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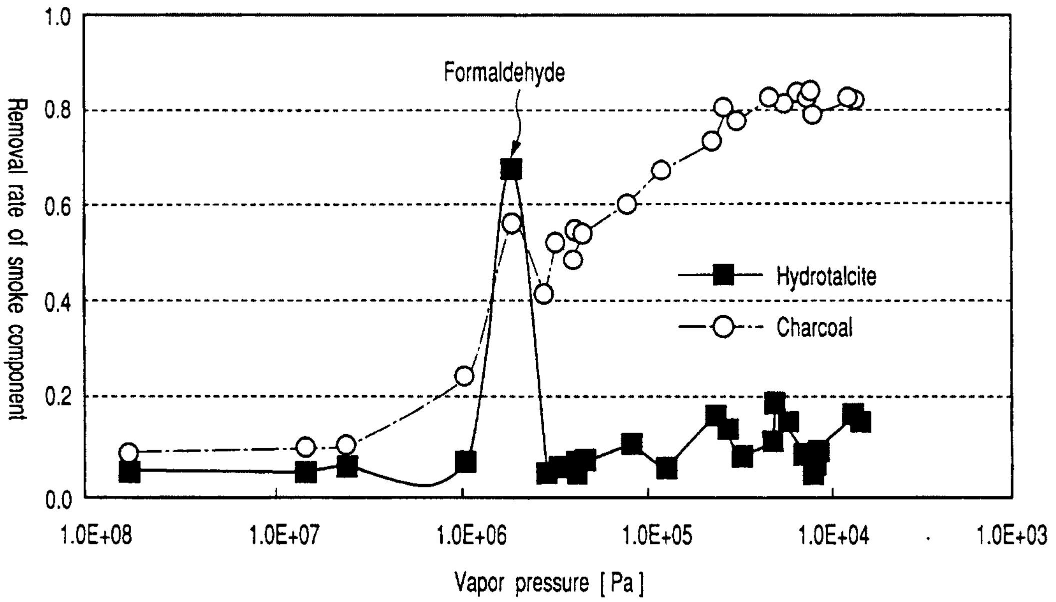
(54) SMOKING FILTER AND SMOKING ARTICLE

(57) A smoking filter contains a hydrotalcite compound exhibiting a lamellar structure in which a large number of octahedral layers of a metal hydroxide are laminated one upon the other. The smoking filter permits selectively removing formaldehyde contained in mainstream smoke.



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Description

Technical Field

[0001] The present invention relates to a smoking filter and a smoking article.

Background Art

[0002] Various chemical components are contained in mainstream smoke that is inhaled by the smoker in smoking a smoking article. Among these chemical components, the lower aldehydes represented by formaldehyde are difficult to remove by adsorption on an ordinary smoking filter. Naturally, it is desirable to remove the aldehydes from the mainstream smoke.

[0003] It was customary to use a filter having activated carbon added thereto as an adsorbent for removing formaldehyde from the mainstream smoke. In addition, it was attempted to use various other adsorbents.

[0004] However, the adsorbent used in the past also adsorbs the components other than formaldehyde, with the result that it was possible for adverse effects to be given to the flavor and taste of the smoking article.

[0005] An object of the present invention is to provide a smoking filter and a smoking article capable of selectively removing formaldehyde contained in mainstream smoke.

Disclosure of Invention

[0006] The smoking filter of the present invention contains a hydrotalcite compound exhibiting a lamellar structure in which a large number of octahedral layers of a metal hydroxide are laminated one upon the other.

[0007] The hydrotalcite compound used in the present invention is represented by a general formula:

$$M^{2+}{}_{1-x}M^{3+}{}_{x}(OH)_2(A^{n-})_{x/n}\cdot mH_2O$$

where M^{2+} represents a divalent metal ion selected from the group consisting of a Mg ion, a Zn ion, a Ni ion and a Ca ion, M^{3+} represents an Al ion, A^{n-} represents an anion having a valency of n, which is selected from the group consisting of CO_3, SO_4, OOC-COO, Cl, Br, F, NO_3, $Fe(CN)_6{}^{3-}$, $Fe(CN)_6{}^{4-}$, phthalic acid, isophthalic acid, terephthalic acid, maleic acid, alkenyl acid and its derivative, malic acid, salicylic acid, acrylic acid, adipic acid, succinic acid, citric acid and sulfonic acid, $0.1 < x < 0.4$, and $0 < m < 2$.

[0008] The smoking filter of the present invention is prepared by dispersing a hydrotalcite compound having an average particle diameter falling within a range of between 200 μm and 800 μm in, for example, the fiber tow or an unwoven fabric sheet. The typical fiber used in the present invention is formed of cellulose acetate.

[0009] It is possible for the smoking filter of the present invention to be prepared by forming a paper sheet added with a hydrotalcite compound having an average particle diameter not larger than 10 μm.

[0010] It is possible for the smoking filter of the present invention to include a plurality of filter segments, at least one filter segment containing a hydrotalcite compound. In this case, it is possible to use a charcoal filter segment in addition to the filter segment containing the hydrotalcite compound.

[0011] It is possible for the smoking filter of the present invention to include a plurality of filter segments and hydrotalcite particles filled in the space present between the adjacent filter segments.

[0012] Further, the smoking article of the present invention includes the smoking filter referred to above and a tobacco rod connected to the smoking filter.

Brief Description of Drawings

[0013]

FIG. 1 is a perspective view showing a filter manufactured in the Examples of the present invention;
FIG. 2 shows the construction of an apparatus used in the Examples of the present invention for measuring formaldehyde contained in cigarette mainstream smoke;
FIG. 3 is a graph showing the removal rate of formaldehyde achieved by various adsorbents;
FIG. 4 shows a collecting method of the vapor phase components from cigarette mainstream smoke, which was employed in the Examples of the present invention;
FIG. 5 shows gas chromatography of the vapor phase components contained in cigarette mainstream smoke, which was used in the Examples of the present invention;

FIG. 6 is a graph showing the relationship between the vapor pressure of the vapor phase components and the removal rate of the vapor phase components, covering the case where hydrotalcite or charcoal was used as the adsorbent;
FIG. 7A is a graph showing the particle size distribution of the hydrotalcite particles;
FIG. 7B is a graph is a graph showing the relationship between the average particle diameter of the hydrotalcite particles and the resistance to draw;
FIG. 8 is a graph showing the relationship between the surface area of the hydrotalcite particle and the formaldehyde reduction rate;
FIG. 9 is a perspective view showing the construction of the paper filter prepared in Example 5;
FIG. 10 is a perspective view showing the construction of the triple segment type filter prepared in Example 6; and
FIG. 11 is a perspective view showing the construction of a filter in another Example of the present invention.

Best Mode for Carrying Out the Invention

[0014] As a result of extensive research conducted from various viewpoints in an attempt to find an adsorbent effective for lowering the formaldehyde content in mainstream smoke, the present inventor has found that hydrotalcite compounds permit effectively removing formaldehyde.

