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(54) ARTICLE WITH TUBULAR AEROSOL-FORMING SUBSTRATE

(57) An aerosol-generating article (10) for producing an inhalable aerosol upon heating comprises an aerosol-forming substrate (12). The aerosol-forming substrate is in the form of a hollow tubular segment defining a substrate cavity extending between an upstream end (18) of the aerosol-forming substrate and a downstream end (20) of the aerosol-forming substrate. The aerosol-forming substrate comprises a plurality of thermally conductive particles and an aerosol-former. The hollow tubular segment is an extruded tube of aerosol-forming material. Related methods and systems are also provided.

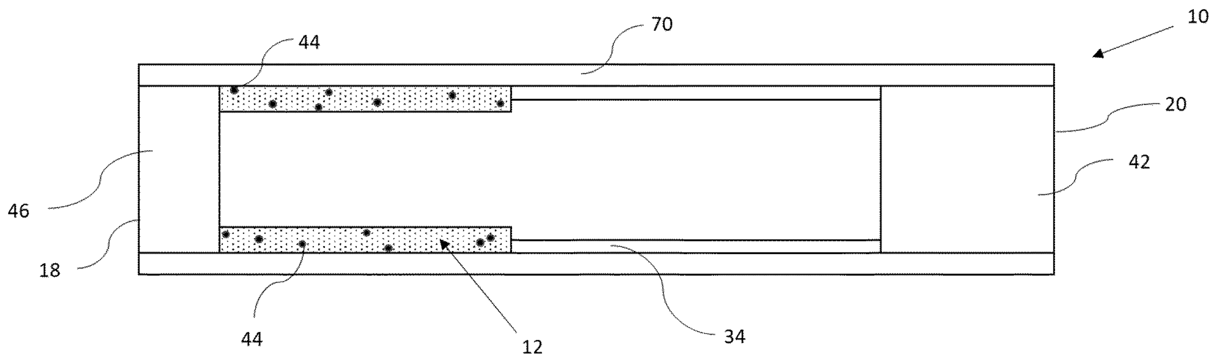

FIGURE 1

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Description

[0001] The present disclosure relates to an aerosol-generating article comprising a tubular aerosol-forming substrate. The present disclosure also relates to a method of making an aerosol-forming substrate for such an article and an aerosol-generating system.

[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 an external heating element 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] In addition, aerosol is generally not immediately generated by the aerosol-generating substrate upon activation of a heating element. This is because there is a pre-heating time after activation of a heating element during which the aerosol-generating substrate is heated to a temperature required for aerosol generation. As such, there may be a relatively long duration between activation of a heating element and generation of a sensorially acceptable aerosol for inhalation by a user.

[0006] It would therefore be desirable to provide an aerosol-generating article having an aerosol-generating substrate that is adapted to provide more efficient aerosolization of the aerosol-generating substrate and that reduces waste of the substrate materials, such as tobacco. It would also be desirable to provide such an aerosol-generating article that can achieve a relatively short preheating time so that a sensorially acceptable aerosol can be delivered to a user shortly after initiation of heating of the aerosol-generating substrate. It would also be desirable to provide such an aerosol-generating article that can provide optimised delivery of aerosol from the aerosol-generating substrate. It would be particularly desirable to provide such an aerosol-generating 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 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.

[0007] Known aerosol-forming substrates typically have relatively low thermal conductivities. Low thermal conductivity of an aerosol-forming substrate may lead to a relatively large temperature gradient in the aerosol-forming substrate during use. This may mean that portions of the aerosol-forming substrate which are located furthest from a heater element do not reach a high temperature and so do not release as many volatile compounds as they would if the aerosol-forming substrate had a higher thermal conductivity. In other words, the low thermal conductivity of the aerosol-forming substrate may undesirably result in a low usage efficiency of the aerosol-forming substrate.

[0008] According to the present disclosure, there is provided an aerosol-generating article for producing an inhalable aerosol upon heating. The aerosol-generating article may comprise a plurality of components including an aerosol-forming substrate. The aerosol-forming substrate may be in the form of a hollow tubular segment, preferably defining a substrate cavity extending between an upstream end of the aerosol-forming substrate and a downstream end of the aerosol-forming substrate. The aerosol-forming substrate preferably comprises a plurality of thermally conductive particles and an aerosol-former.

[0009] For example, there may be provided an aerosol-generating article for producing an inhalable aerosol upon heating, the aerosol-generating article comprising a plurality of components including an aerosol-forming substrate, wherein the aerosol-forming substrate is in the form of a hollow tubular segment defining a substrate cavity extending between an upstream end of the aerosol-forming substrate and a downstream end of the aerosol-forming substrate, and in which the aerosol-forming substrate comprises a plurality of thermally conductive particles and an aerosol-former.

[0010] The use of a tubular geometry for the aerosol-forming substrate may help avoid thermal gradient effects on heating of the substrate. With a tubular geometry, the substrate has no core and aerosol-forming material is concentrated at regions of the substrate that are heated, either internally or externally. This enables the efficiency of extraction to significantly increase, which in turn may reduce the total amount of substrate that is required for a user experience. A reduction in mass of substrate reduces heating inertia and therefore may reduce the time taken to heat to a sufficient temperature, thereby reducing the time to first puff. The use of a thermally conductive substrate may significantly increase the advantages gained by adopting a tubular substrate geometry. An increased or augmented thermal conductivity substrate resulting from the presence of thermally conductive particles may further reduce inertia of the substrate and may further reduce time to first puff and increase the overall extraction efficiency. By selecting specific thermally conductive particles, for example graphite or expanded graphite, weight of the substrate may be reduced even further. Reduction in overall mass of the aerosol forming substrate needed for an adequate user experience has a number of advantages, including a reduction in overall thermal inertia, and reduction in weight of an aerosol-generating article comprising the substrate. Weight reduction of an article may provide reduced shipping costs and reduced energy involved in shipping and may also provide taxation benefits in certain jurisdictions.

[0011] An aerosol-generating article according to the present invention may be particularly advantageously employed in an aerosol-generating system employing progressive heating, or zonal heating. An aerosol-generating article according to the present invention may also be particularly advantageously employed in an aerosol-generating system employing puff on demand heating.

[0012] The aerosol-forming substrate may comprise, on a dry weight basis, between 5 and 95 weight percent [wt %] thermally conductive particles, for example between 10 and 90 wt % thermally conductive particles. The aerosol-forming substrate may comprise, on a dry weight basis, between 7 and 60 wt % of an aerosol former. The aerosol-forming substrate may comprise, on a dry weight basis, between 2 and 20 wt % of fibres. The aerosol-forming substrate may comprise, on a dry weight basis, between 2 and 10 wt % of a binder. Each of the thermally conductive particles may consist of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond.

[0013] Thus, there may be provided an aerosol-forming substrate comprising, on a dry weight basis: between 10 and 90 wt % thermally conductive particles; between 7 and 60 wt % of an aerosol former; between 2 and 20 wt % of fibres; and between 2 and 10 wt % of a binder, wherein each of the thermally conductive particles consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond.

[0014] The aerosol-generating article may comprise, on a dry weight basis: between 5 and 95 wt %, for example between 10 and 90 wt %, of thermally conductive particles, each thermally conductive particle of the thermally conductive particles having a thermal conductivity of at least 1 W/(mK). The thermal conductivity may be measured in at least one direction of the particle. The thermal conductivity may be measured at a temperature of 25 degrees Celsius.

[0015] Where the term "thermally conductive particles" is used to refer to particles comprising carbon, for example particles comprising or consisting of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond, the thermally conductive particles may be referred to as carbon particles or carbon-containing particles.

[0016] Advantageously, the thermally conductive particles may increase the thermal conductivity of the aerosol-forming substrate. The increased thermal conductivity of the substrate may provide a more even temperature distribution throughout the substrate during use. This may result in a greater proportion of the aerosol-forming substrate reaching a sufficiently high temperature to release volatile compounds, and thus a higher usage efficiency of the aerosol-forming substrate. Further, the increased thermal conductivity of the substrate may allow a heater, for example a heating blade configured to heat the substrate, to operate at a lower temperature and thus require less power. Further still, the increased thermal conductivity of the substrate may allow a heater to heat the substrate to a temperature in which volatile compounds are released in less time. Thus, the increased thermal conductivity may reduce the time required to form an inhalable aerosol for a user.

[0017] Advantageously, one or both of the fibres and the binder may increase a tensile strength of material forming the aerosol-forming substrate. The increased tensile strength may, for example, allow the production of a sheet of the aerosol-forming material using existing production machinery, the sheet being formable into a tube to form the aerosol-forming substrate.

[0018] The aerosol-forming substrate may have a thermal conductivity of at least 0.05, 0.1, 0.15, 0.2, 0.22, 0.3, 0.4, or 0.5 W/(mK) in at least one direction, or in all directions, at 25 degrees Celsius. This thermal conductivity may be measured when a moisture content of the substrate is between 0 and 20, or 5 and 15, for example around 10%. This thermal conductivity may be measured when the substrate comprises between 0 and 20, or 5 and 15, for example around 10 wt % water. The moisture or water content of the substrate may be measured using a titration method. The moisture or water content of the substrate may be measured using the Karl Fisher method.

[0019] Optionally, some or all of the thermally conductive particles comprise at least 10, 30, 50, 70, 90, 95, 98, or 99 wt % carbon.

[0020] Optionally, some or all of the thermally conductive particles are graphite particles. Optionally, some or all of the thermally conductive particles are expanded graphite particles. Optionally, some or all of the thermally conductive particles are graphene particles. Optionally, some or all of the thermally conductive particles are carbon nanotubes or carbon nanotube particles. Optionally, some or all of the thermally conductive particles are charcoal particles. Optionally, some or all of the thermally conductive particles are diamond particles, for example artificial diamond particles. Advantageously, such materials may have relatively high thermal conductivities.

[0021] Expanded graphite may have a density less than 2, 1.8, 1.5, 1.2, 1, 0.8, or 0.5, 0.2, 0.1, 0.05, 0.02 grams per centimetre cubed (g / cm^3). Expanded graphite may have a density greater than 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 0.8, 1, 1.2, 1.5 or 1.8 grams per centimetre cubed (g / cm^3). Expanded graphite may have a density between 0.01 and 3, 0.01 and 2, 0.01 and 1.8, 0.01 and 1.5, 0.01 and 1.2, 0.01 and 1, 0.01 and 0.8, 0.01 and 0.5, 0.02 and 3, 0.02 and 2, 0.02 and 1.8, 0.02 and 1.5, 0.02 and 1.2, 0.02 and 1, 0.02 and 0.8, 0.02 and 0.5, 0.01 and 3, 0.05 and 2, 0.05 and 1.8, 0.05 and 1.5, 0.05 and 1.2, 0.05 and 1, 0.05 and 0.8, 0.05 and 0.5 g/cm^3, 0.1 and 3, 0.1 and 2, 0.1 and 1.8, 0.1 and 1.5, 0.1 and 1.2, 0.1 and 1, 0.1 and 0.8, 0.1 and 0.5, 0.2 and 3, 0.2 and 2, 0.2 and 1.8, 0.2 and 1.5, 0.2 and 1.2, 0.2 and 1, 0.2 and 0.8, 0.2 and 0.5, 0.5 and 3, 0.5 and 2, 0.5 and 1.8, 0.5 and 1.5, 0.5 and 1.2, 0.5 and 1, 0.5 and 0.8, 0.8 and 3, 0.8 and 2, 0.8 and 1.8, 0.8 and 1.5, 0.8 and 1.2, 0.8 and 1 grams per centimetre cubed (g / cm^3).

[0022] Optionally, according to aspects where each of the thermally conductive particles does not necessarily consist of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond, some or all of the thermally conductive particles comprise a metal. Alternatively, or in addition, some or all of the thermally conductive particles comprise an alloy. Alternatively, or in addition, some or all of the thermally conductive particles comprise an intermetallic. Advantageously, such materials may have relatively high thermal conductivities.

[0023] Optionally, according to alternative aspects where each of the thermally conductive particles does not necessarily consist of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond, some or all of the thermally conductive particles comprise one or more of silicon carbide, silver, copper, gold, aluminium nitride, aluminium, tungsten, and boron nitride. Optionally, some or all of the thermally conductive particles are silicon carbide particles. Optionally, some or all of the thermally conductive particles are silver particles. Optionally, some or all of the thermally conductive particles are copper particles. Optionally, some or all of the thermally conductive particles are gold particles. Optionally, some or all of the thermally conductive particles are aluminium nitride particles. Optionally, some or all of the thermally conductive particles are aluminium particles. Optionally, some or all of the thermally conductive particles are tungsten particles. Optionally, some or all of the thermally conductive particles are boron nitride particles. Advantageously, such materials may have relatively high thermal conductivities.

[0024] The thermally conductive particles may each have a "particle size". The meaning of the term "particle size" and a method of measuring particle size is set out later.

[0025] The thermally conductive particles may be characterised by a particle size distribution. The particle size distribution may have number D10, D50 and D90 particle sizes. The number D10 particle size is defined such that 10% of the particles have a particles size less than or equal to the number D10 particle size. Similarly, the number D50 particle size is defined such that 50% of the particles have a particles size less than or equal to the number D50 particle size. Thus, the number D50 particle size may be referred to as a median particle size. The number D90 particle size is defined such that 90% of the particles have a particles size less than or equal to the number D90 particle size. Thus, if there were 1,000 particles in the distribution and the particles were order by ascending particle size, one would expect the number D10 particle size to be roughly equal to the particle size of the 100^{th} particle, the number D50 particle size to be roughly equal to the particle size of the 500^{th} particle, and the number D90 particle size to be roughly equal to the particle size of the 900^{th} particle.

