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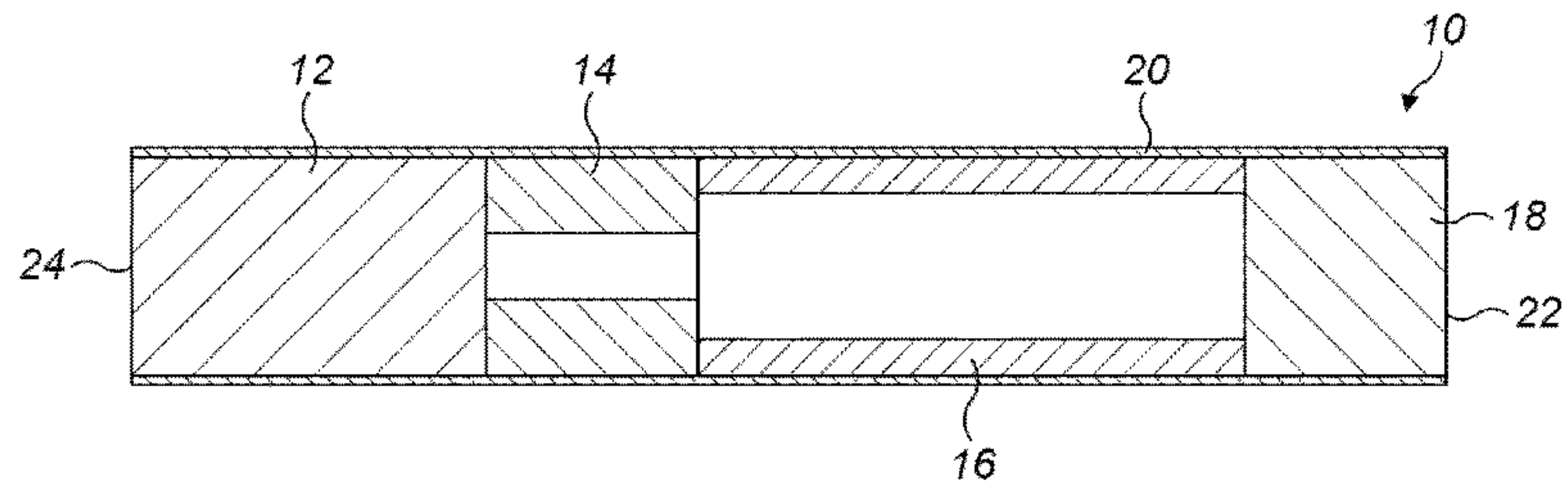

Figure 1

(57) Abstract: An aerosol-generating article (10)(100)(310) comprises: an aerosol-generating substrate (12)(114)(312); and a filter (18)(122)(314) in axial alignment with the aerosol-generating substrate, the filter (18)(122)(314) comprising at least one filter segment (126)(318) of filtration material comprising a plurality of fibres comprising a polyhydroxyalkanoate compound, wherein the fibres provide a total external surface area of between 0.12 square metres per gram and 0.28 square metres per gram. The at least one filter segment comprises at least 20 percent by weight of the polyhydroxyalkanoate compound.

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AEROSOL-GENERATING ARTICLE FILTER HAVING NOVEL FILTRATION MATERIAL

The present invention relates to a filter for an aerosol-generating article and to an aerosol-generating article comprising the filter.

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.

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.

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.

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.

Typically, aerosol-generating articles of the types described may include a mouthpiece comprising a 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.

Cellulose acetate, the most commonly used filtration material, can provide a relatively high filtration efficiency and filters of cellulose acetate tow provide effective filtration of the mainstream smoke generated from the aerosol-generating substrate. However, cellulose acetate has also been found to provide a relatively high level of absorption and trapping of water from the mainstream smoke. 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.

Cellulose acetate and many other commonly used filtration materials are not highly biodegradable. However, alternative dispersible or degradable 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.

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 be particularly desirable to provide such a novel aerosol-generating article that provides an improved smoking experience to the consumer. For example, it would be desirable to provide an aerosol-generating article that is capable of reducing the 'dry' smoke effect that is often found with articles comprising cellulose acetate as the filtration material, as described above. It would be further 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.

The present disclosure relates to an aerosol-generating article for producing an inhalable aerosol upon heating or combustion. The aerosol-generating article may comprise a rod of aerosol-generating substrate and a filter segment in axial alignment with the rod. The filter segment may comprise a filtration material formed of a plurality of fibres comprising a polyhydroxyalkanoate (PHA) compound. The fibres comprising the PHA compound may provide a total external surface area within the filter segment of between 0.12 square metres per gram and about 0.28 square metres per gram.

Further, the present disclosure relates to a filter for an aerosol-generating article. The filter may comprise at least one filter segment of filtration material. The filter segment may comprise a filtration material formed of a plurality of fibres comprising a polyhydroxyalkanoate (PHA) compound. The fibres comprising the PHA compound may provide a total external surface area within the filter segment of between 0.12 square metres per gram and about 0.28 square metres per gram.

According to the present invention there is provided an aerosol-generating article comprising an aerosol-generating substrate and a filter in axial alignment with the aerosol-generating substrate, the filter comprising at least one filter segment of filtration material comprising a plurality of fibres comprising a polyhydroxyalkanoate (PHA) compound. The fibres comprising the polyhydroxyalkanoate compound provide a total external surface area within the filter segment of between about 0.12 square metres per gram and about 0.28 square metres per gram.

According to the present invention there is further provided a filter comprising at least one filter segment of filtration material comprising a plurality of fibres comprising a polyhydroxyalkanoate (PHA) compound. The fibres comprising the polyhydroxyalkanoate compound provide a total external surface area within the filter segment of between about 0.12 square metres per gram and about 0.28 square metres per gram.

The term “aerosol-generating article” is used herein with reference to the invention to describe an article wherein an aerosol-generating substrate is heated or combusted 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 or combusting to generate an aerosol.

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.

The filter of the present invention may find application as the filter of mouthpiece in a heated aerosol-generating article in which the aerosol-generating substrate is heated to generate an aerosol, without combustion of the substrate. However, the filter of the present invention is also suitable for use as the filter of a combustible smoking article in which the aerosol-generating substrate is combusted during use to generate a smoke.

