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(72) **Inventeurs/Inventors:**
MOLONEY, PATRICK, GB;
AOUN, WALID ABI, GB;
LEAH, THOMAS DAVID, GB;
KORUS, ANTON, GB

(73) **Propriétaire/Owner:**
NICOVENTURES TRADING LIMITED, GB

(74) **Agent:** BERESKIN & PARR LLP/S.E.N.C.R.L.,S.R.L.

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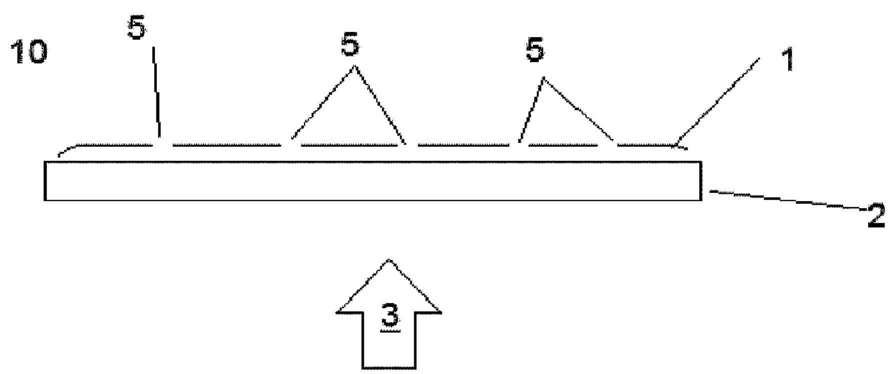

(57) **Abrégé/Abstract:**
Described herein is an aerosol-forming substrate comprising an aerosol-forming material provided on a carrier, wherein the aerosol-forming material comprises an amorphous solid and wherein one or more vents are provided in the aerosol-forming material to allow the passage of aerosol and/or gases through the aerosol-forming material in use.

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(71) Applicant: **NICOVENTURES TRADING LIMITED** [GB/GB]; Globe House, 1 Water Street, London, Greater London WC2R 3LA (GB).

(72) Inventors: **MOLONEY, Patrick**; c/o British American Tobacco (Investments) Limited, Globe House, 1 Water Street, London, Greater London WC2R 3LA (GB). **AOUN, Walid Abi**; Globe House, 1 Water Street, London, Greater London WC1R 3LA (GB). **LEAH, Thomas David**; c/o British American Tobacco (Investments) Limited, Globe House, 1 Water Street, London, Greater London WC2R 3LA (GB). **KORUS, Anton**; c/o Korus Engineering Services LTD, 1 Derwent Business Centre, Clarke Street, Derby, Derbyshire DE1 2BU (GB).

(74) Agent: **EIP**; Fairfax House, 15 Fulwood Place, London, Greater London WC1V 6HU (GB).

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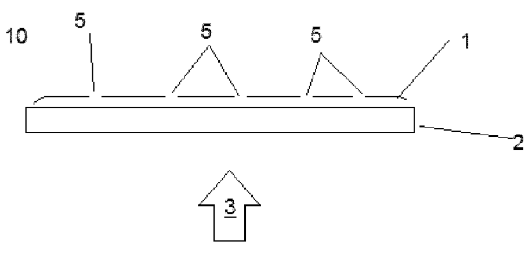

Figure 2

(57) Abstract: Described herein is an aerosol-forming substrate comprising an aerosol-forming material provided on a carrier, wherein the aerosol-forming material comprises an amorphous solid and wherein one or more vents are provided in the aerosol-forming material to allow the passage of aerosol and/or gases through the aerosol-forming material in use.

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AEROSOL GENERATION

Technical Field

The present invention relates to aerosol generation.

Background

Smoking articles such as cigarettes, cigars and the like burn tobacco during use to create tobacco smoke. Alternatives to these types of articles release an inhalable aerosol or vapour by releasing compounds from a substrate material by heating without burning. These may be referred to as non-combustible smoking articles or aerosol generating assemblies.

One example of such a product is a heating device which release compounds by heating, but not burning, a solid aerosolisable material. This solid aerosolisable material may, in some cases, contain a tobacco material. The heating volatilises at least one component of the material, typically forming an inhalable aerosol. These products may be referred to as heat-not-burn devices, tobacco heating devices or tobacco heating products. Various different arrangements for volatilising at least one component of the solid aerosolisable material are known.

As another example, there are e-cigarette / tobacco heating product hybrid devices, also known as electronic tobacco hybrid devices. These hybrid devices contain a liquid source (which may or may not contain nicotine) which is vaporised by heating to produce an inhalable vapour or aerosol. The device additionally contains a solid aerosolisable material (which may or may not contain a tobacco material) and components of this material are entrained in the inhalable vapour or aerosol to produce the inhaled medium.

Summary

A first aspect of the invention provides an aerosol-forming substrate comprising an aerosol-forming material provided on a carrier, wherein the aerosol-forming material comprises an amorphous solid and wherein one or more vents are provided in the aerosol-forming material to allow the passage of aerosol and/or gases through the aerosol-forming material in use.

In some cases, the vent(s) may comprise apertures in the aerosol-forming material. In some cases, the vent(s) may comprise burst points in the aerosol-forming material. In some cases, the vents may comprise apertures and burst points.

In some cases, the carrier of the aerosol-forming substrate may be substantially or wholly impermeable to aerosol and/or gas.

A second aspect of the invention provides an aerosol generating article for use in an aerosol generating assembly, wherein the article comprises an aerosol-forming substrate according to any preceding claim.

A third aspect of the invention provides an aerosol generating assembly comprising (a) an aerosol-forming substrate according to the first aspect of the invention or (b) an aerosol generating article according to the second aspect; and a heater configured to heat but not burn the aerosol-forming substrate.

In some cases, the aerosol generating assembly comprises a heater and an aerosol-forming substrate in which the carrier is substantially impermeable and is disposed between the aerosol-forming material and the heater.

In some cases, the aerosol generating assembly may be a heat-not-burn device.

In some cases, the aerosol generating assembly may be an electronic tobacco hybrid device.

A fourth aspect of the invention provides a method of making an aerosol-forming substrate according to the first aspect, the method comprising (a) forming a slurry comprising components of the amorphous solid or precursors thereof, (b) applying the slurry to the carrier, (c) setting slurry to form a gel and (d) drying to form an amorphous solid.

In some cases, the vents are provided in the aerosol-forming material during step (b).

In other cases, the method of the fourth aspect further comprises a step (e) subsequent to step (d), step (e) comprising forming the vents in the gel. In some cases, step (e) comprises cutting the aerosol-forming material to provide apertures and/or burst points in the aerosol-forming material. For example, the cutting step may employ one or more of a laser, and air jet, a water jet and a sharp implement.

Further aspects of the invention described herein may provide the use of the aerosol-forming substrate, the aerosol generating article or the aerosol generating assembly, in the generation of an inhalable aerosol.

Further features and advantages of the invention will become apparent from the following description, given by way of example only, and with reference to the accompanying figures.

Brief Description of the Drawings

Figure 1 shows a schematic view of an aerosol-forming substrate and heater in which no vent is provided and which is not an embodiment of the invention.

Figure 2 shows a schematic view of a heater and an aerosol-forming substrate that is an embodiment of the invention.

Figure 3 shows a section view of an example of an aerosol generating article.

Figure 4 shows a perspective view of the article of Figure 3.

Figure 5 shows a sectional elevation of an example of an aerosol generating article.

Figure 6 shows a perspective view of the article of Figure 5.

Figure 7 shows a perspective view of an example of an aerosol generating assembly.

Figure 8 shows a section view of an example of an aerosol generating assembly.

Figure 9 shows a perspective view of an example of an aerosol generating assembly.

Detailed Description

The aerosol-forming material described herein comprises an "amorphous solid", which may alternatively be referred to as a "monolithic solid" (i.e. non-fibrous), or as a "dried gel". The amorphous solid is a solid material that may retain some fluid, such as liquid, within it. In some cases, the aerosol-forming material comprises from 50wt%, 60wt% or 70wt% of amorphous solid, to about 90wt%, 95wt% or 100wt% of amorphous solid. In some cases, the aerosol-forming material consists of amorphous solid.

The invention provides an aerosol-forming substrate comprising an aerosol-forming material provided on a carrier, wherein the aerosol-forming material comprises an amorphous solid and wherein one or more vents are provided in the aerosol-forming material to allow the passage of aerosol and/or gases through the aerosol-forming material in use.

The inventors have found that, in the absence of vents, components of the aerosol-forming material which are volatilised during use may become trapped under the aerosol-forming material in gas or aerosol form. This prevents delivery of the aerosol to the user. Further, this trapping can cause separation of the aerosol-forming material from the carrier. This separation in turn compromises heat transfer from the carrier to the aerosol-forming material, reducing aerosol generation and delivery, compromising the user experience.

The vents allow any gas or aerosol that forms under the aerosol-forming material to be released. This provides improved performance. Firstly, it improves aerosol delivery to the user. Secondly, it prevents separation of the aerosol-forming material and the carrier, improving heat transfer from the carrier to the aerosol-forming material and sustaining aerosol generation by this heat transfer throughout the use period.

Figure 1 shows an aerosol-forming substrate 8 comprising an aerosol-forming material 1 provided on a carrier 2, which is not an embodiment of the invention. In use, heat is 3 is supplied to the substrate from the opposite side of the carrier 2 to the aerosol forming material 1. As illustrated in Figure 1, the inventors have found that in the absence of a vent in the aerosol-forming material 1, components of the aerosol-forming material which are volatilised during use may become trapped 4 under the aerosol-forming material 1 in gas or aerosol form. This prevents delivery of the aerosol to the user. Further, this trapping can cause separation of the aerosol-forming material 1 from the carrier 2. This separation in turn compromises heat transfer from the carrier 2 to the aerosol-forming material 1; there is less contact between the component reducing conductive heat transfer and the trapped gas/aerosol acts as an insulator. The result of this poorer heat transfer is a reduction in aerosol generation and delivery, compromising the user experience.

An example of an aerosol-forming substrate 10 according to the invention is illustrated in Figure 2. This substrate 10 comprises an aerosol-forming material 1 provided on a carrier 2. A plurality of vents 5 is provided in the aerosol-forming material 1. These vents allow gas or aerosol that forms under the aerosol-forming material 1 in use to be released. This provides good performance. Firstly, it improves aerosol delivery to the user. Secondly, it prevents separation of the aerosol-forming material 1 and the carrier 2, improving heat transfer from the carrier 2 to the aerosol-forming material 1 and sustaining aerosol generation by this heat transfer throughout the use period.

In some cases, the vent(s) may comprise apertures in the aerosol-forming material.

In some cases, the vent(s) may comprise burst points in the aerosol-forming material. That is, the vents may comprise weaker points in the aerosol-forming material which rupture (or burst) on the build-up of pressure (due to trapped aerosol or gas below the aerosol-forming material).

In some cases, the vents may comprise apertures and burst points.

In cases where there is a plurality of vents, these may be randomly distributed across the aerosol generating material. Alternatively, they may be arranged in a regular pattern. A regular pattern provides the advantage that the distribution of vents can be selected to ensure that the release of gas/aerosol is achieved across the whole of the aerosol-forming material.

In some cases, the aerosol generating material may comprise embedded heating means, such as resistive or inductive heating elements. For example, the heating means may be embedded in the amorphous solid.

In some cases, the carrier of the aerosol-forming substrate may be substantially or wholly impermeable. This prevents aerosol or gas passage through the carrier, thereby controlling the flow and ensuring it is delivered to the user. This can also be used to reduce or prevent condensation or other deposition of the gas/aerosol in use on, for example, the surface of a heater provided in an aerosol generating assembly. Thus, consumption efficiency and hygiene can be improved in some cases.

