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(54) **A FORMULATION FOR USE IN AN AEROSOL-GENERATING SYSTEM**

FORMULIERUNG ZUR VERWENDUNG IN EINEM AEROSOLERZEUGUNGSSYSTEM

FORMULATION DESTINÉE À ÊTRE UTILISÉE DANS UN SYSTÈME DE GÉNÉRATION D'AÉROSOL

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Description

[0001] The present invention relates to a formulation for use in an aerosol-generating system. The invention also relates to an aerosol-generating article comprising the formulation for use in an aerosol-generating system, and an aerosol-generating system comprising the formulation and an atomiser.

[0002] Aerosol-generating systems for delivering an aerosol to a user typically comprise an atomiser configured to generate an inhalable aerosol from a formulation. Some known aerosol-generating systems comprise a thermal atomiser such as an electric heater that is configured to heat and vaporise the formulation to generate an aerosol. Typical formulations for use in aerosol-generating systems are nicotine formulations, which may be liquid nicotine formulations comprising an aerosol former such as glycerine and/or propylene glycol.

[0003] WO2017082728A1 describes a cartridge for a personal electronic delivery system, The cartridge comprises: a tubular element that is provided in the cartridge housing; a fluid path; a reservoir for holding a delivery fluid and a gas, and comprising openings to transfer delivery fluid to the fluid path; and a heater that atomises and/or vaporises delivery fluid in the fluid path. When activated, the heater is configured to heat the gas in the reservoir such that the temperature of the gas in the reservoir rises with a temperature increase in the range of 1.5 to 7.5 °C and delivery fluid is transferred from the reservoir to the fluid path with the heater.

[0004] It would be desirable to provide a formulation that exhibits reduced risk of leakage compared to typical formulations when used in an aerosol-generating system.

[0005] There is provided a formulation for use in an aerosol-generating system. The formulation comprises one or more aerosol formers. The formulation may comprise one or more polymers. The one or more polymers is selected from the group consisting of:

polyvinyl acetate, polyvinyl alcohol, polyethylene glycol, polyglycolic acid, polylactic acid, polydioxanone, polycaprolactone, polyethylene, polypropylene glycol and starch. The formulation may have a melting point between 100 degrees Celsius and 300 degrees Celsius.

[0006] There is provided a formulation for use in an aerosol-generating system, the formulation comprising: one or more aerosol formers; and one or more polymers selected from the group consisting of: polyvinyl acetate, polyvinyl alcohol, polyethylene glycol, polyglycolic acid, polylactic acid, polydioxanone, polycaprolactone, polyethylene, polypropylene glycol and starch; wherein the formulation has a melting point of between 100 degrees Celsius and 300 degrees Celsius.

[0007] There is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a formulation comprising: one or more aerosol formers; and one or more polymers selected from the group consisting of: polyvinyl acetate, polyvinyl alcohol, polyethylene glycol, polyglycolic acid, polylactic acid, polydioxanone, polycaprolactone, polyethylene, polypropylene glycol and starch; wherein the formulation has a melting point of between 100 degrees Celsius and 300 degrees Celsius.

[0008] There is also provided an aerosol-generating device comprising: a formulation comprising: one or more aerosol formers; and one or more polymers selected from the group consisting of: polyvinyl acetate, polyvinyl alcohol, polyethylene glycol, polyglycolic acid, polylactic acid, polydioxanone, polycaprolactone, polyethylene, polypropylene glycol and starch; wherein the formulation has a melting point of between 100 degrees Celsius and 300 degrees Celsius.

[0009] There is also provided an aerosol-generating system comprising: a formulation comprising: one or more aerosol formers; and one or more polymers selected from the group consisting of: polyvinyl acetate, polyvinyl alcohol, polyethylene glycol, polyglycolic acid, polylactic acid, polydioxanone, polycaprolactone, polyethylene, polypropylene glycol and starch; wherein the formulation has a melting point of between 100 degrees Celsius and 300 degrees Celsius.

[0010] As used herein, the term "aerosol-forming substrate" relates to a substrate capable of releasing volatile compounds that can form an aerosol. Such volatile compounds may be released by heating the aerosol-forming substrate or by other aerosolising means. The aerosol-forming substrate may be a liquid, The liquid may be such as an e-liquid. The liquid may be a solution. The liquid may be a colloid. The colloid may have discontinuous solid particles dispersed in a continuous liquid. The colloid may have discontinuous liquid particles dispersed in a continuous liquid. The colloid may have discontinuous liquid particles dispersed in a continuous solid.

[0011] Unless stated otherwise, percentages by weight of components of the formulation recited herein are based on the total weight of the formulation.

[0012] Given that the melting point of the formulation is between 100 degrees Celsius and 300 degrees Celsius, the formulation is not a liquid at standard temperature and pressure. At standard temperature and pressure the formulation may be, for example, a solid or a colloid having a solid continuous phase and a liquid dispersed phase. Therefore, at standard temperature and pressure, the formulation may not easily flow when stored in a reservoir of an aerosol-generating article, aerosol-generating device or aerosol-generating system until the formulation is heated.

[0013] Advantageously, due to the melting point of the formulation, the formulation cannot easily leak out of the aerosol-generating article, aerosol-generating device or aerosol-generating system before it is heated during use of the aerosol-generating article, aerosol-generating device or aerosol-generating system. The melting point of the formulation may therefore reduce the risk of leakage during, for example, transportation or storage of the aerosol-generating article,

aerosol-generating device or aerosol-generating system containing the formulation. The formulation may therefore increase the shelf-life of the aerosol-generating article, aerosol-generating device or aerosol-generating system.

[0014] When the formulation is heated to between 100 degrees Celsius and 300 degrees Celsius, at least a portion of the formulation may transition, or may begin to transition, to the liquid phase. When the formulation is a liquid it may easily flow and be vaporised into an aerosol by a heater of the aerosol-generating article, aerosol-generating device or aerosol-generating system.

[0015] After use of the aerosol-generating article, aerosol-generating device or aerosol-generating system, when the formulation cools below 100 degrees Celsius, the formulation may transition back to being a solid or a colloid having a solid continuous phase. Advantageously, this phase transition puts the formulation back into a state in which it cannot easily flow, which means reduces the risk of the formulation leaking or escaping out of the aerosol-generating article, aerosol-generating device or aerosol-generating system between heating cycles.

[0016] The formulation may be a solid at standard temperature and pressure.

[0017] The formulation may be a colloid at standard temperature and pressure. The colloid may have a solid continuous phase at standard temperature and pressure. The colloid may have a liquid dispersed phase at standard temperature and pressure. In one example, the colloid may have a solid continuous phase and a liquid dispersed phase at standard temperature and pressure.

[0018] The formulation may have an aerosol former content of greater than or equal to about 10 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 15 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 20 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 25 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 30 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 35 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 40 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 45 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 50 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 55 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 60 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 65 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 70 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 75 percent by weight. The formulation may have an aerosol former content of greater than or equal to about 80 percent by weight.

[0019] The formulation may have an aerosol former content of less than or equal to about 90 percent by weight. The formulation may have an aerosol former content of less than or equal to about 85 percent by weight. The formulation may have an aerosol former content of less than or equal to about 80 percent by weight. The formulation may have an aerosol former content of less than or equal to about 75 percent by weight. The formulation may have an aerosol former content of less than or equal to about 70 percent by weight. The formulation may have an aerosol former content of less than or equal to about 65 percent by weight. The formulation may have an aerosol former content of less than or equal to about 60 percent by weight. The formulation may have an aerosol former content of less than or equal to about 55 percent by weight. The formulation may have an aerosol former content of less than or equal to about 50 percent by weight. The formulation may have an aerosol former content of less than or equal to about 45 percent by weight. The formulation may have an aerosol former content of less than or equal to about 40 percent by weight. The formulation may have an aerosol former content of less than or equal to about 35 percent by weight. The formulation may have an aerosol former content of less than or equal to about 30 percent by weight. The formulation may have an aerosol former content of less than or equal to about 25 percent by weight.

[0020] Preferably, the formulation may have an aerosol former content of between about 20 percent by weight and about 85 percent by weight.

[0021] The formulation may have an aerosol former content of between about 20 percent by weight and about 80 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 75 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 70 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 65 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 60 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 55 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 50 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 45 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 40 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 35 percent by weight. For example, the formulation may have an aerosol former content of between about 20 percent by weight and about 25 percent by weight.

[0022] The formulation may have an aerosol former content of between about 25 percent by weight and about 85 percent

by weight. The formulation may have an aerosol former content of between about 30 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 35 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 40 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 45 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 50 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 55 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 60 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 20 percent by weight and about 65 percent by weight. The formulation may have an aerosol former content of between about 70 percent by weight and about 85 percent by weight. The formulation may have an aerosol former content of between about 75 percent by weight and about 85 percent by weight. For example, the formulation may have an aerosol former content of between about 80 percent by weight and about 85 percent by weight.

[0023] The formulation may have an aerosol former content of between about 25 percent by weight and about 80 percent by weight. The formulation may have an aerosol former content of between about 25 percent by weight and about 75 percent by weight. The formulation may have an aerosol former content of between about 30 percent by weight and about 70 percent by weight. The formulation may have an aerosol former content of between about 30 percent by weight and about 65 percent by weight. The formulation may have an aerosol former content of between about 35 percent by weight and about 60 percent by weight.

[0024] Preferably, the formulation may have an aerosol former content of between about 35 percent by weight and about 55 percent by weight. The formulation may have an aerosol former content of between about 40 percent by weight and about 55 percent by weight. The formulation may have an aerosol former content of between about 40 percent by weight and about 50 percent by weight. The formulation may have an aerosol former content of between about 45 percent by weight and about 50 percent by weight.

[0025] The formulation may comprise one or more aerosol formers selected from the group consisting of 1,3-butanediol, glycerine, propylene glycol, triethylene glycol and sorbitol. The glycerine may comprise vegetable glycerine.

[0026] In some preferred embodiments the one or more aerosol formers comprise a majority amount of glycerine. It has been found that glycerine based formulations may provide a better harder solid material. It has also been found that including a minor amount of propylene glycol in glycerine based formulations may provide a less rigid or less brittle solid than glycerine based compositions containing no propylene glycol.

[0027] Using sorbitol as at least one of the aerosol formers is advantageous because sorbitol is less hygroscopic compared to other aerosol formers, which may result in the formulation absorbing less water from the environment and being more stable in humid conditions.

[0028] Advantageously, including propylene glycol in the formulation results in a solid or colloidal formulation that is less rigid, less brittle, and is easier to form into plugs. These properties improve subsequent processing and handling of the formulation during the manufacturing process.

[0029] Advantageously, both glycerine and sorbitol may be less volatile than propylene glycol, which may evaporate in warm conditions.

[0030] The one or more aerosol formers may comprise a combination of glycerine and propylene glycol. The one or more aerosol formers may comprise a combination of vegetable glycerine and propylene glycol.

[0031] As discussed below, including propylene glycol in the formulation may improve vaporisation of the formulation, which can lead to the production of more aerosol for a given heating cycle.

[0032] By including propylene glycol in a glycerine based formulation that includes nicotine, there may also be an improvement in the nicotine content of the aerosol due to more efficient vaporisation of the nicotine because propylene glycol has a lower boiling point (188°C) compared to glycerine (290°C). However, if there is high amount of propylene glycol in the formulation then the nicotine content of the aerosol decreases because the propylene glycol can be vaporised during a heating cycle. Therefore, it may be advantageous to have a limited amount of propylene glycol in the nicotine formulation.