As used herein, the term “aerosol-generating substrate” describes a substrate capable of releasing, upon heating (including combustion), volatile compounds, which can form an aerosol. The aerosol generated from aerosol-generating substrates may be visible or invisible and may include vapours (for example, fine particles of substances, which are in a gaseous state, that are ordinarily liquid or solid at room temperature) as well as gases and liquid droplets of condensed vapours. As used herein, the term “aerosol” encompasses the aerosol produced upon heating of a substrate in a heated aerosol-generating article and the smoke produced upon combustion of a substrate in a combustible smoking article.

As defined above, the present invention provides a filter for an aerosol-generating article, the filter comprising at least one filter segment comprising a filtration material formed with a plurality of fibres comprising a PHA compound having a total external surface area within the filter segment of between 0.12 square metres per gram and 0.28 square metres per gram. The PHA containing fibres are referred to below as the “PHA fibres”. The filter segment comprising the plurality of PHA containing fibres is referred to below as the “PHA filter segment”.

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. 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).

PHA fibres have a lower hydrophilicity compared with fibres of other filtration materials, such as cellulose acetate, of an equivalent weight. In the aerosol-generating articles of the present invention, the filter segment has therefore been found to have a significantly lower tendency to absorb water/steam from the aerosol generated from the aerosol-generating substrate during use. As a result, the level of water in the aerosol 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.

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.

Filters formed with PHA fibres have also been found to provide a good filter hardness, which can be further enhanced by circumscribing the filter segment with a stiff plug wrap.

In accordance with the invention, the PHA filter segment is formed with PHA fibres that are arranged to provide a total external surface area of between 0.12 square metres per gram and 0.28 square metres per gram.

The total external surface area of the PHA fibres within the PHA filter segment is therefore at least about 0.12 square metres per gram. Preferably, the total external surface area of the PHA fibres within the PHA filter segment is at least about 0.13 square metres per gram, more preferably at least about 0.14 square metres per gram, more preferably at least about 0.15 square metres per gram.

In addition, the total external surface area of the PHA fibres within the PHA filter segment is no greater than about 0.28 square metres per gram. Preferably, the total external surface area of the PHA fibres within the PHA filter segment is no greater than about 0.27 square metres per gram, more preferably no greater than about 0.26 square metres per gram, more preferably no greater than about 0.25 square metres per gram.

The defined range of the total external surface area has been found to provide an optimum balance between controlling and reducing the level of water absorption of the PHA filter segment whilst retaining an acceptable level of resistance to draw (RTD) for the PHA filter segment. The PHA filter segment of the present invention is therefore highly versatile as it can be adapted for use in both combustible smoking articles and heated aerosol-generating articles. This enables the manufacturing of filter segments for a variety of types of aerosol-generating articles to be carried out using the same manufacturing apparatus and techniques, since the same filtration material is suitable for use in a variety. The manufacture of filter segments can therefore be carried out in a more efficient manner.

The level of RTD that is provided by the PHA filter segment may be sufficiently low that the PHA filter segment can be used in heated aerosol-generating articles where a relatively low RTD level is preferred. The level of RTD is also sufficiently low that a relatively long PHA filter segment can be provided without adversely impacting the overall RTD, for example in a combustible smoking article.

The majority of the external surfaces of the PHA fibres will typically be exposed within the PHA filter segment and will therefore come into contact with the aerosol generated from the aerosol-generating substrate, as it passes through the PHA filter segment during use. The total external surface area of the PHA fibres therefore affects the filtration of the aerosol as it passes through the PHA filter segment. In turn, the sensory properties of the aerosol can therefore be controlled by varying the total external surface area of the PHA fibres.

For example, by increasing the total external surface area within the defined range, it may be possible to control the absorption and retention of certain aerosol constituents, such as water. This may advantageously improve the sensorial properties of the aerosol delivered to the consumer from the aerosol-generating substrate. As discussed above, the selection of the total external surface area of the PHA fibres within the defined range enables a PHA filter segment to be provided that can reduce the level of water absorption by the filter segment compared to an equivalent cellulose acetate tow segment. This may be beneficial for combustible smoking articles where it is desirable to reduce the water absorption from the mainstream smoke in order to reduce the 'dry smoke' effect. It may also be beneficial for heated aerosol-generating articles in which the aerosol-generating substrate is heated during use to generate an aerosol. For example, it may be advantageous to provide a reduced level of water adsorption by the PHA filter segment where the aerosol-generating substrate is heated at a relatively low temperature, or where a high water content aerosol is desirable.

Advantageously, the level of water absorption provided by the PHA filter segment of the present invention is such that an acceptable smoking experience may be provided for the majority of different types of aerosol-generating article.

The total external surface area of the PHA fibres within the PHA filter segment may be varied within the defined range by controlling at least one of the cross-sectional size, cross-sectional shape and number of PHA fibres.

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 0.12 square metres per gram and about 0.16 square metres per gram.

The PHA fibres may have a Y-shaped cross-section. In such embodiments, the total external surface area of the PHA fibres within the filter segment is preferably between about 0.21 square metres per gram and about 0.28 square metres per gram.

Preferably, the PHA fibres have a denier per filament (dpf) of between about 3.2 and about 5.0. The denier per filament, corresponding to the average denier of an individual PHA fibre within the filter, is 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. The dpf of a filter or filter segment can be readily determined based on the measurement of weight and length of a sample of representative fibres from the filter or filter segment.

The denier per filament (dpf) of the PHA fibres is therefore preferably at least about 3.2. Preferably, the dpf is at least about 3.3, more preferably at least about 3.4, more preferably at least about 3.5, more preferably at least about 3.6, more preferably at least about 3.7.

The denier per filament (dpf) of the PHA fibres is preferably no greater than about 5.0. Preferably, the dpf is no greater than about 4.9, more preferably no greater than about 4.8, more preferably no greater than about 4.7, more preferably no greater than about 4.6, more preferably no greater than about 4.5.

In some embodiments, the denier per filament may be between about 3.3 and about 4.9, or between about 3.4 and about 4.8, or between about 3.5 and about 4.7, or between about 3.6 and about 4.6, or between about 3.7 and about 4.5.

In other embodiments, the denier per filament may be between about 3.2 and about 4.2, or between about 3.2 and about 4.0, or between about 3.2 and about 3.8, or between about 3.2 and about 3.6, or about 3.4.

