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(54) **Title:** DEGRADABLE FILTER ELEMENT FOR SMOKING ARTICLE

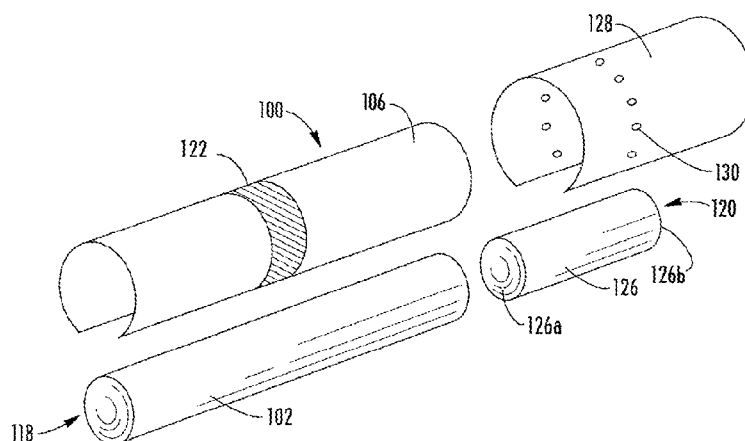


FIG. 1

(57) **Abstract:** A filter material configured for use as a filter element (126) of a smoking article is provided, the filter material including at least one segment of fibrous tow having a plurality of superabsorbent objects dispersed therein, the superabsorbent material being configured to volumetrically expand upon contact with moisture and thereby to exert mechanical force against the fibrous tow. Filter elements and smoking articles, such as cigarettes, that contain the filter material are also provided.

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DEGRADABLE FILTER ELEMENT FOR SMOKING ARTICLE
CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a non-provisional application which claims priority to U.S. provisional application Serial No. 61/360,201, filed June 30, 2010, which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

[0002] The present invention relates to products made or derived from tobacco, or that otherwise incorporate tobacco, and are intended for human consumption, and in particular, to filters for cigarettes. The invention is directed to additives for filter elements configured for increasing the rate of degradation.

BACKGROUND

[0003] Popular smoking articles, such as cigarettes, have a substantially cylindrical rod-shaped structure and include a charge, roll or column of smokable material, such as shredded tobacco (e.g., in cut filler form), surrounded by a paper wrapper, thereby forming a so-called "smokable rod" or "tobacco rod." Normally, a cigarette has a cylindrical filter element aligned in an end-to-end relationship with the tobacco rod. Typically, a filter element comprises plasticized cellulose acetate tow circumscribed by a paper material known as "plug wrap." Certain filter elements can incorporate polyhydric alcohols. Typically, the filter element is attached to one end of the tobacco rod using a circumscribing wrapping material known as "tipping paper." It also has become desirable to perforate the tipping material and plug wrap, in order to provide dilution of drawn mainstream smoke with ambient air. Descriptions of cigarettes and the various components thereof are set forth in Tobacco Production, Chemistry and Technology, Davis et al. (Eds.) (1999). A cigarette is employed by a smoker by lighting one end thereof and burning the tobacco rod. The smoker then receives mainstream smoke into his/her mouth by

drawing on the opposite end (e.g., the filter end) of the cigarette, until the tobacco rod is partially or completely consumed, after which the remaining cigarette portion is discarded.

[0004] The discarded portion of the cigarette rod is primarily composed of the filter element. In general, cigarette filters include solvent cross linked cellulose acetate fiber bundles wrapped in two layers of paper. The first layer of paper, often referred to as plug wrap, holds the fiber bundle together in a rod form and may include a glue line to anchor the fiber bundle to the plug wrap paper; the second layer, often referred to as the tipping, is fully adhered to the plug wrap and attaches the filter tube to the wrapping material surrounding the cigarette's tobacco rod. Cigarette filters are slow to degrade or disperse in the environment. This is generally attributed to the tightly bound nature of the filter plug's design which is configured to provide a specified filtering effect, but which insulates the majority of the filter from environmental effects upon disposal. Studies have shown that once the paper layers (e.g., plug wrap and tipping material) have been fully breached and the cellulose acetate fibers opened and exposed to environmental effects, the degradation and dispersion of the filter elements will progress at a much accelerated rate, rather than taking months or even years to degrade.

[0005] A number of approaches have been used in the art to promote an increased rate of degradation of filter elements. One approach involves incorporation of additives (e.g., water soluble cellulose materials, water soluble fiber bonding agents, photoactive pigments, or phosphoric acid) into the cellulose acetate material in order to accelerate polymer decomposition. See U.S. Pat. Nos. 5,913,311 to Ito et al.; 5,947,126 to Wilson et al.; 5,970,988 to Buchanan et al.; and 6,571,802 to Yamashita. In some cases, conventional cellulose acetate has been replaced with other materials, such as moisture disintegrative sheet materials, extruded starch materials, or polyvinyl alcohol. See U.S. Pat. Nos. 5,709,227 to Arzonico et al; 5,911,224 to Berger; 6,062,228 to Loercks et al.; and

6,595,217 to Case et al. Incorporation of slits into a filter element has been proposed for enhancing biodegradability, such as described in U.S. Pat. Nos. 5,947,126 to Wilson et al. and 7,435,208 to Garthaffner. U.S. Pat. No. 5,453,144 to Kauffman et al. describes use of a water sensitive hot melt adhesive to adhere the plug wrap in order to enhance biodegradability of the filter element upon exposure to water. U.S. Pat. No. 6,344,239 to Asai et al. proposes to replace conventional cellulose acetate filter elements with a filter element comprising a core of a fibrous or particulate cellulose material coated with a cellulose ester to enhance biodegradability. Each of these references is incorporated herein by reference.

[0006] There remains a need in the art for a smoking article filter exhibiting enhanced environmental degradation properties, particularly where the filter can be manufactured with only minor modification of conventional filter rod production equipment.

BRIEF SUMMARY

[0007] Embodiments of the present invention relate to a smoking article and associated methods, and in particular, a rod-shaped smoking article (e.g., a cigarette). The smoking article includes a lighting end (i.e., an upstream end) and a mouth end (i.e., a downstream end). A mouth end piece is located at the extreme mouth end of the smoking article, and the mouth end piece allows the smoking article to be placed in the mouth of the smoker to be drawn upon. The mouth end piece has the form of a filter element comprising a fibrous tow filter material. The fibrous tow filter material may incorporate an effective amount of a degradable starch material (or other degradable polymer material) configured for increasing the rate of degradation of the filter material upon disposal. Dispersal of a degradable material throughout the fibrous tow can enhance degradation by creating voids within the fibrous tow as the degradable material

decomposes, thus increasing available surface area within the fibrous tow for contact with the environment.

[0008] In one aspect, the invention provides a filter material configured for use as a filter element of a smoking article, comprising at least one segment of fibrous tow (e.g., cellulose acetate tow or polyolefin tow, or a combination thereof) including at least one (up to and potentially including a plurality of) superabsorbent object(s) dispersed therein (including being disposed within or between individual fibers of the filter material), the superabsorbent object comprising a superabsorbent material, the volume of which increases when it is exposed to water or other liquid. Exemplary superabsorbent materials may include one or more of polyacrylic acid sodium salt (a/k/a sodium polyacrylate), polyacrylamide copolymer, ethylene maleic anhydride copolymer, cross-linked carboxy-methyl-cellulose, polyvinyl alcohol copolymers, cross-linked polyethylene oxide, various hydrogels, and starch-grafted copolymer of polyacrylonitrile, or any other suitable superabsorbent polymer or non-polymeric material that will volumetrically expand upon contact with material, such as - for example - water, that may commonly be located in cigarette filter disposal locations, and mixtures thereof.

[0009] The invention also provides filter elements for smoking articles such as cigarettes, wherein the filter element comprises one or more segments of fibrous tow filter material as described herein. For example, the filter element can comprise a first segment of fibrous tow filter material and a second segment of fibrous tow filter material, wherein the first segment of fibrous tow filter material comprises a superabsorbent material as described herein and the second segment is devoid of superabsorbent material.

[0010] In another aspect, the invention provides a cigarette comprising a tobacco rod having a smokable filler material contained within a circumscribing wrapping material and a filter element connected to the tobacco rod at one end of the tobacco rod, the filter element comprising at

least one segment of fibrous tow having at least one superabsorbent object dispersed therein.

[0011] In yet another aspect, the invention provides a method of preparing a cigarette filter having a superabsorbent material disposed therein. Methods for including a superabsorbent material into a smoking article filter may include but are not limited to: capsule insertion technology, pellet insertion technology, thread insertion technology using a hydrogel or other superabsorbent polymer or other material formed into a thread/strand or by adhering grains of hydrogel to a carrier thread, sprinkling of grains into tow band, and/or inclusion into filter tow with a plasticizer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In order to assist the understanding of embodiments of the invention, reference will now be made to the appended drawings, which are not necessarily drawn to scale. The drawings are exemplary only, and should not be construed as limiting the invention.

[0013] FIG. 1 is an exploded perspective view of a smoking article having the form of a cigarette, showing the smokable material, the wrapping material components, and the filter element of the cigarette;

[0014] FIG 2 is a cross-sectional view of one embodiment of a filter element;

[0015] FIG. 3 is a cross-sectional view of another embodiment of a filter element;

[0016] FIG. 4A is a cross-sectional view of another embodiment of a filter element;

[0017] FIG. 4B is a longitudinal section view of embodiment of FIG. 4A, including internal expanding elements having expanded to disrupt the filter element and its overlying wrapping layers;

- [0018] FIG. 5 is an exploded perspective view of a smoking article having the form of a cigarette, showing the smokable material, the wrapping material components, and the filter element of the cigarette;
- [0019] FIG. 5A shows one embodiment of a tipping material with holes;
- [0020] FIG. 5B shows another embodiment of a tipping material with holes;
- [0021] FIGS. 6A and 6B show, respectively, "before" and "after" images of cigarettes exposed to water, including a control and two cigarettes embodying aspects of the present invention;
- [0022] FIG. 7 shows a longitudinal section view of a cigarette, the filter of which includes a capsule of a degradation-enhancing material;
- [0023] FIG. 8 shows a longitudinal section view of a cigarette, the filter of which includes an elongate pellet of a degradation-enhancing material;
- [0024] FIG. 9 shows a longitudinal section view of a cigarette, the filter of which includes a plurality of capsules;
- [0025] FIG. 10 shows a longitudinal section view of a cigarette, the filter of which includes a rod of a degradation-enhancing material; and
- [0026] FIG. 11 shows a longitudinal section view of a cigarette, the filter of which includes a plurality of threads of a degradation-enhancing material.

DETAILED DESCRIPTION

[0027] Embodiments of the invention are described with reference to the drawings in which like elements are generally referred to by like numerals. The relationship and functioning of the various elements of this invention may be better understood by reference to the following detailed description. However, the embodiments of this invention are not limited to the embodiments illustrated in the drawings. It should be understood that the drawings are not necessarily to scale, and in certain instances details may have been omitted which are not necessary for an understanding of the present invention, such as conventional fabrication and assembly. As

used in this specification and the claims, the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise.

[0028] As shown in FIG. 1, a smoking article 100 may be embodied as a cigarette. The cigarette 100 includes a generally cylindrical rod 102 of a charge or roll of smokable filler material contained in a circumscribing wrapping material 106. The rod 102 is conventionally referred to as a "tobacco rod." The ends of the tobacco rod 102 are open to expose the smokable filler material. The cigarette 100 is shown as having one optional band 122 (e.g., a printed coating including a film-forming agent, such as starch, ethylcellulose, or sodium alginate) applied to the wrapping material 106, and that band circumscribes the cigarette rod in a direction transverse to the longitudinal axis of the cigarette. That is, the band 122 provides a cross-directional region relative to the longitudinal axis of the cigarette. The band 122 can be printed on the inner surface of the wrapping material (i.e., facing the smokable filler material), or less preferably, on the outer surface of the wrapping material. Although the cigarette can possess a wrapping material having one optional band, the cigarette also can possess wrapping material having further optional spaced bands numbering two, three, or more.