The carrier may be any suitable material which can be used to support an aerosol-forming material that comprises an amorphous solid. In some cases, the carrier may be formed from materials selected from metal foil, paper, carbon paper, greaseproof paper, ceramic, carbon allotropes such as graphite and graphene, plastic, cardboard, wood, or combinations thereof. In some cases, the carrier may comprise or consist of a tobacco material, such as a sheet of reconstituted tobacco. In some cases, the carrier may be formed from materials selected from metal foil, paper, cardboard, wood or combinations thereof. For example, the carrier may be formed from a laminate comprising layers of materials selected from the preceding lists. For example, the carrier may be a paper-backed foil. The foil may be substantially impermeable to gas/aerosol, providing control of flow path, and may also conduct heat to the aerosol-forming gel.

In another case, the foil layer of the paper-backed foil abuts the amorphous solid. The foil is substantially impermeable, thereby preventing water provided in the amorphous solid to be absorbed into the paper which could weaken its structural integrity.

In some cases, the carrier is formed from or comprises metal foil, such as aluminium foil. A metallic carrier may allow for better conduction of thermal energy to the amorphous solid. Additionally, or alternatively, a metal foil may function as a susceptor in an induction heating system. In particular embodiments, the carrier comprises a metal foil layer and a support layer, such as cardboard. In these embodiments, the metal foil layer may have a thickness of less than 20μm, such as from about 1μm to about 10μm, suitably about 5μm.

In one case, the surface of the carrier that abuts the amorphous solid may be porous. For example, in some cases, the carrier comprises or consists of paper. The inventors have found that a porous carrier such as paper is particularly suitable for the present invention; the porous (paper) layer abuts the amorphous solid layer and forms a strong bond. The amorphous solid is formed by drying a gel and, without being limited by theory, it is thought that the slurry from which the gel is formed partially impregnates the porous carrier (e.g. paper) so that when the gel sets and forms cross-links, the carrier is partially bound into the gel. This provides a strong binding between the gel and the carrier (and between the dried gel and the carrier).

In one case, at least a layer of the carrier may be porous in that it is provided with vents similar to those of the amorphous solid. In some cases, the vents of the carrier may be aligned with the one or more vents provided in the aerosol-forming material. For example, the carrier may include a support layer (such as a cardboard layer), a foil layer (such as an aluminium foil layer) disposed on top of the support layer, wherein the amorphous solid is disposed on top of the foil layer. In this example, at least the foil layer may be provided with vents corresponding to the one or more vents provided in the aerosol-forming material. Such vents provided in the foil layer may derive from the process of providing the vents in the amorphous solid disposed thereupon.

In some embodiments, the vents extend throughout the entire thickness of the carrier.

In preferred embodiments, the vents do not extend throughout the entire thickness of the carrier. In the example given above, the cardboard support layer is not provided with one or more vents. As described hereinabove, the carrier of the aerosol-forming substrate may be substantially or wholly impermeable.

In one case, the carrier does not comprise vents.

Additionally, surface roughness may contribute to the strength of bond between the amorphous material and the carrier. The inventors have found that the paper roughness (for the surface abutting the carrier) may suitably be in the range of 50-1000 Bekk seconds, suitably 50-150 Bekk seconds, suitably 100 Bekk seconds (measured over an air pressure interval of 50.66-48.00 kPa). (A Bekk smoothness tester is an instrument used to determine the smoothness of a paper surface, in which air at a specified pressure is leaked between a smooth glass surface and a paper sample, and the time (in seconds) for a fixed volume of air to seep between these surfaces is the "Bekk smoothness".)

Conversely, the surface of the carrier facing away from the amorphous solid may be arranged in contact with the heater, and a smoother surface may provide more efficient heat transfer. Thus, in some cases, the carrier is disposed so as to have a rougher side abutting the amorphous material and a smoother side facing away from the amorphous material.

In some cases, the aerosol-forming substrate may be provided as a planar sheet. In some cases, the aerosol forming substrate may be incorporated into an aerosol generating article or assembly as a planar sheet.

In some cases, the aerosol-forming substrate may be provided as a tube (i.e. a rolled sheet). That is, in some cases the carrier may be in the form of a tube, and the aerosol-forming material may be provided on the inside surface of the tube. In some such cases, the amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a sheet, such as a sheet circumscribing a rod of aerosolisable material (e.g. tobacco). This tube may then be placed in heating chamber in an aerosol generating assembly, so that heat is supplied to the substrate from the outside of the tube. In some cases, the heater may be in the form of a hollow cylindrical tube, defining a heating chamber into which the tubular aerosol-forming substrate is inserted for heating in use.

In some other cases, the carrier may be in the form of a tube, and the aerosol-forming material may be provided on the outside surface of the tube. Such a substrate may be used with a device in which the heater is in the form of a blade or rod which is inserted into the hollow tube of a tubular aerosol-forming substrate. Thus, heat is supplied to the substrate from the inside of the tube.

In some examples, the amorphous solid in sheet form may have a tensile strength of from around 200 N/m to around 900 N/m. In some examples, such as where the amorphous solid does not comprise a filler, the amorphous solid may have a tensile strength of from 200 N/m to 400 N/m, or 200 N/m to 300 N/m, or about 250 N/m. Such tensile strengths may be particularly suitable for embodiments wherein the aerosol generating material is formed as a sheet and then shredded and incorporated into an aerosol generating article. In some examples, such as where the amorphous solid comprises a filler, the amorphous solid may have a tensile strength of from 600 N/m to 900 N/m, or from 700 N/m to 900 N/m, or around 800 N/m. Such tensile strengths may be particularly suitable for embodiments wherein the aerosol generating material is included in an aerosol generating article/assembly as a rolled sheet, suitably in the form of a tube.

In some cases, the amorphous solid may have a thickness of about 0.015mm to about 1.0mm. Suitably, the thickness may be in the range of about 0.05mm, 0.1mm or 0.15mm to about 0.5mm or 0.3mm. The inventors have found that a material having a thickness of 0.2mm is particularly suitable. The amorphous solid may comprise more than one layer, and the thickness described herein refers to the aggregate thickness of those layers.

The inventors have established that if the aerosol-forming amorphous solid is too thick, then heating efficiency is compromised. This adversely affects the power consumption in use. Conversely, if the aerosol-forming amorphous solid is too thin, it is difficult to manufacture and handle; a very thin material is harder to cast and may be fragile, compromising aerosol formation in use.

The inventors have established that the amorphous solid thicknesses stipulated herein optimise the material properties in view of these competing considerations.

The thickness stipulated herein is a mean thickness for the material. In some cases, the amorphous solid thickness may vary by no more than 25%, 20%, 15%, 10%, 5% or 1%.

AEROSOL-FORMING MATERIAL COMPOSITION

In some cases, the amorphous solid may comprise 1-60wt% of a gelling agent wherein these weights are calculated on a dry weight basis.

Suitably, the amorphous solid may comprise from about 1wt%, 5wt%, 10wt%, 15wt%, 20wt% or 25wt% to about 60wt%, 50wt%, 45wt%, 40wt%, 35wt%, 30wt% or 27wt% of a gelling agent (all calculated on a dry weight basis). For example, the amorphous solid may comprise 1-50wt%, 5-40wt%, 10-30wt% or 15-27wt% of a gelling agent.

In some embodiments, the gelling agent comprises a hydrocolloid. In some embodiments, the gelling agent comprises one or more compounds selected from the group comprising alginates, pectins, starches (and derivatives), celluloses (and derivatives), gums, silica or silicones compounds, clays, polyvinyl alcohol and combinations thereof. For example, in some embodiments, the gelling agent comprises one or more of alginates, pectins, hydroxyethyl cellulose, hydroxypropyl cellulose, carboxymethylcellulose, pullulan, xanthan gum guar gum, carrageenan, agarose, acacia gum, fumed silica, PDMS, sodium silicate, kaolin and polyvinyl alcohol. In some cases, the gelling agent comprises alginate and/or pectin, and may be combined with a setting agent (such as a calcium source) during formation of the amorphous solid. In some cases, the amorphous solid may comprise a calcium-crosslinked alginate and/or a calcium-crosslinked pectin.

In some embodiments, the gelling agent comprises alginate, and the alginate is present in the amorphous solid in an amount of from 10-30wt% of the amorphous solid (calculated on a dry weight basis). In some embodiments, alginate is the only gelling agent present in the amorphous solid. In other embodiments, the gelling agent comprises alginate and at least one further gelling agent, such as pectin.

In some embodiments the amorphous solid may include gelling agent comprising carrageenan.

Suitably, the amorphous solid may comprise from about 5wt%, 10wt%, 15wt%, or 20wt% to about 80wt%, 70wt%, 60wt%, 55wt%, 50wt%, 45wt% 40wt%, or 35wt% of an aerosol generating agent (all calculated on a dry weight basis). The aerosol generating agent may act as a plasticiser. For example, the amorphous solid may comprise 5-60wt%, 10-50wt% or 20-40wt% of an aerosol generating agent. In some cases, the aerosol generating agent comprises one or more compound selected from erythritol, propylene glycol, glycerol, triacetin, sorbitol and xylitol. In some cases, the aerosol generating agent comprises, consists essentially of or consists of glycerol. The inventors have established that if the content of the plasticiser is too high, the amorphous solid may absorb water resulting in a material that does not create an appropriate consumption experience in use. The inventors have established that if the plasticiser content is too low, the amorphous solid may be brittle and easily broken. The plasticiser content specified herein provides an amorphous solid flexibility which allows the amorphous solid sheet to be wound onto a bobbin, which is useful in manufacture of aerosol generating articles.

In some cases, the amorphous solid may comprise a flavour. Suitably, the amorphous solid may comprise up to about 60wt%, 50wt%, 40wt%, 30wt%, 20wt%, 10wt% or 5wt% of a flavour. In some cases, the amorphous solid may comprise at least about 0.1wt%, 0.5wt%, 1wt%, 2wt%, 5wt% 10wt%, 20wt% or 30wt% of a flavour (all calculated on a dry weight basis). For example, the amorphous solid may comprise 0.1-60wt%, 1-60wt%, 5-60wt%, 10-60wt%, 20-50wt% or 30-40wt% of a flavour. In some cases, the flavour (if present) comprises, consists essentially of or consists of menthol. In some cases, the amorphous solid does not comprise a flavour.

In some cases, the amorphous solid additionally comprises an active substance. For example, in some cases, the amorphous solid additionally comprises powdered tobacco and/or nicotine and/or a tobacco extract. In some cases, the amorphous solid may comprise from about 1wt%, 5wt%, 10wt%, 15wt%, 20wt% or 25wt% to about 70wt%, 50wt%, 45wt% or 40wt% (calculated on a dry weight basis) of active substance. In some cases, the amorphous solid may comprise from about 1wt%, 5wt%, 10wt%, 15wt%, 20wt% or 25wt% to about 70wt%, 60wt%, 50wt%, 45wt% or 40wt% (calculated on a dry weight basis) of a tobacco material and/or nicotine.

In some cases, the amorphous solid comprises an active substance such as tobacco extract. In some cases, the amorphous solid may comprise 5-60wt% (calculated on a dry weight basis) of tobacco extract. In some cases, the amorphous solid may comprise from about 5wt%, 10wt%, 15wt%, 20wt% or 25wt% to about 55wt%, 50wt%, 45wt% or 40wt% (calculated on a dry weight basis) tobacco extract.