In other embodiments, the denier per filament may be between about 4.0 and about 5.0, or between about 4.2 and about 5.0, or between about 4.4 and about 5.0.

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

The PHA fibres provided within the filter 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-hydroxybutyrate).

The PHA filter segment preferably comprises at least about 5 percent by weight of the PHA fibres, more preferably at least about 10 percent by weight of the PHA fibres, more preferably at least about 20 percent by weight of the PHA fibres, more preferably at least about 30 percent by weight of the PHA fibres, more preferably at least about 40 percent by weight of the PHA fibres, more preferably at least about 50 percent by weight of the PHA fibres, more preferably at least about 60 percent by weight of the PHA fibres, more preferably at least about 70 percent by weight of the PHA fibres, more preferably at least about 80 percent by weight of the PHA fibres, more preferably at least about 90 percent by weight of the PHA fibres, more preferably at least about 95 percent by weight of the PHA fibres.

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.

The PHA filter segment is therefore formed with a relatively high level of PHA fibres. This provides an enhanced biodegradability of the filter and of the aerosol-generating article as a whole. As described above, it has previously been found to be technically challenging to form filter segments with a high proportion of degradable polymers, which provide acceptable filtration properties. However, the inventors have surprisingly found that it is possible to produce a filter segment incorporating a relatively high level of PHA fibres that provides desirable levels of filtration properties such as filtration efficiency and resistance to draw.

The PHA fibres of the filter according to the invention may be produced using any suitable method. Suitable techniques for the manufacture of PHA fibres would be known to the skilled person and include but are not limited to melt spinning, gel spinning and electrospinning. Preferably, the PHA fibres are produced 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.

The PHA fibres may optionally be crimped, in the same way as cellulose acetate fibres in existing filter segments.

The PHA filter segment may be formed of a fibrous filtration material formed with PHA fibres only. However, in certain preferred embodiments of the invention, the PHA fibres may be combined with a plurality of fibres of an additional biodegradable polymer to form the filter segment. For example, the filter segment preferably 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.

In preferred embodiments, the PHA filter segment comprises at least about 10 percent by weight of one such additional biodegradable polymer. More preferably, the PHA 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 PHA filter segment comprises at least about 15 percent by weight of one such additional biodegradable polymer.

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.

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.

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.

The PHA fibres may be formed of the PHA compound alone, or in combination with one or more other polymers such as polylactic acid (PLA). The PHA fibres are therefore formed of a blend of polymers including the PHA compound.

The PHA filter segment preferably comprises at least about 5 percent by weight of the PHA compound, more preferably at least about 10 percent by weight of the PHA compound, more preferably at least about 20 percent by weight of the PHA compound, more preferably at least about 30 percent by weight of the PHA compound, more preferably at least about 40 percent by weight of the PHA compound, more preferably at least about 50 percent by weight of the PHA compound, more preferably at least about 60 percent by weight of the PHA compound, more preferably at least about 70 percent by weight of the PHA compound, more preferably at least about 80 percent by weight of the PHA compound, more preferably at least about 90 percent by weight of the PHA compound, more preferably at least about 95 percent by weight of the PHA compound.

The PHA filter segment of aerosol-generating article according to the invention preferably further comprises an additive for reducing certain smoke constituents in the aerosol generated from the aerosol-generating substrate. For example, the PHA filter segment preferably further 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.

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.

In certain preferred embodiments of the invention, the PHA filter segment comprises polyethylene glycol, such as PEG 400. The combination of the PHA fibres with an additive such as PEG for the reduction of phenolic compounds from the aerosol generated from the aerosol-generating substrate 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 aerosol generated from the aerosol-generating substrate, it is possible to further optimise the filtration capabilities of the filter according to the invention comprising PHA fibres. This in turn improves the sensory characteristics of the aerosol delivered to the consumer.

In particularly preferred embodiments, the PHA 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.

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.

As described above, it has been found that PHA fibres absorb less water from the aerosol generated from the aerosol-generating substrate 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.

For example, when exposed to water in liquid form, the PHA filter segment 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.

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

For example, the amount of water in the aerosol 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 aerosol collected during the smoking of an equivalent combustible smoking article having a filter segment of cellulose acetate tow under the same conditions.

Aerosol-generating articles comprising a filter including a PHA filter segment are therefore able to deliver an aerosol 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.

The PHA filter segment of the aerosol-generating articles according to the invention can advantageously be adapted in order to provide a desired level of resistance to draw (RTD). For some aerosol-generating articles, such as heated aerosol-generating articles having an aerosol-generating substrate that is heated rather than combusted to produce an aerosol, it may be desirable to provide a relatively low RTD for the PHA filter segment. This may the case where it is desirable to provide a low filtration efficiency. Alternatively, a low RTD may be desirable where a relatively long filter or mouthpiece is required, for example, if the aerosol-generating substrate is relatively short. A low RTD may be achieved, for example, by using PHA fibres having a dpf value within the upper part of the defined range, which have a relatively large size.

For alternative aerosol-generating articles, such as combustible articles, it may be more preferable to provide a higher RTD for the PHA filter segment in order to increase the filtration efficiency.

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 30 millimetres H_2O. More preferably, an RTD of the PHA filter segment for a 27 millimetre filter segment is at least about 35 millimetres H_2O, more preferably at least about 40 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 45 millimetres H_2O, more preferably at least about 50 millimetres H_2O. The RTD of the PHA filter segment for a 27 millimetre filter segment is preferably no more than about 150 millimetres H_2O, more preferably no more than 125 millimetres H_2O, more preferably no more than about 100 millimetres H_2O. For example, the RTD of the PHA filter segment for a 27 millimetre filter segment may be between about 30 millimetres H_2O and about 150 millimetres H_2O, or between about 35 millimetres H_2O and about 150 millimetres H_2O, or between about 40 millimetres H_2O and about 125 millimetres H_2O, or between about 45 millimetres H_2O and about 100 millimetres H_2O, or between about 50 millimetres H_2O and about 100 millimetres H_2O.