[0029] A filter element 126 is disposed at the mouth end 120 of the tobacco rod 102, and the lighting end 118 is positioned at the opposite end. The filter element 126 is axially aligned in an end-to-end relationship with and preferably abutting the tobacco rod 102. Filter element 126 may have a generally cylindrical shape, and its diameter may be substantially the same as the diameter of the tobacco rod. The proximal and distal ends 126a, 126b (respectively) of the filter element 126 preferably permit the passage of air and smoke therethrough.

[0030] One exemplary filter element 126 configuration is shown in longitudinal section in FIG. 2. The filter includes a first filter segment 232 that is positioned immediately adjacent one end of the tobacco rod 102. The first filter segment 232 includes filter material 240 (e.g., cellulose

acetate tow impregnated with plasticizer, such as triacetin). A plurality of degradation-enhancing objects (e.g., expandable members), here embodied as superabsorbent objects 250, is disposed within the filter material 240 of the first segment. If desired, the filter element may also incorporate other components that have the ability to alter the properties of the mainstream smoke that passes throughout the filter element, such as adsorbent materials or flavorants. Exemplary adsorbent materials include activated carbon and ion exchange resins, and exemplary flavorants include flavorant-containing capsules and solid botanical additives such as peppermint or spearmint leaves or other plant-based flavorants in particulate form. See, for example, U.S. Pat. No. 6,041,790 to Smith et al. and U.S. Pat. Application Publication Nos. 2004/0237984 to Figlar et al.; 2005/0268925 to Schluter et al.; 2006/0130861 to Luan et al.; and 2006/0174899 to Luan et al., each of which is incorporated herein by reference.

[0031] Exemplary superabsorbent materials included sodium (polyacrylate) polyacrylamide copolymer, ethylene maleic anhydride copolymer, cross-linked carboxy-methyl-cellulose, polyvinyl alcohol copolymers, cross-linked polyethylene oxide, various hydrogels including so-called "hydrogel crystals," and starch-grafted copolymer of polyacrylonitrile, or any other suitable superabsorbent polymer or non-polymeric material. Preferred superabsorbent materials will volumetrically expand upon contact with material, such as - for example - water, that may commonly be located in cigarette filter disposal locations. Volumetric expansion of preferred superabsorbent materials will preferably be by a multiplicative factor of at least two, but volumetric expansion of preferred materials may be about 6x to about 8x or greater. In a typical disposal situation where a filter is properly disposed of into a receptacle and makes its way into a landfill, contact with moisture such as water or other materials in a typical waste-disposal site will allow and enable the volumetric expansion. Then, the volumetric expansion will disrupt and

spread apart the filter fibers, and will also break open the plug wrap 128 and tipping material 146, each of which is configured as a paper or paper-like material subject to ripping, tearing, bursting, and/or other disruption when subjected to mechanical force - particularly in the presence of moisture. (see, e.g. FIG. 4B).

[0032] Other examples of materials useful to form or be included in (alone, or in combination with other materials) absorbent/expanding filter inserts include polyacrylate with poly(ethylene glycol), alginate-poly(sodium acrylate-coacrylamide), alginate-g-poly(sodium acrylate)/kaolin, carboxymethylchitosan-g-poly(acrylic acid) copolymer, acrylic acid and maleic anhydride-copolymerizate, polyvinylalcohol-phosphate, acrylic acid-polyvinyl alcohol copolymer, polyacrylamide, acrylamide/N-vinyl-pyrrolidone/3(2-hydroxyethyl carbamoyl) acrylic acid, poly(acrylamide-co-methyl methacrylate), polyacrylamide/sodium alginate, polyacrylic acid, poly(sodium acrylate) cross-linked with modified poly(ethylene glycol), sulfonated polystyrene, hydrolysed acrylonitrile sulfonated polystyrene, poly(ethylene oxide), n-vinyl-2-pyrrolidone and partially neutralized acrylic acid, poly(tartaramide)s, poly(ester-amide)s containing oxyethylene segments, poly(aspartic acid) and its derivatives, and/or poly(acrylic acid)/attapulgit/sodium humate.

[0033] All of these disruptive actions combine to allow for easier dispersal and degradation of the filter material. Certain microbes, including various bacteria and fungi are known to degrade superabsorbent polymers, which - when provided in certain embodiments - may also assist in the degradation of a disposed filter. For example, certain strains of the fungus *Trichoderma reesei* have the ability to secrete large quantities of cellulosic (e.g., cellulase and hemicellulase) enzymes. Some cellulase enzymes may break down cellulose components into water-soluble sugars including, for example, glucose. As another example, the white rot fungus *Phanerochaete chrysosporium* is known to biodegrade polyacrylates and polyacrylate/polyacrylamide copolymers. (see, e.g.,

Biodegradation of Superabsorbent polymers in soil, James Stahl et al, *Environ. Sci.& Pollut, Research* 7(2) 83-88 (2000)). As another example, starch-grafted-polyacrylonitrile superabsorbent polymers have been shown to be biodegraded by naturally occurring, gram-positive cocco-bacillary rod shaped bacterial cultures (see, e.g., Microbial degradation of Superabsorbent HSPAN Gel by an Indigenously Isolated Bacterial Culture, Gosavi et al, *Macromolecules*, 1999, 32 (13) PP 4264-4271). One or more of these may be provided.

[0034] Although it is not desirable or preferred, some cigarette filters are disposed of by being flushed into water disposal lines or by being left in an open/exposed environment. In these and other disposal circumstances, the volumetric expansion facilitated in embodiments described herein will also hasten the degradation of disposed filters by disrupting the filter and thereby increasing the access of degradation-enhancing environmental components to the filter elements.

[0035] The term "degradation-enhancing object" should be understood within the present specification to refer to discrete objects disposed upon and/or within fibrous filter tow material. These discrete objects will expand upon contact with moisture in a disposal environment, and/or that will actively disperse and/or degrade fibrous filter tow material and that may also actively disperse and/or degrade material such as plug wrap or tipping paper around the filter tow. As such, the term excludes materials such as starches that are taught as being themselves degradable for enhancing filter degradation without the expansion characteristics of the presently-disclosed materials.

[0036] The filter 126 may include a second filter segment 236 longitudinally disposed relative to the first segment 232 and positioned at the mouth end 120 of the cigarette 100. The second filter segment 236 includes filter material 248 (e.g., cellulose acetate tow impregnated with plasticizer, such as triacetin). In the embodiment shown in FIG. 2, the second filter segment 236 does not include the superabsorbent

objects 250; however, such objects can be present in and/or on all filter segments, if desired. A filter segment may be considered devoid of the superabsorbent objects when it includes no more than about 0.5 weight percent of the superabsorbent objects, based on the total weight of the filter segment.

[0037] The filter element 126 is circumscribed along its outer circumferential surface and/or longitudinal periphery by a layer of outer plug wrap 128. In the embodiment of FIG. 2, outer plug wrap 128 overlies each of the first filter segment 232 and the second filter segment 236, so as to provide a combined, two-segment filter element. However, it should be appreciated that a single-segment filter element and/or multi-segment filter elements having two or more segments (one or more of which includes at least one superabsorbent objects) may also be made and used within the scope of the present invention.

[0038] The filter element 126 is attached to the tobacco rod 102 using tipping material 146 (e.g., essentially air impermeable tipping paper), that circumscribes both the entire length of the filter element 126 and an adjacent region of the tobacco rod 102. In certain preferred embodiments, the inner surface of the tipping material 146 may be fixedly secured to the outer surface of the plug wrap 128 and the outer surface of the wrapping material 106 of the tobacco rod using a suitable adhesive, which attaches the filter element and the tobacco rod to one another.

[0039] A ventilated or air diluted smoking article can be provided with an optional air dilution means, such as a series of perforations 130, each of which extend through the tipping material and plug wrap. The optional perforations 130, shown in FIG. 1, may be made by various techniques known to those of ordinary skill in the art, such as laser perforation techniques. Alternatively, so-called off-line air dilution techniques can be used (e.g., through the use of porous paper plug wrap and pre-perforated tipping paper). For cigarettes that are air diluted or ventilated, the amount or degree of air dilution or ventilation can vary. Frequently, the amount of

air dilution for an air diluted cigarette may be greater than about 10 percent, generally may be greater than about 20 percent, and sometimes is greater than about 40 percent. The upper level for air dilution for an air diluted cigarette may be less than about 80 percent, and often is less than about 70 percent. As used herein, the term "air dilution" is the ratio (expressed as a percentage) of the volume of air drawn through the air dilution means to the total volume and air and smoke drawn through the cigarette and exiting the extreme mouth end portion of the cigarette.

[0040] During use, the smoker typically lights the lighting end 118 of the cigarette 100 using a match or cigarette lighter, whereupon the smokable material 102 begins to burn. The mouth end 120 of the cigarette 100 is placed in the lips of the smoker. Thermal decomposition products (e.g., components of tobacco smoke) generated by the burning smokable material 102 are drawn through the cigarette 100, through the filter element 126, and into the mouth of the smoker. Following use of the cigarette 100, the filter element 126 and any residual portion of the tobacco rod 102 may be discarded.

[0041] As described above, the presence of the superabsorbent objects can increase the rate of degradation of the filter element 126. Expansion of the superabsorbent objects through and pushing against the surrounding fibrous tow material, plug wrap, and tipping paper/material will disrupt the tight, typically water-resistant construction of the filter element 126, allowing spaces/voids between those components. The voids provide additional surface area within the filter element 126 for contact with environmental elements such as moisture and air, which may enhance the rate of degradation of the filter.

[0042] Other filter element arrangements may be used without departing from the invention. For example, the filter element could include more than the two segments set forth in FIG. 2. The filter element could also include a cavity formed between two filter material segments. Still further, the filter segment comprising the dispersed superabsorbent objects and/or other

degradation-enhancing object(s) can be more centrally located within the filter element with one or more filter segments that do not contain the particles on each side. Alternatively, all filter segments could include the superabsorbent objects.

[0043] Another embodiment is shown in FIG. 3, which illustrates a three-segment filter 326. As shown in FIG. 3, a first filter segment 331 is disposed immediately adjacent the tobacco rod 102 and held thereto by plug wrap 128 and tipping material 146. The first segment 331 includes superabsorbent objects 350 disposed at the interface between the plug wrap 128 and the filter material 240, and preferably configured, like the other objects described herein, to exert sufficient mechanical force when in contact with moisture in a disposal environment to disrupt the plug wrap and/or tipping material, as well as spreading apart the fibers of fibrous filter tow. A second filter segment 332 is disposed immediately adjacent the first segment 331, nearer the mouth end. It includes a plurality of superabsorbent objects embodied as crystal shaped particles 351 dispersed through the filter material 240.

[0044] FIGS. 4A and 4B depict a two-segment filter 426. As shown in FIG. 4A, a first filter segment 432 is disposed immediately adjacent the tobacco rod 102 and held thereto by plug wrap 128 and tipping material 146. The first segment 432 includes a superabsorbent object 450 embodied as a first capsule 450. A second filter segment 436 is disposed adjacent and slightly spaced apart from the first segment 432, nearer the mouth end. It includes a superabsorbent object 454 embodied as a second capsule 454 incorporated into the filter material 240. FIG. 4B shows the filter 426 after it has been exposed to moisture or another instrumentality activating the superabsorbent objects 450, 454. Those objects have volumetrically expanded, forcing rupturing of the plug wrap 128 and the tipping material 146. In addition, this volumetric expansion will have loosened the fibers of the filter material 240, allowing them to be more easily dispersed and degraded. In these and/or other

embodiments, a degradation-enhancing object such as superabsorbent object 454 may also be disposed in a space between filter segments.