[0026] The particle size distribution may have volume D10, D50 and D90 particle sizes. The volume D10 particle size is defined such that 10% of the sum of the volumes of all of the particles is accounted for by the sum of the volumes of the particles having a particles size less than or equal to the volume D10 particle size. Similarly, the volume D50 particle size is defined such that 50% of the sum of the volumes of all of the particles is accounted for by the sum of the volumes of the particles having a particles size less than or equal to the volume D50 particle size. And the volume D90 particle size is defined such that 90% of the sum of the volumes of all of the particles is accounted for by the sum of the volumes of the particles having a particles size less than or equal to the volume D90 particle size.

[0027] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size, wherein the number D10 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0028] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size, wherein the number D10 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0029] A compromise has to be made when deciding the sizes of the particle. Larger thermally conductive particles may advantageously increase the thermal conductivity of the aerosol-forming substrate more than smaller thermally conductive particles. However, larger thermal conductive particles may reduce the space available for aerosol-forming material in the substrate.

[0030] Optionally, the thermally conductive particles have a particle size distribution having a number D50 particle size, wherein the number D50 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0031] Optionally, the thermally conductive particles have a particle size distribution having a number D50 particle size, wherein the number D50 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0032] Optionally, the thermally conductive particles have a particle size distribution having a number D90 particle size, wherein the number D90 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0033] Optionally, the thermally conductive particles have a particle size distribution having a number D90 particle size, wherein the number D90 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0034] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size and a number D90 particle size, wherein the number D90 particle size is no more than 50, 40, 30, 20, 10, or 5 times the number D10 particle size.

[0035] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size and a number D90 particle size, wherein the number D90 particle size is at least 1.5, 2, 3, 5, 10, or 20 times the number D10 particle size.

[0036] A compromise may be required in relation to the particle size distribution. A tighter particle size distribution, for example characterised by a smaller ratio between the D90 and D10 particle sizes, may advantageously provide a more uniform thermal conductivity throughout the aerosol-forming substrate. This is because there will be less variation in particle size in different locations in the substrate. This may advantageously allow for more efficient usage of the aerosol-forming material throughout the aerosol-forming substrate. However, a tighter particle size distribution may disadvantageously be more difficult and expensive to achieve. The inventors have found that the particle size distributions described above may provide an optimal compromise between these two factors.

[0037] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size, wherein the volume D10 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0038] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size, wherein the volume D10 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns

[0039] Optionally, the thermally conductive particles have a particle size distribution having a volume D50 particle size, wherein the volume D50 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0040] Optionally, the thermally conductive particles have a particle size distribution having a volume D50 particle size, wherein the volume D50 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0041] Optionally, the thermally conductive particles have a particle size distribution having a volume D90 particle size, wherein the volume D90 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0042] Optionally, the thermally conductive particles have a particle size distribution having a volume D90 particle size, wherein the volume D90 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0043] It may be particularly preferably for the thermally conductive particles have a particle size distribution having a volume D10 particle size between 1 and 20 microns. Alternatively, or in addition, it may be particularly preferably for the thermally conductive particles have a particle size distribution having a volume D90 particle size between 50 and 300 microns, or between 50 and 200 microns.

[0044] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size and a volume D90 particle size, wherein the volume D90 particle size is no more than 50, 40, 30, 20, 10, or 5 times the volume D10 particle size.

[0045] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size and a volume D90 particle size, wherein the volume D90 particle size is at least 1.5, 2, 3, 5, 10, or 20 times the volume D10 particle size.

[0046] As explained above, a compromise must be made in relation to the particle size distribution, and the inventors have found that the particle size distributions above may provide an optimal compromise.

[0047] Optionally, each of the thermally conductive particles has a particle size of at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns. Optionally, each of the thermally conductive particles has a particle size of no more than 1,000, 500, 300, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns. It may be particularly preferable for each of the thermally conductive particles to have a particle size of at least 1 micron. Alternatively, or in addition, it may be particularly preferable for each of the thermally conductive particles to have a particle size of no more than 300 microns. Particles smaller than 1 micron may be difficult to handle during manufacturing. In addition, particles smaller than 1 micron may be more likely to pass through a filter in an aerosol-generating article comprising the aerosol-forming substrate. Particles greater than 300 microns may take up a rather large amount of space in the substrate which could be used for aerosol-forming material. Thus, it may be particularly advantageous for each of the thermally conductive particles to have a particle size of at least 1 micron, or a particle size of no more than 300 microns, or both.

[0048] Optionally, each of the thermally conductive particles has three mutually perpendicular dimensions, a largest dimension of the three dimensions being no more than 10, 8, 5, 3, or 2 times larger than a smallest dimension of the three dimensions. Optionally, each of the thermally conductive particles has three mutually perpendicular dimension, a largest dimension of the three dimensions being no more than 10, 8, 5, 3, or 2 times larger than a second largest dimension of the three dimensions. Optionally, each of the thermally conductive particles is substantially spherical. Advantageously, the orientation of substantially spherical particles may not affect the thermal conductivity of the substrate as much as the orientation of non-spherical particles. Thus, the use of more spherical particles may result in less variability between different substrates where the orientations of the particles is not controlled. In addition, substantially spherical particles may be more easy to characterise.

[0049] Optionally, the thermally conductive particles comprise at least 10, 20, 50, 100, 200, 500, or 1000 particles. Advantageously, a greater number of particles in the aerosol-forming substrate may allow the thermal conductivity of the substrate to be more uniform.

[0050] Optionally, the substrate comprises, on a dry weight basis, at least 20, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80 or 85 wt % of the thermally conductive particles. Optionally, the substrate comprises, on a dry weight basis, no more than 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, or 15 wt % of the thermally conductive particles. Optionally, the substrate comprises, on a dry weight basis, between 10 and 90, 20 and 90, 30 and 90, 40 and 90, 50 and 90, 60 and 90, 70 and 90, 80 and 90, 10 and 80, 20 and 80, 30 and 80, 40 and 80, 50 and 80, 60 and 80, 70 and 80, 10 and 70, 20 and 70, 30 and 70, 40 and 70, 50 and 70, 60 and 70, 10 and 60, 20 and 60, 30 and 60, 40 and 60, 50 and 60, 10 and 50, 20 and 50, 30 and 50, 40 and 50, 10 and 40, 20 and 40, 30 and 40, 10 and 30, 20 and 30, or 10 and 20 wt % of the thermally conductive particles. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 50 and 90, or more preferably between 60 and 90, or even more preferably between 65 and 85, wt % of the thermally conductive particles.

[0051] A comprise may be required in relation to the weight percent of thermally conductive particles in the substrate. Increasing the weight percent of particles in the aerosol-forming substrate may advantageously increase the thermal conductivity of the substrate. However, increasing the weight percent of particles in the aerosol-forming substrate may also reduce the available space for one or more of the aerosol former, binder, and fibres, so could result in a substrate which forms less aerosol, or which has less tensile strength.

[0052] Optionally, the substrate comprises, on a dry weight basis, at least 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 wt % of the aerosol former. Optionally, the substrate comprises, on a dry weight basis, no more than 55, 50, 45, 40, 35, 30, 25, 20, or 15 wt % of the aerosol former. Optionally, the substrate comprises, on a dry weight basis, between 7 and 60, 10 and 60, 20 and 60, 30 and 60, 40 and 60, 50 and 60, 7 and 50, 10 and 50, 20 and 50, 30 and 50, 40 and 50, 7 and 40, 10 and 40, 20 and 40, 30 and 40, 7 and 30, 10 and 30, 20 and 30, 7 and 20, 10 and 20, or 7 and 10 wt % of the aerosol former. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 15 and 25 wt % of the aerosol former.

[0053] Optionally, the aerosol-former comprises or consists of one or more of: polyhydric alcohols, such as propylene glycol, polyethylene glycol, triethylene glycol, 1, 3-butanediol and glycerine; esters of polyhydric alcohols, such as glycerol mono-, di- or tri-acetate; and aliphatic esters of mono-, di- or poly-carboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate. Optionally, the aerosol-forming substrate comprises one or both of glycerine and glycerol.

[0054] Optionally, the substrate comprises, on a dry weight basis, at least 2, 4, 6, 8, 10, 12, 14, 16 or 18 wt % of the fibres. Optionally, the substrate comprises, on a dry weight basis, no more than 20, 18, 16, 14, 12, 10, 8, 6, or 4 wt % of the fibres. Optionally, the substrate comprises, on a dry weight basis, between 4 and 20, 6 and 20, 8 and 20, 10 and 20, 12 and 20, 14 and 20, 16 and 20, 18 and 20, 2 and 18, 4 and 18, 6 and 18, 8 and 18, 10 and 18, 12 and 18, 14 and 18, 16 and 18, 2 and 16, 4 and 16, 6 and 16, 8 and 16, 10 and 16, 12 and 16, 14 and 16, 2 and 14, 4 and 14, 6 and 14, 8 and 14, 10 and 14, 12 and 14, 2 and 12, 4 and 12, 6 and 12, 8 and 12, 10 and 12, 2 and 10, 4 and 10, 6 and 10, 8 and 10, 2 and 8, 4 and 8, 6 and 8, 2 and 6, 4 and 6, or 2 and 4 wt % of the fibres. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 2 and 10 wt % of the fibres.

[0055] Optionally, the fibres are cellulose fibres. Advantageously, cellulose fibres are not overly costly and can increase the tensile strength of the substrate.

[0056] Optionally, each of the fibres has three mutually perpendicular dimensions, a largest dimension of the three dimensions being at least 1.5, 2, 3, 5, 10, or 20 times larger than a smallest dimension of the three dimensions. Optionally, each of the fibres has three mutually perpendicular dimensions, a largest dimension of the three dimensions being at least 1.5, 2, 3, 5, 10, or 20 times larger than a second largest dimension of the three dimensions.

[0057] Optionally, the substrate comprises, on a dry weight basis, at least 4, 6, or 8 wt % of the binder. Optionally, the substrate comprises, on a dry weight basis, no more than 8, 6, or 4 wt % of the binder. Optionally, the substrate comprises, on a dry weight basis, between 4 and 10, 6 and 10, 8 and 10, 2 and 8, 4 and 8, 6 and 8, 2 and 6, 4 and 6, 2 and 4 wt % of the binder. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 2 and 10 wt % of the binder.

[0058] Suitable binders are well-known in the art and include, but are not limited to, natural pectins, such as fruit, citrus or tobacco pectins; guar gums, such as hydroxyethyl guar and hydroxypropyl guar; locust bean gums, such as hydroxyethyl and hydroxypropyl locust bean gum; alginate; starches, such as modified or derivatized starches; celluloses, such as methyl, ethyl, ethylhydroxymethyl and carboxymethyl cellulose; tamarind gum; dextran; pullalon; konjac flour; xanthan gum and the like. It may be particularly preferable for the binder to be or comprise guar. It may be particularly preferable for the binder to comprise or consist of one or more of carboxymethyl cellulose or hydroxypropyl cellulose or a gum such as guar gum.

[0059] Optionally, the thermally conductive particles are substantially homogeneously distributed throughout the aerosol-forming substrate. Optionally, the aerosol former is substantially homogeneously distributed throughout the aerosol-forming substrate. Optionally, the fibres are substantially homogeneously distributed throughout the aerosol-forming substrate. Optionally, the binder is substantially homogeneously distributed throughout the aerosol-forming substrate. Advantageously, a homogenous distribution of components of the substrate may result in the substrate have more spatially uniform properties. For example, substantially homogeneously distributed thermally conductive particles may result in the substrate having a substantially uniform thermal conductivity. As another example, substantially homogeneously distributed binder or fibres may result in the substrate having a substantially uniform tensile strength.

[0060] Optionally, the substrate comprises nicotine. Optionally, the substrate comprises, on a dry weight basis, at least 0.01, 1, 2, 3, or 4 wt % nicotine. Optionally, the substrate comprises, on a dry weight basis, no more than 5, 4, 3, 2, or 1 wt % nicotine. Optionally, the substrate comprises, on a dry weight basis, between 0.01 and 5, 1 and 5, 2 and 5, 3 and 5, 4 and 5, 0.01 and 4, 1 and 4, 2 and 4, 3 and 4, 0.01 and 3, 1 and 3, 2 and 3, 0.01 and 2, 1 and 2, 0.01 and 1 wt % nicotine. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 0.5 and 4 wt % nicotine.

[0061] Optionally, the nicotine is substantially homogeneously distributed throughout the aerosol-forming substrate.

[0062] Optionally, the substrate comprises an acid. Optionally, the substrate comprises, on a dry weight basis, at least 0.01, 1, 2, 3, or 4 wt % of the acid. Optionally, the substrate comprises, on a dry weight basis, no more than 5, 4, 3, 2 or 1 wt % of the acid. Optionally, the substrate comprises, on a dry weight basis, between 0.01 and 5, 1 and 5, 2 and 5, 3 and 5, 4 and 5, 0.01 and 4, 1 and 4, 2 and 4, 3 and 4, 0.01 and 3, 1 and 3, 2 and 3, 0.01 and 2, 1 and 2, 0.01 and 1 wt % of the acid. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 0.5 and 5 wt % of acid.

[0063] Optionally, the acid comprises or consists of one or more of fumaric acid, lactic acid, benzoic acid, and levulinic acid.

