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(54) **FILTER INCLUDING ELECTROSTATICALLY CHARGED FIBER MATERIAL**

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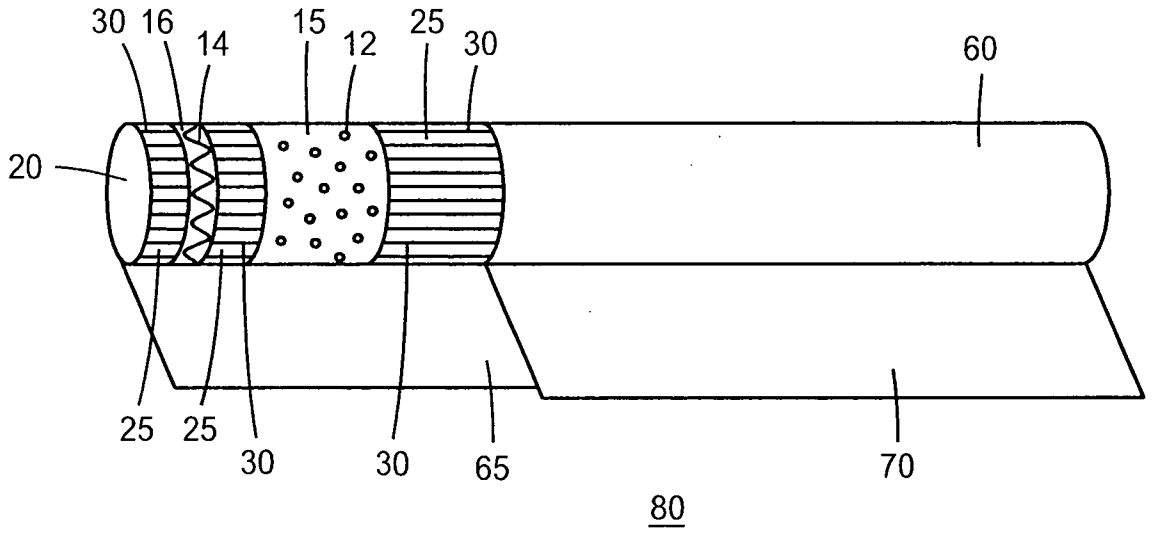
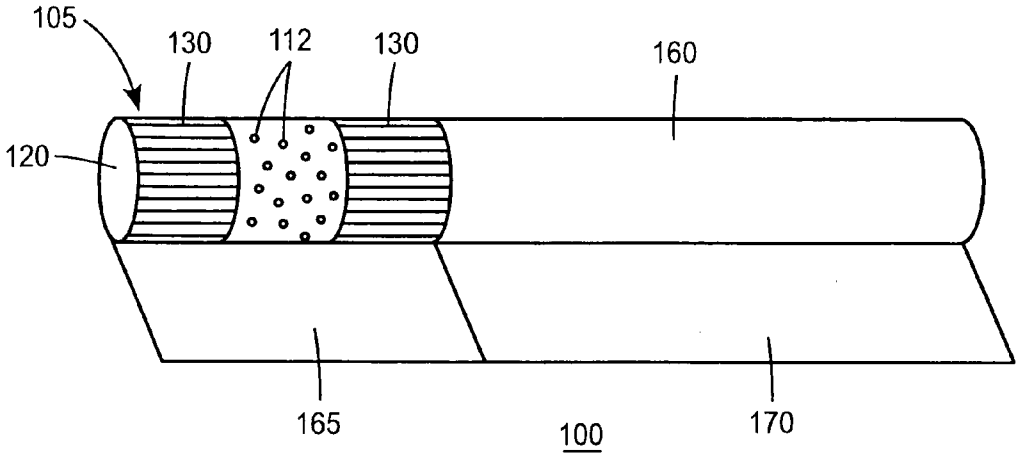
(57) **ABSTRACT**

Provided is a cigarette filter and method for potentially reducing particle breakthrough. The filter includes an adsorbent including adsorbent particles dispersed within the filter and a plug of electrostatically charged fibers. Preferably, the adsorbent is activated carbon. In a preferred embodiment, the electrostatically charged fiber material is located downstream of the activated carbon. Preferably, the electrostatically charged fiber material has permanent electrostatic charges that electrostatically capture the carbon particles to reduce carbon particle breakthrough. In an embodiment, the electrostatically charged fiber material is randomly-oriented so as to mechanically capture particles entrained in mainstream smoke.