[0045] Certain embodiments may include perforation through the tipping material and/or plug wrap of a cigarette, as is described with reference to FIG. 5, which shows an exploded view of a cigarette 500. A cigarette embodiment 500 may be constructed including a tobacco rod 502, circumscribed by a wrapping material 506. A filter 126 made of acetate tow or other filter material providing for longitudinal passage of air therethrough may be circumscribed by plug wrap (not shown separately), which may in turn be circumscribed by tipping material 546, configured to attach the filter portion to the tobacco rod portion of the cigarette 500. As described above, the plug wrap and/or tipping material 546 may include a circumferential or other pattern (or non-pattern) of perforations 530 formed mechanically, by laser (which is generally preferred), or by some other means. In the cigarette embodiment 500, a generally longitudinal plurality of perforations 533 is also provided. (The perforations are shown as rather large, but -as noted above - are not necessarily drawn to scale, and may be different in both relative and absolute size, geometry, and dimensions).

[0046] The generally longitudinal plurality of perforations 533 may be formed substantially co-linear with the central longitudinal axis of the cigarette 500 as shown. However, the generally longitudinal plurality of perforations 533 may be formed in a wavy pattern (FIG. 5A), helical pattern (FIG. 5B), or in any other generally longitudinal orientation that extends from at or near a distal/ lighting end of the filter portion to, or at least near to the mouth-end of the filter portion. In still other embodiments, the perforations 533 may be formed into a pattern such as, for example, lettering, logo(s), geometric patterns, or other designs. The perforations preferably are disposed so as to allow materials overlying the filter material (e.g., plug wrap, tipping material) more easily to split or otherwise be disrupted when subjected to mechanical forces from an expanding object in the filter. Filter materials such acetate tow commonly exhibit a generally

longitudinal orientation or grain, the end(s) of which are exposed at the generally cylindrical end(s) of the filter. As a result, moisture entering the exposed end(s) tends to travel longitudinally through the filter.

[0047] Then, when one or more expandable objects such as fibrous materials, inserted objects, or other materials placed in or on the filter (such as - for example - those items discussed elsewhere in this specification) expand, the mechanical forces of that expansion are directed toward the circumference of the filter material 526, such that at least a portion of the mechanical force (generated by the expansion of the object(s)) is generally transverse to the wrapping material 546 and (if present) plug wrap, as well as generally transverse to the longitudinal orientation or grain of the filter materials. In each of the embodiments described herein, the expansive forces of the object(s) in the presence of moisture will promote rupture of the wrapper (e.g., plug wrap, tipping material) constraining the filter material and/or will promote separation of the fibrous and other materials forming the filter, thereby promotion dispersion and degradation of the filter. The presence of moisture will also promote weakening of the wrapping around the filter (e.g., plug wrap, tipping material), which may be aided by the construction of the filter wrapping as in the perforated embodiments of FIGS. 5-5B and/or by the composition of the filter wrapping (e.g., providing filter wrapping that provides desirable qualities for the forces and level of moisture encountered during manufacture, storage, and use of cigarettes, while allowing permeation and weakening and/or degradation in the presence of moisture encountered in a disposal environment).

[0048] The generally longitudinal plurality of perforations 533 provides a "tearable portion" of the filter region. When an expandable material in the filter is activated and exerts radial force within and/or against the filter material 526 against the plug wrap and tipping material 546, the generally longitudinal plurality of perforations 533 preferably is configured such that swelling or other volumetric expansion of an inner member of the filter 526

will tear the plug wrap and tipping material 546 therealong. In this and all embodiments including an expandable member in and/or on the filter material, it is most preferable that moisture conditions encountered during normal use will not activate the expandable member sufficiently to adversely affect functionality of the filter with regard to air flow, flavor transmission, and integrity of the filter material and surrounding plug wrap and/or tipping material.

[0049] In addition to the superabsorbent objects described above, some cigarette embodiments may include one or more pellets, particles, threads, rods, and/or other-shaped units of a cellulosic polymer that swells when exposed to moisture. The degree of swelling/expansion occasioned by smoking a cigarette so embodied (e.g., from the mouth of the smoker, from moisture/heat generated by pyrolysis of the tobacco rod) preferably will not occur during the consumption of the cigarette in a manner that would adversely affect functionality of the filter with regard to air flow, flavor transmission, and integrity of the filter material and surrounding plug wrap and/or tipping material. Cigarettes according to such an embodiment may be constructed in any manner as described above with reference to one or more of FIGS. 2 through 5B, or any other manner appropriate to provide expansion and disruption of the filter material. In addition, these and other embodiments of a cigarette may include an adhesive used to adhere one or more of wrapping material, tipping material, and plug wrap to each other and/or themselves, where the adhesive is configured to release (e.g., by degradation or other mechanism) when exposed to a high level of moisture.

[0050] During manufacture of typical cigarette filters, two types of adhesives are commonly used: (1) a hot melt adhesive for gluing the edges of the plug wrap, and (2) an aqueous dispersion based adhesive for gluing the tipping paper. Although the physical form of these adhesives may be different, both types typically include ethylene vinyl acetate as the main polymeric ingredient. Ethylene vinyl acetate is not generally

considered a readily biodegradable polymer. In formulating cigarette filters for accelerated degradability (e.g., by employing structures disclosed herein, or forming a filter from polymers that have demonstrated accelerated biodegradability), it may be desirable that the adhesive that holds the fibers together within the two layers of paper are also biodegradable. Certain biodegradable adhesives may be used in cigarette filters as hot melts and as aqueous dispersions.

[0051] Commercially available biodegradable polymers that can be used directly as hot melts or used after blending with commonly used plasticizers and tackifiers include, for example, thermoplastic starches (e.g., Biograde polymers from Biograde Ltd., Biolice polymer from Limgrane, Biomax from DuPont, Bioplast from Biotec, Cereloy Bio polymer from Cerestech Inc., Getrex polymer from IGV, Grace Bio GB 100 polymer from Grace Biotech, Mater-Bi polymers from Novamont, Plantic polymers from Plantic, Re-New polymers from Starch Tech, Solanyl BP from Rodenburg Biopolymers); blends of thermoplastic starches and polyolefins (e.g., BioCeres polymers from FuturaMat, Biograde polymers from Biograde Ltd., Cereloy Eco from Cerestech Inc., CP-Bio PP from Cereplast); blends of thermoplastic starches and polyvinyl alcohol (e.g., Biograde WS from Biograde); blends of thermoplastic starches and biodegradable aliphatic polyesters (e.g., Biopar polymers from BiOP Polymer Technologies, Bioplast polymers from Biotec); and/or blends of thermoplastic starch and polylactic acid (e.g., CP- EXC , CP-INJ, and CP-TH series from Cereplast). Biodegradable polymers that may be applied as aqueous dispersions can be used as tipping glue after converting them to dispersions by one or more of several methods.

[0052] With a solvent-antisolvent approach, the polymer is first dissolved in a water miscible organic solvent. The precipitation of the polymer into dispersion is induced by mixing the solution with water. Another approach includes evaporative precipitation in to a dispersion, where the polymer is dissolved in an organic solvent which is not miscible

with water, and the polymer solution is then sprayed into heated water resulting in an immediate evaporation of the organic solvent, which immediately forms the polymer particles are formed into a dispersion. During a wet ball milling process, micronized powder of the polymer is charged in to ball mill containing milling media (e.g., zirconium dioxide beads, silicium nitride beads, polystyrene beads) with an aqueous stabilizer, which is typically a surfactant. The moving milling media generates high shear forces and causes attrition of the original polymer particles to form a dispersion. High pressure homogenization is a process performed at room temperature with a piston gap homogenizer in an aqueous medium. During this process, a coarse suspension is formed through a very tiny homogenization gap. The particle size reduction to a dispersion is caused by cavitation forces, shear forces, and particle collision. During a microfluidics particle size reduction method, the polymeric material is subjected to ultra high shear forces to break down to smaller sizes that can be dispersed in water and stabilized with a surfactant. Another method uses supercritical fluid technology where a supercritical fluid such as CO₂ is used to effect a particle size reduction of the starting polymer that can then be dispersed into aqueous media. During a spray drying process, the polymer is first spray dried to obtain a powder and then dispersed and stabilized in water with a surfactant. These or other methods may be used to apply one or more of the biodegradable adhesives noted herein, or other adhesive(s) to secure tipping paper and/or plug wrap. The tipping paper and/or plug wrap thus secured will be more easily released to expose underlying filter materials to biodegradation or other degradation processes.

[0053] In addition to the filter-disrupting elements described herein, some embodiments may include other degradability/ biodegradability features such as disposition of one or more non-hazardous agents, distinct from the degradation-enhancing objects of the present specification. These other features (e.g., microbial agents, cellulase and/or other

enzymatic agents) may be selected for being non-hazardous and for being able to lie dormant during normal storage, transport, and - optionally - smoking conditions, then activated to propagate and consume one or more of the materials forming the cigarette (e.g., filter tow, other filter material, plug wrap, tipping material, wrapping material) when exposed to moisture.

[0054] FIGS. 6A-6B illustrate a comparative example using a standard cigarette 680 (a Camel® Wide), a first capsule-containing cigarette embodiment 660, and a second capsule-containing cigarette embodiment 670 (also Camel® Wide cigarettes). The cigarettes are substantially alike in all aspects, except that the first and second capsule-containing embodiments 660, 670 each have a superabsorbent capsule 665 (not visible in FIG. 6A) inserted into the filter tow 692 making up the filter, with care having been exercised not to disrupt the tipping material 693 encircling the filter tow 692. (It is expected that - in longitudinal section - these cigarettes, before smoking, would appear substantially similar to those shown in FIG. 7). The capsule used was a commercially available water-storing gel bead (JRM Chemical, Inc. of Cleveland, OH). All three cigarettes 660, 670, 680 were smoked under the same standard conditions for about the same amount of time. Then they were substantially simultaneously placed into a container 695 of water. After about 10 minutes, as shown in FIG. 6A, one of the capsule-containing embodiments 670 already showed signs of the tipping paper 693 starting to open along its seam 694, but the "control cigarette" 680 shows no sign of change.

[0055] After about 30 minutes, as shown in FIG. 6B (where the cigarettes are rotated to more clearly show the effect), the tipping paper 693 of each of the capsule-containing embodiments 660, 670 is substantially open along its seam, but the "control cigarette" 680 still shows no sign of change along its seam. After this time, the standard cigarette 680 was substantially unaffected other than having gotten wet, while the superabsorbent capsule 665 of the first and second capsule-

containing embodiments 660, 670 have volumetrically expanded so much that they have split open the tipping paper seams 694 and started spreading out the filter tow 692. As shown in FIG. 6B, the wrapping material overlying the filter tow 692 of both of the capsule-containing cigarettes 660, 670 was disrupted from within by the mechanical forces exerted by volumetric expansion of the capsule therein. As a result, the filter tow is already being spread apart such that it may more readily be dispersed and/or degraded. Over a longer time, the expansion will increase, and- in many disposal environments - the filter tow of cigarettes equipped with such a volumetrically-expanding degradation-enhancing element will disperse in a far more rapid time than would the filter material of the standard cigarette.

[0056] The splitting at seam 694 in this and other embodiments may be enhanced by use of a water-soluble (or at least water-sensitive or water-degradable) adhesive along the plug wrap seam 694. Examples of appropriate adhesives include those described in U.S. Pat. Nos. 5,453,144 and 5,498,224 to Kauffman et al. and 5,709,227 to Arzonico et al., each of which is incorporated by reference herein.