For example, the amorphous solid may comprise 5-60wt%, 10-55wt% or 25-55wt% of tobacco extract. The tobacco extract may contain nicotine at a concentration such that the amorphous solid comprises 1wt% 1.5wt%, 2wt% or 2.5wt% to about 6wt%, 5wt%, 4.5wt% or 4wt% (calculated on a dry weight basis) of nicotine. In some cases, there may be no nicotine in the amorphous solid other than that which results from the tobacco extract.

In some embodiments the amorphous solid comprises no tobacco material but does comprise nicotine. In some such cases, the amorphous solid may comprise from about 1wt%, 2wt%, 3wt% or 4wt% to about 20wt%, 15wt%, 10wt% or 5wt% (calculated on a dry weight basis) of nicotine. For example, the amorphous solid may comprise 1-20wt% or 2-5wt% of nicotine.

In some cases, the total content of active substance and/or flavour may be at least about 0.1wt%, 1wt%, 5wt%, 10wt%, 20wt%, 25wt% or 30wt%. In some cases, the total content of active substance and/or flavour may be less than about 80wt%, 70wt%, 60wt%, 50wt% or 40wt% (all calculated on a dry weight basis).

In some cases, the total content of tobacco material, nicotine and flavour may be at least about 0.1wt%, 1wt%, 5wt%, 10wt%, 20wt%, 25wt% or 30wt%. In some cases, the total content of tobacco material, nicotine and flavour may be less than about 80wt%, 70wt%, 60wt%, 50wt% or 40wt% (all calculated on a dry weight basis).

In some embodiments, the amorphous solid is a hydrogel and comprises less than about 20wt% of water calculated on a wet weight basis. In some cases, the hydrogel may comprise less than about 15wt%, 12wt% or 10 wt% of water calculated on a wet weight basis (WWB). In some cases, the hydrogel may comprise at least about 2wt% or at least about 5wt% of water (WWB).

In some embodiments, the amorphous solid comprises from about 1wt% to about 15wt% water, or from about 5wt% to about 15wt% water, calculated on a wet weight basis. Suitably, the water content of the amorphous solid may be from about

5wt%, 7wt% or 9wt% to about 15wt%, 13wt% or 11wt% (WWB), most suitably about 10wt%.

The amorphous solid may be made from a gel, and this gel may additionally comprise a solvent, included at 0.1-50wt%. However, the inventors have established that the inclusion of a solvent in which the flavour is soluble may reduce the gel stability and the flavour may crystallise out of the gel. As such, in some cases, the gel does not include a solvent in which the flavour is soluble.

In some embodiments, the amorphous solid comprises less than 60wt% of a filler, such as from 1wt% to 60wt%, or 5wt% to 50wt%, or 5wt% to 30wt%, or 10wt% to 20wt%.

In other embodiments, amorphous solid comprises less than 20wt%, suitably less than 10wt% or less than 5wt% of a filler. In some cases, the amorphous solid comprises less than 1wt% of a filler, and in some cases, comprises no filler.

The filler, if present, may comprise one or more inorganic filler materials, such as calcium carbonate, perlite, vermiculite, diatomaceous earth, colloidal silica, magnesium oxide, magnesium sulphate, magnesium carbonate, and suitable inorganic sorbents, such as molecular sieves. The filler may comprise one or more organic filler materials such as wood pulp, cellulose and cellulose derivatives. In particular cases, the amorphous solid comprises no calcium carbonate such as chalk.

In particular embodiments which include filler, the filler is fibrous. For example, the filler may be a fibrous organic filler material such as wood pulp, hemp fibre, cellulose or cellulose derivatives. Without wishing to be bound by theory, it is believed that including fibrous filler in an amorphous solid may increase the tensile strength of the material. This may be particularly advantageous in examples wherein the amorphous solid is provided as a sheet, such as when an amorphous solid sheet circumscribes a rod of aerosolisable material.

In some embodiments, the amorphous solid does not comprise tobacco fibres. In particular embodiments, the amorphous solid does not comprise fibrous material.

In some embodiments, the aerosol generating material does not comprise tobacco fibres. In particular embodiments, the aerosol generating material does not comprise fibrous material.

In some embodiments, the aerosol generating substrate does not comprise tobacco fibres. In particular embodiments, the aerosol generating substrate does not comprise fibrous material.

In some embodiments, the aerosol generating article does not comprise tobacco fibres. In particular embodiments, the aerosol generating article does not comprise fibrous material.

In some cases, the amorphous solid may consist essentially of, or consist of a gelling agent, an aerosol generating agent, an active substance, water, and optionally a flavour.

In some cases, the amorphous solid may consist essentially of, or consist of a gelling agent, an aerosol generating agent, a tobacco material and/or a nicotine source, water, and optionally a flavour.

The aerosol generating material comprising the amorphous solid may have any suitable area density, such as from 30 g/m^2 to 120 g/m^2. In some embodiments, aerosol generating material may have an area density of from about 30 to 70 g/m^2, or about 40 to 60 g/m^2. In some embodiments, the amorphous solid may have an area density of from about 80 to 120 g/m^2, or from about 70 to 110 g/m^2, or particularly from about 90 to 110 g/m^2. Such area densities may be particularly suitable where the aerosol-generating material is included in an aerosol generating article/assembly in sheet form, or as a shredded sheet (described further hereinbelow).

AEROSOL GENERATING ARTICLE AND ASSEMBLY

The aerosol generating assembly comprises a heater configured to heat but nor burn the aerosol-forming substrate. The heater may be, in some cases, a thin film, electrically resistive heater. In other cases, the heater may comprise an induction heater or the like. The heater may be a combustible heat source or a chemical heat source which undergoes an exothermic reaction to product heat in use. The aerosol generating assembly may comprise a plurality of heaters. The heater(s) may be powered by a battery.

In some cases, the heater may heat, without burning, the aerosolisable material(s) to between 120°C and 350°C in use. In some cases, the heater may heat, without burning, the aerosolisable material(s) to between 140°C and 250°C in use. In some cases in use, substantially all of the amorphous solid is less than about 4mm, 3mm, 2mm or 1mm from the heater. In some cases, the amorphous solid is disposed between about 0.010mm and 2.0mm from the heater, suitably between about 0.1mm and 1.0mm. In some cases, a surface of the amorphous solid may directly abut the heater.

The aerosol generating article or the aerosol generating assembly may additionally comprise a cooling element and/or a filter. The cooling element, if present, may act or function to cool gaseous or aerosol components. In some cases, it may act to cool gaseous components such that they condense to form an aerosol. It may also act to space the very hot parts of the apparatus from the user. The filter, if present, may comprise any suitable filter known in the art such as a cellulose acetate plug.

The aerosol generating article may additionally comprise ventilation apertures provided in a sidewall of the article. In some cases, the ventilation apertures may be provided in the filter and/or cooling element. These apertures may allow cool air to be drawn into the article during use, which can mix with the heated volatilised components thereby cooling the aerosol.

The ventilation enhances the generation of visible heated volatilised components from the article when it is heated in use. The heated volatilised components are made visible by the process of cooling the heated volatilised components such that supersaturation of the heated volatilised components occurs. The heated volatilised components then undergo droplet formation, otherwise known as nucleation, and eventually the size of the aerosol particles of the heated volatilised components increases by further condensation of the heated volatilised components and by coagulation of newly formed droplets from the heated volatilised components.

In some cases, the ratio of the cool air to the sum of the heated volatilised components and the cool air, known as the ventilation ratio, is at least 15%. A ventilation ratio of 15% enables the heated volatilised components to be made visible by the method described above. The visibility of the heated volatilised components enables the user to identify that the volatilised components have been generated and adds to the sensory experience of the smoking experience.

In another example, the ventilation ratio is between 50% and 85% to provide additional cooling to the heated volatilised components. In some cases, the ventilation ratio may be at least 60% or 65%.

In some cases, the aerosol generating assembly may be a heat-not-burn device. That is, it may contain a solid tobacco-containing material (and no liquid aerosolisable material). In some cases, the amorphous solid may comprise the tobacco material. A heat-not-burn device is disclosed in WO 2015/062983 A2.

In some cases, the aerosol generating assembly may be an electronic tobacco hybrid device. That is, it may contain a solid aerosolisable material and a liquid aerosolisable material. In some cases, the amorphous solid may comprise nicotine. In some cases, the amorphous solid may comprise a tobacco material. In some cases, the amorphous solid may comprise a tobacco material and a separate nicotine source. The separate aerosolisable materials may be heated by separate heaters, the same heater or, in one case, a downstream aerosolisable material may be heated by a hot aerosol which is generated from the upstream aerosolisable material. An electronic tobacco hybrid device is disclosed in WO 2016/135331 A1.

Referring to Figures 3 and 4, there are shown a partially cut-away section view and a perspective view of an example of an aerosol generating article 101. The article 101 is adapted for use with a device having a power source and a heater. The article 101 of this embodiment is particularly suitable for use with the device 51 shown in Figures 7 to 9, described below. In use, the article 101 may be removably inserted into the device shown in Figure 7 at an insertion point 20 of the device 51.

The article 101 of one example is in the form of a substantially cylindrical rod that includes an aerosol-forming substrate 103 as defined herein and a filter assembly 105 in the form of a rod. As shown in the figures, in this example the aerosol-forming substrate is in the form of a tube (but, in other non-illustrated embodiments, may be incorporated into the article 101 in other forms). The aerosol-forming material is provided on the inside surface of the tube. As shown in figures 7 to 9, this tubular substrate is placed in heating chamber in an aerosol generating assembly, so that heat is supplied to the substrate from the outside of the tube in use.

The filter assembly 105 includes three segments, a cooling segment 107, a filter segment 109 and a mouth end segment 111. The article 101 has a first end 113, also known as a mouth end or a proximal end and a second end 115, also known as a distal end. The aerosol-forming substrate 103 is located towards the distal end 115 of the article 101. In one example, the cooling segment 107 is located adjacent to the aerosol-forming substrate 103 between the aerosol-forming substrate 103 and the filter segment 109, such that the cooling segment 107 is in an abutting relationship with the aerosol-forming substrate 103 and the filter segment 103. In other examples, there may be a separation between the aerosol-forming substrate 103 and the cooling segment 107 and between the aerosol-forming substrate 103 and the filter segment 109. The filter segment 109 is located in between the cooling segment 107 and the mouth end segment

111. The mouth end segment 111 is located towards the proximal end 113 of the article 101, adjacent the filter segment 109. In one example, the filter segment 109 is in an abutting relationship with the mouth end segment 111. In one embodiment, the total length of the filter assembly 105 is between 37mm and 45mm, more preferably, the total length of the filter assembly 105 is 41mm.

In one example, the aerosol-forming substrate 103 is between 34mm and 50mm in length, suitably between 38mm and 46mm in length, suitably 42mm in length.

In one example, the total length of the article 101 is between 71mm and 95mm, suitably between 79mm and 87mm, suitably 83mm.

The aerosol-forming substrate 103 is joined to the filter assembly 105 by annular tipping paper (not shown), which is located substantially around the circumference of the filter assembly 105 to surround the filter assembly 105 and extends partially along the length of the aerosol-forming substrate 103. In one example, the tipping paper is made of 58GSM standard tipping base paper. In one example the tipping paper has a length of between 42mm and 50mm, suitably of 46mm.

In one example, the cooling segment 107 is an annular tube and is located around and defines an air gap within the cooling segment. The air gap provides a chamber for heated volatilised components generated from the aerosol-forming substrate 103 to flow. The cooling segment 107 is hollow to provide a chamber for aerosol accumulation yet rigid enough to withstand axial compressive forces and bending moments that might arise during manufacture and whilst the article 101 is in use during insertion into the device 51. In one example, the thickness of the wall of the cooling segment 107 is approximately 0.29mm.