(Prior Art)

FIG. 1

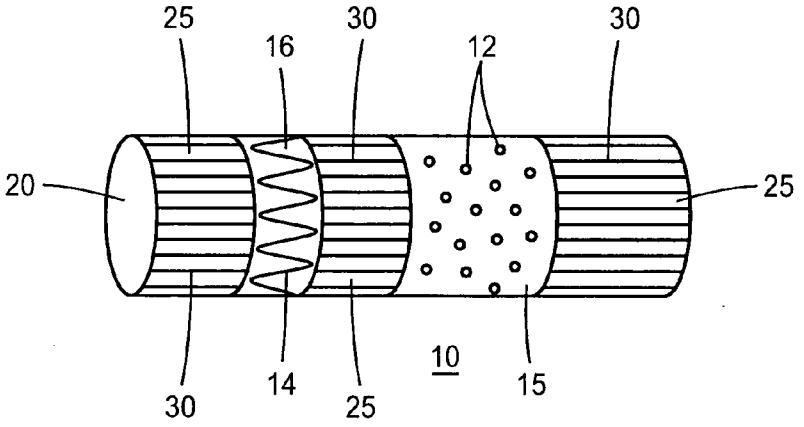


FIG. 2

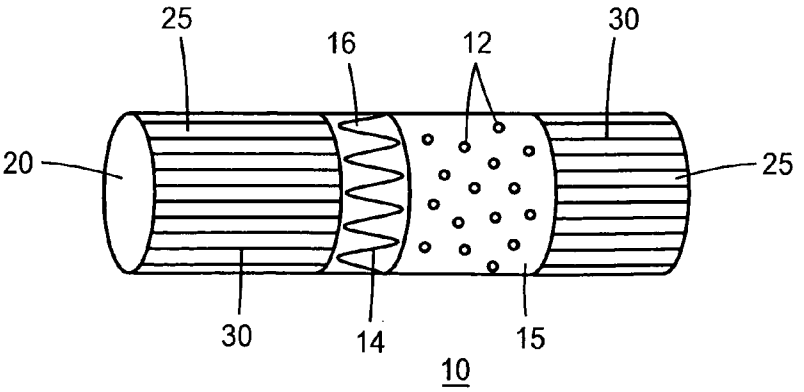


FIG. 3

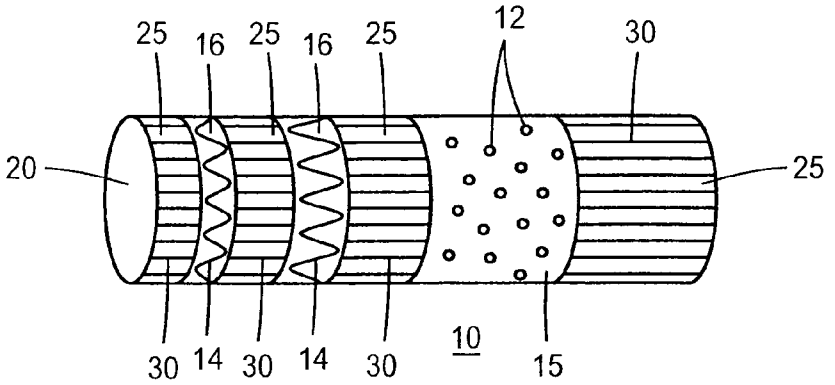

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FIG. 4

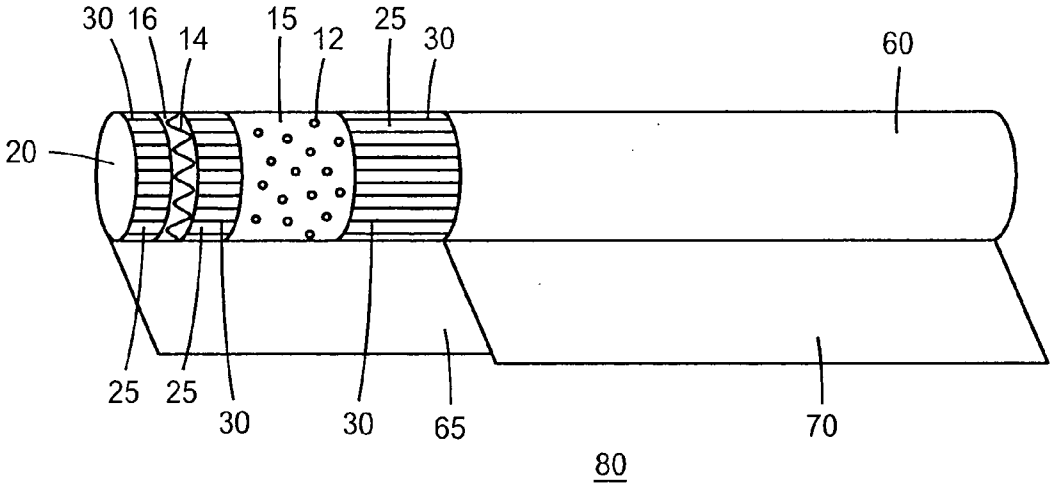
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FIG. 5

FILTER INCLUDING ELECTROSTATICALLY CHARGED FIBER MATERIAL

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority under 35 U.S.C. §119(e) to U.S. provisional Application No. 60/924,814, filed on May 31, 2007, the entire content of which is incorporated herein by reference.

BACKGROUND

[0002] Cigarettes typically comprise filters that may have adsorbent materials, such as carbon, incorporated therein. Filters adapted to be incorporated in a filter cigarette may comprise, for example, particles or granules of carbon such as activated carbon or activated charcoal and/or other adsorbent materials incorporated within the cellulose acetate tow or in cavities between cellulose acetate material.

[0003] During smoking of a cigarette, to the extent that adsorbent particles or fragments of adsorbent particles could possibly be entrained in mainstream smoke and issue through (i.e., breakthrough) the mouth end of the cigarette, techniques to reduce the amount of adsorbent particle breakthrough in mainstream smoke would be of interest.

SUMMARY

[0004] Provided is a filter assembly for a smoking article having reduced adsorbent particle breakthrough.