[0033] The ratio of the weight percent glycerine content to the weight percent propylene glycol content of the formulation may be greater than or equal to about 1. The ratio of the weight percent glycerine content to the weight percent propylene glycol content of the formulation may be greater than or equal to about 1.5. The ratio of the weight percent glycerine content to the weight percent propylene glycol content of the formulation may be greater than or equal to about 2. The ratio of the weight percent glycerine content to the weight percent propylene glycol content of the formulation may be greater than or equal to about 2.5. The ratio of the weight percent glycerine content to the weight percent propylene glycol content of the formulation may be greater than or equal to about 3.

[0034] It has been found that such compositions may provide a balance of hardness and rigidity or brittleness to provide an optimum seal in addition to the advantageous vaporisation properties discussed herein.

[0035] The one or more aerosol formers may comprise one or more polyhydric alcohols. The one or more polyhydric alcohols may comprise one or more water-miscible polyhydric alcohols. As used herein, the term "water-miscible

polyhydric alcohol" describes a polyhydric alcohol that is liquid at 20°C and mixes with water in all proportions to form a homogenous solution.

[0036] The polyethylene may be low density polyethylene.

[0037] Preferably, the one or more polymers are selected from the group consisting of: polyvinyl alcohol, polyethylene glycol, polypropylene glycol and starch.

[0038] More preferably, the one or more polymers are selected from the group consisting of: polyvinyl alcohol, polyethylene glycol and polypropylene glycol.

[0039] Even more preferably, the one or more polymers are selected from the group consisting of: polyvinyl alcohol and polyethylene glycol.

[0040] Most preferably, the one or more polymers consists of polyvinyl alcohol.

[0041] All starches are made up from varying proportions of amylose and amylopectin. The selection of the particular starch for the formulation may be based on the ratio of amylose to amylopectin, which depends on the desired function of the starch. The starch may be corn starch or wheat starch. Preferably, the starch is wheat starch.

[0042] Advantageously, in comparison to wheat starch and corn starch, use of polyvinyl alcohol in a formulation comprising nicotine provides for more consistent nicotine delivery to a user.

[0043] Advantageously, in comparison to corn starch, use of wheat starch in a formulation comprising nicotine provides for more consistent nicotine delivery to a user.

[0044] The formulation may have a polymer content of greater than or equal to about 0.1 percent by weight. The formulation may have a polymer content of greater than or equal to about 0.5 percent by weight. The formulation may have a polymer content of greater than or equal to about 1 percent by weight. The formulation may have a polymer content of greater than or equal to about 2 percent by weight. The formulation may have a polymer content of greater than or equal to about 3 percent by weight. The formulation may have a polymer content of greater than or equal to about 4 percent by weight. The formulation may have a polymer content of greater than or equal to about 5 percent by weight. The formulation may have a polymer content of greater than or equal to about 6 percent by weight. The formulation may have a polymer content of greater than or equal to about 7 percent by weight.

[0045] The formulation may have a polymer content of less than or equal to about 10 percent by weight. The formulation may have a polymer content of less than or equal to about 7 percent by weight. The formulation may have a polymer content of less than or equal to about 6 percent by weight. The formulation may have a polymer content of less than or equal to about 5 percent by weight. The formulation may have a polymer content of less than or equal to about 4 percent by weight. The formulation may have a polymer content of less than or equal to about 3 percent by weight. The formulation may have a polymer content of less than or equal to about 2 percent by weight. The formulation may have a polymer content of less than or equal to about 1 percent by weight.

[0046] The formulation may have a polymer content of between about 0.5 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 0.5 percent by weight and about 6 percent by weight. The formulation may have a polymer content of between about 0.5 percent by weight and about 5 percent by weight. The formulation may have a polymer content of between about 0.5 percent by weight and about 4 percent by weight. The formulation may have a polymer content of between about 0.5 percent by weight and about 3 percent by weight. The formulation may have a polymer content of between about 0.5 percent by weight and about 2 percent by weight. The formulation may have a polymer content of between about 0.5 percent by weight and about 1 percent by weight.

[0047] The formulation may have a polymer content of between about 0.1 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 1 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 2 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 3 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 4 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 5 percent by weight and about 7 percent by weight. The formulation may have a polymer content of between about 6 percent by weight and about 7 percent by weight.

[0048] The one or more polymers may have a weight average molecular weight (M_w) of greater than or equal to 6000 g/mol. The one or more polymers may have a weight average molecular weight of greater than or equal to 60000 g/mol. The one or more polymers may have a weight average molecular weight of greater than or equal to 100000 g/mol. The one or more polymers may have a weight average molecular weight of greater than or equal to 140000 g/mol. The one or more polymers may have a weight average molecular weight of greater than or equal to 200000 g/mol.

[0049] The one or more polymers may have a weight average molecular weight of less than or equal to 8000000 g/mol. The one or more polymers may have a weight average molecular weight of less than or equal to 5000000 g/mol. The one or more polymers may have a weight average molecular weight of less than or equal to 2000000 g/mol. The one or more polymers may have a weight average molecular weight of less than or equal to 1000000 g/mol. The one or more polymers may have a weight average molecular weight of less than or equal to 500000 g/mol. The one or more polymers may have a weight average molecular weight of less than or equal to 200000 g/mol. The one or more polymers may have a weight

270 degrees Celsius. The formulation may have a boiling point of less than or equal to 260 degrees Celsius. The formulation may have a boiling point of less than or equal to 240 degrees Celsius. The formulation may have a boiling point of less than or equal to 220 degrees Celsius. The formulation may have a boiling point of less than or equal to 200 degrees Celsius. The formulation may have a boiling point of less than or equal to 180 degrees Celsius.

[0059] The formulation may have a boiling point of between 180 degrees Celsius and 300 degrees Celsius. The formulation may have a boiling point of between 200 degrees Celsius and 300 degrees Celsius. The formulation may have a boiling point of between 220 degrees Celsius and 300 degrees Celsius. The formulation may have a boiling point of between 240 degrees Celsius and 300 degrees Celsius. The formulation may have a boiling point of between 260 degrees Celsius and 300 degrees Celsius. The formulation may have a boiling point of between 270 degrees Celsius and 300 degrees Celsius.

[0060] The formulation may have a boiling point of between 180 degrees Celsius and 300 degrees Celsius. The formulation may have a boiling point of between 180 degrees Celsius and 280 degrees Celsius. The formulation may have a boiling point of between 180 degrees Celsius and 270 degrees Celsius. The formulation may have a boiling point of between 180 degrees Celsius and 260 degrees Celsius. The formulation may have a boiling point of between 180 degrees Celsius and 240 degrees Celsius. The formulation may have a boiling point of between 180 degrees Celsius and 220 degrees Celsius. The formulation may have a boiling point of between 180 degrees Celsius and 200 degrees Celsius.

[0061] The formulation may have a boiling point of between 180 degrees Celsius and 270 degrees Celsius. The formulation may have a boiling point of between 200 degrees Celsius and 270 degrees Celsius. The formulation may have a boiling point of between 220 degrees Celsius and 270 degrees Celsius. The formulation may have a boiling point of between 240 degrees Celsius and 270 degrees Celsius. The formulation may have a boiling point of between 260 degrees Celsius and 270 degrees Celsius.

[0062] The formulation may be heat-treated after being formed.

[0063] The formulation may be heat treated at a temperature of greater than or equal to about 50 degrees Celsius. The formulation may be heat treated at a temperature of greater than or equal to about 75 degrees Celsius. The formulation may be heat treated at a temperature of greater than or equal to about 100 degrees Celsius. The formulation may be heat treated at a temperature of greater than or equal to about 125 degrees Celsius. The formulation may be heat treated at a temperature of greater than or equal to about 150 degrees Celsius.

[0064] The formulation may be heat treated at a temperature of less than or equal to about 200 degrees Celsius. The formulation may be heat treated at a temperature of less than or equal to about 175 degrees Celsius. The formulation may be heat treated at a temperature of less than or equal to about 150 degrees Celsius. The formulation may be heat treated at a temperature of less than or equal to about 125 degrees Celsius. The formulation may be heat treated at a temperature of less than or equal to about 100 degrees Celsius.

[0065] The formulation may be heat treated at a temperature of between about 75 degrees Celsius and 200 degrees Celsius. The formulation may be heat treated at a temperature of between about 75 degrees Celsius and 175 degrees Celsius. The formulation may be heat treated at a temperature of between about 75 degrees Celsius and 150 degrees Celsius. The formulation may be heat treated at a temperature of between about 75 degrees Celsius and 125 degrees Celsius. The formulation may be heat treated at a temperature of between about 75 degrees Celsius and 100 degrees Celsius.

[0066] The formulation may be heat treated at a temperature of between about 50 degrees Celsius and 175 degrees Celsius. The formulation may be heat treated at a temperature of between about 100 degrees Celsius and 175 degrees Celsius. The formulation may be heat treated at a temperature of between about 125 degrees Celsius and 175 degrees Celsius. The formulation may be heat treated at a temperature of between about 150 degrees Celsius and 175 degrees Celsius.

[0067] The formulation may be heat treated in an oven. The formulation may be heat treated in a ventilated oven.

[0068] Advantageously, heat treating the formulation after it has been formed may decrease swelling of the formulation. Heat treatment of the formulation may improve crosslinking between the one or more polymers and the one or more aerosol formers.

[0069] The formulation may comprise one or more organic acids. In some embodiments the one or more organic acids may be water-soluble organic acids. As used herein with reference to the invention, the term "water-soluble organic acid" describes an organic acid having a water solubility at 20°C of greater than or equal to about 100 mg/ml, preferably greater than or equal to about 500 mg/ml, more preferably greater than or equal to about 750mg/ml most preferably greater than or equal to about 1000mg/ml.

[0070] Unless stated otherwise, water solubility values recited herein are the water solubility measured based on the preliminary test of OECD (1995), Test No. 105: Water Solubility, OECD Guidelines for the Testing of Chemicals, Section 1, OECD Publishing, Paris, <https://doi.org/10.1787/9789264069589-en>. In a stepwise procedure, increasing volumes of distilled water are added at 20°C to 0.1 g of the sample (solid substances must be pulverized) in a 10 ml glass-stoppered measuring cylinder. However, when the substance is an acid, the sample is added to the distilled water in the first step. After each addition of an amount of water, the mixture is shaken for 10 minutes and is visually checked for any undissolved parts

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of the sample. If, after addition of 10 ml of water, the sample or parts of it remain undissolved, the experiment is continued in a 100 ml measuring cylinder. The approximate solubility is given in Table 1 below under that volume of water in which complete dissolution of the sample occurs.

[0071] When the solubility is low, a long time may be required to dissolve a substance and at least 24 hours should be allowed. If, after 24 hours, the substance is still not dissolved, the measuring cylinder is placed for at 40°C in an ultrasound bath for 15 minutes and another 24 hours allowed (up to a maximum of 96 hours). If the substance is still not dissolved, the solubility is considered to be below the limit value or not soluble.