The cooling segment 107 provides a physical displacement between the aerosol-forming substrate 103 and the filter segment 109. The physical displacement provided by the cooling segment 107 will provide a thermal gradient across the length of the cooling segment 107. In one example the cooling segment 107 is configured to provide a temperature differential of at least 40 degrees Celsius between a heated volatilised component entering a first end of the cooling segment 107 and a heated volatilised component exiting a second end of the cooling segment 107. In one example the cooling segment 107 is configured to provide a temperature differential of at least 60 degrees Celsius between a heated volatilised component entering a first end of the cooling segment 107 and a heated volatilised component exiting a second end of the cooling segment 107. This temperature differential across the length of the cooling element 107 protects the temperature sensitive filter segment 109 from the high temperatures of the aerosol-forming substrate 103 when it is heated by the device 51. If the physical displacement was not provided between the filter segment 109 and the aerosol-forming substrate 103 and the heating elements of the device 51, then the temperature sensitive filter segment may 109 become damaged in use, so it would not perform its required functions as effectively.

In one example the length of the cooling segment 107 is at least 15mm. In one example, the length of the cooling segment 107 is between 20mm and 30mm, more particularly 23mm to 27mm, more particularly 25mm to 27mm, suitably 25mm.

The cooling segment 107 is made of paper, which means that it is comprised of a material that does not generate compounds of concern, for example, toxic compounds when in use adjacent to the heater of the device 51. In one example, the cooling segment 107 is manufactured from a spirally wound paper tube which provides a hollow internal chamber yet maintains mechanical rigidity. Spirally wound paper tubes are able to meet the tight dimensional accuracy requirements of high-speed manufacturing processes with respect to tube length, outer diameter, roundness and straightness.

In another example, the cooling segment 107 is a recess created from stiff plug wrap or tipping paper. The stiff plug wrap or tipping paper is manufactured to have a rigidity that is sufficient to withstand the axial compressive forces and bending moments that might arise during manufacture and whilst the article 101 is in use during insertion into the device 51.

The filter segment 109 may be formed of any filter material sufficient to remove one or more volatilised compounds from heated volatilised components from the aerosol-forming substrate. In one example the filter segment 109 is made of a mono-acetate material, such as cellulose acetate. The filter segment 109 provides cooling and irritation-reduction from the heated volatilised components without depleting the quantity of the heated volatilised components to an unsatisfactory level for a user.

In some embodiments, a capsule (not illustrated) may be provided in filter segment 109. It may be disposed substantially centrally in the filter segment 109, both across the filter segment 109 diameter and along the filter segment 109 length. In other cases, it may be offset in one or more dimension. The capsule may in some cases, where present, contain a volatile component such as a flavourant or aerosol generating agent.

The density of the cellulose acetate tow material of the filter segment 109 controls the pressure drop across the filter segment 109, which in turn controls the draw resistance of the article 101. Therefore the selection of the material of the filter segment 109 is important in controlling the resistance to draw of the article 101. In addition, the filter segment performs a filtration function in the article 101.

In one example, the filter segment 109 is made of a 8Y15 grade of filter tow material, which provides a filtration effect on the heated volatilised material, whilst also reducing the size of condensed aerosol droplets which result from the heated volatilised material.

The presence of the filter segment 109 provides an insulating effect by providing further cooling to the heated volatilised components that exit the cooling segment 107. This further cooling effect reduces the contact temperature of the user's lips on the surface of the filter segment 109.

In one example, the filter segment 109 is between 6mm to 10mm in length, suitably 8mm.

The mouth end segment 111 is an annular tube and is located around and defines an air gap within the mouth end segment 111. The air gap provides a chamber for heated volatilised components that flow from the filter segment 109. The mouth end segment 111 is hollow to provide a chamber for aerosol accumulation yet rigid enough to withstand axial compressive forces and bending moments that might arise during manufacture and whilst the article is in use during insertion into the device 51. In one example, the thickness of the wall of the mouth end segment 111 is approximately 0.29mm. In one example, the length of the mouth end segment 111 is between 6mm to 10mm, suitably 8mm.

The mouth end segment 111 may be manufactured from a spirally wound paper tube which provides a hollow internal chamber yet maintains critical mechanical rigidity. Spirally wound paper tubes are able to meet the tight dimensional accuracy requirements of high-speed manufacturing processes with respect to tube length, outer diameter, roundness and straightness.

The mouth end segment 111 provides the function of preventing any liquid condensate that accumulates at the exit of the filter segment 109 from coming into direct contact with a user.

It should be appreciated that, in one example, the mouth end segment 111 and the cooling segment 107 may be formed of a single tube and the filter segment 109 is located within that tube separating the mouth end segment 111 and the cooling segment 107.

Referring to Figures 5 and 6, there are shown a partially cut-away section and perspective views of an example of an article 301. The reference signs shown in Figures 5 and 6 are equivalent to the reference signs shown in Figures 3 and 4, but with an increment of 200.

In the example of the article 301 shown in Figures 5 and 6, a ventilation region 317 is provided in the article 301 to enable air to flow into the interior of the article 301 from the exterior of the article 301. In one example the ventilation region 317 takes the form of one or more ventilation holes 317 formed through the outer layer of the article 301. The ventilation holes may be located in the cooling segment 307 to aid with the cooling of the article 301. In one example, the ventilation region 317 comprises one or more rows of holes, and preferably, each row of holes is arranged circumferentially around the article 301 in a cross-section that is substantially perpendicular to a longitudinal axis of the article 301.

In one example, there are between one to four rows of ventilation holes to provide ventilation for the article 301. Each row of ventilation holes may have between 12 to 36 ventilation holes 317. The ventilation holes 317 may, for example, be between 100 to 500μm in diameter. In one example, an axial separation between rows of ventilation holes 317 is between 0.25mm and 0.75mm, suitably 0.5mm.

In one example, the ventilation holes 317 are of uniform size. In another example, the ventilation holes 317 vary in size. The ventilation holes can be made using any suitable technique, for example, one or more of the following techniques: laser technology, mechanical perforation of the cooling segment 307 or pre-perforation of the cooling segment 307 before it is formed into the article 301. The ventilation holes 317 are positioned so as to provide effective cooling to the article 301.

In one example, the rows of ventilation holes 317 are located at least 11mm from the proximal end 313 of the article, suitably between 17mm and 20mm from the proximal end 313 of the article 301. The location of the ventilation holes 317 is positioned such that user does not block the ventilation holes 317 when the article 301 is in use.

Providing the rows of ventilation holes between 17mm and 20mm from the proximal end 313 of the article 301 enables the ventilation holes 317 to be located outside of the device 51, when the article 301 is fully inserted in the device 51, as can be seen in Figures 8 and 9. By locating the ventilation holes outside of the device, non-heated air is able to enter the article 301 through the ventilation holes from outside the device 51 to aid with the cooling of the article 301.

The length of the cooling segment 307 is such that the cooling segment 307 will be partially inserted into the device 51, when the article 301 is fully inserted into the device 51. The length of the cooling segment 307 provides a first function of providing a physical gap between the heater arrangement of the device 51 and the heat sensitive filter arrangement 309, and a second function of enabling the ventilation holes 317 to be located in the cooling segment, whilst also being located outside of the device 51, when the article 301 is fully inserted into the device 51. As can be seen from Figures 8 and 9, the majority of the cooling element 307 is located within the device 51. However, there is a portion of the cooling element 307 that extends out of the device 51. It is in this portion of the cooling element 307 that extends out of the device 51 in which the ventilation holes 317 are located.

Referring now to Figures 7 to 9 in more detail, there is shown an example of a device 51 arranged to heat an aerosol generating material to volatilise at least one component of said aerosol generating material, typically to form an aerosol which can be inhaled. The device 51 is a heating device which releases compounds by heating, but not burning, the aerosol generating material.

A first end 53 is sometimes referred to herein as the mouth or proximal end 53 of the device 51 and a second end 55 is sometimes referred to herein as the distal end 55 of the device 51. The device 51 has an on/off button 57 to allow the device 51 as a whole to be switched on and off as desired by a user.

The device 51 comprises a housing 59 for locating and protecting various internal components of the device 51. In the example shown, the housing 59 comprises a uni-body sleeve 11 that encompasses the perimeter of the device 51, capped with a top panel 17 which defines generally the ‘top’ of the device 51 and a bottom panel 19 which defines generally the ‘bottom’ of the device 51. In another example the housing comprises a front panel, a rear panel and a pair of opposite side panels in addition to the top panel 17 and the bottom panel 19.

The top panel 17 and/or the bottom panel 19 may be removably fixed to the uni-body sleeve 11, to permit easy access to the interior of the device 51, or may be "permanently" fixed to the uni-body sleeve 11, for example to deter a user from accessing the interior of the device 51. In an example, the panels 17 and 19 are made of a plastics material, including for example glass-filled nylon formed by injection moulding, and the uni-body sleeve 11 is made of aluminium, though other materials and other manufacturing processes may be used.

The top panel 17 of the device 51 has an opening 20 at the mouth end 53 of the device 51 through which, in use, the article 101, 301 including the aerosol-forming substrate may be inserted into the device 51 and removed from the device 51 by a user.

The housing 59 has located or fixed therein a heater arrangement 23, control circuitry 25 and a power source 27. In this example, the heater arrangement 23, the control circuitry 25 and the power source 27 are laterally adjacent (that is, adjacent when viewed from an end), with the control circuitry 25 being located generally between the heater arrangement 23 and the power source 27, though other locations are possible.

The control circuitry 25 may include a controller, such as a microprocessor arrangement, configured and arranged to control the heating of the aerosol-forming substrate in the article 101, 301 as discussed further below.

The power source 27 may be for example a battery, which may be a rechargeable battery or a non-rechargeable battery. Examples of suitable batteries include for example a lithium-ion battery, a nickel battery (such as a nickel–cadmium battery), an alkaline battery and/ or the like. The battery 27 is electrically coupled to the heater arrangement 23 to supply electrical power when required and under control of the control circuitry 25 to heat the aerosol-forming substrate in the article (as discussed, to volatilise the aerosol-forming compositions without causing them to burn).

An advantage of locating the power source 27 laterally adjacent to the heater arrangement 23 is that a physically large power source 25 may be used without causing the device 51 as a whole to be unduly lengthy. As will be understood, in general a physically large power source 25 has a higher capacity (that is, the total electrical energy that can be supplied, often measured in Amp-hours or the like) and thus the battery life for the device 51 can be longer.

In one example, the heater arrangement 23 is generally in the form of a hollow cylindrical tube, having a hollow interior heating chamber 29 into which the article 101, 301 comprising the aerosol-forming substrate is inserted for heating in use. In the illustrated assembly, the aerosol-forming substrate is tubular, with the aerosol forming material disposed on the interior surface of the tube.

Different arrangements for the heater arrangement 23 are possible. For example, the heater arrangement 23 may comprise a single heating element or may be formed of plural heating elements aligned along the longitudinal axis of the heater arrangement 23. The or each heating element may be annular or tubular, or at least part-annular or part-tubular around its circumference. In an example, the or each heating element may be a thin film heater. In another example, the or each heating element may be made of a ceramics material. Examples of suitable ceramics materials include alumina and aluminium nitride and silicon nitride ceramics, which may be laminated and sintered. Other heating arrangements are possible, including for example inductive heating, infrared heater elements, which heat by emitting infrared radiation, or resistive heating elements formed by for example a resistive electrical winding.

In another example (not illustrated), the heater may be in the form of a blade or rod which is inserted into the hollow tube of a tubular aerosol-forming substrate 103, 303. In such an example, the aerosol forming material may be disposed on the outside surface of the tube.