[0005] In a preferred embodiment, the filter assembly is a plug-space-plug filter. Preferably, the filter assembly includes a plug of electrostatically charged fiber material and an adsorbent. Most preferably, a plug of electrostatically charged fiber material is located downstream of the adsorbent. In a preferred embodiment, the plug of electrostatically charged fiber material includes randomly-oriented electrostatically charged fiber material. In another embodiment, the plug of electrostatically charged fiber material includes axially oriented electrostatically charged fiber media. In an embodiment, at least one plug of axially oriented cellulose acetate fibers is located upstream and/or downstream of the adsorbent. In yet another embodiment, at least one plug of axially oriented cellulose acetate fibers is located downstream of the plug of electrostatically charged fiber material.

[0006] Also provided is a smoking article. In a preferred embodiment, the smoking article includes a tobacco rod and a filter assembly.

[0007] Also provided is a method of making a filter assembly for smoking articles that provides reduced and/or eliminated carbon particle breakthrough in mainstream smoke.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** illustrates a prior art plug-space-plug filter for a smoking article.

[0009] FIG. **2** illustrates an embodiment of a plug-space-plug filter including a plug of electrostatically charged fiber material.

[0010] FIG. **3** illustrates a second embodiment of a plug-space-plug filter including a plug of electrostatically charged fiber material.

[0011] FIG. **4** illustrates a third embodiment of a plug-space-plug filter including a plug of electrostatically charged fiber material.