[0057] FIG. 7 shows a cigarette 710 including a one-segment filter 726. The material 740 (e.g., acetate tow or other appropriate material) making up the filter 726 surrounds a capsule 750 of a degradation-enhancing material such as, for example, a compound configured to volumetrically expand upon contacting moisture. The filter material 740 may be encompassed by plug wrap 728 and tipping material 746, and be attached to a wrapping material-encompassed tobacco rod 702.

[0058] FIG. 8 shows a cigarette 810 including a one-segment filter 826. The material 840 (e.g., acetate tow or other appropriate material) making up the filter 826 surrounds an elongate pellet 850 of a degradation-enhancing material such as, for example, a compound configured to volumetrically expand upon contacting moisture. The filter material 840

may be encompassed by plug wrap 828 and tipping material 846, and be attached to a wrapping material-encompassed tobacco rod 802.

[0059] FIG. 9 shows a cigarette 910 including a one-segment filter 926. The material 940 (e.g., acetate tow or other appropriate material) making up the filter 926 surrounds a trio of capsules 950 of a degradation-enhancing material such as, for example, a compound configured to volumetrically expand upon contacting moisture. The filter material 940 may be encompassed by plug wrap 928 and tipping material 946, and be attached to a wrapping material-encompassed tobacco rod 902.

[0060] FIG. 10 shows a cigarette 1010 including a one-segment filter 1026. The material 1040 (e.g., acetate tow or other appropriate material) making up the filter 1026 generally encircles a rod 1050 of a degradation-enhancing material such as, for example, a compound configured to volumetrically expand upon contacting moisture. The filter material 1040 may be encompassed by plug wrap 1028 and tipping material 1046, and be attached to a wrapping material-encompassed tobacco rod 1002.

[0061] FIG. 11 shows a three-segment filter 1126 of a cigarette. The material 1140 (e.g., acetate tow or other appropriate material) making up the central segment of the filter 1126 surrounds a plurality of threads 1150 of a degradation-enhancing material such as, for example, a compound configured to volumetrically expand upon contacting moisture and/or another material as described herein. The filter material 1140 may be encompassed by plug wrap 1128 and tipping material 1146, and be attached to a wrapping material-encompassed tobacco rod.

[0062] Each of the embodiments included herein may include a coating around the expandable/ expanding objects and/or degradability-enhancing features, where the coating is configured to protect the coated feature from moisture for a certain amount of time and/or moisture-volume exposure. Moisture-soluble and moisture disruptable coatings are well-known in the confectionary and pharmaceutical arts. As one example, a thin gelatin

coating may be used to coat the expandable and/or other degradation-enhancing features in a cigarette filter, where the thin gelatin coating will generally withstand moisture levels associated with typical transport, storage, and use of a cigarette without adversely affecting the cigarette, but will be dissolved or otherwise disrupted upon contact with a level of moisture encountered in a disposal environment thereby exposing the coated feature and allowing its activation.

[0063] The dimensions of a representative cigarette 100 may vary. Preferred cigarettes are rod-shaped, and can have diameters of about 7.5 mm (e.g., circumferences of about 20 mm to about 27 mm, often about 22.5 mm to about 25 mm); and can have total lengths of about 70 mm to about 120 mm, often about 80 mm to about 100 mm. The length of the filter element 30 can vary. Typical filter elements can have total lengths of about 15 mm to about 40 mm, often about 20 mm to about 35 mm. For a typical dual-segment filter element, the downstream or mouth end filter segment often has a length of about 10 mm to about 20 mm; and the upstream or tobacco rod end filter segment often has a length of about 10 mm to about 20 mm.

[0064] Various types of cigarette components, including tobacco types, tobacco blends, top dressing and casing materials, blend packing densities and types of paper wrapping materials for tobacco rods, can be employed. See, for example, the various representative types of cigarette components, as well as the various cigarette designs, formats, configurations and characteristics, that are set forth in Johnson, Development of Cigarette Components to Meet Industry Needs, 52nd T.S.R.C. (Sept., 1998); U.S. Pat. Nos. 5,101,839 to Jakob et al.; 5,159,944 to Arzonico et al.; 5,220,930 to Gentry and 6,779,530 to Kraker; U.S. Pat. Publication Nos. 2005/0016556 to Ashcraft et al.; 2005/0066986 to Nestor et al.; 2005/0076929 to Fitzgerald et al.; 2006/0272655 to Thomas et al.; 2007/0056600 to Coleman, III et al.; and 2007/0246055 to Oglesby, each of which is incorporated herein by reference. Most preferably, the entire

smokable rod is composed of smokable material (e.g., tobacco cut filler) and a layer of circumscribing outer wrapping material.

[0065] The filter material can vary, and can be any material of the type that can be employed for providing a tobacco smoke filter for cigarettes. Preferably a traditional cigarette filter material is used, such as cellulose acetate tow, gathered cellulose acetate web, polypropylene tow, gathered cellulose acetate web, gathered paper, strands of reconstituted tobacco, or the like. This may include gathered web filters using paper and/or one or more non-woven fabrics. Especially preferred is filamentary or fibrous tow such as cellulose acetate, polyolefins such as polypropylene, or the like. One filter material that can provide a suitable filter rod is cellulose acetate tow having 3 denier per filament and 40,000 total denier. As another example, cellulose acetate tow having 3 denier per filament and 35,000 total denier can provide a suitable filter rod. As another example, cellulose acetate tow having 8 denier per filament and 40,000 total denier can provide a suitable filter rod. For further examples, see the types of filter materials set forth in U.S. Pat. Nos. 3,424,172 to Neurath; 4,811,745 to Cohen et al.; 4,925,602 to Hill et al.; 5,225,277 to Takegawa et al. and 5,271,419 to Arzonico et al.; each of which is incorporated herein by reference.

[0066] Normally a plasticizer such as triacetin or carbowax is applied to the filamentary tow in traditional amounts using known techniques. In one embodiment, the plasticizer component of the filter material comprises triacetin and carbowax in a 1:1 ratio by weight. The total amount of plasticizer is generally about 4 to about 20 percent by weight, preferably about 6 to about 12 percent by weight. Other suitable materials or additives used in connection with the construction of the filter element will be readily apparent to those skilled in the art of cigarette filter design and manufacture. See, for example, U.S. Pat. No. 5,387,285 to Rivers, which is incorporated herein by reference.

[0067] Filamentary tow, such as cellulose acetate, is processed using a conventional filter tow processing unit such as a commercially available E-60 supplied by Arjay Equipment Corp., Winston-Salem, N.C. Other types of commercially available tow processing equipment, as are known to those of ordinary skill in the art, may similarly be used.

[0068] As illustrated in FIG. 2 and some other figures, the filter elements disclosed herein may include a plurality of longitudinally-extending segments. Each segment can have varying properties and may include various materials capable of filtration or adsorption of particulate matter and/or vapor phase compounds. Typically, a filter element of the invention will include 1 to 6 segments, and frequently may include 2 to 4 segments. In preferred embodiments, the degradation-enhancing objects such as, for example - superabsorbent objects, will not be disposed in the tobacco rod.

[0069] In addition to degradation-enhancing objects (e.g., superabsorbent objects) the filter may include materials constructed to speed or otherwise facilitate breakdown of the filter. These materials (which are distinct from the degradation-enhancing objects) can be made of any filler material that is itself degradable, meaning the material is capable of undergoing degradation or decomposition, for example through chemical reaction that breaks down the particles into decomposition products, particularly under environmental conditions associated with disposal of the filter material. One exemplary type of degradation is biodegradation. As used herein, the term "biodegradable particle" refers to a particulate material that degrades under aerobic and/or anaerobic conditions in the presence of bacteria, fungi, algae, and other microorganisms to carbon dioxide/methane, water and biomass, although materials containing heteroatoms can also yield other products such as ammonia or sulfur dioxide. "Biomass" generally refers to the portion of the metabolized materials incorporated into the cellular structure of the organisms present or converted to humus fractions indistinguishable from material of biological origin.

[0070] Biodegradability can be measured, for example, by placing a sample in environmental conditions expected to lead to decomposition, such as placing a sample in water, a microbe-containing solution, a compost material, or soil. The degree of degradation can be characterized by weight loss of the sample over a given period of exposure to the environmental conditions. Exemplary rates of degradation for certain filter element embodiments of the invention include a weight loss of at least about 20% after burial in soil for 60 days or a weight loss of at least about 30% after 15 days of exposure to a typical municipal composter. However, rates of biodegradation can vary widely depending on the type of degradable particles used, the remaining composition of the filter element, and the environmental conditions associated with the degradation test. U.S. Pat. Nos. 5,970,988 to Buchanan et al. and 6,571,802 to Yamashita provide exemplary test conditions for degradation testing.

[0071] Exemplary biodegradable materials include, without limitation, starch, cellulosic or other organic plant-derived fibrous materials (e.g., cotton, wool, cedar, hemp, bamboo, kapok, or flax), polyvinyl alcohol, aliphatic polyesters, aliphatic polyurethanes, cis-polyisoprene, cis-polybutadiene, polyhydroxy alkanoates, polyanhydrides, and copolymers and blends thereof. The term "aliphatic polyester" refers to polymers having the structure $[-C(O)-R-O]_n$, wherein n is an integer representing the number of monomer units in the polymer chain and R is an aliphatic hydrocarbon, preferably a C1-C10 alkylene, more preferably a C1-C6 alkylene (e.g., methylene, ethylene, propylene, isopropylene, butylene, isobutylene, and the like), wherein the alkylene group can be a straight chain or branched. Exemplary aliphatic polyesters include polyglycolic acid (PGA), polylactic acid (PLA) (e.g., poly(L-lactic acid) or poly(DL-lactic acid)), polyhydroxy butyrate (PHB), polyhydroxy valerate (PHV), polycaprolactone (PCL), and copolymers thereof. These degradable (including biodegradable) materials may include, for example, any of the

materials described in pending U.S. Pat. Application Ser. No. 12/539,226, which is incorporated herein by reference.

[0072] The particle size of the degradable particles (e.g., starch particles) can vary, but is typically small enough to ensure uniform dispersion throughout the fibrous tow filter material without unduly affecting the desirable filtration and mechanical properties of the fibrous tow. As used herein, reference to "particles" or "particulate" materials simply refers to discrete units of relatively small size but does not restrict the cross-sectional shape or overall geometry of the material, which can be characterized as spherical, oblong, ovoid, flake-like, irregular or the like without departing from the invention. The degradable particles usually have a particle size range of about 100 nm to about 20 microns, more typically about 400 nm to about 800 nm, and most often about 400 nm to about 600 nm. In certain embodiments, the particle size of the degradable particles can be characterized as less than about 20 microns, less than about 800 nm, or less than about 600 nm. Certain embodiments of the degradable particles can be characterized as having a particle size of more than about 100 nm or more than about 400 nm.

[0073] The amount of degradable particles used in a filter element can vary, but typical weight percentages are in the range of about 5 to about 30% by weight, based on the overall dry weight of the filter element, more typically about 10 to about 20% by weight. In certain embodiments, the amount of degradable particles in the filter element can be characterized as more than about 5% by weight, more than about 10% by weight, or more than about 15% by weight, but less than about 60% by weight, less than about 50% by weight, or less than about 40% by weight.