In one particular example, the heater arrangement 23 is supported by a stainless steel support tube and comprises a polyimide heating element. The heater arrangement 23 is dimensioned so that substantially the whole of the aerosol-forming substrate 103, 303 of the article 101, 301 is inserted into the heater arrangement 23 when the article 101, 301 is inserted into the device 51.

The or each heating element may be arranged so that selected zones of the aerosol-forming substrate can be independently heated, for example in turn (over time, as discussed above) or together (simultaneously) as desired.

The heater arrangement 23 in this example is surrounded along at least part of its length by a thermal insulator 31. The insulator 31 helps to reduce heat passing from the heater arrangement 23 to the exterior of the device 51. This helps to keep down the power requirements for the heater arrangement 23 as it reduces heat losses generally. The insulator 31 also helps to keep the exterior of the device 51 cool during operation of the heater arrangement 23. In one example, the insulator 31 may be a double-walled sleeve which provides a low pressure region between the two walls of the sleeve. That is, the insulator 31 may be for example a "vacuum" tube, i.e. a tube that has been at least partially evacuated so as to minimise heat transfer by conduction and/or convection. Other arrangements for the insulator 31 are possible, including using heat insulating materials, including for example a suitable foam-type material, in addition to or instead of a double-walled sleeve.

The housing 59 may further comprises various internal support structures 37 for supporting all internal components, as well as the heating arrangement 23.

The device 51 further comprises a collar 33 which extends around and projects from the opening 20 into the interior of the housing 59 and a generally tubular chamber 35 which is located between the collar 33 and one end of the vacuum sleeve 31. The chamber 35 further comprises a cooling structure 35f, which in this example, comprises a plurality of cooling fins 35f spaced apart along the outer surface of the chamber 35, and each arranged circumferentially around outer surface of the chamber 35. There is an air gap 36 between the hollow chamber 35 and the article 101, 301 when it is inserted in the device 51 over at least part of the length of the hollow chamber 35. The air gap 36 is around all of the circumference of the article 101, 301 over at least part of the cooling segment 307.

The collar 33 comprises a plurality of ridges 60 arranged circumferentially around the periphery of the opening 20 and which project into the opening 20. The ridges 60 take up space within the opening 20 such that the open span of the opening 20 at the locations of the ridges 60 is less than the open span of the opening 20 at the locations without the ridges 60. The ridges 60 are configured to engage with an article 101, 301 inserted into the device to assist in securing it within the device 51. Open spaces (not shown in the Figures) defined by adjacent pairs of ridges 60 and the article 101, 301 form ventilation paths around the exterior of the article 101, 301. These ventilation paths allow hot vapours that have escaped from the article 101, 301 to exit the device 51 and allow cooling air to flow into the device 51 around the article 101, 301 in the air gap 36.

In operation, the article 101, 301 is removably inserted into an insertion point 20 of the device 51, as shown in Figures 7 to 9. Referring particularly to Figure 8, in one example, the aerosol-forming substrate 103, 303, which is located towards the distal end 115, 315 of the article 101, 301, is entirely received within the heater arrangement 23 of the device 51. The proximal end 113, 313 of the article 101, 301 extends from the device 51 and acts as a mouthpiece assembly for a user.

In operation, the heater arrangement 23 will heat the article 101, 301 to volatilise at least one component of the aerosol-forming substrate 103, 303.

The primary flow path for the heated volatilised components from the aerosol-forming substrate 103, 303 is axially through the article 101, 301. In examples, such as that illustrated in figures 7 to 9, where the aerosol-forming substrate 103, 303 is tubular, the heated volatilised components from the aerosol-forming substrate flow through the hollow tube. The heated volatilised components then flow through the chamber inside the cooling segment 107, 307, through the filter segment 109, 309, through the mouth end segment 111, 313 to the user.

In one example, the temperature of the heated volatilised components that are generated from the tubular substrate is between 60°C and 250°C, which may be above the acceptable inhalation temperature for a user. As the heated volatilised component travels through the cooling segment 107, 307, it will cool and some volatilised components will condense on the inner surface of the cooling segment 107, 307.

In the examples of the article 301 shown in Figures 5 and 6, cool air will be able to enter the cooling segment 307 via the ventilation holes 317 formed in the cooling segment 307. This cool air will mix with the heated volatilised components to provide additional cooling to the heated volatilised components.

METHOD OF MANUFACTURE

A fourth aspect of the invention provides a method of making an aerosol-forming substrate according to the first aspect, the method comprising (a) forming a slurry comprising components of the amorphous solid or precursors thereof, (b) applying the slurry to the carrier, (c) setting slurry to form a gel and (d) drying to form an amorphous solid.

The step (b) of forming a layer of the slurry may comprise spraying, casting or extruding the slurry, for example. In some cases, the layer is formed by electrospraying the slurry. In some cases, the layer is formed by casting the slurry.

In some cases, the steps (b) and/or (c) and/or (d) may, at least partially, occur simultaneously (for example, during electrospraying). In some cases, these steps may occur sequentially.

In some cases, the vents are provided in the aerosol-forming material during step (b). This may be achieved through, for example, the use of a mould during, e.g. casting, which provides for the formation of apertures, or by the varying of the cast thickness by varying the height of an opening through which the cast passes to provide thinner portions which may act as burst points.

In other cases, the method further comprises a step (e) subsequent to step (d), step (e) comprising forming the vents in the amorphous solid. In some cases, step (e) comprises cutting the aerosol-forming material to provide apertures and/or burst points in the aerosol-forming material. For example, the cutting step may employ one or more of a laser, an air jet, a water jet and a sharp implement.

The step (c) of setting the gel may comprise the addition of a setting agent to the slurry. For example, the slurry may comprise sodium, potassium or ammonium alginate as a gel-precursor, and a setting agent comprising a calcium source (such as calcium chloride), may be added to the slurry to form a calcium alginate gel.

The total amount of the setting agent, such as a calcium source, may be 0.5-5wt% (calculated on a dry weight basis). The inventors have found that the addition of too little setting agent may result in a gel which does not stabilise the gel components and results in these components dropping out of the gel. The inventors have found that the addition of too much setting agent results in a gel that is very tacky and consequently has poor handleability.

Alginate salts are derivatives of alginic acid and are typically high molecular weight polymers (10-600 kDa). Alginic acid is a copolymer of β-D-mannuronic (M) and α-L-guluronic acid (G) units (blocks) linked together with (1,4)-glycosidic bonds to form a polysaccharide. On addition of calcium cations, the alginate crosslinks to form a gel. The inventors have determined that alginate salts with a high G monomer content more readily form a gel on addition of the calcium source. In some cases therefore, the gel-precursor pay comprise an alginate salt in which at least about 40%, 45%, 50%, 55%, 60% or 70% of the monomer units in the alginate copolymer are α-L-guluronic acid (G) units.

The slurry itself may also form part of the invention. In some cases, the slurry solvent may consist essentially of or consist of water. In some cases, the slurry may comprise from about 50wt%, 60wt%, 70wt%, 80wt% or 90wt% of solvent (WWB).

In some examples, the slurry has a viscosity of from about 10 to about 20 Pa·s at 46.5 °C, such as from about 14 to about 16 Pa·s at 46.5 °C.

In cases where the solvent consists of water, the dry weight content of the slurry may match the dry weight content of the amorphous solid. Thus, the discussion herein relating to the solid composition is explicitly disclosed in combination with the slurry aspect of the invention.

EXEMPLARY EMBODIMENTS

In some embodiments, the amorphous solid comprises menthol.

Particular embodiments comprising a menthol-containing amorphous solid may be particularly suitable for including in an aerosol generating article/assembly as a shredded sheet. In these embodiments, the amorphous solid may have the following composition (DWB): gelling agent (preferably comprising alginate, more preferably comprising a combination of alginate and pectin) in an amount of from about 20wt% to about 40wt%, or about 25wt% to 35wt%; menthol in an amount of from about 35wt% to about 60wt%, or from about 40wt% to 55wt%; aerosol generating agent (preferably comprising glycerol) in an amount of from about 10wt% to about 30wt%, or from about 15wt% to about 25wt% (DWB).

In one embodiment, the amorphous solid comprises about 32-33wt% of an alginate/pectin gelling agent blend; about 47-48wt% menthol flavourant; and about 19-20wt% glycerol aerosol generating agent (DWB).

The amorphous solid of these embodiments may have any suitable water content. For example, the amorphous solid may have a water content of from about 2wt% to about 10wt%, or from about 5wt% to about 8wt%, or about 6wt%.

As noted above, the amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a shredded sheet. The shredded sheet may be provided in the article/assembly blended with cut tobacco. Alternatively, the amorphous solid may be provided as a non-shredded sheet. Suitably, the shredded or non-shredded sheet has a thickness of from about 0.015mm to about 1mm, preferably from about 0.02mm to about 0.07mm.

Particular embodiments of the menthol-containing amorphous solid may be particularly suitable for including in an aerosol generating article/assembly as a sheet, such as a sheet circumscribing a rod of aerosolisable material (e.g. tobacco). In these embodiments, the amorphous solid may have the following composition (DWB): gelling agent (preferably comprising alginate, more preferably comprising a combination of alginate and pectin) in an amount of from about 5wt% to about 40wt%, or about 10wt% to 30wt%; menthol in an amount of from about 10wt% to about 50wt%, or from about 15wt% to 40wt%; aerosol generating agent (preferably comprising glycerol) in an amount of from about 5wt% to about 40wt%, or from about 10wt% to about 35wt%; and optionally filler in an amount of up to 60wt% - for example, in an amount of from 5wt% to 20wt%, or from about 40wt% to 60wt% (DWB).

In one of these embodiments, the amorphous solid comprises about 11wt% of an alginate/pectin gelling agent blend, about 56wt% woodpulp filler, about 18% menthol flavourant and about 15wt% glycerol (DWB).

In another of these embodiments, the amorphous solid comprises about 22wt% of an alginate/pectin gelling agent blend, about 12wt% woodpulp filler, about 36% menthol flavourant and about 30wt% glycerol (DWB).

As noted above, the amorphous solid of these embodiments may be included as a sheet. In one embodiment, the sheet is provided on a carrier comprising paper. In one embodiment, the sheet is provided on a carrier comprising metal foil, suitably aluminium metal foil. In this embodiment, the amorphous solid may abut the metal foil. In one embodiment, the sheet forms part of a laminate material with a layer (preferably comprising paper) attached to a top and bottom surface of the sheet. Suitably, the sheet of amorphous solid has a thickness of from about 0.015mm to about 1mm.

In some embodiments, the amorphous solid comprises a flavourant which does not comprise menthol. In these embodiments, the amorphous solid may have the following composition (DWB): gelling agent (preferably comprising alginate) in an amount of from about 5 to about 40wt%, or from about 10wt% to about 35wt%, or from about 20wt% to about 35wt%; flavourant in an amount of from about 0.1wt% to about 40wt%, of from about 1wt% to about 30wt%, or from about 1wt% to about 20wt%, or from about 5wt% to about 20wt%; aerosol generating agent (preferably comprising glycerol) in an amount of from 15wt% to 75wt%, or from about 30wt% to about 70wt%, or from about 50wt% to about 65wt%; and optionally filler (suitably woodpulp) in an amount of less than about 60wt%, or about 20wt%, or about 10wt%, or about 5wt% (preferably the amorphous solid does not comprise filler) (DWB).

In one of these embodiments, the amorphous solid comprises about 27wt% alginate gelling agent, about 14wt% flavourant and about 57wt% glycerol aerosol generating agent (DWB).

In another of these embodiments, the amorphous solid comprises about 29wt% alginate gelling agent, about 9wt% flavourant and about 60wt% glycerol (DWB).

The amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a shredded sheet, optionally blended with cut tobacco. Alternatively, the amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a sheet, such as a sheet circumscribing a rod of aerosolisable material (e.g. tobacco). Alternatively, the amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a layer portion disposed on a carrier.

In some embodiments, the amorphous solid comprises tobacco extract. In these embodiments, the amorphous solid may have the following composition (DWB): gelling agent (preferably comprising alginate) in an amount of from about 5wt% to about 40wt%, or about 10wt% to 30wt%, or about 15wt% to about 25wt%; tobacco extract in an amount of from about 30wt% to about 60wt%, or from about 40wt% to 55wt%, or from about 45wt% to about 50wt%; aerosol generating agent (preferably comprising glycerol) in an amount of from about 10wt% to about 50wt%, or from about 20wt% to about 40wt%, or from about 25wt% to about 35wt% (DWB).

In one embodiment, the amorphous solid comprises about 20wt% alginate gelling agent, about 48wt% Virginia tobacco extract and about 32wt% glycerol (DWB).

The amorphous solid of these embodiments may have any suitable water content. For example, the amorphous solid may have a water content of from about 5wt% to about 15wt%, or from about 7wt% to about 13wt%, or about 10wt%.

The amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a shredded sheet, optionally blended with cut tobacco. Alternatively, the amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a sheet, such as a sheet circumscribing a rod of aerosolisable material (e.g. tobacco). Alternatively, the amorphous solid of these embodiments may be included in an aerosol generating article/assembly as a layer portion disposed on a carrier. Suitably, in any of these embodiments, the amorphous solid has a thickness of from about 50 μm to about 200 μm, or about 50 μm to about 100 μm, or about 60 μm to about 90 μm, suitably about 77 μm.

The slurry for forming this amorphous solid may also form part of the invention. In some cases, the slurry may have an elastic modulus of from about 5 to 1200 Pa (also referred to as storage modulus); in some cases, the slurry may have a viscous modulus of about 5 to 600 Pa (also referred to as loss modulus).

DEFINITIONS

The active substance as used herein may be a physiologically active material, which is a material intended to achieve or enhance a physiological response. The active substance may for example be selected from nutraceuticals, nootropics, psychoactives. The active substance may be naturally occurring or synthetically obtained. The active substance may comprise for example nicotine, caffeine, taurine, theine, vitamins such as B6 or B12 or C, melatonin, cannabinoids, or constituents, derivatives, or combinations thereof. The active substance may comprise one or more constituents, derivatives or extracts of tobacco, cannabis or another botanical.

In some embodiments, the active substance comprises nicotine.

In some embodiments, the active substance comprises caffeine, melatonin or vitamin B12.

As noted herein, the active substance may comprise one or more constituents, derivatives or extracts of cannabis, such as one or more cannabinoids or terpenes.

Cannabinoids are a class of natural or synthetic chemical compounds which act on cannabinoid receptors (i.e., CB1 and CB2) in cells that repress neurotransmitter release in the brain. Cannabinoids may be naturally occurring (phytocannabinoids) from plants such as cannabis, from animals (endocannabinoids), or artificially manufactured (synthetic cannabinoids). Cannabis species express at least 85 different phytocannabinoids, and are divided into subclasses, including cannabigerols, cannabichromenes, cannabidiols, tetrahydrocannabinols, cannabinols and cannabinodiols, and other cannabinoids. Cannabinoids found in cannabis include, without limitation: cannabigerol (CBG), cannabichromene (CBC), cannabidiol (CBD), tetrahydrocannabinol (THC), cannabinol (CBN), cannabinodiol (CBDL), cannabicyclol (CBL), cannabivarin (CBV), tetrahydrocannabivarin (THCV), cannabidivarin (CBDV), cannabichromevarin (CBCV), cannabigerovarin (CBGV), cannabigerol monomethyl ether (CBGM), cannabinerolic acid, cannabidiolic acid (CBDA), Cannabinol propyl variant (CBNV), cannabitriol (CBO), tetrahydrocannabmolic acid (THCA), and tetrahydrocannabivarinic acid (THCV A).

As noted herein, the active substance may comprise or be derived from one or more botanicals or constituents, derivatives or extracts thereof. As used herein, the term "botanical" includes any material derived from plants including, but not limited to, extracts, leaves, bark, fibres, stems, roots, seeds, flowers, fruits, pollen, husk, shells or the like. Alternatively, the material may comprise an active compound naturally existing in a botanical, obtained synthetically. The material may be in the form of liquid, gas, solid, powder, dust, crushed particles, granules, pellets, shreds, strips, sheets, or the like. Example botanicals are tobacco, eucalyptus, star anise, hemp, cocoa, cannabis, fennel, lemongrass, peppermint, spearmint, rooibos, chamomile, flax, ginger, ginkgo biloba, hazel, hibiscus, laurel, licorice (liquorice), matcha, mate, orange skin, papaya, rose, sage, tea such as green tea or black tea, thyme, clove, cinnamon, coffee, aniseed (anise), basil, bay leaves, cardamom, coriander, cumin, nutmeg, oregano, paprika, rosemary, saffron, lavender, lemon peel, mint, juniper, elderflower, vanilla, wintergreen, beefsteak plant, curcuma, turmeric, sandalwood, cilantro, bergamot, orange blossom, myrtle, cassis, valerian, pimento, mace, damien, marjoram, olive, lemon balm, lemon basil, chive, carvi, verbena, tarragon, geranium, mulberry, ginseng, theanine, theacrine, maca, ashwagandha, damiana, guarana, chlorophyll, baobab or any combination thereof. The mint may be chosen from the following mint varieties: *Mentha arvensis*, *Mentha c.v.*, *Mentha niliaca*, *Mentha piperita*, *Mentha piperita citrata c.v.*, *Mentha piperita c.v.*, *Mentha spicata crispa*, *Mentha cordifolia*, *Mentha longifolia*, *Mentha suaveolens variegata*, *Mentha pulegium*, *Mentha spicata c.v.* and *Mentha suaveolens*.

In some embodiments, the botanical is selected from eucalyptus, star anise, cocoa and hemp.

In some embodiments, the botanical is selected from rooibos and fennel.

As used herein, the terms "flavour" and "flavourant" refer to materials which, where local regulations permit, may be used to create a desired taste, aroma or other somatosensorial sensation in a product for adult consumers. They may include naturally occurring flavour materials, botanicals, extracts of botanicals, synthetically obtained materials, or combinations thereof (e.g., tobacco, cannabis, licorice (liquorice), hydrangea, eugenol, Japanese white bark magnolia leaf, chamomile, fenugreek, clove, maple, matcha, menthol, Japanese mint, aniseed (anise), cinnamon, turmeric, Indian spices, Asian spices, herb, wintergreen, cherry, berry, red berry, cranberry, peach, apple, orange, mango, clementine, lemon, lime, tropical fruit, papaya, rhubarb, grape, durian, dragon fruit, cucumber, blueberry, mulberry, citrus fruits, Drambuie, bourbon, scotch, whiskey, gin, tequila, rum, spearmint, peppermint, lavender, aloe vera, cardamom, celery, cascarilla, nutmeg, sandalwood, bergamot, geranium, khat, naswar, betel, shisha, pine, honey essence, rose oil, vanilla, lemon oil, orange oil, orange blossom, cherry blossom, cassia, caraway, cognac, jasmine, ylang-ylang, sage, fennel, wasabi, piment, ginger, coriander, coffee, hemp, a mint oil from any species of the genus Mentha, eucalyptus, star anise, cocoa, lemongrass, rooibos, flax, ginkgo biloba, hazel, hibiscus, laurel, mate, orange skin, rose, tea such as green tea or black tea, thyme, juniper, elderflower, basil, bay leaves, cumin, oregano, paprika, rosemary, saffron, lemon peel, mint, beefsteak plant, curcuma, cilantro, myrtle, cassis, valerian, pimento, mace, damien, marjoram, olive, lemon balm, lemon basil, chive, carvi, verbena, tarragon, limonene, thymol, camphene), flavour enhancers, bitterness receptor site blockers, sensorial receptor site activators or stimulators, sugars and/or sugar substitutes (e.g., sucralose, acesulfame potassium, aspartame, saccharine, cyclamates, lactose, sucrose, glucose, fructose, sorbitol, or mannitol), and other additives such as charcoal, chlorophyll, minerals, botanicals, or breath freshening agents. They may be imitation, synthetic or natural ingredients or blends thereof. They may be in any suitable form, for example, liquid such as an oil, solid such as a powder, or gas.

The flavour may suitably comprise one or more mint-flavours suitably a mint oil from any species of the genus Mentha. The flavour may suitably comprise, consist essentially of or consist of menthol.

In some embodiments, the flavour comprises menthol, spearmint and/or peppermint.

In some embodiments, the flavour comprises flavour components of cucumber, blueberry, citrus fruits and/or redberry.

In some embodiments, the flavour comprises eugenol.

In some embodiments, the flavour comprises flavour components extracted from tobacco.

In some embodiments, the flavour comprises flavour components extracted from cannabis.

In some embodiments, the flavour may comprise a sensate, which is intended to achieve a somatosensorial sensation which are usually chemically induced and perceived by the stimulation of the fifth cranial nerve (trigeminal nerve), in addition to or in place of aroma or taste nerves, and these may include agents providing heating, cooling, tingling, numbing effect. A suitable heat effect agent may be, but is not limited to, vanillyl ethyl ether and a suitable cooling agent may be, but not limited to eucalyptol, WS-3.

As used herein, the term “aerosol generating agent” refers to an agent that promotes the generation of an aerosol. An aerosol generating agent may promote the generation of an aerosol by promoting an initial vaporisation and/or the condensation of a gas to an inhalable solid and/or liquid aerosol.

Suitable aerosol generating agents include, but are not limited to: a polyol such as erythritol, sorbitol, glycerol, and glycols like propylene glycol or triethylene glycol; a non-polyol such as monohydric alcohols, high boiling point hydrocarbons, acids such as lactic acid, glycerol derivatives, esters such as diacetin, triacetin, triethylene glycol diacetate, triethyl citrate or myristates including ethyl myristate and isopropyl myristate and aliphatic carboxylic acid esters such as methyl stearate, dimethyl dodecanedioate and dimethyl tetradecanedioate. The aerosol generating agent may suitably have a composition that does not dissolve menthol. The aerosol generating agent may suitably comprise, consist essentially of or consist of glycerol.

As used herein, the term "tobacco material" refers to any material comprising tobacco or derivatives therefore. The term "tobacco material" may include one or more of tobacco, tobacco derivatives, expanded tobacco, reconstituted tobacco or tobacco substitutes. The tobacco material may comprise one or more of ground tobacco, tobacco fibre, cut tobacco, extruded tobacco, tobacco stem, reconstituted tobacco and/or tobacco extract.

The tobacco used to produce tobacco material may be any suitable tobacco, such as single grades or blends, cut rag or whole leaf, including Virginia and/or Burley and/or Oriental. It may also be tobacco particle 'fines' or dust, expanded tobacco, stems, expanded stems, and other processed stem materials, such as cut rolled stems. The tobacco material may be a ground tobacco or a reconstituted tobacco material. The reconstituted tobacco material may comprise tobacco fibres, and may be formed by casting, a Fourdrinier-based paper making-type approach with back addition of tobacco extract, or by extrusion.

All percentages by weight described herein (denoted wt%) are calculated on a dry weight basis, unless explicitly stated otherwise. All weight ratios are also calculated on a dry weight basis. A weight quoted on a dry weight basis refers to the whole of the extract or slurry or material, other than the water, and may include components which by themselves are liquid at room temperature and pressure, such as glycerol.