[0012] FIG. **5** illustrates a partially unwrapped smoking article including a plug-space-plug filter including a plug of electrostatically charged fiber material.

DETAILED DESCRIPTION

[0013] As used herein, the "upstream" and "downstream" relative positions between filter segments and other features are described in relation to the direction of mainstream smoke as it is drawn from the tobacco rod and through the multi-component filter.

[0014] As used herein, the term "smoke entrainable particles" describes beads, granules, dust, fines, powders and the like having a size of about 0.1 micron to about 10 microns, which may become entrained in mainstream smoke.

[0015] Prior art plug-space-plug filters **105**, as illustrated in FIG. **1**, include a portion of activated carbon **112** between plugs **130** of axially oriented cellulose acetate fibers. As smoke is drawn downstream from the tobacco rod **160** and through the filter **105**, some carbon particles may pass through the channels between the individual cellulose acetate fibers. In a preferred embodiment, the plug-space-plug filter **105** is attached to a tobacco rod **160** that is wrapped with wrapping paper **170** to form a smoking article **100**. Tipping paper **165** surrounds the filter **105** and affixes the filter **105** to the tobacco rod **160**.

[0016] As described herein, a filter assembly for a smoking article produces potentially reduced and/or eliminated particle breakthrough during smoking by using an electrostatic charge to attract the particles and/or a random orientation of the electrostatically charged fibers to mechanically trap particles.

[0017] In a preferred embodiment, the adsorbent is activated carbon. Preferably, the electrostatically charged fiber material is located downstream of the activated carbon contained within the filter assembly so that as smoke is drawn through the filter assembly the carbon particles, having a size of about 0.1 micron to about 10 microns, entrained in the smoke are retained by the electrostatically charged fiber material.

[0018] In a preferred embodiment, illustrated in FIG. **2**, the filter assembly **10** is a plug-space-plug oriented filter assembly. Preferably, a portion of activated carbon **12** is located in the cavity **15** of the filter **10**, and a plug **16** of electrostatically charged fiber material **14** is located downstream to reduce carbon particle breakthrough as mainstream smoke passes through the filter assembly **10**. Preferably, the portion of activated carbon is included as a plug of carbon on tow filter material, carbon paper, and/or a bed of loose carbon beads, granules, particles, and the like in a cavity of the filter. The electrostatically charged fiber material has permanent electrostatic charges, which can capture the carbon particles, thereby reducing or eliminating carbon particle breakthrough as mainstream smoke travels through the filter. In an embodiment, the electrostatically charged fiber material is randomly-oriented so as to also mechanically capture smoke entrainable particles.

[0019] In a preferred embodiment, the electrostatically charged fiber material includes electret fibers. (e.g. 3M Filtrete™ fiber) Preferably, electret fibers have a diameter of about 3 micrometer to about 30 micrometers and a basis weight in the range of about 10 to 500 g/m^2. Preferably, the electret fibers range in weight from about 2.5 denier to about 8 denier. Preferred fibers have a Y-shaped cross-section.

[0020] Also preferably, the filter assembly includes about 30 mg to about 200 mg of adsorbent. In a preferred embodiment, the filter assembly **10** also includes about 25 mg to about 75 mg of electrostatically charged fiber material **14**, which forms a plug of about 3 mm to about 6 mm in length. Preferably, the amount of electrostatically charged fiber material **14** used depends on the amount of adsorbent, such as activated carbon, contained within the filter assembly **10**. In a preferred embodiment, a plug of electrostatically charged fiber material **14** having a plug length of about 1 mm is used for about 18 mg of activated carbon.

[0021] In a preferred embodiment, the adsorbent and/or smoke entrainable particles include any suitable adsorbent media. Exemplary adsorbents include molecular sieves such as zeolites, silicas, silicates, aluminas, and/or carbons (e.g. activated carbon). A preferred adsorbent media is activated carbon.

[0022] By "activated carbon" is meant any porous, high surface area form of carbon that can be used as a sorbent in filters. Activated carbon can be derived via thermal treatment of any suitable carbon source. The activation treatment typically increases the porosity, and activated carbon can be provided with a wide range of pore sizes or the pore sizes can be controlled to provide a desired pore size distribution.

