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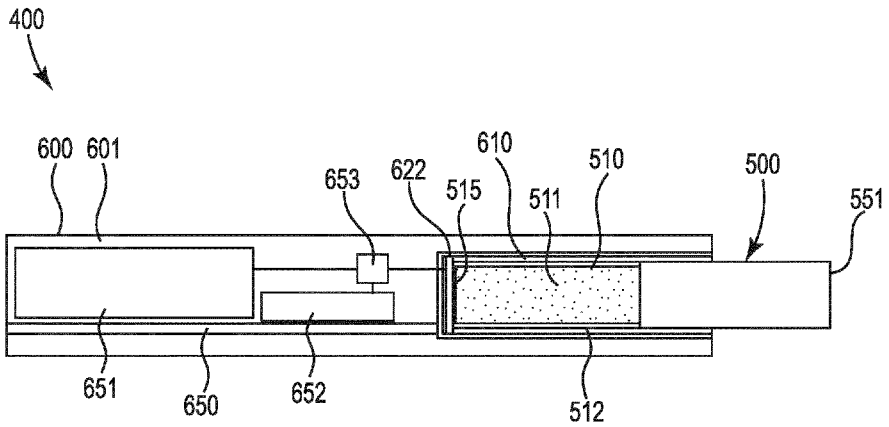

Fig. 1

(57) Abstract: A nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight,wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s, wherein the one or more water-miscible polyhydric alcohols comprise glycerine and propylene glycol, and wherein the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1.5. An aerosol-generating article (500) for use in an aerosol-generating system (600), the aerosol-generating article (500) containing the nicotine formulation (511). An aerosol-generating system (600) comprising the nicotine formulation (511) and an atomiser (622) configured to generate an aerosol from the nicotine formulation (511).

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HIGH VISCOSITY NICOTINE FORMULATION

The invention relates to a nicotine formulation for use in an aerosol-generating system. The invention also relates to an aerosol-generating article comprising the nicotine formulation for use in an aerosol-generating system and an aerosol-generating system comprising the nicotine formulation and an atomiser.

Aerosol-generating systems for delivering nicotine to a user that comprise an atomiser configured to generate an inhalable aerosol from a nicotine formulation are known. Some known aerosol-generating systems comprise a thermal atomiser such as an electric heater that is configured to heat and vaporise the nicotine formulation to generate an aerosol. Other known aerosol-generating systems comprise a non-thermal atomiser that is configured to generate an aerosol from the nicotine formulation using, for example, impinging jet, ultrasonic or vibrating mesh technologies. Typical nicotine formulations for use in aerosol-generating systems are liquid nicotine formulations comprise glycerine, propylene glycol and water as solvents.

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

It would also be desirable to provide a nicotine formulation that exhibits more efficient vaporization of nicotine and increased nicotine delivery to a user compared to typical liquid nicotine formulations when used in an aerosol-generating system.

According to the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

According to the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight, wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s, wherein the one or more water-miscible polyhydric alcohols comprise glycerine and propylene glycol, and wherein the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1.5.

According to the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight, wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s, wherein the one or more water-miscible polyhydric alcohols comprise glycerine and propylene glycol, and wherein the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1.5.

According to the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight, wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s, wherein the one or more water-miscible polyhydric alcohols comprise glycerine and propylene glycol, and wherein the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1.5; and an atomiser configured to generate an aerosol from the nicotine formulation.

As used herein with reference to the invention, the term “nicotine” describes nicotine, nicotine base or a nicotine salt. In embodiments in which the nicotine formulation comprises a nicotine base or a nicotine salt, the amounts of nicotine recited herein are the amount of free base nicotine or amount of protonated nicotine, respectively.

As used herein with reference to the invention, 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.

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

The increased hardness or viscosity of nicotine formulation according to the invention compared to typical liquid nicotine formulations may advantageously reduce the risk of leakage

of nicotine formulations according to the invention when used in an aerosol-generating system compared to typical liquid nicotine formulations.

Advantageously, including propylene glycol in the nicotine formulation may result in a solid formulation that is less rigid, less brittle, and is easier to form into plugs. These properties improve subsequent processing and handling of the nicotine formulation during the manufacturing process.