[0064] Optionally, the acid is substantially homogeneously distributed throughout the aerosol-forming substrate.

[0065] Optionally, the substrate comprises at least one botanical. Optionally, the substrate comprises, on a dry weight basis, at least 0.01, 1, 2, 5, 10, or 15 wt % of the at least one botanical. Optionally, the substrate comprises, on a dry weight basis, no more than 20, 15, 10, 5, 2 or 1 wt % of the at least one botanical. Optionally, the substrate comprises, on a dry weight basis, between 0.01 and 20, 1 and 20, 2 and 20, 5 and 20, 10 and 20, 15 and 20, 0.01 and 15, 1 and 15, 2 and 15, 5 and 15, 10 and 15, 0.01 and 10, 1 and 10, 2 and 10, 5 and 10, 0.01 and 5, 1 and 5, 2 and 5, 0.01 and 2, 1 and 2, 0.01 and 1 wt % of the at least one botanical. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 1 and 15 wt % of the at least one botanical.

[0066] Optionally, the at least one botanical comprises or consists of one or both of clove and rosmarinus.

[0067] Optionally, the at least one botanical is substantially homogeneously distributed throughout the aerosol-forming substrate.

[0068] Optionally, the substrate comprises at least one flavourant. Optionally, the substrate comprises, on a dry weight basis, at least 0.1, 1, 2, or 5 wt % of the at least one flavourant. Optionally, the substrate comprises, on a dry weight basis, no more than 10, 5, 2 or 1 wt % of the at least one flavourant. Optionally, the substrate comprises, on a dry weight basis, between 0.1 and 10, 1 and 10, 2 and 10, 5 and 10, 0.1 and 5, 1 and 5, 2 and 5, 0.1 and 2, 1 and 2, 0.1 and 1 wt % of the at least one flavourant. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 0.1 and 5 wt % of the at least one flavourant.

[0069] Optionally, the at least one flavourant is present as a coating, for example a coating on one or more other components of the aerosol-forming substrate. Alternatively, or in addition, the at least one flavourant is substantially homogeneously distributed throughout the aerosol-forming substrate.

[0070] Optionally, the aerosol-forming substrate comprises at least one organic material such as tobacco. Optionally, the at least one organic material comprises one or more of herb leaf, tobacco leaf, fragments of tobacco ribs, reconstituted tobacco, homogenised tobacco, extruded tobacco and expanded tobacco. Optionally, the at least one organic material is substantially homogeneously distributed throughout the aerosol-forming substrate.

[0071] The substrate may comprise, on a dry weight basis, less than 10, 5, 3, 2, or 1 wt % tobacco. Optionally, the aerosol-forming substrate is a tobacco-free aerosol-forming substrate.

[0072] The tubular segment of the aerosol-forming substrate may described as a rod. As such, there may be provided a rod of aerosol-forming substrate.

[0073] The aerosol forming substrate is preferably in the form of a tube having an outer diameter, an inner diameter, and a length, in which the length of the tube is between 5 mm and 100 mm, the outer diameter is between 3 mm and 20 mm, and the inner diameter is between 2.5 mm and 19.5 mm. The length of the tube may be between 8 mm and 25 mm, the outer diameter of the tube may be between 6 mm and 8 mm, and the inner diameter of the tube may be between 5 mm and 7.9 mm.

[0074] A susceptor element may be located within the rod of aerosol-forming substrate. The susceptor element may be an elongate susceptor element. The susceptor element may extend longitudinally within the rod of aerosol-forming substrate, for example in contact with an inner surface of the tubular aerosol-generating substrate. The rod may be substantially cylindrical, for example right cylindrical, in shape. The susceptor element may extend all the way to a downstream end of the rod of aerosol-forming substrate. The susceptor element may extend all the way to an upstream end of the rod of aerosol-forming substrate. The susceptor element may have substantially the same length as the rod of aerosol-forming substrate. The susceptor element may extend from the upstream end to the downstream end of the rod of aerosol-forming substrate. The susceptor element may be in the form of a pin, rod, strip or blade. The susceptor element may have a length of between 5 and 15, 6 and 12, or 8 and 10 millimetres. The susceptor element may have a width of between 1 and 5 millimetres. The susceptor element may have a thickness of between 0.01 and 2, 0.5 and 2, or 0.5 and 1 millimetres.

[0075] Alternatively, there may be no susceptor materials present in the aerosol-forming substrate or in the rod of aerosol-forming substrate.

[0076] Optionally, some or each of the thermally conductive particles may be inductively heatable, for example to a temperature of at least 100, 150, or 200 degrees Celsius. Optionally, some or each of the thermally conductive particles comprise or consist of one or more susceptor materials. Advantageously, this may allow the thermally conductive particles to be inductively heated. The thermally conductive particles may comprise or be the only susceptor material(s) present in the aerosol-forming substrate or in the rod of aerosol-forming substrate. That is, there may be no susceptor elements present in the aerosol-forming substrate or in the rod of aerosol-forming substrate except for the thermally conductive or carbon particles.

[0077] Suitable susceptor materials include but are not limited to: carbon, carbon-based materials, graphene, graphite, expanded graphite, molybdenum, silicon carbide, stainless steels, niobium, aluminium, nickel, nickel-containing compounds, titanium, and composites of metallic materials. Suitable susceptor materials may comprise a ferromagnetic material, for example, ferritic iron, a ferromagnetic alloy, such as ferromagnetic steel or stainless steel, ferromagnetic particles, and ferrite. A suitable susceptor material may be, or comprise, aluminium. A susceptor material preferably comprises more than 5 percent, preferably more than 20 percent, more preferably more than 50 percent or more than 90 percent of ferromagnetic or paramagnetic materials. Preferred susceptor materials may comprise a metal, metal alloy or carbon.

[0078] Particularly preferred susceptor materials may be, or comprise, carbon, carbon-based materials, graphene, graphite, or expanded graphite. Advantageously, such materials have relatively high thermal conductivities, relatively low densities, and may be inductively heated.

[0079] Optionally, the aerosol-forming substrate has a thermal conductivity of greater than 0.05, 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.75, 1, 1.25, 1.5, 2, 5, 10, 20, 50, 100, 200, or 500 W/(mK) in at least one direction at 25 degrees Celsius.

[0080] Optionally, the aerosol-forming substrate has a density of no more than 1500, 1450, 1400, 1350, 1300, 1250, 1200, 1100, 1050, 1000, 950, 900, 850, 800, 850, 800, 750, 700, 650, or 600 kg/m^3. Optionally, the aerosol-forming substrate has a density of between 600 and 1400, 800 and 1200, or 900 and 1100 kg/m^3. Advantageously, reducing a density of the substrate may reduce transportation costs of the substrate.

[0081] Optionally, the aerosol-forming substrate has a moisture content of between 1 and 20, or 3 and 15 wt %. This moisture content may be measured after 48 hours equilibration at 50 % relative humidity at 20 degrees Celsius. Optionally, the aerosol-forming substrate comprises between 1 and 20, or 3 and 15 wt % water. The moisture or water content of the substrate may be measured using a titration method. The moisture or water content of the substrate may be measured using the Karl Fisher method.

[0082] Optionally, the aerosol-forming substrate is formed from a sheet of aerosol-forming material that is rolled to form the tubular segment. Thus, the hollow tubular segment may be a rolled sheet of aerosol-forming material, for example a rolled sheet of homogenised tobacco material or for example a rolled sheet of tobacco free aerosol-forming material.

[0083] The aerosol-forming substrate may have a thickness equivalent to a single layer of the sheet of aerosol-forming material. The aerosol-forming substrate may have a thickness that is equivalent to two or more layers of the sheet. The sheet of aerosol-forming material may have a thickness of at least 5, 10, 20, 50, 100, 150, or 200 microns. Optionally, the sheet or strip may have a thickness of no more than 2000, 1000, 500, 400, 300, or 250 microns. Optionally, sheet may have a thickness of between 100 and 350, or 150 and 300 microns.

[0084] Optionally, the sheet of aerosol-forming material has a grammage of at least 20, 50, or 100 g/m^2. Optionally, the sheet or strip has a grammage of no more than 300 g/m^2. Optionally, the sheet has a grammage of between 20 and 300, 50 and 250, or 100 and 250 g/m^2.

[0085] Optionally, the sheet has a density of at least 0.1, 0.2, 0.3, or 0.5 g/m^3. Optionally, the sheet has a density of no more than 2, 1.5, 1.2, or 1 g/m^3. Optionally, the sheet has a density of between 0.1 and 2, 0.2 and 2, 0.3 and 2, 0.3 and 1.5, or 0.3 and 1.2 g/m^3.

[0086] The hollow tubular segment may be an extruded tube of aerosol-forming material, for example an extruded tube of homogenised tobacco material or for example an extruded tube of tobacco-free aerosol-forming material.

[0087] The aerosol-generating article may be in the form of a rod and may comprise a plurality of components, including the aerosol-forming substrate, assembled within a wrapper or casing.

[0088] Optionally, the aerosol-generating article comprises a front plug. Optionally, the aerosol-generating article comprises a first hollow tube, for example a first hollow acetate tube. Optionally, the aerosol-generating article comprises a second hollow tube, for example a second hollow acetate tube. Optionally, the second hollow tube comprises one or more ventilation holes. Optionally, the aerosol-generating article comprises a mouth plug filter. Optionally, the aerosol-generating article comprises wrapper, for example a paper wrapper.

[0089] Optionally, the front plug is arranged a most upstream end of the article. Optionally, the aerosol-forming substrate is arranged downstream of the front plug. Optionally, the first hollow tube is arranged downstream of the aerosol-forming substrate. Optionally, the second hollow tube is arranged downstream of the first hollow tube. Optionally, the mouth plug filter is arranged downstream of one or both of the first hollow tube and the second hollow tube. Optionally, the mouth plug filter is arranged at a most downstream end of the article. Optionally, the most downstream end of the article, which may be referred to as a mouth end of the article, may be configured for insertion into a mouth of a user. A user may be able to inhale on, for example directly on, the mouth end of the article.

[0090] Optionally, the front plug, the tubular aerosol-forming substrate, one or both of the first hollow tube and the second hollow tube, and the mouth plug filter are circumscribed by a wrapper, for example a paper wrapper.

[0091] Optionally, the front plug has a length of between 2 and 10, 3 and 8, or 4 and 6 mm, for example around 5 mm. Optionally, the aerosol-forming substrate has a length of between 5 and 20, 8 and 15, or 10 and 15 mm, for example around 12 mm. Optionally, the first hollow tube has a length of between 2 and 20, 5 and 15, or 5 and 10 mm, for example around 8 mm. Optionally, the second hollow tube has a length of between 2 and 20, 5 and 15, or 5 and 10 mm, for example around 8 mm. Optionally, the mouth plug filter has a length of between 5 and 20, 8 and 15, or 10 and 15 mm, for example around 12 mm. The lengths of one or more of the front plug, the aerosol-forming substrate, the first hollow tube, the second hollow tube, and the mouth plug filter may extend in a longitudinal direction.

[0092] One or more of the front plug, the aerosol-forming substrate, the first hollow tube, the second hollow tube, and the mouth plug filter may be substantially cylindrical, for example right cylindrical, in shape.

[0093] According to an aspect of the present disclosure, there is provided an aerosol-generating system.

[0094] The system may comprise an aerosol-generating article and an electrical aerosol-generating device. The article may be an article as described above, for example an article according to the third aspect.

[0095] Optionally, the electrical aerosol-generating device is configured to resistively heat the aerosol-generating article in use.

[0096] Optionally, the electrical aerosol-generating device is configured to inductively heat the aerosol-generating article, for example the aerosol forming substrate of the aerosol-generating article, in use.

[0097] According to the present disclosure, there is provided a method of forming a hollow tubular aerosol-forming substrate, for example a substrate for an aerosol-generating article as described above. The method may comprise forming a slurry comprising one or more or all of the thermally conductive particles, the aerosol former, the fibres, and the binder. The method may comprise casting and drying the slurry to form the aerosol-forming substrate, or extruding the slurry to form the aerosol-forming substrate, or casting and drying the slurry to form a precursor such as a sheet of aerosol-forming material and then forming the precursor into the aerosol-forming substrate.

[0098] Optionally, the slurry comprises water. Optionally, the slurry comprises between 20 and 90, 30 and 90, 40 and 90, 40 and 85, 50 and 80, 60 and 80, or 60 and 75 wt % water.

[0099] Optionally, the slurry comprises an acid. Optionally, the acid comprises or consists of one or more of fumaric acid, lactic acid, benzoic acid, and levulinic acid.

[0100] Optionally, the slurry comprises nicotine.

[0101] Optionally, forming the slurry comprises forming a first mixture. The first mixture may comprise the aerosol former. The first mixture may comprise the fibres. The first mixture may comprise water. The first mixture may comprise the acid. The first mixture may comprise the nicotine. Forming the slurring may comprise forming a second mixture. The second mixture may comprise the thermally conductive particles. The second mixture may comprise the binder. Forming the slurry may comprise adding the second mixture to the first mixture to form a combined mixture.

[0102] Thus, forming the slurry may comprise:

forming a first mixture comprising the aerosol former, the fibres, water, optionally, the acid, and optionally, the nicotine;
forming a second mixture comprising the thermally conductive particles and the binder;
and adding the second mixture to the first mixture to form a combined mixture.

[0103] The combined mixture may subsequently be formed into the slurry, for example by mixing.

[0104] Optionally, forming the first mixture comprises providing the aerosol former or a solution comprising the aerosol former and the nicotine.