[0023] In a preferred embodiment, the carbon is in the form of granules and the like. Preferably, the carbon of the preferred embodiment is a high surface area, activated carbon, for example a coconut shell based carbon of typical ASTM mesh size used in the cigarette industry or finer. A particularly preferred activated carbon is commercially available from PICA USA, Inc., Truth or Consequences, N. Mex. The activated carbon could also be manufactured via the carbonization of coal, wood, pitch, peat, cellulose fibers, lignite and olive pits. Carbonization is usually carried out at elevated temperatures, e.g., 400-1000° C. in an inert atmosphere, followed by activation under reducing or oxidizing conditions.

[0024] In a preferred embodiment, the activated carbon can be in the form of beads. In other embodiments, the activated carbon can be in the form of granules and/or fibers. Preferably, the activated carbon is adapted to adsorb constituents of mainstream smoke, particularly, those of the gas phase including aldehydes, ketones and other volatile organic compounds, and in particular 1,3-butadiene, acrolein, isoprene, propionaldehyde, acrylonitrile, benzene, toluene, styrene, acetaldehyde and hydrogen cyanide.

[0025] In other embodiments, the carbon can be in the form of carbon on tow and/or carbon paper.

[0026] Most preferably, the activated carbon comprises granulated particles ranging in size from about 100 microns to about 5 mm. In an embodiment, the particles of activated carbon have an average size of from about 0.2 to 2 mm (e.g., about 200, 500, 1000 or 2000 microns).

[0027] Activated carbon beads contained in the filter assembly preferably range in size from 0.2 mm to about 0.7 mm, as described in U.S. Patent Application Publication No. 2003/0154993, the entire content of which is incorporated herein by reference.

[0028] Preferably, activated carbon can have any desired pore size distribution that comprises pores such as micropores, mesopores and macropores. The term "microporous" generally refers to such materials having pore sizes of about 20 Angstroms or less while the term "mesoporous" generally refers to such materials with pore sizes of about 20-500 Angstroms.

[0029] In an embodiment, the activated carbon can be selected to have an appropriate surface area to preferentially adsorb targeted constituents from smoke. For example, the preferred activated carbon typically has a surface area greater than about 50 m^2/g (e.g., at least about 100, 200, 500, 1000 or 2000 m^2/g). Typically, the absorptive capacity of the activated carbon increases with increasing surface area.

[0030] Furthermore, surface area typically increases with decreasing particle size. When used as cigarette filter material, however, carbon particles having a small particle size may pack together too densely to permit smoke to flow through the filter with desired resistance to draw (RTD) during smoking. On the other hand, if the particle size is too large there may be insufficient surface area to accomplish the desired degree of filtration. Therefore, such factors can be taken into account in selecting carbon particles suitable for filtration of mainstream and/or sidestream smoke.

[0031] Preferably at least some, if not all of the activated carbon is flavor-bearing or otherwise impregnated with a flavorant so that the carbon is adapted not only to remove one or more gas phase smoke constituents from smoke, but also to release flavor into the mainstream smoke stream. Preferably, the flavorant is added to the carbon by spraying flavorant upon a batch of activated carbon in a mixing (tumbling) drum or alternatively in a fluidized bed with nitrogen as the fluidizing agent, wherein flavorant may then be sprayed onto the carbon in the bed as described in U.S. Pat. No. 6,761,174 to Jupe et al., the entire content of which is incorporated herein by reference.

[0032] The term "mainstream" smoke refers to the mixture of gases passing down the tobacco rod and issuing through the filter end, i.e., the amount of smoke issuing or drawn from the mouth end of a cigarette during smoking of the cigarette. The mainstream smoke contains smoke that is drawn in through both the lighted region, as well as through the cigarette paper wrapper. The term "side stream" smoke refers to smoke produced during static burning.

