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(54) AEROSOL-GENERATING ELEMENT COMPRISING A FILTER WITH A HIGH CONTENT OF A POLYHYDROXYALKANOATE POLYMER OR COPOLYMER

AEROSOLERZEUGUNGSELEMENT MIT EINEM FILTER MIT EINEM HOHEM GEHALT AN EINEM POLYHYDROXYALKANOATPOLYMER ODER -COPOLYMER

ÉLÉMENT DE GÉNÉRATION D'AÉROSOL COMPRENANT UN FILTRE AVEC UNE TENEUR ÉLEVÉE EN POLYMÈRE OU COPOLYMÈRE DE POLYHYDROXYALKANOATE

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Description

[0001] The present invention relates to a filter for an aerosol-generating article and to an aerosol-generating article comprising the filter. The present invention further relates to an aerosol-generating system comprising an aerosol-generating device and one such aerosol-generating article.

[0002] Conventional aerosol-generating articles, such as filter cigarettes, typically comprise a cylindrical rod of tobacco cut filler surrounded by a paper wrapper and a cylindrical filter axially aligned, most often in an abutting end-to-end relationship, with the wrapped tobacco rod. The cylindrical filter typically comprises one or more plugs of a fibrous filtration material, such as cellulose acetate tow, circumscribed by a paper plug wrap. Conventionally, the wrapped tobacco rod and the filter are joined by a band of tipping wrapper, normally formed of an opaque paper material that circumscribes the entire length of the filter and an adjacent portion of the wrapped tobacco rod.

[0003] Aerosol-generating articles in which an aerosol-generating substrate, such as a tobacco-containing substrate, is heated rather than combusted, are also known in the art. Typically in such articles an aerosol is generated by the transfer of heat from a heat source to a physically separate aerosol-generating substrate or material.

[0004] By way of example, aerosol-generating articles have been proposed wherein an aerosol is generated by electrical heating of an aerosol-generating substrate. A number of prior art documents disclose aerosol-generating devices for consuming aerosol-generating articles. Such devices include, for example, electrically heated aerosol-generating devices in which an aerosol is generated by the transfer of heat from one or more electrical heater elements of the aerosol-generating device to the aerosol-generating substrate of a heated aerosol-generating article. As another example, aerosol-generating articles are also known wherein an aerosol is generated by the transfer of heat from a combustible fuel element or heat source to an aerosol-generating substrate. The combustible fuel element or heat source may be located in contact with, within, around, or downstream of the aerosol-generating substrate.

[0005] During use of one such aerosol-generating article, volatile compounds are released from the aerosol-generating substrate by heat transfer and are entrained in air drawn through the aerosol-generating article. As the released compounds cool, they condense to form an aerosol.

[0006] Typically, aerosol-generating articles of the types described may include a mouthpiece comprising a filter segment formed of porous filtration material such as cellulose acetate. In some known aerosol-generating articles a hollow tubular segment formed of a filtration material such as cellulose acetate is provided at a location between the aerosol-generating substrate and the mouth end of the article to impart structural strength to the article.

[0007] US 2012/000480 A1 describes a mouth end filter element for an aerosol-generating article, the filter element comprising a fibrous tow filter material that incorporates a biodegradable material configured for increasing the rate of degradation of the filter material upon disposal. This may include non-fibrous biodegradable material incorporated within the biodegradable tow. In an embodiment, the fibres have a core of a biodegradable material coated with cellulose acetate. US 2012/000480 A1 discloses a list of possible biodegradable polymers that can be used as the core material, including polyhydroxyalkanoates (PHA), polylactic acid (PLA), polycaprolactones, polybutylene succinate adipate, polyvinyl alcohol (PVA), starch, polyesteramide, regenerated cellulose (for example, rayon), and various aromatic copolyesters, and any combination of these polymers, blends of such biodegradable polymers, and non-biodegradable polymers such as starch-polyolefin mixtures. After an aerosol-generating article has been consumed and discarded, it may be desirable for any component of the article comprising filtration material to break down as quickly as possible. However, cellulose acetate, and many other commonly used filtration materials are not highly biodegradable. However, alternative dispersible or biodegradable materials are often not able to provide an acceptable filtration efficiency and smoking experience for the consumer. Furthermore, many known dispersible and degradable materials are unsuitable for use in the existing manufacturing processes, and would require too significant a modification of the existing methods and equipment to make their use commercially feasible.

[0008] Further, cellulose acetate has been found to provide a relatively high level of adsorption and trapping of water from the mainstream smoke when used in conventional smoking articles. The mainstream smoke delivered to the consumer therefore has a significantly reduced moisture content and may, under certain conditions, be perceived as undesirably 'dry'. This may have an adverse effect on the overall smoking experience.

[0009] Thus, it would be desirable to provide a novel and improved aerosol-generating article that has enhanced biodegradation properties compared to known articles including conventional filtration materials such as cellulose acetate. It would also be desirable to provide a novel and improved aerosol-generating article that provides an acceptable smoking experience to the consumer, in particular, one that is capable of reducing the 'dry' smoke effect that is often found with articles comprising cellulose acetate as the filtration material.

[0010] It would be desirable to provide one such aerosol-generating article wherein the resistance to draw (RTD) of a filtration material segment can be adjusted so as to achieve an acceptable RTD of the article as a whole. Further, it would be desirable to provide such an aerosol-generating article that can effectively be produced in an automated, high-speed manufacturing process without requiring major modifications of existing equipment.

[0011] The present disclosure relates to an aerosol-generating article for producing an inhalable aerosol upon heating.

The aerosol-generating article may comprise a rod of aerosol-generating substrate and a filter segment formed of fibrous filtration material. The filter segment is arranged in longitudinal alignment with the rod. The filter segment comprises at least about 85 percent by weight based on the total weight of fibrous filtration material of a polyhydroxyalkanoate (PHA) polymer or copolymer. The RTD of the filter segment is between 35 millimetres H_2O and about 55 millimetres H_2O and the length of the filter segment is from about 4 millimetres to about 27 millimetres.

[0012] Further, the present disclosure relates to a filter for an aerosol-generating article. The filter may comprise a filter segment formed of fibrous filtration material. The filter segment comprises at least about 85 percent by weight based on the total weight of fibrous filtration material of fibres comprising a polyhydroxyalkanoate PHA polymer or copolymer. The RTD of the filter segment is between 35 millimetres H_2O and about 55 millimetres H_2O and the length of the filter segment is from about 4 millimetres to about 27 millimetres.

[0013] A system comprising an aerosol-generating device and an aerosol-generating article for use with the aerosol-generating device is also disclosed. The aerosol-generating article may comprise a rod of aerosol-generating substrate and a filter segment formed of fibrous filtration material.

[0014] According to the present invention, there is provided an aerosol-generating article for producing an inhalable aerosol upon heating, the aerosol-generating article comprising: a rod of aerosol-generating substrate; a filter segment formed of fibrous filtration material, the filter segment arranged in longitudinal alignment with the rod; wherein the filter segment comprises at least about 85 percent by weight based on the total weight of fibrous filtration material of a PHA polymer or copolymer.

[0015] According to the present invention, there is also provided a filter for an aerosol-generating article, the filter comprising a filter segment formed of fibrous filtration material, wherein the filter segment comprises at least about 85 percent by weight based on the total weight of fibrous filtration material of a PHA polymer or copolymer.

[0016] As used herein, the term "longitudinal" refers to the direction corresponding to the main longitudinal axis of the aerosol-generating article, which extends between the upstream and downstream ends of the aerosol-generating article. As used herein, the terms "upstream" and "downstream" describe the relative positions of elements, or portions of elements, of the aerosol-generating article in relation to the direction in which the aerosol is transported through the aerosol-generating article during use.

[0017] The term "aerosol-generating article" is used herein with reference to the invention to describe an article wherein an aerosol-generating substrate is heated to produce and deliver an aerosol to a consumer. As used herein, the term "aerosol-generating substrate" denotes a substrate capable of releasing volatile compounds upon heating to generate an aerosol.

[0018] A conventional cigarette is lit when a user applies a flame to one end of the cigarette and draws air through the other end. The localised heat provided by the flame and the oxygen in the air drawn through the cigarette causes the end of the cigarette to ignite, and the resulting combustion generates an inhalable smoke. By contrast, in heated aerosol-generating articles, an aerosol is generated by heating a flavour generating substrate, such as, for example, a tobacco-based substrate or a substrate containing an aerosol-former and a flavouring. Known heated aerosol-generating articles include, for example, electrically heated aerosol-generating articles and aerosol-generating articles in which an aerosol is generated by the transfer of heat from a combustible fuel element or heat source to a physically separate aerosol forming material.

[0019] As described briefly above, in contrast with existing aerosol-generating articles, an article in accordance with the present invention comprises a filter segment formed of fibrous filtration material and comprising at least about 85 percent by weight based on the total weight of the fibrous filtration material of a PHA polymer or copolymer.

[0020] Thus, in the filter segment of an aerosol-generating article in accordance with the invention a PHA polymer or copolymer accounts for at least 85 percent by weight of the fibrous filtration material. This means that the remainder of the fibrous filtration material may comprise a material other than a PHA polymer or copolymer. Further, this means that other components of the filter segment - such as, for example, a plug wrapper circumscribing the fibrous filtration material, or an insert such as a flow restrictor or an additive delivery material, for example a breakable capsule, which may be provided at a location in the filter segment may comprise a material other than a PHA polymer or copolymer.