[0105] Optionally, forming the first mixture comprises adding the acid to the aerosol former or the solution comprising the aerosol former and the nicotine to form a first pre-mixture.

[0106] Optionally, forming the first mixture comprises adding the water to the aerosol former or the solution comprising the aerosol former and the nicotine, or to the first pre-mixture, to form a second pre-mixture.

[0107] Optionally, forming the first mixture comprises adding the fibres to the second pre-mixture.

[0108] Optionally, forming the second mixture comprises mixing the thermally conductive particles and the binder.

[0109] Optionally, the method, for example the step of forming the slurry, comprises a first mixing of the combined mixture. Optionally, the first mixing occurs under a first pressure of no more than 500, 400, 300, 250, or 200 mbar. Optionally, the first mixing occurs for between 1 and 10, 2 and 8, or 3 and 6 minutes, for example for around 4 minutes.

[0110] Optionally, the method, for example the step of forming the slurry, comprises, after the first mixing, a second mixing. Optionally, the second mixing occurs under a second pressure which is less than the first pressure. Optionally, the second pressure is no more than 500, 400, 300, 200, 150, or 100 mbar. Optionally, the second mixing occurs for between 5 and 120, 5 and 80, 5 and 40, or 10 and 30 seconds, for example around 20 seconds.

[0111] Optionally, casting the slurry comprises casting the slurry onto a flat support, for example a steel flat support.

[0112] Optionally, after casting the slurry and before drying the slurry, the method comprises setting a thickness of the slurry, for example setting a thickness of the slurry to between 100 and 1200, 200 and 1000, 300 and 900, 500 and 700 microns, for example around 600 microns.

[0113] Optionally, drying the slurry comprises providing a flow of a gas such as air over or past the slurry. Optionally, the flow of gas is heated. Optionally, the flow of gas is heated to a temperature of between 100 and 160, or 120 and 140 degrees Celsius. Optionally, the flow of gas is provided for between 1 and 10 or 2 and 5 minutes. Optionally, drying the slurry comprises drying the slurry until the slurry has a moisture content of between 1 and 20, 2 and 15, 2 and 10, or 3 and 7 wt %.

[0114] Optionally, drying the slurry forms the precursor for forming into the aerosol-forming substrate, the precursor being a sheet of aerosol-forming material. Optionally, the method comprises cutting the sheet of aerosol-forming material.

[0115] A sheet of aerosol-forming material may be formed into the aerosol-forming substrate by rolling the sheeting of aerosol-forming substrate into a tube. Walls of the tube are thus formed from the sheet of aerosol-forming material. The tubular shape may be maintained by overlapping a portion of the rolled sheet and affixing the overlapped portion with an adhesive such as a gum. The walls of the tube formed by rolling the sheet of aerosol-forming material may have a thickness that is equal to the thickness of the sheet of aerosol-forming material, that is the tube may be formed from a single layer of the sheet of aerosol-forming material. The walls of the tube may, however, be formed from multiple layers of the sheet rolled into the form of a tube. Once rolled and fastened, the tube of aerosol-forming material can be cut into lengths to form tubular segments of aerosol-forming substrate.

[0116] As would be understood by the skilled person having read this disclosure, the features described herein in relation to one aspect may be applicable to any other aspect.

[0117] As used herein, the term "aerosol-forming substrate" may refer to a substrate capable of releasing an aerosol or volatile compounds that can form an aerosol. Such volatile compounds may be released by heating the aerosol-forming substrate. An aerosol-forming substrate may comprise an aerosol-forming material. An aerosol-forming substrate may be adsorbed, coated, impregnated or otherwise loaded onto a carrier or support. An aerosol-forming substrate may conveniently be part of an aerosol-generating article or smoking article.

[0118] As used herein, the term "thermally conductive particles" may refer to particles having a thermal conductivity greater than 0.3, preferably 0.5, or more preferably 1 W/(mK) in at least one direction at 25 degrees Celsius, for example in all directions at 25 degrees Celsius. The particles may exhibit anisotropic or isotropic thermal conductivity.

[0119] As used herein, the term "expanded graphite" may refer to a graphite-based material, or a material having a graphite-like structure. Expanded graphite may have carbon layers (similar to graphite, for example) with spacing between the carbon layers greater than the spacing found between carbon layers in regular graphite. Expanded graphite may have carbon layers with elements or compounds intercalated into spaces between the carbon layers.

[0120] As used herein, the term "particle size" may refer to a single dimension and may be used to characterise the size of a given particle. The dimension may be the diameter of a spherical particle occupying the same volume as the given particle. All particle sizes and particle size distributions herein can be obtained using a standard laser diffraction technique. Particle sizes and particle size distributions as stated herein may be obtained using a commercially available sensor, for example a Sympatec HELOS laser diffraction sensor.

[0121] As used herein, where not otherwise specified, the term "density" may be used to refer to true density. Thus, where not otherwise specified, the density of a powder or plurality of particles may refer to the true density of the powder or plurality of particles (rather than the bulk density of the powder or plurality of particles, which can vary greatly depending on how the powder or plurality of particles are handled). The measurement of true density can be done using a number of standard methods, these methods often being based on Archimedes' principle. The most widely used method, when used to measure the true density of a powder, entails the powder being placed inside a container (a pycnometer) of known volume, and weighed. The pycnometer is then filled with a fluid of known density, in which the powder is not soluble. The volume of the powder is determined by the difference between the volume as shown by the pycnometer, and the volume of liquid added (i.e. the volume of air displaced).

[0122] As used herein, the term "aerosol-generating article" may refer to an article able to generate, or release, an aerosol, for example when heated.

[0123] As used herein, the term "longitudinal" may refer to a direction extending between a downstream or proximal end and an upstream or distal end of a component such as an aerosol-forming substrate or aerosol-generating article.

[0124] As used herein, the term "transverse" may refer to a direction perpendicular to the longitudinal direction.

[0125] As used herein, the term "aerosol-generating device" may refer to a device for use with an aerosol-generating article to enable the generation, or release, of an aerosol.

[0126] As used herein, the term "sheet" may refer to a generally planar, laminar element having a width and a length which are substantially greater than, for example at least 2, 3, 5, 10, 20 or 50 times, its thickness.

[0127] As used herein, the term "aerosol former" may refer to any suitable known compound or mixture of compounds that, in use, facilitates formation of an aerosol. The aerosol may be a dense and stable aerosol. The aerosol may be substantially resistant to thermal degradation at the operating temperature of the aerosol-forming substrate or aerosol-generating article.

[0128] As used herein, the term "aerosol-cooling element" may refer to a component of an aerosol-generating article located downstream of the aerosol-forming substrate such that, in use, an aerosol formed by the substrate or by volatile compounds released from the aerosol-forming substrate passes through and is cooled by the aerosol-cooling element before being inhaled by a user.

[0129] As used herein, the term "rod" may refer to a generally cylindrical, for example right cylindrical, element of substantially circular, oval or elliptical cross-section.

[0130] As used herein, the term "ventilation level" may refer to a volume ratio between the airflow admitted into an aerosol-generating article via the ventilation zone (ventilation airflow) and the sum of the aerosol airflow and the ventilation airflow. The greater the ventilation level, the higher the dilution of the aerosol flow delivered to the consumer.

[0131] The invention is defined in the claims. However, 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.

Exi. An aerosol-generating article for producing an inhalable aerosol, the aerosol-generating article comprising a hollow tubular aerosol forming substrate, in which the aerosol-forming substrate comprises a plurality of thermally conductive particles and an aerosol-former.

Ex1. An aerosol-generating article for producing an inhalable aerosol upon heating, the aerosol-generating article comprising a plurality of components including an aerosol-forming substrate, wherein the aerosol-forming substrate is in the form of a hollow tubular segment defining a substrate cavity extending between an upstream end of the aerosol-forming substrate and a downstream end of the aerosol-forming substrate, in which the aerosol-forming substrate comprises a plurality of thermally conductive particles and an aerosol-former.

Ex2. An aerosol-generating article according to example Exi or Ex1, in which each of the plurality of thermally conductive particles has a thermal conductivity greater than 1, 2, 5, 10, 20, 50, 100, 200, 500 or 1000 W/mK.

Ex3. An aerosol-generating article according to any preceding example in which the aerosol-forming substrate comprises, on a dry weight basis: between 5 and 95 wt %, for example between 10 and 90 wt %, of thermally conductive particles, each thermally conductive particle of the thermally conductive particles having a thermal conductivity of at least 1 W/(mK) in at least one direction at 25 degrees Celsius.

Ex4. An aerosol-generating article according to example Ex3 in which the aerosol-forming substrate further comprises between 7 and 60 wt % of the aerosol former; between 2 and 20 wt % of fibres; and between 2 and 10 wt % of a binder.

Ex5. An aerosol-generating article according to example Ex3 or Ex4 wherein the aerosol-forming substrate has a thermal conductivity of at least 0.12 W/(mK), for example at least 0.14 W/(mK), for example at least 0.22 W/(mK) in at least one direction at 25 degrees Celsius.

Ex6. An aerosol-generating article according to any preceding example in which the aerosol-forming substrate comprises, on a dry weight basis: between 10 and 90 wt % thermally conductive particles; between 7 and 60 wt % of the aerosol former; between 2 and 20 wt % of fibres; and between 2 and 10 wt % of a binder, wherein each of the thermally conductive particles consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond.

Ex 7. An aerosol-generating article according to any preceding example, wherein each thermally conductive particle of the plurality of thermally conductive particles has a thermal conductivity of at least 0.3, 0.5, 1, 2, 5, or 10 W/(mK) in at least one direction, for example when measured at 25 degrees Celsius.

Ex 8. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles comprise carbon, for example at least 10, 30, 50, 70, 90, 95, 98, or 99 wt % carbon.

Ex 9. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles are graphite particles, or some or all of the thermally conductive particles are expanded graphite particles, or some of the thermally conductive particles are graphite particles and some of the thermally conductive particles are expanded graphite particles.

Ex 10. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles are diamond particles, for example artificial diamond particles.

Ex 11. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles are graphene particles.

Ex 12. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles are carbon nanotubes.

Ex 13. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles are charcoal particles.

Ex 14. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles comprise a metal.

Ex 15. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles comprise one or both of copper and aluminium.

Ex 16. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles comprise an alloy.

Ex 17. An aerosol-generating article according to any preceding example, wherein some or all of the thermally conductive particles comprise an intermetallic.

Ex 18. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D10 particle size, wherein the number D10 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 19. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D10 particle size, wherein the number D10 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

Ex 20. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D50 particle size, wherein the number D50 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 21. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D50 particle size, wherein the number D50 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

Ex 22. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D90 particle size, wherein the number D90 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 23. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D90 particle size, wherein the number D90 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

Ex 24. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a volume D10 particle size, wherein the volume D10 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 25. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a volume D10 particle size, wherein the volume D10 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns

Ex 26. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a volume D50 particle size, wherein the volume D50 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 27. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a volume D50 particle size, wherein the volume D50 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

Ex 28. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a volume D90 particle size, wherein the volume D90 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 29. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a volume D90 particle size, wherein the volume D90 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

Ex 30. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a number D10 particle size, a number D90 particle size, a volume D10 particle size, and a volume D90 particle size, wherein: the number D90 particle size is no more than 50, 40, 30, 20, 10, or 5 times the number D10 particle size, or the volume D10 particle size is no more than 50, 40, 30, 20, 10, or 5 times the volume D10 particle size, or both the number D90 particle size is no more than 50, 40, 30, 20, 10, or 5 times the number D10 particle size and the volume D10 particle size is no more than 50, 40, 30, 20, 10, or 5 times the volume D10 particle size.

Ex 31. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution and one or both of a number D10 particle size and a volume D10 particle size is between 1 and 20 microns.

Ex 32. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles have a particle size distribution, wherein one or both of a number D90 particle size and a volume D90 particle size is between 50 and 300 microns or between 50 and 200 microns.

Ex 33. An aerosol-generating article according to any preceding example, wherein each of the thermally conductive particles has a particle size of at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

Ex 34. An aerosol-generating article according to any preceding example, wherein each of the thermally conductive particles has a particle size of no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

Ex 35. An aerosol-generating article according to any preceding example, wherein each of the thermally conductive particles has three mutually perpendicular dimensions, a largest dimension of the three dimensions being no more than 10, 8, 5, 3, or 2 times larger than one or both of a smallest dimension of the three dimensions and a second largest dimension of the three dimensions.

Ex 36. An aerosol-generating article according to any preceding example, wherein each of the thermally conductive particles is substantially spherical.

Ex 37. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles comprise at least 10, 20, 50, 100, 200, 500, or 1000 particles.

Ex 38. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, at least 20, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80 or 85 wt % of the thermally conductive particles.

Ex 39. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, no more than 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, or 15 wt % of the thermally conductive particles.

Ex 40. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, between 10 and 90, 20 and 90, 30 and 90, 40 and 90, 50 and 90, 60 and 90, 70 and 90, 80 and 90, 10 and 80, 20 and 80, 30 and 80, 40 and 80, 50 and 80, 60 and 80, 70 and 80, 10 and 70, 20 and 70, 30 and 70, 40 and 70, 50 and 70, 60 and 70, 10 and 60, 20 and 60, 30 and 60, 40 and 60, 50 and 60, 10 and 50, 20 and 50, 30 and 50, 40 and 50, 10 and 40, 20 and 40, 30 and 40, 10 and 30, 20 and 30, or 10 and 20 wt % of the thermally conductive particles.