[0074] In certain embodiments, the degradable particles (e.g., starch particles) are characterized as having certain solubility properties. For example, in certain applications, it may be desirable for the particles to have a high degree of solubility in water. In other embodiments, hydrophobicity (i.e., relatively low water solubility) will be desired. Many

polymer materials, including starch materials, can be chemically modified in order to increase or reduce water solubility. In some embodiments, the particles can be viewed as highly soluble in water. In other embodiments, the particles have a low level of solubility in water and/or in certain other solvents, such as solvents used in the cellulose acetate fiber manufacturing process (e.g., the particles can be insoluble in acetone). As used herein, the term "soluble" refers to a material with a solubility in the given solvent of at least about 50 g/L, typically at least about 75 g/L, and often at least about 100 g/L at 25°C. A material characterized as "insoluble" refers to a material having a solubility in the given solvent of no more than about 5 g/L, typically less than about 2 g/L, and often less than about 0.5 g/L at 25°C.

[0075] The process for making filter elements according to the invention can vary, but a process for making cellulose acetate filter elements typically begins with forming cellulose fibers. The first step in conventional cellulose acetate fiber formation is esterifying a cellulose material.

Cellulose is a polymer formed of repeating units of anhydroglucose. Each monomer unit has three hydroxyl groups available for ester substitution (e.g., acetate substitution). Cellulose esters may be formed by reacting cellulose with an acid anhydride. To make cellulose acetate, the acid anhydride is acetic anhydride. Cellulose pulp from wood or cotton fibers is typically mixed with acetic anhydride and acetic acid in the presence of an acid catalyst such as sulfuric acid. The esterification process of cellulose will often result in essentially complete conversion of the available hydroxyl groups to ester groups (e.g., an average of about 2.9 ester groups per anhydroglucose unit). Following esterification, the polymer is typically hydrolyzed to drop the degree of substitution (DS) to about 2 to about 2.5 ester groups per anhydroglucose unit. The resulting product is typically produced in flake form that can be used in subsequent processing.

[0076] To form a fibrous material, the cellulose acetate flake is typically dissolved in a solvent (e.g., acetone, methanol, methylene chloride, or

mixtures thereof) to form a viscous solution. The concentration of cellulose acetate in the solution is typically about 15 to about 35 percent by weight. Additives such as whitening agents (e.g., titanium dioxide) can be added to the solution if desired. The resulting liquid is sometimes referred to as a liquid "dope."

[0077] The cellulose acetate dope is spun into filaments using a nonwoven fabric melt-spinning technique. The cellulose acetate dope is spun into filaments by extruding the liquid dope through a spinneret. The filaments pass through a curing/drying chamber, which solidifies the filaments prior to collection. The collected fibers are combined into a tow band, crimped, and dried. Conventional crimp ratios are in the range of 1.2 to 1.8. The fibers are typically packaged in bales that are suitable for later use in filter element formation processes.

[0078] The process of forming the actual filter element typically involves mechanically withdrawing the cellulose acetate tow from the bale and separating the fibers into a ribbon-like band. The tow band is subjected to a "blooming" process wherein the tow band is separated into individual fibers. Blooming can be accomplished, for example, by applying different tensions to adjacent sections of the tow band or applying pneumatic pressure. The bloomed tow band then passes through a relaxation zone that allows the fibers to contract, followed by passage into a bonding station. The bonding station typically applies a plasticizer such as triacetin to the bloomed fibers, which softens the fibers and allows adjacent fibers to fuse together. The bonding process forms a homogenous mass of fibers with increased rigidity. The bonded tow is then wrapped in plug wrap and cut into filter rods. Cellulose acetate tow processes are set forth, for example, in U.S. Pat. Nos. 2,953,838 to Crawford et al. and 2,794,239 to Crawford et al., which are incorporated by reference herein.

[0079] For filter elements including an expandable or other degradation-enhancing objects embodied as one or more capsules or pellets, the filter-forming step may include placement of the one or more capsules and/or

pellets into assembled filter tow in a manner similar to methods now known and used for capsule or pellet insertion. Methods and machines for completing this assembly step include those disclosed in U.S. Pat. Nos. 7,115,085 to Deal et al. and 7,479,098 to Thomas et al., each of which is incorporated by reference. Superabsorbent, otherwise expandable, and/or other degradation-enhancing objects may be distributed into filter tow before or during the time it is spread and gathered for bulking, fed into the filter tow as it is gathered for bulking, placed into a cavity in the filter (e.g., in the manner used for providing charcoal granules in charcoal segmented filters), or by any other method appropriate for distributing one or more particles, pellets, rods, threads, or other shaped or amorphous degradation-enhancing objects including superabsorbent and other expandable objects. Methods for including a superabsorbent material into a smoking article filter may include but are not limited to: capsule insertion technology, pellet insertion technology, thread insertion technology using a hydrogel or other superabsorbent polymer or other material formed into a thread/strand or by adhering grains of hydrogel to a carrier thread, sprinkling of grains into tow band, and/or inclusion into filter tow with a plasticizer

[0080] Filter element components or segments for filter elements for multi-segment filtered cigarettes typically are provided from filter rods that are produced using traditional types of rod-forming units, such as those available as KDF-2 and KDF-3E from Hauni-Werke Korber & Co. KG. Typically, filter material, such as filter tow, is provided using a tow processing unit. An exemplary tow processing unit has been commercially available as E-60 supplied by Arjay Equipment Corp., Winston-Salem, NC. Other exemplary tow processing units have been commercially available as AF-2, AF-3, and AF-4 from Hauni-Werke Korber & Co. KG. In addition, representative manners and methods for operating a filter material supply units and filter-making units are set forth in U.S. Pat. Nos. 4,281,671 to Byrne; 4,862,905 to Green, Jr. et al.; 5,060,664 to Siems et al.; 5,387,285

to Rivers; and 7,074,170 to Lanier, Jr. et al. Other types of technologies for supplying filter materials to a filter rod-forming unit are set forth in U.S. Pat. Nos. 4,807,809 to Pryor et al. and 5,025,814 to Raker; which are incorporated herein by reference.

[0081] Cigarette filter rods can be used to provide multi-segment filter rods. The production of multi-segment filter rods can be carried out using the types of rod-forming units that traditionally have been employed to provide multi-segment cigarette filter components. Multi-segment cigarette filter rods can be manufactured using a cigarette filter rod making device available under the brand name Mulfi from Hauni-Werke Korber & Co. KG of Hamburg, Germany. Representative types of filter designs and components, including representative types of segmented cigarette filters, are set forth in U.S. Pat. Nos. 4,920,990 to Lawrence et al.; 5,012,829 to Thesing et al.; 5,025,814 to Raker; 5,074,320 to Jones, Jr. et al.; 5,105,838 to White et al.; 5,271,419 to Arzonico et al.; 5,360,023 to Blakley et al.; 5,396,909 to Gentry et al.; and 5,718,250 to Banerjee et al.; U.S. Pat. Appl. Pub. Nos. 2002/0166563 to Jupe et al., 2004/0261807 to Dube et al.; 2005/0066981 to Crooks et al.; 2006/0090769 to Woodson et al.; 2006/0124142 to Zhang; 2006/0144412 to Mishra et al., 2006/0157070 to Belcastro et al.; and 2007/0056600 to Coleman, III et al.; PCT Publication No. WO 03/00971 1 to Kim; PCT Publication No. WO 03/047836 to Xue et al.; all of which are incorporated herein by reference.

Multi-segment filter elements typically are provided from so-called "six-up" filter rods, "four-up" filter rods and "two-up" filter rods that are of the general format and configuration conventionally used for the manufacture of filtered cigarettes can be handled using conventional-type or suitably modified cigarette rod handling devices, such as tipping devices available as Lab MAX, MAX, MAX S or MAX 80 from Hauni-Werke Korber & Co. KG. See, for example, the types of devices set forth in U.S. Pat. Nos. 3,308,600 to Erdmann et al.; 4,281,670 to Heitmann et al.; 4,280,187 to Reuland et al.; 4,850,301 to Greene, Jr. et al.; and 6,229,115 to Vos et al.;

and U.S. Pat. Application Publication Nos. 2005/0103355 to Holmes, 2005/1094014 to Read, Jr., and 2006/0169295 to Draghetti, each of which is incorporated herein by reference.

[0082] Manners and methods for incorporating degradable particles and/or superabsorbent objects into desired regions of the filter element can vary. The particles can be incorporated into a polymeric material prior to fiber formation, incorporated into the fibrous filter materials during the fiber formation process, or incorporated into the fibrous tow during the rod-forming process.

[0083] For example, the particles and/or superabsorbent objects could be introduced into the cellulose acetate or polyolefin "dope" prior to spinning the cellulose acetate or polyolefin fibers. For degradable particles, starch particles may be admixed into the fiber precursor solution. In such an embodiment, the particles are preferably insoluble in the dope solvent (e.g., acetone) and instead form a slurry or dispersion in the liquid composition. Alternatively, the particles can be soluble in the dope solvent. Still further, the degradable particles could be dry-blended with the polymer (e.g., polypropylene or cellulose acetate) prior to fiber formation, such as by using a twin-screw extruder conventionally used to mix additives with polymeric materials. U.S. Pat. No. 6,136,246 to Rauwendaal et al., which is incorporated by reference herein, discloses an exemplary screw extruder that could be used to mix degradable particles and/or superabsorbent objects with a polymer material prior to fiber formation. One advantage of incorporating the particles into the fibers prior to, or during, fiber formation is that each individual fiber that forms the fibrous tow filter material will have a plurality of degradable particles dispersed and imbedded therein, which may enhance degradation of the filter element produced using the fibers. The amount of degradable particles added to the fiber precursor solution or admixed with a polymeric material using a dry-blending technique is typically in the range of about 5 to about 40% by weight, more often about 10 to about 30% by weight,

based on the total weight of the precursor solution or total weight of the blended components.

[0084] In another method, particulate materials (including superabsorbent objects) can be incorporated into "dalmation" types of filter regions using the general types of techniques used to add particulate material in traditional dalmation filter manufacture. Techniques for production of dalmation filters are known, and representative dalmation filters have been provided commercially by Filtrona Greensboro Inc. Alternatively, any other known types of techniques and equipment for producing filter segments incorporating granular materials can be suitably altered so as to introduce degradable particles and/or superabsorbent objects into regions of filter segments. Unlike superabsorbent objects, degradable particles can be applied to the fibrous tow as a slurry in a suitable solvent (e.g., water). However, either may be added as free-flowing particulates. The particles can also be applied within a binder or adhesive matrix, or attached to a carrier material, such as a carrier fiber or capsule, and inserted into the fibrous tow with the carrier material. In certain alternative embodiments, the degradable particles and/or superabsorbent objects (when the latter are initially presented in smaller, particulate-range sizes) can be introduced to the inner surface of the plug wrap or within the side seam adhesive formulation. Exemplary processes for introducing additives into fibrous filter tow during filter rod formation are set forth in U.S. Pat. Application Publication Nos. 2008/00291 18 to Nelson et al. and 2008/0302373 to Stokes et al., as well as in U.S. Appl. Serial Nos. 12/124,891 filed May 21, 2008; 12/259,838 filed October 28, 2008; and 12/407,260 filed March 19, 2009, all of which are incorporated by reference herein in their entirety.