[0021] Because fibres containing a PHA polymer or copolymer (in the following, also referred to as "PHA fibres") have a lower hydrophilicity compared with fibres of other filtration materials, such as cellulose acetate, of an equivalent weight, in aerosol-generating articles in accordance with the present invention the filter segment has been found to have a significantly lower tendency to absorb water/steam. As a result, the level of water in the mainstream smoke can advantageously be maintained at a higher level. This directly addresses the issue of "dry smoke" often encountered with conventional smoking articles, and provides an improved smoking experience for the consumer.

[0022] As PHA fibres have a much higher level of biodegradability compared with fibres of other filtration materials, such as cellulose acetate, articles in accordance with the present invention are more biodegradable as a whole. At the same time, as PHA fibres are obtained by means of a natural, fermentation process, aerosol-generating articles in accordance with the present invention also provide improved sustainability for the production process.

[0023] By adjusting parameters such as the denier per filament, total denier, cross sectional shape, etc. it is possible

to adjust the RTD of the filter segment to desirable ranges for any given filter length or filter design.

[0024] The term "denier per filament" (DPF) corresponds to the weight in grams of a single fibre or filament having a length of 9000 metres. In the present invention, the value of DPF therefore gives an indication of the thickness of each of the individual PHA fibres within the filter segment. The denier per filament is expressed in units of denier, where 1 denier corresponds to 1 gram per 9000 metres.

[0025] Preferably, the total denier of the filtration material comprising the PHA fibres is between about 20,000 and about 50,000 or 40,000, more preferably between about 25,000 and about 30,000.

[0026] The "total denier" of the filtration material defines the total weight in grams of 9000 metres of the combined fibres forming the filtration material. The total denier for the filter segment therefore corresponds to the denier per filament multiplied by the total number of fibres in the filter segment.

[0027] In addition, the overall weight of the filter may be advantageously controlled, and this may also contribute to help with biodegradation of the filter segment and of the aerosol-generating article as a whole.

[0028] PHA properties also lead to good filter hardness, which can be further enhanced by circumscribing the filter segment with a stiff plug wrap.

[0029] Aerosol-generating articles in accordance with the present invention comprise a rod of aerosol-generating substrate.

[0030] The rod of aerosol-generating substrate may be produced using randomly oriented shreds, strands, or strips of tobacco material. As an alternative, as has been proposed, for example in international patent application WO-A-2012/164009, the rod of aerosol-generating substrate may be formed from one or more gathered sheets of tobacco material. Alternative rods for aerosol-generating articles have also been proposed that are formed from strands of homogenised tobacco material, which may be formed by casting, rolling, calendering or extruding a mixture comprising particulate tobacco and at least one aerosol former to form a sheet of homogenised tobacco material. Further, a rod of aerosol-generating substrate may be formed from strands of homogenised tobacco material obtained by extruding a mixture comprising particulate tobacco and at least one aerosol former to form continuous lengths of homogenised tobacco material.

[0031] The rod of aerosol generating substrate preferably has an external diameter that is approximately equal to the external diameter of the aerosol generating article.

[0032] Preferably, the rod of aerosol generating substrate has an external diameter of at least 5 millimetres. The rod of aerosol generating substrate may have an external diameter of between about 5 millimetres and about 12 millimetres, for example of between about 5 millimetres and about 10 millimetres or of between about 6 millimetres and about 8 millimetres. In a preferred embodiment, the rod of aerosol generating substrate has an external diameter of 7.2 millimetres, to within 10 percent.

[0033] The rod of aerosol generating substrate may have a length of between about 5 millimetres and about 100 mm. Preferably, the rod of aerosol generating substrate has a length of at least about 5 millimetres, more preferably at least about 7 millimetres. In addition, or as an alternative, the rod of aerosol generating substrate preferably has a length of less than about 80 millimetres, more preferably less than about 65 millimetres, even more preferably less than about 50 millimetres. In particularly preferred embodiments, the rod of aerosol generating substrate has a length of less than about 35 millimetres, more preferably less than 25 millimetres, even more preferably less than about 20 millimetres. In one embodiment, the rod of aerosol generating substrate may have a length of about 10 millimetres. In a preferred embodiment, the rod of aerosol generating substrate has a length of about 12 millimetres.

[0034] Preferably, the rod of aerosol generating substrate has a substantially uniform cross-section along the length of the rod. Particularly preferably, the rod of aerosol generating substrate has a substantially circular cross-section.

[0035] In preferred embodiments, the aerosol-generating substrate comprises one or more gathered sheets of homogenised tobacco material. Preferably the one or more sheets of homogenised tobacco material are textured. As used herein, the term 'textured sheet' denotes a sheet that has been crimped, embossed, debossed, perforated or otherwise deformed. Textured sheets of homogenised tobacco material for use in the invention may comprise a plurality of spaced-apart indentations, protrusions, perforations or a combination thereof. According to a particularly preferred embodiment of the invention, the rod of aerosol-generating substrate comprises a gathered crimped sheet of homogenised tobacco material circumscribed by a wrapper.

[0036] As used herein, the term 'crimped sheet' is intended to be synonymous with the term 'creped sheet' and denotes a sheet having a plurality of substantially parallel ridges or corrugations. Preferably, the crimped sheet of homogenised tobacco material has a plurality of ridges or corrugations substantially parallel to the cylindrical axis of the rod according to the invention. This advantageously facilitates gathering of the crimped sheet of homogenised tobacco material to form the rod. However, it will be appreciated that crimped sheets of homogenised tobacco material for use in the invention may alternatively or in addition have a plurality of substantially parallel ridges or corrugations disposed at an acute or obtuse angle to the cylindrical axis of the rod. In certain embodiments, sheets of homogenised tobacco material for use in the rod of the article of the invention may be substantially evenly textured over substantially their entire surface. For example, crimped sheets of homogenised tobacco material for use in the manufacture of a rod for use in an aerosol-

generating article in accordance with the invention may comprise a plurality of substantially parallel ridges or corrugations that are substantially evenly spaced-apart across the width of the sheet.

[0037] Sheets or webs of homogenised tobacco material for use in the invention may have a tobacco content of at least about 40 percent by weight on a dry weight basis, more preferably of at least about 60 percent by weight on a dry weight basis, more preferably or at least about 70 percent by weight on a dry basis and most preferably at least about 90 percent by weight on a dry weight basis.

[0038] Sheets or webs of homogenised tobacco material for use in the aerosol-generating substrate may comprise one or more intrinsic binders, that is tobacco endogenous binders, one or more extrinsic binders, that is tobacco exogenous binders, or a combination thereof to help agglomerate the particulate tobacco. Alternatively, or in addition, sheets of homogenised tobacco material for use in the aerosol-generating substrate may comprise other additives including, but not limited to, tobacco and non-tobacco fibres, aerosol-formers, humectants, plasticisers, flavourants, fillers, aqueous and non-aqueous solvents and combinations thereof.

[0039] Suitable extrinsic binders for inclusion in sheets or webs of homogenised tobacco material for use in the aerosol-generating substrate are known in the art and include, but are not limited to: gums such as, for example, guar gum, xanthan gum, arabic gum and locust bean gum; cellulosic binders such as, for example, hydroxypropyl cellulose, carboxymethyl cellulose, hydroxyethyl cellulose, methyl cellulose and ethyl cellulose; polysaccharides such as, for example, starches, organic acids, such as alginic acid, conjugate base salts of organic acids, such as sodium-alginate, agar and pectins; and combinations thereof.

[0040] Suitable non-tobacco fibres for inclusion in sheets or webs of homogenised tobacco material for use in the aerosol-generating substrate are known in the art and include, but are not limited to: cellulose fibres; soft-wood fibres; hard-wood fibres; jute fibres and combinations thereof. Prior to inclusion in sheets of homogenised tobacco material for use in the aerosol-generating substrate, non-tobacco fibres may be treated by suitable processes known in the art including, but not limited to: mechanical pulping; refining; chemical pulping; bleaching; sulphate pulping; and combinations thereof.

[0041] Substrates for heated aerosol-generating articles typically comprise an "aerosol former", that is, a compound or mixture of compounds that, in use, facilitates formation of the aerosol, and that preferably is substantially resistant to thermal degradation at the operating temperature of the aerosol-generating article. Examples of suitable aerosol-formers include: polyhydric alcohols, such as propylene glycol, triethylene glycol, 1,3-butanediol and glycerin; esters of polyhydric alcohols, such as glycerol mono-, di- or triacetate; and aliphatic esters of mono-, di- or polycarboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate. Preferred aerosol formers are polyhydric alcohols or mixtures thereof, such as propylene glycol, triethylene glycol, 1,3-butanediol and, most preferred, glycerine.

[0042] Preferably, the aerosol-generating substrate comprises at least 10 percent by weight of an aerosol former, more preferably at least 12 percent by weight of an aerosol former, more preferably at least about 15 percent by weight of an aerosol former. Alternatively or in addition, the aerosol-generating substrate preferably comprises no more than 30 percent by weight of an aerosol former, more preferably no more than about 25 percent by weight of an aerosol former, more preferably no more than about 20 percent by weight of an aerosol former. For example, the aerosol-generating substrate may comprise between about 10 percent and about 30 percent by weight of an aerosol former, or between about 12 percent and about 25 percent by weight of an aerosol former, or between about 15 percent and about 20 percent by weight of an aerosol former. In a particularly preferred embodiment, the aerosol-generating substrate comprises around 18 percent by weight of an aerosol former.

[0043] In aerosol-generating articles in accordance with the present invention, the filter segment is formed of fibrous filtration material and comprises at least 85 percent by weight of a PHA polymer or copolymer based on the total weight of the fibrous filtration material.