Ex 41. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, at least 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 wt % of the aerosol former.

Ex 42. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, no more than 55, 50, 45, 40, 35, 30, 25, 20, or 15 wt % of the aerosol former.

Ex 43. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, between 7 and 60, 10 and 60, 20 and 60, 30 and 60, 40 and 60, 50 and 60, 7 and 50, 10 and 50, 20 and 50, 30 and 50, 40 and 50, 7 and 40, 10 and 40, 20 and 40, 30 and 40, 7 and 30, 10 and 30, 20 and 30, 7 and 20, 10 and 20, or 7 and 10 wt % of the aerosol former, particularly preferably between 15 and 25 wt% of the aerosol former.

Ex 44. An aerosol-generating article according to any preceding example, wherein the aerosol-former comprises or consists of one or more of: polyhydric alcohols, such as propylene glycol, polyethylene glycol, triethylene glycol, 1, 3-butanediol and glycerine; esters of polyhydric alcohols, such as glycerol mono-, di- or tri-acetate; and aliphatic esters of mono-, di- or poly-carboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate.

Ex 45. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate comprises one or both of glycerine and glycerol.

Ex 46. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, at least 2, 4, 6, 8, 10, 12, 14, 16 or 18 wt % of the fibres.

Ex 47. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, no more than 20, 18, 16, 14, 12, 10, 8, 6, or 4 wt % of the fibres.

Ex 48. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, between 4 and 20, 6 and 20, 8 and 20, 10 and 20, 12 and 20, 14 and 20, 16 and 20, 18 and 20, 2 and 18, 4 and 18, 6 and 18, 8 and 18, 10 and 18, 12 and 18, 14 and 18, 16 and 18, 2 and 16, 4 and 16, 6 and 16, 8 and 16, 10 and 16, 12 and 16, 14 and 16, 2 and 14, 4 and 14, 6 and 14, 8 and 14, 10 and 14, 12 and 14, 2 and 12, 4 and 12, 6 and 12, 8 and 12, 10 and 12, 2 and 10, 4 and 10, 6 and 10, 8 and 10, 2 and 8, 4 and 8, 6 and 8, 2 and 6, 4 and 6, or 2 and 4 wt % of the fibres, particularly preferably between 2 and 10 wt% of the fibres.

Ex 49. An aerosol-generating article according to any preceding example, wherein the fibres are cellulose fibres.

Ex 50. An aerosol-generating article according to any preceding example, wherein each of the fibres has three mutually perpendicular dimensions, a largest dimension of the three dimensions being at least 1.5, 2, 3, 5, 10, or 20 times larger than a smallest dimension of the three dimensions.

Ex 51. An aerosol-generating article according to any preceding example, wherein each of the fibres has three mutually perpendicular dimensions, a largest dimension of the three dimensions being at least 1.5, 2, 3, 5, 10, or 20 times larger than a second largest dimension of the three dimensions.

Ex 52. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, at least 4, 6, or 8 wt % of the binder.

Ex 53. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, no more than 8, 6, or 4 wt % of the binder.

Ex 54. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, between 4 and 10, 6 and 10, 8 and 10, 2 and 8, 4 and 8, 6 and 8, 2 and 6, 4 and 6, 2 and 4 wt % of the binder, particularly preferably between 2 and 10 wt% of the binder.

Ex 55. An aerosol-generating article according to any preceding example, wherein the binder comprises or consists of one or both of carboxymethyl cellulose or hydroxypropyl cellulose.

Ex 56. An aerosol-generating article according to any preceding example, wherein the binder comprises or consists of one or more gums such as guar gum.

Ex 57. An aerosol-generating article according to any preceding example, wherein the thermally conductive particles are substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 58. An aerosol-generating article according to any preceding example, wherein the aerosol former is substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 59. An aerosol-generating article according to any preceding example, wherein the fibres are substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 60. An aerosol-generating article according to any preceding example, wherein the binder is substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 61. An aerosol-generating article according to any preceding example, wherein the substrate comprises nicotine.

Ex 62. An aerosol-generating article according to example Ex 61, wherein the substrate comprises, on a dry weight basis, at least 0.01, 1, 2, 3, or 4 wt % nicotine.

Ex 63. An aerosol-generating article according to any of examples Ex 61 to Ex 62, wherein the substrate comprises, on a dry weight basis, no more than 5, 4, 3, 2, or 1 wt % nicotine.

Ex 64. An aerosol-generating article according to any preceding example, wherein the substrate comprises, on a dry weight basis, between 0.01 and 5, 1 and 5, 2 and 5, 3 and 5, 4 and 5, 0.01 and 4, 1 and 4, 2 and 4, 3 and 4, 0.01 and 3, 1 and 3, 2 and 3, 0.01 and 2, 1 and 2, 0.01 and 1 wt % nicotine, particularly preferably between 0.5 and 4 wt% nicotine.

Ex 65. An aerosol-generating article according to any of examples Ex 61 to Ex 63, wherein the nicotine is substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 66. An aerosol-generating article according to any preceding example, wherein the substrate comprises an acid.

Ex 67. An aerosol-generating article according to example Ex 66, wherein the substrate comprises, on a dry weight basis, at least 0.01, 1, or 2 wt % of the acid.

Ex 68. An aerosol-generating article according to any of examples Ex 66 to Ex 67, wherein the substrate comprises, on a dry weight basis, no more than 3, 2 or 1 wt % of the acid.

Ex 69. An aerosol-generating article according to any of examples Ex 66 to Ex 68, wherein the substrate comprises, on a dry weight basis, between 0.01 and 3, 1 and 3, 2 and 3, 0.01 and 2, 1 and 2, 0.01 and 1 wt % of the acid, particularly preferably between 0.5 and 5 wt% of the acid. Ex 70. An aerosol-generating article according to any of examples Ex 66 to Ex 69, wherein the acid comprises or consists of one or more of fumaric acid, lactic acid, benzoic acid, and levulinic acid.

Ex 71. An aerosol-generating article according to any of examples Ex 66 to Ex 70, wherein the acid is substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 72. An aerosol-generating article according to any preceding example, wherein the substrate comprises at least one botanical.

Ex 73. An aerosol-generating article according to example Ex 72, wherein the substrate comprises, on a dry weight basis, at least 0.01, 1, 2, 5, 10, or 15 wt % of the at least one botanical.

Ex 74. An aerosol-generating article according to any of examples Ex 72 to Ex 73, wherein the substrate comprises, on a dry weight basis, no more than 20, 15, 10, 5, 2 or 1 wt % of the at least one botanical.

Ex 75. An aerosol-generating article according to any of examples Ex 72 to Ex 74, wherein the substrate comprises, on a dry weight basis, between 0.01 and 20, 1 and 20, 2 and 20, 5 and 20, 10 and 20, 15 and 20, 0.01 and 15, 1 and 15, 2 and 15, 5 and 15, 10 and 15, 0.01 and 10, 1 and 10, 2 and 10, 5 and 10, 0.01 and 5, 1 and 5, 2 and 5, 0.01 and 2, 1 and 2, 0.01 and 1 wt % of the at least one botanical, particularly preferably between 1 and 15 wt% of the at least one botanical.

Ex 76. An aerosol-generating article according to any of examples Ex 72 to Ex 75, wherein the at least one botanical comprises or consists of one or both of clove and rosmarinus.

Ex 77. An aerosol-generating article according to any of examples Ex 72 to Ex 76, wherein the at least one botanical is substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 78. An aerosol-generating article according to any preceding example, wherein the substrate comprises at least one flavourant.

Ex 79. An aerosol-generating article according to example Ex 78, wherein the substrate comprises, on a dry weight basis, at least 0.1, 1, 2, or 5 wt % of the at least one flavourant.

Ex 80. An aerosol-generating article according to any of examples Ex 78 to Ex 79, wherein the substrate comprises, on a dry weight basis, no more than 10, 5, 2 or 1 wt % of the at least one flavourant.

Ex 81. An aerosol-generating article according to any of examples Ex 78 to Ex 80, wherein the substrate comprises, on a dry weight basis, between 0.1 and 10, 1 and 10, 2 and 10, 5 and 10, 0.1 and 5, 1 and 5, 2 and 5, 0.1 and 2, 1 and 2, 0.1 and 1 wt % of the at least one flavourant, particularly preferably between 0.1 and 5 wt% of the at least one flavourant.

Ex 82. An aerosol-generating article according to any of examples Ex 78 to Ex 81, wherein the at least one flavourant is present as a coating, for example a coating on one or more other components of the aerosol-forming substrate.

Ex 83. An aerosol-generating article according to any of examples Ex 78 to Ex 82, wherein the at least one flavourant is substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 84. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate comprises one or more organic materials such as tobacco.

Ex 85. An aerosol-generating article according to any preceding example, wherein the organic material comprises one or more of herb leaf, tobacco leaf, fragments of tobacco ribs, reconstituted tobacco, homogenised tobacco, extruded tobacco and expanded tobacco.

Ex 86. An aerosol-generating article according to any preceding example, wherein the organic materials are substantially homogeneously distributed throughout the aerosol-forming substrate.

Ex 87. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate is a tobacco-free aerosol-forming substrate, for example in which the aerosol-forming substrate does not comprise tobacco.

Ex 88. An aerosol-generating article according to any preceding example, wherein some or each of the thermally conductive particles comprise a susceptor material and/or are formed from a susceptor material, for example a carbon susceptor material.

Ex 89. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate has a thermal conductivity of at least 0.15, 0.2, 0.22, 0.3, 0.4, 0.5, 0.75, 1, 1.25, or 1.5 W/(mK) in at least one direction, or in all directions, at 25 degrees Celsius.

Ex 90. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate has a density of less than 1500, 1050, 1000, 950, 900, 850, 800, 850, 800, 750, 700, or 650 kg/m3.

Ex 91. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate has a density of between 500 and 900 or 600 and 800 kg/m^3.

Ex 92. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate has a moisture content of between 1 and 20, or 3 and 15 wt %.

Ex 93. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate comprises between 1 and 20, or 3 and 15 wt % water.

Ex 94. An aerosol-generating article according to any preceding example wherein the aerosol-forming substrate has a density of at least 0.1, 0.2, 0.3, or 0.5 g/m^3.

Ex 95. An aerosol-generating article according to any preceding example wherein the aerosol-forming substrate has a density of no more than 2, 1.5, 1.2, or 1 g/m^3.

Ex 96. An aerosol-generating article according to any preceding example wherein the aerosol-forming substrate has a density of between 0.1 and 2, 0.2 and 2, 0.3 and 2, 0.3 and 1.5, or 0.3 and 1.2 g/m^3.

Ex97. An aerosol-generating article according to any preceding example in which the substrate is in the form of a tube having a width in a radial dimension and a length in a longitudinal dimension, in which the length is between 5 mm and 100 mm, for example between 6 mm and 80 mm, for example between 7 mm and 60 mm, for example between 8 mm and 55 mm, for example between 9 mm and 50 mm, for example between 10 mm and 45 mm, for example between 11 mm and 35 mm, for example between 12 mm and 25 mm.

Ex98. An aerosol-generating article according to any preceding example in which the substrate is in the form of a tube having a width in a radial dimension and a length in a longitudinal dimension, in which the width is defined by an outer diameter of the tube, the outer diameter being between 3 mm and 20 mm, for example between 4 mm and 12 mm, for example between 4.5 mm and 10 mm, for example between 5 mm and 9 mm, for example between 6 mm and 8 mm, for example between 6.5 mm and 7.5 mm, for example about 7 mm.

Ex99. An aerosol-generating article according to any preceding example in which the substrate is in the form of a tube having an outer diameter and an inner diameter, the inner diameter being between 2.5 mm and 19 mm, for example between 3.5 mm and 11.5 mm, for example between 4 mm and 9 mm, for example between 4.5 mm and 8.5 mm, for example between 5.5 mm and 7.5 mm, for example between 6.9 mm and 7.3 mm, for example about 7 mm.

Ex100. An aerosol-generating article according to any preceding example in which the substrate is in the form of a tube having a length, an outer diameter and an inner diameter, a wall thickness of the tube being defined by the difference between the outer diameter and the inner diameter, in which the wall thickness is between 100 micron and 5 mm, for example between 150 micron and 3 mm, for example between 200 micron and 2 mm, for example between 250 micron and 1.5 mm, for example between 300 micron and 1 mm, for example between 350 micron and 500 micron.

Ex101. An aerosol-generating article according to any preceding example in which the substrate is in the form of a tube, and the tube is a rolled sheet of aerosol-forming material, for example a rolled sheet of homogenised tobacco material, for example a rolled sheet of cast leaf tobacco, or for example a rolled sheet of tobacco free aerosol-forming material.

Ex102. An aerosol-generating article according to any of examples Exi to Ex 100 in which the substrate is in the form of a tube, and the tube is an extruded tube of aerosol-forming material, for example an extruded tube of homogenised tobacco material or for example an extruded tube of tobacco-free aerosol-forming material.

Ex 103. An aerosol-generating article according to any preceding example, wherein the aerosol-generating article comprises a front plug, for example wherein the front plug has a length of between 2 mm and 10 mm, 3 mm and 8 mm, or 4 mm and 6 mm, for example around 5 mm. Ex 104. An aerosol-generating article according to any preceding example, wherein the aerosol-generating article comprises a first hollow support tube, for example a first hollow acetate tube, for example in which the first hollow support tube is located downstream of the aerosol-forming substrate within the aerosol-generating article.