Including propylene glycol in the nicotine formulation has also been shown to improve vaporisation of the nicotine formulation, which leads to the production of more aerosol for a given heating cycle.

By including propylene glycol in the nicotine formulation, there may also be an improvement in the nicotine content of the aerosol due to vaporisation of the nicotine. It is believed that this may be due to propylene glycol having a lower boiling point (188°C) compared to glycerine (290°C). However, if there is high amount of propylene glycol in the nicotine formulation then the nicotine content of the aerosol has been found to decrease. Therefore, it may be advantageous to have a limited amount of propylene glycol in the nicotine formulation.

Nicotine formulations according to the invention may advantageously be used as aerosol-forming substrates in aerosol-generating systems that comprise an automatic or manual mechanism to move or advance the aerosol-forming substrate toward the atomiser as illustrated in FIGS. 1-3. The aerosol-forming substrate thus maintains contact with the atomiser even as the aerosol-forming substrate is consumed during use. In such aerosol-generating systems, the advancement mechanism may form a portion of an aerosol-generating article comprising the nicotine formulation or a portion of an aerosol-generating device that receives an aerosol-generating article comprising the nicotine formulation.

The nicotine formulation may be a solid nicotine formulation.

As used herein with reference to the invention, the term “solid nicotine formulation” describes a solid formulation comprising nicotine.

The nicotine formulation may be a liquid nicotine formulation.

As used herein with reference to the invention, the term “liquid nicotine formulation” describes a liquid formulation comprising nicotine or a gel formulation comprising nicotine.

As used herein with reference to the invention, the term “gel” describes a substantially dilute cross-linked system, which exhibits no flow when in the steady-state.

The nicotine formulation may be solid at 25°C or have a viscosity at 25°C of greater than or equal to about 250 Pa·s, greater than or equal to about 500 Pa·s or greater than or equal to about 750 Pa·s.

Preferably the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 1000 Pa·s. For example, the nicotine formulation may be solid at 25°C or

have a viscosity at 25°C of greater than or equal to about 2500 Pa·s, greater than or equal to about 5000 Pa·s or greater than or equal to about 7500 Pa·s.

More preferably the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 10,000 Pa·s. For example, the nicotine formulation may be solid at 25°C or have a viscosity at 25°C of greater than or equal to about 12,500 Pa·s, greater than or equal to about 15,000 Pa·s or greater than or equal to about 17,500 Pa·s.

Unless stated otherwise, viscosity values recited herein are the viscosity of a 1 cubic centimetre (cm^3) sample volume of nicotine formulation measured using a Thermo Scientific HAAKE RheoStress 6000 rheometer using a parallel plate P20 probe with a MP60 (60 mm diameter) measuring plate at 25°C at a speed of 6 revolutions per minute (rpm).

The nicotine formulation may comprise natural nicotine or synthetic nicotine.

The nicotine formulation may have a nicotine content of greater than or equal to about 0.5 percent by weight.

Preferably, the nicotine formulation has a nicotine content of greater than or equal to about 1 percent by weight. More preferably, the nicotine formulation has a nicotine content of greater than or equal to about 1.5 percent by weight.

The nicotine formulation may have a nicotine content of less than or equal to about 10 percent by weight or less than or equal to about 8 percent by weight.

Preferably, the nicotine formulation has a nicotine content of less than or equal to about 5 percent by weight. More preferably, the nicotine formulation has a nicotine content of less than or equal to about 3 percent by weight.

The nicotine formulation may have a nicotine content of between about 0.5 percent by weight and about 10 percent by weight. For example, the nicotine formulation may have a nicotine content of between about 0.5 percent by weight and about 8 percent by weight, between about 0.5 percent by weight and about 5 percent by weight or between about 0.5 percent by weight and about 3 percent by weight.

Preferably, the nicotine formulation has a nicotine content of between about 1 percent by weight and about 10 percent by weight. For example, the nicotine formulation may have a nicotine content of between about 1 percent by weight and about 8 percent by weight, between about 1 percent by weight and about 5 percent by weight or between about 1 percent by weight and about 3 percent by weight.

More preferably, the nicotine formulation has a nicotine content of between about 1.5 percent by weight and about 10 percent by weight. For example, the nicotine formulation may have a nicotine content of between about 1.5 percent by weight and about 8 percent by weight, between about 1.5 percent by weight and about 5 percent by weight or between about 1.5 percent by weight and about 3 percent by weight.

The nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight.

Preferably, the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 50 percent by weight. More preferably, the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 60 percent by weight. For example, the nicotine formulation may have a water-miscible polyhydric alcohol content of greater than or equal to about 70 percent by weight, greater than or equal to about 80 percent by weight or greater than or equal to about 90 percent by weight.

Preferably, the nicotine formulation has a water-miscible polyhydric alcohol content of less than or equal to about 95 percent by weight.

The nicotine formulation may have a water-miscible polyhydric alcohol content of between about 40 percent by weight and about 95 percent by weight.

Preferably, the nicotine formulation has a water-miscible polyhydric alcohol content of between about 50 percent by weight and about 95 percent by weight. More preferably, the nicotine formulation has a water-miscible polyhydric alcohol content of between about 60 percent by weight and about 95 percent by weight. For example, the nicotine formulation may have a water-miscible polyhydric alcohol content of between about 70 percent by weight and about 95 percent by weight, between about 80 percent by weight and about 95 percent by weight or between about 90 percent by weight and about 95 percent by weight.

Preferably, the nicotine formulation comprises one or more water-miscible polyhydric alcohols selected from the group consisting of 1,3-butanediol, glycerine, propylene glycol, and triethylene glycol.

More preferably, the nicotine formulation comprises glycerine.

Most preferably, the nicotine formulation comprises vegetable glycerine.

The nicotine formulation may have a glycerine content of greater than or equal to about 5 percent by weight. The nicotine formulation may have a glycerine content of greater than or equal to about 10 percent by weight, greater than or equal to about 20 percent by weight or greater than or equal to about 30 percent by weight.

Preferably, the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight.

According to a preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising glycerine, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article

containing a nicotine formulation comprising glycerine, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising glycerine, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

More preferably, the nicotine formulation has a glycerine content of greater than or equal to about 50 percent by weight. Most preferably, the nicotine formulation has a glycerine content of greater than or equal to about 60 percent by weight. For example, the nicotine formulation may have a glycerine content of greater than or equal to about 70 percent by weight, greater than or equal to about 80 percent by weight or greater than or equal to about 90 percent by weight.

Preferably, the nicotine formulation has a glycerine content of less than or equal to about 95 percent by weight.

The nicotine formulation may have a glycerine content of between about 5 percent by weight and about 95 percent by weight. For example, the nicotine formulation may have a glycerine content of between about 10 percent by weight and about 95 percent by weight, between about 20 percent by weight and about 95 percent by weight or between about 30 percent by weight and about 95 percent by weight.

Preferably, the nicotine formulation has a glycerine content of between about 40 percent by weight and about 95 percent by weight. More preferably, the nicotine formulation has a glycerine content of between about 50 percent by weight and about 95 percent by weight. Most preferably, the nicotine formulation has a glycerine content of between about 60 percent by weight and about 95 percent by weight. For example, the nicotine formulation may have a glycerine content of between about 70 percent by weight and about 95 percent by weight, between about 80 percent by weight and about 95 percent by weight or between about 90 percent by weight and about 95 percent by weight.

The nicotine formulation may comprise glycerine and propylene glycol.

In embodiments in which the nicotine formulation comprises glycerine and propylene glycol, preferably the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1. More preferably, the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1.5. For example, the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine

formulation may be greater than or equal to about 2, greater than or equal to about 2.5 or greater than or equal to about 3.

Preferably, the nicotine formulation comprises one or more metal salts.

Bonding between the one or more metal salts and the one or more polyhydric alcohols in the nicotine formulation may solidify the nicotine formulation or increase the viscosity of the nicotine formulation to greater than or equal to about 100 Pa·s. This may advantageously reduce the risk of leakage of the nicotine formulation when used in an aerosol-generating system compared to a typical liquid nicotine formulation that does not include one or more metal salts.

Bonding between the one or more metal salts and the one or more polyhydric alcohols in the nicotine formulation may elevate the boiling point of the one or more polyhydric alcohols. This may advantageously enhance vaporization of nicotine from the nicotine 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.