[0044] PHAs are a family of polyhydroxyesters of 3-, 4-, 5- and 6-hydroxyalkanoic acids, which are produced by a variety of bacterial species under nutrient-limiting conditions with excess carbon and are found as discrete cytoplasmic inclusions in bacterial cells. Due to their excellent biocompatibility, PHAs have been proposed for use in a wide variety of biomedical applications, including drug delivery systems and tissue engineering scaffolds.

[0045] A PHA molecule is typically made up of 600 to 35,000 (R)-hydroxy fatty acid monomer units. Depending on the total number of carbon atoms within a PHA monomer, PHA can be classified as either short-chain length PHA (scl-PHA; 3 to 5 carbon atoms), medium-chain length PHA (mcl-PHA; 6 to 14 carbon atoms), or long-chain length PHA (lcl-PHA; 15 or more carbon atoms).

[0046] The first and most prevalent PHA is poly(β-hydroxybutyrate) (PHB). The next member of the PHA family, having a pendant ethyl group, is poly(3-hydroxyvalerate) or PHV. Having an ethyl group (HV unit) instead of the methyl group of PHB gives PHV more flexibility and less crystallinity than PHB.

[0047] The PHA-containing fibres provided within the filter segment of the aerosol-generating articles according to the invention may be formed of any suitable PHA compound, including PHA polymers or copolymers. Suitable PHA compounds include but are not limited to: polyhydroxypropionate, polyhydroxyvalerate, polyhydroxybutyrate, polyhydroxyhexanoate and polyhydroxyoctanoate. In a particularly preferred embodiment, the PHA compound is poly(3-hydroxybu-

tyrate).

[0048] In an aerosol-generating article in accordance with the invention the filter segment comprises at least 85 percent by weight of a PHA polymer or copolymer. Without wishing to be bound by theory, it is understood that higher contents of PHA in the filter segment are generally associated with an improved biodegradability of the filter segment and of the aerosol-generating article as a whole.

[0049] In preferred embodiments, the filter segment comprises at least about 90 percent by weight of a PHA polymer or copolymer. Without wishing to be bound by theory, it is understood that higher contents of PHA in the filter segment are generally associated with an improved biodegradability of the filter segment and of the aerosol-generating article as a whole.

[0050] More preferably, the filter segment comprises at least about 91 percent by weight of a PHA polymer or copolymer or at least about 92 percent by weight of a PHA polymer or copolymer or at least about 93 percent by weight of a PHA polymer or copolymer or at least about 94 percent by weight of a PHA polymer or copolymer. In some particularly preferred embodiments, the filter segment comprises at least about 95 percent by weight of a PHA polymer or copolymer.

[0051] The remainder of the fibres within the PHA filter segment may comprise any suitable material. Suitable fibrous materials would be known to the skilled person and include but are not limited to polylactic acid (PLA) and cellulose acetate.

[0052] In some embodiments, the filter segment may comprise some cellulose acetate. Without wishing to be bound by theory, it is understood that a certain amount of cellulose acetate in the filter segment may impart desirable filtration properties and mechanical properties to the filter segment as well as facilitating manufacture of the filter segment.

[0053] In certain embodiments, the filter segment comprises at least about 5 percent by weight of cellulose acetate. By way of example, the filter segment may comprise at least about 6 percent by weight of cellulose acetate or at least about 7 percent by weight of cellulose acetate or at least about 8 percent by weight of cellulose acetate or at least about 9 percent by weight of cellulose acetate. In some embodiments, the filter segment comprises at least about 10 percent by weight of cellulose acetate.

[0054] In aerosol-generating articles in accordance with the present invention, the filter segment preferably comprises less than about 15 percent by weight of cellulose acetate.

[0055] In some embodiments, the filter segment comprises less than about 5 percent by weight of cellulose acetate, preferably less than 3 percent by weight of cellulose acetate, more preferably less than 1 percent by weight of cellulose acetate, even more preferably less than 0.1 percent by weight cellulose acetate. This may favourable further contribute to enhance biodegradability of the filter segment and of the aerosol-generating article as a whole.

[0056] Preferably, an aerosol-generating article in accordance with the present invention comprises less than or equal to about 10 percent by weight of cellulose acetate measured with reference to the overall weight of the aerosol-generating article. More preferably, an aerosol-generating article in accordance with the present invention comprises less than or equal to about 7 percent by weight of cellulose acetate measured with reference to the overall weight of the aerosol-generating article. Even more preferably, an aerosol-generating article in accordance with the present invention comprises less than or equal to about 5 percent by weight of cellulose acetate measured with reference to the overall weight of the aerosol-generating article. This advantageously indicates that not only the filter segment has a low or null content of cellulose acetate, but also that any other component of the article containing a fibrous filtration material contains little to no cellulose acetate. Embodiments of aerosol-generating articles in accordance with the invention having such low contents of cellulose acetate present particularly favourable biodegradability properties.

[0057] In some preferred embodiments, an aerosol-generating article in accordance with the present invention comprises less than or equal to about 3 percent by weight of cellulose acetate measured with reference to the overall weight of the aerosol-generating article. More preferably, an aerosol-generating article in accordance with the present invention comprises less than or equal to about 2 percent by weight of cellulose acetate measured with reference to the overall weight of the aerosol-generating article. Even more preferably, an aerosol-generating article in accordance with the present invention comprises less than or equal to about 1 percent by weight of cellulose acetate measured with reference to the overall weight of the aerosol-generating article.

[0058] In some highly preferred embodiments, an aerosol-generating article in accordance with the present invention is substantially free of cellulose acetate.

[0059] In some embodiments, the filter segment further comprises at least about 5 percent by weight of at least one biodegradable polymer selected from the group consisting of starch, polybutylene succinate (PBS), polybutyrate adipate terephthalate (PBAT), thermoplastic starch and thermoplastic starch blends (TPS), polycaprolactone (PCL), polyglycolide (PGA), polyvinyl alcohol (PVOH/PVA), viscose, regenerated cellulose, polysaccharides, cellulose acetate with a degree of substitution (DS) of less than 2.1, polyamides, protein-based biopolymers, chitosan-chitin based biopolymers, and combinations thereof. The inventors have found that including one or more of these ingredients in the blend from which the fibrous material of the filter segment is formed further contributes to enhancing biodegradability of the filter segment and of the aerosol-generating article as a whole.

[0060] In addition, while it has previously been found to be technically challenging to manufacture PHA-containing filaments or fibres, using existing techniques and apparatus, the inventors have surprisingly found that it is possible to

produce a filaments or fibres incorporating a high level of PHAs when the PHAs are combined in a blend as described above, as this makes it easier to form the filaments by a spinning technique.

[0061] In preferred embodiments, the filter segment comprises at least about 10 percent by weight of one such additional biodegradable polymer. More preferably, the filter segment comprises at least about 11 percent by weight or at least 12 percent by weight or at least 13 percent by weight or at least 14 percent by weight of the additional biodegradable polymer. Even more preferably, the filter segment comprises at least about 15 percent by weight of one such additional biodegradable polymer.

[0062] In particularly preferred embodiments, the at least one biodegradable polymer is one or more of PBAT, PCL and PBS. Without wishing to be bound by theory, the inventors have found that use of one or more of these selected biodegradable polymers contributes to improving the mechanical, thermal and morphological properties of the polymer mix. In particular, use of PBAT and PBS in combination has been found to provide especially well balanced mechanical properties, especially in terms of tensile strength and elongation.

[0063] In some embodiments, the fibrous filtration material comprises at least about 3 percent by weight of a plasticiser selected from triacetin, triethylene glycol diacetate (TEGDA), ethylene vinyl acetate, polyvinyl alcohol, starch or combinations thereof.

[0064] In some embodiments, the fibrous filtration material also further comprises a water based adhesive. This has the effect of structurally reinforcing the structure of the hollow tube segment. By way of example, compounds such as starch adhesive, methyl cellulose or polyvinyl acetate may be used to this purpose.

[0065] Preferably, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of at least about 1. More preferably, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of at least about 2. Even more preferably, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of at least about 3.2.

[0066] In preferred embodiments, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of less than or equal to about 10. More preferably, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of less than or equal to about 7.5. Even more preferably, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of less than or equal to about 5.

[0067] In some embodiments, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of from about 1 to about 10, more preferably from about 2 to about 10, even more preferably from about 3.2 to about 10. In other embodiments, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of from about 1 to about 7.5, more preferably from about 2 to about 7.5, even more preferably from about 3.2 to about 7.5. In further embodiments, the fibrous filtration material of which the filter segment is formed comprises a plurality of fibres comprising a PHA polymer or copolymer and having a denier per filament of from about 1 to about 5, more preferably from about 2 to about 5, even more preferably from about 3.2 to about 5.

[0068] Without wishing to be bound by theory, the inventors have found that when the filter segment is formed with PHA fibres having a relatively low DPF of between 1.5 and 3.2, the filter segment exhibits a relatively low RTD, which may be desirable for the design of certain filters. One such low range of DPF also advantageously reduces the overall weight of the filter segment, which further improves the biodegradability of the aerosol-generating article.

[0069] The transverse cross-sectional shape of the PHA fibres may be varied, for example, in order to control the external surface area of the fibres within the filter. By controlling the external surface area of the PHA fibres, the total surface area of the PHA fibres that is exposed to the mainstream smoke as it passes through the filter segment may also be controlled. This in turn will control to some extent the filtration properties of the PHA fibres, for example, the amount of water that is adsorbed by the fibres.

[0070] The total external surface area of the PHA fibres within the filter segment is preferably between about 0.15 square metres per gram and about 0.55 square metres per gram. (please add subranges).

[0071] The PHA fibres may have a substantially round cross-section. In such embodiments, the total external surface area of the PHA fibres within the filter segment is preferably between about 0.15 square metres per gram and about 0.30 square metres per gram.

