0038] [Table 2]

Table 2 The amount of cellulose for Examples and Comparative Examples (weight%)

		Ex. 1	Ex. 2	Ex. 3	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
A	160°C-10 min	11.7	-	-	-	-	-
B	180°C-10 min	8.8	-	-	-	-	-
C	180°C-30 min	8.6	-	-	-	-	-
D	180°C-60 min	7.5	7.5	8.8	-	-	-
Y	150°C -5 min	-	-	-	13.5	-	-
Z	150°C-15 min	-	-	-	10.8	-	-
X	None	-	-	-	12.2	12.2	12.2

[0039] As shown in Fig. 1, tobacco materials for comparison treated under conditions Y and Z (hereinafter, referred to as "Comparative Example 1Y" and the like) in Comparative Example 1 tend to have an increased viscosity. This is presumably because a large amount of polysaccharides were extracted into an aqueous medium but were not decomposed by high-temperature high-pressure treatment under such conditions, thereby increasing interactions with water. Meanwhile, the tobacco materials of the present invention, such as Example 1A, are considered to achieve a lower viscosity through extraction of a large amount of polysaccharides and the like including hemicellulose into an aqueous medium, followed by decomposition. As described above, it is clear that the tobacco materials of the present invention with a certain content or less of hemicellulose exhibit a low viscosity.

[0040] [Example 4]

A hydrogen ion concentration in a slurry was measured by using a pH meter from Mettler Toledo for the tobacco materials of the present invention treated under high-temperature high-pressure conditions A and C in Example 1 [the content of tobacco particles (bone dry): 16.7% by weight]. These tobacco materials were poured into 50 mL vials and subjected to a storage test. The storage test was performed by placing the vials in a constant-temperature room at 35°C. A total viable count was measured for samples obtained immediately after the start of the storage test, after 72 hours, and after 120 hours. The total viable count was measured in accordance with the method posted on the home page of Japan Food Research Laboratories as in the following.

1) A sample was diluted with sterile water to prepare serial tenfold diluted samples.

2) Each of the samples diluted to the respective concentrations were inoculated on a standard agar medium and cultured at 35°C for two days. After the culture, the number of colonies was counted.

3) The initial viable count of the samples was calculated on the basis of differences in the number of colonies appeared for the respective dilutions.

[0041] [Comparative Example 4]

The tobacco material for comparison that did not undergo high-temperature high-pressure treatment of Comparative Example 1 was subjected to a storage test in the same manner as Example 4.

[0042] These results are shown in Figs. 2 and 3. As is clear from Fig. 2, the count increases 100 to 1,000-fold during the storage in the tobacco material of Comparative Example 4 that was not subjected to high-temperature high-pressure treatment, whereas microorganisms did not proliferate even after the storage for 120 hours in the tobacco materials of the present invention. Fig. 3 reveals that slurries have been changed to the environment that suppresses proliferation of microorganisms by the high-temperature high-pressure treatment.

CLAIMS

1. A tobacco material comprising an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less, wherein

the hemicellulose content in the tobacco material is 0.8% by weight or less based on bone-dry tobacco particles.

2. The tobacco material according to claim 1, wherein the pH is 4.8 or less.

3. The tobacco material according to claim 1, wherein the aqueous dispersion medium contains an aqueous organic compound.

4. The tobacco material according to claim 3, wherein the aqueous organic compound is selected from the group consisting of monohydric alcohols, polyhydric alcohols, sugar alcohols, sugars, polyhydric alcohol esters, and combinations thereof.

5. The tobacco material according to claim 1, wherein the water content in the aqueous dispersion medium exceeds 50% by weight.

6. The tobacco material according to claim 1, wherein the content of the tobacco particles is 1 to 40% by weight.

7. The tobacco material according to claim 1, wherein the tobacco particles are particles derived from a tobacco raw material, a fermented tobacco raw material, or a heat-treated tobacco raw material.

