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(54) **AEROSOL-GENERATING ARTICLE COMPRISING HOLLOW TUBULAR SUBSTRATE ELEMENT WITH SEALING ELEMENT**

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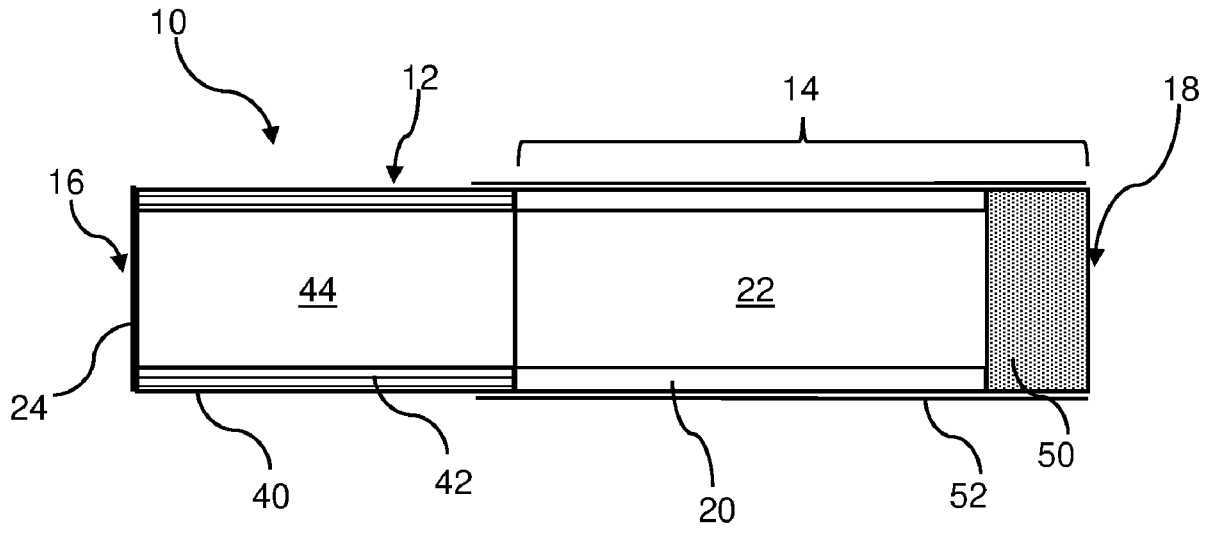
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(57) **ABSTRACT**

An aerosol-generating article is provided, including: an aerosol-generating substrate including a hollow tubular substrate element having a peripheral wall defining a longitudinal airflow channel extending between an upstream end and a downstream end of the hollow tubular substrate element, the peripheral wall being formed of one or more layers of homogenised plant material; a sealing element at the upstream end of the hollow tubular substrate element, the sealing element being arranged to provide a substantially airtight seal at an upstream end of the longitudinal airflow channel; and a downstream section provided downstream of the aerosol-generating substrate.



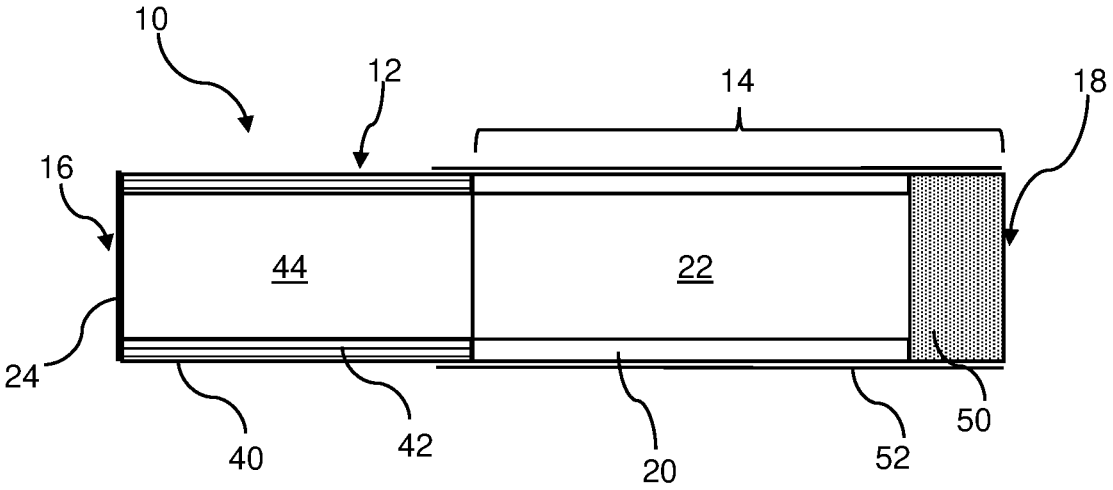


Figure 1

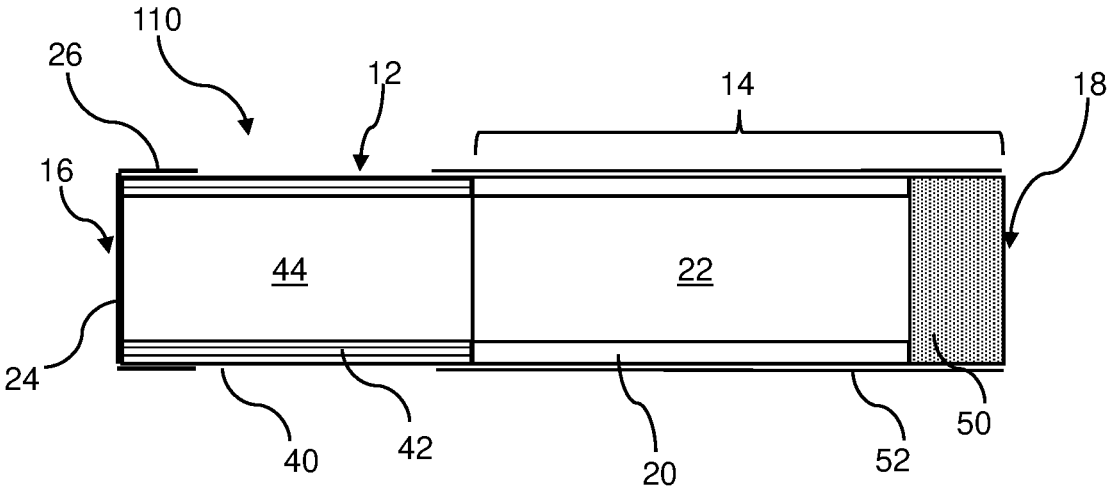


Figure 2

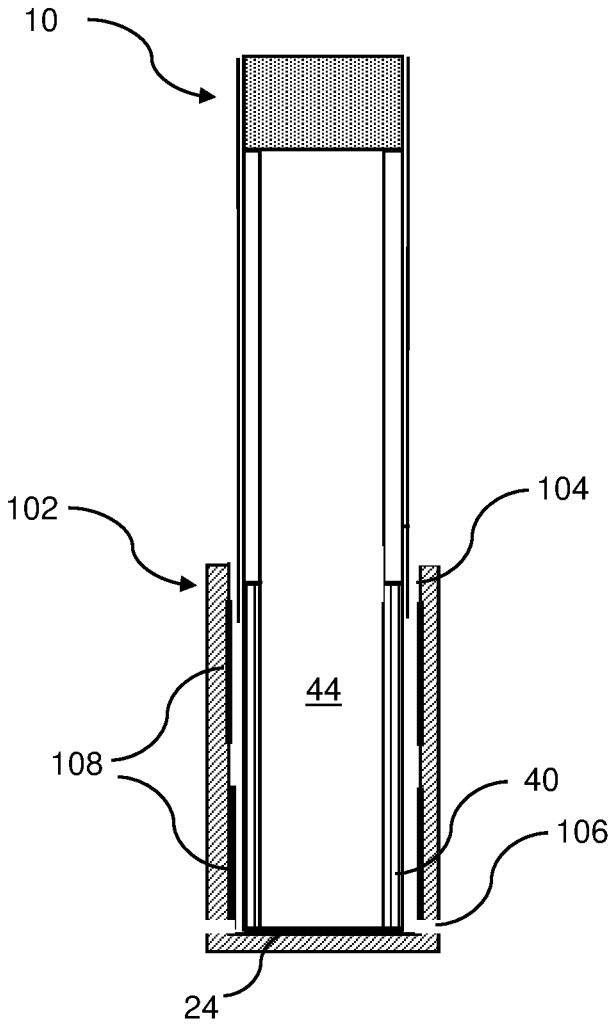


Figure 3

AEROSOL-GENERATING ARTICLE COMPRISING HOLLOW TUBULAR SUBSTRATE ELEMENT WITH SEALING ELEMENT

[0001] The present invention relates to an aerosol-generating article comprising an aerosol-generating substrate that is adapted to produce an inhalable aerosol upon heating.

[0002] Aerosol-generating articles in which an aerosol-generating substrate, such as a tobacco-containing substrate, is heated rather than combusted, are known in the art. Typically, in such heated smoking articles an aerosol is generated by the transfer of heat from a heat source to a physically separate aerosol-generating substrate or material, which may be located in contact with, within, around, or downstream of the heat source. During use of the aerosol-generating article, volatile compounds are released from the aerosol-generating substrate by heat transfer from the heat source and are entrained in air drawn through the aerosol-generating article. As the released compounds cool, they condense to form an aerosol.

[0003] 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. For example, electrically heated aerosol-generating devices have been proposed that comprise an internal heater blade which is adapted to be inserted into the aerosol-generating substrate. Use of an aerosol-generating article in combination with an external heating system is also known. For example, WO-A-2020/115151 describes the provision of one or more heating elements arranged around the periphery of the aerosol-generating article when the aerosol-generating article is received in a cavity of the aerosol-generating device. As an alternative, inductively heatable aerosol-generating articles comprising an aerosol-generating substrate and a susceptor arranged within the aerosol-generating substrate have been proposed by WO-A-2015/176898.

[0004] In general, it can be difficult to provide efficient heating of an aerosol-generating substrate throughout the whole rod of the substrate. The portions of the substrate closest to the heating element will inevitably be heated most effectively whilst the imperfect transfer of heat through the substrate will mean that portions of the substrate furthest from the heating element may not be effectively heated. The generation of aerosol from these portions of the substrate that are not effectively heated is therefore not optimal and in some cases, parts of the substrate may not reach a sufficiently high temperature during use for an aerosol to be generated at all. For example, where an external heating element is used to heat a rod of aerosol-generating substrate, as described above, the central portion of the rod of aerosol-generating substrate is unlikely to generate as much aerosol as the outer portions of the rod and in some cases, may not generate any aerosol. Overall, the generation of aerosol from the aerosol-generating rod is therefore likely to be inefficient, with potential waste of a portion of the aerosol-generating substrate.

[0005] Aerosol-generating articles are designed in order to provide a specific airflow pattern during use, which determines where air is drawn into the aerosol-generating article during use, how that air flows through the aerosol-generating article and how is it mixed with the aerosol generated from the aerosol-generating substrate. Many existing aerosol-generating articles are designed to provide longitudinal airflow, which means that air is drawn through the article in a longitudinal direction, from the upstream end to the downstream end. Aerosol-generating articles providing transverse airflow, where the air is drawn through the aerosol-generating substrate in a transverse, or circumferential direction, from the outside of the article towards the inside, are also known. In such articles, the transverse airflow is provided instead of longitudinal airflow.

[0006] It has been found to be technically difficult to provide an aerosol-generating article which is capable of utilising both longitudinal and transverse airflow during use, whilst still providing an article which retains other desired characteristics such as an acceptable level of resistance to draw (RTD) and the required level of ventilation.