[0072] The PHA fibres may have a Y-shaped cross-section. In such embodiments, the total external surface are of the PHA fibres within the filter segment is preferably between about 0.25 square metres per gram and about 0.55 square metres per gram.

[0073] The PHA filter segment of the aerosol-generating articles according to the invention may be adapted in order to provide a desired level of resistance to draw (RTD). Advantageously, the PHA fibres can be arranged to provide a relatively high RTD to the PHA filter segment. The PHA filter segment is therefore particularly suitable for use in the filter

of a combustible smoking article, where a relatively high RTD is typically desirable. Alternatively, the PHA filter segment may be particularly suitable in aerosol-generating articles for which a relatively short mouthpiece or filter is preferred, since an acceptable RTD can still be provided.

[0074] Preferably, in aerosol-generating articles in accordance with the present invention an RTD of the PHA filter segment for a 27 millimetre filter segment is at least about 25 millimetres H_2O. More preferably, an RTD of the PHA filter segment for a 27 millimetre filter segment is at least about 50 millimetres H_2O , more preferably at least about 100 millimetres H_2O. Even more preferably, in aerosol-generating articles in accordance with the present invention an RTD of the PHA filter segment for a 27 millimetre filter segment is at least about 150 millimetres H_2O, more preferably at least about 180 millimetres H_2O. The RTD of the PHA filter segment for a 27 millimetre filter segment is preferably no more than about 300 millimetres H_2O, more preferably no more than 250 millimetres H_2O. For example, the RTD of the PHA filter segment for a 27 millimetre filter segment may be between about 25 millimetres H_2O and about 300 millimetres H_2O, or between about 50 millimetres H_2O and about 300 millimetres H_2O, or between about 100 millimetres H_2O and about 250 millimetres H_2O, or between about 150 millimetres H_2O and about 250 millimetres H_2O, or between about 180 millimetres H_2O and about 250 millimetres H_2O, or around 200 millimetres H_2O.

[0075] The RTD of the filter segment is between 35 millimetres H_2O and about 55 millimetres H_2O.

[0076] "Resistance to draw" refers to the static pressure difference between the two ends of a sample when it is traversed by an air flow under steady conditions in which the volumetric flow is 17.5 millilitres per second at the output end. The RTD of a sample can be measured using the method set out in ISO Standard 6565:2002.

[0077] The filter segment of the aerosol-generating articles according to the invention may have a lower RTD compared to a filter segment of cellulose acetate fibres, which may be desirable for certain applications. For example, a relatively low RTD may be advantageous where a relatively low filtration efficiency is desirable or where a relatively long filter is preferred.

[0078] The filter segment of the aerosol-generating article according to the invention has additionally been found to provide a good stability in the RTD, which means that a high variability in the RTD can advantageously be avoided. For example, within a sample of 20 of the aerosol-generating articles according to the invention, there will typically be a standard deviation from the target RTD of between 2 percent and 10 percent, more preferably between 2 percent and 5 percent.

[0079] Preferably, the fibres comprising a PHA polymer or copolymer of the filter segment are crimped.

[0080] In some embodiments, the filter segment may comprise one or more additive for reducing certain constituents in the mainstream smoke. By way of example, the filter segment preferably comprises an additive for the reduction of phenols and phenol derivatives. Suitable additives would be known to the skilled person and include, but are not limited to: polyethylene glycol (PEG), triacetin, tri-ethyl citrate, cellulose acetate flakes or combinations thereof.

[0081] Preferably, the filter segment comprises between about 3 percent and about 15 percent by weight of the additive, more preferably between about 5 percent and about 9 percent by weight of the additive.

[0082] In certain preferred embodiments of the invention, the PHA filter segment comprises polyethylene glycol, such as PEG 400.

[0083] The combination of PHA with an additive such as PEG for the reduction of phenolic compounds from the mainstream smoke has been found to be particularly effective. PHA fibres generally provide a good filtration efficiency for undesirable smoke constituents but are less effective at the removal of phenolic compounds. By incorporating a compound that specifically reduces the level of phenolic compounds in the mainstream smoke, it is possible to further optimise the filtration capabilities of the filter segment of an aerosol-generating article in accordance with the invention. This in turn improves the sensory characteristics of the aerosol delivered to the consumer.

[0084] In particularly preferred embodiments, the filter segment further comprises at least about 5 percent by weight of polyethylene glycol, based on the total weight of the filtration material. Preferably, the filter segment comprises no more than 10 percent by weight of polyethylene glycol, based on the total weight of the filtration material.

[0085] In other preferred embodiments of the invention, the PHA filter segment further comprises a mixture of cellulose acetate and triacetin. Preferably, the mixture comprises at least 90 percent by weight of triacetin and up to 10 percent by weight cellulose acetate. The mixture may be formed by adding cellulose acetate flakes to triacetin to form a solution. The solution may then be sprayed onto the PHA fibres in the PHA filter segment. This combination has been found to advantageously replicate the combined effects of triacetin and cellulose acetate fibres in the filter of a conventional cigarette.

[0086] As described above, it has been found that PHA fibres absorb less water from the mainstream smoke than an equivalent amount of cellulose acetate fibres, due to the lower affinity of the PHA fibres to water. As demonstrated in the examples below, the amount of water absorbed by a PHA filter segment is significantly lower than the amount of water absorbed by a comparative filter segment formed of an equivalent weight of cellulose acetate fibres.

[0087] For example, when exposed to water in liquid form, the filter segment of the aerosol-generating article of the present invention preferably absorbs less than half the amount of water that is absorbed under the same conditions by an equivalent filter segment formed of cellulose acetate fibres.

[0088] The reduced absorption of water by the PHA fibres in the filter segment of the present invention, compared to cellulose acetate results in a higher level of water in the mainstream smoke delivered from the aerosol-generating article during use.

[0089] For example, the amount of water in the mainstream smoke collected during the smoking of a combustible smoking article comprising a filter according to the invention with PHA fibres under ISO conditions was at least 10 percent higher and preferably at least 15 percent higher than the amount of water in the mainstream smoke collected during the smoking of an equivalent combustible smoking article having a filter segment of cellulose acetate tow under the same conditions.

[0090] Aerosol-generating articles comprising a filter including a PHA filter segment are therefore able to deliver a mainstream smoke having a higher moisture level, which is more sensorially acceptable to the consumer. In particular, the 'dry smoke' effect that may be experienced during smoking of an aerosol-generating article with a conventional cellulose acetate filter can advantageously be reduced.

[0091] The fibres comprising a PHA polymer or copolymer of the filter segment may be manufactured by one of several techniques, including melt spinning, gel spinning, and electrospinning. Preferably, the fibres comprising a PHA polymer or copolymer of the filter segment in aerosol-generating articles in accordance with the present invention are manufactured by melt spinning. Melt spinning is often regarded as the most economical process of spinning, since no solvent needs to be recovered or evaporated, as is by contrast the case with solution spinning. Further, the spinning rate with melt spinning is generally fairly high, which is advantageous in terms of overall productivity and manufacturing efficiency.

[0092] In this process, a viscous melt of polymer or of a polymer blend is extruded through a spinneret containing a number of holes into a chamber, where a blast of cold air or gas is directed onto the surface of filaments emanating from the spinneret. As the air strikes the filaments, the filaments are solidified and collected such as on a take-up wheel. The melt spinning process is advantageously characterised by defined filament cross-section geometries and affords a significant variety of fineness and filament count. By increasing the number of openings in the spinneret, a high spinning capacity can be achieved, which is difficult to match with other spinning processes.

[0093] According to the invention, the filter segment has a length of at least about 4 millimetres. Preferably, a length of the filter segment is at least about 5 millimetres. More preferably, a length of the filter segment is at least about 7 millimetres. Even more preferably, a length of the filter segment is at least about 10 millimetres.

[0094] The length of the filter segment is less than or equal to about 27 millimetres. More preferably, a length of the filter segment is less than or equal to about 25 millimetres. Even more preferably a length of the filter segment it less than or equal to about 20 millimetres.

[0095] The length of the filter segment is from about 4 millimetres to about 27 millimetres, and preferably is from about 5 millimetres to about 27 millimetres, more preferably from about 10 millimetres to about 27 millimetres, even more preferably from about 15 millimetres to about 27 millimetres, most preferably from about 20 millimetres to about 27 millimetres. As a further alternative, in such embodiments, a length of the filter segment may be from about 4 millimetres to about 25 millimetres, and preferably is from about 5 millimetres to about 25 millimetres, more preferably from about 10 millimetres to about 25 millimetres, even more preferably from about 15 millimetres to about 30 millimetres, most preferably from about 20 millimetres to about 25 millimetres.

[0096] The filter segment preferably has an external diameter that is about equal to the external diameter of the aerosol-generating article. Preferably, the filter segment has an external diameter of at least 5 millimetres. The filter segment may have an external diameter of between about 5 millimetres and about 12 millimetres, for example of between about 5 millimetres and about 10 millimetres or of between about 6 millimetres and about 8 millimetres. In a preferred embodiment, the filter segment has an external diameter of 7.2 millimetres, to within 10 percent.

[0097] Preferably, in aerosol-generating articles in accordance with the present invention the filter segment has an average radial hardness of at least 80 percent, more preferably at least 85 percent. The filter segment is therefore able to provide a desirable level of filter hardness, which is comparable to that provided by a conventional cellulose acetate tow filter. If desired, the radial hardness of the filter segment of aerosol-generating articles in accordance with the invention may be further increased by circumscribing the filter segment by a stiff plug wrap, for example, a plug wrap having a basis weight of at least about 80 grams per square metre (gsm), or at least about 100 gsm, or at least about 110 gsm.