Conversely, a weight percentage quoted on a wet weight basis refers to all components, including water.

For the avoidance of doubt, where in this specification the term "comprises" is used in defining the invention or features of the invention, embodiments are also disclosed in which the invention or feature can be defined using the terms "consists essentially of" or "consists of" in place of "comprises". Reference to a material "comprising" certain features means that those features are included in, contained in, or held within the material.

The above embodiments are to be understood as illustrative examples of the invention. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS

1. An aerosol-forming substrate comprising an aerosol-forming material provided on a carrier, wherein the aerosol-forming material comprises an amorphous solid and wherein one or more vents are provided in the aerosol-forming material to allow the passage of aerosol and/or gases through the aerosol-forming material in use;

wherein the amorphous solid comprises 5-60 wt% gelling agent.

2. The aerosol-forming substrate according to claim 1, wherein the vents comprise apertures in the aerosol-forming material and/or burst points in the aerosol-forming material.

3. The aerosol-forming substrate according to claim 1, wherein the amorphous solid comprises 10-60 wt% gelling agent.

4. The aerosol-forming substrate according to claim 1, wherein the amorphous solid comprises 15-60 wt% gelling agent.

5. The aerosol-forming substrate according to any one of claims 1-4, wherein the carrier is substantially impermeable to gas and/or aerosol.

6. An aerosol generating article for use in an aerosol generating assembly, wherein the article comprises the aerosol-forming substrate according to any one of claims 1-5.

7. An aerosol generating assembly comprising the aerosol-forming substrate according to any one of claims 1 to 5 or the aerosol generating article according to claim 6; and a heater, configured to heat but not burn the aerosol-forming substrate.

8. The aerosol generating assembly according to claim 7, wherein the carrier of the aerosol-forming substrate is substantially impermeable and is disposed between the aerosol-forming material and the heater.

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9. The aerosol generating assembly according to claim 7 or claim 8, wherein the assembly is a heat-not-burn device.

10. The aerosol generating assembly according to claim 7 or claim 8, wherein the assembly is an electronic tobacco hybrid device.

11. A method of making the aerosol-forming substrate according to any one of claims 1 to 5 comprising (a) forming a slurry comprising components of the amorphous solid or precursors thereof, (b) applying the slurry to the carrier, (c) setting slurry to form a gel and (d) drying to form an amorphous solid.

12. The method according to claim 11, in which the vents are provided in the aerosol-forming material during step (b).

13. The method according to claim 11, further comprising (e) forming the vents in the amorphous solid.

14. The method according to claim 13, wherein the step (e) of forming vents in the amorphous solid comprises cutting the gel to provide apertures and/or burst points.

15. The method according to claim 14, wherein the cutting step employs one or more of a laser, an air jet, a water jet and a sharp implement.

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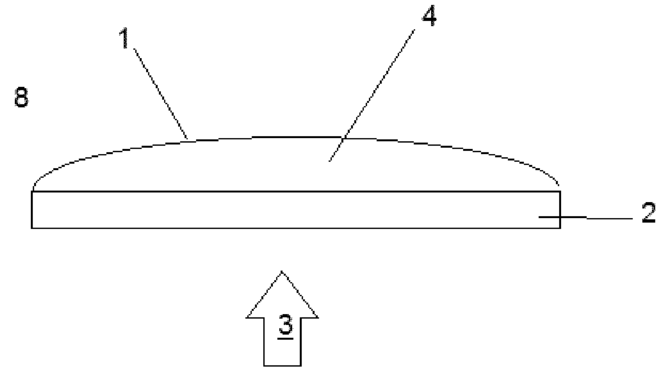