[0007] It would therefore be desirable to provide an aerosol-generating article that is adapted so that there is greater flexibility over the airflow that can be provided. In particular, it would be desirable if both longitudinal and transverse airflow can be utilised for the same article, whilst maintaining the desired characteristics of the article. It would be particularly desirable to provide such an article with a relatively simple design so that it can be manufactured in a cost effective way and incorporated into existing product designs. It would be further desirable to provide an aerosol-generating article having an aerosol-generating substrate that is adapted to provide more efficient aerosolisation of the aerosol-generating substrate and that reduces waste of the substrate materials, such as tobacco. It would be further desirable to provide such an article that can be readily adapted so that it can be heated in a variety of types of heating device, including inductive and resistive heating devices.

[0008] The present disclosure relates to an aerosol-generating article. The aerosol-generating article may comprise an aerosol-generating substrate comprising a hollow tubular substrate element. The hollow tubular substrate element may have a peripheral wall defining a longitudinal airflow channel extending between the upstream end and the downstream end of the hollow tubular substrate element. The peripheral wall may be formed of one or more layers of homogenised plant material. The aerosol-generating article may further comprise a sealing element at the upstream end of the hollow tubular substrate element. The sealing element may be arranged to provide a substantially airtight seal at the upstream end of the hollow tubular substrate element. The aerosol-generating article may further comprise a downstream section provided downstream of the aerosol-generating substrate.

[0009] According to the present invention there is provided: an aerosol-generating article comprising: an aerosol-generating substrate comprising a hollow tubular substrate element having a peripheral wall defining a longitudinal airflow channel extending between the upstream end and the downstream end of the hollow tubular substrate element, wherein the peripheral wall is formed of one or more layers of homogenised plant material; a sealing element at the upstream end of the hollow tubular substrate element, wherein the sealing element is arranged to provide a substantially airtight seal at an upstream end of the longitudinal

channel; and a downstream section provided downstream of the aerosol-generating substrate.

[0010] As used herein, the term "aerosol-generating article" refers to a heated article for producing an aerosol, wherein the article comprises an aerosol-generating substrate that is suitable and intended to be heated or combusted in order to release volatile compounds that can form an aerosol. Such articles are commonly referred to as heat-not-burn articles. 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 an aerosol-generating substrate and not by combusting the aerosol-generating substrate. 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-generating substrate.

[0011] Also known are aerosol-generating articles that are adapted to be used in an aerosol-generating system that supplies the aerosol former to the aerosol-generating articles. In such a system, the aerosol-generating substrate in the aerosol-generating articles contains substantially less aerosol former relative to those aerosol-generating substrates which carries and provides substantially all the aerosol former used in forming the aerosol during operation.

[0012] As used herein, the term "aerosol-generating substrate" refers to a substrate capable of releasing upon heating volatile compounds, which can form an aerosol. The aerosol generated from aerosol-generating substrates of aerosol-generating articles described herein 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.

[0013] As used herein, the term "homogenised plant material" encompasses any plant material formed by the agglomeration of particles of plant. For example, sheets or webs of homogenised tobacco material for the aerosol-generating substrates of the present invention may be formed by agglomerating particles of tobacco material obtained by pulverising, grinding or comminuting plant material and optionally one or more of tobacco leaf lamina and tobacco leaf stems. The homogenised plant material may be produced by casting, extrusion, paper making processes or other any other suitable processes known in the art.

[0014] As used herein, the term "substantially airtight seal" means that the sealing element provides a seal over the upstream end of the longitudinal channel that substantially prevents air from being drawn into the longitudinal channel at the upstream end of the hollow tubular substrate element, during normal use of the aerosol-generating article in an aerosol-generating device. The sealing element preferably provides an airtight seal that prevents any air from entering the longitudinal channel through the upstream end.

[0015] In aerosol-generating articles according to the present invention, the upstream end of the longitudinal channel is therefore covered and sealed by the sealing element provided at the upstream end of the hollow tubular substrate element. With the sealing element in place and still intact, longitudinal airflow is prevented through the longitudinal airflow channel, since air cannot enter the longitudinal airflow channel at the upstream end. Instead, the hollow tubular substrate element is adapted so that air is drawn transversely through the peripheral wall, from the outside of the hollow tubular substrate element through the layer or layers of homogenised plant material and into the longitudinal airflow channel. The hollow tubular substrate element is preferably porous as a result of the arrangement of overlapping layers of homogenised plant material, as described in more detail below.

[0016] The provision of transverse airflow may be particularly advantageous when heating of the hollow tubular substrate element occurs externally, so that heat is transferred through the peripheral wall from the outside to the inside of the hollow tubular substrate element. The transverse airflow may work particularly effectively due to the tubular form of the substrate, which provides a relatively thin wall for the air to penetrate.

[0017] Once the sealing element is removed or punctured, an opening is provided at the upstream end of the longitudinal airflow channel and longitudinal airflow between the upstream end and the downstream end of the hollow tubular substrate element is enabled. A combination of longitudinal and transverse airflow is then possible, with the airflow being partially longitudinal and partially transverse. The addition of the longitudinal airflow may advantageously improve the flow of aerosol through the hollow tubular substrate element.

[0018] The inclusion of the sealing element therefore provides much greater flexibility in terms of the possible airflow designs that can be achieved for aerosol-generating articles according to the invention. There is also greater control over the airflow that is provided during use, so that aerosol-generating articles according to the invention can be more precisely adapted to provide the desired airflow patterns during use. This may advantageously enable the aerosol-generating article to be optimised according to the specific design of the aerosol-generating device with which the aerosol-generating article is intended to be used.

[0019] Aerosol-generating articles according to the invention therefore provide a novel configuration which enables both longitudinal and transverse airflow to be provided during use, either separately or potentially in combination. The configuration as defined can be incorporated into an aerosol-generating article whilst still being able to achieve desirable levels of ventilation and RTD.

[0020] The sealing element may advantageously be adapted so that it is automatically punctured, pierced or ruptured when the aerosol-generating article is inserted into the heating cavity of an aerosol-generating device. In some cases, the presence of the sealing element may also facilitate the proper insertion of a heating element into the article, for example, where an internal heating element is inserted into the hollow tubular substrate element.

[0021] Furthermore, the sealing element may advantageously prevent contamination or deterioration of the inside of the hollow tubular substrate element, prior to use.

[0022] As defined above, the present invention provides an aerosol-generating article having an aerosol-generating substrate which is in the form of a hollow tubular substrate element. The hollow tubular substrate element comprises one or more layers of homogenised plant material, which form the peripheral wall of the hollow tubular substrate

element. The "peripheral" wall of the hollow tubular substrate corresponds to the main wall defining the tubular structure. Preferably, the hollow tubular substrate element consists of the peripheral wall only. The peripheral wall therefore contains all of the homogenised plant material that will generate an aerosol upon heating of the aerosol-generating substrate.

[0023] The peripheral wall of the hollow tubular substrate element defines a longitudinal airflow channel, wherein the term "longitudinal" relates to the longitudinal axis of the aerosol-generating article. Preferably, the longitudinal airflow channel is empty or substantially empty so that there is nothing in the channel that may potentially impede the flow of air and aerosol through the hollow tubular substrate element. In particular, the longitudinal airflow channel is substantially free from plant material, including tobacco material.

[0024] The provision of an aerosol-generating substrate in a tubular form advantageously enables the amount of plant material in the aerosol-generating substrate to be optimised so that aerosol can be efficiently generated from the aerosol-generating substrate upon heating. The tubular form also removes the central portion of homogenised plant material that would potentially not be heated as effectively as the outer portion, in particular, in an aerosol-generating device comprising external heating means. Overall, the amount of plant material can therefore be significantly reduced compared to conventional solid plugs of homogenised plant material and plant waste can be reduced. For example, where the homogenised plant material comprises tobacco particles, it has been found that the amount of tobacco material used in the hollow tubular substrate element of aerosol-generating articles according to the invention can be reduced by up to 40 percent compared to the amount of tobacco material used in the solid plug of substrate in a conventional aerosol-generating article, whilst retaining a similar delivery of aerosol to the consumer.

[0025] The amount of plant material provided in the substrate can be readily adapted through controlling the parameters of the hollow tubular substrate element, such as the density of the peripheral wall and the wall thickness. In this way, it is possible to adapt the hollow tubular substrate element so that it matches the heating zone of the associated aerosol-generating device. The proportion of the aerosol-generating substrate that can be heated to the necessary temperature for aerosol generation is therefore maximised so that the generation of aerosol from the aerosol-generating substrate is optimised.

[0026] As described above, the hollow tubular substrate element is formed of one or more layers of homogenised plant material. Preferably, the hollow tubular substrate element is formed by a plurality of overlapping layers of homogenised plant material. Preferably, the plurality of overlapping layers of homogenised plant material are directly overlying each other so that adjacent layers are in direct contact with each other, without intermediate layers. The plurality of overlapping layers of homogenised plant material can advantageously be arranged to define a plurality of voids between adjacent layers. As a result, the peripheral wall typically has a porous structure which enables transverse airflow through the peripheral wall during use, as described above. As described in more detail below, the voids that are defined between adjacent layers of homogenised plant material can advantageously provide both transverse and longitudinal porosity so that aerosol generated upon heating of the aerosol-generating substrate is effectively released into the longitudinal airflow channel and flows through the channel mixed with external air, which is drawn through the article upon puffing by the consumer.

[0027] The multi-layered arrangement of the layers additionally provides a relatively dense structure which has sufficient structural rigidity to provide the aerosol-generating substrate in an aerosol-generating article without the need for any additional support, such as carrier layers or internal support members within the longitudinal airflow channel.

[0028] The diameter of the longitudinal airflow channel can be adapted to provide greater control over air flow management through the aerosol-generating article.

[0029] The hollow tubular substrate element has a relatively simple structure that can be produced in a straightforward and cost effective way, using existing apparatus. The hollow tubular substrate element can then be incorporated into aerosol-generating articles with other components, using known assembly methods and apparatus.

[0030] Advantageously, if desired, the hollow tubular substrate element can be incorporated directly into the aerosol-generating article without an outer wrapper. This provides a distinctive appearance and texture to the outer surface of the aerosol-generating substrate.

[0031] As described above, the hollow tubular substrate element forming the aerosol-generating substrate of aerosol-generating articles according to the invention is formed of a plurality of overlapping layers of homogenised plant material. The layers overlap with each other in a transverse direction in order to provide a multi-layered structure.

[0032] Preferably, the hollow tubular substrate element comprises at least about 2 overlapping layers of homogenised plant material, more preferably at least about 3 overlapping layers of homogenised plant material.

[0033] The hollow tubular substrate element preferably comprises up to about 10 overlapping layers of homogenised plant material, more preferably up to about 5 overlapping layers of homogenised plant material. For example, the hollow tubular substrate element may comprise between about 2 and about 10 overlapping layers of homogenised plant material, or between about 3 and about 5 overlapping layers of homogenised plant material.

[0034] As described above, the peripheral wall of the hollow tubular substrate element preferably has a porous structure as a result of the voids formed between overlapping layers of homogenised plant material. Preferably, the peripheral wall is porous both transversally and longitudinally.

[0035] Preferably, the peripheral wall of the hollow tubular substrate element has a cross-sectional porosity of at least about 0.3, more preferably at least about 0.35 and most preferably at least about 0.4.

[0036] Preferably, the peripheral wall has a cross-sectional porosity of up to about 0.7, more preferably up to about 0.65, most preferably up to about 0.6.

[0037] For example, the cross-sectional porosity of the peripheral wall may be between about 0.3 and about 0.7, or between about 0.35 and about 0.65 or between about 0.4 and about 0.6.