[0098] As used herein, the term "radial hardness" refers to resistance to compression in a direction transverse to a longitudinal axis of the filter segment. Radial hardness of an aerosol-generating article around a filter may be determined by applying a load across the article at the location of the filter, transverse to the longitudinal axis of the article, and measuring the average (mean) depressed diameters of the articles. Radial hardness is given by:

$$Radial\ hardness\ (\%) = \frac{D_d}{D_S} * 100\ \%$$

where D_S is the original (undepressed) diameter, and D_d is the depressed diameter after applying a set load for a set duration. The harder the material, the closer the hardness is to 100%.

[0099] To determine the hardness of a portion (such as a filter segment) of an aerosol article, aerosol-generating articles should be aligned parallel in a plane and the same portion of each aerosol-generating article to be tested should be subjected to a set load for a set duration. This test is performed using a known DD60A Densimeter device (manufactured and made commercially available by Heinr Borgwaldt GmbH, Germany), which is fitted with a measuring head for aerosol-generating articles, such as cigarettes, and with an aerosol-generating article receptacle.

[0100] The load is applied using two load-applying cylindrical rods, which extend across the diameter of all of the aerosol-generating articles at once. According to the standard test method for this instrument, the test should be performed such that twenty contact points occur between the aerosol-generating articles and the load applying cylindrical rods. In some cases, the filters to be tested may be long enough such that only ten aerosol-generating articles are needed to form twenty contact points, with each smoking article contacting both load applying rods (because they are long enough to extend between the rods). In other cases, if the filters are too short to achieve this, then twenty aerosol-generating articles should be used to form the twenty contact points, with each aerosol-generating article contacting only one of the load applying rods, as further discussed below.

[0101] Two further stationary cylindrical rods are located underneath the aerosol-generating articles, to support the aerosol-generating articles and counteract the load applied by each of the load applying cylindrical rods.

[0102] For the standard operating procedure for such an apparatus, an overall load of 2 kg is applied for a duration of 20 seconds. After 20 seconds have elapsed (and with the load still being applied to the smoking articles), the depression in the load applying cylindrical rods is determined, and then used to calculate the hardness from the above equation. The temperature is kept in the region of 22 degrees Centigrade $\pm$ 2 degrees. The test described above is referred to as the DD60A Test. The standard way to measure the filter hardness is when the aerosol-generating article have not been consumed. Additional information regarding measurement of average radial hardness can be found in, for example, U.S. Published Patent Application Publication Number 2016/0128378.

[0103] In some embodiments, the filter segment described above is the only segment formed of filtration material forming a mouth end filter of the aerosol-generating article. In other embodiments, the aerosol-generating article may comprise one or more additional filter segments formed of filtration material, which may be provided upstream or downstream of the filter segment comprising a PHA polymer or copolymer as described above. For example, the filter segment comprising a PHA polymer or copolymer may be combined with one or more axially aligned filter plugs formed of a fibrous filtration material, which may or may not include PHA-containing fibres. Alternatively or in addition, the filter segment comprising a PHA polymer or copolymer may be combined with one or more tubular elements, such as a tubular element formed of a fibrous filtration material or a cardboard tube. Alternatively or in addition, the PHA filter segment may be combined with an aerosol-cooling element.

[0104] The filter segment of aerosol-generating articles according to the invention may optionally comprise a flavourant. Flavourants can be incorporated using a variety of different means, which would be known to the skilled person. For example, a flavourant may be incorporated in the form of a capsule which may be provided in the filter segment comprising a PHA polymer or copolymer, or in an additional filter segment of the aerosol-generating article.

[0105] The filter segment of aerosol-generating articles according to the invention is preferably circumscribed by an outer wrapper, for example, a tipping wrapper that circumscribes the filter segments, the downstream end of the aerosol-generating substrate and any additional components that may be provided in between. The tipping wrapper may comprise a removable tipping wrapper portion, as described in WO-A-2017/162838. This enables at least a portion of the tipping wrapper to be removed before the aerosol-generating article is discarded. The removal of the tipping wrapper exposes the underlying filter segments and may therefore advantageously speed up the rate of biodegradation of the filter materials.

[0106] In some embodiments, an aerosol-generating article in accordance with the present invention may further comprise one or more additional elements that are typically assembled with the rod of aerosol-generating substrate in a same wrapper. Examples of such additional elements include a support element adapted to enhance the structural strength to the aerosol-generating article, a cooling element adapted to favour cooling of the aerosol prior to reaching the filter segment, and so forth.

[0107] For example, in one preferred embodiment, an aerosol-generating article comprises, in linear sequential arrangement, a rod of aerosol-generating substrate, a support element located immediately downstream of the support element, an aerosol-cooling element located downstream of the support element, and an outer wrapper circumscribing the rod, the support element, and the aerosol-cooling element. The rod, the support element, and the aerosol-cooling element are provided in linear arrangement and upstream of a filter segment as described above. In one particularly preferred embodiment, the rod, the support element, and the aerosol-cooling element are provided in linear arrangement and immediately upstream of a filter segment as described above.

[0108] For example, a support element may be provided in the form of a tubular element of a fibrous filtration material. The fibrous filtration material may comprise cellulose acetate. In preferred embodiments, the fibrous filtration comprises a polyhydroxyalkanoate (PHA) polymer or copolymer.

[0109] In another preferred embodiment of the present invention, the aerosol-generating article comprises in a linear sequential arrangement: an aerosol-generating substrate, a transfer element, an aerosol-cooling element, a spacer element and a filter segment as described above.

[0110] In certain preferred embodiments of the present invention, the aerosol-generating article further comprises a combustible heat source at the upstream end of the aerosol-generating article, in contact with the upstream end of the aerosol-generating substrate. For example, the aerosol-generating article may comprise a carbonaceous heat source at the upstream end, for heating the aerosol-generating substrate to generate an aerosol during use. Suitable carbonaceous heat sources would be known to the skilled person.

[0111] The invention will now be further described with reference to the figures in which:

Figure 1 shows a schematic longitudinal cross-sectional view of an aerosol-generating article according to a first embodiment of the invention, for use with an aerosol-generating device comprising a heater element;
Figure 2 shows a schematic longitudinal cross-sectional view of an aerosol-generating article according to a second embodiment of the invention, comprising an integral heat source; and
Figure 3 shows a schematic longitudinal cross-sectional view of an aerosol-generating article according to a third embodiment of the invention;
Figure 4 shows a schematic longitudinal cross-sectional view of an aerosol-generating system comprising an electrically operated aerosol-generating device and the aerosol-generating article shown in Figure 1.

[0112] The aerosol-generating article 10 shown in Figure 1 comprises a rod of aerosol-generating substrate 12, a support element provided as a hollow tubular element 14, a cooling element 16, and a mouth end filter segment 18. These four elements are arranged sequentially and in coaxial alignment and are circumscribed by a substrate wrapper 20 to form the aerosol-generating article 10. The aerosol-generating article 10 has a mouth end 22 and a distal end 24 located at the opposite end of the article to the mouth end 22. The aerosol-generating article 10 shown in Figure 1 is particularly suitable for use with an electrically operated aerosol-generating device comprising a heater for heating the rod of aerosol-generating substrate.

[0113] In use air is drawn through the aerosol-generating article by a user from the distal end 24 to the mouth end 22. The distal end 24 of the aerosol-generating article may also be described as the upstream end of the aerosol-generating article 10 and the mouth end 22 of the aerosol-generating article 10 may also be described as the downstream end of the aerosol-generating article 10. Elements of the aerosol-generating article 10 located between the mouth end 22 and the distal end 24 can be described as being upstream of the mouth end 22 or, alternatively, downstream of the distal end 24.

[0114] The aerosol-generating substrate 24 is located at the extreme distal or upstream end of the aerosol-generating article 10. In the embodiment illustrated in Figure 1, the aerosol-generating substrate 12 comprises a gathered sheet of crimped homogenised tobacco material circumscribed by a wrapper. The crimped sheet of homogenised tobacco material comprises glycerin as an aerosol former.

[0115] The support element 14 is located immediately downstream of the aerosol-generating substrate 12 and abuts the aerosol-generating substrate 12. In the embodiment shown in Figure 1, the support element is a hollow tube formed of a fibrous filtration material. The support element 14 locates the aerosol-generating substrate 12 at the extreme distal end 24 of the aerosol-generating article 10 so that it can be penetrated by a heating element of an aerosol-generating device. In effect, the support element 14 acts to prevent the aerosol-generating substrate 16 from being forced downstream within the aerosol-generating article 10 towards the aerosol-cooling element 16 when a heating element of an aerosol-generating device is inserted into the aerosol-generating substrate 12. The support element 14 also acts as a spacer to space the aerosol-cooling element 16 of the aerosol-generating article 10 from the aerosol-generating substrate 12.

[0116] The aerosol-cooling element 16 is located immediately downstream of the support element 14 and abuts the support element 14. In use, volatile substances released from the aerosol-generating substrate 12 pass along the aerosol-cooling element 16 towards the mouth end 22 of the aerosol-generating article 10. The volatile substances may cool within the aerosol-cooling element 16 to form an aerosol that is inhaled by the user. In the embodiment illustrated in Figure 1, the aerosol-cooling element comprises a tubular element 20. The crimped and gathered sheet of polylactic acid defines a plurality of longitudinal channels that extend along the length of the aerosol-cooling element 40.