Without wishing to be bound by theory, the interactions between the one or more metal salts and the molecules of the one or more polyhydric alcohols in the nicotine formulation may be stronger than the interactions between the molecules of the one or more polyhydric alcohols. This may result in more energy being required to vaporize the one or more polyhydric alcohols. In use, the inclusion of one or more metal salts in the nicotine formulation may thereby advantageously increase the percentage of nicotine in an aerosol generated from the nicotine formulation by up to one order of magnitude compared to a typical liquid nicotine formulation that does not include one or more metal salts.

Preferably, the nicotine formulation has a metal salt content of greater than or equal to about 0.5 percent by weight.

The nicotine formulation may have a metal salt content of greater than or equal to about 0.75 percent by weight or greater than or equal to about 1 percent by weight.

Preferably, the nicotine formulation has a metal salt content of less than or equal to about 15 percent by weight. More preferably, the nicotine formulation has a metal salt content of less than or equal to about 12 percent by weight. For example, the nicotine formulation may have a metal salt content of less than or equal to about 10 percent by weight.

Preferably, the nicotine formulation has a metal salt content of between about 0.5 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a metal salt content of between about 0.5 percent by weight and about 12 percent by weight or between about 0.5 percent by weight and about 10 percent by weight.

The nicotine formulation may have a metal salt content of between about 0.75 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a metal salt content of between about 0.75 percent by weight and about 12 percent by weight or between about 0.75 percent by weight and about 10 percent by weight.

The nicotine formulation may have a metal salt content of between about 1 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a metal salt content of between about 1 percent by weight and about 12 percent by weight or between about 1 percent by weight and about 10 percent by weight.

The one or more metal salts may have a molar mass of less than or equal to about 500 g/mol or less than or equal to about 400 g/mol.

Preferably, the one or more metal salts are one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates.

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

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

Preferably, the one or more metal salts comprise metal stearates.

Advantageously, covalent bonding between the one or more metal stearates and the one or more water-miscible polyhydric alcohols in the nicotine formulation may further elevate the boiling point of the one or more water-miscible polyhydric alcohols. When the formulation includes nicotine, this may advantageously enhance the efficiency of vaporization of nicotine from the nicotine 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.

According to a preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols; and one or more metal salts selected

from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

More preferably, the one or more metal salts are selected from the group consisting of metal alginates and metal stearates.

Most preferably, the nicotine formulation comprises one or more metal stearates.

According to a preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and one or more metal stearates, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According a preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols; and one or more metal stearates, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According a preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and one or more metal stearates, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

Preferably, the nicotine formulation comprises glycerine and one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates.

According to a preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: glycerine; and one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation comprising: glycerine; and one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising: glycerine; and one or more metal salts selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

More preferably, the nicotine formulation comprises glycerine and one or more metal salts selected from the group consisting of metal alginates and metal stearates.

Most preferably, the nicotine formulation comprises glycerine and one or more metal stearates.

According to a preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: glycerine; and one or more metal stearates, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation comprising: glycerine; and one or more metal stearates, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising: glycerine; and one or more metal stearates, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

Covalent bonding between the one or more metal stearates and the glycerine in the nicotine formulation may solidify the nicotine formulation or increase the viscosity of the nicotine formulation to greater than or equal to about 100 Pa·s. This may advantageously reduce the risk of leakage of the nicotine formulation when used in an aerosol-generating system.

Covalent bonding between the one or more metal stearates and the glycerine in the nicotine formulation may elevate the boiling point of the glycerine. This may advantageously enhance vaporization of nicotine from the nicotine formulation when used in an aerosol-generating system.

The nicotine formulation may comprise one or more salts of any suitable metal.

Preferably, the one or more metal salts are one or more alkali metal salts.

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

More preferably, the one or more metal salts are one or more sodium salts selected from the group consisting of sodium alginate, sodium benzoate, sodium cinnamate, sodium cycloheptanecarboxylate, sodium levulinate, sodium propanoate, sodium stearate and sodium undecanoate.

Most preferably, the one or more salts are one or more sodium salts selected from the group consisting of sodium alginate and sodium stearate.