In certain preferred embodiments of the invention, the PHA filter segment has an RTD (based on the length of the PHA filter segment in the article) of at least about 60 millimetres H_2O. More preferably, an RTD of the PHA filter segment is at least about 65 millimetres H_2O, more preferably at least about 70 millimetres H_2O. Even more preferably, in aerosol-generating articles in accordance with the present invention an RTD of the PHA filter segment is at least about 75 millimetres H_2O, more preferably at least about 80 millimetres H_2O. The RTD of the PHA filter segment (based on the length of the PHA filter segment in the article) is preferably no more than about 120 millimetres H_2O, more preferably no more than about 110 millimetres H_2O, more preferably no more than about 100 millimetres H_2O. For example, the RTD of the PHA filter segment may be between about 60 millimetres H_2O and about 120 millimetres H_2O, or between about 65 millimetres H_2O and about 120 millimetres H_2O, or between about 70 millimetres H_2O and about 110 millimetres H_2O, or between about 75 millimetres H_2O and about 110 millimetres H_2O, or between about 80 millimetres H_2O and about 100 millimetres H_2O, or around 90 millimetres H_2O. Such ranges may be particularly suitable for combustible smoking articles.

In other preferred embodiments of the invention, the PHA filter segment has an RTD (based on the length of the PHA filter segment in the article) of least about 10 millimetres H_2O. More preferably, an RTD of the PHA filter segment is at least about 12 millimetres H_2O, more preferably at least about 15 millimetres H_2O. Even more preferably, in aerosol-generating articles in accordance with the present invention an RTD of the PHA filter segment is at least about 18 millimetres H_2O, more preferably at least about 20 millimetres H_2O. The RTD of the PHA filter segment (based on the length of the PHA filter segment in the article) is preferably no more than about 40 millimetres H_2O, more preferably no more than about 35 millimetres H_2O, more preferably no more than about 30 millimetres H_2O. For example, the RTD of the PHA filter segment may be between about 10 millimetres H_2O and about 40 millimetres H_2O, or between about 12 millimetres H_2O and about 40 millimetres H_2O, or between about 15 millimetres H_2O and about 35 millimetres H_2O, or between about 20 millimetres H_2O and about 30 millimetres H_2O, or around 27 millimetres H_2O. Such ranges may be particularly suitable for heated aerosol-generating articles in which the aerosol-generating substrate is heated rather than combusted to produce an aerosol.

"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.

The PHA 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.

Preferably, the PHA filter segment of the aerosol-generating articles according to the invention has an average radial hardness of at least 80 percent, more preferably at least 85 percent. The PHA 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 PHA filter segment may be further increased by circumscribing the PHA 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.

As used herein, the term "radial hardness" refers to resistance to compression is a direction transverse to a longitudinal axis. 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:

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

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%.

To determine the hardness of a portion (such as a filter) 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.

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.

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.

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 ± 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.

As described above, the use of PHA fibres to produce the filter segment of aerosol-generating articles according to the invention advantageously provides improved biodegradability compared to conventional cellulose acetate filters.

Preferably, the PHA filter segment has a biodegradability in aqueous medium of at least about 45 percent, more preferably at least about 50 percent and most preferably at least about 55 percent, when measured in accordance with the test method described in ISO 14851 Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium – Method by measuring the oxygen demand in a closed respirometer (2005).

Under the same test conditions, a cellulose acetate filter segment shows a biodegradability of approximately 30 percent. The use of PHA fibres instead of cellulose acetate fibres to form a filter segment can therefore be seen to provide a significant improvement in the biodegradability of the filter segment.

The size of the PHA filter segment may be varied depending upon the type of aerosol-generating article into which it is incorporated.

Preferably, the PHA filter segment has a length of at least about 4 millimetres, more preferably a length of at least about 5 millimetres, more preferably a length of at least about 7 millimetres, most preferably a length of at least about 10 millimetres.

Preferably, the PHA filter segment has a length of less than or equal to about 30 millimetres, a length of less than or equal to about 27 millimetres, more preferably, a length of less than or equal to about 25 millimetres, most preferably a length of less than or equal to about 20 millimetres.

For example, the length of the PHA filter segment is preferably from about 5 millimetres to about 30 millimetres, more preferably from about 10 millimetres to about 30 millimetres, even more preferably from about 15 millimetres to about 30 millimetres, most preferably from about 20 millimetres to about 30 millimetres. Alternatively, in such embodiments a length of the PHA filter segment may be 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 PHA 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.

For embodiments of the present invention where the aerosol-generating article is in the form of a combustible smoking article, as described in more detail below, the length of the PHA filter segment is preferably between about 20 millimetres and about 30 millimetres, more preferably between about 25 millimetres and about 30 millimetres, most preferably around 27 millimetres.

For alternative embodiments of the present invention where the aerosol-generating article is in the form of a heated aerosol-generating article having an aerosol-generating substrate that is intended to be heated by electrical heating means or an integral heat source, as described in more detail below, the length of the PHA filter segment is preferably between about 5 millimetres and about 15 millimetres, more preferably between about 5 millimetres and about 10 millimetres, most preferably around 7 millimetres.

The PHA 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 PHA 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 PHA filter segment has an external diameter of 7.2 millimetres, to within 10 percent.

The shape of the PHA filter segment may also be varied depending upon the desired construction of the aerosol-generating article. In certain embodiments, the PHA filter segment may be in the form of a solid, cylindrical plug of fibrous filtration material comprising the PHA fibres. Such a filter segment would therefore provide a similar construction to a conventional plug of cellulose acetate tow.

In alternative embodiments, the PHA filter segment may be in the form of a hollow tube segment. A hollow tube segment has a greater exposed surface area that a cylindrical plug of an equivalent diameter and this may further improve the biodegradation of the PHA filter segment.

The hollow tube segment preferably has a wall thickness of at least about 0.3 millimetres. More preferably, the hollow tube segment has a wall thickness of at least about 0.4 millimetres. Even more preferably, the hollow tube segment has a wall thickness of at least about 0.5 millimetres.

Preferably, the hollow tube segment has a wall thickness of less than or equal to about 1.9 millimetres. More preferably, the hollow tube segment has a wall thickness of less than or equal to about 1.5 millimetres. Even more preferably, the hollow tube segment has a wall thickness of less than or equal to about 1.2 millimetres. Particularly preferably, the hollow tube segment has a wall thickness of less than or equal to about 0.9 millimetres.

In some embodiments, the hollow tube segment may typically have a length of at least about 4 millimetres. Preferably, a length of the hollow tube segment is at least about 5 millimetres. More preferably, a length of the hollow tube segment is at least about 7 millimetres. Even more preferably, a length of the hollow tube segment is at least about 10 millimetres.

