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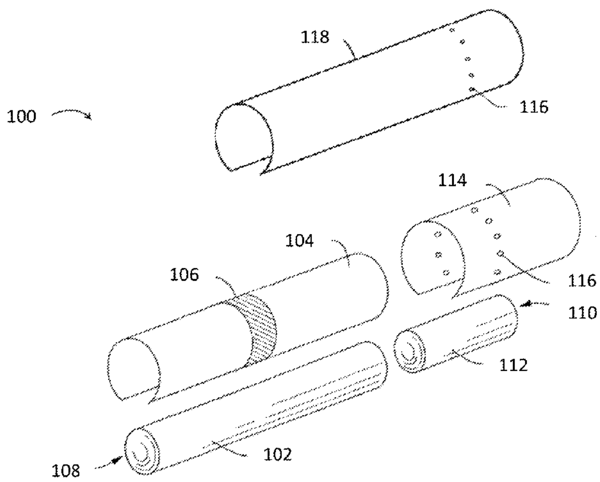

FIG. 1

(57) **Abstract:** The present disclosure provides filter materials adapted for use as a filter element in an aerosol delivery device and methods of forming such filter materials suitable for use as a filter element in such devices. The disclosure provides, in some embodiments, a filter material which includes a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, reconstituted tobacco, and combinations thereof, wherein the filter material is in the form of a nonwoven sheet or a fibrous tow.

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ALTERNATIVE FILTER MATERIALS AND COMPONENTS FOR AN AEROSOL DELIVERY DEVICE

FIELD OF THE INVENTION

The present disclosure relates to aerosol generating components, aerosol delivery devices, aerosol delivery systems, such as smoking articles, and components thereof that utilize electrically-generated heat or combustible ignition sources to heat aerosol forming materials, preferably without significant combustion, in order to provide an inhalable substance in the form of an aerosol for human consumption. In particular, the disclosure relates to filter materials for use as filter elements in aerosol delivery devices, e.g., such as cigarettes or other smoking articles, and related methods for producing such filter materials and associated filter elements.

BACKGROUND OF THE INVENTION

Popular smoking articles, such as cigarettes, can have a substantially cylindrical rod-shaped structure and can 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,” and the filter element is attached to one end of the tobacco rod using a circumscribing wrapping material known as “tipping material.” It also can be 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.

The currently available filter technology for forming filter elements may have several drawbacks. For example, conventional filter elements comprising a cellulose acetate tow, although being characterized as biodegradable, may require an undesirably long time to actually biodegrade. In some instances, the biodegradation period may be on the order of two to ten years. Furthermore, some jurisdictions have classified cellulose acetate tow as a “single use plastic” and such a classification has led to regulation of such materials to reduce their detrimental effects on the environment. In response, alternate filter materials have been proposed, such as gathered paper, nonwoven polypropylene web or gathered strands of shredded web. However, even if filter elements comprising such alternate materials exhibit accelerated biodegradability over conventional cellulose acetate tow filter elements, the effect thereof on the mainstream smoke may not meet the expectations of the smoker. That is, conventional cellulose acetate tow is generally plasticized with an appropriate plasticizer, such as triacetin, upon the tow being bloomed and formed into the filter rod from which the filter elements are obtained. In this regard, the triacetin plasticizer provides a particular effect on the mainstream smoke (i.e., taste) that is pleasant to the smoker or has otherwise become expected by the smoker. One issue with alternate filter materials is that those materials may not necessarily blend with or suitably receive a plasticizer such as triacetin. That is, even if such alternate filter materials receive the triacetin, the effect of the combination on the mainstream smoke, for example, the taste of the smoke, may not be pleasant to the smoker or otherwise be similar enough to the sensation expected by the smoker who is accustomed to the organoleptic properties associated with triacetin-treated cellulose acetate tow filter elements.

Further advancements in filter elements and apparatuses and methods for producing the same may be desirable, wherein such advancements maximize or otherwise enhance the biodegradability of the filter tow / filter element, while blending with conventional plasticizers to retain the sensory effects on the mainstream smoke (i.e., smoke taste), expected by the smoker.

SUMMARY OF THE INVENTION

The present disclosure relates to aerosol delivery devices that utilize electrically-generated heat or combustible ignition sources to heat a substrate carrying one or more aerosol forming materials, in order to provide an inhalable substance in the form of an aerosol for human consumption. More specifically, the present disclosure generally provides filter materials and components suitable for use in aerosol delivery devices and methods of preparing such filter materials and components. In some aspects, filter materials according to the present disclosure may be formed of a nonwoven sheet or a fibrous tow including a plurality of fibers comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, reconstituted tobacco, and combinations thereof.

In one aspect, the present disclosure provides a filter material adapted for use as a filter element in an aerosol delivery device. In such embodiments, the filter material can comprise a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, and combinations thereof; and the filter material can be in the form of a nonwoven sheet or a fibrous tow. In some embodiments, the filter material is in the form of a pleated nonwoven sheet gathered to form a rod-like element. In some embodiments, the nonwoven sheet has a basis weight of about 20 gsm to about 90 gsm, about 40 gsm to about 80 gsm, or about 50 gsm to about 70 gsm. In some embodiments, the denier per filament (dpf) of the filter material is about 1 dpf to about 30 dpf, about 1 dpf to about 25 dpf, or about 1 dpf to about 5 dpf.

In some embodiments, the filter material can optionally be crimped. In some embodiments, for example, the crimped filter material can have a crimp depth of about 1 micron to about 180 microns, about 1 micron to about 150 microns, or about 50 microns to about 100 microns. In some embodiments, the nonwoven sheet has a width of about 110 mm to about 160 mm, or about 115 mm to about 150 mm. In certain embodiments, filter materials according to the present disclosure may further comprise a plasticizer. In some embodiments, the plasticizer is triacetin. In some embodiments, filter materials according to the present disclosure may further comprise a binder. In such embodiments, the binder may be selected from the group consisting of polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof. As noted herein, in some embodiments, filter materials prepared according to the present disclosure may be in the form of a nonwoven sheet. In such embodiments, the nonwoven sheet can be a wetlaid nonwoven sheet, a drylaid nonwoven sheet, or an airlaid nonwoven sheet.

Some aspect of the present disclosure provide a filter element adapted for use in an aerosol delivery device, wherein the filter element comprises one or more segments of a filter material prepared according to the present disclosure. In some embodiments, the one or more segments of filter material have a hardness of about 75 percent or higher, about 80 percent or higher, or about 85 percent or higher. In some embodiments, a filter element prepared according to the present disclosure can exhibit a pressure drop in the range of about 40 mmWG to about 400 mmWG, or about 200 mmWG to about 300 mmWG. Another aspect of the present disclosure provides an aerosol delivery device comprising a filter element prepared according to the present disclosure.

Still further aspects of the present disclosure provide methods for forming a filter material suitable for use as a filter element in an aerosol delivery device. In some embodiments, such methods may comprise receiving a nonwoven sheet or a fibrous tow, the nonwoven sheet or the fibrous tow comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, and combinations thereof; and processing the nonwoven sheet or the fibrous tow to provide a filter material suitable for use as a filter element for an aerosol delivery device. In some embodiments, such methods may further comprise forming the nonwoven sheet or fibrous tow as is known in the art. For example, the nonwoven sheet can be formed using a wetlaid, airlaid, or drylaid forming process. Other forming processes known in the art may also be suitable for forming a filter element as described herein. In some embodiments, for example, the nonwoven sheet is formed using a forming process selected from the group consisting of hydroentangling, needle punching, spun-bonding, melt-blowing, spun-lacing, carding, point-bonding, spinning, and combinations thereof.

In some embodiments, forming the fibrous tow may comprise blending the plurality of fibers to provide a mixed fiber blend; and drawing the mixed fiber blend to provide the fibrous tow. In some embodiments, the processing step may comprise gathering the nonwoven sheet or fibrous tow to form a rod-like element suitable for use as a filter element.

In still other embodiments, the processing may comprise wrapping the rod-like element with a circumscribing wrapping material thereby forming a continuous rod suitable for use as a filter element. In certain embodiments, the processing may comprise crimping the nonwoven sheet or fibrous tow. In such embodiments, the crimped nonwoven sheet or the crimped fibrous tow can have a crimp depth of about 1 micron to about 180 microns, about 1 micron to about 150 microns, or about 50 microns to about 100 microns.

In some embodiments, the methods of the present disclosure may further comprise applying a plasticizer to the nonwoven sheet or fibrous tow. In some embodiments, the plasticizer is triacetin. In some embodiments, the methods of the present disclosure may further comprise applying a binder to the nonwoven sheet or fibrous tow. In such embodiments, the binder may be selected from the group consisting of polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof. In some embodiments, the nonwoven sheet can have a basis weight of about 20 gsm to about 90 gsm, about 40 gsm to about 80 gsm, or about 50 gsm to about 70 gsm. In some embodiments, the denier per filament (dpf) of the filter material is about 1 dpf to about 30 dpf, about 1 dpf to about 25 dpf, or about 1 dpf to about 5 dpf. In certain embodiments, the nonwoven sheet can have a width of about 110 mm to about 160 mm, or about 115 mm to about 150 mm.

The disclosure includes, without limitations, the following embodiments.

Embodiment 1: A filter material adapted for use as a filter element in an aerosol delivery device, the filter material comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, and combinations thereof, wherein the filter material is in the form of a nonwoven sheet or a fibrous tow.

Embodiment 2: The filter material of embodiment 1, wherein the filter material is in the form of a pleated nonwoven sheet gathered to form a rod-like element.

Embodiment 3: The filter material of any one of embodiments 1-2, wherein the nonwoven sheet has a basis weight of about 20 gsm to about 90 gsm.

Embodiment 4: The filter material of any one of embodiments 1-3, wherein the nonwoven sheet has a basis weight of about 40 gsm to about 80 gsm.

Embodiment 5: The filter material of any one of embodiments 1-4, wherein the nonwoven sheet has a basis weight of about 50 gsm to about 70 gsm.

Embodiment 6: The filter material of any one of embodiments 1-5, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 30 dpf.

Embodiment 7: The filter material of any one of embodiments 1-6, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 25 dpf.

Embodiment 8: The filter material of any one of embodiments 1-7, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 5 dpf.

Embodiment 9: The filter material of any one of embodiments 1-8, wherein the filter material is optionally crimped.

Embodiment 10: The filter material of any one of embodiments 1-9, wherein the crimped filter material has a crimp depth of about 1 micron to about 180 microns.

Embodiment 11: The filter material of any one of embodiments 1-10, wherein the crimped filter material has a crimp depth of about 1 micron to about 150 microns.

Embodiment 12: The filter material of any one of embodiments 1-11, wherein the crimped filter material has a crimp depth of about 50 microns to about 100 microns.

Embodiment 13: The filter material of any one of embodiments 1-12, wherein the nonwoven sheet has a width of about 110 mm to about 160 mm.

Embodiment 14: The filter material of any one of embodiments 1-13, wherein the nonwoven sheet has a width of about 115 mm to about 150 mm.

Embodiment 15: The filter material of any one of embodiments 1-14, further comprising a plasticizer.

Embodiment 16: The filter material of any one of embodiments 1-15, wherein the plasticizer is triacetin.

Embodiment 17: The filter material of any one of embodiments 1-16, further comprising a binder.

Embodiment 18: The filter material of any one of embodiments 1-17, wherein the binder is selected from the group consisting of polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof.

Embodiment 19: The filter material of any one of embodiments 1-18, wherein the nonwoven sheet is a wetlaid nonwoven sheet, a drylaid nonwoven sheet, or an airlaid nonwoven sheet.

Embodiment 20: A filter element adapted for use in an aerosol delivery device, the filter element comprising one or more segments of a filter material according to any one of embodiments 1-19.

Embodiment 21: The filter element of embodiment 20, wherein the one or more segments of filter material have a hardness of about 75 percent or higher.

Embodiment 22: The filter element of any one of embodiments 20-21, wherein the one or more segments of filter material have a hardness of about 80 percent or higher.

Embodiment 23: The filter element of any one of embodiments 20-22, wherein the one or more segments of filter material have a hardness of about 85 percent or higher.

Embodiment 24: The filter element of any one of embodiments 20-23, wherein the filter element exhibits a pressure drop in the range of about 40 mmWG to about 400 mmWG.

Embodiment 25: The filter element of any one of embodiments 20-24, wherein the filter element exhibits a pressure drop in the range of about 200 mmWG to about 300 mmWG.

Embodiment 26: An aerosol delivery device comprising the filter element according to any one of embodiments 20-25.

Embodiment 27: A method for forming a filter material suitable for use as a filter element in an aerosol delivery device, the method comprising: receiving a nonwoven sheet or a fibrous tow, the nonwoven sheet or the fibrous tow comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, and combinations thereof; and processing the nonwoven sheet or the fibrous tow to provide a filter material suitable for use as a filter element for an aerosol delivery device.

Embodiment 28: The method of embodiment 27, further comprising forming the nonwoven sheet or fibrous tow.

Embodiment 29: The method of any one of embodiments 27-28, wherein the nonwoven sheet is formed using a wetlaid, airlaid, or drylaid forming process.

Embodiment 30: The method of any one of embodiments 27-29, wherein the nonwoven sheet is formed using a forming process selected from the group consisting of hydroentangling, needle punching, spun-bonding, melt-blowing, spun-lacing, carding, point-bonding, spinning, and combinations thereof.

Embodiment 31: The method of any one of embodiments 27-30, wherein forming the fibrous tow comprises: blending the plurality of fibers to provide a mixed fiber blend; and drawing the mixed fiber blend to provide the fibrous tow.

Embodiment 32: The method of any one of embodiments 27-31, wherein the processing comprises gathering the nonwoven sheet or fibrous tow to form a rod-like element suitable for use as a filter element.

Embodiment 33: The method of any one of embodiments 27-32, wherein the processing further comprises wrapping the rod-like element with a circumscribing wrapping material thereby forming a continuous rod suitable for use as a filter element.

Embodiment 34: The method of any one of embodiments 27-33, wherein the processing comprises crimping the nonwoven sheet or fibrous tow.

Embodiment 35: The method of any one of embodiments 27-34, wherein the crimped nonwoven sheet or the crimped fibrous tow have a crimp depth of about 1 micron to about 180 microns.

Embodiment 36: The method of any one of embodiments 27-35, wherein the crimped nonwoven sheet or the crimped fibrous tow have a crimp depth of about 1 micron to about 150 microns.

Embodiment 37: The method of any one of embodiments 27-36, wherein the crimped nonwoven sheet or the crimped fibrous tow have a crimp depth of about 50 microns to about 100 microns.

Embodiment 38: The method of any one of embodiments 27-37, further comprising applying a plasticizer to the nonwoven sheet or fibrous tow.

Embodiment 39: The method of any one of embodiments 27-38, wherein the plasticizer is triacetin.

Embodiment 40: The method of any one of embodiments 27-39, further comprising applying a binder to the nonwoven sheet or fibrous tow.

Embodiment 41: The method of any one of embodiments 27-40, wherein the binder is selected from the group consisting of polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof.

Embodiment 42: The method of any one of embodiments 27-41, wherein the nonwoven sheet has a basis weight of about 20 gsm to about 90 gsm.

Embodiment 43: The method of any one of embodiments 27-42, wherein the nonwoven sheet has a basis weight of about 40 gsm to about 80 gsm.

Embodiment 44: The method of any one of embodiments 27-43, wherein the nonwoven sheet has a basis weight of about 50 gsm to about 70 gsm.

Embodiment 45: The method of any one of embodiments 27-44, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 30 dpf.

Embodiment 46: The method of any one of embodiments 27-45, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 25 dpf.

Embodiment 47: The method of any one of embodiments 27-46, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 5 dpf.

Embodiment 48: The method of any one of embodiments 27-47, wherein the nonwoven sheet has a width of about 110 mm to about 160 mm.

Embodiment 49: The method of any one of embodiments 27-48, wherein the nonwoven sheet has a width of about 115 mm to about 150 mm.