[0038] As used herein, the term "porosity" refers to a fraction of void space in an air permeable or porous body. Specifically, in the context of the present invention, the term

"cross-sectional porosity" refers to the fraction of void space in a cross-sectional area of the peripheral wall of the hollow tubular substrate element. The cross-sectional porosity is the area fraction of void space in a transverse cross-sectional area of the peripheral wall. The transverse cross-sectional area of the peripheral wall is the area of the peripheral wall in a plane that is perpendicular to the longitudinal axis of the hollow tubular substrate element.

[0039] Further details relating to the measurement of cross-sectional porosity in a porous or air permeable body can be found in the publication of International patent application WO-A-2016/023965 in the name of the present applicant.

[0040] The cross-sectional porosity of the peripheral wall enables aerosol to pass in a transverse direction through the peripheral wall so that it can be drawn into and through the longitudinal airflow channel.

[0041] Preferably, the peripheral wall of the hollow tubular substrate element has a density of at least about 200 milligrams per cubic centimetre, more preferably at least about 300 milligrams per cubic centimetre, more preferably at least about 400 milligrams per cubic centimetre, more preferably at least about 500 milligrams per cubic centimetre, more preferably at least about 600 milligrams per cubic centimetre, more preferably at least about 700 milligrams per cubic centimetre, more preferably at least about 800 milligrams per cubic centimetre.

[0042] Preferably, the peripheral wall of the hollow tubular substrate element has a density of less than about 1 gram per cubic centimetre.

[0043] In the context of the present invention the "density" refers to the bulk density of the peripheral wall including the overlapping layers, rather than the density of the individual layers. The relatively high density of the peripheral wall maximises the amount of plant material that can be provided for a given length of the aerosol-generating substrate, so that the amount of aerosol generated from the hollow tubular substrate element can be maximised.

[0044] Preferably, the peripheral wall provides at least about 150 milligrams of homogenised plant material per centimetre of length of the hollow tubular substrate, more preferably at least about 200 milligrams of homogenised plant material per centimetre of length, more preferably at least about 300 milligrams of homogenised plant material per centimetre of length, more preferably at least about 400 milligrams of homogenised plant material per centimetre of length, more preferably at least about 500 milligrams of homogenised plant material per centimetre of length, more preferably at least about 600 milligrams of homogenised plant material per centimetre of length, more preferably at least about 700 milligrams of homogenised plant material per centimetre of length, more preferably at least about 800 milligrams of homogenised plant material per centimetre of length. This is based on a measurement taken at 22.5 degrees Celsius, 60 percent humidity.

[0045] Preferably, the longitudinal tensile strength of the hollow tubular substrate element, measured according to TAPPI test method T494 om-01 2006, is between 11 kNewtons per metre and 14 kNewtons per metre.

[0046] Preferably, the axial compressive strength of the hollow tubular substrate element, measured according to the test method described in ASTM D695-15 (2018), is between 7 MPa and 9 MPa.

[0047] Preferably, the radial compressive strength of the hollow tubular substrate element, measured according to the test method described in ASTM D2412-11 (2018), is between 7 MPa and 9 MPa.

[0048] Preferably, the hollow tubular substrate element has a length of at least about 10 millimetres, more preferably at least about 12 millimetres, more preferably at least about 15 millimetres.

[0049] Preferably, the hollow tubular substrate element has a length of up to about 40 millimetres, more preferably up to about 37 millimetres, more preferably up to about 35 millimetres.

[0050] For example, the hollow tubular substrate element may have a length of between about 10 millimetres and about 40 millimetres, or between about 12 millimetres and about 37 millimetres, or between about 15 millimetres and about 35 millimetres.

[0051] As discussed above, the length of the hollow tubular substrate element can advantageously be matched to the longitudinal dimensions of the heating element in the corresponding aerosol-generating device which will be used to heat the aerosol-generating article. In this way, as much as possible of the aerosol-generating substrate can be heated during use, in order to optimise the amount of aerosol that can be generated and reduce the amount of plant material waste, such as tobacco waste.

[0052] Preferably, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is at least about 0.15. More preferably, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is at least about 0.25. More preferably, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is at least about 0.4.

[0053] Preferably, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is up to about 0.6. More preferably, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is up to about 0.55. More preferably, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is up to about 0.5.

[0054] For example, the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article may be between about 0.15 and about 0.6, more preferably between about 0.25 and about 0.55, more preferably between about 0.4 and about 0.5.

[0055] Preferably, the hollow tubular substrate element has an external diameter of at least about 4 millimetres, more preferably at least about 4.25 millimetres and more preferably at least about 4.5 millimetres.

[0056] Preferably, the hollow tubular substrate element has an external diameter of up to about 9 millimetres, more preferably up to about 8 millimetres and more preferably up to about 7.5 millimetres.

[0057] For example, the hollow tubular substrate element may have an external diameter of between about 4 millimetres and about 9 millimetres, or between about 4.25 millimetres and about 8 millimetres, or between about 4.5 millimetres and about 7.5 millimetres.

[0058] Preferably, the external diameter of the hollow tubular substrate element is substantially the same as the external diameter of the aerosol-generating article.

[0059] As described above, the hollow tubular substrate element provides a longitudinal airflow channel which is defined by the peripheral wall. The longitudinal airflow channel extends between the upstream and downstream ends of the hollow tubular substrate element and is preferably open at the downstream end. The longitudinal airflow channel provides the main passageway for the flow of air and aerosol through the article.

[0060] Preferably, the hollow tubular substrate element provides an unrestricted flow channel. This means that the hollow tubular segment provides a negligible level of resistance to draw (RTD). The term "negligible level of RTD" is used to describe an RTD of less than 1 mm H_2O per 10 millimetres of length of the hollow tubular element, preferably less than 0.4 mm H_2O per 10 millimetres of length of the hollow tubular element, more preferably less than 0.1 mm H_2O per 10 millimetres of length of the hollow tubular element.

[0061] The longitudinal airflow channel preferably has a diameter of at least 3 millimetres. This corresponds to the internal diameter of the hollow tubular substrate element. Preferably, the longitudinal airflow channel has a diameter of at least about 3.25 millimetres, more preferably at least about 3.5 millimetres.

[0062] Preferably, the longitudinal airflow channel has a diameter of up to about 7 millimetres, more preferably up to about 6 millimetres, more preferably up to about 5.5 millimetres.

[0063] For example, the longitudinal airflow channel may have a diameter of between about 3 millimetres and about 7 millimetres, or between about 3.25 millimetres and about 6 millimetres, or between about 3.5 millimetres and about 5.5 millimetres.

[0064] The provision of an airflow channel having a minimum diameter of 3 millimetres enables the volume of the channel to be sufficiently large that it provides a desired level of airflow, whilst also retaining a sufficient wall thickness. This is necessary so that there is a sufficient amount of plant material provided within the hollow tubular substrate element and so that the hollow tubular substrate element has a sufficiently high rigidity that it can be self-supporting.

[0065] The longitudinal airflow channel may have a constant diameter along the length of the hollow tubular substrate element. However, the diameter of the longitudinal airflow channel may vary along the length of the hollow tubular substrate element.

[0066] Preferably, the longitudinal airflow channel has a transverse cross-section that is substantially circular. Alternatively, the longitudinal airflow channel may have a transverse cross-section that is substantially oval.

[0067] Preferably, the ratio of the internal diameter to the external diameter of the hollow tubular substrate element is at least about 0.4, more preferably at least about 0.45 and more preferably at least about 0.5.

[0068] Preferably, the external diameter of the hollow tubular substrate element and the diameter of the longitudinal airflow channel are adapted to provide a desired wall thickness for the peripheral wall. Preferably, the peripheral wall has a wall thickness of at least about 1 millimetre, more preferably at least about 1.25 millimetres and more preferably at least about 1.5 millimetres.

[0069] Preferably, the peripheral wall has a wall thickness of up to about 2.25 millimetres, more preferably up to about 2 millimetres, more preferably up to about 1.8 millimetres.

[0070] For example, the peripheral wall may have a thickness of between 1 millimetre and about 2.25 millimetres, or between about 1.25 millimetres and about 2 millimetres, or between about 1.5 millimetres and about 1.8 millimetres.

[0071] The overlapping layers of homogenised plant material may be arranged in any suitable way in order to provide the desired wall thickness and porosity for the peripheral wall. Each layer of homogenised plant material will typically extend around the hollow tubular substrate element at least once and preferably, each layer of homogenised plant material extends around the hollow tubular substrate element a plurality of times to build up the structure of the peripheral wall.

[0072] Preferably, the plurality of layers of homogenised plant material are helically wound about the longitudinal axis of the hollow tubular substrate element. This provides a spiral wound structure that is similar to that the layered structure of conventional paper straws. Hollow tubular substrate elements incorporating a helical arrangement of layers for use in the present invention can be manufactured using existing straw making apparatus, such as the Hauni Straw Maker (HSM) from Hauni Maschinenbau GmbH.

[0073] The use of a spiral wound structure provides optimal structural strength to the hollow tubular substrate element, with increased mechanical strength in all directions compared to a similar structure with simple longitudinal wrapping. In addition, the helically wound arrangement enables a higher density of homogenised plant material to be obtained in the peripheral wall. The manufacturing method used to create the helical arrangement of layers additionally provides greater control over the dimensions of the hollow tubular substrate element, so that there is minimal variation in the external and internal diameter. This provides greater consistency between products.

[0074] The hollow tubular substrate element may optionally include an adhesive agent for sealing adjacent layers to each other. Suitable adhesive agents would be known to the skilled person. Preferably, the adhesive agent is a water based adhesive, for example, a water based starch adhesive or a polyvinyl alcohol (PVOH) adhesive.

[0075] The peripheral wall of the hollow tubular substrate element, which is formed of one or more layers of homogenised plant material is preferably at least partially exposed on the outer surface of the hollow tubular substrate element. The hollow tubular substrate element is therefore preferably unwrapped along at least a part of its length. The outer surface of the peripheral wall should provide an acceptable surface to form the exterior of the aerosol-generating article and the layered structure may provide a distinctive appearance and texture.

[0076] Alternatively, the hollow tubular substrate element may be overwrapped with at least one wrapper. For example, the hollow tubular substrate element may be overwrapped with a conventional paper wrapper. The hollow tubular substrate element may be overwrapped with a tobacco containing wrapper, such as a tobacco paper wrapper.

[0077] The hollow tubular substrate element is formed of a plurality of layers of homogenised plant material, which are preferably in sheet form. As used herein with reference

to the invention, the term "sheet" describes a laminar element having a width and length substantially greater than the thickness thereof.

[0078] The sheets may each individually have a thickness of between 100 micrometres and 600 micrometres, preferably between 150 micrometres and 300 micrometres, and most preferably between 200 micrometres and 250 micrometres.

[0079] Preferably the homogenised plant material is a homogenised tobacco material. The homogenised tobacco material comprises tobacco particles. Sheets 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 50 percent by weight on a dry weight basis more preferably at least about 70 percent by weight on a dry weight basis and most preferably at least about 90 percent by weight on a dry weight basis.

[0080] With reference to the present invention, the term "tobacco particles" describes particles of any plant member of the genus *Nicotiana*. The term "tobacco particles" encompasses ground or powdered tobacco leaf lamina, ground or powdered tobacco leaf stems, tobacco dust, tobacco fines, and other particulate tobacco by-products formed during the treating, handling and shipping of tobacco. In a preferred embodiment, the tobacco particles are substantially all derived from tobacco leaf lamina. By contrast, isolated nicotine and nicotine salts are compounds derived from tobacco but are not considered tobacco particles for purposes of the invention and are not included in the percentage of particulate plant material.

[0081] The homogenised plant material preferably comprises one or more aerosol formers. Upon volatilisation, an aerosol former can convey other vaporised compounds released from the aerosol-generating substrate upon heating, such as nicotine and flavourants, in an aerosol. Suitable aerosol formers for inclusion in the homogenised plant material are known in the art and include, but are not limited to: polyhydric alcohols, such as triethylene glycol, propylene glycol, 1,3-butanediol and glycerol; 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.