[0117] The filter segment 18 is located immediately downstream of the aerosol-cooling element 16 and abuts the aerosol-cooling element 16. In the embodiment illustrated in Figure 1, the filter segment 18 comprises a single cylindrical plug of a fibrous filtration material formed of a plurality of PHA fibres having a denier per filament of approximately 3 and a total denier of approximately 27,000. The PHA fibres have a round cross-sectional shape and are substantially longitudinally aligned with each other along the length of the filter segment. The exposed surface area of the PHA fibres corresponds to about 0.16 square metres per gram. The PHA fibres have been formed by a melt spinning process and are crimped. In more detail, the fibres contain about 85 percent by weight of a PHA polymer or copolymer combined with 15 percent by weight of a of PBAT/PBS blend with a 1:1 PBAT to PBS ratio. The plug of fibrous filtration material

is circumscribed by a plug wrap (not shown).

[0118] The aerosol-generating article 100 shown in Figure 2 comprises a combustible heat source 112, a rod of aerosol-generating substrate 114, a transfer element 116, an aerosol-cooling element, 118, a spacer element 120 and a mouthpiece filter segment 122. These elements are arranged sequentially and in coaxial alignment and are circumscribed by a substrate wrapper to form the aerosol-generating article 100.

[0119] The combustible heat source 112 comprises a substantially circularly cylindrical body of carbonaceous material, having a length of about 10 millimetres. The combustible heat source 112 is a blind heat source. In other words, the combustible heat source 112 does not comprise any air channels extending therethrough.

[0120] The rod of aerosol-generating substrate 114 is arranged at a proximal end of the combustible heat source 112. The aerosol-generating substrate 114 comprises a substantially circularly cylindrical plug of tobacco material 124 circumscribed by filter plug wrap 126.

[0121] A non-combustible, substantially air impermeable first barrier 128 is arranged between the proximal end of the combustible heat source 112 and a distal end of the aerosol-generating substrate 114. The first barrier 128 comprises a disc of aluminium foil. The first barrier 128 also forms a heat-conducting member between the combustible heat source 112 and the aerosol-generating substrate 114, for conducting heat from the proximal face of the combustible heat source 112 to the distal face of the aerosol-generating substrate 114.

[0122] A heat-conducting element 130 circumscribes a proximal portion of the combustible heat source 112 and a distal portion of the aerosol-forming substrate 114. The heat-conducting element 130 comprises a tube of aluminium foil. The heat-conducting element 130 is in direct contact with the proximal portion of the combustible heat source 112 and the filter plug wrap 126 of the aerosol-generating substrate 114.

[0123] The mouthpiece filter 122 comprises a single cylindrical plug 126 of a fibrous filtration material formed of a plurality of PHA fibres having a denier per filament of approximately 3 and a total denier of approximately 27,000. The PHA fibres have a round cross-sectional shape and are substantially longitudinally aligned with each other along the length of the filter segment. The exposed surface area of the PHA fibres corresponds to about 0.16 square metres per gram. The PHA fibres have been formed by a melt spinning process and are crimped. The plug of fibrous filtration material is circumscribed by a plug wrap (not shown).

[0124] The aerosol-generating article 310 shown in Figure 3 is a combustible smoking article comprising an aerosol-generating substrate 312 and a filter 314 arranged in coaxial alignment with each other. The aerosol-generating substrate 312 comprises a tobacco rod circumscribed by an outer wrapper (not shown). A tipping wrapper 316 circumscribes both the filter 314 and an end portion of the aerosol-generating substrate 312 and attaches the filter 314 to the aerosol-generating substrate 312.

[0125] The filter 314 comprises a single cylindrical plug 318 of a fibrous filtration material formed of PHA fibres having a denier per filament of approximately 3 and a total denier of approximately 27,000. The PHA fibres have a round cross-sectional shape and are substantially longitudinally aligned with each other along the length of the filter segment. The exposed surface area of the PHA fibres corresponds to about 0.16 square metres per gram. The PHA fibres have been formed by a melt spinning process and are crimped. The plug of fibrous filtration material is circumscribed by a plug wrap (not shown).

[0126] Figure 4 shows a portion of an electrically operated aerosol-generating system 200 that utilises a heater blade 210 to heat the rod of aerosol-generating substrate 12 of the aerosol-generating article 10 shown in Figure 1. The heater blade 210 is mounted within an aerosol-generating article chamber within a housing of an electrically operated aerosol-generating device 212. The aerosol-generating device 212 defines a plurality of air holes 214 for allowing air to flow to the aerosol-generating article 10, as illustrated by the arrows in Figure 4. The aerosol-generating device 212 comprises a power supply and electronics, which are not shown in Figure 4.

Comparative Example

[0127] A PHA filter segment according to the invention was prepared from PHA fibres, with the parameters shown in Table 1 below. The PHA fibres were formed using a melt spinning process, the fibres were then crimped and formed into a filter segment using standard filter making apparatus. For the purposes of comparison, a conventional cellulose acetate (CA) tow filter segment was prepared, with similar values of denier per filament (dpf) and total denier.

Table 1: parameters of PHA filter segment and cellulose acetate filter segment

Parameter	PHA filter segment	CA filter segment
Denier per filament	3.2	3
Total denier	27000	27000
Weight in filter segment (mg)	406.76	409.76

(continued)

Parameter	PHA filter segment	CA filter segment
Exposed surface area (m^2/g)	0.161	0.329

[0128] In a first test, the water absorption by exposure to water of the PHA filter segment according to the invention and the CA filter segment were compared. For each filter segment, the plug wrap was removed and the filter segment was attached to the probe of a force tensiometer (KRUSS force tensiometer, Model K100). The filter segment is moved down by the probe towards a container of water and automatically stopped when the filter segment makes contact with the water. The filter segment is retained in contact with the water for 300 seconds so that the filter material can absorb water and then the filter segment is weighed in order to determine the amount of water absorbed during the test period. For each of the PHA filter segment and the CA filter segment, this test was repeated three times and an average value of water absorption was calculated, as shown below in Table 2:

Table 2: Water absorption of the PHA and CA filter segments after exposure to water

	PHA filter segment	CA filter segment
Water absorption in 300 sec (g)	0.51	1.37

[0129] The amount of water absorbed by the PHA filter segment according to the invention during the test was therefore less than 40 percent of the amount of water absorbed by the CA filter segment. This test therefore demonstrates the significantly reduced affinity of water of the PHA filter segment according to the invention compared to the conventional CA filter segment.

[0130] In a second test, the water absorption by exposure to moisture of the PHA filter segment according to the invention and the CA filter segment were compared. For each filter segment, the plug wrap was removed and the fibres forming the filter segment were placed in a petri dish and exposed to air at 22 degrees Celsius and 50 percent relative humidity for 70 hours. This was conducted in a vapour sorption analyser (ProUmid SPSx-1μ). For each filter segment, the weight of the fibres is measured at the start of the test and the change in weight over time due to the absorption of water vapour by the fibres is measured. For each of the PHA filter segment and the CA filter segment, a value of the percentage difference in mass of the sample (%dm) was calculate, which expresses the increase in the weight of the sample as a percentage of the original weight. The values of %dm for each of the samples at the end of the 70 hour test are shown below in Table 3:

Table 3: Water absorption of the PHA and CA filter segments after exposure to moisture

	PHA filter segment	CA filter segment
% Difference in mass after 70 hours (% dm)	0.0133	0.6784

[0131] The results demonstrate that the amount of water vapour absorbed by the cellulose acetate fibres during the 70 hour test was more than 50 times greater than the amount of water vapour absorbed by the PHA fibres. The PHA fibres absorbed very little water vapour during the test. This further demonstrates the significantly reduced affinity of water of the PHA filter segment according to the invention compared to the conventional CA filter segment.

[0132] In a third test, the absorption of water from the mainstream smoke by a PHA filter segment according to the present invention and a conventional CA filter segment were compared. For each of the filter segments, a conventional smoking article was prepared as described above with reference to Figure 3, with a combustible tobacco rod and a single segment of the filtration material forming the filter. Each of the smoking articles was then smoked in a cigarette-smoking machine under ISO conditions as set out in ISO 3308:2000 (puff volume 35 ml; 2 second puff duration every 60 seconds) and an analysis of the resultant smoke was carried out. For each of the filter segments, the amount of water in the mainstream smoke collected during the smoking test was measured, as shown in Table 4:

Table 4: Water in mainstream smoke generated during smoking test under ISO conditions

	PHA filter segment	CA filter segment
Water (mg per smoking article)	0.82	0.68

[0133] This demonstrates that when smoked under equivalent conditions, the smoking article incorporating the PHA

filter segment produces a mainstream smoke having a water content that is approximately 20 percent higher than the water content of the mainstream smoke from the smoking article including the CA filter segment. This demonstrates that the PHA filter segment is absorbing less water from the mainstream smoke than the CA filter segment, thereby reducing the potential problem of dry smoke as described above.

Claims

1. An aerosol-generating article (10) for producing an inhalable aerosol upon heating, the aerosol-generating article comprising:

   a rod (12) of aerosol-generating substrate, wherein the aerosol-generating substrate comprises at least 10 percent by weight of an aerosol former;
   a filter segment (18) formed of fibrous filtration material, the filter segment arranged in longitudinal alignment with the rod (12);
   wherein the filter segment (18) comprises at least about 85 percent by weight based on the total weight of fibrous filtration material of a polyhydroxyalkanoate (PHA) polymer or copolymer;
   wherein an RTD of the filter segment (18) is between about 35 millimetres H_2O and about 55 millimetres H_2O; and wherein a length of the filter segment (18) is from about 4 millimetres to about 27 millimetres.

2. An aerosol-generating article according to claim 1 wherein the filter segment (18) comprises at least about 90 percent by weight based on the total weight of fibrous filtration material of a polyhydroxyalkanoate (PHA) polymer or copolymer.