[008S] Filter elements of the present invention can be incorporated within the types of cigarettes set forth in U.S. Pat. Nos. 4,756,318 to Clearman et al.; 4,714,082 to Banerjee et al.; 4,771,795 to White et al.; 4,793,365 to Sensabaugh et al.; 4,989,619 to Clearman et al.; 4,917,128 to

Clearman et al.; 4,961,438 to Korte; 4,966,171 to Serrano et al.; 4,969,476 to Bale et al.; 4,991,606 to Serrano et al.; 5,020,548 to Farrier et al.; 5,027,836 to Shannon et al.; 5,033,483 to Clearman et al.; 5,040,551 to Schlatter et al.; 5,050,621 to Creighton et al.; 5,052,413 to Baker et al.; 5,065,776 to Lawson; 5,076,296 to Nystrom et al.; 5,076,297 to Farrier et al.; 5,099,861 to Clearman et al.; 5,105,835 to Drewett et al.; 5,105,837 to Barnes et al.; 5,115,820 to Hauser et al.; 5,148,821 to Best et al.; 5,159,940 to Hayward et al.; 5,178,167 to Riggs et al.; 5,183,062 to Clearman et al.; 5,211,684 to Shannon et al.; 5,240,014 to Deevi et al.; 5,240,016 to Nichols et al.; 5,345,955 to Clearman et al.; 5,396,911 to Casey, III et al.; 5,551,451 to Riggs et al.; 5,595,577 to Bensalem et al.; 5,727,571 to Meiring et al.; 5,819,751 to Barnes et al.; 6,089,857 to Matsuura et al.; 6,095,152 to Beven et al.; and 6,578,584 to Beven; which are incorporated herein by reference. Still further, filter elements of the present invention can be incorporated within the types of cigarettes that have been commercially marketed under the brand names "Premier" and "Eclipse" by R. J. Reynolds Tobacco Company. See, for example, those types of cigarettes described in Chemical and Biological Studies on New Cigarette Prototypes that Heat Instead of Burn Tobacco, R. J. Reynolds Tobacco Company Monograph (1988) and Inhalation Toxicology, 12:5, p. 1-58 (2000); which are incorporated herein by reference.

[0086] Cigarette rods typically are manufactured using a cigarette making machine, such as a conventional automated cigarette rod making machine. Exemplary cigarette rod making machines are of the type commercially available from Molins PLC or Hauni-Werke Korber & Co. KG. For example, cigarette rod making machines of the type known as MkX (commercially available from Molins PLC) or PROTOS (commercially available from Hauni-Werke Korber & Co. KG) can be employed. A description of a PROTOS cigarette making machine is provided in U.S. Pat. No. 4,474,190 to Brand, at col. 5, line 48 through col. 8, line 3, which is incorporated herein by reference. Types of equipment suitable for the

manufacture of cigarettes also are set forth in U.S. Pat. Nos. 4,781,203 to La Hue; 4,844,100 to Holznagel; 5,131,416 to Gentry; 5,156,169 to Holmes et al.; 5,191,906 to Myracle, Jr. et al.; 6,647,870 to Blau et al.; 6,848,449 to Kitao et al.; and 6,904,917 to Kitao et al.; and U.S. Pat. Application Publication Nos. 2003/0145866 to Hartman; 2004/0129281 to Hancock et al.; 2005/0039764 to Barnes et al.; and 2005/0076929 to Fitzgerald et al.; each of which is incorporated herein by reference.

[0087] The components and operation of conventional automated cigarette making machines will be readily apparent to those skilled in the art of cigarette making machinery design and operation. For example, descriptions of the components and operation of several types of chimneys, tobacco filler supply equipment, suction conveyor systems and garniture systems are set forth in U.S. Pat. Nos. 3,288,147 to Molins et al.; 3,915,176 to Heitmann et al.; 4,291,713 to Frank; 4,574,816 to Rudszinat; 4,736,754 to Heitmann et al. 4,878,506 to Pinck et al.; 5,060,665 to Heitmann; 5,012,823 to Keritsis et al. and 6,360,751 to Fagg et al.; and U.S. Pat. Publication No. 2003/0136419 to Muller; each of which is incorporated herein by reference. The automated cigarette making machines of the type set forth herein provide a formed continuous cigarette rod or smokable rod that can be subdivided into formed smokable rods of desired lengths.

[0088] Preferred cigarettes of the present invention exhibit desirable resistance to draw. For example, an exemplary cigarette exhibits a pressure drop of between about 50 and about 200 mm water pressure drop at 17.5 cc/sec. air flow. Preferred cigarettes exhibit pressure drop values of between about 60 mm and about 180, more preferably between about 70 mm to about 150 mm, water pressure drop at 17.5 cc/sec. air flow. Typically, pressure drop values of cigarettes are measured using a Filtrona Cigarette Test Station (CTS Series) available from Filtrona Instruments and Automation Ltd.

[0089] Those of skill in the art will appreciate that embodiments not expressly illustrated herein may be practiced within the scope of the present invention, including that features described herein for different embodiments may be combined with each other and/or with currently-known or future-developed technologies while remaining within the scope of the claims presented here. It is therefore intended that the foregoing detailed description be regarded as illustrative rather than limiting. And, it should be understood that the following claims, including all equivalents, are intended to define the spirit and scope of this invention.

CLAIMS

We claim:

- 5 1. A filter material configured for use as part of a smoking article, comprising:
at least one segment of fibrous tow
at least one degradation-enhancing object, the degradation-enhancing object configured to be activated by contact with moisture in a disposal environment.
- 10 2. The filter material of claim 1, wherein the at least one degradation-enhancing object comprises a superabsorbent material configured to volumetrically expand upon contact with moisture and thereby to exert mechanical force against the fibrous tow.
- 15 3. The filter material of claim 2, wherein the superabsorbent material comprises a material selected from the group consisting of sodium polyacrylate) polyacrylamide copolymer, ethylene maleic anhydride copolymer, cross-linked carboxy-methyl-cellulose, polyvinyl alcohol copolymer, cross-linked polyethylene oxide, hydrogel, starch-grafted
- 20 copolymer of polyacrylonitrile, polyacrylate with poly(ethylene glycol), alginate-poly(sodium acrylate-coacrylamide), alginate-g-poly(sodium acrylate)/kaolin, carboxymethylchitosan-g-poly(acrylic acid) copolymer, copolymerizate of acrylic acid and maleic anhydride, polyvinylalcohol-phosphate, acrylic acid-polyvinyl alcohol copolymer, polyacrylamide ,
- 25 acrylamide/N-vinyl-pyrrolidone/3(2-hydroxyethyl carbamoyl) acrylic acid, poly(acrylamide-co-methyl methacrylate), polyacrylamide/sodium alginate, polyacrylic acid, poly(sodium acrylate) cross-linked with modified poly(ethylene glycol) , sulfonated polystyrene, hydrolysed acrylonitrile
- 30 sulfonated polystyrene , poly(ethylene oxide) , n-vinyl-2-pyrrolidone with

partially neutralized acrylic acid, poly(tartaramide)s, poly(ester-amide)s with oxyethylene segments, poly(aspartic acid), poly(aspartic acid) derivative, poly(acrylic acid)/attapulgate/sodium humate, and any combination thereof.

5

4. The filter material of claim 2, wherein the superabsorbent material is configured as a selected one of a capsule, pellet, or thread.

10

5. The filter material of claim 2, wherein the superabsorbent material is configured, dimensioned, and disposed such that volumetric expansion thereof will spread apart the filter material.

15

6. The filter material of claim 1, further comprising at least one of plug wrap material and tipping material circumscribing the fibrous tow.

20

7. The filter material of claim 6, wherein the degradation-enhancing object is disposed between the fibrous tow and the circumscribing material.

8. The filter material of claim 1, wherein the fibrous tow comprises a plurality of individual filaments, and wherein a plurality of degradation-enhancing objects are disposed between the individual filaments.

25

9. The filter material of claim 1, wherein the at least one degradation-enhancing object comprises a coating.

30

10. The filter material of claim 9, wherein the coating is configured to be disruptable by moisture.

11. The filter material of claim 1, wherein the fibrous tow comprises cellulose acetate tow, polyolefin tow, or a combination thereof.

12. A filter element for a smoking article comprising one or more segments of fibrous tow filter material according to claim 1.

13. The filter element of claim 12, comprising a first segment of fibrous tow filter material and a second segment of fibrous tow filter material, wherein the first segment of fibrous tow filter material comprises a superabsorbent material and the second segment is devoid of superabsorbent material.

14. The filter material of claim 1, further comprising at least one degradability-promoting feature selected from the group consisting of microbial agents, cellulase, and fungal agents.

15. A cigarette comprising:

a tobacco rod having a smokable filler material contained within a circumscribing wrapping material and a filter element connected to the tobacco rod at one end of the tobacco rod, said filter element comprising at least one segment of fibrous tow having at least one degradation-enhancing object disposed therein, the degradation-enhancing object configured to be activated by contact with water.

16. The cigarette of claim 15, wherein the at least one degradation-enhancing object comprises a superabsorbent material configured to volumetrically expand upon contact with moisture and thereby to exert mechanical force against the fibrous tow sufficient to disperse the fibrous tow.

17. The cigarette of claim 16, wherein the superabsorbent material comprises a material selected from the group consisting of sodium polyacrylate) polyacrylamide copolymer, ethylene maleic anhydride copolymer, cross-linked carboxy-methyl-cellulose, polyvinyl alcohol

5 copolymer, cross-linked polyethylene oxide, hydrogel, starch-grafted
copolymer of polyacrylonitrile, polyacrylate with poly(ethylene glycol),
alginate-poly(sodium acrylate-coacrylamide), alginate-g-poly(sodium
acrylate)/kaolin, carboxymethylchitosan-g-poly(acrylic acid) copolymer,
10 copolymerizate of acrylic acid and maleic anhydride, polyvinylalcohol-
phosphate, acrylic acid-polyvinyl alcohol copolymer, polyacrylamide ,
acrylamide/N-vinyl-pyrrolidone/3(2-hydroxyethyl carbamoyl) acrylic acid,
poly(acrylamide-co-methyl methacrylate), polyacrylamide/sodium alginate,
polyacrylic acid, poly(sodium acrylate) cross-linked with modified
15 poly(ethylene glycol) , sulfonated polystyrene, hydrolysed acrylonitrile
sulfonated polystyrene , poly(ethylene oxide) , n-vinyl-2-pyrrolidone with
partially neutralized acrylic acid, poly(tartaramide)s, poly(ester-amide)s
with oxyethylene segments, poly(aspartic acid), poly(aspartic acid)
derivative, poly(acrylic acid)/attapulgate/sodium humate, and any
20 combination thereof.

18. The cigarette of claim 16, wherein the superabsorbent material is
configured as a selected one of a capsule, pellet, or thread.
- 20 19. The cigarette of claim 16, further comprising at least one of plug wrap
material and tipping material circumscribing the fibrous tow, and where the
mechanical force is sufficient to disrupt the at least one plug wrap material
and/or tipping material.
- 25 20. The cigarette of claim 15, wherein the at least one degradation-
enhancing object is disposed in a location selected from the group
consisting of: between fibers of the fibrous tow, between the fibrous tow
and an overlying wrapping material, between segments of fibrous tow, and
any combination thereof.

21. The cigarette of claim 20, wherein the at least one degradation-enhancing object comprises a coating.

5 22. The cigarette of claim 21, wherein the coating is configured to be disruptable by moisture.

23. The cigarette of claim 21, wherein the fibrous tow comprises cellulose acetate tow, polyolefin tow, or a combination thereof.

10 24. A cigarette including a filter configured to degrade at an enhanced rate in a disposal environment where moisture is contacted, the cigarette comprising:

a tobacco rod circumscribed by a wrapping material; and

15 a filter attached to the tobacco rod by a tipping material, the filter comprising:

a fibrous tow material circumscribed by plug wrap material contacting the tipping material; and

20 at least one superabsorbent degradation-enhancing object contacting at least one of the tow material, the plug wrap material, and the tipping material, the object configured to volumetrically expand upon contact with moisture in a disposal environment.

25 25. The cigarette of claim 24, wherein the volumetric expansion of the object is configured as sufficient to exert mechanical force against the fibrous tow that will disperse the fibrous tow and disrupt at least a portion of the plug wrap, the tipping material, or both the plug wrap and tipping material.