Ex 105. An aerosol-generating article according to any preceding example, wherein the aerosol-generating article comprises a second hollow support tube, for example a second hollow acetate tube, for example in which the second hollow support tube is located downstream of the aerosol-forming substrate within the aerosol-generating article..

Ex 106. An aerosol-generating article according to example Ex 105, wherein the second hollow support tube comprises one or more ventilation holes.

Ex 107. An aerosol-generating article according to any preceding example, wherein the aerosol-generating article comprises a mouth plug filter.

Ex 108. An aerosol-generating article according to any preceding example, wherein the aerosol-generating article comprises a wrapper, for example a paper wrapper, for example in which components of the aerosol-generating article including the aerosol-forming substrate are assembled within the wrapper.

Ex 109. An aerosol-generating article according to any preceding example, wherein the aerosol-generating article comprises a front plug, the aerosol-forming substrate arranged downstream of the front plug, a first hollow support tube arranged downstream of the aerosol-forming substrate, a second hollow support tube arranged downstream of the first hollow support tube, and a mouth plug filter arranged downstream of the second hollow tube, preferably wherein the front plug, the aerosol-forming substrate, the first hollow support tube, the second hollow support tube, and the mouth plug filter are circumscribed by a wrapper, for example a paper wrapper. Ex 110. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate has a length of between 5 millimetres and 30 millimetres.

Ex 111. An aerosol-generating article according to any preceding example, wherein the aerosol-forming substrate has a length of between 5 millimetres and 16 millimetres.

Ex 112. An aerosol-generating article according to any preceding example, wherein a wall thickness of the aerosol-forming substrate is between 5 percent and 40 percent of the external diameter of the aerosol-forming substrate.

Ex 113. A method of forming a hollow tubular aerosol-forming substrate for an aerosol-generating article, for example an aerosol-generating article as defined by any of examples Ex i to Ex 112, the method comprising:

forming a slurry comprising thermally conductive particles, an aerosol former, fibres, and a binder;
casting the slurry into the shape of the hollow tubular aerosol-forming substrate, and drying the cast slurry to form the hollow tubular aerosol forming substrate.

Ex 114. A method of forming a hollow tubular aerosol-forming substrate for an aerosol-generating article, for example an aerosol-generating article as defined by any of examples Ex i to Ex 112, the method comprising:

forming a slurry comprising thermally conductive particles, an aerosol former, fibres, and a binder;
extruding the slurry into the shape of the hollow tubular aerosol-forming substrate, and drying the extruded slurry into a hollow tube.

Ex 115. A method according to example Ex 114 further comprising the step of cutting the hollow tube to form the hollow tubular aerosol forming substrate.

Ex 116. A method of forming a hollow tubular aerosol-forming substrate for an aerosol-generating article, for example an aerosol-generating article as defined by any of examples Ex i to Ex 112, the method comprising:

forming a slurry comprising thermally conductive particles, an aerosol former, fibres, and a binder;
casting and drying the slurry to form a sheet of aerosol-forming material, and forming the sheet into a hollow tube.

Ex 117. A method according to example Ex 116 further comprising the step of cutting the hollow tube to form the hollow tubular aerosol forming substrate.

Ex 118. A method according to example Ex 116 or Ex 117 in which the step of forming the sheet into a hollow tube comprises steps of rolling the sheet into a tubular shape, and applying adhesive to an overlapped porting of the rolled sheet to maintain the rolled sheet in a tubular shape.

Ex 119. A method according to any of examples Ex 113 to Ex 118, wherein the slurry comprises water.

Ex 120. A method according to any of examples Ex 113 to Ex 119, wherein the slurry comprises between 40 and 90, 40 and 85, 50 and 80, 60 and 80, 60 and 75 wt % water.

Ex 121. A method according to any of examples Ex 113 to Ex 120, wherein the slurry comprises an acid such as fumaric acid.

Ex 122. A method according to any of examples Ex 113 to Ex 121, wherein the slurry comprises nicotine.

Ex 123. A method according to any of examples Ex 113 to Ex 122, wherein forming the slurry comprises:

forming a first mixture comprising:

the aerosol former;
the fibres;
water;
optionally, the acid; and
optionally, the nicotine,

forming a second mixture comprising:

the thermally conductive particles; and
the binder,

and adding the second mixture to the first mixture to form a combined mixture.

Ex 124. A method according to example Ex 123, wherein forming the first mixture comprises providing the aerosol former or a solution comprising the aerosol former and the nicotine.

Ex 125. A method according to example Ex 124, wherein forming the first mixture comprises adding the acid to the aerosol former or the solution comprising the aerosol former and the nicotine to form a first pre-mixture.

Ex 126. A method according to any of examples Ex 123 to Ex 125, wherein forming the first mixture comprises adding the water to the aerosol former or the solution comprising the aerosol former and the nicotine, or to the first pre-mixture, to form a second pre-mixture.

Ex 127. A method according to example Ex 126, wherein forming the first mixture comprises adding the fibres to the second pre-mixture.

Ex 128. A method according to any of examples Ex 126 to Ex 127, wherein forming the second mixture comprises mixing the thermally conductive particles and the binder.

Ex 129. A method according to any of examples Ex 126 to Ex 128, wherein the method comprises a first mixing of the combined mixture.

Ex 130. A method according to example Ex 129, wherein the first mixing occurs under a first pressure of no more than 500, 400, 300, 250, or 200 mbar.

Ex 131. A method according to example Ex 129 or Ex 130, wherein the first mixing occurs for between 1 and 10, 2 and 8, or 3 and 6 minutes, for example for around 4 minutes.

Ex 132. A method according to any of examples Ex 129 to Ex 131, wherein the method comprises, after mixing the first mixing, a second mixing.

Ex 133. A method according to example Ex 132, wherein the second mixing occurs under a second pressure which is less than the first pressure.

Ex 134. A method according to example Ex 133, wherein the second pressure is no more than 500, 400, 300, 200, 150, or 100 mbar.

Ex 135. A method according to example Ex 132 or Ex 133 or Ex 134, wherein the second mixing occurs for between 5 and 120, 5 and 80, 5 and 40, or 10 and 30 seconds, for example around 20 seconds.

Ex 136. A method according to any of examples Ex 116 to Ex 135, wherein casting the slurry comprises casting the slurry onto a flat support, for example a steel flat support.

Ex 137. A method according to any of examples Ex 113 to Ex 136, wherein after casting the slurry and before drying the slurry, the method comprises setting a thickness of the slurry, for example setting a thickness of the slurry to between 100 and 1,000, 200 and 900, 300 and 800, 500 and 700 microns, for example around 600 microns.

Ex 138. A method according to any of examples Ex 113 to Ex 137, wherein drying the slurry comprises providing a flow of a gas such as air over or past the slurry.

Ex 139. A method according to example Ex 138, wherein the flow of gas is heated.

Ex 140. A method according to example Ex 139, wherein the flow of gas is heated to a temperature of between 100 and 160, or 120 and 140 degrees Celsius.

Ex 141. A method according to any of examples Ex 138 to Ex 140, wherein the flow of gas is provided for between 1 and 10 or 2 and 5 minutes.

Ex 142. A method according to any of examples Ex 113 to Ex 141, wherein drying the slurry comprises drying the slurry until the slurry has a moisture content of between 1 and 20, 2 and 15, 2 and 10, or 3 and 7 wt %.

Ex 143. A method according to any of examples Ex 113 to Ex 142, wherein drying the slurry forms the precursor for forming into the aerosol-forming substrate, the precursor being a sheet of aerosol-forming material.

Ex 144. An aerosol-generating system comprising an aerosol-generating article according to any of examples Ex i to Ex 112 and an electrical aerosol-generating device.

Ex 145. An aerosol-generating system according to example Ex 144, wherein the electrical aerosol-generating device is configured to resistively heat the aerosol-generating article in use.

Ex 146. An aerosol-generating system according to any of examples Ex 144 to Ex 145, wherein the electrical aerosol-generating device is configured to inductively heat the aerosol-generating article, for example the aerosol forming substrate of the aerosol-generating article, in use.

[0132] Aspects and embodiments of this disclosure, which may be combined with other features set out in this disclosure, are set out in the following numbered clauses.

1. An aerosol-generating article for producing an inhalable aerosol upon heating, the aerosol-generating article comprising a plurality of components including an aerosol-forming substrate, wherein the aerosol-forming substrate is in the form of a hollow tubular segment defining a substrate cavity extending between an upstream end of the aerosol-forming substrate and a downstream end of the aerosol-forming substrate, in which the aerosol-forming substrate comprises a plurality of thermally conductive particles and an aerosol-former.
2. An aerosol-generating article according to clause 1 in which the aerosol-forming substrate comprises, on a dry weight basis: between 5 and 95 wt %, for example between 10 and 90 wt %, of thermally conductive particles, each thermally conductive particle of the thermally conductive particles having a thermal conductivity of at least 1 W/(mK) in at least one direction at 25 degrees Celsius.
3. An aerosol-generating article according to clause 1 or 2, wherein the aerosol-forming substrate has a thermal conductivity of at least 0.12 W/(mK) in at least one direction at 25 degrees Celsius.
4. An aerosol-generating article according to any preceding clause in each of the thermally conductive particles consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond.
5. An aerosol-generating article according to any preceding clause in which the aerosol-forming substrate comprises, on a dry weight basis: between 10 and 90 wt % thermally conductive particles; between 7 and 60 wt % of an aerosol former; between 2 and 20

wt % of fibres; and between 2 and 10 wt % of a binder, wherein each of the thermally conductive particles consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond.

6. An aerosol-generating article according to any preceding clause, wherein the thermally conductive particles are substantially homogeneously distributed throughout the aerosol-forming substrate.

7. An aerosol-generating article according to any preceding clause, wherein the aerosol-forming substrate comprises one or more organic materials such as tobacco.

8. An aerosol-generating article according to any of clauses 1 to 6, wherein the aerosol-forming substrate is a tobacco-free aerosol-forming substrate.

9. An aerosol-generating article according to any preceding clause in which the aerosol forming substrate is in the form of a tube having an outer diameter, an inner diameter, and a length, in which the length of the tube is between 5 mm and 100 mm, the outer diameter is between 3 mm and 20 mm, and the inner diameter is between 2.5 mm and 19.5 mm.

10. An aerosol-generating article according to clause 9 in which the length of the tube is between 8 mm and 25 mm, the outer diameter of the tube is between 6 mm and 8 mm, and the inner diameter of the tube is between 5 mm and 7.9 mm.

11. An aerosol-generating article according to any preceding clause in which the hollow tubular segment is a rolled sheet of aerosol-forming material, for example a rolled sheet of homogenised tobacco material or for example a rolled sheet of tobacco free aerosol-forming material.

12. An aerosol-generating article according to any of clauses 1 to 10 in which the hollow tubular segment is an extruded tube of aerosol-forming material, for example an extruded tube of homogenised tobacco material or for example an extruded tube of tobacco-free aerosol-forming material.

13. A method of forming a hollow tubular aerosol-forming substrate for an aerosol-generating article, for example an aerosol-generating article as defined by any of clauses 1 to 12, the method comprising:

forming a slurry comprising thermally conductive particles, an aerosol former, fibres, and a binder;
casting and drying the slurry to form a sheet of aerosol-forming material, and
forming the sheet into a hollow tube.

14. A method according to clause 13, wherein forming the slurry comprises:

forming a first mixture comprising:

the aerosol former;
the fibres;
water;
optionally, a acid; and
optionally, nicotine,

forming a second mixture comprising:

the thermally conductive particles; and
the binder,

and adding the second mixture to the first mixture to form a combined mixture.

15. An aerosol-generating system comprising an aerosol-generating article according to any of clauses 1 to 12 and an electrical aerosol-generating device, preferably wherein the electrical aerosol-generating device is configured to resistively heat the aerosol-generating article in use, or wherein the electrical aerosol-generating device is configured to inductively heat the aerosol-generating article, for example the aerosol forming substrate of the aerosol-generating article, in use.

[0133] Examples will now be further described with reference to the figures in which:

Figure 1 shows a schematic cross-sectional view of a first embodiment of an aerosol-generating article;
Figure 2 shows a schematic cross-sectional view of a first embodiment of an aerosol-generating system, comprising the article of figure 1;
Figure 3 shows a schematic cross-sectional view of a second embodiment of an aerosol-generating system, comprising the article of figure 1; and
Figure 4 shows a schematic cross-sectional view of a third embodiment of an aerosol-generating system, comprising the article of figure 1.

[0134] Figure 1 shows a schematic cross-sectional view of an exemplary aerosol-generating article 10 according to an embodiment of the invention. The aerosol-generating article 10 extends from an upstream or distal end 18 to a downstream or proximal or mouth end 20 and has an overall length of about 45 millimetres and a diameter of about 7.2 mm.

[0135] The aerosol-generating article 10 comprises a plurality of elements arranged coaxially and assembled within a wrapper 70. The plurality of elements forming the article are, from distal end to proximal end, a front plug 46, a tubular segment of thermally enhanced aerosol-forming substrate 12, a cardboard tube free flow filter 34, and a mouthpiece filter 42. The wrapper 70 is a cigarette paper.

[0136] The front plug 46, also referred to as an upstream element, is located immediately upstream of the tubular aerosol-forming substrate 12. The front plug 46 is provided in the form of a cylindrical plug of cellulose acetate. The front plug 46 has a diameter of about 7.2

mm and a length of about 5 millimetres. The RTD of the front plug 46 is about 30 millimetres H_2O.