8. The tobacco material according to claim 7, wherein the variety of the tobacco raw material is flue-cured, burley, domestic, or oriental.

9. A production method for the tobacco material according to claim 1 comprising:

preparing a dispersion containing an aqueous dispersion medium and tobacco particles that are dispersed in the dispersion medium and have an average particle size of 30 μm or less; and

heating the dispersion to 160°C or higher.

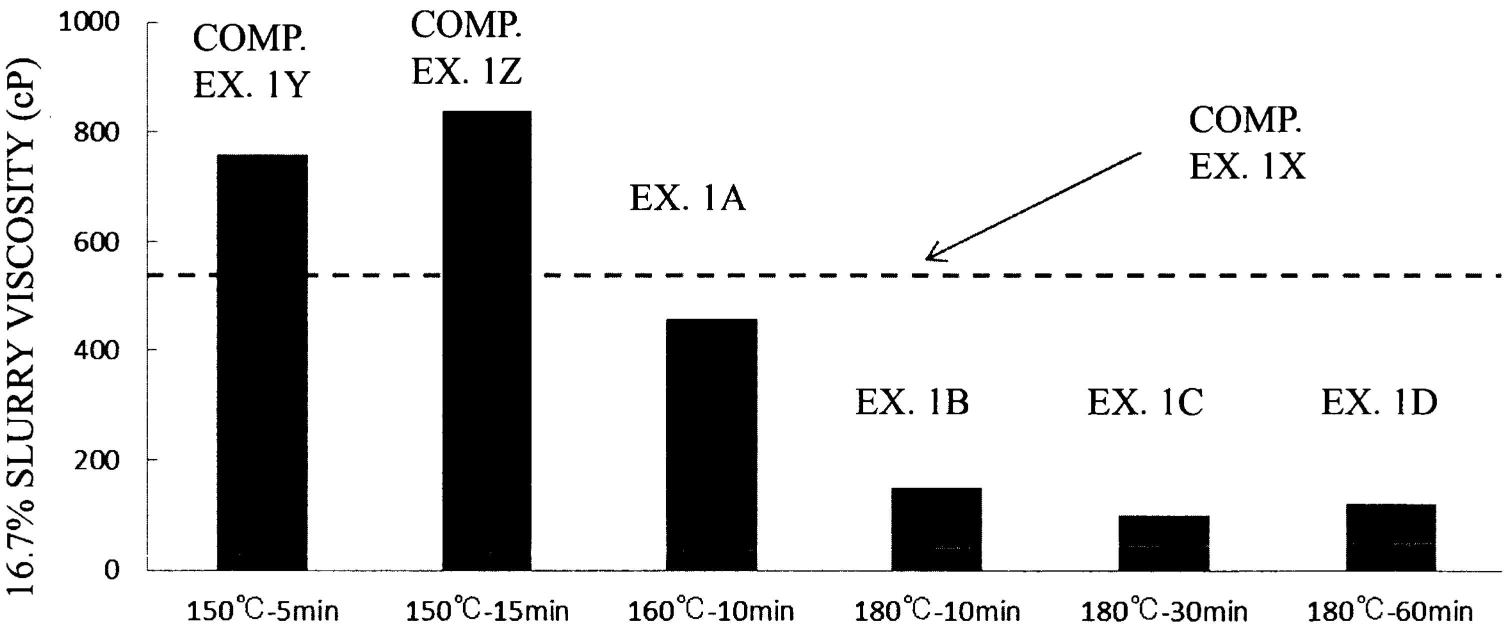
10. The production method according to claim 9, wherein the heating is performed under pressure.

11. A tobacco product comprising the tobacco material according to claim 1.

12. The tobacco product according to claim 11, further comprising a base material, wherein 0.01 to 5% by weight of the tobacco particles are contained relative to the base material.

13. A production method for the tobacco product according to claim 12 comprising adding the tobacco material according to claim 1 to the base material.