[0015] The hydrotalcite compound exhibits a lamellar structure in which a large number of octahedral layers of a divalent or trivalent metal hydroxide are laminated one upon the other, and an anion is intercalated in the octahedral layers. The octahedral layer is referred to as a host and exhibits basicity. It is considered reasonable to understand that the removal of formaldehyde achieved by the hydrotalcite compound results from contribution of the basicity of the host and from the ion exchange function performed by the intercalated anions.

[0016] In the present invention, it is possible to use a natural or synthetic hydrotalcite compound. The hydrotalcite compound is represented by a general formula:

$$M^{2+}{}_{1-x}M^{3+}{}_{x}(OH)_2(A^{n-})_{x/n}\cdot mH_2O.$$

[0017] In the most general hydrotalcite compound, a Mg ion constitutes the divalent metal ion M^{2+} included in the general formula given above, an Al ion constitutes the trivalent metal ion M^{3+}, and $CO_3{}^{2-}$ or $SO_4{}^{2-}$ constitutes the anion A^{n-}. It is possible for a Zn ion, a Ni ion or a Ca ion to constitute the divalent metal ion M^{2+} in addition to the Mg ion. Also, it is possible for the anion to be selected from the group consisting of OOC-COO, Cl, Br, F, NO_3, $Fe(CN)_6{}^{3-}$, $Fe(CN)_6{}^{4-}$, phthalic acid, isophthalic acid, terephthalic acid, maleic acid, alkenyl acid and its derivative, malic acid, salicylic acid, acrylic acid, adipic acid, succinic acid, citric acid and sulfonic acid in addition to $CO_3{}^{2-}$ and $SO_4{}^{2-}$. The symbol x in the general formula is larger than 0.1 and smaller than 0.4, i.e., $0.1 < x < 0.4$, and the symbol m is larger than 0 and smaller than 2, i.e., $0 < m < 2$. The Mg-Al-based hydrotalcite compound is stable in the case where the value of x falls within a range of between 0.20 and 0.33.

[0018] In order to manufacture the hydrotalcite, a reaction is carried out by adding an alkali carbonate or both an alkali carbonate and a caustic alkali to an aqueous solution containing a water-soluble aluminum salt selected from the group consisting of aluminum sulfate, aluminum acetate and aluminum potassium sulfate or aluminic acid and a water-soluble magnesium salt while maintaining the pH value of the reaction mixture at 8.0 or more.

[0019] It is possible to control a micro pore size of the hydrotalcite compound by, for example, the size of the anion intercalated in the hydrotalcite compound. It is also possible for the hydrotalcite compound to perform various functions depending on the nature of the anion and on the state of the interlayer water.

[0020] Various types are conceivable as given below in respect of a smoking filter having a hydrotalcite compound added thereto:

(1) A smoking filter in which the hydrotalcite compound is dispersed in the fiber tow or an unwoven fabric made of cellulose acetate.
(2) A smoking filter prepared by forming a paper sheet added with a hydrotalcite compound.
(3) A smoking filter formed of at least two segments comprising at least one segment, which is formed of the smoking filter referred to in item (1) or (2) given above, and the other segment, which is formed of the conventional cellulose acetate filter or a charcoal filter.
(4) A smoking filter prepared by filling the space of the plug-space-plug structure with the hydrotalcite compound. In this case, the plug is selected from the conventional cellulose acetate filter or charcoal filter, or the filter referred to in item (1) or (2) given above. Also, where there are two or more spaces, it suffices to fill at least one space with the hydrotalcite compound, and it is possible to fill the other space with charcoal.

[0021] It is desirable to control the particle diameter of the hydrotalcite compound as follows. In the case of using a smoking filter in which the hydrotalcite compound is dispersed in the cellulose acetate tow or unwoven fabric, or in which the hydrotalcite compound is filled in the space of the plug-space-plug, it is desirable for the hydrotalcite compound to have a particle diameter of 200 to 800 μm, more desirably 400 to 600 μm. On the other hand, in the case of using a smoking filter prepared by forming a paper sheet made by adding the hydrotalcite compound, it is desirable for the hydrotalcite compound to have a particle diameter not larger than 10 μm.

(Examples)

Example 1:

[0022] A hydrotalcite compound represented by $Mg_6Al_2(OH)_{16}CO_3 \cdot 4H_2O$ was used. The particle diameter of the hydrotalcite compound was controlled to 250 to 500 μm by pulverization and sieving. A filter 1 shown in FIG. 1 was prepared by using the hydrotalcite compound. To be more specific, a hydrotalcite powder 3 was filled in the space present between two acetate filter segments 2, 2 each wrapped with a plug wrapper and, then, the resultant structure was wrapped with a forming paper 4 so as to prepare the filter 1 of the plug-space-plug structure.

[0023] For comparison, filters of the plug-space-plug structure as shown in FIG. 1 were prepared by using following adsorbents: charcoal, charcoal having a high specific surface area, alkali metal salt impregnated charcoal, amine impregnated charcoal, active alumina, magnesium oxide, aluminum oxide, magnesium silicate, zinc oxide, silica gel, zeolite, construction material pulp for formalin, a column packing material for gas chromatography (GC), and water-absorbing resin.

[0024] These filters were made equal to each other in the amount of the adsorbent. Also, a test cigarette was prepared by connecting a tobacco section containing 12 mg of tar to each of the filters.

[0025] The amount of formaldehyde contained in cigarette mainstream smoke was measured according to "Health Canada - Official Method" (2,4-DNPH-HPLC method) so as to provide the removal rate of formaldehyde.

[0026] To be more specific, 9.51 g of 2,4-dinitrophenyl hydrazine (DNPH) was dissolved in 1L of acetonitrile under heating, followed by adding 5.6 mL of a 60% perchloric acid to the solution and subsequently adding ultra pure water to the solution, thereby preparing 2L of a trapping solution.

[0027] The construction of the measuring apparatus will now be described with reference to FIG. 2. As shown in the drawing, a DNPH trapping solution 12 is put in a Drechsel-type trap 11. The Drechsel-type trap 11 has an inner volume of 100 mL, and an amount of the DNPH trapping solution 12 is 80 mL. The trap 11 is put in an ice water bath 13 so as to be cooled. The lower end of a glass pipe 14 to which a cigarette 10 is attached is dipped in the trapping solution 12 within the trap 11. Further, a glass pipe 15 having a Cambridge pad 16 mounted thereto is arranged to communicate with the dead volume of the trap 11, and a smoking machine 17 was connected to the Cambridge pad 16.

[0028] The cigarette 10 was attached to the glass pipe 14 so as to permit the cigarette 10 to be automatically smoked under the standard smoking conditions specified in ISO standards. To be more specific, the operation of sucking 35 mL of the smoke in a single puff for two seconds for a single cigarette was repeated at an interval of 58 seconds. While the mainstream smoke was being bubbled, formaldehyde was converted into a derivative of DNPH. Two cigarettes were used for the measurement. In this case, the cigarettes using the different adsorbents were controlled to exhibit the same pressure loss.