In embodiments in which the nicotine formulation comprises sodium alginate, the nicotine formulation may have a sodium alginate content of greater than or equal to about 0.25 percent by weight or greater than or equal to about 0.5 percent by weight. For example, the nicotine formulation may have a sodium alginate content of greater than or equal to about 0.75 percent by weight or greater than or equal to about 1 percent by weight.

Preferably, the nicotine formulation has a sodium alginate content of less than or equal to about 15 percent by weight. More preferably, the nicotine formulation has a sodium alginate

content of less than or equal to about 12 percent by weight. For example, the nicotine formulation may have a sodium alginate content of less than or equal to about 10 percent by weight.

In embodiments in which the nicotine formulation comprises sodium alginate, the nicotine formulation may have a sodium alginate content of between about 0.25 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium alginate content of between about 0.25 percent by weight and about 12 percent by weight or between about 0.25 percent by weight and about 10 percent by weight.

In embodiments in which the nicotine formulation comprises sodium alginate, the nicotine formulation may have a sodium alginate content of between about 0.5 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium alginate content of between about 0.5 percent by weight and about 12 percent by weight or between about 0.5 percent by weight and about 10 percent by weight.

The nicotine formulation may have a sodium alginate of between about 0.75 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium alginate of between about 0.75 percent by weight and about 12 percent by weight or between about 0.75 percent by weight and about 10 percent by weight.

The nicotine formulation may have a sodium alginate of between about 1 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium alginate content of between about 1 percent by weight and about 12 percent by weight or between about 1 percent by weight and about 10 percent by weight.

Particularly preferably, the nicotine formulation comprises sodium stearate.

A metal salt with a high weighted average molecular weight may improve the above mentioned advantages related to efficiency of vaporization of nicotine. However, if the weighted average 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 trade-off in improved efficiency of vaporization of nicotine, whilst maintaining solubility.

According to a preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and sodium stearate, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and sodium stearate, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to

about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising: one or more water-miscible polyhydric alcohols; and sodium stearate, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

In embodiments in which the nicotine formulation comprises sodium stearate, preferably the nicotine formulation has a sodium stearate content of greater than or equal to about 0.25 percent by weight. More preferably, the nicotine formulation has a sodium stearate content of greater than or equal to about 0.5 percent by weight.

For example, the nicotine formulation may have a sodium stearate content of greater than or equal to about 0.75 percent by weight or greater than or equal to about 1 percent by weight.

Preferably, the nicotine formulation has a sodium stearate content of less than or equal to about 15 percent by weight. More preferably, the nicotine formulation has a sodium stearate content of less than or equal to about 12 percent by weight. For example, the nicotine formulation may have a sodium stearate content of less than or equal to about 10 percent by weight.

Preferably, the nicotine formulation has a sodium stearate content of between about 0.25 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium stearate content of between about 0.25 percent by weight and about 12 percent by weight or between about 0.25 percent by weight and about 10 percent by weight.

More preferably, the nicotine formulation has a sodium stearate content of between about 0.5 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium stearate content of between about 0.5 percent by weight and about 12 percent by weight or between about 0.5 percent by weight and about 10 percent by weight.

The nicotine formulation may have a sodium stearate content of between about 0.75 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium stearate content of between about 0.75 percent by weight and about 12 percent by weight or between about 0.75 percent by weight and about 10 percent by weight.

The nicotine formulation may have a sodium stearate content of between about 1 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a sodium stearate content of between about 1 percent by weight and about 12 percent by weight or between about 1 percent by weight and about 10 percent by weight.

Particularly preferably, the nicotine formulation comprises glycerine and sodium stearate.

Covalent bonding between the sodium stearate and the glycerine in the nicotine formulation may solidify the nicotine formulation or increase the viscosity of the nicotine

formulation to greater than or equal to about 100 Pa·s. This may advantageously reduce the risk of leakage of the nicotine formulation when used in an aerosol-generating system.

Covalent bonding between the sodium stearate and the glycerine in the nicotine formulation may elevate the boiling point of the glycerine. This may advantageously enhance vaporization of nicotine from the nicotine formulation when used in an aerosol-generating system.

According to a particularly preferred embodiment of the invention there is provided a nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising: glycerine; and sodium stearate, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a particularly preferred embodiment of the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation comprising: glycerine; and sodium stearate, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s.