Fig. 1A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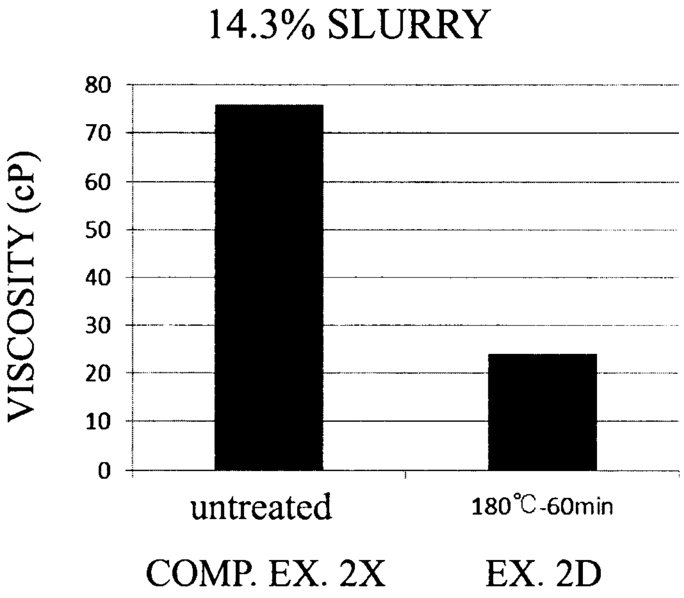
1000
800
600
400
200
0
COMP. EX. 1Y
COMP. EX. 1Z
EX. 1A
COMP. EX. 1X
EX. 1B
EX. 1C
EX. 1D
150℃-5min
150℃-15min
160℃-10min
180℃-10min
180℃-30min
180℃-60min

Fig. 1B


14.3% SLURRY
VISCOSITY (cP)
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70
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40
30
20
10
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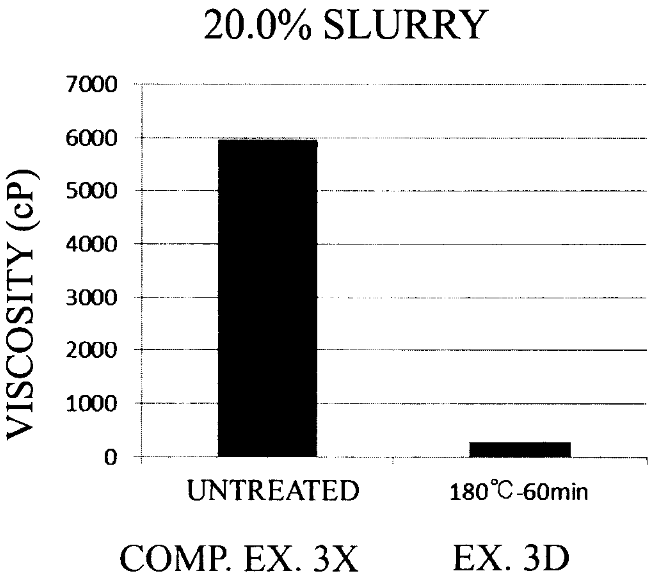
untreated
180℃-60min
COMP. EX. 2X
EX. 2D