[0033] As seen in FIG. **2**, preferably, the buccal end **20** of the filter assembly **10** is in the form of a plug **25** of cellulose acetate fibers **30**. Preferably, the cellulose acetate fibers **30** are axially oriented. Preferably, the plug **25** is positioned downstream of a plug **16** of electrostatically charged fiber material **14**, which is also downstream of the activated carbon **12**. In an embodiment, the electrostatically charged fiber material **14** is randomly oriented. In another embodiment, the electrostatically charged fiber material **14** is axially oriented. Preferably, the activated carbon **12** is held in cavity **15**. A second plug **25** of cellulose acetate fibers **30** is located immediately upstream of the electrostatically charged fiber material **14**, and immediately downstream of the activated carbon **12**.

[0034] In a preferred embodiment, the filter assembly **10** contains about 40 mg to about 70 mg of cellulose acetate fibers. Preferably, one or more plugs of cellulose acetate fibers are added to adjust the length of the filter.

[0035] If carbon particles become entrained in the mainstream smoke, the electrostatically charged fiber material attracts and captures the carbon particles to reduce carbon particle breakthrough. Preferably, the electrostatically charged fiber material have permanent electrostatic charges so that the carbon particles are captured in the filter.

[0036] In an embodiment, when the electrostatically charged fiber material is randomly oriented, carbon particles are also captured mechanically because the carbon particles are not able to travel in channels between the fibers.

[0037] In another embodiment, as illustrated in FIG. **3**, the filter assembly **10** includes a portion of activated carbon **12**. Preferably, a plug **16** of electrostatically charged fiber material **14** is located immediately downstream of the activated carbon **12**. Plugs **25** of cellulose acetate fibers **30** are located immediately upstream of the activated carbon **12** and immediately downstream of the electrostatically charged fiber material **14**.

[0038] In yet another embodiment, as illustrated in FIG. **4**, the filter assembly **10** includes a portion of activated carbon **12**. Preferably, a plug **25** of cellulose acetate fibers **30** is located immediately downstream and immediately upstream of the cavity **15** filled with the activated carbon **12**.

[0039] As seen in FIG. **5**, the filter assembly **10** is adapted to be incorporated in a smoking article **80**.

[0040] The term "smoking article" includes cigarettes, cigars, pipes, and cigarillos. Non-traditional cigarettes such as cigarettes for electrical smoking systems, as described in commonly-assigned U.S. Pat. Nos. 6,026,820; 5,988,176; 5,915,387; and 5,499,636, are also included in the definition of smoking articles or cigarettes generally.

[0041] Preferably, the smoking article is a cigarette. The cigarette may contain tobacco material and a filter. In an embodiment, the cigarette may also contain at least one sorbent. A traditional cigarette typically contains two sections, a tobacco-containing portion sometimes referred to as the tobacco rod, and a filter portion which may be referred to as the filtration zone. Tipping paper typically surrounds the filter, which forms the buccal end of the cigarette. The tipping paper overlaps with the tobacco rod in order to hold the filter and tobacco rod together. The tobacco rod, or tobacco containing element of the cigarette includes the paper wrapper in which the tobacco is wrapped and the adhesive holding the seams of the paper wrapper together. The tobacco rod has a first end which is integrally attached to the filter and a second end which is lit or heated for smoking the tobacco. When the tobacco rod is lit or heated for smoking, the smoke travels from the lit end downstream to the filter end of the tobacco rod and further downstream through the filter.

[0042] The following examples are given to illustrate embodiments of the filter and should not be construed to limit the scope of such embodiments.

EXAMPLE 1

[0043] An electret fiber segment consisting of 55 mg of randomly oriented electrostatically charged fiber material (e.g. 3M Filtrete™) is placed downstream of a cavity filled with 110 mg of activated carbon to form a filter.

EXAMPLE 2

[0044] An electret fiber segment consisting of 55 mg of randomly oriented electrostatically charged fiber material (e.g. Toyobo Elitolon FA-65S) is placed downstream of a cavity filled with 110 mg of activated carbon to form a filter.