3. An aerosol-generating article according to claim 1 or 2 wherein the filter segment (18) comprises at least about 95 percent by weight based on the total weight of fibrous filtration material of a polyhydroxyalkanoate (PHA) polymer or copolymer.

4. An aerosol-generating article according to any one of the preceding claims wherein the filter segment (18) further comprises at least about 5 percent by weight based on the total weight of fibrous filtration material of at least one biodegradable polymer selected from the group consisting of starch, polybutylene succinate (PBS), polybutyrate adipate terephthalate (PBAT), thermoplastic starch and thermoplastic starch blends (TPS), polycaprolactone (PCL), polyglycolide (PGA), polyvinyl alcohol (PVOH/PVA), viscose, regenerated cellulose, polysaccharides, cellulose acetate with a degree of substitution (DS) of less than 2.1, polyamides, protein-based biopolymers, chitosan-chitin based biopolymers, and combinations thereof.

5. An aerosol-generating article according to claim 4 wherein the filter segment (18) comprises at least about 10 percent based on the total weight of fibrous filtration material of the at least one biodegradable polymer.

6. An aerosol-generating article according to claim 4 or 5 wherein the filter segment (18) comprises less than or equal to about 15 percent by weight based on the total weight of fibrous filtration material of the at least one biodegradable polymer.

7. An aerosol-generating article according to any one of claims 4 to 6 wherein the at least one biodegradable polymer is one or more of PBAT, PCL and PBS.

8. An aerosol-generating article according to any one of the preceding claims wherein the fibrous filtration material comprises a plurality of fibres comprising a polyhydroxyalkanoate (PHA) polymer or copolymer and having a denier per filament from about 1 to about 10.

9. An aerosol-generating article according to any one of the preceding claims wherein the fibrous filtration material comprises a plurality of fibres comprising a polyhydroxyalkanoate (PHA) polymer or copolymer and having a denier per filament from about 3.2 to about 5.

10. An aerosol-generating article according to any one of the preceding claims wherein an RTD of the filter segment is between about 40 millimetres H_2O and about 50 millimetres H_2O.

11. An aerosol-generating article according to any one of the preceding claims wherein the fibrous filtration material

comprises crimped fibres comprising a polyhydroxyalkanoate (PHA) polymer or copolymer.

12. An aerosol-generating article according to any one of the preceding claims wherein a diameter of the filter segment is from about 5 millimetres to about 12 millimetres.

13. A filter for an aerosol-generating article (10), the filter comprising a filter segment (18) formed of fibrous filtration material, wherein the filter segment (18) comprises at least about 85 percent by weight based on the total weight of fibrous filtration material of fibres comprising a polyhydroxyalkanoate (PHA) polymer or copolymer; wherein an RTD of the filter segment (18) is between about 35 millimetres H_2O and about 55 millimetres H_2O; and wherein a length of the filter segment (18) is from about 4 millimetres to about 27 millimetres.

Patentansprüche

1. Aerosolerzeugender Artikel (10) zum Erzeugen eines inhalierbaren Aerosols bei der Erwärmung, der aerosolerzeugende Artikel aufweisend:

einen Stab (12) aus aerosolerzeugendem Substrat, wobei das aerosolerzeugende Substrat wenigstens 10 Gewichtsprozent eines Aerosolbildners umfasst;
ein aus Faserfiltermaterial gebildetes Filtersegment (18), wobei das Filtersegment in Längsausrichtung mit dem Stab (12) angeordnet ist;
wobei das Filtersegment (18) wenigstens etwa 85 Gewichtsprozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, eines Polyhydroxyalkanoat-(PHA-)Polymers oder -Copolymers umfasst;
wobei ein RTD des Filtersegments (18) zwischen etwa 35 Millimeter H_2O und etwa 55 Millimeter H_2O liegt; und
wobei eine Länge des Filtersegments (18) von etwa 4 Millimeter bis etwa 27 Millimeter beträgt.

2. Aerosolerzeugender Artikel nach Anspruch 1, wobei das Filtersegment (18) wenigstens etwa 90 Gewichtsprozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, eines Polyhydroxyalkanoat-(PHA-)Polymers oder -Copolymers umfasst.

3. Aerosolerzeugender Artikel nach Anspruch 1 oder 2, wobei das Filtersegment (18) wenigstens etwa 95 Gewichtsprozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, eines Polyhydroxyalkanoat-(PHA-)Polymers oder -Copolymers umfasst.

4. Aerosolerzeugender Artikel nach einem der vorhergehenden Ansprüche, wobei das Filtersegment (18) ferner wenigstens etwa 5 Gewichtsprozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, wenigstens eines biologisch abbaubaren Polymers umfasst, ausgewählt aus der Gruppe bestehend aus Stärke, Polybutylensuccinat (PBS), Polybutyrat-Adipat-Terephthalat (PBAT), thermoplastischer Stärke und thermoplastischen Stärkemischungen (TPS), Polycaprolacton (PCL), Polyglycolid (PGA), Polyvinylalkohol (PVOH/PVA), Viskose, regenerierter Cellulose, Polysacchariden, Celluloseacetat mit einem Substitutionsgrad (DS) von weniger als 2,1, Polyamide, Biopolymere auf Proteinbasis, Biopolymere auf Chitosan-Chitin-Basis und Kombinationen davon.

5. Aerosolerzeugender Artikel nach Anspruch 4, wobei das Filtersegment (18) wenigstens etwa 10 Prozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, des wenigstens einen biologisch abbaubaren Polymers umfasst.

6. Aerosolerzeugender Artikel nach Anspruch 4 oder 5, wobei das Filtersegment (18) weniger als oder gleich etwa 15 Gewichtsprozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, des wenigstens einen biologisch abbaubaren Polymers umfasst.

7. Aerosolerzeugender Artikel nach einem der Ansprüche 4 bis 6, wobei das wenigstens eine biologisch abbaubare Polymer eines oder mehrere von PBAT, PCL und PBS ist.

8. Aerosolerzeugender Artikel nach einem der vorhergehenden Ansprüche, wobei das Faserfiltermaterial eine Vielzahl von Fasern umfasst, die ein Polyhydroxyalkanoat-(PHA-)Polymer oder -Copolymer umfassen und einen Denier pro Filament von etwa 1 bis etwa 10 aufweisen.

9. Aerosolerzeugender Artikel nach einem der vorhergehenden Ansprüche, wobei das Faserfiltermaterial eine Vielzahl von Fasern umfasst, die ein Polyhydroxyalkanoat-(PHA-)Polymer oder -Copolymer umfassen und einen Denier pro

Filament von etwa 3,2 bis etwa 5 aufweisen.

10. Aerosolerzeugender Artikel nach einem der vorhergehenden Ansprüche, wobei ein RTD des Filtersegments zwischen etwa 40 Millimeter H_2O und etwa 50 Millimeter H_2O liegt.

11. Aerosolerzeugender Artikel nach einem der vorhergehenden Ansprüche, wobei das Faserfiltermaterial gewellte Fasern umfasst, die ein Polyhydroxyalkanoat-(PHA-)Polymer oder -Copolymer umfassen.

12. Aerosolerzeugender Artikel nach einem der vorhergehenden Ansprüche, wobei ein Durchmesser des Filtersegments von etwa 5 Millimeter bis etwa 12 Millimeter beträgt.

13. Filter für einen aerosolerzeugenden Artikel (10), wobei der Filter ein aus Faserfiltermaterial gebildetes Filtersegment (18) umfasst, wobei das Filtersegment (18) wenigstens etwa 85 Gewichtsprozent, basierend auf dem Gesamtgewicht des Faserfiltermaterials, an Fasern umfasst, die ein Polyhydroxyalkanoat-(PHA-)Polymer oder -Copolymer umfassen; wobei ein RTD des Filtersegments (18) zwischen etwa 35 Millimeter H_2O und etwa 55 Millimeter H_2O liegt; und wobei eine Länge des Filtersegments (18) von etwa 4 Millimeter bis etwa 27 Millimeter beträgt.

Revendications

1. Article de génération d'aérosol (10) destiné à produire un aérosol inhalable lors du chauffage, l'article de génération d'aérosol comprenant :

une tige (12) de substrat de génération d'aérosol, dans lequel le substrat de génération d'aérosol comprend au moins 10 pour cent en poids d'un agent de formation d'aérosol ;
un segment filtrant (18) formé de matière de filtration fibreuse, le segment filtrant étant agencé en alignement longitudinal avec la tige (12) ;
dans lequel le segment filtrant (18) comprend au moins environ 85 pour cent en poids, sur la base du poids total de la matière de filtration fibreuse, d'un polymère ou d'un copolymère de polyhydroxyalcanoate (PHA) ;
dans lequel une RTD du segment filtrant (18) est entre environ 35 millimètres H_2O et environ 55 millimètres H_2O ; et dans lequel une longueur du segment filtrant (18) est d'environ 4 millimètres à environ 27 millimètres.

2. Article de génération d'aérosol selon la revendication 1 dans lequel le segment filtrant (18) comprend au moins environ 90 pour cent en poids, sur la base du poids total de la matière de filtration fibreuse, d'un polymère ou d'un copolymère de polyhydroxyalcanoate (PHA).

3. Article de génération d'aérosol selon la revendication 1 ou 2 dans lequel le segment filtrant (18) comprend au moins environ 95 pour cent en poids, sur la base du poids total de la matière de filtration fibreuse, d'un polymère ou d'un copolymère de polyhydroxyalcanoate (PHA).