Table 1

ml of water in which 0.1 g of sample is soluble	0.1	0.5	1	2	10	100	>100
Approximate solubility (mg/ml)	>1000	1000 to 200	200 to 100	100 to 50	50 to 10	10 to 1	<1

[0072] Advantageously, when the formulation includes nicotine, including an organic acid in the formulation may improve the delivery of nicotine to a user.

[0073] Advantageously, including an organic acid in the formulation may provide a plasticizing effect within the formulation, which may improve the mechanical properties of the formulation.

[0074] The formulation may have an organic acid content of greater than or equal to about 0.1 percent by weight. The formulation may have an organic acid content of greater than or equal to about 0.5 percent by weight. The formulation may have an organic acid content of greater than or equal to about 1 percent by weight. The formulation may have an organic acid content of greater than or equal to about 1.5 percent by weight. The formulation may have an organic acid content of greater than or equal to about 2 percent by weight. The formulation may have an organic acid content of greater than or equal to about 2.5 percent by weight. The formulation may have an organic acid content of greater than or equal to about 3 percent by weight. The formulation may have an organic acid content of greater than or equal to about 3.5 percent by weight. The formulation may have an organic acid content of greater than or equal to about 4 percent by weight. The formulation may have an organic acid content of greater than or equal to about 4.5 percent by weight. The formulation may have an organic acid content of greater than or equal to about 5 percent by weight.

[0075] The formulation may have an organic acid content of less than or equal to about 10 percent by weight. The formulation may have an organic acid content of less than or equal to about 5 percent by weight. The formulation may have an organic acid content of less than or equal to about 4.5 percent by weight. The formulation may have an organic acid content of less than or equal to about 4 percent by weight. The formulation may have an organic acid content of less than or equal to about 3.5 percent by weight. The formulation may have an organic acid content of less than or equal to about 3 percent by weight. The formulation may have an organic acid content of less than or equal to about 2.5 percent by weight. The formulation may have an organic acid content of less than or equal to about 2 percent by weight. The formulation may have an organic acid content of less than or equal to about 1.5 percent by weight. The formulation may have an organic acid content of less than or equal to about 1 percent by weight. The formulation may have an organic acid content of less than or equal to about 0.5 percent by weight.

[0076] The formulation may have an organic acid content of between about 0.1 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 0.5 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 1 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 1.5 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 2 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 2.5 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 3 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 3.5 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 4 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 4.5 percent by weight and about 5 percent by weight.

[0077] The formulation may have an organic acid content of between about 0.1 percent by weight and about 8 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 5 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 4.5 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 4 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 3.5 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 3 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 2.5 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 2 percent by weight.

weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 1.5 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 1 percent by weight. The formulation may have an organic acid content of between about 0.1 percent by weight and about 0.5 percent by weight.

[0078] The formulation may have an organic acid content of between about 0.5 percent by weight and about 4.5 percent by weight. The formulation may have an organic acid content of between about 1 percent by weight and about 4.5 percent by weight. The formulation may have an organic acid content of between about 1.5 percent by weight and about 4.5 percent by weight. The formulation may have an organic acid content of between about 1.5 percent by weight and about 4 percent by weight. The formulation may have an organic acid content of between about 2 percent by weight and about 4 percent by weight. The formulation may have an organic acid content of between about 2 percent by weight and about 3.5 percent by weight. The formulation may have an organic acid content of between about 2.5 percent by weight and about 3.5 percent by weight. The formulation may have an organic acid content of between about 2.5 percent by weight and about 3 percent by weight.

[0079] The one or more organic acids may comprise one or more polycarboxylic acids, one or more monocarboxylic acids or a combination of monocarboxylic acids and polycarboxylic acids.

[0080] The one or more organic acids may be selected from the group consisting of: malonic acid, citric acid, 2-ethylbutyric acid, acetic acid, adipic acid, benzoic acid, butyric acid, cinnamic acid, cycloheptane-carboxylic acid, fumaric acid, glycolic acid, hexanoic acid, lactic acid, levulinic acid, malic acid, myristic acid, octanoic acid, oxalic acid, propanoic acid, pyruvic acid, succinic acid and undecanoic acid.

[0081] In some embodiments, the one or more organic acids are selected from the group consisting of: malonic acid, citric acid, lactic acid, benzoic acid, levulinic acid, fumaric acid and acetic acid.

[0082] In some embodiments the one or more organic acids are selected from the group consisting of: malonic acid, citric acid, lactic acid, fumaric acid and acetic acid

[0083] Most preferably, the one or more organic acids consists of lactic acid.

[0084] The formulation may comprise one or more metal salts.

[0085] Bonding between the one or more metal salts and the one or more aerosol formers in the formulation may elevate the boiling point of the one or more aerosol formers. When the formulation includes nicotine, this may advantageously enhance the efficiency of vaporisation of nicotine from the formulation when used in an aerosol-generating system as compared to a typical liquid nicotine formulation that does not include one or more metal salts.

[0086] The one or more metal salts may be selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinate, metal propanoates, metal stearates and metal undecanoates.

[0087] Preferably, the one or more metal salts are selected from the group consisting of metal cinnamates, metal cycloheptanecarboxylates, metal levulinate, metal propanoates, metal stearates and metal undecanoates.

[0088] Preferably, the one or more metal salts are selected from the group consisting of metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinate, metal propanoates, metal stearates and metal undecanoates.

[0089] Preferably the one or more metal salts are selected from the group consisting of metal cinnamates, metal cycloheptanecarboxylates, metal stearates and metal undecanoates

The one or more salts may be salts of any suitable metal.

[0090] Preferably, the one or more metal salts are alkali metal salts.

[0091] More preferably, the one or more metal salts are sodium salts.

[0092] Preferably, the vaporisable barrier comprises one or more non-saccharide sodium salts.

[0093] A metal salt with a high molecular weight may improve the above mentioned advantages related to efficiency of vaporisation of nicotine and speed of formation of the solid layer. However, if the molecular weight of a metal salt is too high then properties such as solubility begin to be negatively affected. Advantageously, including sodium stearate in the formulation may provide an optimal balance in improved efficiency of vaporisation of nicotine and speed of formation of the solid layer, whilst maintaining solubility.

[0094] More preferably, the formulation comprises one or more sodium salts selected from the group consisting of sodium benzoate, sodium cinnamate, sodium cycloheptanecarboxylate, sodium levulinate, sodium propanoate, sodium stearate and sodium undecanoate.

[0095] Preferably the one or more metal salts are selected from the group consisting of sodium cinnamates, sodium cycloheptanecarboxylates, sodium levulinate, sodium propanoates, sodium stearates and sodium undecanoates.

[0096] Preferably the one or more sodium salts are selected from the group consisting of sodium benzoates, sodium cinnamates, sodium cycloheptanecarboxylates, sodium levulinate, sodium propanoates, sodium stearates and sodium undecanoates.

[0097] Preferably the one or more metal salts are selected from the group consisting of sodium cinnamates, sodium cycloheptanecarboxylates, sodium stearates and sodium undecanoates.

[0098] Most preferably, the formulation comprises sodium stearate.

[0099] Advantageously, including one or more metal stearates in the formulation improves the mechanical properties of the formulation.

[0100] Advantageously, covalent bonding between the one or more metal stearates and the one or more aerosol formers in the formulation may further elevate the boiling point of the one or more aerosol formers. When the formulation includes nicotine, this may advantageously enhance the efficiency of vaporisation of nicotine from the formulation when used in an aerosol-generating system as compared to a typical liquid nicotine formulation that does not include one or more metal stearates.

[0101] The formulation may have a metal salt content of greater than or equal to about 0.1 percent by weight. The formulation may have a metal salt content of greater than or equal to about 0.25 percent by weight. The formulation may have a metal salt content of greater than or equal to about 0.5 percent by weight. The formulation may have a metal salt content of greater than or equal to about 0.75 percent by weight. The formulation may have a metal salt content of greater than or equal to about 1 percent by weight. The formulation may have a metal salt content of greater than or equal to about 1.25 percent by weight. The formulation may have a metal salt content of greater than or equal to about 1.5 percent by weight. The formulation may have a metal salt content of greater than or equal to about 1.75 percent by weight.

[0102] The formulation may have a metal salt content of less than or equal to about 5 percent by weight. For example, the formulation may have a metal salt content of less than or equal to about 3 percent by weight. The formulation may have a metal salt content of less than or equal to about 2 percent by weight. The formulation may have a metal salt content of less than or equal to about 1.75 percent by weight. The formulation may have a metal salt content of less than or equal to about 1.5 percent by weight. The formulation may have a metal salt content of less than or equal to about 1.25 percent by weight. The formulation may have a metal salt content of less than or equal to about 1 percent by weight. The formulation may have a metal salt content of less than or equal to about 0.75 percent by weight. The formulation may have a metal salt content of less than or equal to about 0.5 percent by weight.

[0103] The formulation may have a metal salt content of between about 0.1 percent by weight and about 5 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 3 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 1.75 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 1.5 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 1.25 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 1 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 0.75 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 0.5 percent by weight. The formulation may have a metal salt content of between about 0.1 percent by weight and about 0.25 percent by weight.

[0104] The formulation may have a metal salt content of between about 0.25 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 0.5 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 0.75 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 1 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 1.25 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 1.5 percent by weight and about 2 percent by weight. The formulation may have a metal salt content of between about 1.75 percent by weight and about 5 percent by weight.

[0105] The formulation may comprise nicotine. The formulation may comprise liquid nicotine.

[0106] The nicotine may be a nicotine base. The nicotine may be a nicotine salt. The formulation may comprise natural nicotine. The formulation may comprise synthetic nicotine.

[0107] The nicotine salt may be formed using one or more organic acids. The nicotine salt may comprise one or more organic acids.

[0108] The nicotine may be provided as a tobacco extract which may include other tobacco components such as tobacco flavour components.

[0109] The formulation may have a nicotine content of greater than or equal to about 0.5 percent by weight. The formulation may have a nicotine content of greater than or equal to about 1 percent by weight. The formulation may have a nicotine content of greater than or equal to about 1.5 percent by weight. The formulation may have a nicotine content of greater than or equal to about 2 percent by weight. The formulation may have a nicotine content of greater than or equal to about 3 percent by weight. The formulation may have a nicotine content of greater than or equal to about 5 percent by weight.

[0110] The formulation may have a nicotine content of less than or equal to about 10 percent by weight. The formulation may have a nicotine content of less than or equal to about 8 percent by weight. The formulation may have a nicotine content of less than or equal to about 5 percent by weight. The formulation may have a nicotine content of less than or equal to about 3 percent by weight. The formulation may have a nicotine content of less than or equal to about 2 percent by weight. The

formulation may have a nicotine content of less than or equal to about 1 percent by weight.

[0111] The formulation may have a nicotine content of between about 0.5 percent by weight and about 10 percent by weight. The formulation may have a nicotine content of between about 0.5 percent by weight and about 8 percent by weight. The formulation may have a nicotine content of between about 0.5 percent by weight and about 5 percent by weight. The formulation may have a nicotine content of between about 0.5 percent by weight and about 3 percent by weight. The formulation may have a nicotine content of between about 0.5 percent by weight and about 2 percent by weight. The formulation may have a nicotine content of between about 0.5 percent by weight and about 1 percent by weight.

[0112] The formulation may have a nicotine content of between about 1 percent by weight and about 5 percent by weight. The formulation may have a nicotine content of between about 2 percent by weight and about 5 percent by weight. The formulation may have a nicotine content of between about 3 percent by weight and about 5 percent by weight. The formulation may have a nicotine content of between about 4 percent by weight and about 5 percent by weight.