These and other features, aspects, and advantages of the disclosure will be apparent from a reading of the following detailed description together with the accompanying drawings, which are briefly described below. The invention includes any combination of two, three, four, or more of the above-noted embodiments as well as combinations of any two, three, four, or more features or elements set forth in this disclosure, regardless of whether such features or elements are expressly combined in a specific embodiment description herein. This disclosure is intended to be read holistically such that any separable features or elements of the disclosed invention, in any of its various aspects and embodiments, should be viewed as intended to be combinable unless the context clearly dictates otherwise.

BRIEF DESCRIPTION OF THE DRAWINGS

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.

FIG. 1 is an exploded view of an example embodiment of a smoking article, according to an example embodiment of the present disclosure;

FIG. 2 illustrates a perspective view of an aerosol delivery device comprising a control body and an aerosol generating component, wherein the aerosol generating component and the control body are coupled to one another, according to an example embodiment of the present disclosure;

FIG. 3 illustrates a perspective view of the aerosol delivery device of FIG. 1 wherein the aerosol generating component and the control body are decoupled from one another, according to an example embodiment of the present disclosure;

FIG. 4 illustrates a perspective schematic view of an aerosol generating component, according to an example embodiment of the disclosure;

FIG. 5 illustrates a schematic cross-section drawing of a substrate portion of an aerosol generating component, according to an example embodiment of the present disclosure;

FIG. 6 illustrates a perspective view of an aerosol delivery device, according to an example embodiment of the present disclosure;

FIG. 7 illustrates a perspective view of the aerosol delivery device of FIG. 5 with an outer wrap removed, according to one embodiment of the present disclosure;

FIG. 8 is a graph showing the filtration efficiency (measured in terms of tar delivery) of four regenerated cellulose filter materials prepared according to an example embodiment of the present disclosure and having varying denier per filament (dpf) as compared to a conventional cellulose acetate filter and a conventional paper based filter having a basis weight of 36 gsm; and

FIG. 9 is a graph showing the vent-corrected filtration efficiency (measured in terms of tar delivery) of four regenerated cellulose filter materials prepared according to an example embodiment of the present disclosure and having varying denier per filament (dpf) as compared to a conventional cellulose acetate filter and a conventional paper based filter having a basis weight of 36 gsm.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present disclosure will now be described more fully hereinafter with reference to example embodiments thereof. These example embodiments are described so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Indeed, the disclosure is embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. As used in the specification, and in the appended claims, the singular forms “a”, “an”, “the”, include plural referents unless the context clearly dictates otherwise.

As described herein, embodiments of the disclosure relate to filter materials adapted for use as a filter element in aerosol delivery devices and methods for producing such filter materials. In this regard, filter materials prepared according to the methods described herein can be employed, for example, in a variety of aerosol delivery devices including, but not limited to, conventional cigarettes, tobacco heating products, heat-not-burn smoking articles, electronic smoking articles and the like. Reference to “filter material” or “filter element” does not imply that the material is used for purposes of filtration in all embodiments, but only that the material is capable of some level of filtration of gas phase and/or particulate phase components of an aerosol at least in certain embodiments. In certain embodiments, the filter material may provide other functions that do not relate directly to filtration, such as mouthfeel or other sensory characteristics or biodegradability or resistance to draw.

Filter materials according to the present disclosure are typically in the form of a nonwoven sheet-like material, or in the form of a fibrous tow. In such embodiments, the nonwoven sheet or the fibrous tow typically comprises a plurality of fibers therein. In some embodiments, filter materials according to the disclosure (either in the form of a nonwoven sheet or a fibrous tow) may be formed of alternative or recycled fiber materials. Such alternative fibers materials may beneficially provide increased biodegradability and/or reduced plasticity when compared to the types of fiber inputs used in conventional cigarette filters, e.g., such as cellulose acetate. In some embodiments, filter materials prepared according to the present disclosure may comprise a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, kenaf, esparto, jute, flax, wood, reconstituted tobacco, and combinations thereof. As used herein, the term “fiber” is defined as a basic element of textiles. It should be noted that the filter materials of the present disclosure may include any of the noted fiber inputs individually or in combination with one or more other fiber inputs. Fibers are often in the form of a rope- or string-like element. As used herein, the term “fiber” is intended to include fibers, filaments, continuous filaments, staple fibers, and the like.

In some embodiments, a filter material as described herein may comprise regenerated cellulose fibers, in particular. It should be noted that the filter materials may comprise solely regenerated cellulose fibers or the regenerated cellulose fibers may be combined with one or more other fiber inputs as described herein. Regenerated cellulose fibers are typically prepared by extracting non-cellulosic compounds from wood, contacting the extracted wood with caustic soda, followed by carbon disulfide and then by sodium hydroxide, giving a viscous solution. The solution is subsequently forced through spinneret heads to create viscous threads of regenerated fibers. Exemplary methods for the preparation of regenerated cellulose are provided in U.S. Pat. No. 4,237,274 to Leoni et al; U.S. Pat. No. 4,268,666 to Baldini et al; U.S. Pat. No. 4,252,766 to Baldini et al.; U.S. Pat. No. 4,388,256 to Ishida et al.; U.S. Pat. No. 4,535,028 to Yokogi et al.; U.S. Pat. No. 5,441,689 to Laity; U.S. Pat. No. 5,997,790 to Vos et al.; and U.S. Pat. No. 8,177,938 to Sumnicht, which are incorporated herein by reference. The manner in which the regenerated cellulose is made is not limiting, and can include, for example, both the rayon and the TENCEL processes. Various suppliers of regenerated cellulose are known, including Lenzing (Austria), Cordenka (Germany), Aditya Birla (India), and Daicel (Japan). Examples of regenerated cellulose fibers include, but are not limited to, rayon, viscose, viscose rayon, lyocell, and the like.

In other embodiments, filter materials of the present disclosure may comprise hemp fibers. It should be noted that the filter materials may comprise solely hemp fibers or the hemp fibers may be combined with one or more other fiber inputs as described herein. Hemp fibers are widely considered one of the strongest members of the bast natural fibers family, which are derived from the hemp plant belonging to the *Cannabis* plant species. Hemp-based fibers are used widely in composite materials and paper-like materials due to their high biodegradability and low density as compared to many artificial fibers. An example method for the separation and extraction of hemp fibers is provided in U.S. Pat. No. 8,591,701 to Sung et al., which is incorporated herein by reference. The manner in which the hemp fibers are prepared is not limiting and can include any methods commonly known in the art. In some embodiments, reconstituted hemp, and in particular sheets of reconstituted hemp, may be incorporated into the filter materials described herein.

In some embodiments, filter materials of the present disclosure may comprise reconstituted tobacco materials. It should be noted that the filter materials may comprise solely reconstituted tobacco materials or the reconstituted tobacco materials may be combined with one or more other fiber inputs as described herein. Tobacco reconstitution processes traditionally convert portions of tobacco that normally might be wasted into commercially useful forms. For example, tobacco stems, pieces of tobacco scrap and tobacco dust can be used to manufacture reconstituted tobaccos of fairly uniform consistency. The precise amount of each type of tobacco within a tobacco blend used for the manufacture of a particular cigarette brand varies from brand to brand. See, for example, *Tobacco Encyclopedia,* Voges (Ed.) p. 44-45 (1984), Browne, *The Design of Cigarettes,* 3rd Ed., p.43 (1990) and *Tobacco Production, Chemistry and Technology,* Davis et al. (Eds.) p. 346 (1999). Reconstituted tobacco materials, and sheets of reconstituted tobacco in particular, are commonly used in the tobacco industry for preparing wrapping materials or tipping materials in conventional cigarette rods. Such reconstituted tobacco sheet materials and methods of forming such sheet materials are described in U.S. Pat. Nos. 6,705,325 to Hicks et al.; 6,827,087 to Wanna et al.; and U.S. Patent Application Publication Nos. 2004/0177856 to Monsalud, Jr. et al. and 2005/0056294 to Wanna et al., which are all incorporated herein by reference.

In some embodiments, the filter material may comprise one or more coatings, fillers, binders, additives, and/or other components. In such embodiments, the filter material may comprise both the plurality of fibers and one or more coatings, fillers, binders, additives, surface treatments, or other materials applied thereto or incorporated therein. One such coating may be, for example, a plasticizer such as triacetin which is normally applied to conventional filter materials in traditional amounts using known techniques. In some embodiments, the filter material may comprise a binder. Example binder materials include, but are not limited to, polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof. In other instances, the material applied to the filter material may be applied in liquid form, and may comprise such substances as, for example, the aforementioned triacetin, carbowax, flavoring compounds, propylene glycol, tri-ethyl-citrate, or any other suitable substance. Further, in this regard, each coating, filler, or other component applied to the filter material may contribute some functionality or property to the formed filter rod portion, such as, for example, smoke filtering, smoke taste, water dispersibility, biodegradability, and/or compostability.

As noted herein, the fiber inputs used for forming filter materials of the present disclosure (e.g., the regenerated cellulose, hemp, sisal, kenaf, esparto, flax, jute, wood, reconstituted tobaccos, and combinations thereof) are typically in continuous filament form and can have varying denier per filament, i.e., “dpf”. Denier per filament is a measurement of the weight per unit length of the individual filaments of the fibers and can be manipulated to achieve a desired pressure drop across the filter material or filter element produced from the fibers. An exemplary dpf range for the filaments comprising the fiber inputs can be about 1 dpf to about 30 dpf (e.g., about 1 dpf to about 25 dpf, about 1 to about 15 dpf, about 1 dpf to about 10 dpf, or about 1 dpf to about 5 dpf) where denier is expressed in units of grams / 9000 meters, although larger and smaller filaments can be used without departing from the present disclosure. In some embodiments, filter materials prepared according to the present disclosure may have a dpf of about 30 dpf or less, about 20 dpf or less, about 10 dpf or less, about 5 dpf or less, about 2.5 dpf or less, or about 1.5 dpf or less.

Some aspects of the present disclosure provide methods for forming filter materials suitable for use as a filter element in a smoking article. In some embodiments, such methods comprise forming a nonwoven web of sheet-like material from a plurality of fibers. In other embodiments, the disclosed methods may comprise receiving an already formed nonwoven web of sheet-like material including the plurality of fibers. In some embodiments, the plurality of fibers may comprise regenerated cellulose fibers, hemp fibers, sisal fibers, kenaf fibers, esparto fibers, wood fibers, flax fibers, jute fibers, reconstituted tobacco, and combinations thereof. The term “nonwoven” is used herein in reference to fibrous materials, webs, mats, batts, or sheets in which fibers are aligned in an undefined or random orientation. The nonwoven fibers are initially presented as unbound fibers or filaments. An important step in the manufacturing of nonwovens involves binding the various fibers or filaments together. The manner in which the fibers or filaments are bound can vary, and include thermal, mechanical and chemical techniques that are selected in part based on the desired characteristics of the final filter material.

Nonwoven sheet-like materials as described herein may be produced by conventional methods of forming that include drylaid, or airlaid, or wetlaid processing. It is known in the industry that the terms drylaid, airlaid or wetlaid, which may be rendered as dry-laid, air-laid or wet-laid, are broad in meaning and that each incorporates a variety of equipment, processes and means. The use of drylaid, airlaid, and wetlaid are not limiting and each do not define a single process for means of manufacturing.

The term “airlaid” as used herein, generally refers to a processes for producing a fibrous mat or batt using short or long staple fibers, or blends of the same. In this process, air is used to transfer the fibers from the fiber opening and aligning section of the process and to then to convey those fibers to a forming surface where the fibrous mat or batt is collected and then subjected to a further step of bonding or consolidating to produce an airlaid nonwoven material.

The term “drylaid” as used herein, generally refers to a process for producing a fibrous mat or batt by a process using mechanical fiber opening and alignment, such as carding, where the fibrous mat or batt is transferred by mechanical rather than by means of air to a conveyor surface, where the fibrous mat or batt is then subjected to a further step of bonding or consolidating to produce a drylaid nonwoven material.

The term “wetlaid” as used herein, generally refers to a process for producing a fibrous sheet through means similar to paper making where the fibers are suspended in an aqueous medium and the web is formed by filtering the suspension on a conveyor belt or perforated drum. Depending on the end use application and fibers used to produce the nonwoven material, some means of bonding or consolidating may be required to achieve final properties in the wetlaid nonwoven material.

In other embodiments, nonwoven sheet-like material as described herein may be produced using alternative methods, e.g., such as mechanical, thermal, or adhesive bonding or forming techniques. For example, mechanical means rely on creating entanglements between and among fibers to produce desired physical properties, where needlepunch and hydroentangling are nonexclusive examples of those means. Other examples of alternative forming techniques include, but are not limited to, spun-bonding, melt-blowing, spun-lacing, carding, point-bonding, spinning, and the like.

In various embodiments, the formed nonwoven material can be processed to provide a filter material suitable for use in a filter element for a smoking article as described herein. For example, in some embodiments, the nonwoven web of sheet-like material can be passed through a web preforming unit and pleated to form a rod-like element comprising a plurality of pleats. See, for example, the filters, apparatuses and methods discussed in U.S. Pat. No. 4,807,809 to Pryor et al., herein incorporated by reference in its entirety.

The rod-like element can then be circumscribed with wrapping material thereby forming a continuous rod that can be used as a filter element or a segment of a filter element, for example. The width of the sheet-like material can vary and typically is a width capable of being pleated to form the rod. The total width of the strip employed in providing a desired rod can depend upon factors such as the thickness of the sheet-like material, the number of pleats desired, the nature or character of the pleats produced, the surface character of the material (i.e., a fibrous surface character versus a smooth surface), the porosity of the material, the moisture content of the material, the lubricity properties of the material, the friction characteristics of the web preforming apparatus relative to the sheet-like material, and other such factors. In some embodiments, for example, the nonwoven sheet-like material may have a width in the range of about 110 mm to about 160 mm, about 115 mm to about 150 mm, or about 120 mm to about 140mm.

In some embodiments, the nonwoven sheet-like material may optionally be subjected to a crimping step. “Crimp” is texture or waviness of individual fibers or the nonwoven sheet-like material as a whole. Crimp amplitude or depth, which is reported in terms of the amplitude or depth of a single crimp in microns, is an indirect measure of the degree of crimp applied to the nonwoven sheet-like material. In some embodiments, crimping can generally involve passing the nonwoven sheet-like material through one or more crimping or embossing rollers causing the nonwoven sheet-like material to buckle, providing a crimped nonwoven sheet. Typically, the nonwoven sheet-like material is passed through the crimping or embossing rollers at a specific depth in order to achieve the desired crimp amplitude/depth in the crimped nonwoven sheet. Various crimp levels can be provided or the nonwoven sheet-like material may not be crimped in some embodiments. For example, in some embodiments, the crimp amplitude/depth may be in the range of about 1 micron to about 180 microns, about 1 micron to about 150 microns, about 75 microns to about 150 microns, or about 50 microns to about 100 microns.

Several characteristics known in the art can be used to characterize the web of sheet-like material (i.e., paper). Basis weight and caliper are two parameters used to characterize paper. In some embodiments, the basis weights of paper comprising tobacco pulp described herein can range from about 20 to about 90 g/m^2, about 40 to about 80 g/m^2, or about 50 to about 70 g/m^2. The caliper of nonwoven sheet-like material described herein can range from about 0.01 to about 4.0 mils, or about 0.01 to about 1.0 mils, or about 0.01 to about 0.5 mils, for example.

Preferred nonwovens and sheet-like materials are thin, and have reasonably high tensile strengths, resiliencies and relatively good flexibilities. In particular, it is desirable that the web have a good "hand" to hold a fold but not tear, crinkle, shatter or otherwise break during the folding or pleating process. It is desirable that the modulus of the web be such that pleating readily occurs. In particular, the web should not be so hard that it does not pleat, nor should the web be so soft that rods of poor resiliency are provided. As such, the rod-like element of pleated web can be provided at a high speed and can be enclosed within the outer wrapping material.