[0137] The tubular segment of aerosol-forming substrate 12 has an outer diameter of about 7.2 millimetres, an inner diameter of about 6.8 millimetres, and a length of about 12 millimetres. The aerosol-forming substrate 12 is formed from a rolled sheet of aerosol-forming material, comprising thermally conductive particles 44. The tubular aerosol forming substrate 12 is configured to form an aerosol when heated to a temperature of between 150 degrees Centigrade and 350 degrees Centigrade. Some specific examples of suitable aerosol-forming substrate compositions are provided below.

[0138] The cardboard tube 34 has a length of 16 mm and provides a free space within the article 10 within which volatile components generated by heating of the aerosol-forming substrate can cool and form an aerosol.

[0139] The mouthpiece element 42 is provided in the form of a cylindrical plug of low-density cellulose acetate. The mouthpiece element 42 has a length of about 12 millimetres and an external diameter of about 7.2 mm. The RTD of the mouthpiece element 42 is about 12 millimetres H_2O.

[0140] It should be clear that the configuration of the aerosol-generating article 10 of figure 1 is intended to serve as an example only. The thermally enhanced, tubular, aerosol-forming substrate 12 could, for example, be employed in an aerosol generating article that is longer, for example 80 mm long, and thinner, for example 4.5 mm in diameter.

[0141] In a specific embodiment of an aerosol-generating article as illustrated in Figure 1, the tubular segment 12 of aerosol-forming substrate comprises, on a dry weight basis, around 76.1 wt % thermally conductive particles 44. In this embodiment, the thermally conductive particles 44 are graphite particles, specifically FP 99,5 (>99.5% purity) graphite particles from Graphit Kropfmül GmbH, AMG Graphite GK, though other particles or mixtures of particles could be used. Each thermally conductive particle has a thermal conductivity of around 6 W/(mK) in at least one direction at 25 degrees Celsius.

[0142] The tubular aerosol-forming substrate 12 comprises, on a dry weight basis, around 17.7 wt % of an aerosol former. In this embodiment, the aerosol former is glycerol, specifically ICOF Europe food grade (>99.5% purity) glycerol.

[0143] The tubular aerosol-forming substrate 12 comprises, on a dry weight basis, around 3.9 wt % of fibres. In this embodiment, the fibres are cellulose fibres, specifically Birch cellulose fibres from Stora Enso OYJ.

[0144] The tubular aerosol-forming substrate 12 comprises, on a dry weight basis, around 2.3 wt % of a binder. In this embodiment, the binder is a guar gum, specifically guar gum from Gumix International Inc.

[0145] The tubular aerosol-forming substrate comprises about 10 wt % water, when measured at 25 degrees Celsius.

[0146] In other embodiments, the tubular aerosol-forming substrate 12 further comprises one or more of nicotine, an acid such as fumaric acid, a botanical such as clove or rosmarinus, and a flavourant.

[0147] The tubular aerosol-forming substrate 12 has a thermal conductivity of at least 0.1 W/(mK) in at least one direction at 25 degrees Celsius. The aerosol-forming substrate 12 may have a thermal conductivity of 0.2, 0.5, 1, 1.5 or greater W/(mK) in at least one direction at 25 degrees Celsius

[0148] Each of the thermally conductive particles 44 is substantially spherical in shape. The thermally conductive particles 44 are substantially homogeneously distributed throughout the aerosol-forming substrate. The particle size distribution has a volume D10 particle size of around 6 microns, a volume D50 particle size of around 20 microns, and a volume D90 particle size of around 56 microns. Each of the thermally conductive particles 44 has a particle size greater than around 1 microns and less than around 300 microns.

[0149] The thermally conductive particles 44 have a density of around 2200 kilograms per metre cubed. The aerosol-forming substrate has a density of around 800 kilograms per metre cubed.

[0150] The aerosol-forming substrate is formed by the process set out below.

[0151] A slurry is formed using a lab disperser capable of mixing viscous liquids, dispersing powders through liquids, and removing gas from a mixture (for example by applying a vacuum or other suitably low pressure). In this embodiment, a commercially available lab disperser from PC Laborsystem was used.

[0152] To form the slurry, a first mixture is formed by adding to the lap disperser around 7.11 grams of the aerosol former, then around 157.5 grams of water, then around 1.57 grams of the fibres. Then, these first ingredients are mixed at 25 degrees Celsius for 5 minutes at 600-700 rpm to ensure a homogeneous mixture and to hydrate the fibres. Then, a second mixture is formed by manually mixing around 32.95 grams of the thermally conductive particles and around 0.92 grams of the binder. This mixing of the second mixture avoids the formation of lumps in the lab dispersion. Then, the second mixture is added to the first mixture to form a combined mixture. Then, the combined mixture is mixed at 5000 rpm for 4 minutes at 25 degrees Celsius and a first reduced pressure of around 200 mbar. The reduced pressure may help to ensure that the thermally conductive particles are homogeneously dispersed in the mixture and that there is little trapped air and few lumps in the combined mixture. Then, the combined mixture is mixed at 5000 rpm for 20 second minutes at 25 degrees Celsius and a second reduced pressure of around 100 mbar. This second reduced pressure may help to remove any remaining air bubbles. This forms a slurry for casting.

[0153] The slurry is then cast and dried using a suitable apparatus. In this embodiment, a commercially available Labcoater Mathis apparatus is used. This apparatus includes a stainless steel, flat support, and a coma blade for adjusting a thickness of slurry cast onto the flat support.

[0154] The slurry is cast onto the flat support and a gap between the coma blade and the flat support is set at 0.6 millimetres. This ensures that a thickness of the slurry is no more than 0.6 millimetres at any given point.

[0155] The slurry is then dried with hot air between 120 and 140 degrees Celsius for between 2 and 5 minutes. After this drying, a sheet of the aerosol-forming substrate is formed. This sheet has a thickness of around 300 microns, a grammage of around 250 grams per metre squared, and a density of around 0.79 kilograms per metre cubed.

[0156] The sheet is then rolled to form a tube. Adhesive is applied to an overlapping portion of the rolled sheet to affix the sheet in the form of a tube and the tube is then cut into 12 mm lengths to for the tubular aerosol-forming substrate 12.

[0157] After forming the tubular aerosol-forming substrate 12, the aerosol-generating article 10 is assembled by positioning the various components of the article 10 and wrapping the components in the wrapper 70.

[0158] Other embodiments may have the same structure as described above, but have an aerosol-forming substrate of a different composition. For example, in a further embodiment the aerosol-forming material comprises a tube of thermally enhanced homogenised tobacco comprising thermally conductive particles 44. The thermally conductive particles 44 are carbon particles, specifically expanded graphite particles, having a particle size distribution with a D10 particle size of 6.6 microns, a D50 particle size of 20 microns, and a D90 particle size of 56 microns. Each of the expanded graphite particles has a particle size greater than 2 microns and less than 100 microns. The expanded graphite particles have a volume mean particle size of around 35 microns. Each of the expanded graphite particles is substantially spherical in shape. The expanded graphite particles have a density of less than 1000 kilograms per metre cubed. The aerosol-forming substrate, including the aerosol-forming material and the thermally conductive particles 44, have a combined density of around 760 kilograms per metre cubed. The expanded graphite particles make up approximately 5% of the aerosol-forming substrate by weight.

[0159] The tube 12 of aerosol-forming substrate is formed by a process including the following steps:

- pre-mixing a binder, guar gum, with an aerosol-former, glycerine, to form a first pre-mixture;
- pre-mixing finely shredded tobacco material and a powder consisting of the expanded graphite particles 44 and having a bulk density of around 0.065 grams per centimetre cubed, to form a second pre-mixture;
- mixing the first and second pre-mixtures with water to form a slurry;
- homogenising the slurry using a high-shear mixer;
- casting the slurry onto a conveyor belt;
- controlling a thickness of the slurry and drying the slurry to form a sheet of aerosol-forming substrate; and
- rolling the sheet of aerosol forming substrate into a tube and cutting the tube to form tubular segments of aerosol-forming substrate.

[0160] Aerosol-forming substrates formed with compositions including conductive particles according to the present invention have demonstrated improved aerosol delivery compared to reference substrates without thermally conductive particles.

[0161] Figure 2 shows a schematic cross-sectional view of a first embodiment of an aerosol-generating system 100. The system 100 comprises an aerosol-generating device 102 and the aerosol-generating article 10 of Figure 1.

[0162] The aerosol-generating device 102 comprises a battery 104, a controller 106, a heating blade 108 coupled to the battery, and a puff-detection mechanism (not shown). The controller 106 is coupled to the battery 104, the heating blade 108 and the puff-detection mechanism.

[0163] The aerosol-generating device 102 further comprises a housing 110 defining a substantially cylindrical cavity for receiving a portion of the article 10. The heating blade 108 is positioned centrally within the cavity and extends longitudinally from a base of the cavity.

[0164] In this embodiment, the heating blade 108 comprises a substrate and an electrically resistive track located on the substrate. The battery 104 is coupled to the heating blade 108 so as to be able to pass a current through the electrically resistive track and heat the electrically resistive track and heating blade 108 to an operational temperature.

[0165] In use, a user inserts the article 10 into the cavity, causing the heating blade 108 to penetrate the upstream element 46 and extend into the internal bore or cavity of the tubular of aerosol-forming substrate 12 of the article 10. Figure 3 shows the article 10 inserted into the cavity of the device 102, and the heating blade extending into the internal bore of the tubular aerosol-forming substrate.

[0166] Then, the user puffs on the downstream end of the article 10. This causes air to flow through an air inlet (not shown) of the device 102, then through the article 10, from the upstream end 18 to the downstream end 20, and into the mouth of the user.

[0167] The user puffing on the article 10 causes air to flow through the air inlet of the device. The puff-detection mechanism detects that the air flow rate through the air inlet has increased to greater than a non-zero threshold flow rate. The puff-detection mechanism sends a signal to the controller 106 accordingly. The controller 106 then controls the battery 104 so as to pass a current through the electrically resistive track and heat up the heating blade 108. This heats up the tubular aerosol-forming substrate.

[0168] The thermally conductive particles 44 have a significantly higher thermal conductivity than the surrounding aerosol-forming material. As such, these particles may act as local hot-spots and provide a more even temperature throughout the aerosol-forming substrate, particularly in a radial direction from the heating blade 108 where, with prior art substrates, there would be a significant temperature gradient. Further, because the aerosol-forming substrate is in the form of a tube, the temperature equalizes relatively quickly between the inner surface of the tube and the outer surface of the tube. The combination of a tubular structure for the aerosol forming substrate and the presence of thermally conductive particles in the aerosol-forming substrate allows a greater proportion of the aerosol-forming substrate to swiftly a sufficiently high temperature to release volatile compounds, and thus allows a higher usage efficiency of the aerosol-forming substrate.

[0169] Heating of the aerosol-forming substrate causes the aerosol-forming substrate to release volatile compounds. These compounds are entrained by the air flowing from the upstream end 18 of the article 10 towards the downstream end 20 of the article 10. The compounds cool and condense to form an aerosol as they pass through the cardboard tube 34. The aerosol then passes through the mouthpiece element 42, which may filter out unwanted particles entrained in the air flow, and into the mouth of the user.

[0170] When the user stops inhaling on the article 10, the air flow rate through the air inlet of the device decreases to less than the non-zero threshold flow rate. This is detected by the puff-detection mechanism. The puff-detection mechanism sends a signal to the controller 106 accordingly. The controller 106 then controls the battery 104 so as to reduce the current being passed through the electrically resistive track to zero.

[0171] After a number of puffs on the article 10, the user may choose to replace the article 10 with a fresh article.

[0172] Figure 3 shows a schematic cross-sectional view of a second embodiment of an aerosol-generating system 300. The system 300 comprises an aerosol-generating device 302 and the aerosol-generating article 10 of Figure 1.

[0173] The aerosol-generating device 302 comprises a battery 304, a controller 306, an external resistance heater 308, and a puff-detection mechanism (not shown). The controller 306 is coupled to the battery 304, the resistance heater 308 and the puff-detection mechanism.

[0174] The aerosol-generating device 302 further comprises a housing 310 defining a substantially cylindrical cavity for receiving a portion of the article 10. The external heater 208 is located on an inner surface of the cavity.

[0175] Use of the system is similar to that described above in relation to the system of Figure 2, with the difference that the tubular aerosol-forming substrate 12 is heated from the outside rather than by a heater located in an internal portion of the aerosol-forming substrate.

[0176] Figure 4 shows a schematic cross-sectional view of a third embodiment of an aerosol-generating system 400. The system 400 comprises an aerosol-generating device 402 and the aerosol-generating article 10 of Figure 1.

[0177] The aerosol-generating device 402 comprises a battery 404, a controller 406, an inductor coil 408, and a puff-detection mechanism (not shown). The controller 406 is coupled to the battery 404, the inductor coil 408 and the puff-detection mechanism.

[0178] The aerosol-generating device 402 further comprises a housing 410 defining a substantially cylindrical cavity for receiving a portion of the article 10. The inductor coil 408 spirals around the cavity.

[0179] The battery 404 is coupled to the inductor coil 408 so as to be able to pass an alternating current through the inductor coil 408.