[0113] The formulation may have a nicotine content of between about 1 percent by weight and about 2 percent by weight. The formulation may have a nicotine content of between about 2 percent by weight and about 3 percent by weight. The formulation may have a nicotine content of between about 3 percent by weight and about 5 percent by weight. The formulation may have a nicotine content of between about 2 percent by weight and about 4 percent by weight. The formulation may have a nicotine content of between about 1 percent by weight and about 4 percent by weight.

[0114] The formulation may comprise water.

[0115] The formulation may have a water content of greater than or equal to about 10 percent by weight. The formulation may have a water content of greater than or equal to about 20 percent by weight. The formulation may have a water content of greater than or equal to about 30 percent by weight. The formulation may have a water content of greater than or equal to about 40 percent by weight. The formulation may have a water content of greater than or equal to about 50 percent by weight. The formulation may have a water content of greater than or equal to about 60 percent by weight.

[0116] The formulation may have a water content of less than or equal to about 70 percent by weight. The formulation may have a water content of less than or equal to about 60 percent by weight. The formulation may have a water content of less than or equal to about 50 percent by weight. The formulation may have a water content of less than or equal to about 40 percent by weight. The formulation may have a water content of less than or equal to about 30 percent by weight. The formulation may have a water content of less than or equal to about 20 percent by weight.

[0117] The formulation may have a water content of between about 20 percent by weight and about 70 percent by weight. The formulation may have a water content of between about 20 percent by weight and about 60 percent by weight. The formulation may have a water content of between about 20 percent by weight and about 50 percent by weight. The formulation may have a water content of between about 20 percent by weight and about 40 percent by weight. The formulation may have a water content of between about 20 percent by weight and about 30 percent by weight.

[0118] The formulation may have a water content of between about 30 percent by weight and about 60 percent by weight. The formulation may have a water content of between about 40 percent by weight and about 60 percent by weight. The formulation may have a water content of between about 50 percent by weight and about 50 percent by weight.

[0119] The formulation may have a water content of between about 10 percent by weight and about 70 percent by weight. The formulation may have a water content of between about 30 percent by weight and about 50 percent by weight.

[0120] The aerosol-generating system may comprise an aerosol-generating article.

[0121] The aerosol-generating article may comprise an atomiser configured to generate an aerosol from the formulation.

[0122] The aerosol-generating article may be a cartridge.

[0123] A cartridge containing the formulation and an atomiser may be referred to as a "cartomiser".

[0124] The atomiser may be a thermal atomiser.

[0125] As used herein, the term "thermal atomiser" describes an atomiser that is configured to heat the formulation to generate an aerosol.

[0126] The aerosol-generating article may comprise any suitable type of thermal atomiser. For example, the thermal atomiser may comprise a heater. The thermal atomiser may comprise an electric heater. In one example, the thermal atomiser may comprise an electric heater comprising a resistive heating element. In another example, the thermal atomiser may comprise an electric heater comprising an inductive heating element.

[0127] The heater may comprise a heating element. The heating element may be a grid element. The heating element may be a grid layer. The heating element may be a mesh element. The heating element may be a mesh layer. In such embodiments, the formulation may flow into the interstitial spaces forming the grid or mesh.

[0128] The atomiser may be a non-thermal atomiser.

[0129] As used herein, the term "non-thermal atomiser" describes an atomiser that is configured to generate an aerosol from the formulation by means other than heating.

[0130] The aerosol-generating article may comprise any suitable type of non-thermal atomiser. For example, the non-thermal atomiser may be an impinging jet atomiser. In another example, the non-thermal atomiser may be an ultrasonic

atomiser. In another example, the non-thermal atomiser may be a vibrating mesh atomiser.

[0131] The aerosol-generating article may comprise a porous material for hosting the formulation. The porous material may be crimped.

[0132] The aerosol-generating system may comprise an aerosol-generating device.

[0133] The aerosol-generating device may comprise a reservoir for containing the formulation.

[0134] The aerosol-generating device may comprise a housing defining a device cavity configured to receive at least a portion of the aerosol-generating article.

[0135] The aerosol-generating device may comprise an atomiser configured to generate an aerosol from the formulation.

[0136] The atomiser may be a thermal atomiser.

[0137] As used herein, the term "thermal atomiser" describes an atomiser that is configured to heat the formulation to generate an aerosol.

[0138] The aerosol-generating device may comprise any suitable type of thermal atomiser. For example, the thermal atomiser may comprise a heater. The thermal atomiser may comprise an electric heater. In one example, the thermal atomiser may comprise an electric heater comprising a resistive heating element. In another example, the thermal atomiser may comprise an electric heater comprising an inductive heating element.

[0139] The heater may comprise a heating element. The heating element may be a grid element. The heating element may be a grid layer. The heating element may be a mesh element. The heating element may be a mesh layer. In such embodiments, the formulation may flow into the interstitial spaces forming the grid or mesh.

[0140] The aerosol-generating device may comprise a porous material for hosting the formulation. The porous material may be crimped.

[0141] According to the invention there is further provided an aerosol-generating system comprising a formulation according to the invention and an atomiser configured to generate an aerosol from the formulation.

[0142] The atomiser may be a thermal atomiser.

[0143] The aerosol-generating system may comprise any suitable type of thermal atomiser.

[0144] The thermal atomiser may comprise an electric heater. For example, the thermal atomiser may comprise an electric heater comprising a heating element. The heating element may be a resistive heating element or an inductive heating element.

[0145] The heating element may be a grid or mesh element or layer. In such embodiments, the formulation may flow into the interstitial spaces forming the grid or mesh element.

[0146] The aerosol-generating system may comprise an aerosol-generating article according to the invention containing the formulation and an aerosol-generating device comprising a housing defining a device cavity configured to receive at least a portion of the aerosol-generating article.

[0147] The aerosol-generating system may comprise a consumable aerosol-generating article according to the invention containing the formulation and a reusable aerosol-generating device comprising a housing defining a device cavity configured to receive at least a portion of the aerosol-generating article.

[0148] The aerosol-generating device may comprise a battery and control electronics.

[0149] The aerosol-generating system may comprise: an aerosol-generating article according to the invention containing the formulation and the atomiser; and an aerosol-generating device comprising a housing defining a device cavity configured to receive at least a portion of the aerosol-generating article.

[0150] The aerosol-generating system may comprise: an aerosol-generating article according to the invention containing the formulation; and an aerosol-generating device comprising a housing defining a device cavity configured to receive at least a portion of the aerosol-generating article and the atomiser.

[0151] The aerosol-generating system may comprise a porous material for hosting the formulation. The porous material may be crimped.

[0152] For the avoidance of doubt, features described above in relation to the formulation may also relate, where appropriate, to the aerosol-generating article, the aerosol-generating device, and the aerosol-generating system. Similarly, features described above in relation to the aerosol-generating article may also relate, where appropriate, to the aerosol-generating device and to the aerosol-generating system, and *vice versa*.

[0153] Specific embodiments will now be described, by way of example only, with reference to the following examples and the accompanying drawings, in which:

Figure 1 shows schematically a sectional side view of an aerosol-generating system comprising an aerosol-generating device and an aerosol-generating article comprising a formulation according to the invention;

Figure 2 shows schematically a sectional view of the aerosol-generating system of Figure 1, with the aerosol-generating article inserted into the aerosol-generating device;

Figure 3 shows schematically a sectional view of an alternative aerosol-generating system comprising an aerosol-generating article comprising a formulation according to the invention;

Figure 4 shows schematically a sectional view of an aerosol-generating article comprising a formulation according to the invention, before heating of the aerosol-forming substrate;

Figure 5 shows schematically a sectional view of an aerosol-generating article comprising a formulation according to the invention, during heating of the aerosol-forming substrate;

Figure 6 is a graph showing average aerosolised collected mass in mg per puff for a range of different aerosol former compositions;

Figure 7 is a graph showing average nicotine in mg per puff for a range of different aerosol former compositions; and

Figure 8 is a graph showing average nicotine percent for a range of different aerosol former compositions.

[0154] Aerosol-generating systems for delivering to a user typically comprise an atomiser configured to generate an inhalable aerosol from a formulation. Some known aerosol-generating systems comprise a thermal atomiser such as an electric heater that is configured to heat and vaporise the formulation to generate an aerosol. Typical formulations for use in aerosol-generating systems are nicotine formulations, which may be liquid nicotine formulations comprising an aerosol former such as glycerine and/or propylene glycol.

[0155] An aerosol generating system can comprise an aerosol-generating device and an aerosol-generating article containing a formulation. Typical aerosol-generating systems may suffer from a problem of unwanted leakage of the formulation out of the aerosol-generating article. Leakage of a formulation may occur in a number of different situations, such as: when there is too much of the formulation in a reservoir of the aerosol-generating article; when the material forming one or more parts of the aerosol-generating article or system fails to retain the formulation as designed; due to a change in pressure, for example when at a high altitude during transport by an aeroplane; or at a high temperature, for example due to hot weather.

[0156] It would be desirable to provide a formulation that provides a reduced risk of leakage from an aerosol-generating article or system compared to typical formulations.

[0157] Figures 1 and 2 show an aerosol-generating system including an aerosol-generating device 10 and an aerosol-generating article 20. In this example, the aerosol-generating article 20 is cartridge.

[0158] The aerosol-generating device 10 is configured to receive the aerosol-generating article 20 in a cavity 18. The aerosol-generating article 20 includes a housing 24. The housing 24 defines a reservoir 22. The reservoir 22 has a reservoir opening that can be covered by a removable cover 26. An aerosol-forming substrate is disposed in the reservoir 22. The aerosol-forming substrate in the reservoir 22 may be a formulation according to the invention.

[0159] In the example shown in Figures 1 and 2, the aerosol-generating article 20 includes an atomiser configured to generate an aerosol from the formulation in the reservoir 22. The atomiser may be a thermal atomiser. In the example shown in Figures 1 and 2 the atomiser is an electric heater 30. In other examples, the atomiser may be another type of atomiser, such as a non-thermal atomiser.

[0160] In the example of Figures 1 and 2, the aerosol-generating article 20 contains an aerosol-forming substrate and an atomiser and may therefore be referred to as a "cartomiser".

[0161] The aerosol-generating article 20 is replaceable by a user when the aerosol-forming substrate provided in the reservoir 22 is depleted.

[0162] Figure 1 shows the aerosol-generating article 20 just prior to insertion into the aerosol-generating device 10. The arrow 1 in Figure 1 indicates the direction of insertion of the aerosol-generating article 20 in to the aerosol-generating device 10.

[0163] The aerosol-generating device 10 is portable and has a size comparable to a conventional cigar or cigarette. The aerosol-generating device 10 comprises a main body 11 and a mouthpiece portion 12. The main body 11 contains a battery 14, such as a lithium iron phosphate battery, control electronics 16 and a cavity 18.

[0164] The mouthpiece portion 12 is connected to the main body 11 by a hinged connection 21 and can move between an open position as shown in Figure 1 and a closed position as shown in Figure 2. The mouthpiece portion 12 is placed in the open position to allow for insertion and removal of an aerosol-generating article 20 and is placed in the closed position when the aerosol-generating system is to be used to generate aerosol.