In some embodiments, a plasticizer and/or binder may be applied to the nonwoven sheet before, during, or after formation thereof. In some embodiments, the plasticizer and/or binder may be added to the pleated nonwoven sheet during rod formation to provide the desired sensory characteristics and/or to improve smoke chemistry. The plasticizer, which can in some embodiments comprise triacetin and/or carbowax as noted herein, may be applied to the nonwoven sheet in traditional amounts using known techniques. In some embodiments, the plasticizer and/or binder may be applied to the nonwoven sheet in an amount of about 0.1% to about 30% by weight, based on the total weight of the nonwoven sheet. In certain embodiments, the plasticizer and/or binder may be applied to the nonwoven sheet in an amount of about 1% to about 20% by weight, about 3% to about 15% by weight, or about 6% to about 12% by weight, based on the total weight of the nonwoven sheet. For example, the plasticizer and/or binder may be applied to the nonwoven sheet in an amount of at least about 2%, at least about 4%, at least about 6%, at least about 8%, at least about 10%, at least about 12%, at least about 14%, at least about 16%, or at least about 18% by weight, based on the total weight of the nonwoven sheet. Other suitable materials 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, US Patent No. 5,387,285 to Rivers, which is incorporated herein by reference.

In some aspects, the present disclosure provides a method for forming a filter material suitable for use in a filter element for a smoking article. In some embodiments, such methods may comprise forming a fibrous tow comprising a plurality of fibers, for example, rather than forming a nonwoven sheet-like material as described previously herein. In other embodiments, the disclosed methods may comprise receiving an already formed fibrous tow comprising the plurality of fibers. A "tow fiber" or "fibrous tow", as used herein, refers to a substantially untwisted bundle of two or more substantially continuous filaments of a fiber, e.g., a plurality of fibers. The material composition of the plurality of fibers forming the fibrous tow may vary depending on the desired characteristics of the filter element to be produced from the fibrous tow. In some embodiments, the plurality of fibers forming the fibrous tow may be selected from the group consisting of regenerated cellulose, hemp, sisal, kenaf, esparto, wood, flax, jute, reconstituted tobacco, and combinations thereof.

Generally, such methods may optionally comprise the additional steps of blending the plurality of fibers to form a mixed fiber blend; drawing the mixed fiber blend to reduce the denier per filament of the fibers of the mixed fiber blend and form a drawn fiber blend; and crimping the drawn fiber blend to form a mixed fiber tow. The method can include further steps, such as incorporating the mixed fiber tow into a filter element suitable for use in a smoking article, which will typically entail one or more of blooming the mixed fiber tow and applying a plasticizer to the mixed fiber tow.

The plurality of fibers is typically undrawn or partially drawn prior to said blending step so that the fibers will not have a tendency to break during the subsequent drawing step. The arrangement of the plurality of fibers within the mixed fiber blend can vary. In certain embodiments, the longitudinal axes of the plurality of fibers in the mixed fiber blend are disposed substantially parallel to each other. In another embodiment, the plurality of fibers of the mixed fiber blend are arranged such that the fibers are one of alternatingly disposed and substantially uniformly interspersed with respect to each other, over a cross-section of the mixed fiber blend.

As noted herein, once the once the plurality of fibers have been combined into a mixed fiber blend, the mixed fiber blend can then be drawn and crimped to form a mixed fiber tow. The drafting or drawing process generally results in reducing the weight/yard of a fiber bundle and increasing its length. In such instances, depending, for example, on the extent of the drawing process for the mixed fiber blend, the component yarns can be provided in a slightly higher denier per filament so as to facilitate the achievement of the desired total denier and denier per filament of the mixed fiber tow following the drawing process. It may also be desirable for the mixed fiber blend to be heated prior to and/or during the drawing process so as to facilitate drawing of the fibers therein.

A typical drawing process consists of multiple drawing stages using equipment known in the art. In one embodiment, the mixed fiber blend is withdrawn from a creel and passed through several draw stands, each consisting of several rollers that apply tension to the fiber blend. In between the draw stands, the fiber blend can pass through a heated water bath, a steam chest, heated rolls, or combinations thereof. The number of draw stands can vary, but 2 to 4 draw stands are used in a typical drawing process.

Following drawing, the mixed fiber blend may optionally be subjected to a crimping step. “Crimp” is texture or waviness of individual fibers or the mixed fiber blend as a whole. Crimp amplitude or depth, which is reported in terms of the amplitude/depth of a single crimp in microns, is an indirect measure of the degree of crimp applied to the mixed fiber blend. In some embodiments, crimping can generally involve passing the fiber bundle through rollers and into a “stuffing box” or “stuffer box,” wherein friction generates pressure, causing the fibers to buckle. Various crimp levels can be provided or the mixed fiber blend may not be crimped in some embodiments. For example, in some embodiments, the crimp width may be in the range of about 1 micron to about 180 microns, about 1 micron to about 150 microns, about 75 microns to about 150 microns, or about 50 microns to about 100 microns.

Once the mixed fiber tow is drawn and optionally crimped, the drawn and optionally crimped mixed fiber tow can be processed into a filter element of a smoking article in a similar manner to conventional cellulose acetate tow. For example, the mixed fiber tow can be bloomed to form the filter element of the smoking article, wherein the blooming process can also involve or otherwise be associated with a plasticizing process in which a suitable plasticizer, such as triacetin, carbowax and/or triethyl citrate, is applied to the bloomed mixed fiber tow. Other suitable materials 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, US Patent No. 5,387,285 to Rivers, which is incorporated herein by reference.

The plasticized fiber product can then be subjected to one or more rod making operations. Rod making operations can include shaping of the plasticized fiber product. For example, the plasticized fiber product can be compressed or otherwise shaped to form a continuous cylindrical rod shape. The rod making operations can optionally include cutting the plasticized fiber product into segments. In this regard, the plasticized fiber product can be longitudinally subdivided into cylindrical shaped filter segments. In some embodiments the length of the filter segments can be selected based on a desired length of the filter element for a single cigarette. By way of further example, in another embodiment the filter segments can be cut to lengths which are equivalent to two times the length of the filter element for a single cigarette, and the filter segment can be cut in two at a later time. For example, the filter segment can connect two rods of tobacco, and the filter segment can be divided to form the filters for two cigarettes.

Filter materials, filter elements, and filter rods for aerosol delivery devices that are produced in accordance with the present disclosure can be used to provide multi-segment filter rods. Such multi-segment filter rods can be employed for the production of filtered cigarettes possessing multi-segment filter elements. The production of multi-segment filter rods can be carried out using the types of rod-forming units that 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. 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 (i.e., pulp in esterified form), 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 US Patent 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 US Patent Nos. 4,807,809 to Pryor et al. and 5,025,814 to Raker; which are incorporated herein by reference.

Smoking articles incorporating filter elements produced in accordance with the present disclosure can be manufactured using traditional types of cigarette making techniques. For example, 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.; 6,229,115 to Vos et al.; 7,296,578 to Read, Jr.; and 7,434,585 to Holmes; each of which is incorporated herein by reference. The operation of those types of devices will be readily apparent to those skilled in the art of automated cigarette manufacture.

The dimensions of a representative smoking article according to the present disclosure can vary. In some embodiments, smoking articles according to the present disclosure are rod-shaped, and can have diameters of about 7.5 mm (e.g., circumferences of about 10 mm to about 35 mm, often about 16 mm to about 24 mm); and can have total lengths of about 60 mm to about 150 mm, often about 80 mm to about 144 mm. However, the lengths of the smoking article may vary. In some embodiments, for example, smoking articles according to the present disclosure can have total lengths of about 140 mm or less, about 100 mm or less, about 80 mm or less, about 60 mm or less, or about 40 mm or less. The length of the filter element can also vary. Typical filter elements can have total lengths of about 15 mm to about 40 mm, often about 20 mm to about 35 mm.

Certain filter elements and smoking articles prepared according to the methods of the present disclosure may exhibit desirable resistance to draw. For example, an exemplary smoking article including a filter element prepared according to the methods described herein exhibits a pressure drop of between about 40 mmWG and about 400 mmWG. In certain embodiments, smoking articles including filter elements prepared according to the methods described herein may exhibit pressure drop values of between about 100 mmWG and about 350 mmWG, about 150 mmWG to about 325 mmWG, or about 200 mmWG to about 300 mmWG. Typically, pressure drop values of smoking articles are measured using a Filtrona Quality Test Modules (QTM Series) available from Filtrona Instruments and Automation Ltd.

Filter elements formed according to the invention typically exhibit a hardness that is comparable or even increase as compared to filter elements made from conventional cellulose acetate tow. Filter hardness is a measurement of the compressibility of the filter material. A test instrument that can be used for harness testing is a D61 Automatic Hardness Tester available from Sodim SAS. This instrument applies a constant load (e.g., 300 g) to the sample for a fixed period of time (e.g., 3 to 5 seconds) and digitally displays the compression value as a percentage difference in the average diameter of the filter element. In certain embodiments, filter elements prepared according to the present disclosure can exhibit a hardness in the range of about 70% to about 99%. In some embodiments, filter elements prepared according to the present disclosure can exhibit a hardness of about 75% or higher, about 80% or higher, about 85% or higher, or about 90% or higher. Testing procedures for cigarette filter hardness are described, for example, in in US Pat. Nos. 3,955,406 to Strydom and 4,232,130 to Baxter et al., both of which are incorporated by reference herein.

FIG. 1 illustrates an exploded view of a smoking article in the form of a cigarette **100** that can be produced by the apparatuses, systems, and methods disclosed herein. The cigarette **100** includes a generally cylindrical rod **102** containing a charge or roll of smokable filler material contained in a circumscribing wrapping material **104**. 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 **106** (e.g., a printed coating including a film-forming agent, such as starch, ethylcellulose, or sodium alginate) applied to the wrapping material **104**, and that band circumscribes the cigarette rod **102** in a direction transverse to the longitudinal axis of the cigarette **100**. That is, the band **106** provides a cross-directional region relative to the longitudinal axis of the cigarette **100**. The band **106** can be printed on the inner surface of the wrapping material **104** (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.

At one end of the tobacco rod **102** is the lighting end **108**, and at the mouth end **110** is positioned a filter element **112** (e.g., including one or more segments of a filter material as disclosed herein). The filter element **112** can be produced according to the methods described in the present disclosure. The filter element **112** can have a generally cylindrical shape, and the diameter thereof can be essentially equal to the diameter of the tobacco rod **102**. The filter element **112** is circumscribed along its outer circumference or longitudinal periphery by a layer of outer plug wrap **114** to form a filter element. The filter element is positioned adjacent one end of the tobacco rod **102** such that the filter element and tobacco rod are axially aligned in an end-to-end relationship, preferably abutting one another. The ends of the filter element permit the passage of air and smoke therethrough.

A ventilated or air diluted smoking article can be provided with an optional air dilution means, such as a series of perforations **116**, each of which extend through the tipping material **118** and plug wrap **114**. The optional perforations **116** can 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 material). 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 is greater than about 10 percent, generally is greater than about 20 percent, often is greater than about 30 percent, and sometimes is greater than about 40 percent. Typically, the upper level for air dilution for an air diluted cigarette is 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. The filter element **112** can be attached to the tobacco rod **102** using the tipping material **118** (e.g., essentially air impermeable tipping material), that circumscribes both the entire length of the filter element and an adjacent region of the tobacco rod **102**. The inner surface of the tipping material **118** is fixedly secured to the outer surface of the plug wrap **114** and the outer surface of the wrapping material **104** of the tobacco rod **102**, using a suitable adhesive; and hence, the filter element and the tobacco rod are connected to one another to form the cigarette **100**.

It should be noted that the types of smoking articles described herein and depicted in the embodiments referred to above are not meant to be limiting of the present disclosure. In particular, filter materials and/or filter elements of the present disclosure may be incorporated into a variety of different smoking articles, including but not limited to, conventional cigarettes, heat-not-burn devices, tobacco heating products, electronic smoking articles, aerosol delivery devices, and the like. Some example of smoking articles that would be suitable for use with the filter materials and filter elements as described herein are set forth in US 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 smoking articles that have been commercially marketed under the brand names “Premier” and “Eclipse” by R. J. Reynolds Tobacco Company. See, for example, those types of smoking articles 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.

While the disclosed filter materials and filter elements are generally described herein above in terms of embodiments associated with smoking articles, it should be understood that the mechanisms, components, and features of such smoking articles may be embodied in many different forms and/or associated with a variety of smoking articles as would be understood by a person of ordinary skill in the art. For example, the filter materials and filter elements provided herein may be employed in conjunction with embodiments of traditional smoking articles (e.g., cigarettes, cigars, pipes, etc.), heat-not-burn cigarettes, electronic smoking articles, aerosol delivery devices, and the like. Accordingly, it should be understood that use of various filter materials and filter elements with smoking articles as described herein above are discussed in terms of embodiments relating to smoking articles by way of example only, and such filter materials and filter elements may be embodied and used in various other products and devices.

Some embodiments of aerosol delivery devices according to the present disclosure use electrical energy to heat a material to form an inhalable substance (e.g., electrically heated tobacco products). Other embodiments of aerosol delivery devices according to the present disclosure use an ignitable heat source to heat a material (preferably without combusting the material to any significant degree) to form an inhalable substance (e.g., carbon heated tobacco products). Preferably, the material is heated without combusting the material to any significant degree. Components of such devices and systems have the form of articles that are sufficiently compact to be considered hand-held devices. That is, use of components of preferred aerosol delivery devices does not result in the production of smoke in the sense that aerosol results principally from by-products of combustion or pyrolysis of tobacco, but rather, use of those preferred systems results in the production of vapors resulting from volatilization or vaporization of certain components incorporated therein. In some example embodiments, components of aerosol delivery devices may be characterized as electronic cigarettes, and those electronic cigarettes may incorporate tobacco and/or components derived from tobacco, and hence deliver tobacco derived components in aerosol form.

Aerosol delivery devices and/or aerosol provision systems according to the disclosure may provide many of the sensations (e.g., inhalation and exhalation rituals, types of tastes or flavors, organoleptic effects, physical feel, use rituals, visual cues such as those provided by visible aerosol, and the like) of smoking a cigarette, cigar or pipe that is employed by lighting and burning tobacco (and hence inhaling tobacco smoke), without any substantial degree of combustion of any component thereof. For example, the user of an aerosol delivery device in accordance with some example embodiments of the present disclosure can hold and use that component much like a smoker employs a traditional type of smoking article, draw on one end of that piece for inhalation of aerosol produced by that piece, take or draw puffs at selected intervals of time, and the like.

Aerosol delivery devices and/or aerosol provision systems of the present disclosure may also be characterized as being vapor-producing articles or medicament delivery articles. Thus, such articles or devices may be adapted so as to provide one or more substances (e.g., flavors and/or pharmaceutical active ingredients) in an inhalable form or state. For example, inhalable substances may be substantially in the form of a vapor (i.e., a substance that is in the gas phase at a temperature lower than its critical point). Alternatively, inhalable substances may be in the form of an aerosol (i.e., a suspension of fine solid particles or liquid droplets in a gas). For purposes of simplicity, the term "aerosol" as used herein is meant to include vapors, gases and aerosols of a form or type suitable for human inhalation, whether or not visible, and whether or not of a form that might be considered to be smoke-like. The physical form of the inhalable substance is not necessarily limited by the nature of the inventive devices but rather may depend upon the nature of the medium and the inhalable substance itself as to whether it exists in a vapor state or an aerosol state. In some embodiments, the terms "vapor" and "aerosol" may be interchangeable. Thus, for simplicity, the terms "vapor" and "aerosol" as used to describe aspects of the disclosure are understood to be interchangeable unless stated otherwise.

In some embodiments, aerosol delivery devices and/or aerosol provision systems of the present disclosure may comprise some combination of a power source (e.g., an electrical power source), a control component (e.g., means for actuating, controlling, regulating and ceasing power for heat generation, such as by controlling electrical current flow from the power source to other components of the article, e.g., a microprocessor, individually or as part of a microcontroller), a heat source (e.g., an electrical resistance heating element or other component and/or an inductive coil or other associated components and/or one or more radiant heating elements), a filter material as described herein, and an aerosol generating component that includes a substrate portion capable of yielding an aerosol upon application of sufficient heat. Note that it is possible to physically combine one or more of the above-noted components. For instance, in certain embodiments, a conductive heater trace can be printed on the surface of a substrate material (e.g., a cellulosic film) using a conductive ink such that the heater trace can be powered by the power source and used as the resistance heating element. Example conductive inks include graphene inks and inks containing various metals, such as inks including silver, gold, palladium, platinum, and alloys or other combinations thereof (e.g., silver-palladium or silver-platinum inks), which can be printed on a surface using processes such as gravure printing, flexographic printing, off-set printing, screen printing, ink-jet printing, or other appropriate printing methods.