[0180] In use, a user inserts the article 10 into the cavity. Figure 4 shows the article 10 inserted into the cavity of the device 402. Airflow is detected and the device actuated as described above in relation to the system of Figure 1. When a puff is detected, the controller 406 controls the battery 404 so as to pass an alternating current through the inductor coil 408. This causes the inductor coil 408 to generate a fluctuating electromagnetic field. The aerosol-forming substrate 12 is located within this fluctuating electromagnetic field. The materials of the particles 44, for example graphite or expanded graphite, are susceptor materials. Thus, the fluctuating electromagnetic field causes eddy currents in the particles 44. This causes the particles 44 to heat up, thereby also heating aerosol-forming material of the aerosol-forming substrate.

[0181] For the purpose of the present description and of the appended claims, except where otherwise indicated, all numbers expressing amounts, quantities, percentages, and so forth, are to be understood as being modified in all instances by the term "about". Also, all ranges include the maximum and minimum points disclosed and include any intermediate ranges therein, which may or may not be specifically enumerated herein. In this context, therefore, a number A is understood as A $\pm$ 10% of A. Within this context, a number A may be considered to include numerical values that are within general standard error for the measurement of the property that the number A modifies. The number A, in some instances as used in the appended claims, may deviate by the percentages enumerated above provided that the amount by which A deviates does not materially affect the basic and novel characteristic(s) of the claimed invention. Also, all ranges include the maximum and minimum points disclosed and include any intermediate ranges therein, which may or may not be specifically enumerated herein.

Claims

1. An aerosol-generating article (10) for producing an inhalable aerosol upon heating, the aerosol-generating article comprising an aerosol-forming substrate (12), wherein:

the aerosol-forming substrate is in the form of a hollow tubular segment defining a substrate cavity extending between an upstream end (18) of the aerosol-forming substrate and a downstream end (20) of the aerosol-forming substrate;
the aerosol-forming substrate comprises a plurality of thermally conductive particles (44) and an aerosol-former; and
the hollow tubular segment is an extruded tube of aerosol-forming material.

2. An aerosol-generating article (10) according to claim 1, wherein the aerosol-forming substrate (12) comprises one or more organic materials such as tobacco.

3. An aerosol-generating article (10) according to claim 1, wherein the aerosol-forming substrate (12) is a tobacco-free aerosol-forming substrate.

4. An aerosol-generating article (10) according to any preceding claim, wherein the aerosol-forming substrate has a length of between 5 and 20 mm.

5. An aerosol-generating article (10) according to any preceding claim, wherein the aerosol-forming substrate is in the form of a tube having a width in a radial dimension and a length in a longitudinal dimension, in which the width is defined by an outer diameter of the tube, the outer diameter being between 3 mm and 20 mm.

6. An aerosol-generating article (10) according to any preceding claim, wherein the aerosol-forming substrate is in the form of a tube having an outer diameter, an inner diameter, and a length, a wall thickness of the tube being defined by a difference between the outer diameter and the inner diameter, wherein the wall thickness is between 100 microns and 5 mm.

7. An aerosol-generating article (10) according to any preceding claim, wherein the aerosol forming substrate is in the form of a tube having an outer diameter, an inner diameter, and a length, a wall thickness of the tube being defined by a difference between the outer diameter and the inner diameter, wherein the wall thickness is between 5 percent and 40 percent of the outer diameter.

8. An aerosol-generating article (10) according to any preceding claim, wherein the article comprises one or more or all of: a front plug (46), a first hollow tube, a second hollow tube, a mouth plug filter (42), and a wrapper (70).

9. An aerosol-generating article (10) according to any of claims 1 to 7, wherein the article comprises:

a front plug (46), the aerosol-forming substrate arranged downstream of the front plug;
a first hollow support tube arranged downstream of the aerosol-forming substrate;
a second hollow support tube arranged downstream of the first hollow support tube; and
a mouth plug filter (42) arranged downstream of the second hollow tube.

10. An aerosol-generating article (10) according to claim 9, wherein the aerosol-generating article comprises a wrapper (70), and wherein the front plug (46), the aerosol-forming substrate, the first hollow support tube, the second hollow support tube, and the mouth plug filter (42) are circumscribed by the wrapper.

11. An aerosol-generating article (10) according to any of claims 8 to 10, wherein one or more of:

the front plug (46)has a length of between 2 and 10 mm;
the first hollow tube has a length of between 2 and 20 mm;
the second hollow tube has a length of between 2 and 20 mm; and
the mouth plug filter (42) has a length of between 5 and 20 mm.

12. An aerosol-generating article (10) according to any of claims 8 to 11, wherein the second hollow tube comprises one or more ventilation holes.

13. A method of forming a hollow tubular aerosol-forming substrate (12) for an aerosol-generating article (10), for example an aerosol-generating article as defined by any of claims 1 to 12, the method comprising:

forming a slurry comprising thermally conductive particles (44), an aerosol former, fibres, and a binder;
extruding the slurry into the shape of the hollow tubular aerosol-forming substrate, and drying the extruded slurry into a hollow tube.

14. A method according to claim 13, wherein the method comprises a step of cutting the hollow tube to form the hollow tubular aerosol-forming substrate (12).

15. An aerosol-generating system (100) comprising an aerosol-generating article (10) according to any of claims 1 to 12 and an electrical aerosol-generating device (102).

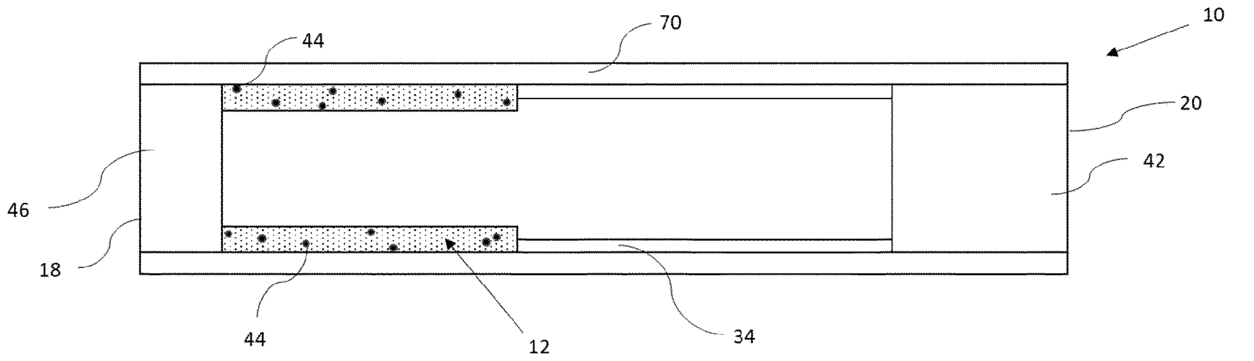

FIGURE 1

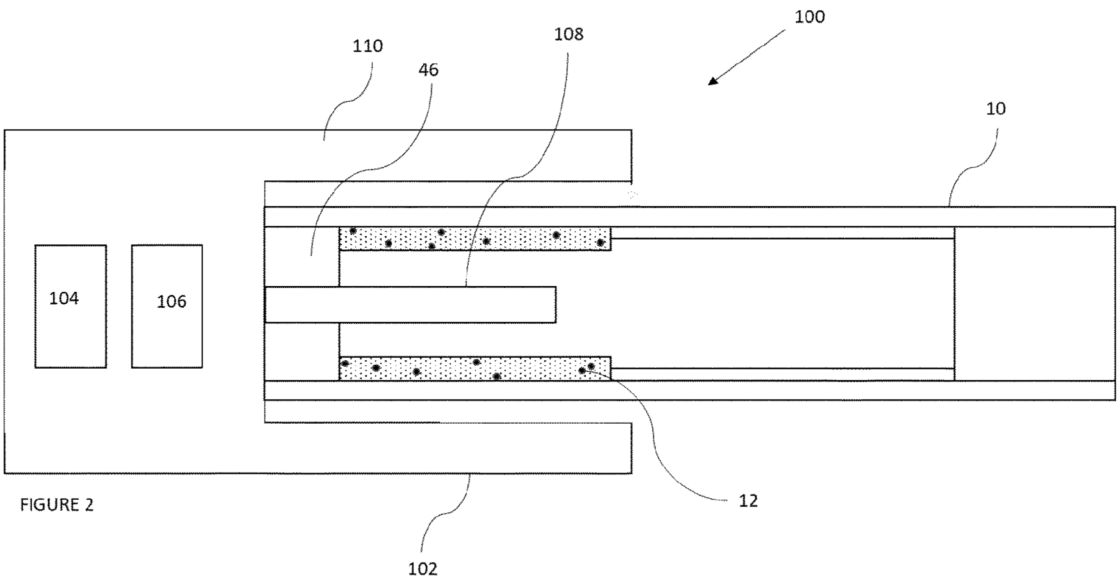

FIGURE 2

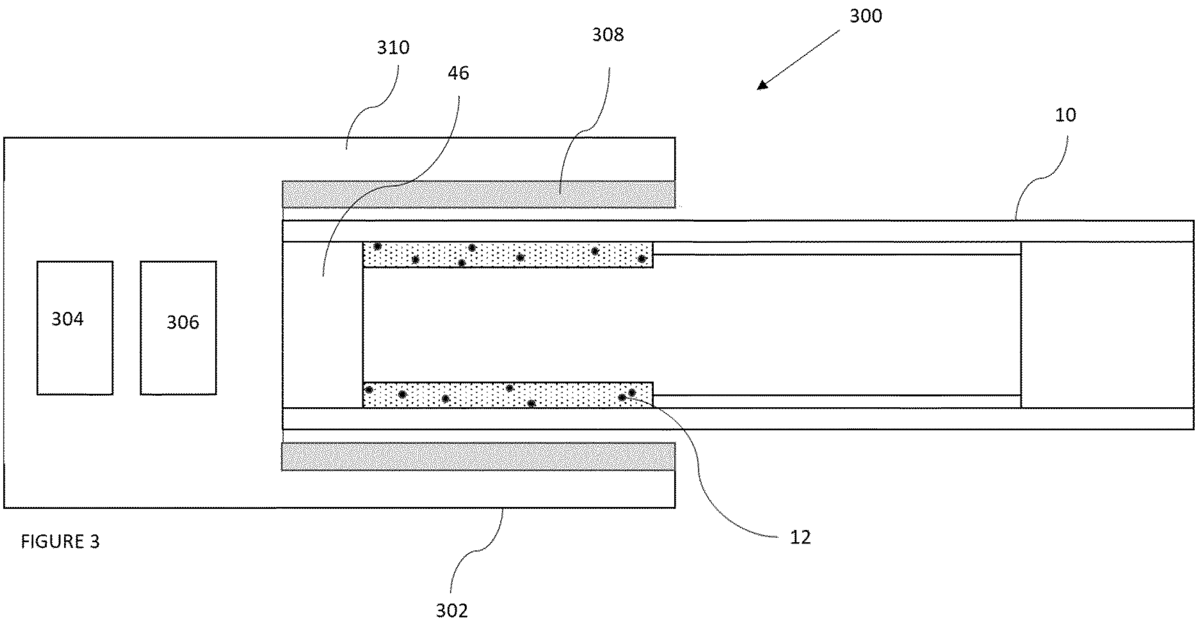

FIGURE 3

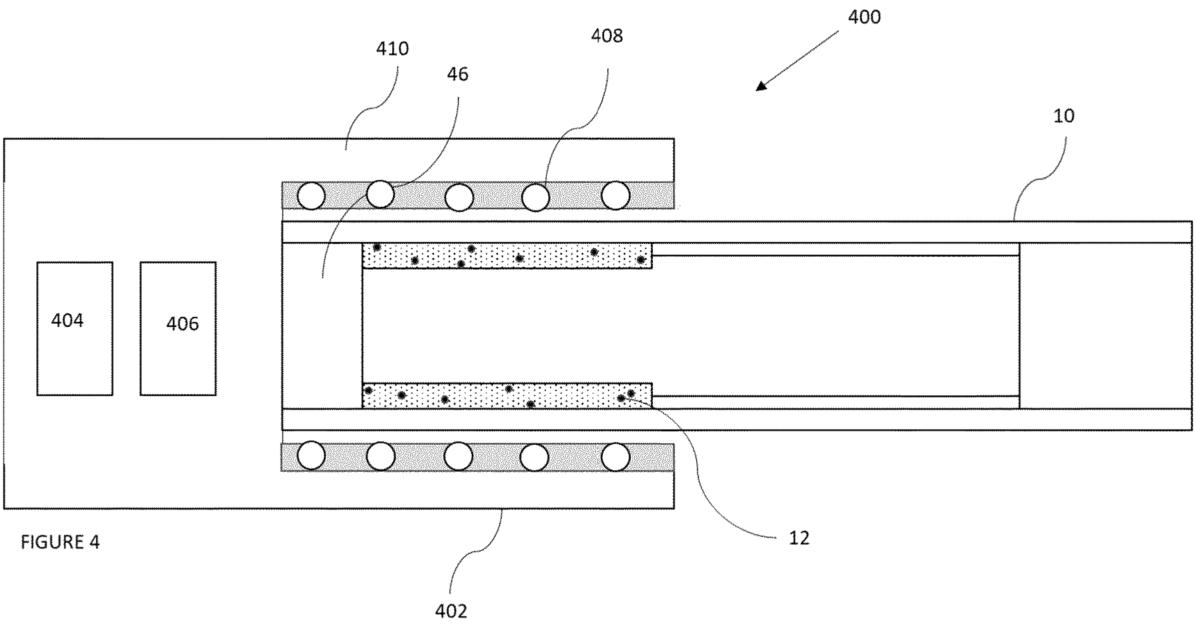

FIGURE 4

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 2020115151 A **[0003]**
- WO 2015176898 A **[0003]**