Figure 1

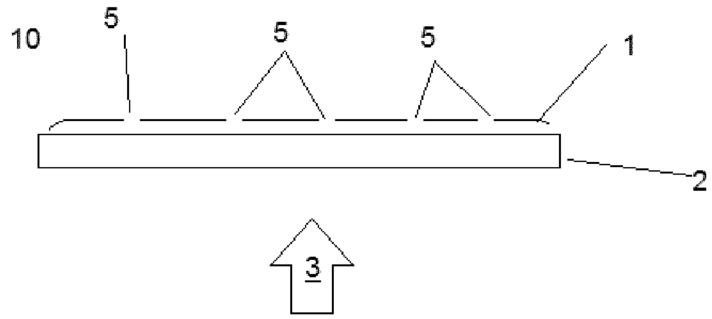


Figure 2

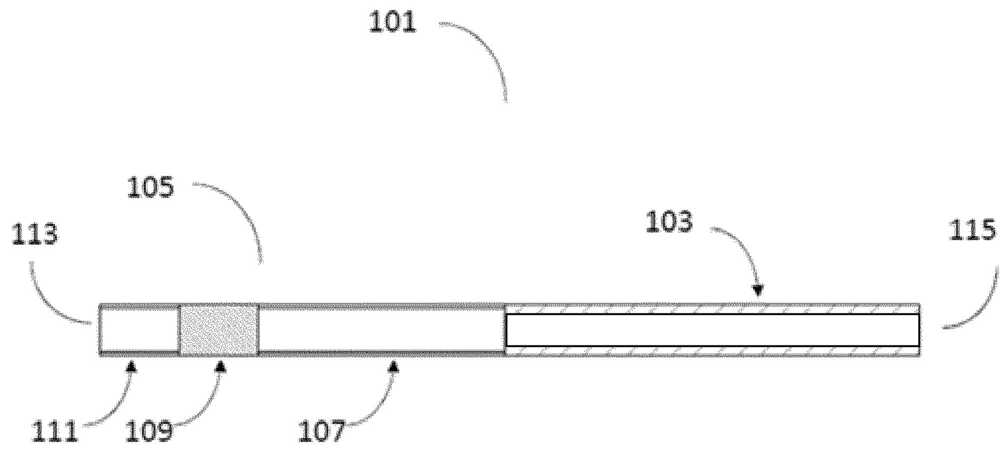


Figure 3

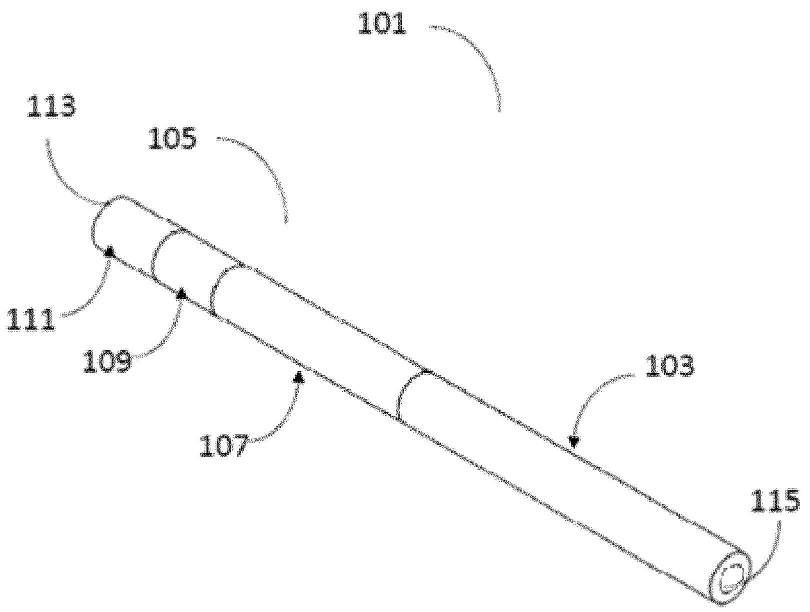


Figure 4

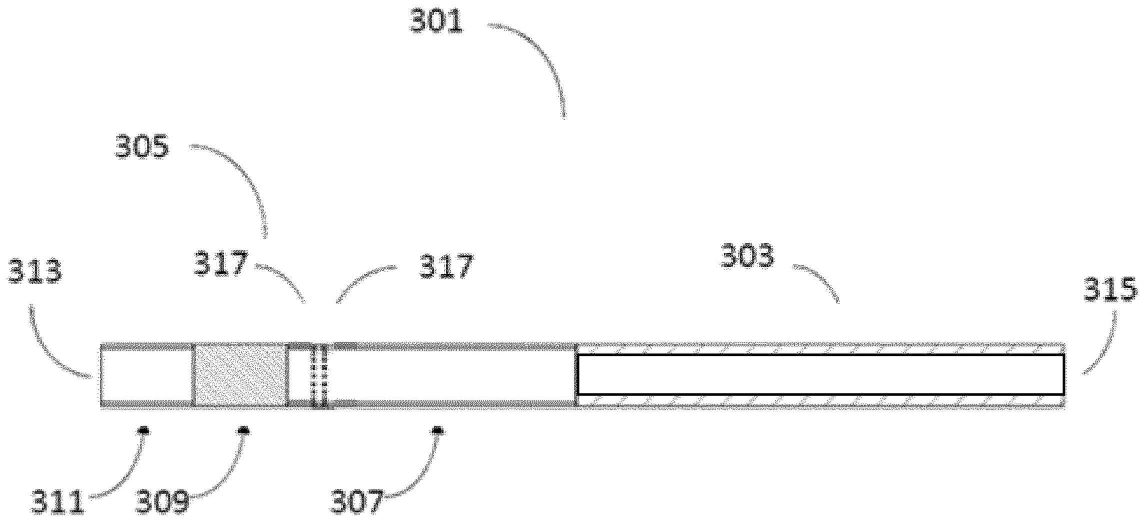


Figure 5

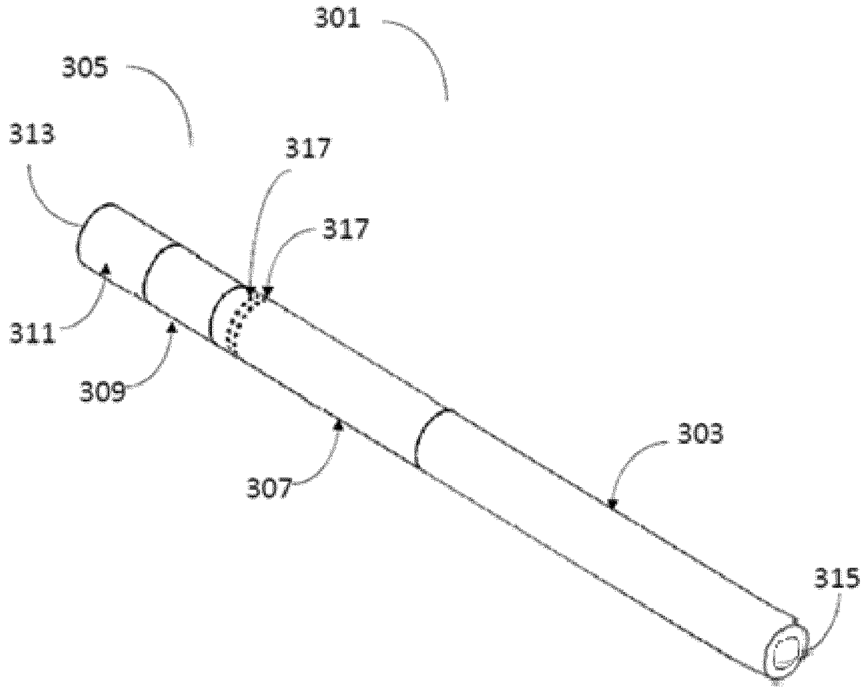


Figure 6

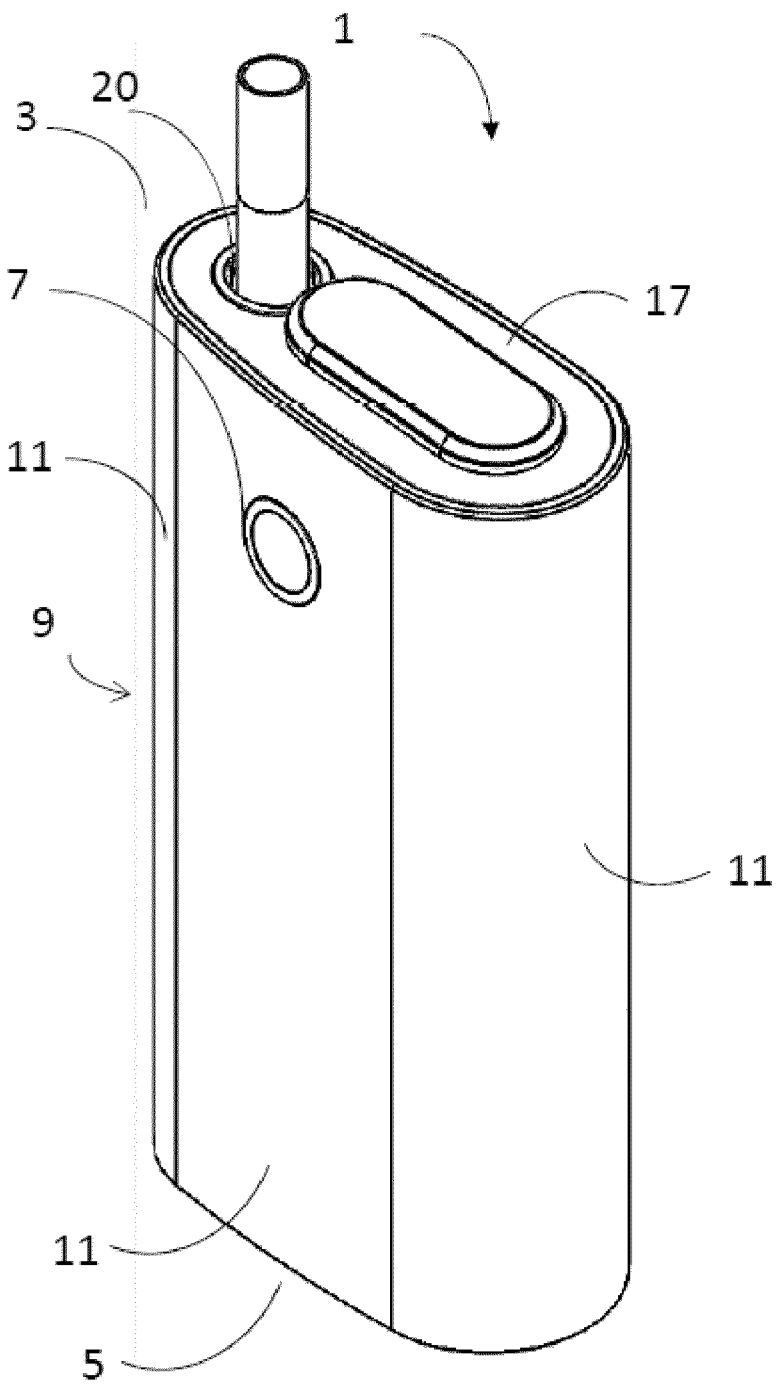


Figure 7

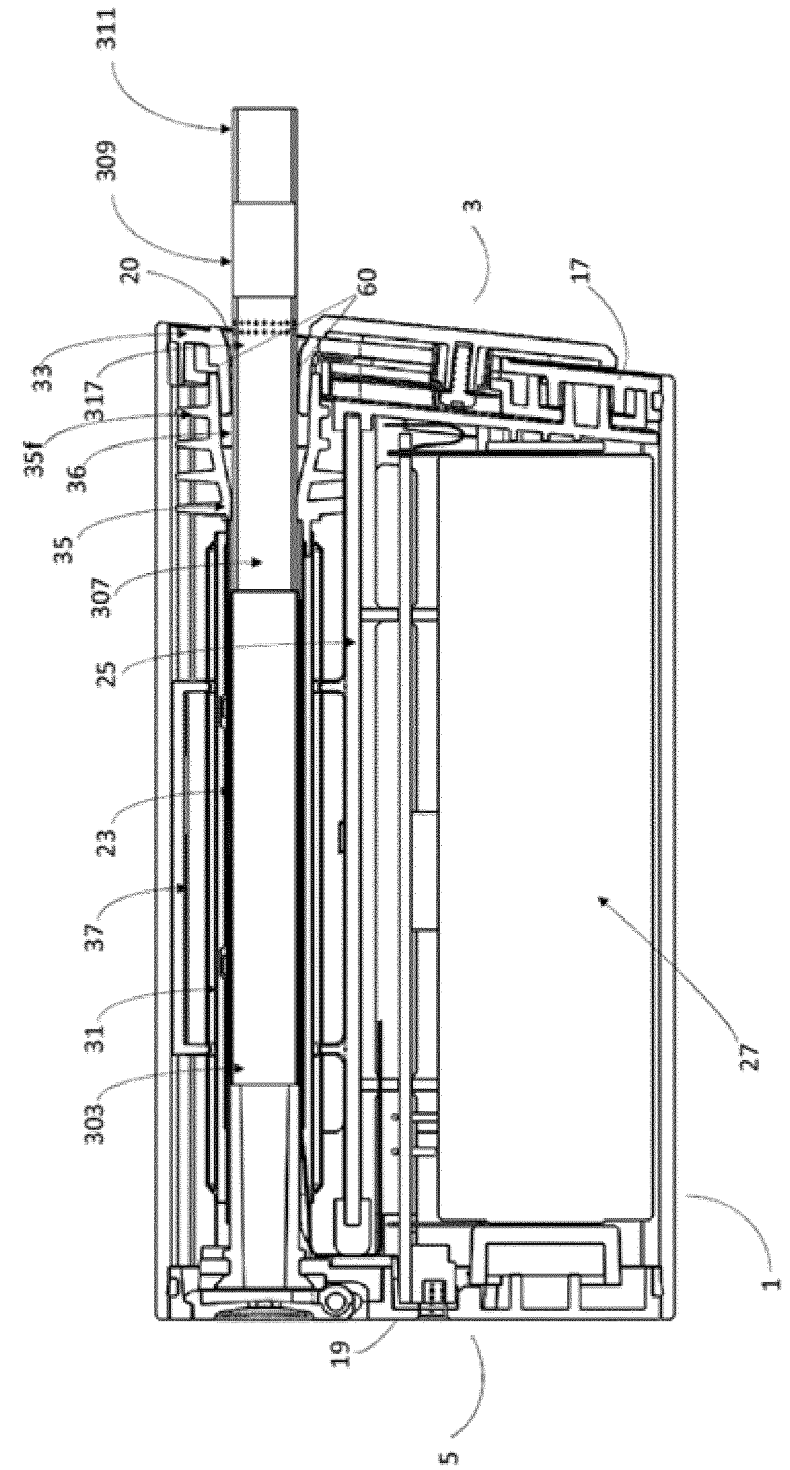


Figure 8

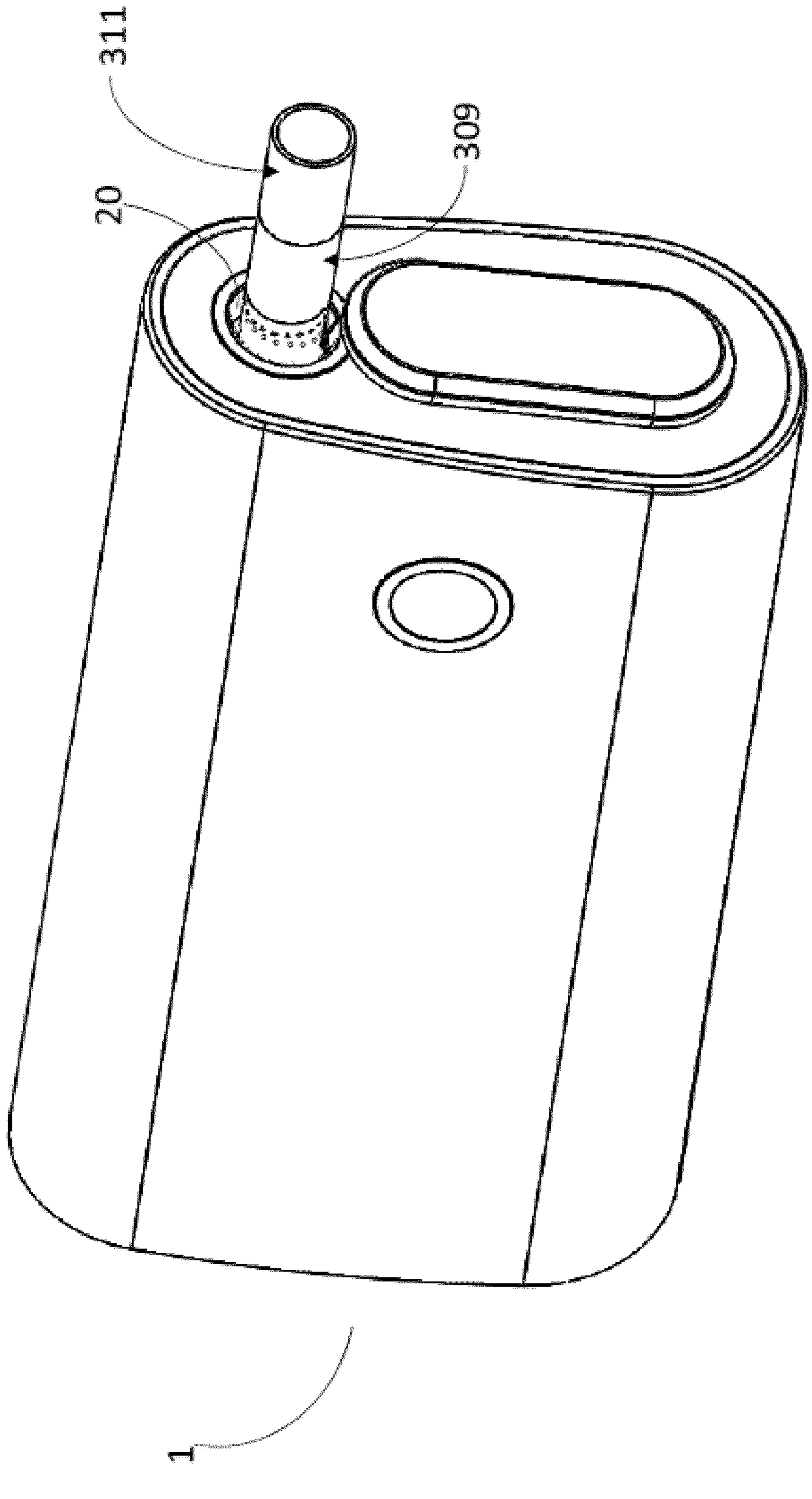
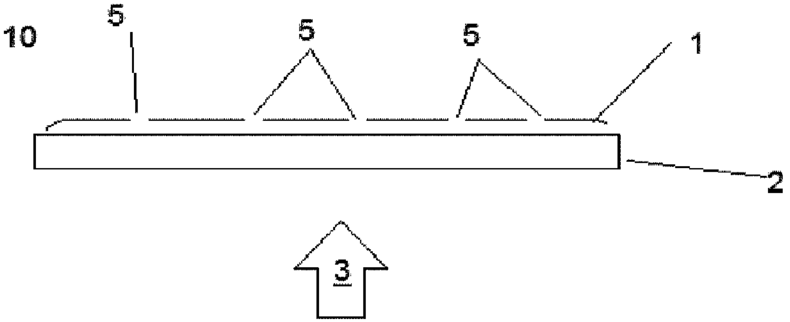


Figure 9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