In various embodiments, a number of these components may be provided within an outer body or shell, which, in some embodiments, may be referred to as a housing. The overall design of the outer body or shell may vary, and the format or configuration of the outer body that may define the overall size and shape of the aerosol delivery device may vary. Although other configurations are possible, in some embodiments an elongated body resembling the shape of a cigarette or cigar may be a formed from a single, unitary housing or the elongated housing can be formed of two or more separable bodies. For example, an aerosol delivery device may comprise an elongated shell or body that may be substantially tubular in shape and, as such, resemble the shape of a conventional cigarette or cigar. In one example, all of the components of the aerosol delivery device are contained within one housing or body. In other embodiments, an aerosol delivery device may comprise two or more housings that are joined and are separable. For example, an aerosol delivery device may possess at one end a control body comprising a housing containing one or more reusable components (e.g., an accumulator such as a rechargeable battery and/or rechargeable supercapacitor, and various electronics for controlling the operation of that article), and at the other end and removably coupleable thereto, an outer body or shell containing a disposable portion (e.g., a disposable flavor-containing aerosol generating component).

In other embodiments, aerosol delivery devices and/or aerosol provision systems of the present disclosure may generally include an ignitable heat source configured to heat a substrate material. The substrate material and/or at least a portion of the heat source may be covered in an outer wrap, or wrapping, a casing, a component, a module, a member, or the like. The overall design of the enclosure is variable, and the format or configuration of the enclosure that defines the overall size and shape of the aerosol generating component is also variable. Although other configurations are possible, it may be desirable, in some aspects, that the overall design, size, and/or shape of these embodiments resemble that of a conventional cigarette or cigar. In various aspects, the heat source may be capable of generating heat to aerosolize a substrate material that comprises, for example, a substrate material associated with an aerosol forming material, an extruded structure and/or substrate, tobacco and/or a tobacco related material, such as a material that is found naturally in tobacco that is isolated directly from the tobacco or synthetically prepared, in a solid or liquid form (e.g., beads, sheets, shreds, a wrap), or the like.

More specific formats, configurations and arrangements of various substrate materials, aerosol generating components, and components within aerosol delivery devices of the present disclosure will be evident in light of the further disclosure provided hereinafter. Additionally, the selection of various aerosol delivery device components may be appreciated upon consideration of the commercially available electronic aerosol delivery devices. Further, the arrangement of the components within the aerosol delivery device may also be appreciated upon consideration of the commercially available electronic aerosol delivery devices.

In this regard, FIG. 2 illustrates an aerosol delivery device **200** according to an example embodiment of the present disclosure. The aerosol delivery device **200** may include a control body **202** and an aerosol generating component **204**. In various embodiments, the aerosol generating component **204** and the control body **202** may be permanently or detachably aligned in a functioning relationship. In this regard, FIG. 2 illustrates the aerosol delivery device **200** in a coupled configuration, whereas FIG. 3 illustrates the aerosol delivery device **200** in a decoupled configuration. Various mechanisms may connect the aerosol generating component **204** to the control body **202** to result in a threaded engagement, a press-fit engagement, an interference fit, a sliding fit, a magnetic engagement, or the like.

In various embodiments, the aerosol delivery device **200** according to an example embodiment of the present disclosure may have a variety of overall shapes, including, but not limited to an overall shape that may be defined as being substantially rod-like or substantially tubular shaped or substantially cylindrically shaped. In the embodiments of FIGS. 2-3, the device **200** has a substantially round cross-section; however, other cross-sectional shapes (e.g., oval, square, triangle, etc.) also are encompassed by the present disclosure. For example, in some embodiments one or both of the control body **202** or the aerosol generating component **204** (and/or any subcomponents) may have a substantially rectangular shape, such as a substantially rectangular cuboid shape. In other embodiments, one or both of the control body **202** or the aerosol generating component **204** (and/or any subcomponents) may have other hand-held shapes. For example, in some embodiments the control body **202** may have a small box shape, various pod mod shapes, or a fob-shape. Thus, such language that is descriptive of the physical shape of the article may also be applied to the individual components thereof, including the control body **202** and the aerosol generating component **204**.

Alignment of the components within the aerosol delivery device of the present disclosure may vary across various embodiments. In some embodiments, the substrate portion may be positioned proximate a heat source so as to maximize aerosol delivery to the user. Other configurations, however, are not excluded. Generally, the heat source may be positioned sufficiently near the substrate portion so that heat from the heat source can volatilize the substrate portion (as well as, in some embodiments, one or more flavorants, active ingredients, or the like that may likewise be provided for delivery to a user) and form an aerosol for delivery to the user. When the heat source heats the substrate portion, an aerosol is formed, released, or generated in a physical form suitable for inhalation by a consumer. It should be noted that the foregoing terms are meant to be interchangeable such that reference to release, releasing, releases, or released includes form or generate, forming or generating, forms or generates, and formed or generated. Specifically, an inhalable substance is released in the form of a vapor or aerosol or mixture thereof, wherein such terms are also interchangeably used herein except where otherwise specified.

As noted above, the aerosol delivery device **200** of various embodiments may incorporate a battery and/or other electrical power source to provide current flow sufficient to provide various functionalities to the aerosol delivery device, such as powering of the heat source, powering of control systems, powering of indicators, and the like. As will be discussed in more detail below, the power source may take on various embodiments. Preferably, the power source may be able to deliver sufficient power to rapidly activate the heat source to provide for aerosol formation and power the aerosol delivery device through use for a desired duration of time. In some embodiments, the power source is sized to fit conveniently within the aerosol delivery device so that the aerosol delivery device can be easily handled. Examples of useful power sources include lithium-ion batteries that are preferably rechargeable (e.g., a rechargeable lithium-manganese dioxide battery). In particular, lithium polymer batteries can be used as such batteries can provide increased safety. Other types of batteries – e.g., N50-AAA CADNICA nickel-cadmium cells – may also be used. Additionally, a preferred power source is of a sufficiently light weight to not detract from a desirable smoking experience. Some examples of possible power sources are described in U.S. Pat. No. 9,484,155 to Peckerar et al., and U.S. Pat. App. Pub. No. 2017/0112191 to Sur et al., the disclosures of which are incorporated herein by reference in their respective entireties.

In specific embodiments, one or both of the control body **202** and the aerosol generating component **204** may be referred to as being disposable or as being reusable. For example, the control body **202** may have a replaceable battery or a rechargeable battery, solid-state battery, thin-film solid-state battery, rechargeable supercapacitor or the like, and thus may be combined with any type of recharging technology, including connection to a wall charger, connection to a car charger (i.e., cigarette lighter receptacle), and connection to a computer, such as through a universal serial bus (USB) cable or connector (e.g., USB 2.0, 3.0, 3.1, USB Type-C), connection to a photovoltaic cell (sometimes referred to as a solar cell) or solar panel of solar cells, a wireless charger, such as a charger that uses inductive wireless charging (including for example, wireless charging according to the Qi wireless charging standard from the Wireless Power Consortium (WPC)), or a wireless radio frequency (RF) based charger. An example of an inductive wireless charging system is described in U.S. Pat. App. Pub. No. 2017/0112196 to Sur et al., which is incorporated herein by reference in its entirety. Further, in some embodiments, the aerosol generating component **204** may comprise a single-use device. A single use component for use with a control body is disclosed in U.S. Pat. No. 8,910,639 to Chang et al., which is incorporated herein by reference in its entirety.

In further embodiments, the power source may also comprise a capacitor. Capacitors are capable of discharging more quickly than batteries and can be charged between puffs, allowing the battery to discharge into the capacitor at a lower rate than if it were used to power the heat source directly. For example, a supercapacitor – e.g., an electric double-layer capacitor (EDLC) – may be used separate from or in combination with a battery. When used alone, the supercapacitor may be recharged before each use of the article. Thus, the device may also include a charger component that can be attached to the smoking article between uses to replenish the supercapacitor.

Further components may be utilized in the aerosol delivery device of the present disclosure. For example, the aerosol delivery device may include a flow sensor that is sensitive either to pressure changes or air flow changes as the consumer draws on the article (e.g., a puff-actuated switch). Other possible current actuation/deactuation mechanisms may include a temperature actuated on/off switch or a lip pressure actuated switch. An example mechanism that can provide such puff-actuation capability includes a Model 163PC01D36 silicon sensor, manufactured by the MicroSwitch division of Honeywell, Inc., Freeport, Ill. Representative flow sensors, current regulating components, and other current controlling components including various microcontrollers, sensors, and switches for aerosol delivery devices are described in U.S. Pat. No. 4,735,217 to Gerth et al., U.S. Pat. Nos. 4,922,901, 4,947,874, and 4,947,875, all to Brooks et al., U.S. Pat. No. 5,372,148 to McCafferty et al., U.S. Pat. No. 6,040,560 to Fleischhauer et al., U.S. Pat. No. 7,040,314 to Nguyen et al., and U.S. Pat. No. 8,205,622 to Pan, all of which are incorporated herein by reference in their entireties. Reference is also made to the control schemes described in U.S. Pat. No. 9,423,152 to Ampolini et al., which is incorporated herein by reference in its entirety.

In another example, an aerosol delivery device may comprise a first conductive surface configured to contact a first body part of a user holding the device, and a second conductive surface, conductively isolated from the first conductive surface, configured to contact a second body part of the user. As such, when the aerosol delivery device detects a change in conductivity between the first conductive surface and the second conductive surface, a vaporizer is activated to vaporize a substance so that the vapors may be inhaled by the user holding unit. The first body part and the second body part may be a lip or parts of a hand(s). The two conductive surfaces may also be used to charge a battery contained in the personal vaporizer unit. The two conductive surfaces may also form, or be part of, a connector that may be used to output data stored in a memory. Reference is made to U.S. Pat. No. 9,861,773 to Terry et al., which is incorporated herein by reference in its entirety.

In addition, U.S. Pat. No. 5,154,192 to Sprinkel et al. discloses indicators for smoking articles; U.S. Pat. No. 5,261,424 to Sprinkel, Jr. discloses piezoelectric sensors that can be associated with the mouth-end of a device to detect user lip activity associated with taking a draw and then trigger heating of a heating device; U.S. Pat. No. 5,372,148 to McCafferty et al. discloses a puff sensor for controlling energy flow into a heating load array in response to pressure drop through a mouthpiece; U.S. Pat. No. 5,967,148 to Harris et al. discloses receptacles in a smoking device that include an identifier that detects a non-uniformity in infrared transmissivity of an inserted component and a controller that executes a detection routine as the component is inserted into the receptacle; U.S.

Pat. No. 6,040,560 to Fleischhauer et al. describes a defined executable power cycle with multiple differential phases; U.S. Pat. No. 5,934,289 to Watkins et al. discloses photonic-optronic components; U.S. Pat. No. 5,954,979 to Counts et al. discloses means for altering draw resistance through a smoking device; U.S. Pat. No. 6,803,545 to Blake et al. discloses specific battery configurations for use in smoking devices; U.S. Pat. No. 7,293,565 to Griffen et al. discloses various charging systems for use with smoking devices; U.S. Pat. No. 8,402,976 to Fernando et al. discloses computer interfacing means for smoking devices to facilitate charging and allow computer control of the device; U.S. Pat. No. 8,689,804 to Fernando et al. discloses identification systems for smoking devices; and PCT Pat. App. Pub. No. WO 2010/003480 by Flick discloses a fluid flow sensing system indicative of a puff in an aerosol generating system; all of the foregoing disclosures being incorporated herein by reference in their entireties.

Further examples of components related to electronic aerosol delivery articles and disclosing materials or components that may be used in the present device include U.S. Pat. No. 4,735,217 to Gerth et al.; U.S. Pat. No. 5,249,586 to Morgan et al.; U.S. Pat. No. 5,666,977 to Higgins et al.; U.S. Pat. No. 6,053,176 to Adams et al.; U.S. Pat. No. 6,164,287 to White; U.S. Pat No. 6,196,218 to Voges; U.S. Pat. No. 6,810,883 to Felter et al.; U.S. Pat. No. 6,854,461 to Nichols; U.S. Pat. No. 7,832,410 to Hon; U.S. Pat. No. 7,513,253 to Kobayashi; U.S. Pat. No. 7,896,006 to Hamano; U.S. Pat. No. 6,772,756 to Shayan; U.S. Pat. Nos. 8,156,944 and 8,375,957 to Hon; U.S. Pat. No. 8,794,231 to Thorens et al.; U.S. Pat. No. 8,851,083 to Oglesby et al.; U.S. Pat. Nos. 8,915,254 and 8,925,555 to Monsees et al.; U.S. Pat. No. 9,220,302 to DePiano et al.; U.S. Pat. App. Pub. Nos. 2006/0196518 and 2009/0188490 to Hon; U.S. Pat. App. Pub. No. 2010/0024834 to Oglesby et al.; U.S. Pat. App. Pub. No. 2010/0307518 to Wang; PCT Pat. App. Pub. No. WO 2010/091593 to Hon; and PCT Pat. App. Pub. No. WO 2013/089551 to Foo, each of which is incorporated herein by reference in its entirety. Further, U.S. Pat. App. Pub. No. 2017/0099877 to Worm et al. discloses capsules that may be included in aerosol delivery devices and fob-shape configurations for aerosol delivery devices, and is incorporated herein by reference in its entirety. A variety of the materials disclosed by the foregoing documents may be incorporated into the present devices in various embodiments, and all of the foregoing disclosures are incorporated herein by reference in their entireties.

Referring to FIG. 3, in the depicted embodiment, the aerosol generating component **204** comprises a heated end **206**, which is configured to be inserted into the control body **202**, and a mouth end **208**, upon which a user draws to create the aerosol. At least a portion of the heated end **206** may include a substrate portion **210**. In some embodiments, the substrate portion **210** is loaded with the aerosol forming material. In various embodiments the substrate portion **210** may comprise various materials impregnated with the aerosol forming materials. In various embodiments, the aerosol generating component **204**, or a portion thereof, may be wrapped in an exterior overwrap material **212**. In various embodiments, the mouth end **208** of the aerosol generating component **204** includes a filter element **214** which may, for example, be made of at least one segment of a filter material as described herein above (i.e., comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, flax, jute, esparto, kenaf, wood fibers, reconstituted tobacco, and combinations thereof). In various embodiments, the filter element **214** may increase the structural integrity of the mouth end of the aerosol source member, and/or provide filtering capacity, if desired, and/or provide resistance to draw. In some embodiments, the filter element may comprise discrete segments as noted herein. For example, some embodiments may include a segment providing filtering, a segment providing draw resistance, a hollow segment providing a space for the aerosol to cool, a segment providing increased structural integrity, other filter segments, and any one or any combination of the above.

In some embodiments, the material of the exterior overwrap **212** may comprise a material that resists transfer of heat, which may include a paper or other fibrous material, such as a cellulose material. The exterior overwrap material may also include at least one filler material imbedded or dispersed within the fibrous material. In various embodiments, the filler material may have the form of water insoluble particles. Additionally, the filler material may incorporate inorganic components. In various embodiments, the exterior overwrap may be formed of multiple layers, such as an underlying, bulk layer and an overlying layer, such as a typical wrapping paper in a cigarette. Such materials may include, for example, lightweight "rag fibers" such as flax, hemp, sisal, rice straw, and/or esparto. The exterior overwrap may also include a material typically used in a filter element of a conventional cigarette, such as cellulose acetate. Further, an excess length of the exterior overwrap at the mouth end **208** of the aerosol generating component may function to simply separate the substrate portion **210** from the mouth of a consumer or to provide space for positioning of a filter material, as described below, or to affect draw on the article or to affect flow characteristics of the vapor or aerosol leaving the device during draw. Further discussions relating to the configurations for exterior overwrap materials that may be used with the present disclosure may be found in U.S. Pat. No. 9,078,473 to Worm et al., which is incorporated herein by reference in its entirety.

FIG. 4 illustrates a perspective schematic view of an aerosol generating component according to an example embodiment of the disclosure. In particular, FIG. 4 illustrates the aerosol generating component **204** having a substrate portion **210** that comprises a series of overlapping layers **230** of a substrate in sheet form **220**. With reference to the description above, in the depicted embodiment, the substrate sheet **220** comprises a film or layer as disclosed herein. In various embodiments, the term "overlapping layers" may also include bunched, crumpled, crimped, and/or otherwise gathered layers in which the individual layers may not be obvious.