[0029] The formaldehyde derivative thus formed was measured by high-performance liquid chromatography (HPLC). In the first step, the trapping solution was filtered, followed by diluting the filtered trapping solution with a Trizma Base solution (4 mL of trapping solution : 6 mL of Trizma Base solution). Then, the diluted solution was measured by the HPLC. The measuring conditions of the HPLC were as follows:

Column: HP LiChrospher 100RP-18(5μ)250 × 4 mm
Guard column: HP LiChrospher 100RP-18(5μ)4 × 4 mm
Column temperature: 30°C
Detecting wavelength: DAD 356 nm
Injection amount: 20 μL

[0030] Mobile phase: Gradients by three phases (solution A: ultra pure aqueous solution containing 30% of acetonitrile, 10% of tetrahydrofuran and 1% of isopropanol; solution B: ultra pure aqueous solution containing 65% of acetonitrile, 1% of tetrahydrofuran and 1% of isopropanol; solution C: 100% of acetonitrile).

[0031] The removal rate of formaldehyde is represented by:

$$E = (W - W') / W$$

where E represents the removal rate of formaldehyde, W represents the amount of formaldehyde measured in the case of using a cigarette containing no adsorbent, and W' represents the amount of formaldehyde measured in the case of using a cigarette containing an adsorbent.

[0032] FIG. 3 is a graph showing the removal rates of formaldehyde in the case of using various adsorbents. As apparent from FIG. 3, formaldehyde was most effectively removed in the case of using hydrotalcite as the adsorbent.

Example 2:

[0033] The removal rate of the vapor phase components contained in cigarette mainstream smoke was measured by using as an adsorbent a hydrotalcite compound or charcoal constituting the most general adsorbent for a cigarette.

[0034] A filter similar to that shown in FIG. 1 was manufactured as in Example 1 by preparing a hydrotalcite compound having a particle diameter of 250 to 500 μm or charcoal as an adsorbent and loading the adsorbent in an amount of 50 mg. Then, a cigarette was prepared by connecting a tobacco section containing 12 mg of tar to the filter thus manufactured.

[0035] The method of measuring the removal rate of the vapor phase components from cigarette mainstream smoke will now be described with reference to FIGS. 4 and 5.

[0036] FIG. 4 shows the trapping method of the vapor phase components. As shown in the drawing, a cigarette 10 was attached to a smoking machine 17 so as to permit the cigarette 10 to be automatically smoked under the standard smoking conditions specified in the ISO standards. In this case, the particle phase in the mainstream smoke was removed by a Cambridge filter, and the vapor phase was trapped by a gas bag 20. Also, the operation of sucking 35 mL of the smoke in 2 seconds in a single puff for each cigarette was repeated at an interval of 58 seconds. Further, 10 conditioned cigarettes (conditioned under temperature of 22°C and humidity of 60%) were automatically smoked.

[0037] FIG. 5 shows gas chromatography. As shown in the drawing, a prescribed amount of the vapor phase components trapped in the gas bag 20 is stored in a sample loop 21. After a standard gas is injected, the vapor phase components are injected into a gas chromatograph 22. The components are separated in a column (DB-WAX) and detected in a detector. Further, the amounts of the components are analyzed by using a program installed in a personal computer 23. The analytical value was obtained by dividing the peak area of each of the vapor phase components by the peak area of the standard gas.

[0038] The removal rate E of each of the vapor phase components is represented by:

$$E = (A - A')/A$$

where E represents the removal rate of each of the vapor phase components, A represents the analytical value of the component measured by using a cigarette containing no adsorbent, and A' represents the analytical value of the component measured by using a cigarette containing an adsorbent.

[0039] FIG. 6 is a graph showing the relationship between the vapor pressure of the vapor phase component and the removal rate of the component. As apparent from FIG. 6, the removal rate is increased with increase in the vapor pressure of the vapor phase component in the case of using charcoal as an adsorbent. On the other hand, in the case of using a hydrotalcite compound as an adsorbent, the removal rate is specifically high in respect of formaldehyde, supporting that the hydrotalcite compound permits selectively removing formaldehyde.

Example 3:

[0040] In the case of using a hydrotalcite compound in a cigarette filter constructed as shown in, for example, FIG. 1, it is necessary to control appropriately the size of the hydrotalcite compound in order to control the resistance to draw and the outflow of tar/nicotine.

[0041] If the hydrotalcite compound is granulated, it is possible to prepare samples differing from each other in the particle size distribution. In this case, the samples are classified depending on the average particle diameter of the hydrotalcite compound. FIG. 7A shows three types of samples having the average particle diameters of 250 μm, 500 μm, and 800 μm, respectively.

[0042] Filters of the construction as shown in FIG. 1 were prepared by using hydrotalcite particles differing from each other in the average particle diameter. These filters differed from each other in the loading amount of the hydrotalcite particles. For reference, filters of the construction shown in FIG. 1 were also prepared by using charcoal. These filters also differed from each other in the loading amount of the charcoal.

[0043] The resistance to draw was examined in respect of these filters under the sucking flow rate of 1050 mL/min. Here, the resistance to draw was calculated by excluding the resistance to draw due to the two acetate filter segments 2, 2 shown in FIG. 1.

[0044] FIG. 7B is a graph showing the relationship between the average particle diameter and the resistance to draw. As apparent from FIG. 7B, the resistance to draw is high in the case of using the adsorbent particles having the average particle diameter of 250 μm and is low in the case of using the adsorbent particles having the average particle diameter of 800 μm. FIG. 7B also indicates that it is reasonable to use hydrotalcite particles having the average particle diameter falling within a range of between 400 μm and 600 μm in designing cigarettes.

[0045] In the case of using granulated particles, it is possible to provide hydrotalcite particles having a desired size by employing any granulating method such as rolling granulation, compression molding, coating granulation, or extrusion molding. It should be noted in this connection that, in order to avoid the breakage of the hydrotalcite particles in the manufacturing process of the filter, it is desirable to employ a granulating method that permits manufacturing granulated hydrotalcite particles having an appropriate hardness. The present inventor found that it is possible to prevent the hydrotalcite particles from being broken in the manufacturing process of the filter if the hydrotalcite particles have a hardness falling within a range of between 300 g/mm^2 and 3,000 g/mm^2.

Example 4:

[0046] This Example is intended to support that the reduction rate of the formaldehyde content in mainstream smoke achieved by the hydrotalcite particle is dependent on the surface area of the hydrotalcite particle.

[0047] Various granulated hydrotalcite particles were prepared by means of (A) rolling granulation, (B) compression molding, and (C) extrusion molding. The average surface area per unit weight of the hydrotalcite particles was calculated by using a laser scattering type particle size distribution measuring apparatus.

[0048] Filters of the construction as shown in FIG. 1 were prepared by using hydrotalcite particles having various surface areas. In this case, the total surface area of the hydrotalcite particles was adjusted by controlling the amount of the hydrotalcite particles. Then, the relationship between the total surface area of the hydrotalcite particles and the reduction rate of the formaldehyde content in the mainstream smoke was examined. FIG. 8 is a graph showing the result.

[0049] As apparent from FIG. 8, it has been found that the reduction rate of the formaldehyde content in the mainstream smoke can be increased with increase in the total surface area of the hydrotalcite particles. This tendency is exhibited regardless of the granulating method of the hydrotalcite particles.