Where the PHA filter segment is in the form of a hollow tube segment, the filtration material may comprise some cellulose acetate in addition to the PHA fibres. For example, the hollow tube segment may comprise between about 5 percent and about 15 percent by weight of cellulose acetate. Without wishing to be bound by theory, it is understood that a certain amount of cellulose acetate in the hollow tube segment may impart desirable filtration properties and mechanical properties to the hollow tube segment as well as facilitating manufacture of the hollow tube segment.

The filter of aerosol-generating articles according to the invention may be a single segment filter consisting of the PHA filter segment only. Alternatively, the filter of aerosol-generating articles according to the invention may further comprise one or more additional filter segments formed of filtration material, which may be provided upstream or downstream of the PHA filter segment as described above. For example, the PHA filter segment may be combined with one or more axially aligned filter plugs formed of a fibrous filtration material, which may or may not include PHA fibres. Alternatively or in addition, the PHA filter segment may be combined with one or more tubular elements, such as a hollow acetate tube or a cardboard tube. For example, in certain embodiments the filter may include a support element in the form of a hollow acetate tube. Alternatively or in addition, the PHA filter segment may be combined with an aerosol-cooling element.

Preferably, the additional filter segments are formed of a material other than cellulose acetate. Particularly preferably, the additional filter segments comprise PHA fibres, which may optionally be held in the desired shape by means of a suitable adhesive such as PVA. Preferably, each of the additional filter segments comprises at least about 25 percent by weight of a PHA compound, more preferably at least about 50 percent by weight of a PHA compound.

The filter 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 PHA filter segment, or in an additional filter segment.

Preferably, the filter of aerosol-generating article according to the invention comprises a capsule within the PHA filter segment, wherein the capsule contains an additive for modifying the aerosol generated from the aerosol-generating substrate during use. Preferably, the additive is a flavourant. The use of PHA fibres having a dpf value within the range of 3.2 to 5.0 means that the PHA fibres may have a relatively large cross section. This in turn means that there is an increased amount of space available between the individual fibres compared to filters formed from fibres with a lower dpf value. The PHA filter segment formed from the PHA fibres having a dpf within this range is therefore particularly suitable for the incorporation of a capsule. A capsule can be readily incorporated into the PHA filter segment during manufacturing. Furthermore, the capsule will be effectively retained in the desired axial position within the PHA filter segment.

The filter 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.

As defined above, the aerosol-generating articles according to the invention further comprises an aerosol-generating substrate, which is preferably in the form of a rod of an aerosol-generating substrate. Preferably, the aerosol-generating substrate is a rod of a tobacco material.

The aerosol generating substrate may have a length of between about 5 millimetres and about 100 mm. Preferably, the 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 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 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 aerosol generating substrate may have a length of about 10 millimetres. In a preferred embodiment, the aerosol generating substrate has a length of about 12 millimetres.

In certain embodiments, aerosol-generating articles according to the present invention are filter cigarettes or other combustible smoking articles in which the aerosol generating substrate comprises a tobacco material that is combusted to form smoke. In any such embodiments, the aerosol generating substrate may comprise a tobacco rod. The tobacco rod may comprise one or more of cut filler and reconstituted tobacco.

For embodiments in which the aerosol-generating article is in the form of a combustible smoking article, the aerosol-generating substrate, which will typically be a tobacco rod, preferably has a length of between about 10 millimetres and about 100 millimetres, more preferably a total length of between about 30 millimetres and about 70 millimetres. The tobacco rod may comprise one or more of cut filler and reconstituted tobacco.

As discussed above, the filter of the present invention comprising the PHA segment also finds application in heated aerosol-generating articles in which a tobacco material is heated to form an aerosol, rather than combusted. In one type of heated aerosol generating article, a tobacco material is heated by one or more electrical heating elements to produce an aerosol. In another type of heated aerosol generating article, an aerosol is produced by the transfer of heat from a combustible or chemical heat source to a physically separate tobacco material, which may be located within, around or downstream of the heat source. The present invention further encompasses aerosol generating articles in which a nicotine-containing aerosol is generated from a tobacco material, tobacco extract, or other nicotine source, without combustion, and in some cases without heating, for example through a chemical reaction.

For embodiments in which the aerosol-generating article is in the form of a heated aerosol-generating article in which the aerosol-generating substrate is intended to be heated to form an aerosol, the aerosol-generating substrate preferably has a length of between about 5 millimetres and about 40 millimetres, more preferably between about 9 millimetres and about 15 millimetres.

For such embodiments in which the aerosol-generating article is in the form of a heated aerosol-generating article, the aerosol-generating substrate is preferably formed of a homogenised tobacco material, formed from the agglomeration of tobacco particles. The aerosol-generating substrate may comprise one or more gathered sheets of homogenised tobacco material. The one or more sheets may be textured. As used herein, the term ‘textured sheet’ denotes a sheet that has been crimped, embossed, debossed, perforated or otherwise deformed. Alternatively, the aerosol-generating substrate may comprise a plurality of strips or strands of homogenised tobacco material. The strips or strands may be substantially aligned with each other in the longitudinal direction, or may be randomly oriented.

The homogenised tobacco material for use in the aerosol-generating substrate 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.

The 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, the 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.

Suitable extrinsic binders for inclusion in 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.

Suitable non-tobacco fibres for inclusion in 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 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.

Aerosol-generating 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.

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.

The aerosol-generating articles according to the invention may further comprise one or more additional components between the filter and the aerosol-generating substrate. For example, the aerosol-generating articles may further comprise one or more of: a support element, an aerosol-cooling element and a transfer element. The construction of such components would be known to the skilled person.

For example, in certain preferred embodiments of the present invention, the aerosol-generating article comprises in a linear sequential arrangement: an aerosol-generating substrate, a support element immediately downstream of the aerosol-generating substrate, an aerosol-cooling element located immediately downstream of the support element and a mouthpiece comprising the PHA filter segment, at the downstream end of the filter.

In other preferred embodiments 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 mouthpiece filter.

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.

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; and

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.

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.

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.

The aerosol-generating substrate 12 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.

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.

The aerosol-cooling element 16 is located immediately downstream of the support element 14 and abuts the support element 16. 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.

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 3.4 and a total denier of approximately 34,000. 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 total external 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).

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.

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.

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.

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.

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.

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 3.4 and a total denier of approximately 34,000. 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).

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.