FIG. 5 illustrates a schematic cross-section drawing of a substrate portion of an aerosol generating component according to an example embodiment of the present disclosure. In particular, FIG. 5 illustrates the substrate portion **210**, which comprises a series of overlapping layers **230** of the substrate sheet **220**. In the depicted embodiment, at least a portion of the overlapping layers **230** is substantially surrounded about its outer surface with a first cover layer **232**. Although in various embodiments the composition of the first cover layer **232** may vary, in the depicted embodiment the first cover layer **232** comprises a combination of a fibrous material, the aerosol forming materials, and a binder material. Reference is made to the discussions herein relating possible aerosol forming materials and binder materials. In various embodiments, the first cover layer **232** may be constructed via a casting process, such as that described in U.S. Pat. No. 5,697,385 to Seymour et al., the disclosure of which is incorporated herein by reference in its entirety.

In the depicted embodiment, at least a portion of the overlapping layers **230** and the first cover layer **232** are substantially surrounded about an outer surface with a second cover layer **234**. Although the composition of the second cover layer **234** may vary, in the depicted embodiment the second cover layer **234** comprises a metal foil material, such as an aluminum foil material. In other embodiments, the second cover layer may comprise other materials, including, but not limited to, a copper material, a tin material, a gold material, an alloy material, a ceramic material, or other thermally conductive amorphous carbon-based material, and/or any combinations thereof. The depicted embodiment further includes a third cover layer **236**, which substantially surrounds the overlapping layers **230**, first cover layer **232**, and the second cover layer **234**, about an outer surface thereof. In the depicted embodiment, the third cover layer **236** comprises a paper material, such as a conventional cigarette wrapping paper. In various embodiments, the paper material may comprise rag fibers, such as non-wood plant fibers, and may include flax, hemp, sisal, rice straw, and/or esparto fibers.

Referring back to FIG. 3, in various embodiments, other components may exist between the substrate portion **210** and the mouth end **208** of the aerosol generating component **204**. For example, in some embodiments one or any combination of the following may be positioned between the substrate portion **210** and the mouth end **208** of the aerosol generating component **204**: an air gap; a hollow tube structure; phase change materials for cooling air; flavor releasing media; ion exchange fibers capable of selective chemical adsorption; aerogel particles as filter medium; and other suitable materials. Some examples of possible phase change materials include, but are not limited to, salts, such as $AgNO_3$, $AlCl_3$, $TaCl_3$, $InCl_3$, $SnCl_2$, AlI_3, and TiI_4; metals and metal alloys such as selenium, tin, indium, tin-zinc, indium-zinc, or indium-bismuth; and organic compounds such as D-mannitol, succinic acid, p-nitrobenzoic acid, hydroquinone and adipic acid. Other examples are described in U.S. Pat. No. 8,430,106 to Potter et al., which is incorporated herein by reference in its entirety.

FIG. 6 illustrates a perspective view of an aerosol delivery device, according to another example embodiment of the present disclosure, and FIG. 7 illustrates a perspective view of the aerosol generating component of FIG. 6 with an outer wrap removed. In particular, FIG. 6 illustrates an aerosol delivery device **300** that includes an outer wrap **302**, and FIG. 7 illustrates the aerosol delivery device **300** wherein the outer wrap **302** is removed to reveal the other components of the aerosol delivery device **300**. In the depicted embodiment, the aerosol delivery device **300** of the depicted embodiment includes a heat source **304**, a substrate portion **310**, an intermediate component **308**, and a filter element **312**. In the depicted embodiment, the intermediate component **308** and the filter element **312** together comprise a mouthpiece **314**.

In various embodiments, the heat source **304** may be configured to generate heat upon ignition thereof. In the depicted embodiment, the heat source **304** comprises a combustible fuel element that has a generally cylindrical shape and that incorporates a combustible carbonaceous material. In other embodiments, the heat source **304** may have a different shape, for example, a prism shape having a triangular, cubic or hexagonal cross-section. Carbonaceous materials generally have a high carbon content. Certain example carbonaceous materials may be composed predominately of carbon, and/or typically may have carbon contents of greater than about 60 percent, generally greater than about 70 percent, often greater than about 80 percent, and frequently greater than about 90 percent, on a dry weight basis.

In some instances, the heat source **304** may incorporate elements other than combustible carbonaceous materials (e.g., tobacco components, such as powdered tobaccos or tobacco extracts; flavoring agents; salts, such as sodium chloride, potassium chloride and sodium carbonate; heat stable graphite fibers; iron oxide powder; glass filaments; powdered calcium carbonate; alumina granules; ammonia sources, such as ammonia salts; binding agents, such as guar gum, ammonium alginate and sodium alginate; and/or phase change materials for lowering the temperature of the heat source, described herein above). Although specific dimensions of an applicable heat source may vary, in some embodiments, the heat source **304** may have a length in an inclusive range of approximately 7 mm to approximately 20 mm, and in some embodiments may be approximately 17 mm, and an overall diameter in an inclusive range of approximately 3 mm to approximately 8 mm, and in some embodiments may be approximately 4.8 mm (and in some embodiments, approximately 7 mm). Although in other embodiments, the heat source may be constructed in a variety of ways, in the depicted embodiment, the heat source **304** is extruded or compounded using a ground or powdered carbonaceous material, and has a density that is greater than about 0.5 g/cm^3, often greater than about 0.7 g/cm^3, and frequently greater than about 1 g/cm^3, on a dry weight basis. See, for example, the types of fuel source components, formulations and designs set forth in U.S. Pat. No. 5,551,451 to Riggs et al. and U.S. Pat. No. 7,836,897 to Borschke et al., which are incorporated herein by reference in their entireties. Although in various embodiments, the heat source may have a variety of forms, including, for example, a substantially solid cylindrical shape or a hollow cylindrical (e.g., tube) shape, the heat source **304** of the depicted embodiment comprises an extruded monolithic carbonaceous material that has a generally cylindrical shape but with a plurality of grooves **316** extending longitudinally from a first end of the extruded monolithic carbonaceous material to an opposing second end of the extruded monolithic carbonaceous material. In some embodiments, the aerosol delivery device, and in particular, the heat source, may include a heat transfer component. In various embodiments, a heat transfer component may be proximate the heat source, and, in some embodiments, a heat transfer component may be located in or within the heat source. Some examples of heat transfer components are described in in U.S. Pat. App. Pub. No. 2019/0281891 to Hejazi et al., which is incorporated herein by reference in its entirety.

Although in the depicted embodiment, the grooves **316** of the heat source **304** are substantially equal in width and depth and are substantially equally distributed about a circumference of the heat source **304**, other embodiments may include as few as two grooves, and still other embodiments may include as few as a single groove. Still other embodiments may include no grooves at all. Additional embodiments may include multiple grooves that may be of unequal width and/or depth, and which may be unequally spaced around a circumference of the heat source. In still other embodiments, the heat source may include flutes and/or slits extending longitudinally from a first end of the extruded monolithic carbonaceous material to an opposing second end thereof. In some embodiments, the heat source may comprise a foamed carbon monolith formed in a foam process of the type disclosed in U.S. Pat. No. 7,615,184 to Lobovsky, which is incorporated herein by reference in its entirety. As such, some embodiments may provide advantages with regard to reduced time taken to ignite the heat source. In some other embodiments, the heat source may be co-extruded with a layer of insulation (not shown), thereby reducing manufacturing time and expense. Other embodiments of fuel elements include carbon fibers of the type described in U.S. Pat. No. 4,922,901 to Brooks et al. or other heat source embodiments such as is disclosed in U.S. Pat. App. Pub. No. 2009/0044818 to Takeuchi et al., each of which is incorporated herein by reference in its entirety.

Generally, the heat source is positioned sufficiently near a substrate portion carrying one or more aerosol forming materials so that the aerosol formed/volatilized by the application of heat from the heat source to the aerosol forming materials (as well as any flavorants, medicaments, and/or the like that are likewise provided for delivery to a user) is deliverable to the user by way of the mouthpiece. That is, when the heat source heats the substrate portion, an aerosol is formed, released, or generated in a physical form suitable for inhalation by a consumer. It should be noted that the foregoing terms are meant to be interchangeable such that reference to release, releasing, releases, or released includes form or generate, forming or generating, forms or generates, and formed or generated. Specifically, an inhalable substance is released in the form of a vapor or aerosol or mixture thereof.

Referring back to FIGS. 6 and 7, the outer wrap **302** may be provided to engage or otherwise join together at least a portion of the heat source **304** with the substrate portion **310** and at least a portion of the mouthpiece **314**. In various embodiments, the outer wrap **302** is configured to be retained in a wrapped position in any manner of ways including via an adhesive, or a fastener, and the like, to allow the outer wrap **302** to remain in the wrapped position. Otherwise, in some other aspects, the outer wrap **302** may be configured to be removable as desired. For example, upon retaining the outer wrap **302** in a wrapped position, the outer wrap **302** may be able to be removed from the heat source **304**, the substrate portion **310**, and/or the mouthpiece **314**.

In some embodiments, in addition to the outer wrap **302**, the aerosol delivery device may also include a liner that is configured to circumscribe the substrate portion **310** and at least a portion of the heat source **304**. Although in other embodiments the liner may circumscribe only a portion of the length of the substrate portion **310**, in some embodiments, the liner may circumscribe substantially the full length of the substrate portion **310**. In some embodiments, the outer wrap material **302** may include the liner. As such, in some embodiments the outer wrap material **302** and the liner may be separate materials that are provided together (e.g., bonded, fused, or otherwise joined together as a laminate). In other embodiments, the outer wrap **302** and the liner may be the same material. In any event, the liner may be configured to thermally regulate conduction of the heat generated by the ignited heat source **304**, radially outward of the liner. As such, in some embodiments, the liner may be constructed of a metal foil material, an alloy material, a ceramic material, or other thermally conductive amorphous carbon-based material, and/or an aluminum material, and in some embodiments may comprise a laminate. In some embodiments, depending on the material of the outer wrap **302** and/or the liner, a thin layer of insulation may be provided radially outward of the liner. Thus, the liner may advantageously provide, in some aspects, a manner of engaging two or more separate components of the aerosol delivery device **300** (such as, for example, the heat source **304**, the substrate portion **310**, and/or a portion of the mouthpiece **314**), while also providing a manner of facilitating heat transfer axially therealong, but restricting radially outward heat conduction.

As shown in FIG. 6, the outer wrap **302** (and, as necessary, the liner, and the substrate portion **310**) may also include one or more openings formed therethrough that allow the entry of air upon a draw on the mouthpiece **314**. In various embodiments, the size and number of these openings may vary based on particular design requirements. In the depicted embodiment, a plurality of openings **320** are located proximate an end of the substrate portion **310** closest to the heat source **304**, and a plurality of separate cooling openings **321** are formed in the outer wrap **302** (and, in some embodiments, the liner) in an area proximate the filter **312** of the mouthpiece **314**. Although other embodiments may differ, in the depicted embodiment, the openings **320** comprise a plurality of openings substantially evenly spaced about the outer surface of the aerosol delivery device **300**, and the openings **321** also comprise a plurality of openings substantially evenly spaced around the outer surface of the aerosol delivery device **300**. Although in various embodiments the plurality of openings may be formed through the outer wrap **302** (and, in some embodiments, the liner) in a variety of ways, in the depicted embodiment, the plurality of openings **320** and the plurality of separate cooling openings **321** are formed via laser perforation.

Referring back to FIG. 7, the aerosol delivery device **300** of the depicted embodiment also includes an intermediate component **308** and at least one filter element **312**. It should be noted that in various embodiments, the intermediate component **308** or the filter element **312**, individually or together, may be considered a mouthpiece **314** of the aerosol delivery device **300**. In the depicted embodiment, the intermediate component **308** comprises a hollow tube structure, and is included to add structural integrity to the aerosol delivery device **300** and provide for cooling the produced aerosol. In some embodiments, the intermediate component **308** may be used as a container for collecting the aerosol. In various embodiments, such a component may be constructed from any of a variety of materials and may include one or more adhesives. Example materials include, but are not limited to, paper, paper layers, paperboard, plastic, cardboard, and/or composite materials. In the depicted embodiment, the intermediate component **308** comprises a hollow cylindrical element constructed of a paper or plastic material (such as, for example, ethyl vinyl acetate (EVA), or other polymeric materials such as poly ethylene, polyester, silicone, etc. or ceramics (e.g., silicon carbide, alumina, etc.), or other acetate fibers), and the filter element comprises at least one segment of filter material as described herein above (e.g., a filter element comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, flax, sisal, jute, kenaf, wood, reconstituted tobacco, and combinations thereof).

As noted, in some embodiments the mouthpiece **314** may comprise a filter element **312** configured to receive the aerosol therethrough in response to the draw applied to the mouthpiece **314**. In various embodiments, the filter element **312** is provided, in some aspects, as a circular disc radially and/or longitudinally disposed proximate the second end of the intermediate component **308**. In this manner, upon draw on the mouthpiece **314**, the filter element **312** receives the aerosol flowing through the intermediate component **308** of the aerosol delivery device **300**. In some embodiments, the filter element **312** may comprise discrete segments. For example, some embodiments may include a segment providing filtering, a segment providing draw resistance, a hollow segment providing a space for the aerosol to cool, a segment providing increased structural integrity, other filter segments, and any one or any combination of the above.

In various embodiments the size and shape of the intermediate component **308** and/or the filter element **312** may vary, for example the length of the intermediate component **308** may be in an inclusive range of approximately 10 mm to approximately 30 mm, the diameter of the intermediate component **308** may be in an inclusive range of approximately 3 mm to approximately 8 mm, the length of the filter element **312** may be in an inclusive range of approximately 10 mm to approximately 20 mm, and the diameter of the filter element **312** may be in an inclusive range of approximately 3 mm to approximately 8 mm. In the depicted embodiment, the intermediate component **308** has a length of approximately 20 mm and a diameter of approximately 4.8 mm (and in some embodiments, approximately 7 mm), and the filter element **312** has a length of approximately 15 mm and a diameter of approximately 4.8 mm (or in some embodiments, approximately 7 mm).

In various embodiments, ignition of the heat source **304** results in aerosolization of the aerosol forming materials associated with the substrate portion **310**. In certain embodiments, the elements of the substrate portion **310** do not experience thermal decomposition (e.g., charring, scorching, or burning) to any significant degree, and the aerosolized components are entrained in the air that is drawn through the aerosol delivery device **300**, including the filter element **312**, and into the mouth of the user. In various embodiments, the mouthpiece **314** (e.g., the intermediate component **308** and/or the filter element **312**) is configured to receive the generated aerosol therethrough in response to a draw applied to the mouthpiece **314** by a user. In some embodiments, the mouthpiece **314** may be fixedly engaged to the substrate portion **310**. For example, an adhesive, a bond, a weld, and the like may be suitable for fixedly engaging the mouthpiece **314** to the substrate portion **310**. In one example, the mouthpiece **314** is ultrasonically welded and sealed to an end of the substrate portion **310**.

Although an aerosol delivery device and/or an aerosol provision system according to the present disclosure may take on a variety of embodiments, as discussed in detail above, the use of the aerosol delivery device and/or aerosol provision system by a consumer will be similar in scope. The foregoing description of use of the aerosol delivery device and/or aerosol provision system is applicable to the various embodiments described through minor modifications, which are apparent to the person of skill in the art in light of the further disclosure provided herein. The description of use, however, is not intended to limit the use of the articles of the present disclosure but is provided to comply with all necessary requirements of disclosure herein.

Many modifications and other embodiments of the disclosure will come to mind to one skilled in the art to which this disclosure pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the disclosure is not to be limited to the specific embodiments disclosed herein and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

EXPERIMENTAL

Aspects of the present invention are more fully illustrated by the following examples, which are set forth to illustrate certain aspects of the present invention and are not to be construed as limiting thereof.

Example 1

Testing was conducted to evaluate various properties (e.g., such as tensile strength, elongation, etc.) of filter materials formed of regenerated cellulose or hemp fibers as compared to conventional filter materials formed of cellulose acetate fibers. In addition, four different binder materials (e.g., including polyvinyl alcohol (PVOH), pectin, starch, and micro-fibrillated cellulose (MFC)) were evaluated in combination with each of the different fiber materials used.