30 26. The cigarette of claim 24, wherein at least one of the plug wrap and the tipping paper further comprises a biodegradable adhesive.

27. A cigarette including a filter configured to degrade at an enhanced rate in a disposal environment where moisture is contacted, the cigarette comprising:

a tobacco rod circumscribed by a wrapping material; and

5 a filter attached to the tobacco rod by a tipping material, the filter comprising:

a gathered web filters made using a selected one of paper, non-woven fabric, or combination thereof, circumscribed by plug wrap material contacting the tipping material; and

10 at least one superabsorbent degradation-enhancing object contacting at least one of the tow material, the plug wrap material, and the tipping material, the object configured to volumetrically expand upon contact with moisture in a disposal environment.

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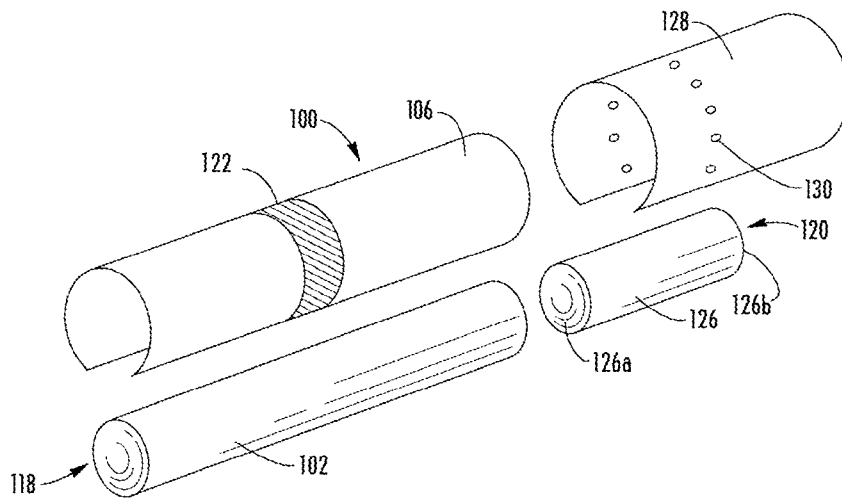


FIG. 1

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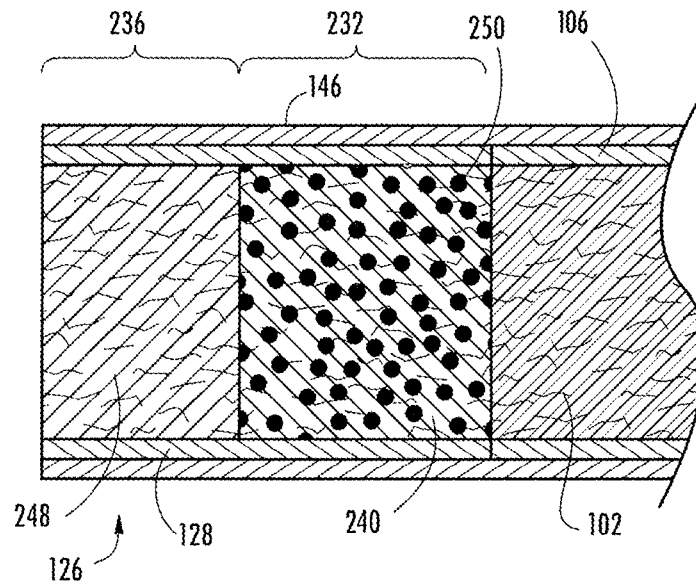


FIG. 2

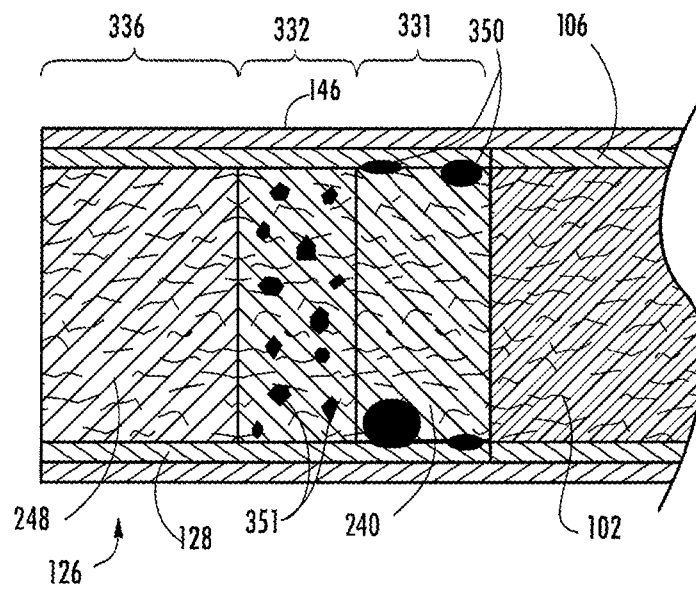


FIG. 3

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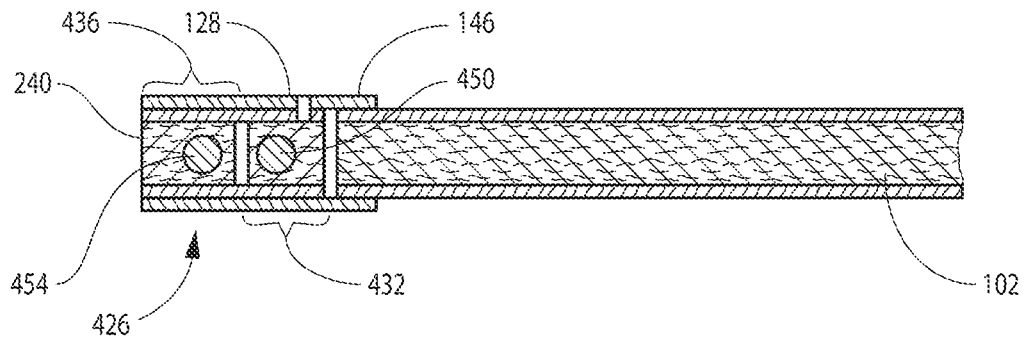


FIG. 4A

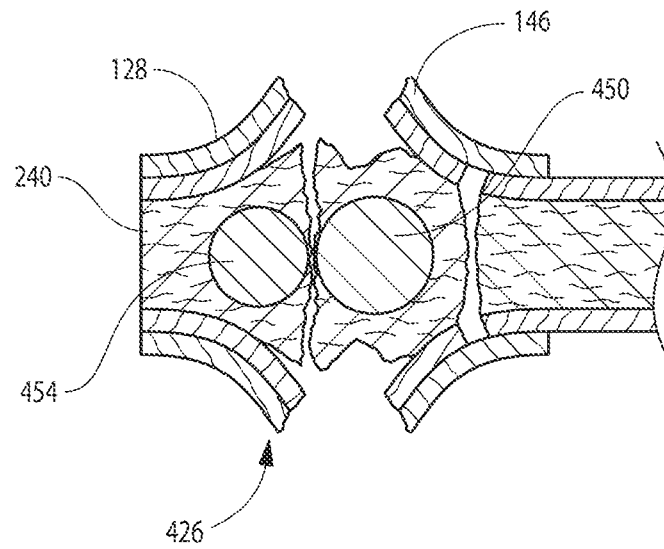


FIG. 4B

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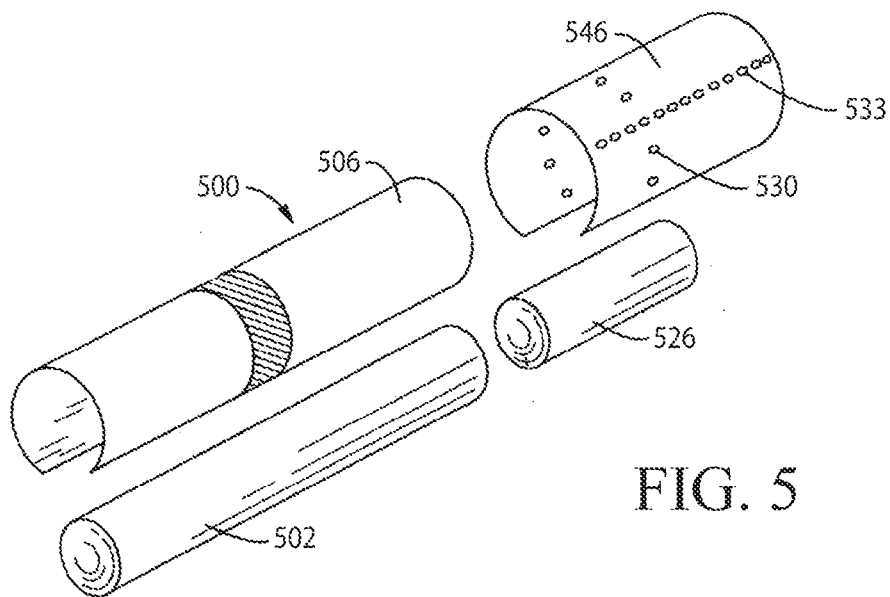


FIG. 5

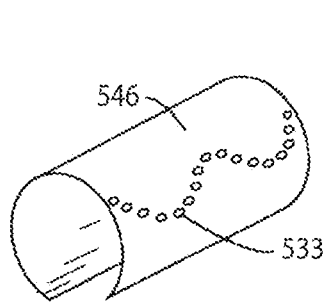


FIG. 5A

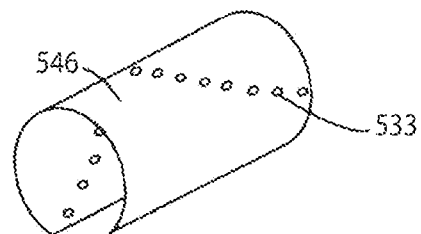


FIG. 5B

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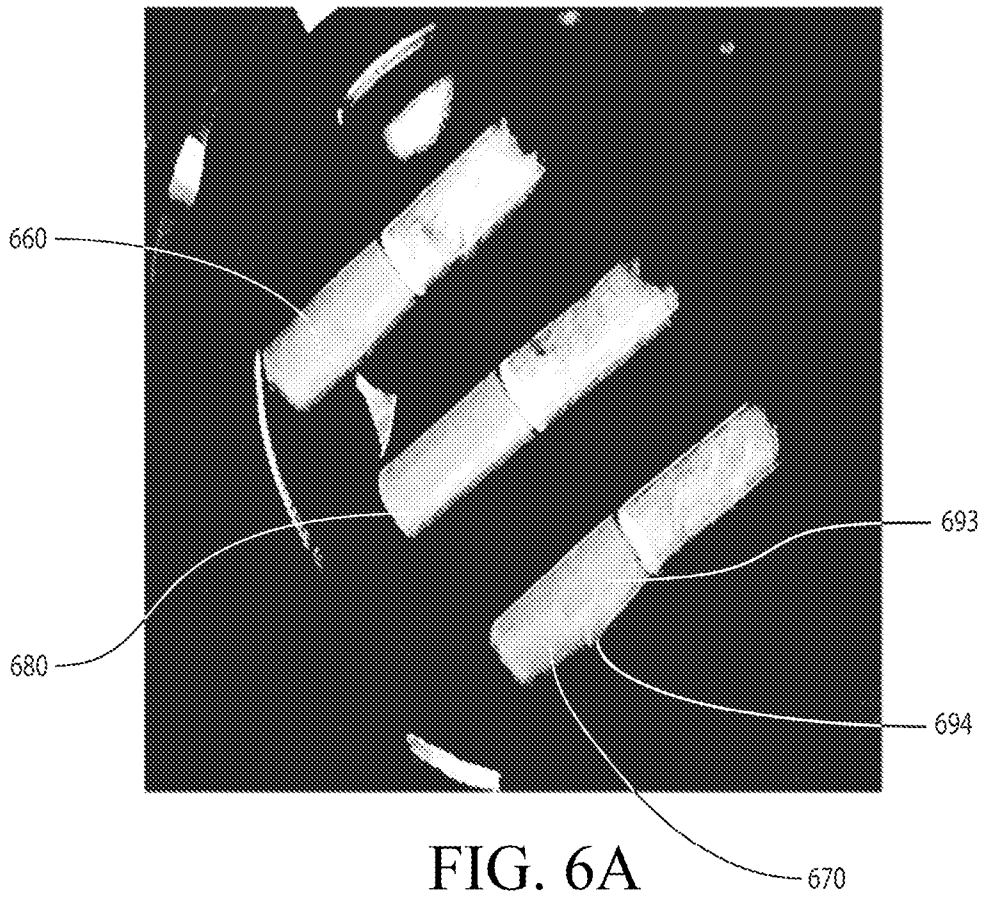