[0165] The mouthpiece portion 12 comprises a plurality of air inlets 13 and an outlet 15. In use, a user sucks or puffs on the outlet 15 to draw air from the air inlets 13, through the mouthpiece portion to the outlet 15, and thereafter into the mouth or lungs of the user. Internal baffles 17 are provided to force the air flowing through the mouthpiece portion 12 past the aerosol-generating article 20.

[0166] The housing 24 includes a capillary material soaked in the aerosol-forming substrate. The capillary material in this example is positioned adjacent the electric heater 30.

[0167] The cavity 18 has a circular cross-section and is sized to receive a housing 24 of the aerosol-generating article 20. Electrical connectors 19 are provided at the sides of the cavity 18 to provide an electrical connection between the control electronics 16 and battery 14 and corresponding electrical contacts on the aerosol-generating article 20. This setup allows power to be supplied to the electric heater 30.

[0168] Figure 2 shows the aerosol-generating article 20 inserted into the cavity 18 of the aerosol-generating device 10.

In this position, the electrical connectors 19 rest against the corresponding electrical contacts on the aerosol-generating article 20. The cover 26 has been fully removed and the mouthpiece portion 12 has been moved to a closed position.

[0169] The mouthpiece portion 12 is retained in the closed position by a clasp mechanism (not illustrated). It will be apparent to a person of ordinary skill in the art that other suitable mechanisms for retaining the mouthpiece in a closed position may be used, such as a snap fitting or a magnetic closure.

[0170] The mouthpiece portion 12 in a closed position retains the aerosol-generating article 20 in electrical contact with the electrical connectors 19 so that a good electrical connection is maintained in use, whatever the orientation of the aerosol-generating system is.

[0171] In use, when the aerosol-generating device 10 is activated by a user, the electric heater 30 melts and aerosolises at least a portion of the aerosol-forming substrate in the reservoir 22. As a user sucks or puffs on the outlet 15, air flows through the air inlets 13 and over the electric heater 30 and the capillary material. The air flowing over the electric heater 30 and the capillary material entrains the volatilized aerosol components from the vaporised aerosol-forming substrate. The air with entrained aerosol-forming substrate then flows out through the outlet 15 and to the user. This air flow regime is shown in Figure 2.

[0172] Figure 3 shows an alternative embodiment of an aerosol-generating system including an aerosol-generating article 200. In this example, the aerosol-generating article 200 is a "lipstick" advance mechanism aerosol-generating article 200. The aerosol-generating article 200 includes a body 212. The body 212 defines a reservoir 210. The reservoir 210 has a reservoir opening 215. The aerosol-forming substrate 211 is disposed in the reservoir 210. A heater 222 is disposed proximate to the reservoir opening 215. In this example, the body 212 includes a ring or rotation element 251 that is coupled to the movable rigid base 213. The ring or rotation element 251 translates rotational movement into lateral movement via a spiral or helical groove 214. Pins (not shown) couple the rigid base 213 to the spiral or helical groove 214 to provide the lateral movement of the aerosol-forming substrate 211. The aerosol-forming substrate 211 is a formulation according to the invention that may flow into and through a mesh layer of the heater 222.

[0173] In alternative embodiments (not shown), the aerosol-generating system may comprise an automatic mechanism to move or advance the aerosol-forming substrate 211 toward the heater 222. In such alternative embodiments, the controller 253 of the aerosol-generating device 200 may activate an actuator or advancement mechanism to advance the aerosol-forming substrate 211 and rigid base 213 toward the heater 222 upon detecting that the heater 222 is not in contact the aerosol-forming substrate 211. The actuator or advancement mechanism may be provided on the aerosol-generating article 200.

[0174] Figures 4 and 5 are schematic sectional views of an alternative aerosol-generating article 300. Figure 4 shows the aerosol-generating article 300 before it has been used by the user. The aerosol-generating article 300 includes a body 312 defining a reservoir 310 having a reservoir opening 315. Aerosol-forming substrate 311 is disposed in the reservoir 310. The aerosol-generating article 300 includes a heater 322 located across the reservoir opening 315. In this example, the heater 322 has a heating element in the form of a mesh layer 323. The aerosol-generating article 300 also includes a transfer element 324. The transfer element 324 is preferably formed from a porous material. In the example of Figure 4, the transfer element 324 is formed from a layer of glass fibers. The transfer element 324 provides control of the flow of the aerosol-forming substrate 311 from the reservoir 310 to the mesh layer 313 of the heater 322. In this example, the aerosol-forming substrate 311 is a formulation according to the invention.

Examples

[0175] One formulation according to the invention (Example A) is prepared having the composition shown in Table 1. The formulation of Example A is a solid at standard temperature and pressure.

Table 2

Example		A
Glycerine (% by weight)	aerosol former	15.9
Polypropylene Glycol (% by weight)	aerosol former	14
Polyvinyl Alcohol (% by weight)	polymer	7
Water (% by weight)		60
Nicotine (% by weight)		2
Lactic (% by weight)	organic acid	1.1

[0176] The formulation of Example A is prepared by:

- (1) heating the one or more aerosol formers to a temperature of between about 100 degrees Celsius and about 120 degrees Celsius using a hotplate stirrer;
- (2) adding the one or more polymers to the one or more aerosol formers, while stirring constantly, and then continuing to heat the mixture to a temperature of between about 85°C and about 95°C until the mixture was clear;
- (3) adding water to the clear mixture;
- (4) decreasing the heating temperature of the mixture to about 50°C and adding the organic acid and the nicotine to the mixture, while stirring constantly; and
- (5) pouring the heated mixture into a mould and then allowing the mixture to cool and congeal to form the formulation.

[0177] An example of use of a formulation according to the invention as an aerosol-forming substrate will now be described with reference to the formulation of Example A when used as an aerosol-forming substrate 311 in the aerosol-generating article 300 shown in Figures 4 and 5.

[0178] Figure 4 shows the aerosol-forming substrate 311 at standard temperature and pressure. Figure 5 shows the aerosol-forming substrate 311 at an elevated temperature when heated by the heater 322.

[0179] In the example of Figures 4 and 5, the aerosol-forming substrate 311 is a solid at standard temperature and pressure because the melting point of the aerosol-forming substrate 311 is between 60 degrees Celsius and 300 degrees Celsius. In another example, the aerosol-forming substrate 311 is a colloid at standard temperature and pressure. The colloid may have a solid continuous phase and a liquid dispersed phase.

[0180] Therefore, before the heater 322 has been activated, the aerosol-forming substrate 311 is in the solid phase.

[0181] The aerosol-generating article 300 is inserted into the aerosol-generating device 10 that is shown in Figure 1. The aerosol-generating device 300 is then activated by a user. Activation of the aerosol-generating device 10 involves activation of the heater 322 of the aerosol-generating article 300. Activation of the heater 322 heats a portion of the aerosol-generating substrate 311 contained within the transfer element 324. In this example, the heater 322 is activated at a power of 0.8 Watts for a time of six minutes. In one example, the heater 322 may be activated at a different power level. In another example, the heater 322 may be activated for a different time period.

[0182] Activation of the heater 322 at a power of 0.8 Watts for six minutes increases the temperature of the mesh layer 323 to around 200 degrees Celsius.

[0183] Heating of aerosol-forming substrate 311 contained within the transfer element 324 increases the temperature of at least a portion of the aerosol-forming substrate 311, which causes the heated portion of the aerosol-generating substrate 311 to melt into a liquid.

[0184] Figure 5 shows an example in which the whole of the aerosol-forming substrate 311 has been transitioned into a liquid through heating of the aerosol-forming substrate 311 by the heater 322. In another example, at least a portion, or only a portion of the aerosol-forming substrate 311 is melted into a liquid when the heater 322 activates. For example, the portion of the aerosol-forming substrate 311 that is adjacent the heater 322 may melt into a liquid, but the remaining portion of the aerosol-forming substrate 311 may remain as a solid.

[0185] The temperature of the aerosol-forming substrate 311 increases until at least a portion of the melted aerosol-forming substrate 311 contained within the transfer element 324 vaporises into an aerosol.

[0186] The aerosol can then be inhaled by a user through the outlet 15.

[0187] After the first heating cycle of the heater 322 has finished, the aerosol-forming substrate 311 cools down. The aerosol-forming substrate 311 forms back into a solid, as is shown in Figure 4.

[0188] The aerosol-generating article 300 may be used several times before the aerosol-generating substrate 311 contained within the reservoir 310 is fully consumed. Thus, the aerosol-generating article 300 may experience multiple heating cycles. Therefore, in use, the aerosol-forming substrate may experience multiple phase changes.

[0189] Advantageously, the aerosol-forming substrate 311 is stored as a solid or a substantially solid colloid within the reservoir 310. Since the aerosol-forming substrate 311 is stored as a solid, it is far less likely to leak or escape out of the reservoir 310 than a liquid aerosol-forming substrate 311. In view of this, an aerosol-generating article, aerosol-generating device or an aerosol-generating system that includes an aerosol-forming substrate 311 consisting of the formulation according to the invention has an improved shelf-life.

[0190] In addition, an aerosol-forming substrate 311 consisting of the formulation according to the invention melts into a liquid when it is heated during the normal heating cycle of an aerosol-generating article, aerosol-generating device or an aerosol-generating system. This means that the aerosol-forming substrate flows as a normal liquid aerosol-forming substrate and can be vaporised into an aerosol as normal. As discussed, depending on the specific design of the aerosol-generating article, aerosol generating device or aerosol generating system either a portion of the aerosol-forming substrate or the entire aerosol-forming substrate may melt during a heating cycle.

[0191] Furthermore, when an aerosol-forming substrate 311 consisting of the formulation according to the invention cools down after a heating cycle, it solidifies back into a solid and can therefore no longer flow out of the reservoir 310. This prevents leakage of the aerosol-forming substrate 311 between uses of the aerosol-generating article, aerosol-generating device or an aerosol-generating system.

[0192] Figure 6 shows the average aerosolised collected mass in mg per puff for a range of different aerosol former compositions when the weight percent of propylene glycol (PG) is varied relative to the weight percent of vegetable glycerine (VG). For example, the data for "25% PGvsVG" is for a formulation comprising an aerosol former composition that contains 25 percent by weight propylene glycol and 75 percent by weight vegetable glycerine.

[0193] Figure 7 is a graph showing average nicotine in mg per puff for a range of different aerosol former compositions when the weight percent of propylene glycol (PG) is varied relative to the weight percent of vegetable glycerine (VG). For example, the data for "25% PGvsVG" is for a formulation comprising an aerosol former composition that contains 25 percent by weight propylene glycol and 75 percent by weight vegetable glycerine.

[0194] Figure 8 is a graph showing average nicotine percent for a range of different aerosol former compositions when the weight percent of propylene glycol (PG) is varied relative to the weight percent of vegetable glycerine (VG). For example, the data for "25% PGvsVG" is for a formulation comprising an aerosol former composition that contains 25 percent by weight propylene glycol and 75 percent by weight vegetable glycerine.

[0195] The data in the graphs shows that, as discussed above, by including propylene glycol as an aerosol former in a formulation that includes nicotine, there is an improvement in the nicotine content of the aerosol. For example, the highest weight percent of nicotine is when there is 5 weight percent of propylene glycol in the aerosol former. This improvement may be due to more efficient vaporisation of the nicotine because propylene glycol has a lower boiling point (188°C) compared to glycerine (290°C).