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 3.4 and a total denier of approximately 34,000. 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 total external 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).

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

A PHA filter segment according to the invention is prepared from PHA fibres, with the parameters shown in Table 1 below. The PHA fibres are formed using a melt spinning process, the fibres are 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 is 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
External surface area (m^2/g)	0.161	0.329

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 are compared. For each filter segment, the plug wrap is removed and the filter segment is 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 is 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

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.

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 are compared. For each filter segment, the plug wrap is removed and the fibres forming the filter segment are placed in a petri dish and exposed to air at 22 degrees Celsius and 50 percent relative humidity for 70 hours. This is 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) is calculated, 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

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.

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 are compared. For each of the filter segments, a conventional smoking article is 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 is 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 is carried out. For each of the filter segments, the amount of water in the mainstream smoke collected during the smoking test is 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

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 comprising:

an aerosol-generating substrate;

a filter in axial alignment with the aerosol-generating substrate, the filter comprising at least one filter segment of filtration material formed of a plurality of fibres comprising a polyhydroxyalkanoate compound, wherein the fibres provide a total external surface area within the filter segment of between 0.12 square metres per gram and 0.28 square metres per gram and wherein the at least one filter segment comprises at least 20 percent by weight of the polyhydroxyalkanoate compound.

2. An aerosol-generating article according to claim 1, wherein the plurality of fibres comprising the polyhydroxyalkanoate compound have a round cross-sectional shape and provide a total external surface area within the filter segment of between 0.12 square meters per gram and 0.16 square meters per gram.

3. An aerosol-generating article according to claim 1, wherein the plurality of fibres comprising the polyhydroxyalkanoate compound have a Y-shaped cross-sectional shape and provide a total external surface area within the filter segment of between 0.21 square meters per gram and 0.28 square meters per gram.

4. An aerosol-generating article according to any preceding claim, wherein the fibres comprising the polyhydroxyalkanoate compound have a denier per filament (dpf) of between 3.2 and 5.0.

5. An aerosol-generating article according to any preceding claim, wherein the total denier of the fibres comprising the polyhydroxyalkanoate compound is between 25,000 and 40,000.

6. An aerosol-generating article according to any preceding claim, wherein the filtration material further comprises a plurality of fibres of at least one additional, biodegradable polymer.

7. An aerosol-generating article according to any preceding claim, wherein the resistance to draw (RTD) of the filter segment comprising the plurality of fibres comprising the polyhydroxyalkanoate compound is between 10 millimetres H_2O to about 40 millimetres H_2O.

8. An aerosol-generating article according to any preceding claim, wherein the filter segment comprising the plurality of fibres comprising the polyhydroxyalkanoate compound has a biodegradability in aqueous medium of at least 50 percent when tested according to ISO 14851.

9. An aerosol-generating article according to any preceding claim, wherein the filter segment comprising the plurality of fibres comprising the polyhydroxyalkanoate compound further comprises at least 5 percent by weight of polyethylene glycol.

10. An aerosol-generating article according to any preceding claim, where the filter segment comprising the plurality of fibres comprising the polyhydroxyalkanoate compound has an average radial hardness of at least 80 percent.

11. An aerosol-generating article according to any preceding claim, wherein the filter segment comprising the plurality of fibres comprising the polyhydroxyalkanoate compound is circumscribed by a wrapper having a basis weight of at least 100 grams per square metre (gsm).

12. An aerosol-generating article according to any preceding claim wherein the filter segment comprising the plurality of fibres comprising the polyhydroxyalkanoate compound is in the form of a hollow tubular element.

13. An aerosol-generating article according to any preceding claim wherein the aerosol-generating substrate is a rod of tobacco having a length of between 5 millimetres and 15 millimetres.

14. A filter for an aerosol-generating article, the filter comprising at least one filter segment of filtration material formed of a plurality of fibres comprising a polyhydroxyalkanoate compound, wherein the fibres provide a total external surface area within the filter segment of between 0.12 square metres per gram and about 0.28 square metres per gram and wherein the at least one filter segment comprises at least about 20 percent by weight of the polyhydroxyalkanoate compound.