[0082] The homogenised plant material may have an aerosol former content of between about 5 percent and about 30 percent by weight on a dry weight basis, such as between about 10 percent and about 25 percent by weight on a dry weight basis, or between about 15 percent and about 20 percent by weight on a dry weight basis. The aerosol former may act as a humectant in the homogenised plant material.

[0083] The two or more overlapping layers of homogenised plant material forming the peripheral wall of the hollow tubular substrate element may all be formed of the same homogenised plant material. Alternatively, the peripheral wall includes one or more layers of a first homogenised plant material and one or more layers of a second homogenised plant material that is different to the first homogenised plant material. The peripheral wall is therefore formed from a combination of at least two different homogenised plant materials. The first homogenised plant material and the second homogenised plant material may differ from each other in composition. For example, the first and second homogenised plant materials may have a different tobacco content to each other, or a different aerosol former content, or both. Alternatively or in addition, the first and second homogenised plant materials have be provided with different levels of flavourants in order to provide flavour profiles. Alternatively or in addition, the first homogenised plant material and the second homogenised plant material may differ from each other in one or more physical parameters including but not limited to density, porosity or thickness.

[0084] The use of different homogenised plant materials within the hollow tubular substrate element provides greater flexibility over delivery of the aerosol upon heating. For example, the composition of the first and second homogenised plant materials may be adapted to provide delivery of aerosol at different times or different rates. The use of different homogenised plant materials can also provide improved stability, for example by avoiding the combination of potentially incompatible components.

[0085] Preferably, in embodiments in which the aerosol-generating substrate comprises homogenised tobacco material, the plurality of layers of homogenised tobacco material includes one or more sheets of cast leaf.

[0086] Preferably, the cast leaf has a porosity of between about 20 and about 60 percent, more preferably between about 30 percent and about 50 percent, more preferably between about 35 percent and about 45 percent, at 25 degrees Celsius.

[0087] Alternatively or in addition to the one or more sheet of cast leaf, the plurality of layers of homogenised tobacco material may include one or more layers of cigarillo paper.

[0088] Preferably, the cigarillo paper has a porosity of between about 30 percent and about 80 percent, more preferably between about 40 percent and about 70 percent, more preferably between about 50 percent and about 60 percent, at 25 degrees Celsius.

[0089] The peripheral wall may be formed of alternating layers of cast leaf and cigarillo paper.

[0090] The hollow tubular substrate element of aerosol-generating articles according to the present invention preferably comprises one or more susceptor elements located in contact with the peripheral wall, for inductive heating of the homogenised plant material during use.

[0091] As used herein, the term 'susceptor element' refers to an element comprising a material that is capable of converting electromagnetic energy into heat. When a susceptor element is located in an alternating electromagnetic field, the susceptor is heated. Heating of the susceptor element may be the result of at least one of hysteresis losses and eddy currents induced in the susceptor, depending on the electrical and magnetic properties of the susceptor material.

[0092] A susceptor element may be arranged such that, when the aerosol-generating article is received in the cavity of the aerosol-generating device, the oscillating electromagnetic field generated by the inductor coil induces a current in the susceptor element, causing the susceptor element to heat up. In these embodiments, the aerosol-generating device is preferably capable of generating a fluctuating electromagnetic field having a magnetic field strength (H-field strength) of between 1 and 5 kilo amperes per metre (kA m), preferably between 2 and 3 kA/m, for example about 2.5 kA/m. The electrically-operated aerosol-generating device is preferably capable of generating a fluctuating electromagnetic field having a frequency of between 1 and 30 MHz, for example between 1 and 10 MHz, for example between 5 and 7 MHz.

[0093] The susceptor element may comprise any suitable material. The susceptor element may be formed from any material that can be inductively heated to a temperature sufficient to release volatile compounds from the aerosol-forming substrate. Suitable materials for the elongate susceptor element include graphite, molybdenum, silicon carbide, stainless steels, niobium, aluminium, nickel, nickel containing compounds, titanium, and composites of metallic materials. Some susceptor elements comprise a metal or carbon. Advantageously the susceptor element may comprise or consist of a ferromagnetic material, for example, ferritic iron, a ferromagnetic alloy, such as ferromagnetic steel or stainless steel, ferromagnetic particles, and ferrite. A suitable susceptor element may be, or comprise, aluminium. The susceptor element preferably comprises more than about 5 percent, preferably more than about 20 percent, more preferably more than about 50 percent or more than about 90 percent of ferromagnetic or paramagnetic materials. Some elongate susceptor elements may be heated to a temperature in excess of about 250 degrees Celsius.

[0094] The susceptor element may comprise a non-metallic core with a metal layer disposed on the non-metallic core. For example, the susceptor element may comprise metallic tracks formed on an outer surface of a ceramic core or substrate.

[0095] Preferably, the hollow tubular substrate element comprises one or more susceptor elements on a surface of the peripheral wall. The hollow tubular substrate element may comprise one or more susceptor elements on the inner surface of the peripheral wall, within the longitudinal airflow channel. Alternatively or in addition, the hollow tubular substrate element may comprise one or more susceptor elements on the outer surface of the peripheral wall.

[0096] Preferably, the hollow tubular substrate element comprises a tubular susceptor element provided over at least one surface of the peripheral wall. The tubular susceptor element may be provided over the inner surface of the peripheral wall, to heat the hollow tubular substrate element internally. Alternatively, the tubular susceptor element may be provided over the outer surface of the hollow tubular substrate element to heat the hollow tubular substrate element externally.

[0097] The use of a tubular susceptor element advantageously optimises heating of the homogenised plant material within the peripheral wall, since the susceptor element is in contact with a relatively large surface area of the homogenised plant material. Due to the tubular form of the hollow tubular substrate element, the thickness of the substrate is relatively low so that heat can be transferred efficiently through the peripheral wall, from the side on which the tubular susceptor element is located.

[0098] As defined above, the aerosol-generating articles of the present invention further comprise a sealing element provided at the upstream end of the hollow tubular substrate element to provide an airtight seal, which prevents air from being drawn into the upstream end of the longitudinal airflow channel during use. The sealing element therefore covers and seals the opening of the longitudinal airflow channel at the upstream end.

[0099] The sealing element may be formed of any suitable material that can be affixed to the hollow tubular substrate and which is substantially impermeable to air so that an airtight seal can be provided. The sealing element may be adapted such that it is removable by the consumer prior to use.

[0100] Preferably, the sealing element comprises a film layer affixed to the peripheral wall at the upstream end of the hollow tubular substrate element. Preferably, the film layer is pierceable.

[0101] This means that the film layer is capable of being pierced or punctured by means of a heating element, susceptor wick or other piercing element provided in the heating cavity of an aerosol-generating device. This piercing of the film layer preferably occurs when the aerosol-generating article is inserted into the heating cavity prior to use.

[0102] The film layer is preferably formed of a laminate material comprising a plurality of overlapping layers. The film layer may comprise one or more polymer layers. Suitable polymers include but are not limited to polyethylene terephthalate (PET), low and high density polyethylene (LDPE and HDPE respectively), polypropylene (PP), polyvinyl chloride (PVC), polyamide, polyolefin, polystyrene, ethylene vinyl alcohol copolymer and combinations thereof. Alternatively or in addition, the film layer may comprise one more metallic layers, for example, one or more aluminium layers.

[0103] The film layer may be heat sealed to the peripheral wall of the hollow tubular substrate element. Alternatively, the film layer may be affixed to the peripheral wall of the hollow tubular substrate element by means of a suitable adhesive, as described below.

[0104] In alternative embodiments, the sealing element comprises a paper wrapper. The paper wrapper may be folded over the upstream end of the hollow tubular substrate element. The paper wrapper may be formed of any of the paper materials used to provide plug wraps or tipping wrappers for conventional aerosol-generating articles. Preferably, in order to ensure that an airtight seal is provided, the paper wrapper is coated or laminated with an impermeable coating layer, for example, a layer of a wax. Suitable coating materials would be known to the skilled person.

[0105] The sealing element is preferably affixed to the upstream end of the hollow tubular substrate element by means of an adhesive layer. The adhesive layer is preferably provided between the sealing element and the areas of the peripheral wall of the hollow tubular substrate element which are covered by the sealing element.

[0106] Suitable adhesives would be known to the skilled person and include most food grade adhesives, such as polysaccharide adhesives.

[0107] The sealing element may be provided over just the upstream face of the hollow tubular substrate element. In such embodiments, the sealing element will be affixed to the upstream face or edge of the peripheral wall. Alternatively, the sealing element may extend at least part way along the external surface of the peripheral wall of the hollow tubular substrate element, from the upstream end. This may facilitate the sealing of the sealing element to the peripheral wall, as a result of the increase area of contact between the sealing element and the peripheral wall. For example, the sealing element may extend at least 1 millimetre along the external surface of the peripheral wall, from the upstream end, more preferably at least 2 millimetres, more preferably at least 3 millimetres.

[0108] In certain embodiments, aerosol-generating articles according to the invention further comprise a fixing band

extending circumferentially around the hollow tubular substrate element and overlying the portion of the sealing element extending downstream from the upstream end of the hollow tubular substrate element, as described above. The fixing band is preferably affixed to the external surface of the hollow tubular substrate element. Preferably, the fixing band is a band of paper.

[0109] The provision of a fixing band overlying the sealing element helps to retain the sealing element in place on the hollow tubular substrate element. It may also provide a more uniform appearance on the outside of the hollow tubular substrate element and a more desirable surface texture for the consumer. Preferably, an adhesive is used to affix the fixing band to the external surface of the hollow tubular substrate element.

[0110] The fixing band preferably has a length of at least 2 millimetres, more preferably at least 3 millimetres and more preferably at least 4 millimetres.

[0111] As defined above, in the aerosol-generating articles of the present invention, the aerosol-generating substrate formed of the hollow tubular substrate element is combined with a downstream section, located downstream of the aerosol-generating substrate. The downstream section is preferably located immediately downstream of the aerosol-generating substrate. The downstream section of the aerosol-generating article preferably extends between the aerosol-generating substrate and the downstream end of the aerosol-generating article. The downstream section may comprise one or more elements, each of which will be described in more detail within the present disclosure.

[0112] Preferably, the downstream section comprises at least one hollow tubular element. The hollow tubular element may be provided immediately downstream of the aerosol-generating substrate. In other words, the hollow tubular element may abut a downstream end of the aerosol-generating substrate. This arrangement optimises flow of the aerosol from the longitudinal airflow channel of the hollow tubular substrate element into the downstream section and through the aerosol-generating article.

[0113] Preferably, the downstream section of the aerosol-generating article comprises a single hollow tubular element. In other words, the downstream section of the aerosol-generating article may comprise only one hollow tubular element.

[0114] As used throughout the present disclosure, the "hollow tubular element" denotes a generally elongate element defining a lumen or airflow passage along a longitudinal axis thereof. In particular, the term "tubular" will be used in the following with reference to a tubular element having a substantially cylindrical cross-section and defining at least one airflow conduit establishing an uninterrupted fluid communication between an upstream end of the tubular element and a downstream end of the tubular element. However, it will be understood that alternative geometries (for example, alternative cross-sectional shapes) of the tubular segment may be possible. The hollow tubular element may be an individual, discrete element of the aerosol-generating article which has a defined length and thickness.

[0115] In the context of the present invention, the hollow tubular element of the downstream section provides an unrestricted flow channel through the airflow passage. This means that the hollow tubular element provides a negligible level of resistance to draw (RTD), as defined above. The airflow passage should therefore be free from any components that would obstruct the flow of air in a longitudinal direction. Preferably, the airflow passage is substantially empty.