Example 5:

[0050] This Example is intended to examine the reduction rate of formaldehyde contained in mainstream smoke, which is achieved by a paper filter to which hydrotalcite particles are added, and by a cellulose acetate filter to which granulated hydrotalcite particles are added.

[0051] Specifically, a paper sheet was made while adding hydrotalcite particles having an average particle diameter not larger than 10 μm. Then, the paper filter 7 shown in FIG. 9 was prepared by using the resultant paper sheet. For comparison, a filter was prepared by forming a paper sheet to which hydrotalcite particles were not added.

[0052] A filter was also prepared by dispersing granulated hydrotalcite particles in the cellulose acetate tow. For comparison, a cellulose acetate filter was prepared without using hydrotalcite particles.

[0053] Incidentally, the filters thus prepared were 25 mm long and were made as uniform as possible in the resistance to draw.

[0054] The reduction rate of the formaldehyde content in mainstream smoke was examined by using the filter thus prepared. Table 1 shows the result.

[0055] As shown in Table 1, the ratio of formaldehyde outflow to tar outflow was decreased in the paper filter containing the hydrotalcite particles, compared with the acetate filter containing the hydrotalcite particles. It is considered reasonable to understand that the result was achieved by the large contact surface area of the hydrotalcite particles having an average particle diameter not larger than 10 μm dispersed in the paper filter.

Table 1

	HT amount (mg)	Length (mm)	Resistance to draw (mmWG)	Tar outflow (mg/cigarette)	FA outflow (μg/cigarette)	FA/Tar (-)
Acetate filter	0	25	65.5	12.53	72.86	5.81
	146.7	25	61.9	12.19	35.70	2.93
Paper filter	0	25	65.0	7.31	48.56	6.64
	48.3	25	65.5	6.42	14.03	2.19

Example 6:

[0056] This Example is intended to support that the reduction rate of the organic vapor components can be increased by the combination of a hydrotalcite filter and a charcoal filter.

[0057] Filters I, II, III of the triple segment structure including an acetate filter segment, a hydrotalcite (HT) filter segment and a charcoal filter segment as shown in Table 2 were prepared. The acetate filter segment was prepared by bundling cellulose acetate tow and was 7 mm long. The hydrotalcite (HT) filter segment was prepared by bundling cellulose acetate tow having 70 mg of hydrotalcite particles dispersed therein and was 10 mm long. Further, the charcoal filter segment was prepared by bundling cellulose acetate tow having 70 mg of charcoal particles dispersed therein and was 10 mm long.

[0058] FIG. 10 shows the construction of the filter III shown in Table 2. As shown in the drawing, a charcoal filter segment 5 is arranged on the side of the cut tobacco, an acetate filter segment is arranged on the inhaling side, and an HT filter segment 6 is arranged intermediate between the charcoal filter segment 5 and the acetate filter segment 2.

[0059] The reduction rate of the total organic vapor (TOV) and the reduction rate of formaldehyde (FA) from mainstream smoke were examined by using these filters. Table 2 shows the results.

[0060] As shown in Table 2, the filter III permits lowering the content of the total organic vapor because of the function of the charcoal filter and also permits lowering the formaldehyde content because of the function of the hydrotalcite (HT) filter.

Table 2

	Cut tobacco side	Center	Inhaling side	TOV reduction rate (%)	FA reduction rate (%)
I	charcoal filter	acetate filter	acetate filter	62.7	67.2
II	acetate filter	HT filter	acetate filter	20.8	69.3
III	charcoal filter	HT filter	acetate filter	64.8	71.9

Weight of additives: 70 mg/10 mm
Filter length: 10mm, 10mm, and 7mm
Ventilation resistance of filter tip: 72 mmWG/27 mm
Ventilation hole: no

[0061] Various modifications are conceivable as follows in respect of the filter of the present invention.

[0062] For example, in the filter of the construction as shown in FIG. 1, it is possible to use another filter segment in place of at least one of the acetate filter segments 2. To be more specific, it is possible to use a hydrotalcite filter segment or a charcoal filter segment in place of at least one of the acetate filter segments 2. In the case of using a charcoal filter segment, it is desirable to arrange the charcoal filter segment on the cut tobacco side as in FIG. 10.

[0063] In the structure shown in FIG. 10, the cellulose acetate tow having a hydrotalcite compound dispersed therein were used for forming the hydrotalcite filter segment. Alternatively, it is also possible to use a hydrotalcite filter segment prepared by forming a paper sheet made by adding hydrotalcite compound.

[0064] It is also possible to prepare a filter of a four-segment structure by attaching an additional filter segment to the filter of the three-segment structure shown in FIG. 10.

[0065] Further, it is possible to use a filter comprising a charcoal filter segment 5, a space filled with hydrotalcite particles 3, a hydrotalcite (HT) filter segment 6 and an acetate filter segment 2, as shown in FIG. 11.

[0066] It is possible for the hydrotalcite filter segment 6 to be acetate filter-based or paper filter-based in this case, too. It is possible for the arrangement of the space filled with the HT particles 3 and the HT filter segment 6 to be opposite to that shown in FIG. 11. In FIG. 11, the space is filled with HT particles. Alternatively, it is possible for the space to be filled with charcoal particles.

Industrial Applicability

[0067] According to the present invention, it is possible to provide a smoking filter and a smoking article, which permit effectively lowering the formaldehyde content in mainstream smoke.

Claims

1. A smoking filter containing a hydrotalcite compound exhibiting a lamellar structure in which a large number of octahedral layers of a metal hydroxide are laminated one upon the other.

2. The smoking filter according to claim 1, **characterized in that** the hydrotalcite compound is represented by a general formula:

$$M^{2+}{}_{1-x}M^{3+}{}_{x}(OH)_2(A^{n-})_{x/n}\cdot mH_2O$$

   where M^{2+} represents a divalent metal ion selected from the group consisting of a Mg ion, a Zn ion, a Ni ion and a Ca ion, M^{3+} represents an Al ion, A^{n-} represents an anion having a valency of n, which is selected from the group consisting of CO_3, SO_4, OOC-COO, Cl, Br, F, NO_3, $Fe(CN)_6{}^{3-}$, $Fe(CN)_6{}^{4-}$, phthalic acid, isophthalic acid, terephthalic acid, maleic acid, alkenyl acid and its derivative, malic acid, salicylic acid, acrylic acid, adipic acid, succinic acid, citric acid and sulfonic acid, $0.1 < x < 0.4$, and $0 < m < 2$.

3. The smoking filter according to claim 1, **characterized in that** a hydrotalcite compound having an average particle diameter falling within a range of between 200 μm and 800 μm is dispersed in fiber tow or an unwoven fabric sheet.

4. The smoking filter according to claim 3, **characterized in that** the fiber is formed of cellulose acetate.

5. The smoking filter according to claim 1, **characterized in that** the filter is prepared by forming a paper sheet added with a hydrotalcite compound having an average particle diameter not larger than 10 μm.

6. The smoking filter according to claim 1, **characterized by** comprises filter segments, at least one filter segment containing a hydrotalcite compound.