[0045] Using filters configured as in Examples 1 and 2 and a control plug-space-plug filter, which does not include electrostatically charged fiber media downstream of activated carbon, the potential for activated carbon particles breakthrough was measured under non-lit dry puff conditions using a laser light scattering particle counter (Met-One Laser Particle Counter Model 237B: Hach Ultra Analytics, Richmond, Calif.).

[0046] The laser light scattering particle counter was placed next to a cigarette holder aligned with the air flow through the cigarette. The filter was inserted into a cigarette filter holder to a depth of approximately 9±1 mm and machine puffed under non-lit (dry-puff) conditions using a 55 ml/puff; 2 second puff duration; 12 puffs/cig profile. The results are illustrated in Table 1.

TABLE 1

	Number of carbon particle breakthrough (particle size > 0.3 μm)											
Electret fiber	AVG	SD	Filter 1	Filter 2	Filter 3	Filter 4	Filter 5	Filter 6	Filter 7	Filter 8	Filter 9	Filter 10
3M Filtrete ™	9	17	0	21	12	2	1	2	0	0	2	54
Toyobo Elitolon FA-65S	3	8	0	2	0	27	1	0	0	0	0	0
Control	1097	225	1010	1429	1155	1102	1087	738	1395	1395	841	

[0047] The filters containing 3M Filtrete™ showed an average carbon particle breakthrough of about 9 particles per cigarette. The particle breakthrough ranged from about 0 particles to about 54 particles per cigarette.

[0048] Filters containing Toyobo Elitolon FA-65S showed an average carbon particle breakthrough of about 3 particles per cigarette. The particle breakthrough ranged from about 0 particles to about 27 particles per cigarette.

[0049] In contrast, the control filter, not including electrostatically charged fiber material, showed an average carbon particle breakthrough of about 1097 particles per cigarette. Thus, the filters including electret fibers showed significant reductions in carbon particle breakthrough per cigarette.

[0050] Also provided is a method of making a filter assembly including filling a cavity of a plug-space-plug filter assembly with adsorbent, such as activated carbon particles, wherein a plug of electrostatically charged fiber material is located downstream of the cavity. In an embodiment, the plug of electrostatically charged fiber material is located immediately downstream of the activated carbon. In another embodiment, the electrostatically charged fiber material is located downstream of the activated carbon, and a plug of cellulose acetate fibers is located at the mouth end of the filter. Preferably, the electrostatically charged fiber material is randomly-oriented within the plug. In an embodiment, the electrostatically charged fiber material is axially oriented.

[0051] In a preferred embodiment, a plug of axially oriented cellulose acetate fibers is placed upstream of the activated carbon. In another embodiment, a plug of axially ori-

ented cellulose acetate fibers is also placed downstream of the plug of electrostatically charged fiber material or of the activated carbon.

[0052] In use randomly oriented electrostatically charged fiber material catches carbon particles both mechanically and electrostatically. In traditional filters, axially-oriented cellulose acetate is placed downstream of the activated carbon, and carbon particles are able to breakthrough by traveling in the channels between the cellulose acetate fibers. Here, because the fibers are randomly oriented, the carbon particles are unable to travel in the channels between the fibers.

[0053] In addition, both axially oriented and randomly-oriented electrostatically charged fibers carry an electrostatic charge that attracts and captures additional carbon particles.

[0054] It will be understood that the foregoing description is of the preferred embodiments, and is, therefore, merely representative of the article and methods of manufacturing the same. It can be appreciated that variations and modifications of the different embodiments in light of the above teachings will be readily apparent to those skilled in the art. Accordingly, the exemplary embodiments, as well as alternative embodiments, may be made without departing from the spirit and scope of the articles and methods as set forth in the attached claims.

We claim:

1. A filter assembly for a smoking article comprising:
an adsorbent including smoke entrainable adsorbent particles contained within a filter; and
a plug of electrostatically charged fiber material downstream of the adsorbent,
wherein said plug of electrostatically charged fiber material provides reduced adsorbent particle breakthrough.