[0116] The hollow tubular element of the downstream section provides an empty cavity downstream of the aerosol-generating substrate, which enhances cooling and nucleation of aerosol particles generated by the aerosol-generating substrate. The hollow tubular element of the downstream section therefore functions as an aerosol-cooling element.

[0117] The length of the hollow tubular element may be at least about 12 millimetres. The length of the hollow tubular element may be at least about 15 millimetres. The length of the hollow tubular element may be at least about 20 millimetres.

[0118] The length of the hollow tubular element of the downstream section may be less or equal than about 50 millimetres. The length of the hollow tubular element may be less or equal than about 45 millimetres. The length of the hollow tubular element may be less or equal than about 40 millimetres.

[0119] For example, the length of the hollow tubular element of the downstream section may be between about 12 millimetres and 50 millimetres. The length of the hollow tubular element may be between about 15 millimetres and 45 millimetres. The length of the hollow tubular element may be between about 20 millimetres and 40 millimetres. The length of the hollow tubular element may be about 30 millimetres.

[0120] A relatively long hollow tubular element provides and defines a relatively long internal cavity within the downstream section of the aerosol-generating article. Providing a relatively long cavity maximises the nucleation benefits described above, thereby improving aerosol formation and cooling.

[0121] The ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be less than or equal to about 1.25. Preferably, a ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be less than or equal to about 1. More preferably, a ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be less than or equal to about 0.75.

[0122] The ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be at least about 0.25. Preferably, a ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be at least about 0.30. More preferably, a ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be at least about 0.40.

[0123] For example, the ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section may be between about 0.25 and about 1.25, or between about 0.3 and about 1, or between about 0.4 and about 0.75.

[0124] The ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section may be less than or equal to about 1. Preferably, the ratio between the length of the hollow tubular element of the downstream section and the total length of the

downstream section may be less than or equal to about 0.90. More preferably, the ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section may be less than or equal to about 0.85.

[0125] The ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section may be at least about 0.35. Preferably, the ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section may be at least about 0.45. More preferably, the ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section may be at least about 0.50.

[0126] For example, the ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section may be between about 0.35 and about 1, or between about 0.45 and about 0.9, or between about 0.5 and about 0.85.

[0127] The ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be less than or equal to about 0.80. Preferably, the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be less than or equal to about 0.70. More preferably, the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be less than or equal to about 0.60.

[0128] The ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be at least about 0.25. Preferably, the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be at least about 0.30. More preferably, the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be at least about 0.40.

[0129] For example, the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article may be between about 0.25 and about 0.8, or between about 0.3 and about 0.7, or between about 0.4 and about 0.6.

[0130] The wall thickness of the hollow tubular element of the downstream section may be at least about 100 micrometres. The wall thickness of the hollow tubular element of the downstream section may be at least about 150 micrometres. The wall thickness of the hollow tubular element of the downstream section may be at least about 200 micrometres, preferably at least about 250 micrometres and even more preferably at least about 500 micrometres (or 0.5 mm).

[0131] The wall thickness of the hollow tubular element of the downstream section may be less than or equal to about 2 millimetres, preferably less than or equal to about 1.5 millimetres and even more preferably less than or equal to about 1.25 mm. The wall thickness of the hollow tubular element of the downstream section may be less than or equal to about 1 millimetre. The wall thickness of the hollow tubular element of the downstream section may be less than or equal to about 500 micrometres.

[0132] The wall thickness of the hollow tubular element of the downstream section may between about 100 micrometres and about 2 millimetres, preferably between about 150 micrometres and about 1.5 millimetres, even more preferably between about 200 micrometres and about 1.25 millimetres.

[0133] Keeping the wall thickness of the hollow tubular segment of the downstream section relatively low ensures that the overall internal volume of the hollow tubular element—which is made available for the aerosol to begin the nucleation process as soon as the aerosol components leave the aerosol-generating substrate—and the cross-sectional surface area of the hollow tubular element are effectively maximised, whilst at the same time ensuring that the hollow tubular element has the necessary structural strength to prevent a collapse of the aerosol-generating article as well as to provide some support to the rod of aerosol-generating substrate, and that the RTD of the hollow tubular element is minimised. Greater values of cross-sectional surface area of the cavity of the hollow tubular element are understood to be associated with a reduced speed of the aerosol stream travelling along the aerosol-generating article, which is also expected to favour aerosol nucleation. Further, it would appear that by utilising a hollow tubular element having a relatively low thickness, it is possible to substantially prevent diffusion of the ventilation air prior to its contacting and mixing with the stream of aerosol, which is also understood to further favour nucleation phenomena. In practice, by providing a more controllably localised cooling of the stream of volatilised species, it is possible to enhance the effect of cooling on the formation of new aerosol particles.

[0134] The hollow tubular element of the downstream section preferably has an outer diameter that is approximately equal to the outer diameter of the aerosol-generating substrate and to the outer diameter of the aerosol-generating article.

[0135] The hollow tubular element may have an outer diameter of between 5 millimetres and 12 millimetres, for example of between 5 millimetres and 10 millimetres or of between 6 millimetres and 8 millimetres. Preferably, the hollow tubular element has an external diameter of 7.2 millimetres plus or minus 10 percent.

[0136] The hollow tubular element of the downstream section may have a constant internal diameter along a length of the hollow tubular element. However, the internal diameter of the hollow tubular element may vary along the length of the hollow tubular element.

[0137] The hollow tubular element of the downstream section may have an internal diameter of at least about 2 millimetres. For example, the hollow tubular element may have an internal diameter of at least about 2.5 millimetres, at least about 3 millimetres, or at least about 3.5 millimetres. The provision of a hollow tubular element having an internal diameter as set out above may advantageously provide sufficient rigidity and strength to the hollow tubular element.

[0138] The hollow tubular element of the downstream section may have an internal diameter of no more than about 10 millimetres. For example, the hollow tubular element may have an internal diameter of no more than about 9 millimetres, no more than about 8 millimetres, or no more than about 7.5 millimetres. The provision of a hollow tubular element having an internal diameter as set out above may advantageously reduce the resistance to draw of the hollow tubular segment.

[0139] For example, the hollow tubular element of the downstream section may have an internal diameter of between about 2 millimetres and about 10 millimetres,

between about 2.5 millimetres and about 9 millimetres, between about 3 millimetres and about 8 millimetres, or between about 3.5 millimetres and about 7.5 millimetres.

[0140] The ratio of the internal diameter of the hollow tubular substrate element to the internal diameter of the hollow tubular element of the downstream section is preferably between about 0.8 and about 1.2, more preferably between about 0.9 and about 1.1, most preferably about 1.

[0141] Particularly preferably, the internal diameter of the hollow tubular substrate element is substantially equal to the internal diameter of the hollow tubular element of the downstream section.

[0142] The hollow tubular element of the downstream section may comprise a paper-based material. The hollow tubular element may comprise at least one layer of paper. The paper may be very rigid paper. The paper may be crimped paper, such as crimped heat resistant paper or crimped parchment paper.

[0143] Preferably, the hollow tubular element may comprise cardboard. The hollow tubular element may be a cardboard tube. The hollow tubular element may be formed from cardboard. Advantageously, cardboard is a cost-effective material that provides a balance between being deformable in order to provide ease of insertion of the article into an aerosol-generating device and being sufficiently stiff to provide suitable engagement of the article with the interior of the device. A cardboard tube may therefore provide suitable resistance to deformation or compression during use.

[0144] The hollow tubular segment may be a paper tube. The hollow tubular segment may be a tube formed from spirally wound paper. The hollow tubular segment may be formed from a plurality of layers of the paper. The paper may have a basis weight of at least about 50 grams per square meter, at least about 60 grams per square meter, at least about 70 grams per square meter, or at least about 90 grams per square meter.

[0145] The hollow tubular segment of the downstream section may comprise a polymeric material. For example, the hollow tubular segment may comprise a polymeric film. The polymeric film may comprise a cellulosic film. The hollow tubular segment may comprise low density polyethylene (LDPE) or polyhydroxyalkanoate (PHA) fibres. The hollow tube may comprise cellulose acetate tow.

[0146] Where the hollow tubular segment comprises cellulose acetate tow, the cellulose acetate tow may have a denier per filament of between about 2 and about 4 and a total denier of between about 25 and about 40.

[0147] In some embodiments, the aerosol-generating article according to the present invention may comprise a ventilation zone at a location along the downstream section. In more detail, in those embodiments wherein the downstream section comprises a hollow tubular element, the ventilation zone may be provided at a location along the hollow tubular element.

[0148] As such, a ventilated cavity is provided downstream of the rod of aerosol-generating substrate. This provides particularly efficient cooling of the aerosol and promotes enhanced nucleation of aerosol particles.

[0149] The ventilation zone may typically comprise a plurality of perforations through the peripheral wall of the hollow tubular element. Preferably, the ventilation zone comprises at least one circumferential row of perforations. In some embodiments, the ventilation zone may comprise two circumferential rows of perforations. For example, the perforations may be formed online during manufacturing of the aerosol-generating article. Preferably, each circumferential row of perforations comprises from 8 to 30 perforations.

[0150] The downstream section may further comprise a mouthpiece element. The mouthpiece element may be located at the downstream end of the aerosol-generating article. The mouthpiece element is preferably located downstream of the hollow tubular element of the downstream section, which is described above. The mouthpiece element may extend between the hollow tubular element of the downstream section and the downstream end of the aerosol-generating article.

[0151] The provision of a mouthpiece element at the downstream end of the aerosol-generating articles according to the present invention provides an appealing appearance and mouthfeel to the consumer.

[0152] The mouthpiece element may comprise at least one mouthpiece filter segment formed of a fibrous filtration material. Parameters or characteristics described in relation to the mouthpiece element as a whole may equally be applied to a mouthpiece filter segment of the mouthpiece element.

[0153] The fibrous filtration material may be for filtering the aerosol that is generated from the aerosol-generating substrate. Suitable fibrous filtration materials would be known to the skilled person. Particularly preferably, the at least one mouthpiece filter segment comprises a cellulose acetate filter segment formed of cellulose acetate tow.

[0154] The mouthpiece element may consist of a single mouthpiece filter segment. The mouthpiece element may include two or more mouthpiece filter segments axially aligned in an abutting end to end relationship with each other.

[0155] The downstream section may comprise a mouth end cavity at the downstream end, downstream of the mouthpiece element as described above. The mouth end cavity may be defined by a further hollow tubular element provided at the downstream end of the mouthpiece. The mouth end cavity may be defined by an outer wrapper of the aerosol-generating article, wherein the outer wrapper extends in a downstream direction from (or past) the mouthpiece element.

[0156] The mouthpiece element may optionally comprise a flavourant, which may be provided in any suitable form. For example, the mouthpiece element may comprise one or more capsules, beads or granules of a flavourant, or one or more flavour loaded threads or filaments.

[0157] Preferably, the mouthpiece element, or mouthpiece filter segment thereof, has a low particulate filtration efficiency.

[0158] Preferably, the mouthpiece element is circumscribed by a plug wrap. Preferably, the mouthpiece element is unventilated such that air does not enter the aerosol-generating article along the mouthpiece element.

[0159] The mouthpiece element preferably has an external diameter that is approximately equal to the external diameter of the aerosol-generating article. The diameter of a mouthpiece element (or mouthpiece filter segment) may be substantially the same as the outer diameter of the hollow tubular element. As mentioned in the present disclosure, the outer diameter of the hollow tubular element may be about 7.2 mm, plus or minus 10 percent.