7. The smoking filter according to claim 6, **characterized by** comprises a charcoal filter segment in addition to the filter segment containing the hydrotalcite compound.

8. The smoking filter according to claim 1, **characterized by** comprises filter segments and hydrotalcite particles filled in the space present between the adjacent filter segments.

9. A smoking article including the smoking filter according to any of claims 1 to 8 and a tobacco rod connected to the smoking filter.

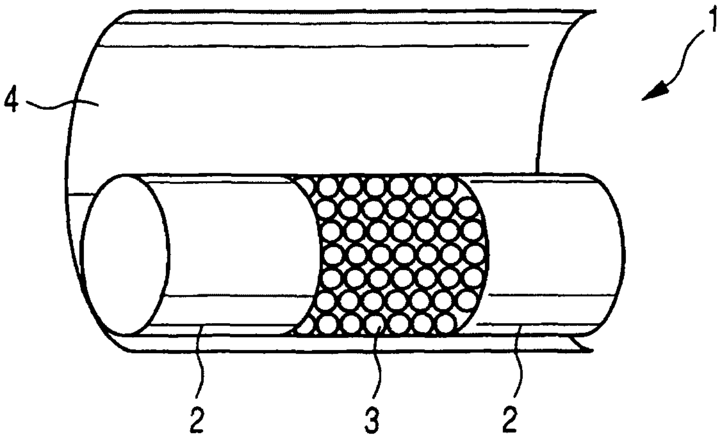


FIG. 1