Fig. 1C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VISCOSITY (cP)
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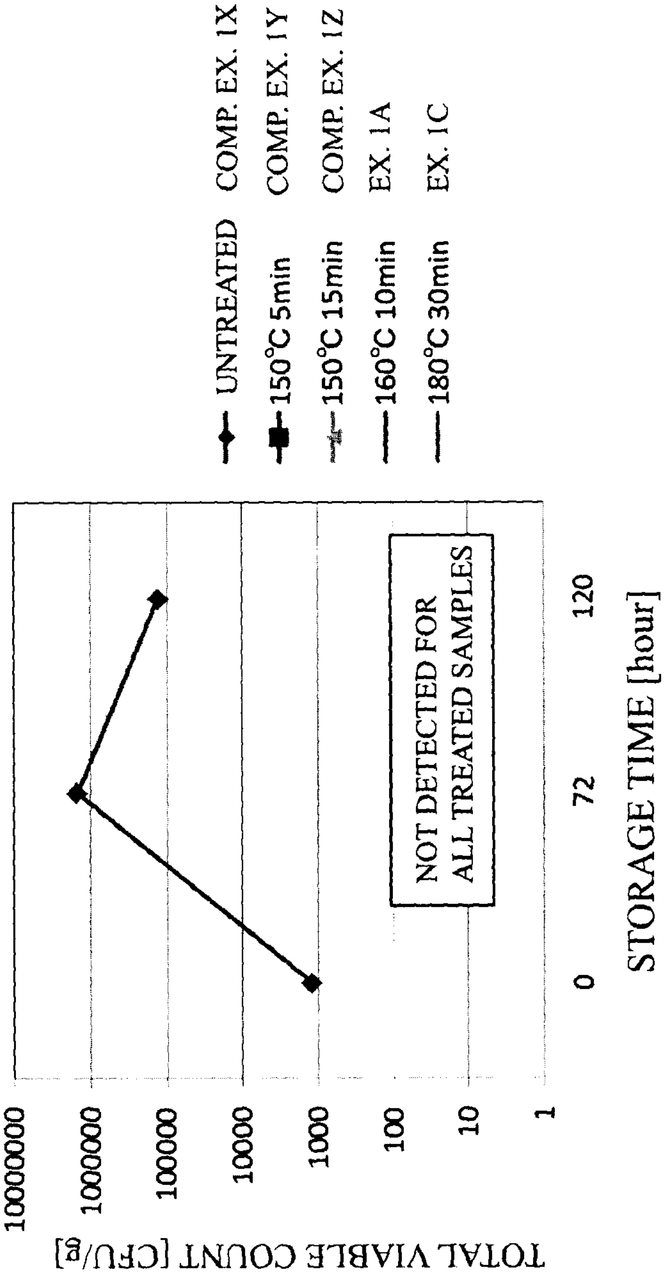
5000
4000
3000
2000
1000
0
UNTREATED
180℃-60min
COMP. EX. 3X
EX. 3D