2. The filter assembly of claim **1**, wherein said plug of electrostatically charged fiber material is located immediately downstream of said adsorbent.

3. The filter assembly of claim **1**, wherein said plug of electrostatically charged fiber material contains about 25 mg to about 75 mg of electrostatically charged fiber material.

4. The filter assembly of claim **1**, wherein said plug of electrostatically charged fiber material includes randomly-oriented electrostatically charged fiber material and/or axially oriented electrostatically charged fiber material.

5. The filter assembly of claim **1**, wherein said filter assembly contains about 30 mg to about 200 mg of said adsorbent.

6. The filter assembly of claim **1**, wherein said adsorbent comprises carbon on tow filter material, carbon paper, and/or a bed of loose carbon beads, granules, particles, and the like in a cavity of the filter.

7. The filter assembly of claim **1**, wherein said filter assembly is a plug-space-plug filter, and wherein said adsorbent includes activated carbon located in the space and the plug of electrostatically charged fiber material includes randomly-oriented and/or axially oriented electrostatically charged fiber material incorporated in the downstream plug of the plug-space-plug filter.

8. The filter assembly of claim **1**, wherein said adsorbent includes at least one flavorant.

9. The filter assembly of claim **1**, wherein said smoke entrainable adsorbent particles range in size from about 0.1 microns to about 10 microns.

10. The filter assembly of claim **1**, wherein said plug of electrostatically charged fiber material includes electret fibers and/or wherein said electrostatically charged fiber material is about 2.5 denier to about 8.0 denier.

11. The filter assembly of claim **10**, wherein said plug of electrostatically charged fiber material mechanically and/or electrostatically captures said adsorbent particles to reduce adsorbent particle breakthrough.

12. The filter assembly of claim **1**, further including a plug of axially-oriented cellulose acetate fibers upstream and/or downstream of said adsorbent.

13. A cigarette comprising the filter assembly of claim **1** attached to a tobacco rod, wherein an outer surface of said plug including electrostatically charged fiber material is in contact with tipping paper attaching the filter assembly to the tobacco rod.

14. A smoking article comprising:
a tobacco rod; and
a filter assembly including an adsorbent including smoke entrainable adsorbent particles and a plug of electrostatically charged fiber material,
wherein said plug of electrostatically charged fiber material provides reduced breakthrough of said particles.

15. The smoking article of claim **14**, wherein said plug of electrostatically charged fiber material is located downstream of said adsorbent in the filter assembly.

16. The smoking article of claim **14**, said smoke entrainable adsorbent particles range in size from about 0.1 microns to about 10 microns.

17. The smoking article of claim **14**, wherein said adsorbent is included in said smoking article in an amount of about 30 mg to about 200 mg.

18. The smoking article of claim **14**, wherein said filter assembly contains about 25 mg to about 70 mg of electrostatically charged fiber material.

19. The smoking article of claim **14**, wherein said adsorbent comprises carbon on tow filter material, carbon paper, and/or a bed of loose carbon beads, granules, particles, and the like in a cavity of the filter.

20. The smoking article of claim **14**, wherein said filter assembly further includes one or more plugs of cellulose acetate fibers upstream and/or downstream of said adsorbent.

21. A method of making a filter rod for a smoking article comprising:
placing 2-up plugs of filter material in spaced apart relationship;
placing plugs of electrostatically charged fiber material between the 2-up plugs such that cavities are formed at upstream and downstream ends of every other 2-up plug;
placing an adsorbent in the cavities; and
cutting said plugs of filter material centrally to form 2-up filter assemblies.

22. The method of claim **21**, further including attaching a tobacco rod to each of said 2-up filter assemblies.

23. The method of claim **21**, further including cutting said 2-up filter assemblies centrally to form complete cigarettes.

24. A method of treating mainstream tobacco smoke, comprising:
drawing mainstream smoke through a smoking article;
during said drawing step, contacting said mainstream tobacco smoke with an adsorbent; and
subsequent to said contacting step, contacting said mainstream tobacco smoke with an electrostatically charged fiber.

* * * * *