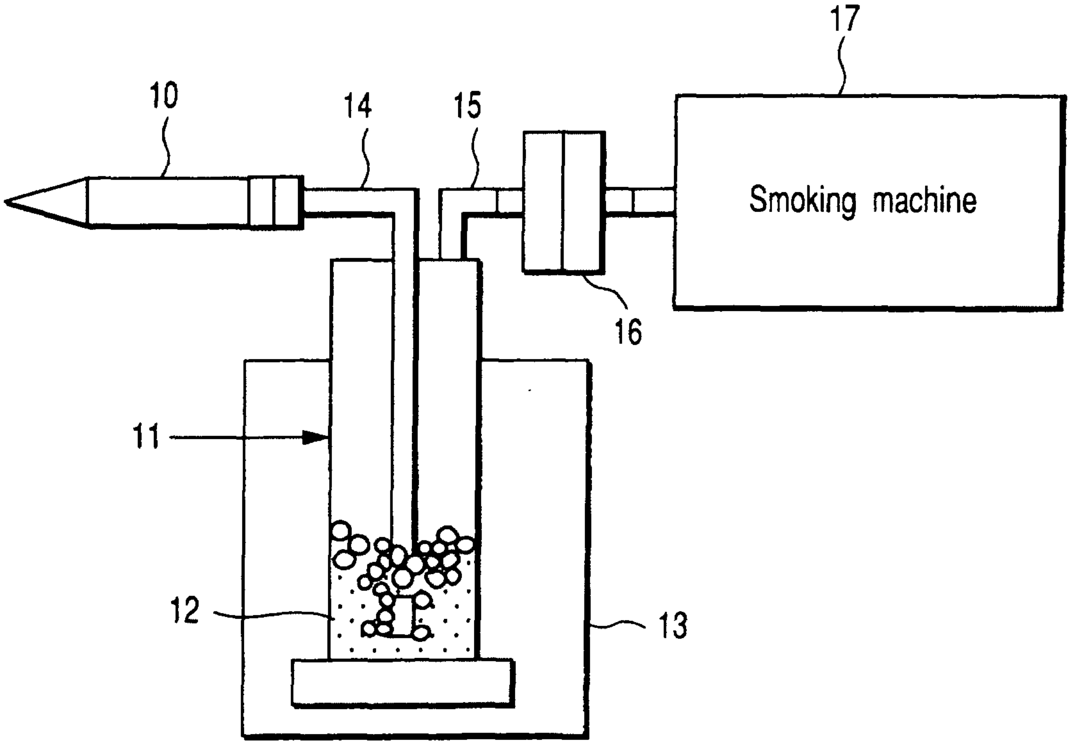


FIG. 2

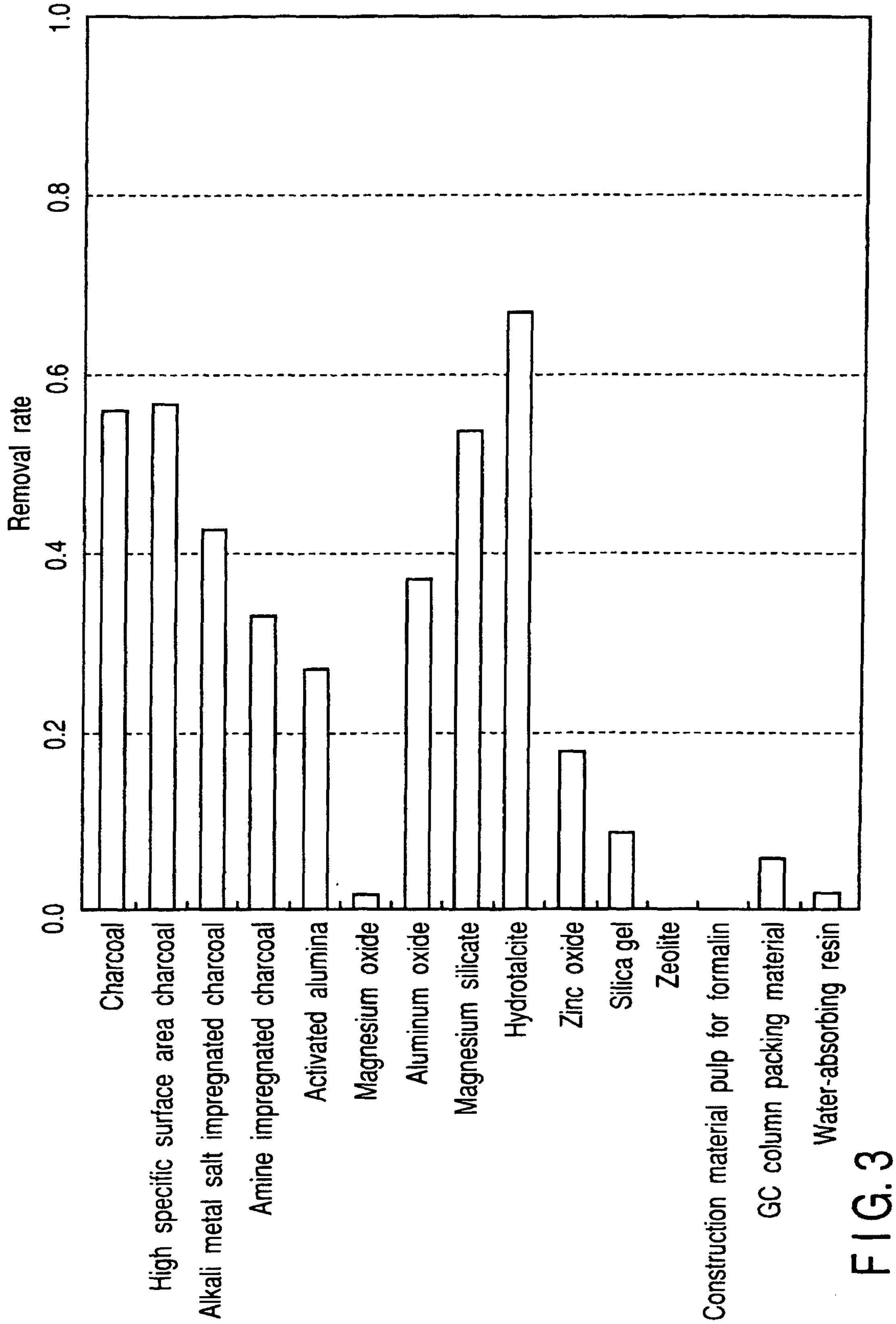

Removal rate
0.0
0.2
0.4
0.6
0.8
1.0
Charcoal
High specific surface area charcoal
Alkali metal salt impregnated charcoal
Amine impregnated charcoal
Activated alumina
Magnesium oxide
Aluminum oxide
Magnesium silicate
Hydrotalcite
Zinc oxide
Silica gel
Zeolite
Construction material pulp for formalin
GC column packing material
Water-absorbing resin

FIG. 3

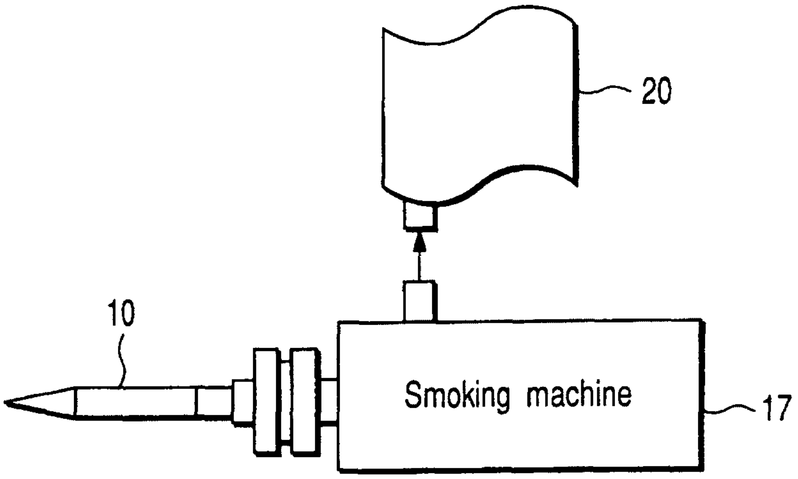


FIG. 4

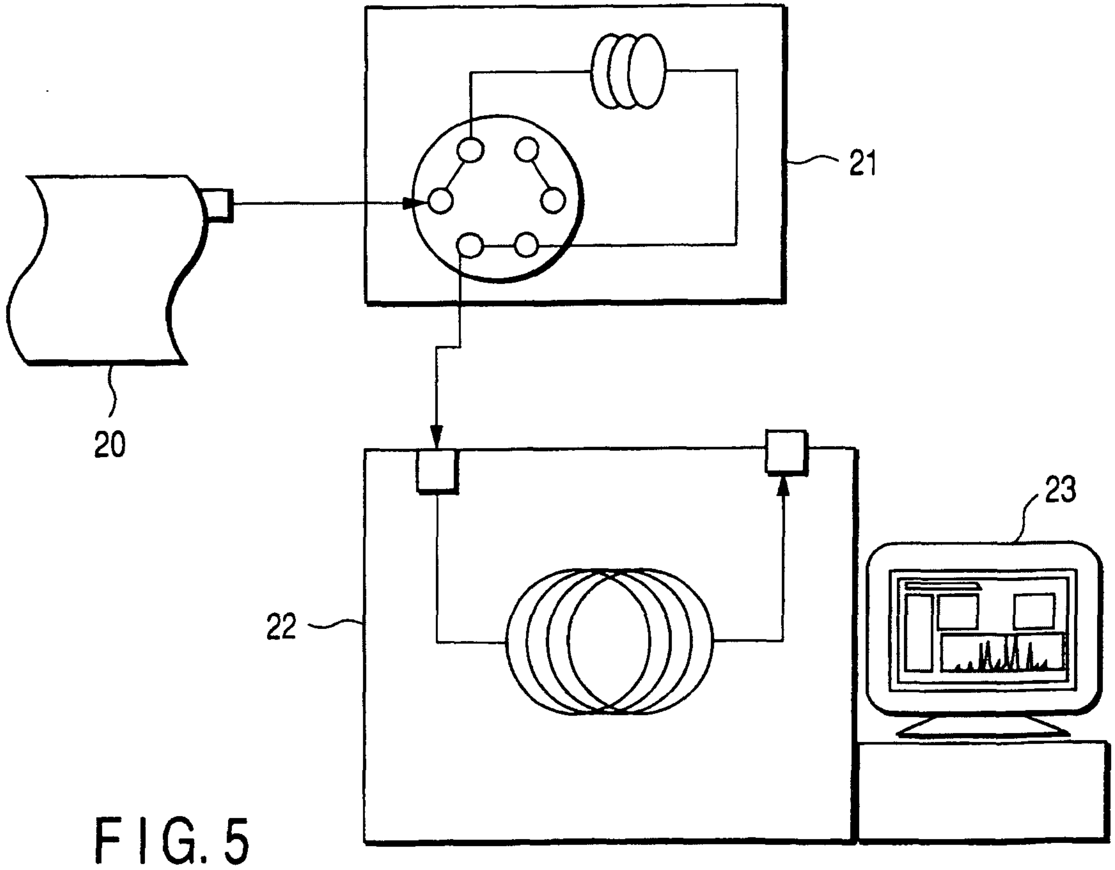
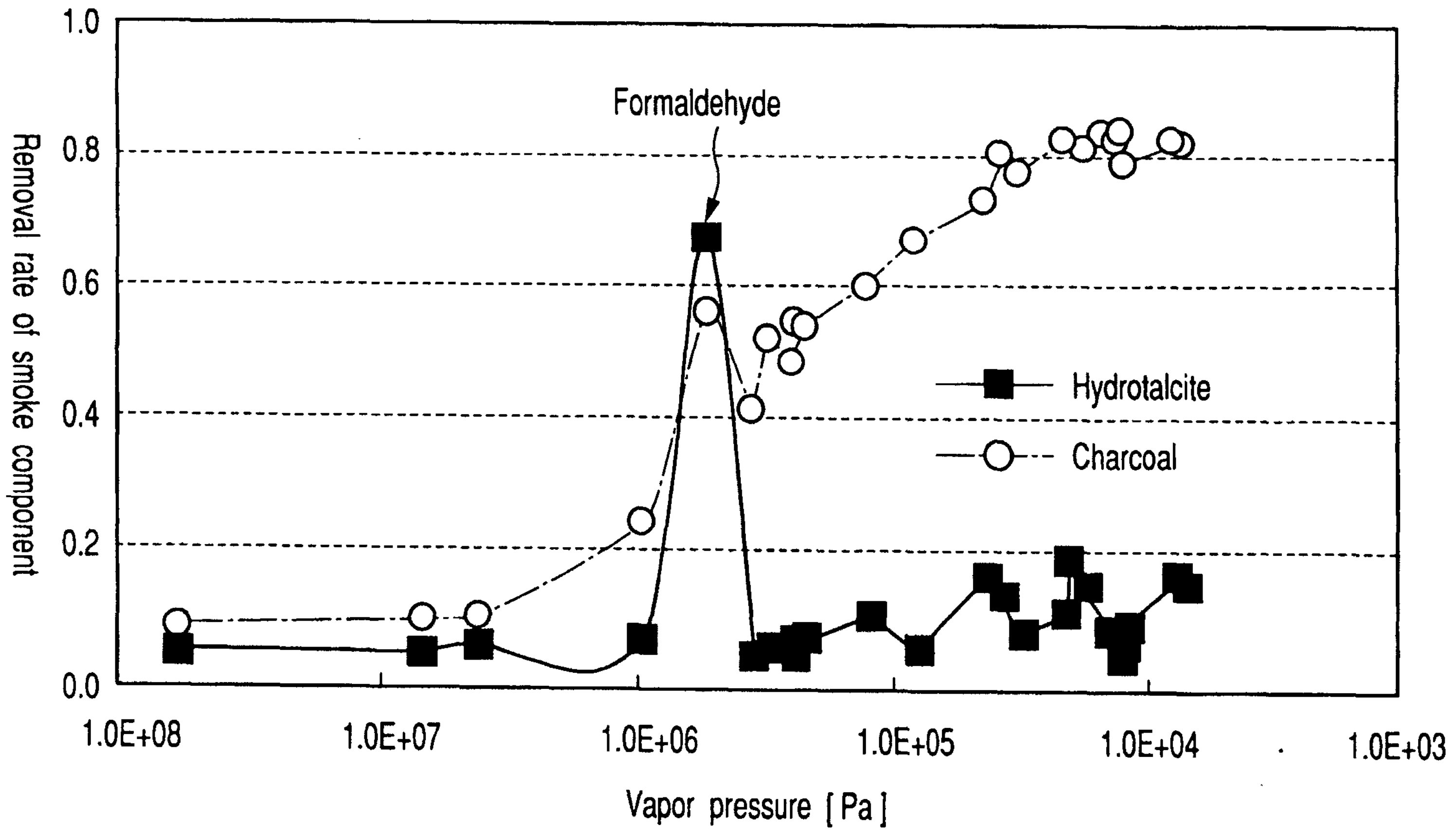