Preparation of the filter materials required formation of a wet-laid nonwoven material according to conventional wet-laid papermaking techniques. Twelve different nonwoven materials (labeled samples “A-L” in Table 1 below) were prepared using a combination of one fiber species and one binder material. Three duplicative samples of each of the twelve nonwoven materials were prepared and the composition of each sample is discussed in more detail below.

Samples A1-A3 represent a wet-laid nonwoven material comprising about 95% cellulose acetate (“CA”) and about 4% polyvinyl alcohol (PVOH), each having a basis weight of 57.6 gsm, 62.3 gsm, and 62.7 gsm, respectively.

Samples B1-B3 represent a wet-laid nonwoven material comprising about 95% regenerated cellulose and about 4% polyvinyl alcohol (PVOH), each having a basis weight of 59.6 gsm, 64 gsm, and 62.7 gsm, respectively.

Samples C1-C3 represent a wet-laid nonwoven material comprising about 70% abaca hemp pulp, about 26% raw hemp fibers having lengths of about 20 mm, and about 4% polyvinyl alcohol (PVOH), each having a basis weight of 69 gsm, 61.2 gsm, and 63 gsm, respectively.

Samples D1-D3 represent a wet-laid nonwoven material comprising about 95% cellulose acetate (“CA”) and about 4% pectin, each having a basis weight of 61.5 gsm, 61.5 gsm, and 61.2 gsm, respectively.

Samples E1-E3 represent a wet-laid nonwoven material comprising about 95% regenerated cellulose and about 4% pectin, each having a basis weight of 58.9 gsm, 60.3 gsm, and 60.6 gsm, respectively.

Samples F1-F3 represent a wet-laid nonwoven material comprising about 70% abaca hemp pulp, about 26% raw hemp fibers having lengths of about 20 mm, and about 4% pectin, each having a basis weight of 61.3 gsm, 60.2 gsm, and 64.3 gsm, respectively.

Samples G1-G3 represent a wet-laid nonwoven material comprising about 95% cellulose acetate (“CA”) and about 4% starch, each having a basis weight of 61.23 gsm, 61.74 gsm, and 61.23 gsm, respectively.

Samples H1-H3 represent a wet-laid nonwoven material comprising about 95% regenerated cellulose and about 4% starch, each having a basis weight of 61.23 gsm, 58.28 gsm, and 58.54 gsm, respectively.

Samples I1-I3 represent a wet-laid nonwoven material comprising about 70% abaca hemp pulp, about 26% raw hemp fibers having lengths of about 20 mm, and about 4% starch, each having a basis weight of 61.2 gsm, 64.2 gsm, and 60.7 gsm, respectively.

Samples J1-J3 represent a wet-laid nonwoven material comprising about 95% cellulose acetate ("CA") and about 4% micro fibrillated cellulose (MFC), each having a basis weight of 61.5 gsm, 60.8 gsm, and 61.1 gsm, respectively.

Samples K1-K3 represent a wet-laid nonwoven material comprising about 95% regenerated cellulose and about 4% micro fibrillated cellulose (MFC), each having a basis weight of 58.6 gsm, 58.9 gsm, and 60.2 gsm, respectively.

Samples L1-L3 represent a wet-laid nonwoven material comprising about 70% abaca hemp pulp, about 26% raw hemp fibers having lengths of about 20 mm, and about 4% micro fibrillated cellulose (MFC), each having a basis weight of 58.9 gsm, 60.7 gsm, and 60.2 gsm, respectively.

After preparation of the samples, the samples were evaluated to determine their average tensile strength and average elongation. Average tensile strength was measured using ASTM D-4595-17 (Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method). Average elongation was measured using ASTM D-5034-21 (Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)). Results are shown in Table 1 below.

Table 1.

Label	Measured Basis Weight (GSM)	Average Tensile (lbs)	Average Elongation (in)	Standard Deviation Tensile	Standard Deviation Elongation	Description
A1	57.6	1.5	0.08	0.52	0.03	CA with PVOH
A2	62.3					
A3	62.7					
B1	59.6	4.7	0.09	1.66	0.03	Regenerated Cellulose with PVOH
B2	64					
B3	62.7					
C1	69	4.9	0.20	1.64	0.07	Hemp with PVOH
C2	61.2					
C3	63					
D1	61.5	1.7	0.07	0.60	0.03	CA with Pectin
D2	61.5					
D3	61.2					
E1	58.9	5.0	0.07	1.66	0.02	Regenerated Cellulose with Pectin
E2	60.3					
E3	60.6					
F1	61.3	4.8	0.26	1.61	0.09	Hemp with Pectin
F2	60.2					

Label	Measured Basis Weight (GSM)	Average Tensile (lbs)	Average Elongation (in)	Standard Deviation Tensile	Standard Deviation Elongation	Description
F3	64.3					
G1	61.23	0.7	0.11	0.23	0.07	CA with Starch
G2	61.74					
G3	61.23					
H1	61.23	2.6	0.09	0.90	0.03	Regenerated Cellulose with Starch
H2	58.28					
H3	58.54					
I1	61.2	2.7	0.22	0.96	0.08	Hemp with Starch
I2	64.2					
I3	60.7					
J1	61.5	0.6	0.17	0.20	0.06	CA with MFC
J2	60.8					
J3	61.1					
K1	58.6	0.7	0.17	0.22	0.07	Regenerated Cellulose with MFC
K2	58.9					
K3	60.2					
L1	58.9	2.5	0.18	0.85	0.06	Hemp with MFC
L2	60.7					
L3	60.2					

As shown in Table 1, the nonwoven materials formed of regenerated cellulose and hemp fibers generally exhibited higher tensile strength and elongation as compared to the nonwoven materials formed of cellulose acetate. Further, the nonwoven materials formed of hemp fibers generally also exhibited higher elongation as compared to the nonwoven materials formed of cellulose acetate. With respect to the addition of the binder materials, it should be noted that use of PVOH and pectin appeared to produce similar results and the measured tensile strength was significantly higher for samples including PVOH or pectin as the binder when compared to samples including starch or MFC as the binder. Finally, it should also be noted that use of pectin was observed to be more effective in increasing the tensile strength of the samples containing regenerated cellulose fibers, whereas use of PVOH was observed to be more effective in increasing the tensile strength of the samples containing hemp fibers. Although, the difference in effectiveness between PVOH and pectin was observed to be relatively minor.

<u>Example 2</u>

Trials were conducted to convert samples of wet-laid nonwoven materials into rod-like elements suitable for use as a filter element in a smoking article. First, sample wet-laid nonwoven materials were formed from a variety of different fiber inputs (e.g., including cellulose acetate, hemp, and reconstituted cellulose) using conventional wet-laid papermaking techniques. After formation of the nonwoven samples (10 samples per fiber input), each of the samples were optionally crimped/embossed and then gathered to form a rod-like element suitable for use as a filter element. The sample filter elements formed of cellulose acetate were treated as the control sample as they represent conventional cellulose acetate-based filters known in the art. Each sample filter element was then measured to determine the weight, circumference, and hardness. Hardness was measured using ASTM D2240 (Standard Test Method for Rubber Property—Durometer Hardness). Next, the pressure drop across each sample filter element was measured using ASTM D6830 (Standard Test Method for Characterizing the Pressure Drop and Filtration Performance of Cleanable Filter Media). Results are shown in Tables 2-7 below.

Table 2.

Cellulose acetate					
120mm WIDE		**Weight (g)**	**Circumference (mm)**	**PD Close (mmWG)**	**Hardness (%)**
No Crimp					
Sample 1		0.965	24.51	308	80.22
Sample 2		0.777	23.58	241	77.7
Sample 3		0.848	24.09	242	79.07
Sample 4		0.841	24.22	236	77.55
Sample 5		0.847	24.36	244	75.46
Sample 6		0.872	24.48	243	77.39
Sample 7		0.833	24.31	230	73.05
Sample 8		0.955	24.35	297	84
Sample 9		0.827	24.01	230	77.7
Sample 10		0.877	23.93	271	78.94
	Average	0.864 +/- 0.06	24.184 +/- 0.29	254.2 +/- 28.02	78.12 +/- 2.88

As shown in Table 2, the 10 control samples prepared from cellulose acetate (“CA”) filter materials exhibited an average pressure drop of about 254 mmWG and an average hardness of about 78%.

Table 3.

Hemp					
130mm WIDE		**Weight (g)**	**Circumference (mmWG)**	**PD Close (mmWG)**	**Hardness (%)**
121 microns crimp					
Sample 1		1.042	23.43	52	90.09
Sample 2		1.057	24.07	44	87.57
Sample 3		1.029	23.85	28	87.64
Sample 4		1.042	23.54	55	89.6
Sample 5		1.043	23.57	50	87.84
Sample 6		1.052	23.4	46	75.91
Sample 7		1.089	23.79	57	89.56
Sample 8		1.068	23.73	37	83.79
Sample 9		1.084	23.35	69	92.26
Sample 10		1.071	23.73	40	93.56
	Average	1.06 +/- 0.02	23.646 +/- 0.23	47.8 +/- 11.53	87.78 +/- 4.97

As shown in Table 3, ten sample filter rods were prepared from a filter material formed of hemp fibers. The filter material had a width of 130 mm and a crimp width of 121 microns. As shown in Table 3, the 10 samples prepared from hemp-based filter materials exhibited an average pressure drop of about 48 mmWG and an average hardness of about 88%. It should be noted that the pressure drop decreased as compared to the CA control filter rods; however, the average hardness increased significantly as compared to the CA control filter rods. Without intending to be bound by theory, it is hypothesized that the decreased pressure drop in the hemp filter samples was attributable to the high rigidity of the hemp materials which caused some difficulties in sufficiently forming a filter rod therefrom, which led to gaps in the hemp filter samples reducing the pressure drop. It should be noted that such difficulty was not encountered when forming the regenerated cellulose filter samples discussed herein below, particularly the regenerated cellulose filter samples having lower dpf values.

Table 4.

1.5 dpf rayon					
150 micron crimp		Weight (g)	Circumference (mm)	PD Close (mmWG)	Hardness (%)
Sample 1		1.055	23.88	308	87.55
Sample 2		1.104	23.76	271	89.16
Sample 3		1.04	23.59	279	87.31
Sample 4		1.181	24.15	370	84.94
Sample 5		1.154	24.17	360	91.87
Sample 6		1.114	24.68	262	89.57
Sample 7		1.18	24.23	363	86.53
Sample 8		1.133	23.87	346	90.9
Sample 9		1.162	24.4	259	85.18
Sample 10		1.132	23.95	239	82.55
	Average	1.126 +/- 0.05	24.07 +/- 0.32	305.7 +/- 49.95	87.56 +/- 2.89

As shown in Table 4, ten sample filter rods were prepared from a filter material formed of regenerated cellulose fibers (e.g., rayon). The filter material had a dpf of about 1.5 and a crimp width of 150 microns. As shown in Table 4, the 10 samples prepared from 1.5 dpf regenerated cellulose filter materials exhibited an average pressure drop of about 306 mmWG and an average hardness of about 88%. It should be noted that both the pressure drop and the average hardness increased significantly as compared to the CA control filter rods.

Table 5.

3 dpf viscose rayon					
150mm WIDE		Weight (g)	Circumference (mm)	PD Close (mmWG)	Hardness (%)
Uncrimped					
Sample 1		0.885	24.07	121	80.03
Sample 2		0.893	23.61	164	72.59
Sample 3		0.855	23.78	213	74.35
Sample 4		0.932	24.1	131	75.29
Sample 5		0.891	24.02	174	78.61
Sample 6		1.191	24.2	350	88.47
Sample 7		1.107	24.62	234	84.41
Sample 8		0.821	23.75	207	84.22
Sample 9		1	23.91	202	84.23
Sample 10		0.79	23.62	165	74.83
	Average	0.937 +/- 0.13	23.97 +/- 0.31	196.1 +/- 64.91	79.7 +/- 5.41

As shown in Table 5, ten sample filter rods were prepared from a filter material formed of regenerated cellulose fibers (e.g., viscose rayon). The filter material had a width of 150 mm, a dpf of about

3, and the filter material was prepared uncrimped. As shown in Table 5, the 10 samples prepared from 3 dpf regenerated cellulose-based filter materials exhibited an average pressure drop of about 196 mmWG and an average hardness of about 80%. It should be noted that the average pressure drop decreased slightly as compared to the CA control filter rods; however, the average hardness increased slightly as compared to the CA control filter rods.

Table 6.

4.5 dpf viscose rayon					
115mm WIDE		**Weight (g)**	**Circumference (mm)**	**PD Close (mmWG)**	**Hardness (%)**
No crimp					
Sample 1		1.038	23.54	228	82.88
Sample 2		0.955	23.77	210	84.45
Sample 3		1.156	23.57	393	89.24
Sample 4		0.988	24.1	223	88.1
Sample 5		1.006	24.33	233	88.78
Sample 6		0.913	23.57	201	84.77
Sample 7		0.951	23.72	201	84.05
Sample 8		0.94	23.78	221	89.55
Sample 9		0.981	23.82	234	89.66
Sample 10		0.983	23.94	228	90.03
	Average	0.99 +/- 0.07	23.81 +/- 0.25	237.2 +/- 56.07	87.15 +/- 2.77

As shown in Table 6, ten sample filter rods were prepared from a filter material formed of regenerated cellulose fibers (e.g., viscose rayon). The filter material had a width of 115 mm, a dpf of about 4.5, and the filter material was prepared uncrimped. As shown in Table 6, the 10 samples prepared from 4.5 dpf regenerated cellulose-based filter materials exhibited an average pressure drop of about 237 mmWG and an average hardness of about 87%. It should be noted that the pressure drop decreased slightly as compared to the CA control filter rods; however, the average hardness increased significantly as compared to the CA control filter rods.

Table 7.

25 dpf viscose rayon					
120mm WIDE		**Weight (g)**	**Circumference (mm)**	**PD Close (mmWG)**	**Hardness**
87 microns crimp					
Sample 1		0.966	24.15	86	78.13
Sample 2		0.928	24.1	80	75.89
Sample 3		0.972	24.37	101	80.41
Sample 4		1.097	24.85	110	82.87
Sample 5		0.95	24.22	83	80.54
Sample 6		1.017	23.89	106	82.36
Sample 7		0.911	23.79	68	72.65
Sample 8		0.908	24.14	73	73.91
Sample 9		0.914	24.54	79	83.8
Sample 10		0.925	24.04	63	79.09
	Average	0.99 +/- 0.06	24.21 +/- 0.31	84.9 +/- 16	78.97 +/- 3.81

As shown in Table 7, ten sample filter rods were prepared from a filter material formed of regenerated cellulose fibers (e.g., viscose rayon). The filter material had a width of 120 mm, a crimp width of 87 microns, and a dpf of about 25. As shown in Table 7, the 10 samples prepared from 25 dpf regenerated cellulose-based filter materials exhibited an average pressure drop of about 85 mmWG and an average hardness of about 79%. It should be noted that the pressure drop decreased significantly as compared to the CA control filter rods; however, the average hardness increased slightly as compared to the CA control filter rods.

Based on the foregoing data in Tables 4-7, it was determined that the dpf of the regenerated cellulose filter samples could be varied (e.g., blending regenerated cellulose materials with various dpf values) to achieve the desired pressure drop. For example, higher dpf regenerated cellulose materials could be blended with lower dpf regenerated cellulose materials and/or hemp materials in varying ratios to achieve the desired pressure drop and/or hardness in the final filter material.

<u>Example 3</u>

Testing was conducted to evaluate the filtration efficiency of filter materials formed of regenerated cellulose as compared to conventional filter materials formed of cellulose acetate fibers and traditional paper filters. Preparation of the filter materials required formation of a wet-laid nonwoven material according to conventional wet-laid papermaking techniques. Four different filter samples were prepared using regenerated cellulose having varying denier per filament values. The first sample is a regenerated cellulose filter material formed using wet-laid techniques and having a denier per filament (dpf) of 1.5. The second sample is a regenerated cellulose filter material formed using wet-laid techniques and having a denier per filament (dpf) of 3. The third sample is a regenerated cellulose filter material formed using wet-laid techniques and having a denier per filament (dpf) of 4.5. The fourth sample is a regenerated cellulose filter material formed using wet-laid techniques and having a denier per filament (dpf) of 25. In addition, two control samples were prepared. The first control sample is a conventional cellulose acetate filter material formed using wet-laid techniques. The second control sample is a conventional paper filter prepared using wet-laid techniques and having a basis weight of 36 grams per square meter (gsm).