[0160] The diameter of the mouthpiece element may be between about 5 mm and about 10 mm. The diameter of the mouthpiece element may be between about 6 mm and about 8 mm. The diameter of the mouthpiece element may be between about 7 mm and about 8 mm. The diameter of the mouthpiece element may be about 7.2 mm, plus or minus 10 percent. The diameter of the mouthpiece element may be about 7.25 mm, plus or minus 10 percent.

[0161] Unless otherwise specified, the resistance to draw (RTD) of a component or the aerosol-generating article is measured in accordance with ISO 6565-2015. The RTD refers the pressure required to force air through the full length of a component. The terms "pressure drop" or "draw resistance" of a component or article may also refer to the "resistance to draw". Such terms generally refer to the measurements in accordance with ISO 6565-2015 are normally carried out at under test at a volumetric flow rate of about 17.5 millilitres per second at the output or downstream end of the measured component at a temperature of about 22 degrees Celsius, a pressure of about 101 kPa (about 760 Torr) and a relative humidity of about 60%.

[0162] The resistance to draw (RTD) of the downstream section may be at least about 0 mm H_2O. The RTD of the downstream section may be at least about 3 mm H_2O. The RTD of the downstream section may be at least about 6 mm H_2O.

[0163] The RTD of the downstream section may be no greater than about 12 mm H_2O. The RTD of the downstream section may be no greater than about 11 mm H_2O. The RTD of the downstream section may be no greater than about 10 mm H_2O.

[0164] The resistance to draw of the downstream section may be greater than or equal to about 0 mm H_2O and less than about 12 mm H_2O. Preferably, the resistance to draw of the downstream section may be greater than or equal to about 3 mm H_2O and less than about 12 mm H_2O. The resistance to draw of the downstream section may be greater than or equal to about 0 mm H_2O and less than about 11 mm H_2O. Even more preferably, the resistance to draw of the downstream section may be greater than or equal to about 3 mm H_2O and less than about 11 mm H_2O. Even more preferably, the resistance to draw of the downstream section may be greater than or equal to about 6 mm H_2O and less than about 10 mm H_2O. Preferably, the resistance to draw of the downstream section may be about 8 mm H_2O.

[0165] The resistance to draw (RTD) characteristics of the downstream section may be wholly or mostly attributed to the RTD characteristics of the mouthpiece element of the downstream section. In other words, the RTD of the mouthpiece element of the downstream section may wholly define the RTD of the downstream section.

[0166] The resistance to draw (RTD) of the mouthpiece element may be at least about 0 mm H_2O. The RTD of the mouthpiece element may be at least about 3 mm H_2O. The RTD of the mouthpiece element may be at least about 6 mm H_2O.

[0167] The RTD of the mouthpiece element may be no greater than about 12 mm H_2O. The RTD of the mouthpiece element may be no greater than about 11 mm H_2O. The RTD of the mouthpiece element may be no greater than about 10 mm H_2O.

[0168] The resistance to draw of the mouthpiece element may be greater than or equal to about 0 mm H_2O and less than about 12 mm H_2O. Preferably, the resistance to draw of the mouthpiece element may be greater than or equal to about 3 mm H_2O and less than about 12 mm H_2O. The resistance to draw of the mouthpiece element may be greater than or equal to about 0 mm H_2O and less than about 11 mm H_2O. Even more preferably, the resistance to draw of the mouthpiece element may be greater than or equal to about 3 mm H_2O and less than about 11 mm H_2O. Even more preferably, the resistance to draw of the mouthpiece element may be greater than or equal to about 6 mm H_2O and less than about 10 mm H_2O. Preferably, the resistance to draw of the mouthpiece element may be about 8 mm H_2O.

[0169] As mentioned above, the mouthpiece element, or mouthpiece filter segment, may be formed of a fibrous material. The mouthpiece element may be formed of a porous material. The mouthpiece element may be formed of a biodegradable material. The mouthpiece element may be formed of a cellulose material, such as cellulose acetate. For example, a mouthpiece element may be formed from a bundle of cellulose acetate fibres having a denier per filament between about 10 and about 15. For example, a mouthpiece element formed from relatively low density cellulose acetate tow, such as cellulose acetate tow comprising fibres of about 12 denier per filament.

[0170] The mouthpiece element may be a solid plug of fibrous filtration material, such as a solid plug of cellulose acetate tow.

[0171] The mouthpiece element may be formed of a polylactic acid based material. The mouthpiece element may be formed of a bioplastic material, preferably a starch-based bioplastic material. The mouthpiece element may be made by injection moulding or by extrusion. Bioplastic-based materials are advantageous because they are able to provide mouthpiece element structures which are simple and cheap to manufacture with a particular and complex cross-sectional profile, which may comprise a plurality of relatively large air flow channels extending through the mouthpiece element material, that provides suitable RTD characteristics.

[0172] The mouthpiece element may be formed from a sheet of suitable material that has been crimped, pleated, gathered, woven or folded into an element that defines a plurality of longitudinally extending channels. Such sheet of suitable material may be formed of paper, cardboard, a polymer, such as polylactic acid, or any other cellulose-based, paper-based material or bioplastic-based material. A cross-sectional profile of such a mouthpiece element may show the channels as being randomly oriented.

[0173] The mouthpiece element may be formed in any other suitable manner. For example, the mouthpiece element may be formed from a bundle of longitudinally extending tubes. The longitudinally extending tubes may be formed from polylactic acid. The mouthpiece element may be formed by extrusion, moulding, lamination, injection, or shredding of a suitable material. Thus, it is preferred that there is a low-pressure drop (or RTD) from an upstream end of the mouthpiece element to a downstream end of the mouthpiece element.

[0174] The length of the mouthpiece element may be at least about 1.5 millimetres. The length of the mouthpiece element may be at least about 2 millimetres. The length of the mouthpiece element may equal to or less than about 7 millimetres. The length of the mouthpiece element may be equal to or less than about 4 millimetres. For example, the length of the mouthpiece element may be between about 1.5

millimetres and about 7 millimetres. The length of the mouthpiece element may be between about 2 millimetres and about 4 millimetres.

[0175] The ratio between the length of the mouthpiece element and the length of the downstream section may be less than or equal to about 0.35. Preferably, the ratio between the length of the mouthpiece element and the length of the downstream section may be less than or equal to about 0.30. More preferably, the ratio between a length of the mouthpiece element and the length of the downstream section may be less than or equal to about 0.25.

[0176] The ratio between the length of the mouthpiece element and the length of the downstream section may be at least about 0.03. Preferably, the ratio between a length of the mouthpiece element and the length of the downstream section may be at least about 0.05. More preferably, the ratio between the length of the mouthpiece element and the length of the downstream section may be at least about 0.1.

[0177] For example, the ratio between the length of the mouthpiece element and the length of the downstream section is from about 0.03 to about 0.35, preferably from about 0.05 to about 0.30, more preferably from about 0.1 to about 0.25.

[0178] The ratio between the length of the mouthpiece element and the overall length of the aerosol-generating article may be less than or equal to about 0.20. Preferably, the ratio between the length of the mouthpiece element and the overall length of the aerosol-generating article may be less than or equal to about 0.15. More preferably, the ratio between a length of the mouthpiece element and the overall length of the aerosol-generating article may be less than or equal to about 0.1.

[0179] The ratio between the length of the mouthpiece element and the overall length of the aerosol-generating article may be at least about 0.01. Preferably, the ratio between the length of the mouthpiece element and the overall length of the aerosol-generating article may be at least about 0.02. More preferably, the ratio between the length of the mouthpiece element and the overall length of the aerosol-generating article may be at least about 0.05.

[0180] For example, the ratio between the length of the mouthpiece element and the overall length of the aerosol-generating article is from about 0.01 to about 0.2, preferably from about 0.02 to about 0.15, more preferably from about 0.05 to about 0.1.

[0181] In embodiments where the downstream section comprises a hollow tubular element and a mouthpiece element, a ratio of the length of the hollow tubular element to the length of the mouthpiece element may be at least about 1.5. In other words, the length of the hollow tubular element may be equivalent to about 150% of the length of the mouthpiece. The ratio of the length of the hollow tubular element to the length of the mouthpiece element may be at least about 5. The ratio of the length of the hollow tubular element to the length of the mouthpiece element may be at least about 7.5.

[0182] The ratio of the length of the hollow tubular element to the length of the mouthpiece element may be equal to or less than about 20. The ratio of the length of the hollow tubular element to the length of the mouthpiece element may be equal to or less than about 15. The ratio of the length of the hollow tubular element to the length of the mouthpiece element may be equal to or less than about 12.5.

[0183] For example, the ratio of the length of the hollow tubular element to the length of the mouthpiece element may be between about 1.5 and about 20, or between about 5 and about 15, or between about 7.5 and about 10.

[0184] The overall length of the downstream section is preferably at least about 15 millimetres, more preferably at least about 20 millimetres, more preferably at least about 25 millimetres.

[0185] The overall length of the downstream section is preferably less than about 50 millimetres, more preferably less than about 45 millimetres, more preferably less than about 40 millimetres.

[0186] For example, the downstream section may have an overall length of between about 20 millimetres and about 50 millimetres, more preferably between about 25 millimetres and about 45 millimetres, more preferably between about 30 millimetres and about 40 millimetres.

[0187] The ratio between the total length of the downstream section and an overall length of the aerosol-generating article may be less than or equal to about 0.80. Preferably, the ratio between the length of the downstream section and an overall length of the aerosol-generating article may be less than or equal to about 0.75. More preferably, the ratio between the length of the downstream section and the overall length of the aerosol-generating article may be less than or equal to about 0.70. Even more preferably, the ratio between the length of the downstream section and the overall length of the aerosol-generating article may be less than or equal to about 0.65.

[0188] The ratio between the length of the downstream section and the overall length of the aerosol-generating article may be at least about 0.30. Preferably, the ratio between the length of the downstream section and the overall length of the aerosol-generating article may be at least about 0.40. More preferably, the ratio between a length of the downstream section and the overall length of the aerosol-generating article may be at least about 0.50. Even more preferably, the ratio between a length of the downstream section and the overall length of the aerosol-generating article may be at least about 0.60.

[0189] Preferably, an overall length of an aerosol-generating article in accordance with the invention is at least about 35 millimetres. More preferably, an overall length of an aerosol-generating article in accordance with the invention is at least about 40 millimetres. Even more preferably, an overall length of an aerosol-generating article in accordance with the invention is at least about 45 millimetres. Even more preferably, an overall length of an aerosol-generating article in accordance with the invention is at least about 50 millimetres.

[0190] An overall length of an aerosol-generating article in accordance with the invention is preferably less than or equal to 110 millimetres. More preferably, an overall length of an aerosol-generating article in accordance with the invention is preferably less than or equal to 100 millimetres. Even more preferably, an overall length of an aerosol-generating article in accordance with the invention is preferably less than or equal to 75 millimetres. Even more preferably, an overall length of an aerosol-generating article in accordance with the invention is preferably less than or equal to 70 millimetres.

[0191] For example, the overall length of the aerosol-generating article may be between about 35 millimetres and about 110 millimetres, or between about 40 millimetres and

about 100 millimetres, or between about 45 millimetres and about 75 millimetres, or between about 50 millimetres and about 70 millimetres.

[0192] The aerosol-generating article preferably has an external diameter of at least 4 millimetres. Preferably, the aerosol-generating article has an external diameter of at least 4.5 millimetres. More preferably, the aerosol-generating article has an external diameter of at least 5 millimetres.

[0193] Preferably, the aerosol-generating article has an external diameter of less than or equal to about 9 millimetres. More preferably, the aerosol-generating article has an external diameter of less than or equal to about 8 millimetres. Even more preferably, the aerosol-generating article has an external diameter of less than or equal to about 7 millimetres.

[0194] For example, the aerosol-generating article may have an external diameter of between about 4 millimetres and about 9 millimetres, or between about 4.5 millimetres and about 8 millimetres, or between about 5 millimetres and about 7 millimetres.