FIG. 5


Removal rate of smoke component
1.0
0.8
0.6
0.4
0.2
0.0
Formaldehyde
Hydrotalcite
Charcoal
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
Vapor pressure [Pa]

F I G. 6

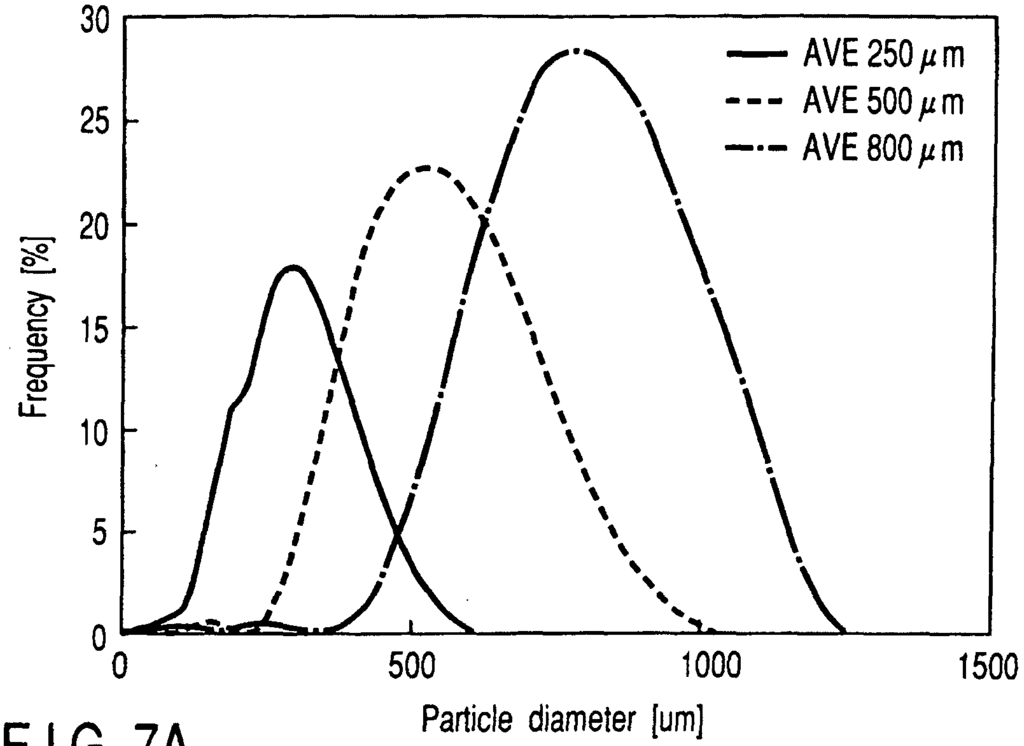

30
25
20
15
10
5
0
Frequency [%]
0
500
1000
1500
Particle diameter [um]
AVE 250 μm
AVE 500 μm
AVE 800 μm

FIG. 7A

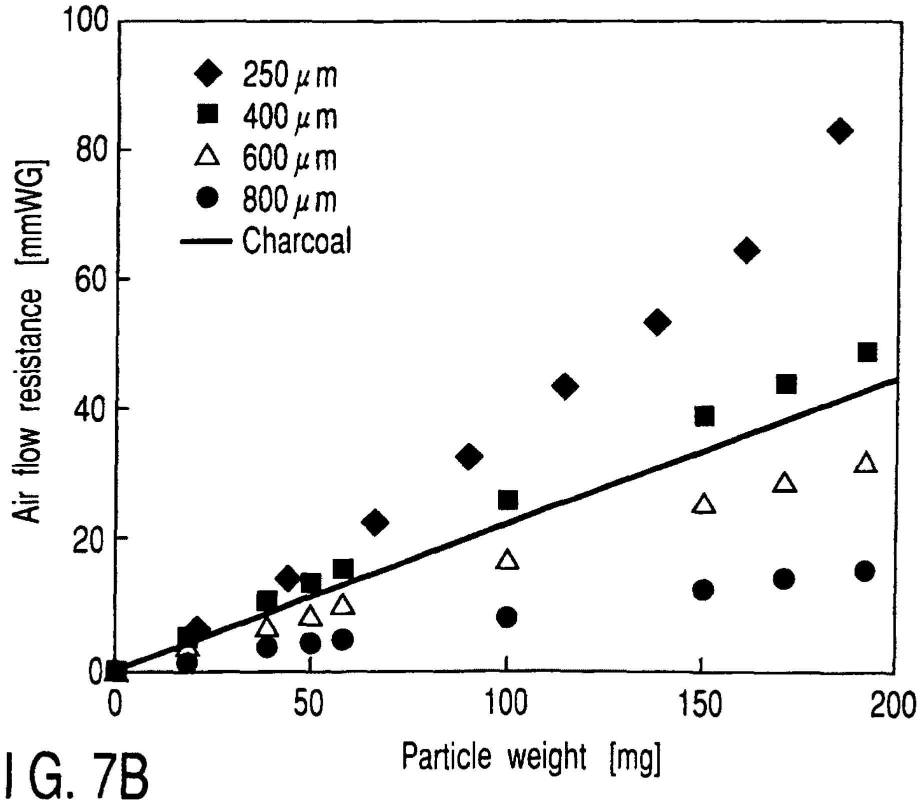

100
80
60
40
20
0
Air flow resistance [mmWG]
0
50
100
150
200
Particle weight [mg]
◆ 250 μm
■ 400 μm
△ 600 μm
● 800 μm
Charcoal