Each of the samples was tested to determine the filtration efficiency measured via the amount of tar delivery according to ISO Standards: ISO-8454 (2007), ISO-4387 (2019), and ISO-3308 (2012) (Determination of total particulate matter, carbon monoxide and nicotine-free dry particulate matter in mainstream tobacco smoke using a linear smoking machine). The results are provided in FIG. 8. It should be noted that the cellulose acetate control sample was vented at 49% and the paper filter was vented at 28%, whereas the regenerated cellulose samples (i.e., Viscose 1.5, Viscose 3, Viscose 4.5, and Viscose 25) were not vented. Thus, the data provided in FIG. 8 does not necessarily show that the regenerated cellulose samples have a lower filtration efficiency/tar delivery as compared to the control samples due to the lack of venting in the regenerated cellulose samples. Rather, the data provided in Figure 8 surprisingly shows that the filtration efficiency/tar delivery can be modified in the regenerated cellulose samples by varying the dpf of the regenerated cellulose samples. For example, the dpf of the regenerated cellulose filter materials can be varied to achieve the desired level of filtration efficiency/tar delivery from the filter material.

Each of the six samples was tested again using the same methods provided for FIG. 8, except that the regenerated cellulose samples were vent corrected to provide data comparable to the two vented control samples. The results are provided in FIG. 9. As shown in FIG. 9, the 3 dpf regenerated cellulose filter and the 4.5 dpf regenerated cellulose filter exhibited similar filtration efficiency/tar delivery as compared to the conventional cellulose acetate control filter. Likewise, the 1.5 dpf regenerated cellulose filter exhibited similar filtration efficiency/tar delivery as compared to the conventional paper filter having a basis weight of 36 gsm.

WHAT IS CLAIMED IS:

1. A filter material adapted for use as a filter element in an aerosol delivery device, the filter material comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, and combinations thereof, wherein the filter material is in the form of a nonwoven sheet or a fibrous tow.

2. The filter material of claim 1, wherein the filter material is in the form of a pleated nonwoven sheet gathered to form a rod-like element.

3. The filter material of claim 1, wherein the nonwoven sheet has a basis weight of about 20 gsm to about 90 gsm.

4. The filter material of claim 1, wherein the nonwoven sheet has a basis weight of about 40 gsm to about 80 gsm.

5. The filter material of claim 1, wherein the nonwoven sheet has a basis weight of about 50 gsm to about 70 gsm.

6. The filter material of claim 1, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 30 dpf.

7. The filter material of claim 1, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 25 dpf.

8. The filter material of claim 1, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 5 dpf.

9. The filter material according to any one of claims 1-8, wherein the filter material is optionally crimped.

10. The filter material of claim 9, wherein the crimped filter material has a crimp depth of about 1 micron to about 180 microns.

11. The filter material of claim 9, wherein the crimped filter material has a crimp depth of about 1 micron to about 150 microns.

12. The filter material of claim 9, wherein the crimped filter material has a crimp depth of about 50 microns to about 100 microns.

13. The filter material according to any one of claims 1-8, wherein the nonwoven sheet has a width of about 110 mm to about 160 mm.

14. The filter material according to any one of claims 1-8, wherein the nonwoven sheet has a width of about 115 mm to about 150 mm.

15. The filter material according to any one of claims 1-8, further comprising a plasticizer.

16. The filter material of claim 15, wherein the plasticizer is triacetin.

17. The filter material according to any one of claims 1-8, further comprising a binder.

18. The filter material of claim 17, wherein the binder is selected from the group consisting of polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof.

19. The filter material according to any one of claims 1-8, wherein the nonwoven sheet is a wetlaid nonwoven sheet, a drylaid nonwoven sheet, or an airlaid nonwoven sheet.

20. A filter element adapted for use in an aerosol delivery device, the filter element comprising one or more segments of a filter material according to any one of claims 1-8.

21. The filter element of claim 20, wherein the one or more segments of filter material have a hardness of about 75 percent or higher.

22. The filter element of claim 20, wherein the one or more segments of filter material have a hardness of about 80 percent or higher.

23. The filter element of claim 20, wherein the one or more segments of filter material have a hardness of about 85 percent or higher.

24. The filter element of claim 20, wherein the filter element exhibits a pressure drop in the range of about 40 mmWG to about 400 mmWG.

25. The filter element of claim 20, wherein the filter element exhibits a pressure drop in the range of about 200 mmWG to about 300 mmWG.

26. An aerosol delivery device comprising the filter element according to claim 20.

27. A method for forming a filter material suitable for use as a filter element in an aerosol delivery device, the method comprising:

receiving a nonwoven sheet or a fibrous tow, the nonwoven sheet or the fibrous tow comprising a plurality of fibers selected from the group consisting of regenerated cellulose, hemp, sisal, esparto, kenaf, jute, flax, wood, and combinations thereof;

processing the nonwoven sheet or the fibrous tow to provide a filter material suitable for use as a filter element for an aerosol delivery device.

28. The method of claim 27, further comprising forming the nonwoven sheet or fibrous tow.

29. The method of claim 28, wherein the nonwoven sheet is formed using a wetlaid, airlaid, or drylaid forming process.

30. The method of claim 28, wherein the nonwoven sheet is formed using a forming process selected from the group consisting of hydroentangling, needle punching, spun-bonding, melt-blowing, spun-lacing, carding, point-bonding, spinning, and combinations thereof.

31. The method of claim 28, wherein forming the fibrous tow comprises:

blending the plurality of fibers to provide a mixed fiber blend; and

drawing the mixed fiber blend to provide the fibrous tow.

32. The method according to any one of claims 27-31, wherein the processing comprises gathering the nonwoven sheet or fibrous tow to form a rod-like element suitable for use as a filter element.

33. The method of claim 32, wherein the processing further comprises wrapping the rod-like element with a circumscribing wrapping material thereby forming a continuous rod suitable for use as a filter element.

34. The method according to any one of claims 27-31, wherein the processing comprises crimping the nonwoven sheet or fibrous tow.

35. The method of claim 34, wherein the crimped nonwoven sheet or the crimped fibrous tow have a crimp depth of about 1 micron to about 180 microns.

36. The method of claim 34, wherein the crimped nonwoven sheet or the crimped fibrous tow have a crimp depth of about 1 micron to about 150 microns.

37. The method of claim 34, wherein the crimped nonwoven sheet or the crimped fibrous tow have a crimp depth of about 50 microns to about 100 microns.

38. The method according to any one of claims 27-31, further comprising applying a plasticizer to the nonwoven sheet or fibrous tow.

39. The method of claim 38, wherein the plasticizer is triacetin.

40. The method according to any one of claims 27-31, further comprising applying a binder to the nonwoven sheet or fibrous tow.

41. The method of claim 40, wherein the binder is selected from the group consisting of polyvinyl alcohol (PVOH), pectin, starch, microfibrillated cellulose (MFC), and combinations thereof.

42. The method according to any one of claims 27-31, wherein the nonwoven sheet has a basis weight of about 20 gsm to about 90 gsm.

43. The method according to any one of claims 27-31, wherein the nonwoven sheet has a basis weight of about 40 gsm to about 80 gsm.

44. The method according to any one of claims 27-31, wherein the nonwoven sheet has a basis weight of about 50 gsm to about 70 gsm.

45. The method according to any one of claims 27-31, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 30 dpf.

46. The method according to any one of claims 27-31, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 25 dpf.

47. The method according to any one of claims 27-31, wherein the denier per filament (dpf) of the filter material is about 1 dpf to about 5 dpf.

48. The method according to any one of claims 27-31, wherein the nonwoven sheet has a width of about 110 mm to about 160 mm.

49. The method according to any one of claims 27-31, wherein the nonwoven sheet has a width of about 115 mm to about 150 mm.

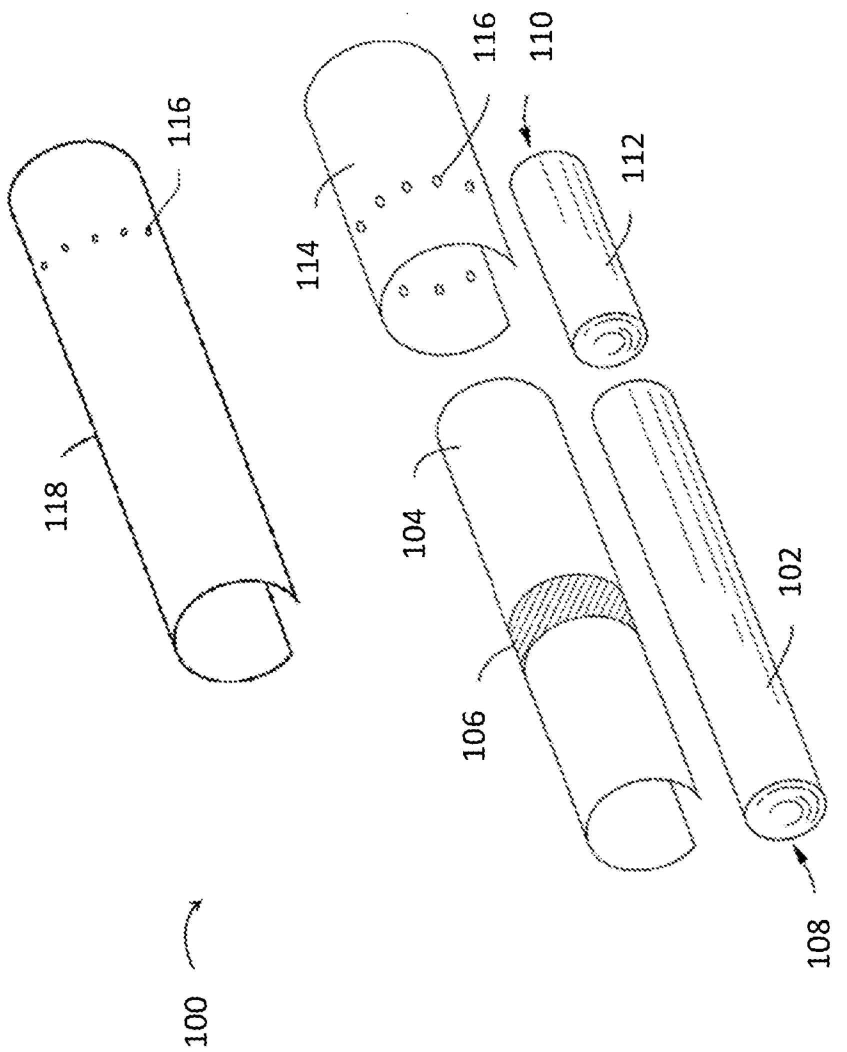


FIG. 1

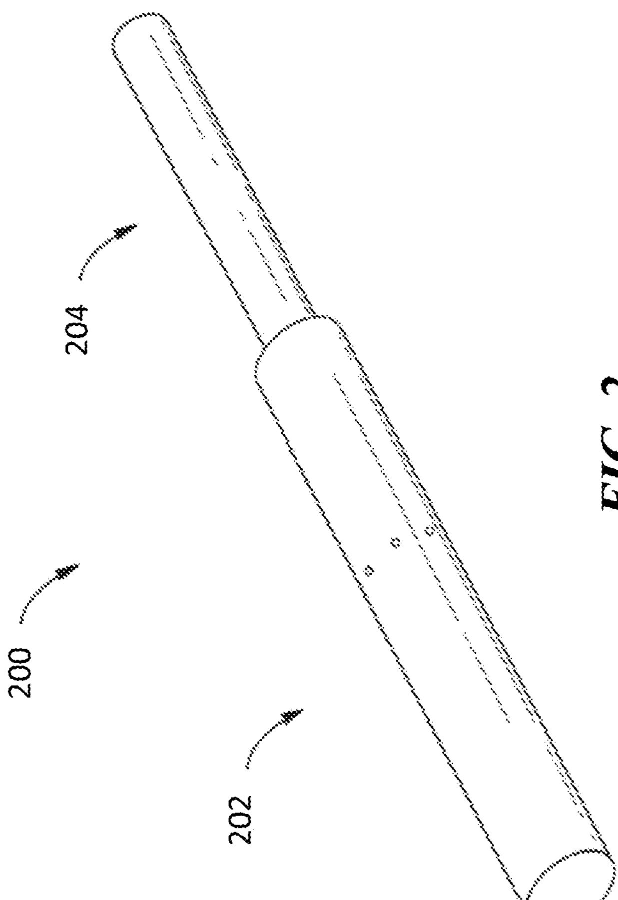
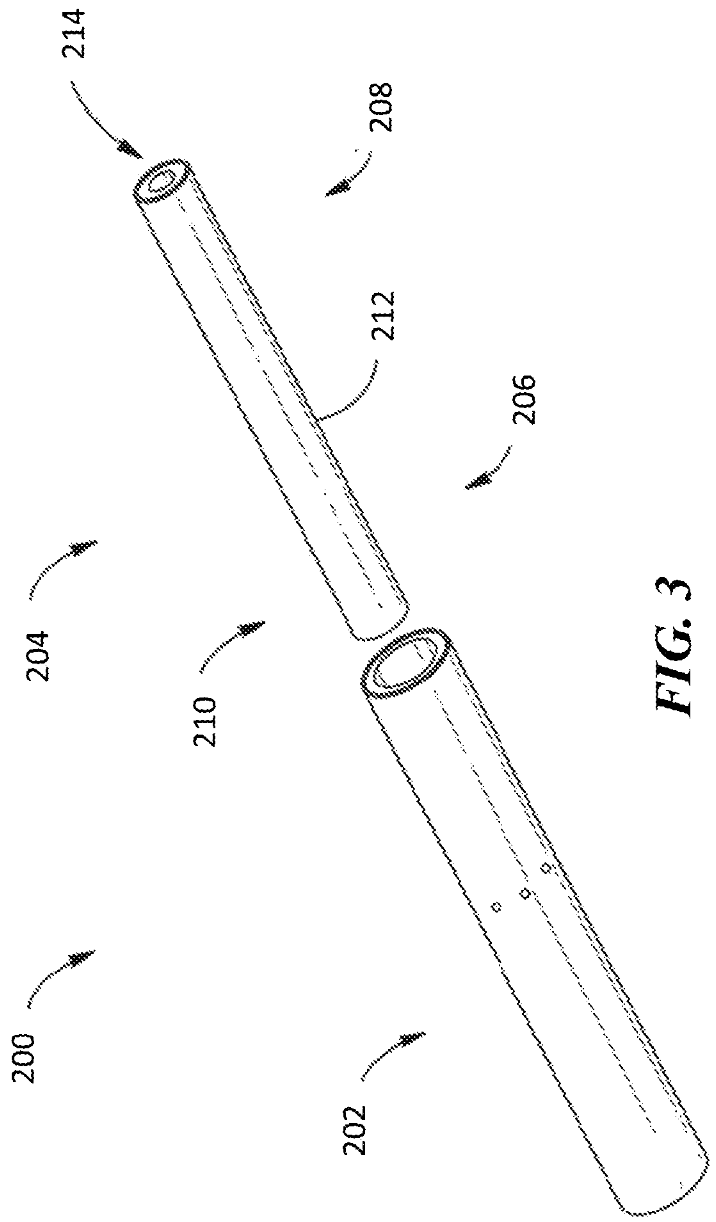