According to a particularly preferred embodiment of the invention there is further provided an aerosol-generating system comprising: a nicotine formulation comprising: glycerine; and sodium stearate, wherein the nicotine formulation has a glycerine content of greater than or equal to about 40 percent by weight and wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s; and an atomiser configured to generate an aerosol from the nicotine formulation.

The nicotine formulation may comprise one or more polymers selected from the group consisting of polyvinyl acetate (PVA), polyvinyl alcohol (PVOH), polyethylene glycol (PEG), polyglycolic acid (PGA), polylactic acid (PLA), polydioxanone (PDO), polycaprolactone (PCL), polyethylene (PE) and low density polyethylene (LDPE).

Inclusion of one or more polymers selected from the group consisting of polyvinyl acetate (PVA), polyvinyl alcohol (PVOH), polyethylene glycol (PEG), polyglycolic acid (PGA), polylactic acid (PLA), polydioxanone (PDO), polycaprolactone (PCL), polyethylene (PE) and low density polyethylene (LDPE) may increase the viscosity of the nicotine formulation to greater than or equal to about 100 Pa·s. This may advantageously reduce the risk of leakage of the nicotine formulation when used in an aerosol-generating system.

The nicotine formulation may comprise water.

The nicotine formulation may have a water content of less than or equal to about 20 percent by weight or less than or equal to about 15 percent by weight.

Preferably, the nicotine formulation has a water content of less than or equal to about 10 percent by weight. For example, the nicotine formulation may a water content of less than or equal to about 8 percent by weight or less than or equal to about 6 percent by weight.

In embodiments in which the nicotine formulation comprises water, the nicotine formulation may have a water content of greater than or equal to about 1 percent by weight. For example, the nicotine formulation may have a water content of greater than or equal to about 2 percent by weight or greater than or equal to about 3 percent by weight.

The nicotine formulation may have a water content of between about 1 percent by weight and about 20 percent by weight. For example, the nicotine formulation may have a water content of between about 2 percent by weight and about 20 percent by weight or between about 3 percent by weight and about 20 percent by weight.

The nicotine formulation may have a water content of between about 1 percent by weight and about 15 percent by weight. For example, the nicotine formulation may have a water content of between about 2 percent by weight and about 15 percent by weight or between about 3 percent by weight and about 15 percent by weight.

In embodiments in which the nicotine formulation comprises water, preferably the nicotine formulation has a water content of between about 1 percent by weight and about 10 percent by weight. For example, the nicotine formulation may have a water content of between about 2 percent by weight and about 10 percent by weight or between about 3 percent by weight and about 10 percent by weight.

The nicotine formulation may have a water content of between about 1 percent by weight and about 8 percent by weight. For example, the nicotine formulation may have a water content of between about 2 percent by weight and about 8 percent by weight or between about 3 percent by weight and about 8 percent by weight.

The nicotine formulation may have a water content of between about 1 percent by weight and about 6 percent by weight. For example, the nicotine formulation may have a water content of between about 2 percent by weight and about 6 percent by weight or between about 3 percent by weight and about 6 percent by weight.

The nicotine 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.

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 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.

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.

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

Table 1

The nicotine formulation may comprise one or more carboxylic acids.

Suitable carboxylic acids include, but are not limited to, acetic acid, citric acid, lactic acid, malic acid, malonic acid and pyruvic acid.

In embodiments in which the nicotine formulation comprises one or more organic acids, the nicotine formulation may have an organic acid content of greater than or equal to about 0.5 percent by weight or greater than or equal to about 1 percent by weight.

Preferably, the nicotine formulation has an organic acid content of less than or equal to about 6 percent by weight. More preferably, the nicotine formulation has an organic acid content of less than or equal to about 4 percent by weight. For example, the nicotine formulation may an organic acid content of less than or equal to about 2 percent by weight.

In embodiments in which the nicotine formulation comprises one or more organic acids, the nicotine formulation may have an organic acid content of between about 0.5 percent by weight and about 6 percent by weight. For example, the nicotine formulation may have an organic acid content of between about 0.5 percent by weight and about 4 percent by weight or between about 0.5 percent by weight and about 2 percent by weight.