Fig. 2


TOTAL VIABLE COUNT [CFU/g]
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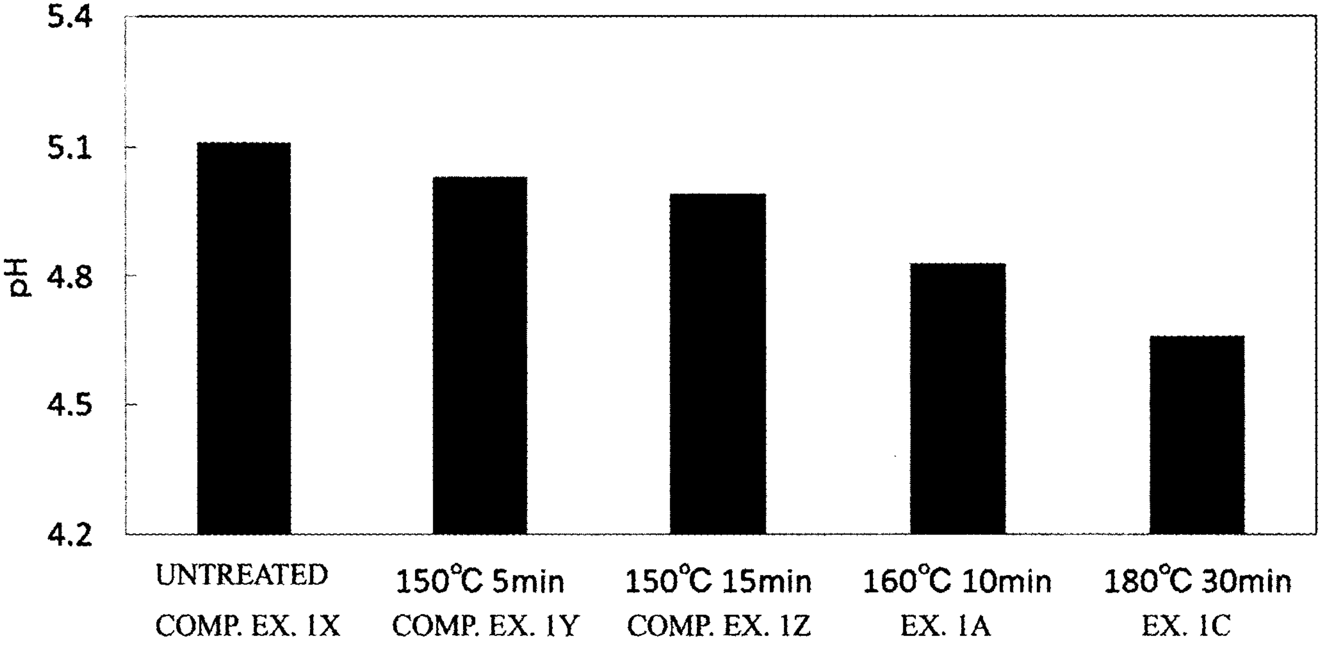
1000000
100000
10000
1000
100
10
1
0
72
120
STORAGE TIME [hour]
NOT DETECTED FOR ALL TREATED SAMPLES
UNTREATED COMP. EX. 1X
150°C 5min COMP. EX. 1Y
150°C 15min COMP. EX. 1Z
160°C 10min EX. 1A
180°C 30min EX. 1C

Fig. 3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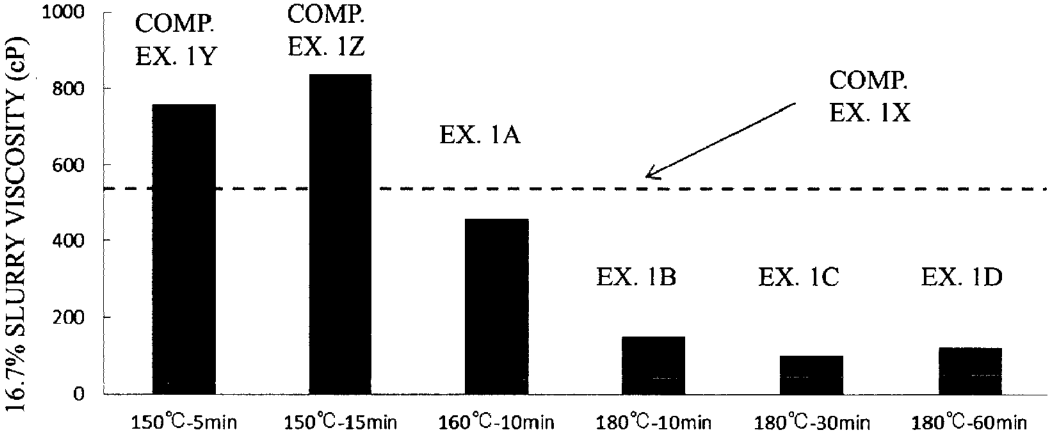
5.1
4.8
4.5
4.2
UNTREATED
COMP. EX. 1X
150°C 5min
COMP. EX. 1Y
150°C 15min
COMP. EX. 1Z
160°C 10min
EX. 1A
180°C 30min
EX. 1C


16.7% SLURRY VISCOSITY (cP)
1000
800
600
400
200
0
COMP. EX. 1Y
COMP. EX. 1Z
COMP. EX. 1X
EX. 1A
EX. 1B
EX. 1C
EX. 1D
150℃-5min
150℃-15min
160℃-10min
180℃-10min
180℃-30min
180℃-60min