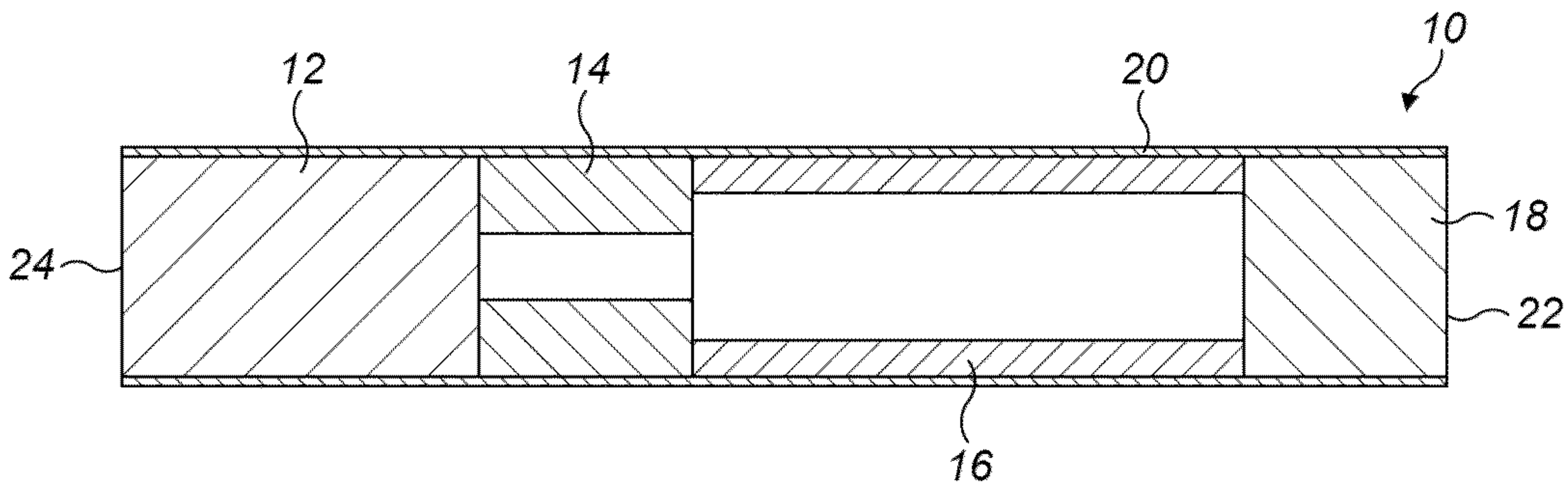

Figure 1

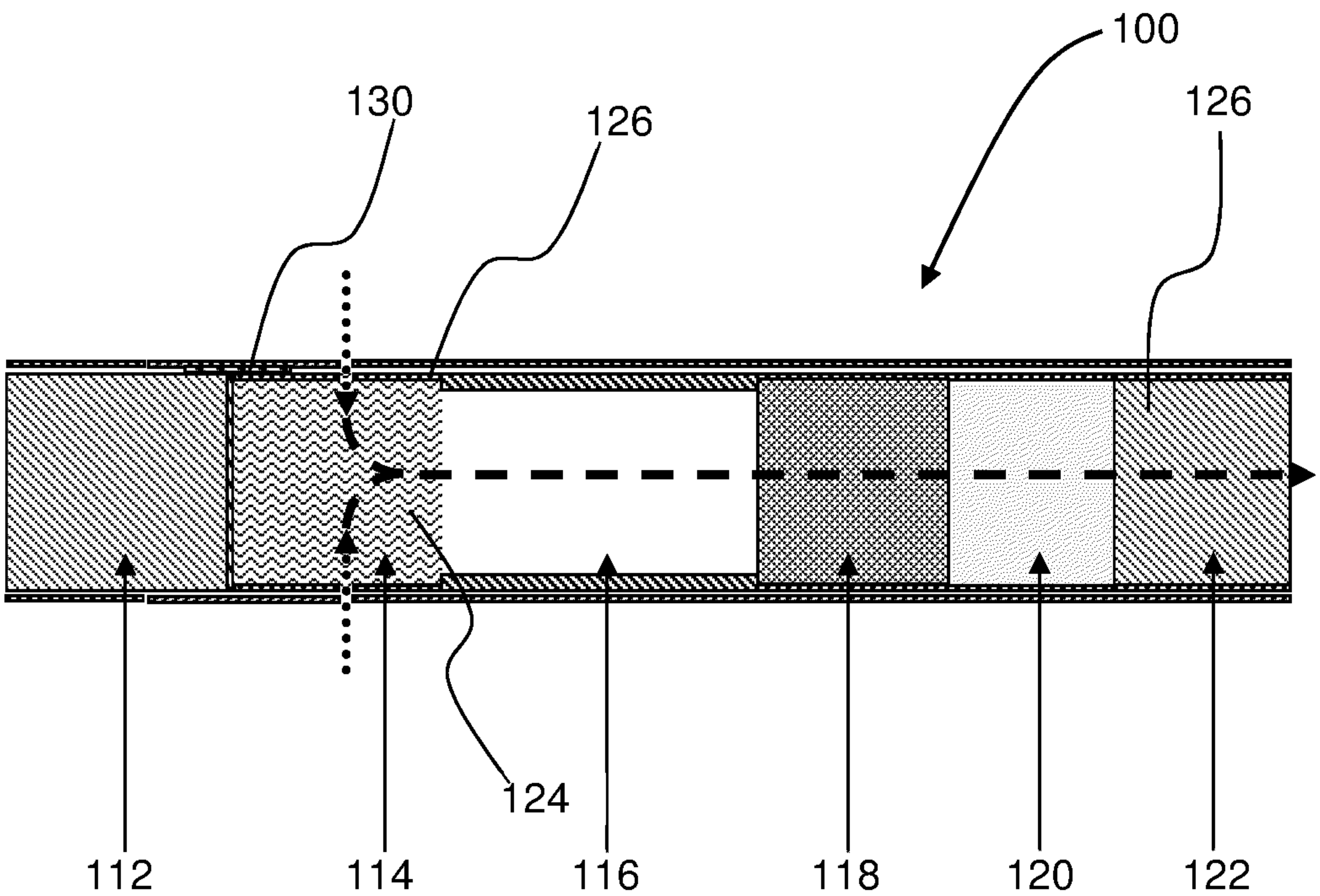

Figure 2

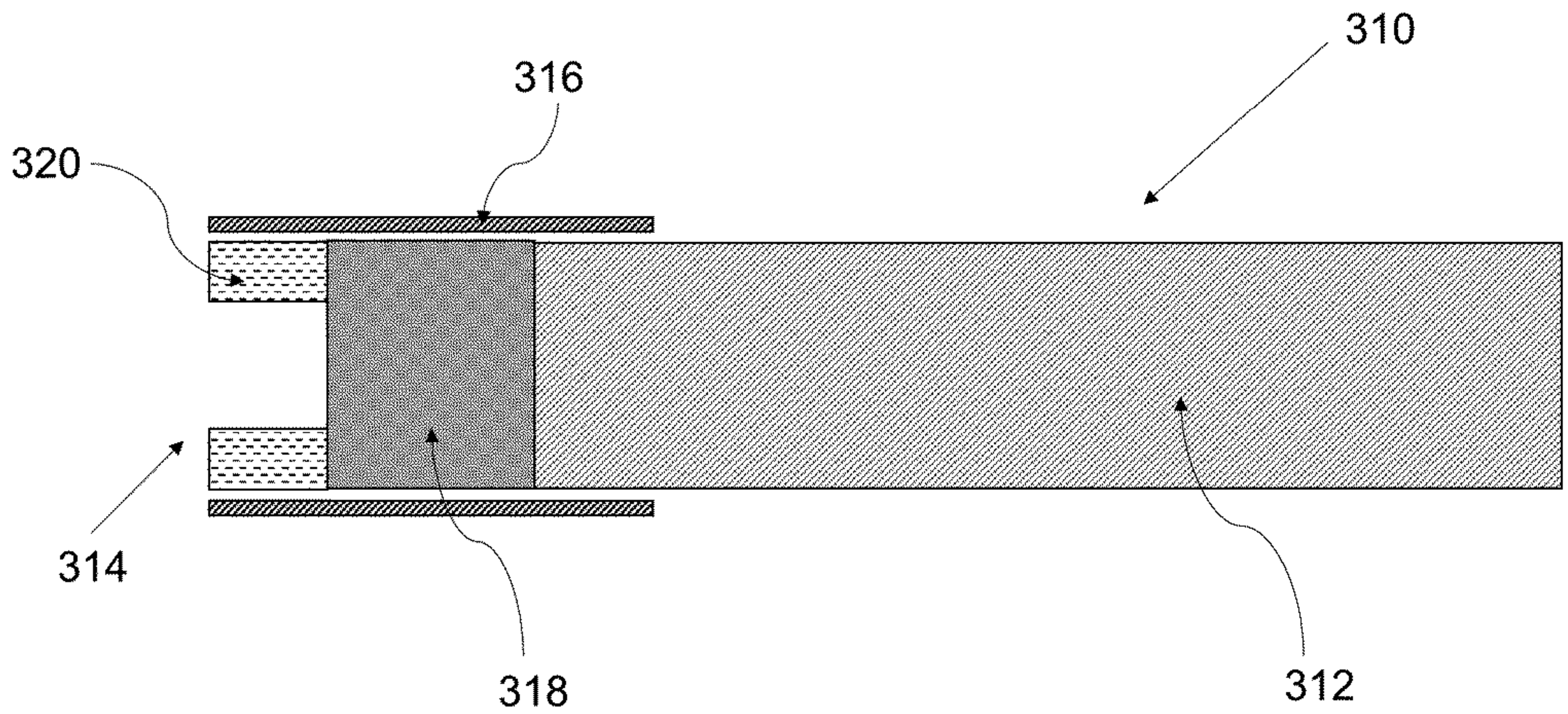

Figure 3

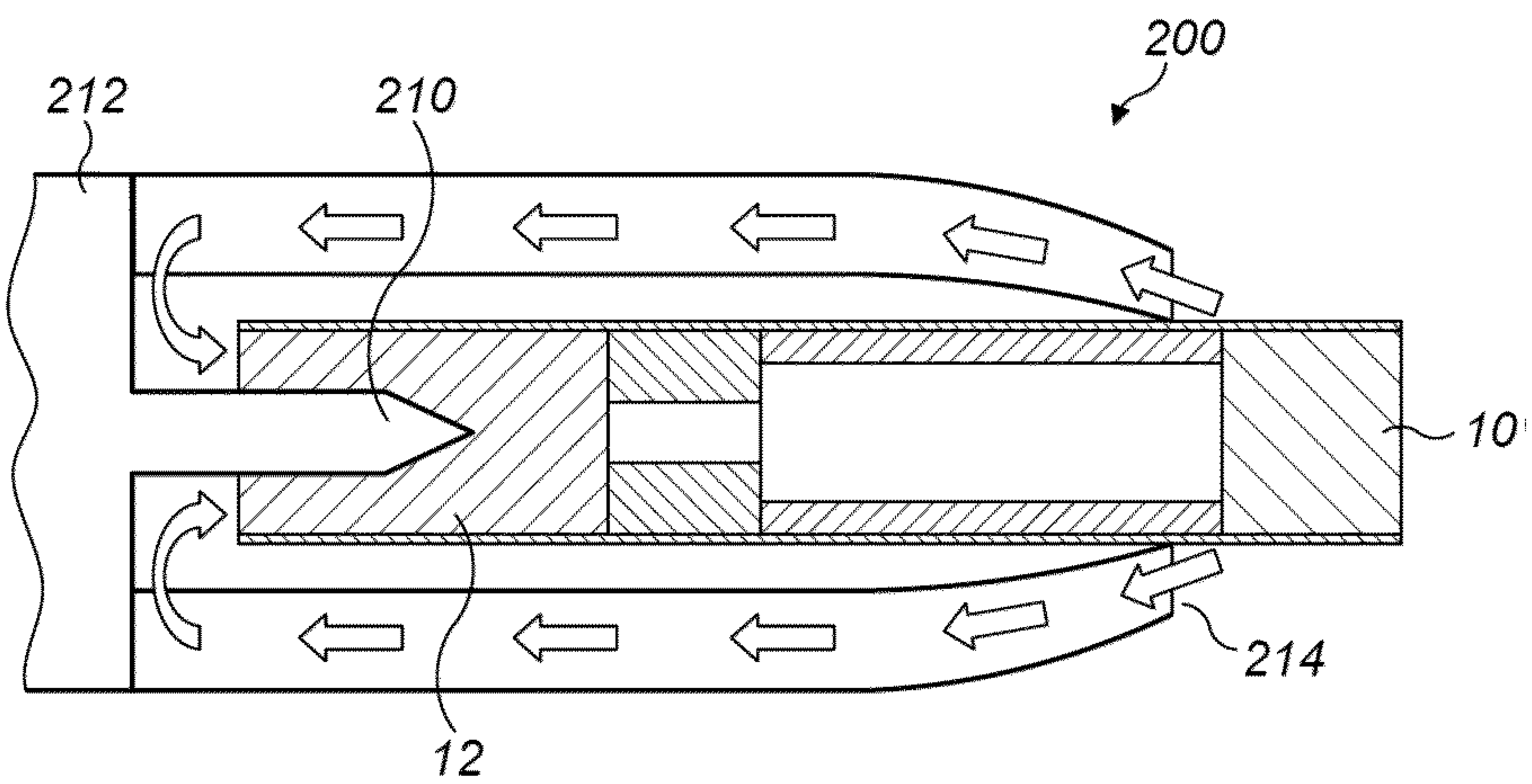

Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/083967

A. CLASSIFICATION OF SUBJECT MATTER
INV. A24D3/06 A24D3/08 A24D3/17
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A24D

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

Electronic data base consulted during the international search (name of data base and, where 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.
A	WO 2017/036588 A1 (JT INT S A [CH]) 9 March 2017 (2017-03-09) page 6, line 4 - page 7, line 14 page 10, line 8 - line 29 page 13, line 13 - line 16 claims 1-15 -----	1-14
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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 :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search	Date of mailing of the international search report
3 February 2021	12/02/2021

Name and mailing address of the ISA/	Authorized officer
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International application No
PCT/EP2020/083967

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	WO 2014/102094 A1 (PHILIP MORRIS PROD [CH]) 3 July 2014 (2014-07-03) page 2, line 9 - line 35 page 10, line 14 - page 11, line 10; claims 1-15 -----	1-14
A	US 2012/000480 A1 (SEBASTIAN ANDRIES D [US] ET AL) 5 January 2012 (2012-01-05) the whole document -----	1-14

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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