[0195] The external diameter of the aerosol-generating article may be substantially constant over the whole length of the article. As an alternative, different portions of the aerosol-generating article may have different external diameters.

[0196] In certain embodiments of the present invention, one or more of the components of the aerosol-generating article are individually circumscribed by their own wrapper.

[0197] Preferably, the aerosol-generating substrate and the downstream section are combined together with an outer wrapper, such as a tipping wrapper.

[0198] Preferably, the components of the aerosol-generating article according to the present invention are made from biodegradable materials.

[0199] Preferably, the aerosol-generating articles according to the present invention as described herein are adapted for use in electrically-operated aerosol-generating systems in which the aerosol-generating substrate of the heated aerosol-generating article is heated by an electrical heat source.

[0200] The heating element of such aerosol-generating devices may be of any suitable form to conduct heat. The heating of the aerosol-generating substrate may be achieved internally, externally or both. The heating element may preferably be a heater blade or pin adapted to be inserted into the substrate so that the substrate is heated from inside. The heating element may partially or completely surround the substrate and externally heat the substrate circumferentially from the outside.

[0201] The aerosol-generating system may be an electrically-operated aerosol generating system comprising an inductive heating device. Inductive heating devices typically comprise an induction source that is configured to be coupled to a susceptor, which may be provided externally to the aerosol-generating substrate or internally within the aerosol-generating substrate, as in certain embodiments of the present invention described above. The induction source generates an alternating electromagnetic field that induces magnetization or eddy currents in the susceptor. The susceptor may be heated as a result of hysteresis losses or induced eddy currents which heat the susceptor through ohmic or resistive heating.

[0202] Electrically operated aerosol-generating systems comprising an inductive heating device may also comprise the aerosol-generating article having the aerosol-generating substrate and a susceptor in thermal proximity to the aerosol-generating substrate. Typically, the susceptor is in direct contact with the aerosol-generating substrate and heat is transferred from the susceptor to the aerosol-generating substrate primarily by conduction. Examples of electrically operated aerosol-generating systems having inductive heating devices and aerosol-generating articles having susceptors are described in WO-A1-95/27411 and WO-A1-2015/177255.

[0203] The electrically operated aerosol-generating system may in some cases comprise an aerosol-generating article as defined above, a source of aerosol former and a means to vaporise the aerosol former, preferably a heating element. The source of aerosol former can be a reservoir, which can be refillable or replaceable, that resides on the aerosol generating device. While the reservoir is physically separate from the aerosol generating article, the vapour that is generated is directed through the aerosol-generating article. The vapour makes contact with the aerosol-generating substrate which releases volatile compounds, such as nicotine and flavorants in the particulate plant material, to form an aerosol. Optionally, to aid volatilization of compounds in the aerosol-generating substrate, the aerosol-generating system may further comprise a heating element to heat the aerosol-generating substrate, preferably in a coordinated manner with the aerosol former. However, in certain embodiments, the heating element used to heat the aerosol generating article is separate from the heater that heats the aerosol former.

[0204] As described above, the hollow tubular substrate element of aerosol-generating articles according to the invention can advantageously be adapted such that the length substantially matches the longitudinal dimensions of the heating element of the aerosol-generating system which is intended to be used to heat the aerosol-generating article. This ensures that the hollow tubular substrate element is heated along substantially its full length, so that the generation of aerosol from the aerosol-generating substrate can be maximised.

[0205] Below, there is provided a non-exhaustive list of non-limiting examples. Any one or more of the features of these examples may be combined with any one or more features of another example, embodiment, or aspect described herein.

[0206] EX 1. An aerosol-generating article comprising: an aerosol-generating substrate comprising a hollow tubular substrate element having a peripheral wall defining a longitudinal airflow channel extending between the upstream end and the downstream end of the hollow tubular substrate element, wherein the peripheral wall is formed of one or more layers of homogenised plant material; a sealing element at the upstream end of the hollow tubular substrate element; and a downstream section provided downstream of the aerosol-generating substrate.

[0207] EX2. An aerosol-generating article according to example EX1, wherein the sealing element is arranged to provide an airtight seal at an upstream end of the longitudinal airflow channel.

[0208] EX3. An aerosol-generating article according to example EX1 or EX2, wherein the sealing element comprises a film layer.

[0209] EX4. An aerosol-generating article according to example EX3, wherein the film layer is pierceable.

[0210] EX5. An aerosol-generating article according to example EX3 or EX4, wherein the film layer comprises one or more polymeric layers.

[0211] EX6. An aerosol-generating article according to example EX5, wherein the one or more polymeric layers are formed of polyethylene terephthalate (PET), low and high density polyethylene (LDPE and HDPE respectively), polypropylene (PP), polyvinyl chloride (PVC), polyamide, polyolefin, polystyrene, ethylene vinyl alcohol copolymer or combinations thereof.

[0212] EX7. An aerosol-generating article according to any of examples EX3 to EX6, wherein the film layer comprises one or more metallic layers.

[0213] EX8. An aerosol-generating article according to example EX7, wherein the film layer comprises one or more layers of aluminium.

[0214] EX9. An aerosol-generating article according to any of examples EX3 to EX8, wherein the film layer is heat sealed to the peripheral wall of the hollow tubular substrate element.

[0215] EX10. An aerosol-generating article according to example EX1 or EX2, wherein the sealing element comprises a paper wrapper.

[0216] EX11. An aerosol-generating article according to example EX10, wherein the paper wrapper is folded over the upstream end of the hollow tubular substrate element.

[0217] EX12. An aerosol-generating article according to example EX10 or EX11, wherein the paper wrapper is provided with an impermeable coating layer.

[0218] EX13. An aerosol-generating article according to example EX12, wherein the paper wrapper is coated with a wax.

[0219] EX14. An aerosol-generating article according to any preceding example, wherein the sealing element is affixed to the upstream end of the hollow tubular substrate element by means of an adhesive layer.

[0220] EX15. An aerosol-generating article according to any preceding example, wherein the sealing element extends downstream at least part way along the external surface of the peripheral wall of the hollow tubular substrate element from the upstream end.

[0221] EX16. An aerosol-generating article according to example EX15, wherein the sealing element extends at least 2 millimetres downstream along the external surface of the peripheral wall, from the upstream end.

[0222] EX17. An aerosol-generating formulation according to example EX15 or EX16, further comprising a fixing band extending circumferentially around the hollow tubular substrate element and overlying the portion of the sealing element extending downstream from the upstream end of the hollow tubular substrate element, wherein the fixing band is affixed to the external surface of the hollow tubular substrate element.

[0223] EX18. An aerosol-generating article according to example EX17, wherein the fixing band is a band of paper.

[0224] EX19. An aerosol-generating article according to example EX17 or EX18, wherein the fixing band has a length of at least 2 millimetres.

[0225] EX20. An aerosol-generating article according to any preceding example, wherein the longitudinal airflow channel has a diameter of at least 3 millimetres.

[0226] EX21. An aerosol-generating article according to any preceding example, wherein the hollow tubular substrate element comprises at least 2 overlapping layers of homogenised plant material.

[0227] EX22. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element comprises up to 10 overlapping layers of homogenised plant material.

[0228] EX23. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall of the hollow tubular substrate element has a cross-sectional porosity of at least about 0.3.

[0229] EX24. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall of the hollow tubular substrate element has a cross-sectional porosity of at least about 0.7.

[0230] EX25. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall of the hollow tubular substrate element has a density of at least 200 milligrams per cubic centimetre.

[0231] EX26. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall of the hollow tubular substrate element has a density of less than 1 gram per cubic centimetre.

[0232] EX27. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall of the hollow tubular substrate element provides at least 150 milligrams of homogenised plant material per centimetre of length of the hollow tubular substrate.

[0233] EX28. An aerosol-generating article according to any of the preceding examples, wherein the longitudinal tensile strength of the hollow tubular substrate element is between 11 kNewtons per metre and 14 kNewtons per metre.

[0234] EX29. An aerosol-generating article according to any of the preceding examples, wherein the axial compressive strength of the hollow tubular substrate element is between 7 MPa and 9 MPa.

[0235] EX30. An aerosol-generating article according to any of the preceding examples, wherein the radial compressive strength of the hollow tubular substrate element is between 7 MPa and 9 MPa.

[0236] EX31. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element has a length of up to 40 millimetres.

[0237] EX32. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element has a length of at least 10 millimetres.

[0238] EX33. An aerosol-generating article according to any of the preceding examples, wherein the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is at least 0.15.

[0239] EX34. An aerosol-generating article according to any of the preceding examples, wherein the ratio of the length of the hollow tubular substrate element to the overall length of the aerosol-generating article is up to 0.6.

[0240] EX35. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element has an external diameter of at least 4 millimetres.

[0241] EX36. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element has an external diameter of up to 9 millimetres.

[0242] EX37. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element provides an unrestricted flow channel.

[0243] EX38. An aerosol-generating article according to any of the preceding examples, wherein the longitudinal airflow channel of the hollow tubular substrate element has a diameter of up to 7 millimetres.

[0244] EX39. An aerosol-generating article according to any of the preceding examples, wherein the ratio of the internal diameter to the external diameter of the hollow tubular substrate element is at least 0.4.

[0245] EX40. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall has a wall thickness of at least 1 millimetre.

[0246] EX41. An aerosol-generating article according to any of the preceding examples, wherein the peripheral wall has a wall thickness of at up to 2.25 millimetres.

[0247] EX42. An aerosol-generating article according to any of the preceding examples, wherein the plurality of layers of homogenised plant material are helically wound about the longitudinal axis of the hollow tubular substrate element.

[0248] EX43. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element further comprises an adhesive agent for sealing adjacent layers to each other.

[0249] EX44. An aerosol-generating article according to any of the preceding examples, wherein the homogenised plant material is a homogenised tobacco material having a tobacco content of at least 40 percent by weight on a dry weight basis.

[0250] EX45. An aerosol-generating article according to any of the preceding examples, wherein the homogenised plant material further comprises one or more aerosol former.

[0251] EX46. An aerosol-generating article according to any of the preceding examples, wherein the hollow tubular substrate element comprises one or more susceptor elements located in contact with the peripheral wall.

[0252] EX47. An aerosol-generating article according to example EX46, wherein the hollow tubular substrate element comprises one or more susceptor elements on a surface of the peripheral wall.

[0253] EX48. An aerosol-generating article according to example EX46, wherein the hollow tubular substrate element comprises a tubular susceptor element provided over at least one surface of the peripheral wall.

[0254] EX49. An aerosol-generating article according to any of the preceding examples, wherein the downstream section comprises a hollow tubular element.

[0255] EX50. An aerosol-generating article according to example EX49, wherein the length of the hollow tubular element of the downstream section is between 12 mm and 50 mm.

[0256] EX51. An aerosol-generating article according to example EX49 or EX50, wherein the ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section is at least 0.25.

[0257] EX52. An aerosol-generating article according to any of examples EX49 to EX51, wherein the ratio between the length of the hollow tubular substrate element and the length of the hollow tubular element of the downstream section is less than or equal to 1.25.

[0258] EX53. An aerosol-generating article according to any of examples EX49 to EX52, wherein the ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section is at least 0.35.

[0259] EX54. An aerosol-generating article according to any of examples EX49 to EX53, wherein the ratio between the length of the hollow tubular element of the downstream section and the total length of the downstream section is less than or equal to 1.

[0260] EX55. An aerosol-generating article according to any of examples EX49 to EX54, wherein the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article is at least 0.25.

[0261] EX56. An aerosol-generating article according to any of examples EX49 to EX55, wherein the ratio between the length of the hollow tubular element of the downstream section and the overall length of the aerosol-generating article is less than or equal to 0.8.