[0196] However, if there is high amount of propylene glycol in the formulation (for example 25 percent by weight propylene glycol) then the nicotine content of the aerosol decreases because the propylene glycol can be vaporised during a heating cycle. Therefore, it is advantageous to have a limited amount of propylene glycol in the nicotine formulation.

[0197] The exemplary embodiments described above are not intended to limit the scope of the claims.

Claims

1. A formulation for use in an aerosol-generating system, the formulation comprising:
 - one or more aerosol formers; and
 - one or more polymers selected from the group consisting of: polyvinyl acetate, polyvinyl alcohol, polyethylene glycol, polyglycolic acid, polylactic acid, polydioxanone, polycaprolactone, polyethylene, polypropylene glycol and starch;
 - wherein the formulation has a melting point of between 100 degrees Celsius and 300 degrees Celsius.
2. A formulation according to claim 1, wherein the formulation has a melting point of between 180 degrees Celsius and 270 degrees Celsius.
3. A formulation according to claim 1 or claim 2, wherein the formulation has an aerosol former content of between 20 percent by weight and 85 percent by weight.
4. A formulation according to claim 3, wherein the formulation has an aerosol former content of between 35 percent by weight and 55 percent by weight.
5. A formulation according to any of claims 2 to 4, wherein the one or more aerosol formers comprise one or more water-miscible polyhydric alcohols.
6. A formulation according to claim 5, wherein the one or more water-miscible polyhydric alcohols are selected from the group consisting of: vegetable glycerol, propylene glycol, and sorbitol.
7. A formulation according to any preceding claim, comprising one or more organic acids.
8. A formulation according to claim 7, wherein the formulation has an organic acid content of less than 10 percent by weight.
9. A formulation according to claim 7 or claim 8, wherein the one or more organic acids are selected from the group consisting of: malonic acid, citric acid, 2-ethylbutyric acid, acetic acid, adipic acid, benzoic acid, butyric acid, cinnamic acid, cycloheptane-carboxylic acid, fumaric acid, glycolic acid, hexanoic acid, lactic acid, levulinic acid, malic acid, myristic acid, octanoic acid, oxalic acid, propanoic acid, pyruvic acid, succinic acid and undecanoic acid.

10. A formulation according to any claim 9, wherein the one or more organic acids are selected from the group consisting of: malonic acid, citric acid, lactic acid, benzoic acid, levulinic acid, fumaric acid and acetic acid..

11. A formulation according to any preceding claim, wherein the formulation has a polymer content of greater than or equal to about 0.5 percent by weight.

12. A formulation according to any preceding claim, comprising one or more metal salts.

13. A formulation according to claim 12, wherein the one or more metal salts are selected from the group consisting of: metal alginates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinate, metal propanoates, metal stearates and metal undecanoates, preferably the one or more metal salts are selected from the group consisting of metal cinnamates, metal cycloheptanecarboxylates, metal stearates and metal undecanoates.

14. An aerosol-generating article (300) for use in an aerosol-generating system, the aerosol-generating article (300) containing a formulation according to any one of claims 1 to 13.

15. An aerosol-generating system comprising:

a formulation according to any one of claims 1 to 13; and
an atomiser configured to generate an aerosol from the formulation.

Patentansprüche

1. Formulierung zum Gebrauch in einem Aerosolerzeugungssystem, wobei die Formulierung Folgendes umfasst:

einen oder mehrere Aerosolbildner; und
ein oder mehrere Polymere, die ausgewählt sind aus der Gruppe bestehend aus: Polyvinylacetat, Polyvinylalkohol, Polyethylenglycol, Polyglycolsäure, Polylactid, Polydioxanon, Polycaprolacton, Polyethylen, Polypropylenglycol und Stärke;
wobei die Formulierung einen Schmelzpunkt zwischen 100 Grad Celsius und 300 Grad Celsius aufweist.

2. Formulierung nach Anspruch 1, wobei die Formulierung einen Schmelzpunkt zwischen 180 Grad Celsius und 270 Grad Celsius aufweist.

3. Formulierung nach Anspruch 1 oder Anspruch 2, wobei die Formulierung einen Aerosolbildnergehalt zwischen 20 Gewichtsprozent und 85 Gewichtsprozent aufweist.

4. Formulierung nach Anspruch 3, wobei die Formulierung einen Aerosolbildnergehalt zwischen 35 Gewichtsprozent und 55 Gewichtsprozent aufweist.

5. Formulierung nach einem beliebigen der Ansprüche 2 bis 4, wobei der eine oder die mehreren Aerosolbildner einen oder mehrere mit Wasser mischbare mehrwertige Alkohole umfassen.

6. Formulierung nach Anspruch 5, wobei der eine oder die mehreren mit Wasser mischbaren mehrwertigen Alkohole ausgewählt sind aus der Gruppe bestehend aus: pflanzlichem Glycerin, Propylenglycol und Sorbit.

7. Formulierung nach einem beliebigen vorhergehenden Anspruch, die eine oder mehrere organische Säuren umfasst.

8. Formulierung nach Anspruch 7, wobei die Formulierung einen Gehalt an organischer Säure von weniger als 10 Gewichtsprozent aufweist.

9. Formulierung nach Anspruch 7 oder Anspruch 8, wobei die eine oder die mehreren organischen Säuren ausgewählt sind aus der Gruppe bestehend aus: Malonsäure, Citronensäure, 2-Ethylbutansäure, Essigsäure, Adipinsäure, Benzoesäure, Butansäure, Zimtsäure, Cycloheptancarbonsäure, Fumarsäure, Glycolsäure, Hexansäure, Milchsäure, Lävulinsäure, Äpfelsäure, Myristinsäure, Octansäure, Oxalsäure, Propansäure, Brenztraubensäure, Bernsteinsäure und Undecansäure.

10. Formulierung nach einem beliebigen Anspruch 9, wobei die eine oder die mehreren organischen Säuren ausgewählt sind aus der Gruppe bestehend aus: Malonsäure, Citronensäure, Milchsäure, Benzoesäure, Lävulinsäure, Fumarsäure und Essigsäure.

11. Formulierung nach einem beliebigen vorhergehenden Anspruch, wobei die Formulierung einen Polymergehalt von mehr als oder gleich etwa 0,5 Gewichtsprozent aufweist.

- 12. Formulierung nach einem beliebigen vorhergehenden Anspruch, die ein oder mehrere Metallsalze umfasst.**

- 13.** Formulierung nach Anspruch 12, wobei das eine oder die mehreren Metallsalze ausgewählt sind aus der Gruppe bestehend aus: Metallalginaten, Metallsinuatmen, Metallsyloheptanearboxylaten, Metallsillevulinen, Metallspropnoaten, Metallslearten und Metallsundeeanoaten, wobei das eine oder die mehreren Metallsalze bevorzugt ausgewählt sind aus der Gruppe bestehend aus Metallsinuatmen, Metallsyloheptanearboxylaten, Metallslearten und Metallsundeeanoaten.

14. Aerosolerzeugender Artikel (300) zum Gebrauch in einem Aerosolerzeugungssystem, wobei der aerosolerzeugende Artikel (300) eine Formulierung nach einem der Ansprüche 1 bis 13 enthält.

- 15. Aerosolerzeugungssystem, umfassend:**

eine Formulierung nach einem der Ansprüche 1 bis 13; und
einen Zerstäuber, der für die Erzeugung eines Aerosols aus der Formulierung ausgelegt ist.

Revendications

1. Formulation destinée à être utilisée dans un système de génération d'aérosol, la formulation comprenant :

un ou plusieurs agents de formation d'aérosol ; et

un ou plusieurs polymères choisis dans le groupe constitué par : acétate de polyvinyle, alcool polyvinylique, polyéthylène glycol, acide polyglycolique, acide polylactique, polydioxanone, polycaprolactone, polyéthylène, polypropylène glycol et amidon ;
dans laquelle la formulation a un point de fusion entre 100 degrés Celsius et 300 degrés Celsius.

2. Formulation selon la revendication 1, dans laquelle la formulation a un point de fusion entre 180 degrés Celsius et 270 degrés Celsius.

3. Formulation selon la revendication 1 ou la revendication 2, dans laquelle la formulation a une teneur en agent de formation d'aérosol entre 20 pour cent en poids et 85 pour cent en poids.

4. Formulation selon la revendication 3, dans laquelle la formulation a une teneur en agent de formation d'aérosol entre 35 pour cent en poids et 55 pour cent en poids.

5. Formulation selon l'une quelconque des revendications 2 à 4, dans laquelle les un ou plusieurs agents de formation d'aérosol comprennent un ou plusieurs alcools polyhydriques miscibles à l'eau.

6. Formulation selon la revendication 5, dans laquelle les un ou plusieurs alcools polyhydriques miscibles à l'eau sont choisis dans le groupe constitué par : glycérol végétal, propylène glycol et sorbitol.

7. Formulation selon une quelconque revendication précédente, comprenant un ou plusieurs acides organiques.

8. Formulation selon la revendication 7, dans laquelle la formulation a une teneur en acide organique inférieure à 10 pour cent en poids.

9. Formulation selon la revendication 7 ou la revendication 8, dans laquelle les un ou plusieurs acides organiques sont choisis dans le groupe constitué par : acide malonique, acide citrique, acide 2-éthylbutyrique, acide acétique, acide adipique, acide benzoïque, acide butyrique, acide cinnamique, acide cycloheptane-carboxylique, acide fumarique, acide glycolique, acide hexanoïque, acide lactique, acide lévulinique, acide malique, acide myristique, acide

octanoïque, acide oxalique, acide propanoïque, acide pyruvique, acide succinique et acide undécanoïque.

5 **10.** Formulation selon la revendication 9, dans laquelle les un ou plusieurs acides organiques sont choisis dans le groupe constitué par : l'acide malonique, l'acide citrique, l'acide lactique, l'acide benzoïque, l'acide lévulinique, l'acide fumarique et l'acide acétique.

11. Formulation selon une quelconque revendication précédente, dans laquelle la formulation a une teneur en polymère supérieure ou égale à environ 0,5 pour cent en poids.

10 **12.** Formulation selon une quelconque revendication précédente, comprenant un ou plusieurs sels métalliques.

15 **13.** Formulation selon la revendication 12, dans laquelle les un ou plusieurs sels métalliques sont choisis dans le groupe constitué par : alginates métalliques, cinnamates métalliques, cycloheptanecarboxylates métalliques, lévulinales métalliques, propanoates métalliques, stéarates métalliques et undécanoates métalliques, de préférence les un ou plusieurs sels métalliques sont choisis dans le groupe constitué par cinnamates métalliques, cycloheptanecarboxylates métalliques, stéarates métalliques et undécanoates métalliques.

20 **14.** Article de génération d'aérosol (300) destiné à être utilisé dans un système de génération d'aérosol, l'article de génération d'aérosol (300) contenant une formulation selon l'une quelconque des revendications 1 à 13.

15. Système de génération d'aérosol, comprenant :

25 une formulation selon l'une quelconque des revendications 1 à 13 ; et
un atomiseur configuré pour générer un aérosol à partir de la formulation.