FIG. 7B

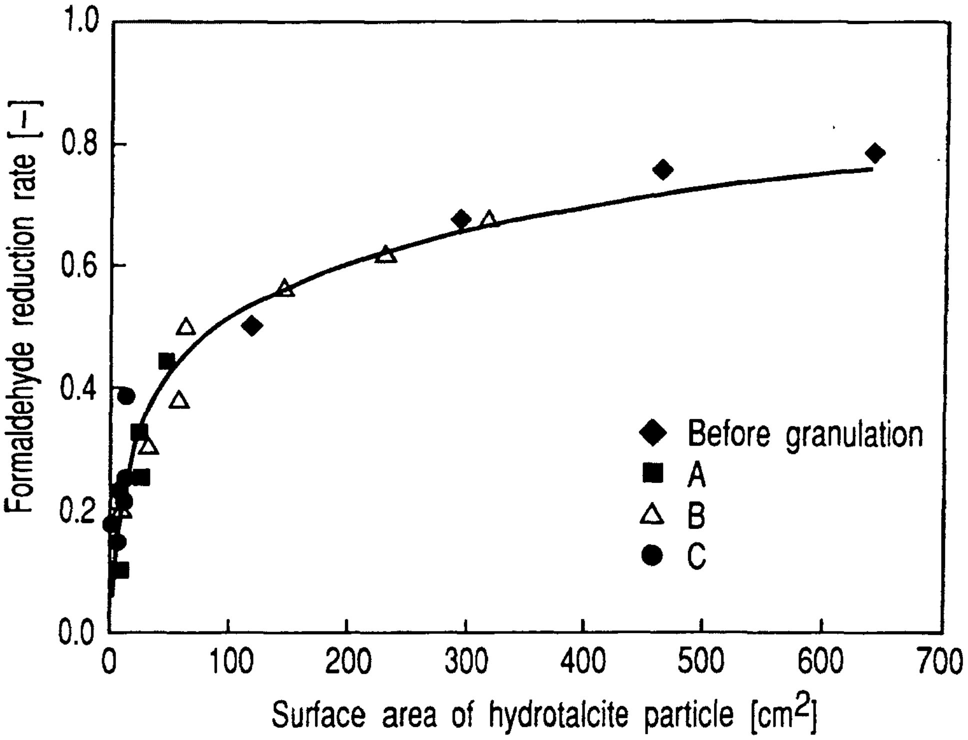

1.0
0.8
0.6
0.4
0.2
0.0
Formaldehyde reduction rate [–]
0
100
200
300
400
500
600
700
Surface area of hydrotalcite particle [cm2]
◆ Before granulation
■ A
△ B
● C

FIG. 8

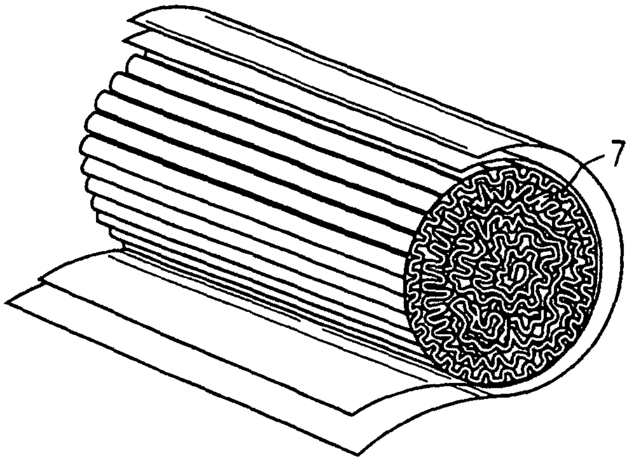


FIG. 9

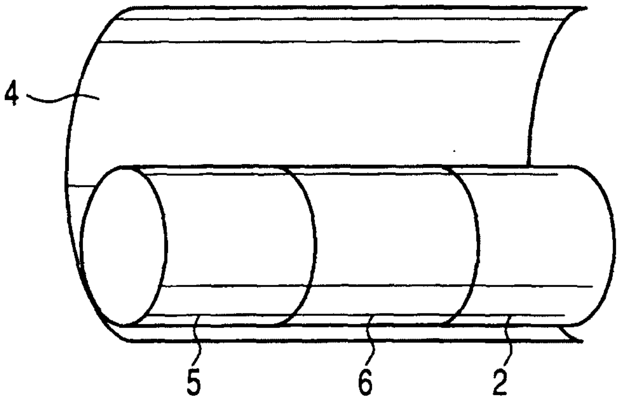


FIG. 10

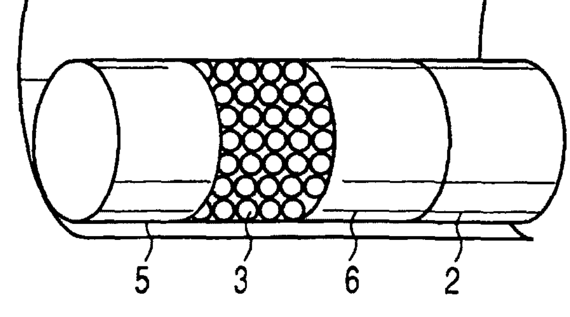


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/00036

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 A24D3/12, 3/10, 3/04, D21H17/67, 27/00

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)
Int.Cl^7 A24D3/00, D21H17/00, 21/00, 27/00, B01J20/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2003
Kokai Jitsuyo Shinan Koho	1971-2003	Jitsuyo Shinan Toroku Koho	1996-2003

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 10-52478 A (Zeon Kasei Co., Ltd.), 24 February, 1998 (24.02.98), (Family: none)	1-9
Y	JP 63-248380 A (Mitsui Toatsu Chemicals, Inc.), 14 October, 1988 (14.10.88), (Family: none)	1-9
A	JP 10-280298 A (Toagosei Co., Ltd.), 20 October, 1998 (20.10.98), Page 4 (Family: none)	1-2,5

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 30 January, 2003 (30.01.03)	Date of mailing of the international search report 12 February, 2003 (12.02.03)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)