[0262] EX57. An aerosol-generating article according to any of examples EX49 to EX56, wherein the wall thickness of the hollow tubular element of the downstream section is at least 100 micrometres.

[0263] EX58. An aerosol-generating article according to any of examples EX49 to EX57, wherein the wall thickness of the hollow tubular element of the downstream section is less than or equal to 2 millimetres.

[0264] EX59. An aerosol-generating article according to any of examples EX49 to EX58, wherein the hollow tubular element of the downstream section has an internal diameter of between 2 millimetres and 10 millimetres.

[0265] EX60. An aerosol-generating article according to any of examples EX49 to EX59, wherein the ratio of the internal diameter of the hollow tubular substrate element to the internal diameter of the hollow tubular element of the downstream section is between 0.8 and 1.2.

[0266] EX61. An aerosol-generating article according to any of the preceding examples, wherein the downstream section further comprises a mouthpiece element.

[0267] EX62. An aerosol-generating article according to example EX61, wherein the mouthpiece element comprises at least one segment of a fibrous filtration material.

[0268] EX63. An aerosol-generating article according to example EX61 or EX62, wherein the downstream section comprises a mouth end cavity at the downstream end, downstream of the mouthpiece element.

[0269] EX64. An aerosol-generating article according to any of the preceding examples, wherein the RTD of the downstream section is no greater than 12 mm H_2O.

[0270] EX65. An aerosol-generating article according to any of the preceding examples, wherein the length of the downstream section is between 20 millimetres and 50 millimetres.

[0271] EX66. An aerosol-generating article according to any of the preceding examples, wherein the ratio between the total length of the downstream section and an overall length of the aerosol-generating article is less than or equal to 0.80.

[0272] EX67. An aerosol-generating article according to any of the preceding examples, wherein the components of the aerosol-generating article are made from biodegradable materials.

[0273] Specific embodiments will be further described, by way of example only, with reference to the accompanying drawings in which:

[0274] FIG. **1** shows a schematic side-sectional view of the aerosol-generating article in accordance with a first embodiment of the invention;

[0275] FIG. **2** shows a schematic side-sectional view of the aerosol-generating article in accordance with a second embodiment of the invention; and

[0276] FIG. **2** shows a schematic side sectional view of an aerosol-generating system comprising an aerosol-generating article in accordance with a third embodiment of the invention and an aerosol-generating device.

[0277] The aerosol-generating article **10** shown in FIG. **1** comprises an aerosol-generating substrate **12** and a downstream section **14** at a location downstream of the aerosol-generating substrate **12**. Thus, the aerosol-generating article **10** extends from an upstream or distal end **16**—which substantially coincides with an upstream end of the aerosol-generating substrate **12**—to a downstream or mouth end **18**, which coincides with a downstream end of the downstream section **14**. The downstream section **14** comprises a hollow tubular element **20** and a mouthpiece element **50**.

[0278] The aerosol-generating article **10** has an overall length of about 45 millimetres and an outer diameter of about 7.2 mm.

[0279] The aerosol-generating substrate **12** comprises a hollow tubular substrate element **40** formed from a plurality of layers of homogenised tobacco material that have been helically wound about the longitudinal axis of the hollow tubular substrate element. The hollow tubular substrate element **40** has a peripheral wall **42** formed of the overlapping layers of homogenised tobacco material. The peripheral wall **42** defines a central, longitudinal airflow channel **44** that extends through the hollow tubular substrate element **40**. The hollow tubular substrate element **40** is unwrapped, so that the layers of homogenised tobacco material are visible on the exterior surface of the aerosol-generating article.

[0280] A sealing element **24** is provided at the upstream end of the hollow tubular substrate element **40**. The sealing element **24** is affixed to the upstream face of the peripheral wall **42** and provides an airtight seal over the upstream end of the longitudinal airflow channel **44**, so that air cannot be drawn into the longitudinal airflow channel through the upstream opening. The sealing element **24** is formed of a layer of a polymeric film.

[0281] With the sealing element **24** in place, longitudinal airflow through the article **10** is not possible. Instead, during use air is drawn transversely through the porous peripheral wall **42** into the longitudinal airflow channel **44**, where it will mix with aerosol and be drawn through to the downstream end of the article **10**.

[0282] The sealing element **24** is capable of being pierced or punctured by a suitable element within the heating cavity of the aerosol-generating device, if desired. Once the sealing element is punctured, longitudinal airflow through the longitudinal airflow channel **44** is enabled. Air can therefore be drawn in through the punctured upstream element **24** and through the hollow tubular substrate element **40** in a longitudinal direction.

[0283] The hollow tubular element **20** of the downstream section **14** is located immediately downstream of the hollow tubular substrate element **40**, the hollow tubular element **20** being in longitudinal alignment with the aerosol-generating substrate **12**. The upstream end of the hollow tubular element **20** abuts the downstream end of the hollow tubular substrate element **40**.

[0284] The hollow tubular element **20** is provided in the form of a hollow cylindrical tube made of cellulose acetate tow. The hollow tubular element **20** defines an internal cavity **22** that extends all the way from an upstream end of the hollow tubular element **20** to a downstream end of the hollow tubular element **20**. The internal cavity **22** is substantially empty, and so substantially unrestricted airflow is enabled along the internal cavity **22**. The hollow tubular element **20** does not substantially contribute to the overall RTD of the aerosol-generating article **10**. The RTD of the hollow tubular element **20** is therefore about 0 mm H_2O.

[0285] As shown in FIG. **1**, the internal diameter of the hollow tubular element **20** of the downstream section **14** is substantially the same as the internal diameter of the hollow tubular substrate element **40**.

[0286] The mouthpiece element **50** extends from the downstream end of the hollow tubular element **20** to the downstream or mouth end **18** of the aerosol-generating article **10**. The mouthpiece element **50** comprises a low-density, cellulose acetate filter segment. The mouthpiece element **50** may be individually wrapped by a plug wrap (not shown).

[0287] The article **10** comprises a tipping wrapper **52** circumscribing the hollow tubular element **20** and the mouthpiece element **50**. The tipping wrapper **52** additionally overlies an upstream portion of the hollow tubular substrate element **40** in order to join the hollow tubular substrate element **40** and the downstream section **14**.

[0288] The aerosol-generating article **10** is particularly suitable for use with an aerosol-generating device comprising external heating means, which heats the aerosol-generating substrate **12** externally. During use, the aerosol-generating article **10** is therefore preferably inserted into the heating cavity of an aerosol-generating device with the external surface of the hollow tubular substrate element **40** proximate the heating element or elements within the cavity. The heating of the hollow tubular substrate element **40** produces an aerosol from the layers of homogenised tobacco, which is drawn through the peripheral wall **42** and into the longitudinal airflow channel **44** of the hollow tubular substrate element **40**, together with the air that is entering the longitudinal airflow channel **44** at the upstream end, as the consumer draws on the article. The combined air and aerosol are drawn through the aerosol-generating article **10** and delivered to the consumer from the downstream end of the aerosol-generating article **10**.

[0289] FIG. **2** illustrates an aerosol-generating article **110** according to a second embodiment of the present invention. The aerosol-generating article **110** has a similar construction to the aerosol-generating article **10** of FIG. **1**, as described above, with the same components. However, the aerosol-generating article **110** further comprises a paper band **26** circumscribing the hollow tubular substrate element **20** at the upstream end. The paper band **26** extends approximately 3 millimetres from the upstream end of the hollow tubular substrate element **20** and is made of a standard tipping paper material. It is adhered to the outside of the hollow tubular substrate element **20** by means of a suitable adhesive. The paper band **26** helps to retain the sealing element **24** in place

at the upstream end of the hollow tubular substrate element **20** and to provide a more uniform appearance.

[0290] FIG. **3** illustrates an aerosol-generating system **100** comprising an aerosol-generating device **102** and an aerosol-generating article **10** according to the first embodiment of the invention, as described above.

[0291] As shown in FIG. **3**, the aerosol-generating device **102** comprises a longitudinal heating cavity **104** for receiving the aerosol-generating article **210**. The heating cavity **104** has a closed, distal end and an open, mouth end. Air flow inlets **106** are provided at the distal end of the cavity so that air can be drawn through the aerosol-generating article **210** during use. The heating cavity **104** comprises an arrangement of peripheral heating elements **108** for externally heating the hollow tubular substrate element of the aerosol-generating article **10** during use.

[0292] The aerosol-generating device **102** further comprises a power source (not shown) for supplying power to the inductor coils **108** and a controller (not shown) to controllably heat the aerosol-generating article **110** during use, when the aerosol-generating article **210** is received within the device **102**.

[0293] As shown in FIG. **3**, the aerosol-generating article **10** is inserted into the heating cavity **104** with the sealing element **24** still intact over the upstream end of the hollow tubular substrate element **40**. Longitudinal airflow through the longitudinal airflow channel **44** is therefore prevented. Instead, the air that enters the heating cavity **104** through the air flow inlets **106** is drawn transversely through the peripheral wall **42** of the hollow tubular substrate element **40** and into the longitudinal airflow channel **44**. This advantageously helps to draw the aerosol that is generated from the layers of homogenised tobacco material in the peripheral wall **42** through into the longitudinal airflow channel **44**.

1.-**15**. (canceled)

16. An aerosol-generating article, comprising:

an aerosol-generating substrate comprising a hollow tubular substrate element having a peripheral wall defining a longitudinal airflow channel extending between an upstream end and a downstream end of the hollow tubular substrate element, wherein the peripheral wall is formed of one or more layers of homogenised plant material;

a sealing element at the upstream end of the hollow tubular substrate element, wherein the sealing element is arranged to provide a substantially airtight seal at an upstream end of the longitudinal airflow channel; and

a downstream section provided downstream of the aerosol-generating substrate.

17. The aerosol-generating article according to claim **16**, wherein the sealing element comprises a film layer affixed to the peripheral wall at the upstream end of the hollow tubular substrate element.

18. The aerosol-generating article according to claim **17**, wherein the film layer is pierceable.

19. The aerosol-generating article according to claim **17**, wherein the film layer comprises one or more polymeric layers.

20. The aerosol-generating article according to claim **17**, wherein the film layer comprises one or more metallic layers.

21. The aerosol-generating article according to claim **17**, wherein the film layer is heat sealed to the peripheral wall of the hollow tubular substrate element.

22. The aerosol-generating article according to claim **16**, wherein the sealing element comprises a paper wrapper folded over the upstream end of the hollow tubular substrate element.

23. The aerosol-generating article according to claim **22**, wherein the paper wrapper is provided with an impermeable coating layer.

24. The aerosol-generating article according to claim **16**, wherein the sealing element is affixed to the upstream end of the hollow tubular substrate element by means of an adhesive layer.

25. The aerosol-generating article according to claim **16**, wherein the sealing element extends downstream at least part way along an external surface of the peripheral wall of the hollow tubular substrate element from the upstream end of the hollow tubular substrate.

26. The aerosol-generating article according to claim **25**, further comprising a fixing band extending circumferentially around the hollow tubular substrate element and overlying the portion of the sealing element extending downstream from the upstream end of the hollow tubular substrate element,

wherein the fixing band is affixed to an external surface of the hollow tubular substrate element.

27. The aerosol-generating article according to claim **26**, wherein the fixing band is a band of paper.

28. The aerosol-generating article according to claim **16**, wherein the longitudinal airflow channel has a length of at least 3 millimetres.

29. The aerosol-generating article according to claim **16**, wherein the peripheral wall of the hollow tubular substrate element has a cross-sectional porosity of at least 0.3.

30. The aerosol-generating article according to claim **16**, wherein the aerosol-generating substrate further comprises a tubular susceptor element on at least one surface of the hollow tubular substrate element.

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