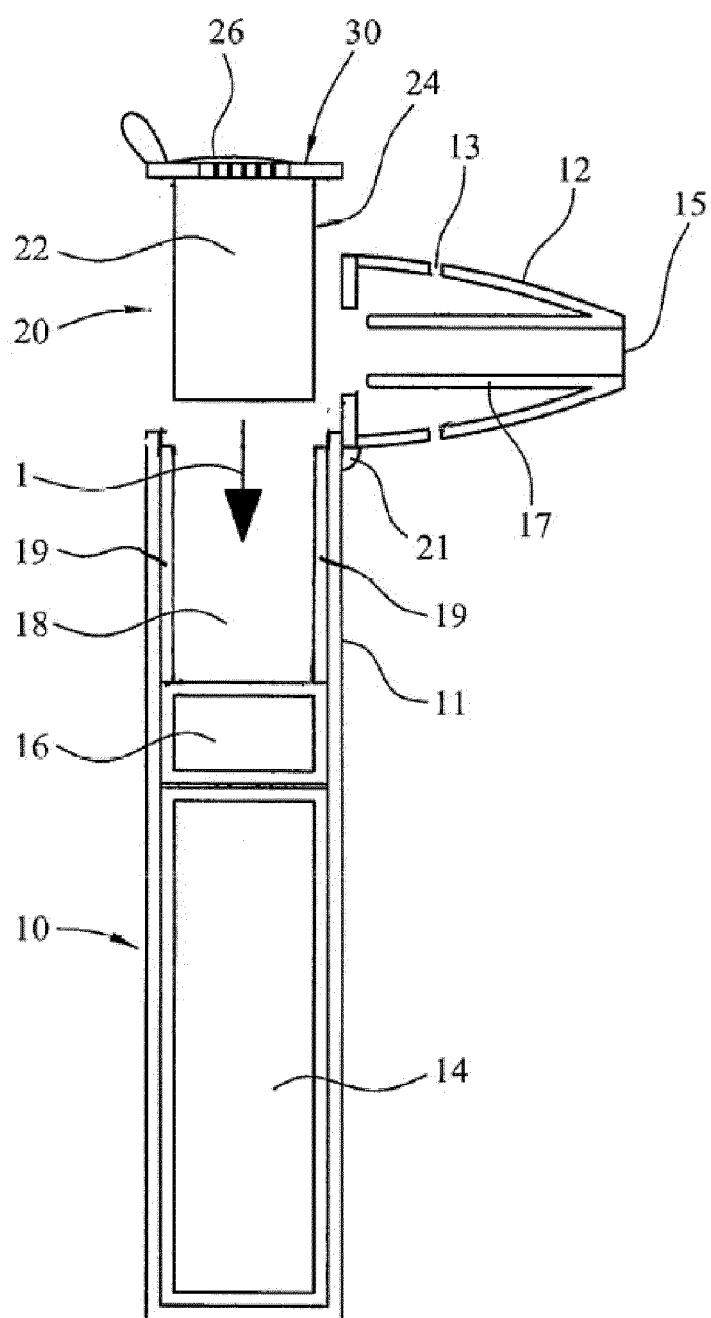


Figure 1

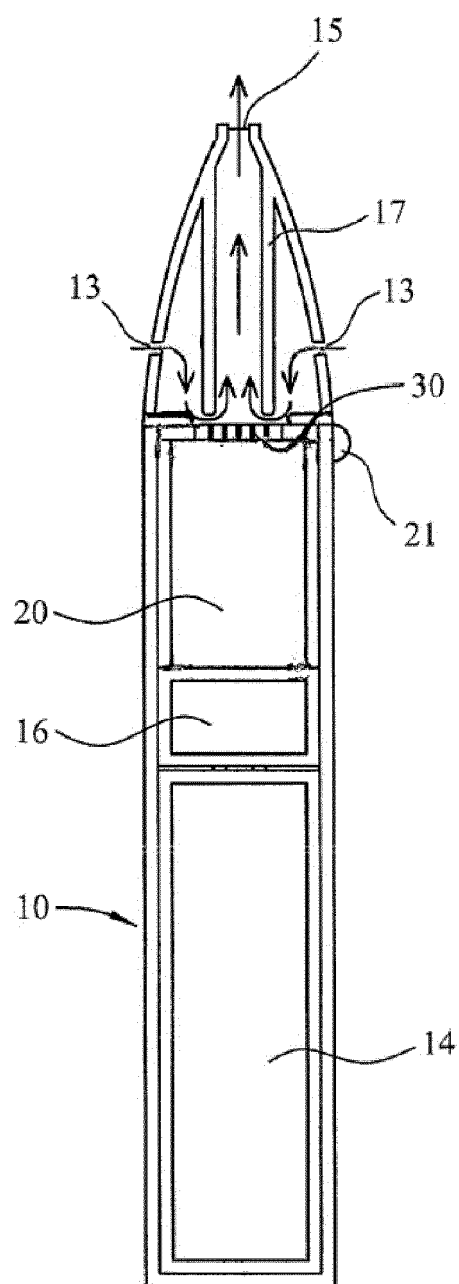


Figure 2

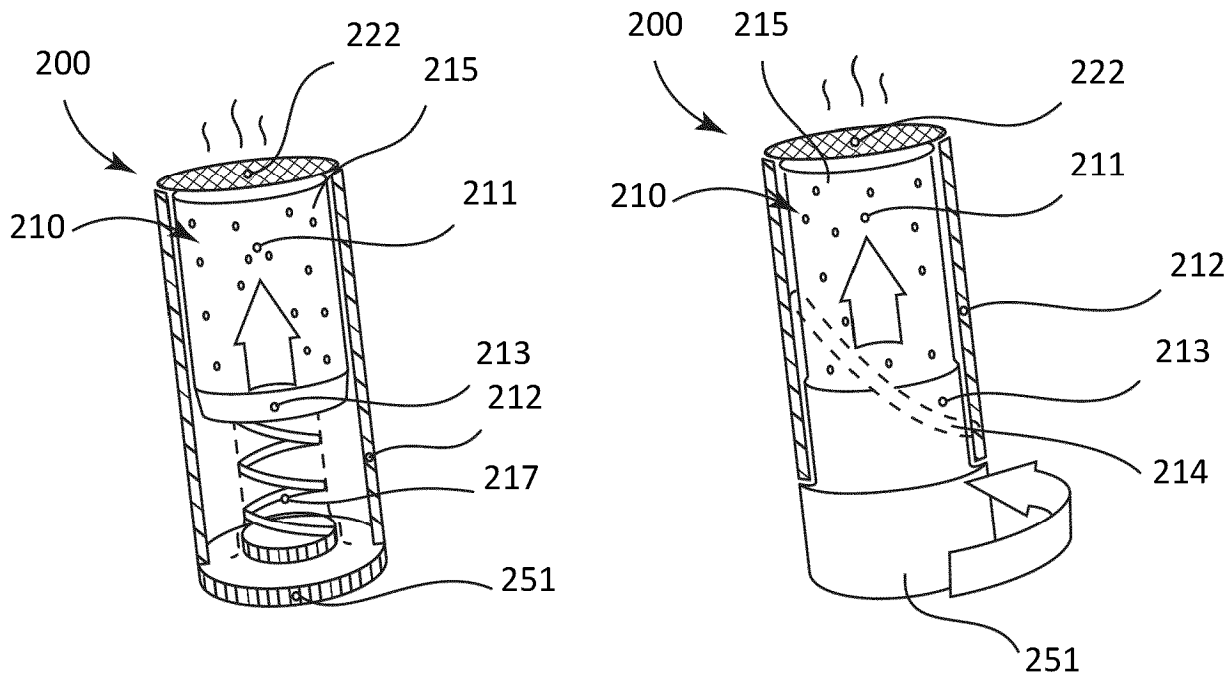


Figure 3

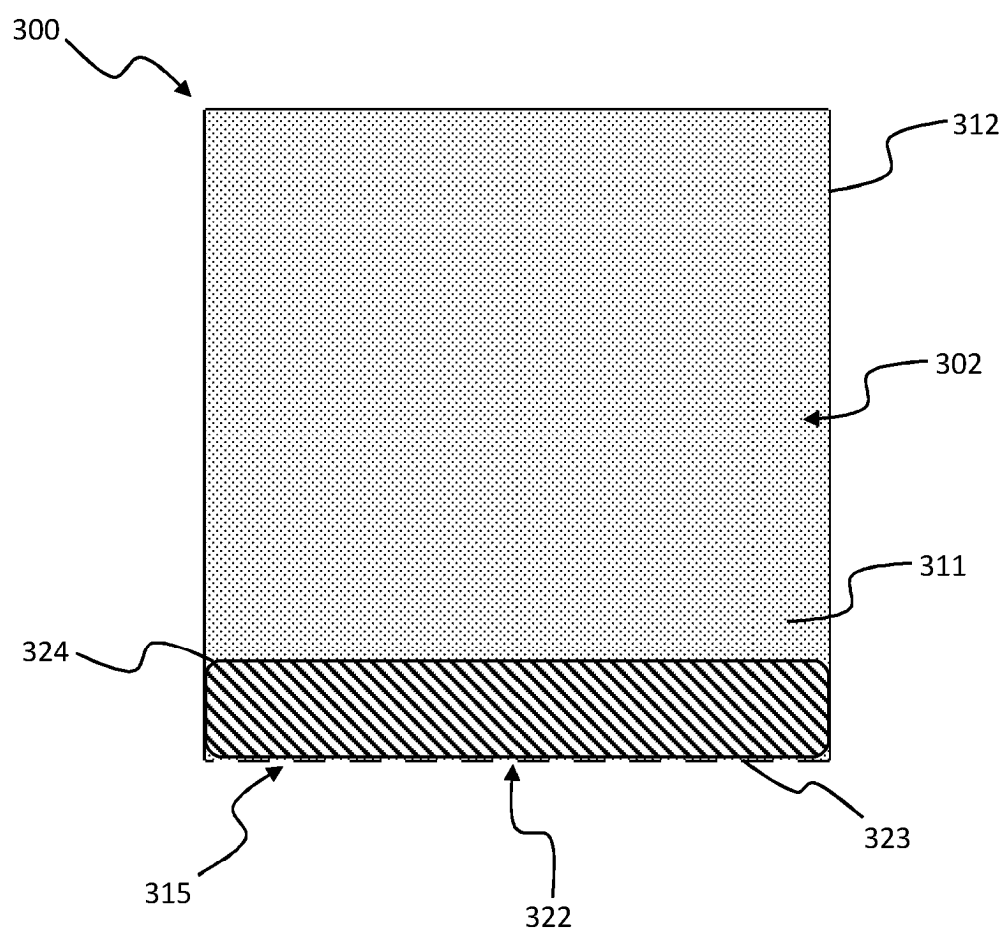


Figure 4

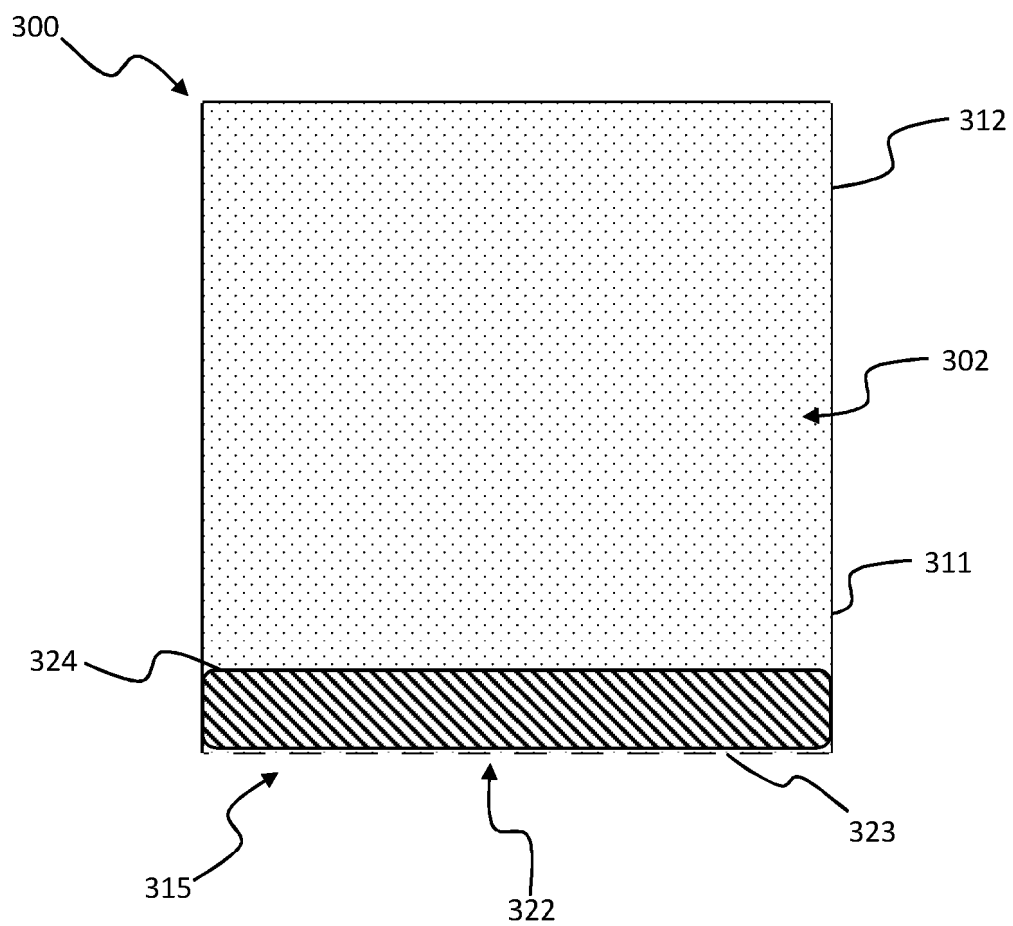