FIG. 2



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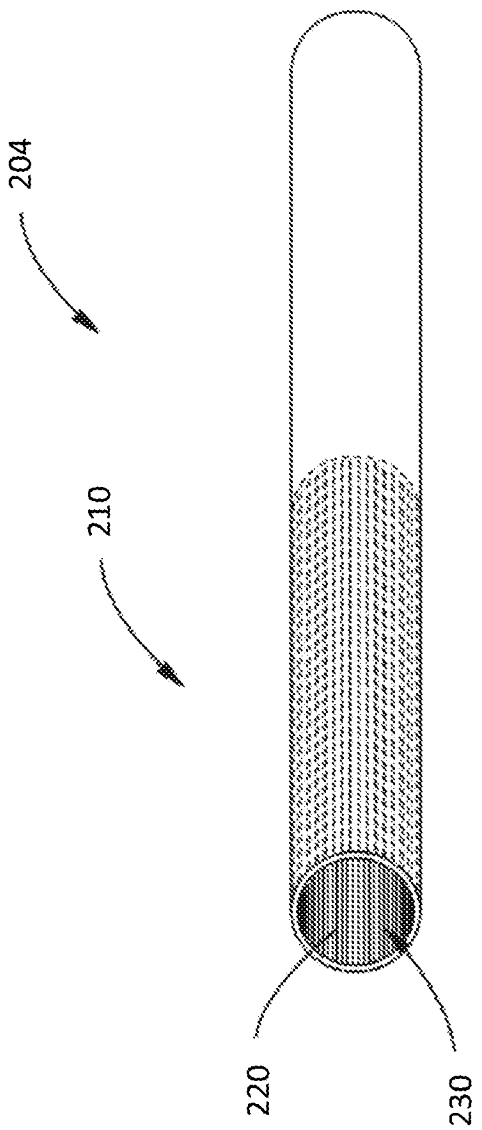


FIG. 4

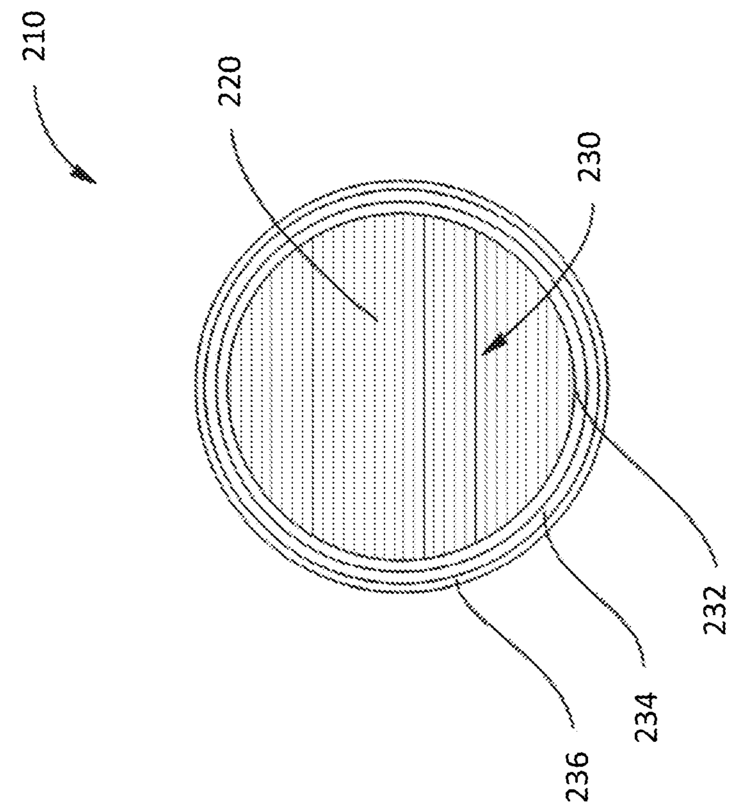


FIG. 5

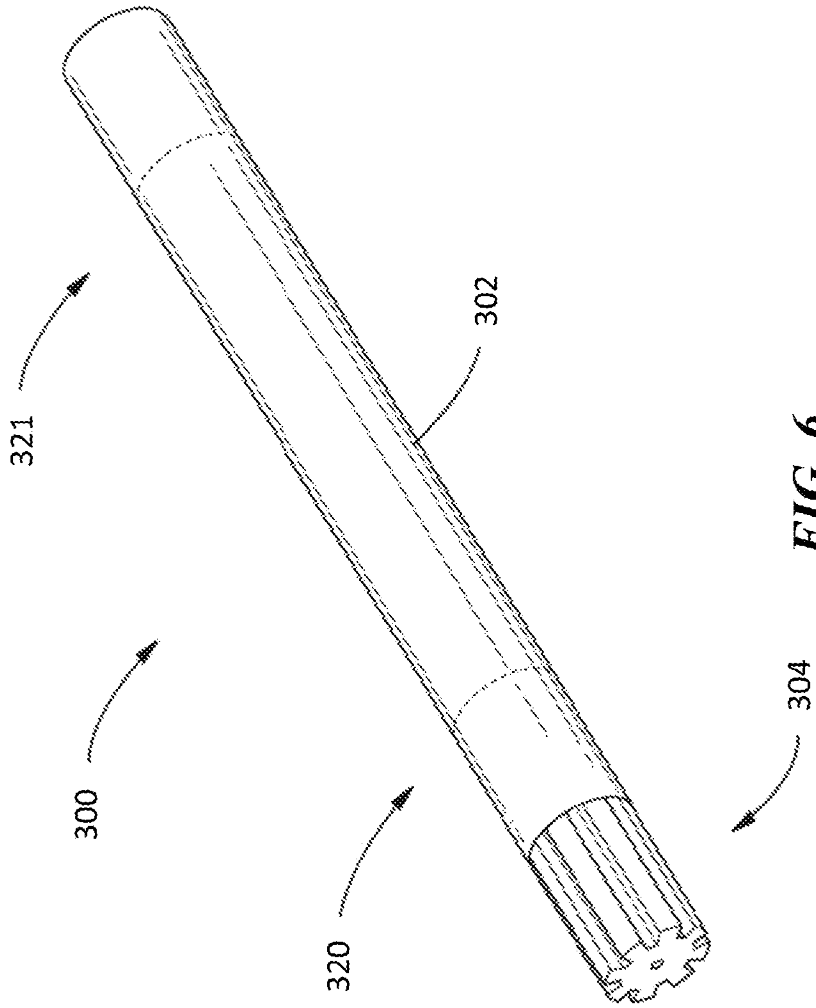


FIG. 6

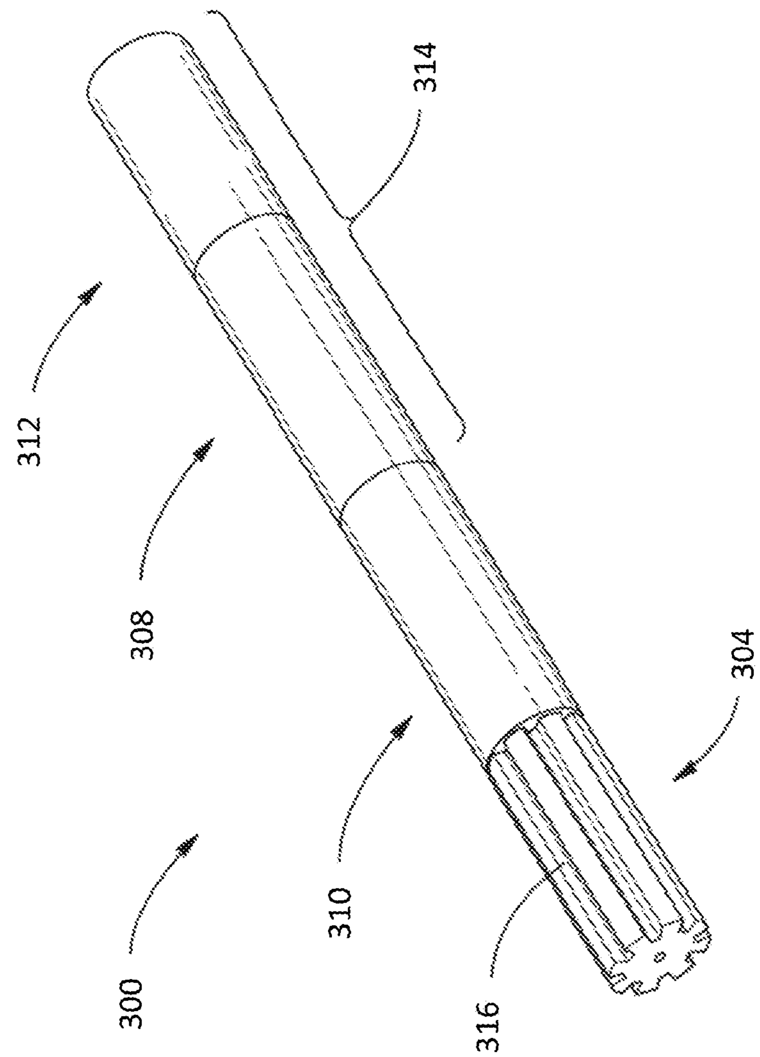
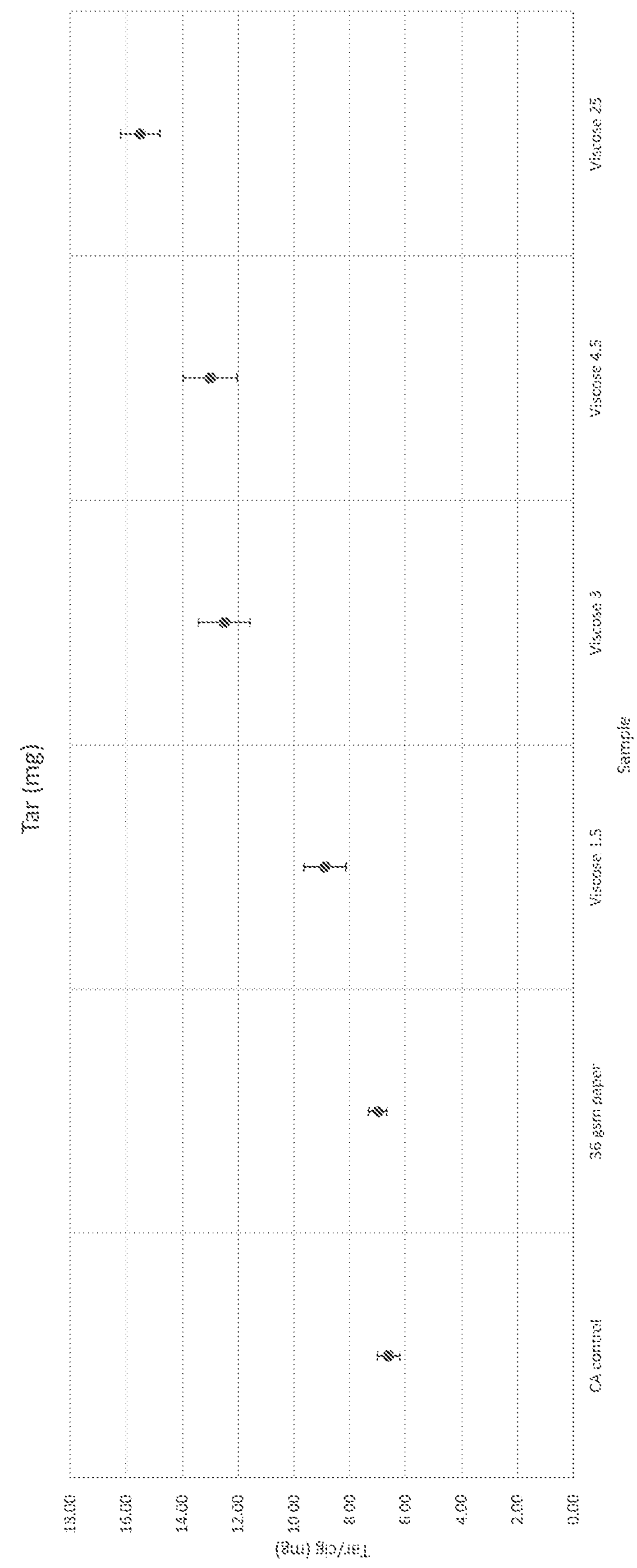


FIG. 7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Tar/cig (mg)
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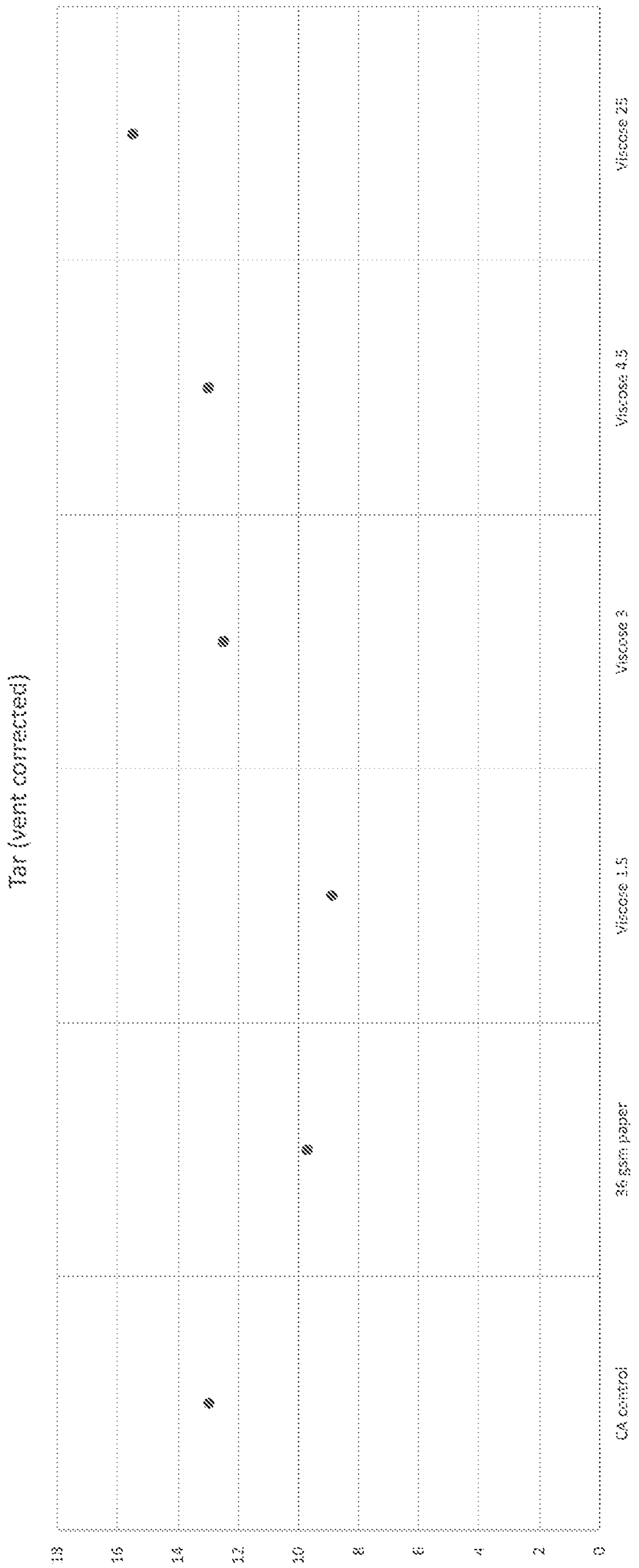
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
CA control
36 gsm paper
Viscose 1.5
Viscose 3
Viscose 4.5
Viscose 25
Sample

FIG. 8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CA control
Viscose 1.5
Viscose 3
Viscose 4.5
Viscose 25
0
2
4
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14
16

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/056573

A. CLASSIFICATION OF SUBJECT MATTER
INV. A24D3/06 A24D3/02 A24D3/10
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 A24F

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 525 363 A (GREENBUTTS LLC [US]) 21 October 2015 (2015-10-21)	1-14, 17-30, 32,33, 40-49
A	paragraph [0001] paragraph [0015] paragraph [0047] paragraph [0009] - paragraph [0010] paragraph [0012] paragraph [0013] paragraph [0036] paragraph [0045] -----	31,34-39

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

* Special categories of cited documents :

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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

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
7 September 2023	18/09/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dimoula, Kerasina

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/056573

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	paragraph [0009] paragraph [0014] paragraph [0016] paragraph [0029] paragraph [0039] paragraph [0012] paragraph [0017] paragraph [0015] -----	2-5,13, 14, 17-19, 28-30, 40-44, 48,49
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A	claims 1-50 -----	17,18, 24,25, 40,41

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Information on patent family members

International application No
PCT/IB2023/056573

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			EP	4241584	A2	13-09-2023
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			KR	20220110257	A	05-08-2022
			PL	3861159	T3	10-10-2022
			US	2023016316	A1	19-01-2023
			WO	2021115619	A1	17-06-2021