4. Article de génération d'aérosol selon l'une quelconque des revendications précédentes, dans lequel le segment filtrant (18) comprend en outre au moins environ 5 pour cent en poids, sur la base du poids total de la matière de filtration fibreuse, d'au moins un polymère biodégradable choisi dans le groupe constitué par amidon, polybutylène succinate (PBS), téréphtalate d'adipate de polybutyrate (PBAT), amidon thermoplastique et mélanges d'amidon thermoplastique (TPS), polycaprolactone (PCL), polyglycolide (PGA), alcool polyviniylique (PVOH/PVA), viscose, cellulose régénérée, polysaccharides, acétate de cellulose avec un degré de substitution (DS) inférieur à 2.1, polyamides, biopolymères à base de protéines, biopolymères à base de chitosane-chitine et des combinaisons de ceux-ci.

5. Article de génération d'aérosol selon la revendication 4 dans lequel le segment filtrant (18) comprend au moins environ 10 pour cent sur la base du poids total de la matière de filtration fibreuse, de l'au moins un polymère biodégradable.

6. Article de génération d'aérosol selon la revendication 4 ou 5 dans lequel le segment filtrant (18) comprend une quantité inférieure ou égale à environ 15 pour cent en poids sur la base du poids total de la matière de filtration fibreuse, de l'au moins un polymère biodégradable.

7. Article de génération d'aérosol selon l'une quelconque des revendications 4 à 6, dans lequel l'au moins un polymère

biodégradable est un ou plusieurs parmi PBAT, PCL et PBS.

8. Article de génération d'aérosol selon l'une quelconque des revendications précédentes, dans lequel la matière de filtration fibreuse comprend une pluralité de fibres comprenant un polymère ou copolymère de polyhydroxyalcanoate (PHA) et ayant un denier par filament d'environ 1 à environ 10.

9. Article de génération d'aérosol selon l'une quelconque des revendications précédentes, dans lequel la matière de filtration fibreuse comprend une pluralité de fibres comprenant un polymère ou copolymère de polyhydroxyalcanoate (PHA) et ayant un denier par filament d'environ 3,2 à environ 5.

10. Article de génération d'aérosol selon l'une quelconque des revendications précédentes, dans lequel une RTD du segment filtrant est entre environ 40 millimètres H_2O et environ 50 millimètres H_2O.

11. Article de génération d'aérosol selon l'une quelconque des revendications précédentes, dans lequel la matière de filtration fibreuse comprend des fibres crêpées comprenant un polymère ou copolymère de polyhydroxyalcanoate (PHA).

12. Article de génération d'aérosol selon l'une quelconque des revendications précédentes, dans lequel un diamètre du segment filtrant est d'environ 5 millimètres à environ 12 millimètres.

13. Filtre destiné à un article de génération d'aérosol (10), le filtre comprenant un segment filtrant (18) formé de matière de filtration fibreuse, dans lequel le segment filtrant (18) comprend au moins environ 85 pour cent en poids sur la base du poids total de la matière de filtration fibreuse de fibres comprenant un polymère ou copolymère de polyhydroxyalcanoate (PHA) ; dans lequel une RTD du segment filtrant (18) est entre environ 35 millimètres H_2O et environ 55 millimètres H_2O ; et dans lequel une longueur du segment filtrant (18) est d'environ 4 millimètres à environ 27 millimètres.

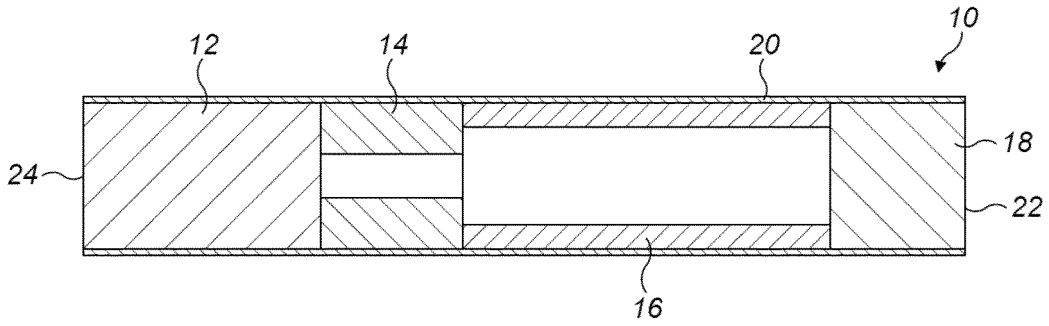

Figure 1

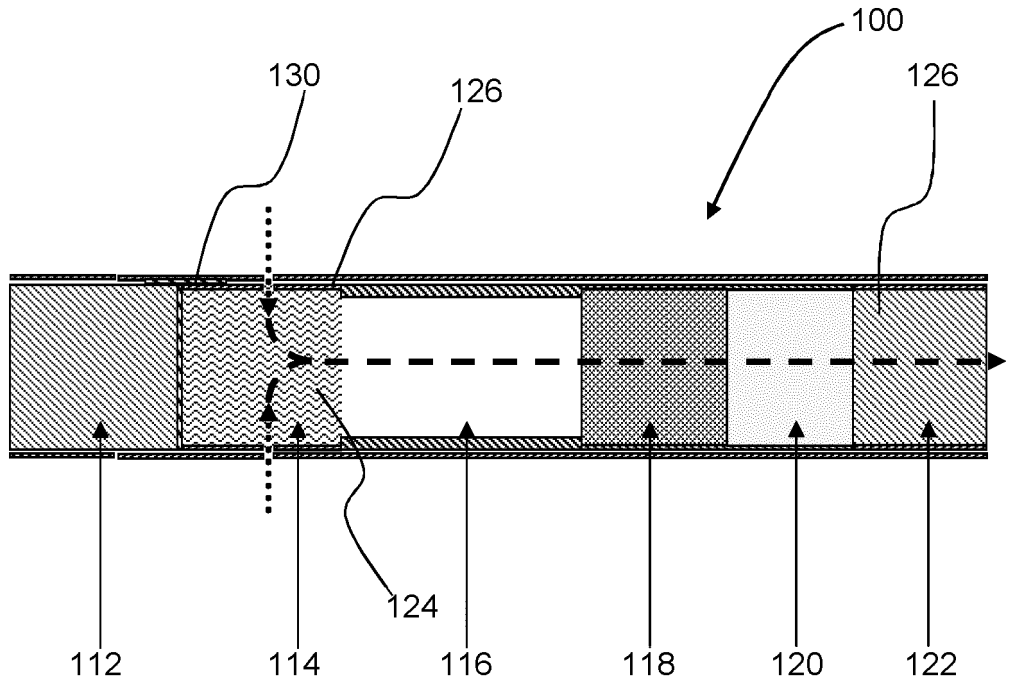

Figure 2

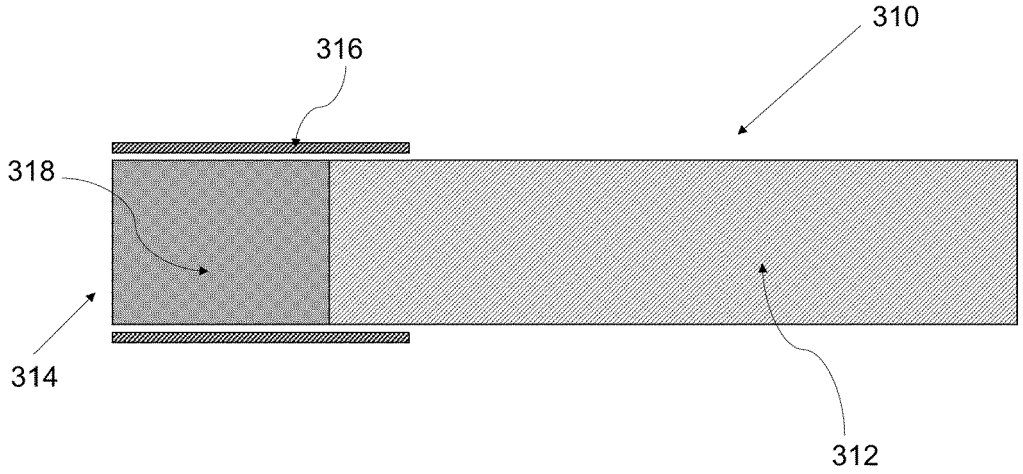

Figure 3

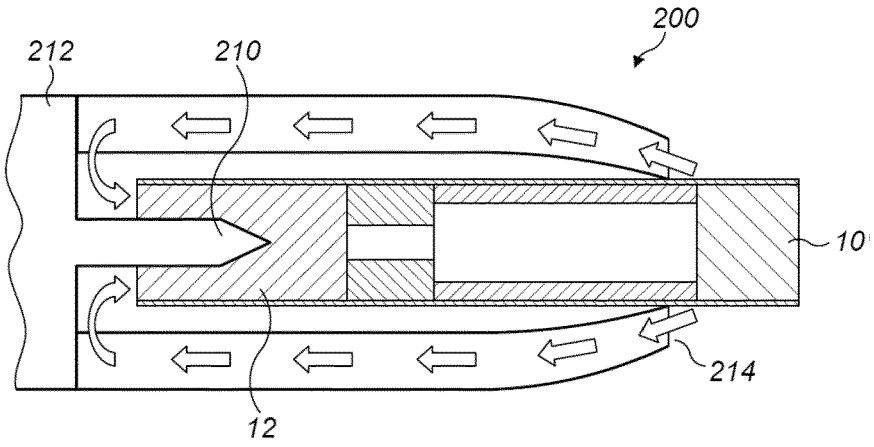

Figure 4

REFERENCES CITED IN THE DESCRIPTION

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