Figure 5

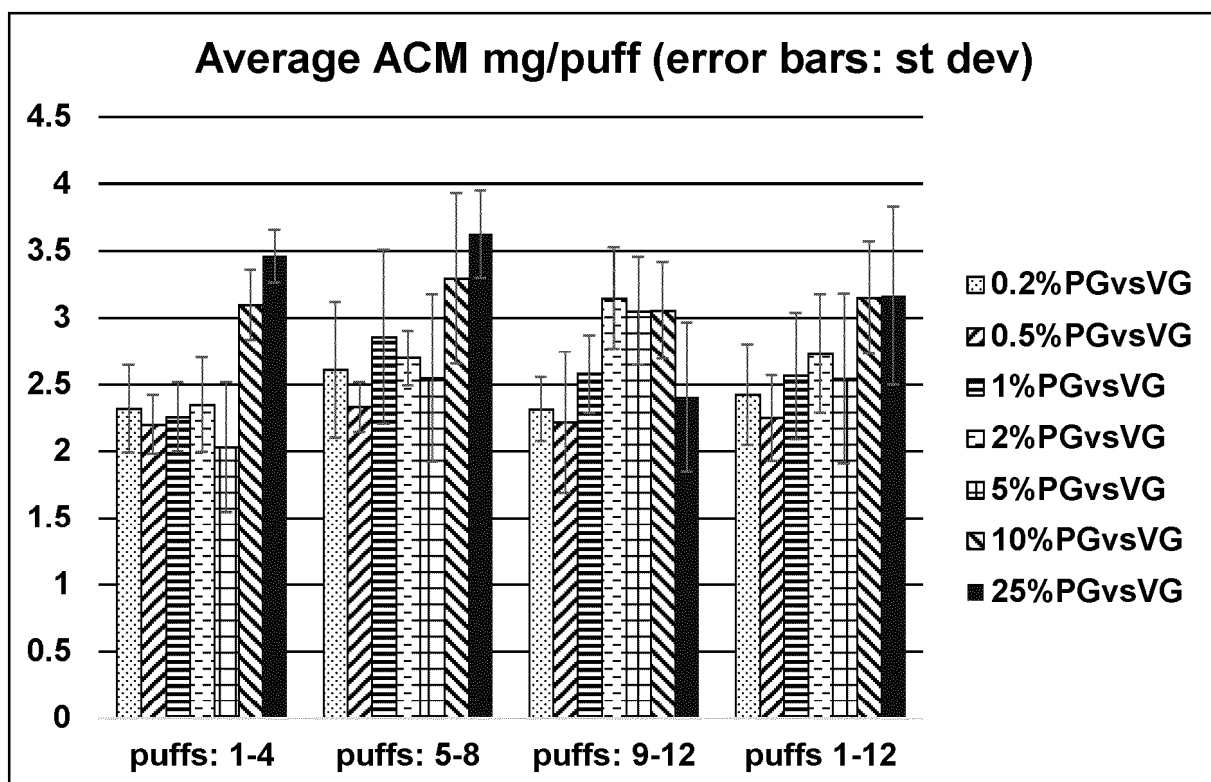
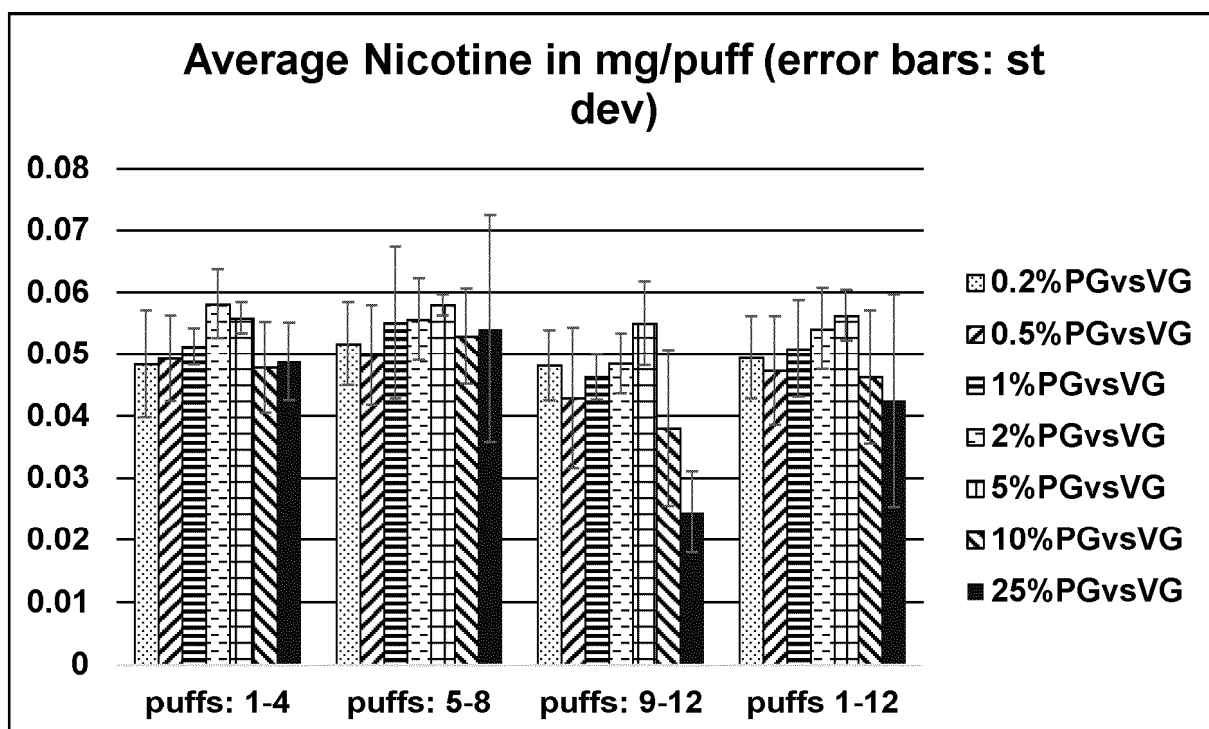


Figure 6

Figure 7

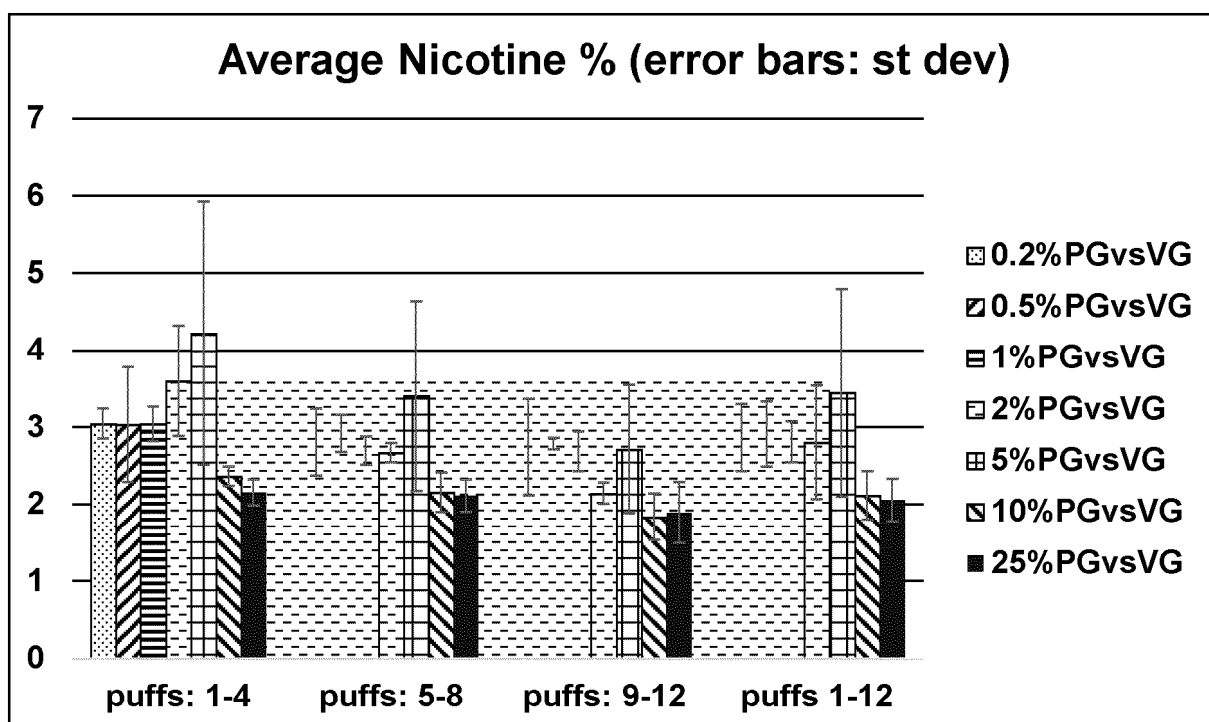


Figure 8

REFERENCES CITED IN THE DESCRIPTION

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