FIG. 6A

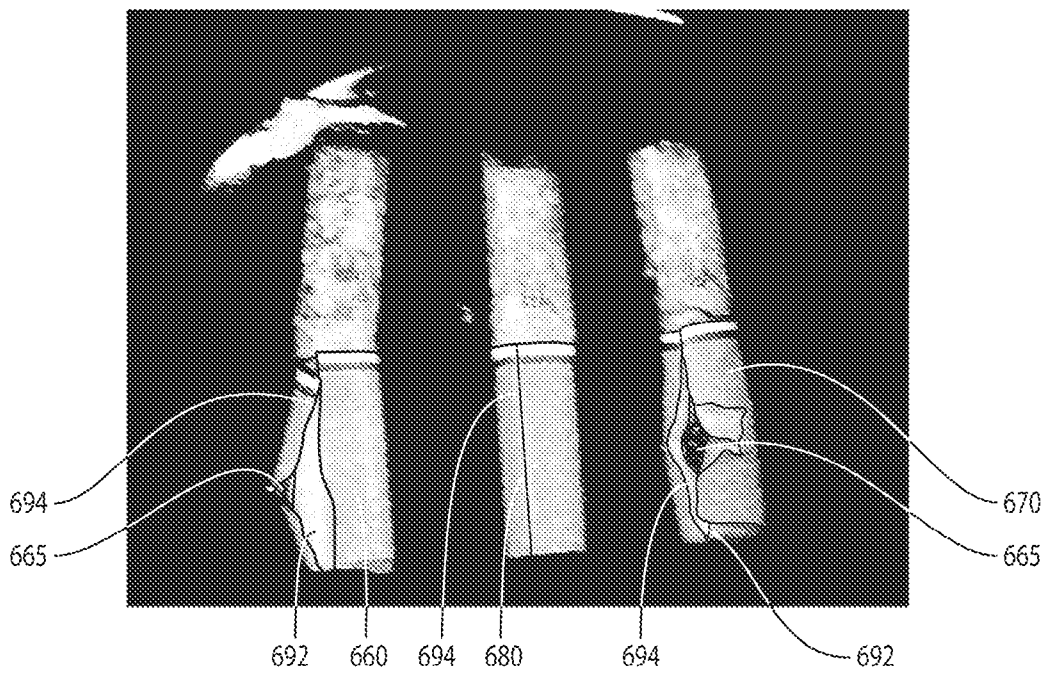


FIG. 6B

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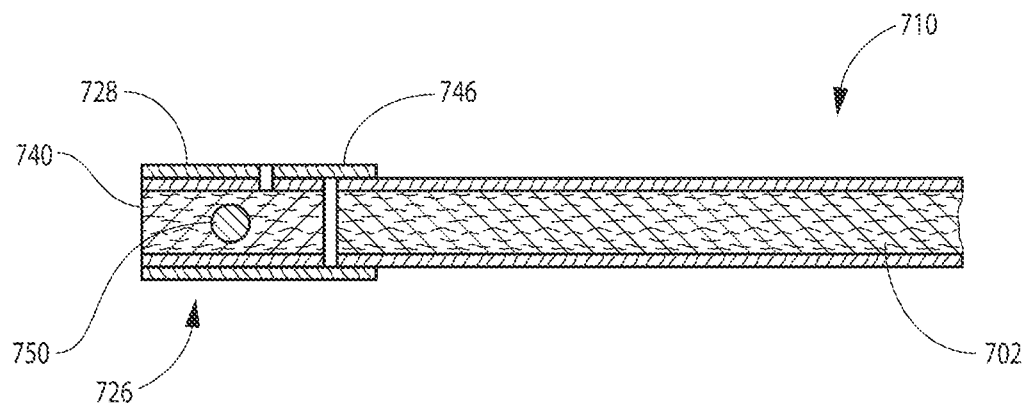


FIG. 7

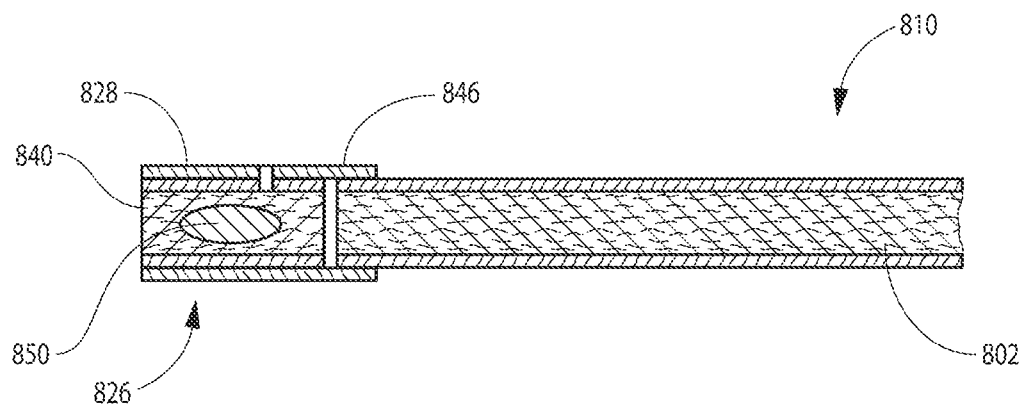


FIG. 8

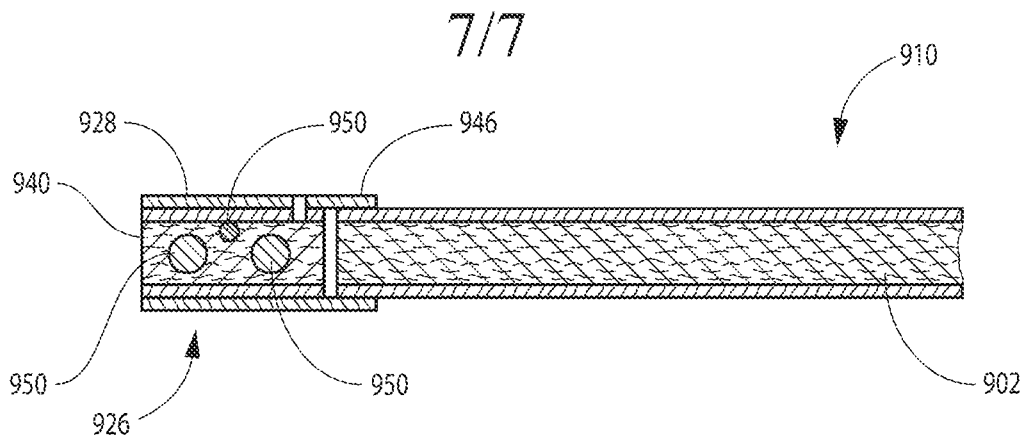


FIG. 9

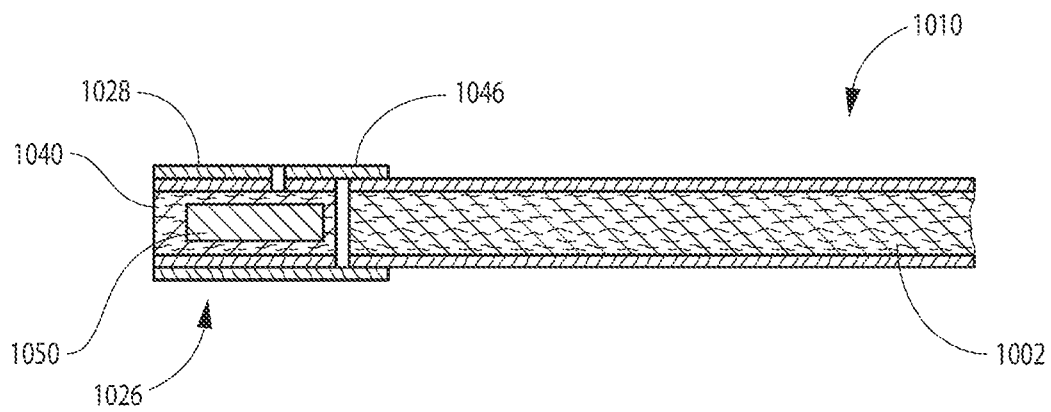


FIG. 10

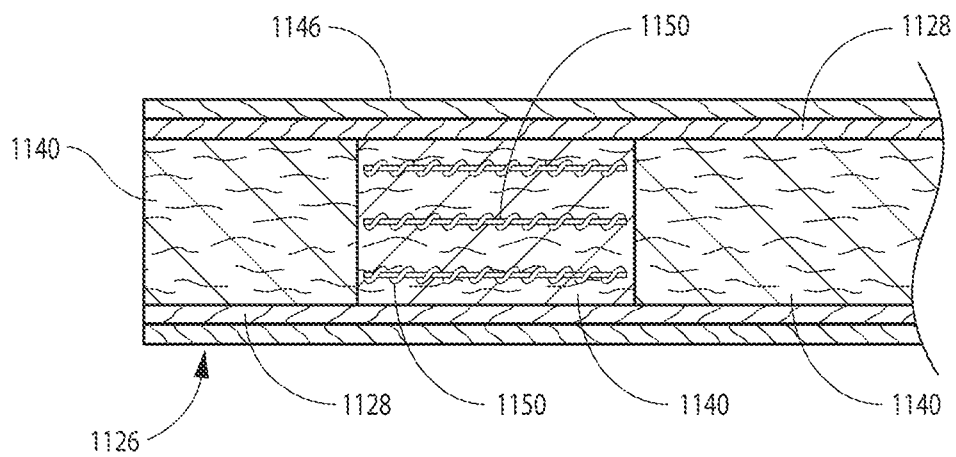


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2011/040475

A. CLASSIFICATION OF SUBJECT MATTER

INV. A24D3/10 A24D3/14

ADD..

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)

A24D

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

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

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/151738 A1 (ROBERTSON RAYMOND M [US] ET AL) 18 June 2009 (2009-06-18) paragraphs [0008], [0017], [0020], [0026], [0034], [0035]; claim 1 -----	1, 6-12, 20-23
A	US 5 954 059 A (BEVEN JOHN LAWSON [GB] ET AL) 21 September 1999 (1999-09-21) column 2, line 14 - line 23; claims -----	2-5
A	US 5 947 126 A (WILSON STEVEN A [US] ET AL) 7 September 1999 (1999-09-07) column 4, line 8 - line 24; example 1 -----	1-27
E	W0 2011/077141 A1 (BRITISH AMERICAN TOBACCO CO [GB]; RUSHFORTH DAVID [GB]) 30 June 2011 (2011-06-30) page 16, line 13 - page 17, line 9 -----	1-5, 13-19, 24-27



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

21 September 2011

Date of mailing of the international search report

28/09/2011

Name and mailing address of the ISA/

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Authorized officer

Lepretre, Francois

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2011/040475

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