The nicotine formulation may have an organic acid content of between about 1 percent by weight and about 6 percent by weight. For example, the nicotine formulation may have an organic

acid content of between about 1 percent by weight and about 4 percent by weight or between about 1 percent by weight and about 2 percent by weight.

The nicotine formulation may comprise one or more flavourants. Suitable flavourants include, but are not limited to, menthol.

Preferably, the nicotine formulation has a flavourant content of less than or equal to about 4 percent by weight. More preferably, the nicotine formulation has a flavourant content of less than or equal to about 3 percent by weight.

According to the invention there is also provided an aerosol-generating article for use in an aerosol-generating system, the aerosol-generating article containing a nicotine formulation according to the invention.

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

The aerosol-generating article may be a cartridge.

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

The atomiser may be a thermal atomiser.

As used herein with reference to the invention, the term "thermal atomiser" describes an atomiser that is configured to heat the nicotine formulation to generate an aerosol.

The aerosol-generating article may comprise any suitable type of thermal atomiser.

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

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

The atomiser may be a non-thermal atomiser.

As used herein with reference to the invention, the term "non-thermal atomiser" describes an atomiser that is configured to generate an aerosol from the nicotine formulation by means other than heating.

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, an ultrasonic atomiser or a vibrating mesh atomiser.

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

The atomiser may be a thermal atomiser.

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

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

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

The atomiser may be a non-thermal atomiser.

The aerosol-generating system may comprise any suitable type of non-thermal atomiser.

For example, the non-thermal atomiser may be an impinging jet atomiser, an ultrasonic atomiser or a vibrating mesh atomiser.

The aerosol-generating system may comprise an aerosol-generating article according to the invention containing the nicotine 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.

The aerosol-generating system may comprise a consumable aerosol-generating article according to the invention containing the nicotine 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.

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

The aerosol-generating system may comprise: an aerosol-generating article according to the invention containing the nicotine 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.

The aerosol-generating system may comprise: an aerosol-generating article according to the invention containing the nicotine 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.

For the avoidance of doubt, features described above in relation to one aspect of the invention may also be applicable to other aspects of the invention. In particular, features described above in relation to the nicotine formulation of the invention may also relate, where appropriate, to the aerosol-generating article of the invention and the aerosol-generating system. Similarly, features described above in relation to the aerosol-generating article of the invention may also relate, where appropriate, to the aerosol-generating system of the invention, and *vice versa*.

Embodiments of the invention will now be described, by way of example only, with reference to the following examples and accompanying drawings, in which:

FIG. 1 is a schematic cross-sectional side view of an aerosol-generating system comprising an aerosol-generating device and an aerosol-generating article comprising a nicotine formulation according to the invention;

FIG. 2 is a schematic sectional view of a spring-loaded aerosol-generating article comprising a nicotine formulation according to the invention; and

FIG. 3 is a schematic sectional view of a “lip-stick” advance mechanism aerosol-generating article comprising a nicotine formulation according to the invention.

FIG. 1 shows an aerosol-generating system 400 comprising an aerosol-generating device 600 and an aerosol-generating article 500.

The aerosol-generating device 600 shown in FIG. 1 is configured for receiving the aerosol-generating article 500. The aerosol-generating device 600 comprises a housing 601 and a receptacle 610 formed in the housing 601. The receptacle 610 is constructed for receiving the aerosol-generating article 500. The receptacle 610 may be sized and shaped so that when the aerosol-generating article 500 is inserted in the receptacle 610, at least a portion of the aerosol-generating article 500 remains outside of the receptacle 610.

The aerosol-generating device 600 comprises a heating element 622 at the closed end of the receptacle 610. The heating element 622 comprises a mesh layer.

The aerosol-generating device 600 may include a power supply 651 operably connected to a controller 653 and optional graphical user interface 652. The power supply 651 operably connected to a controller 653 may be disposed within the housing 601. The graphical user interface 652 may be disposed on the housing 601.

The aerosol-generating article 500 includes a body 512 defining a cavity 512 having a cavity opening 515. An aerosol-forming substrate 511 is disposed in the cavity 510. The body 512 includes a closed end portion 551 that may be a ring or rotation portion or a fixed support.

Alternatively, the aerosol-generating article 500 may include an advancement mechanism may be arranged in the proximal end of the aerosol-generating article 500. The advancement mechanism may be configured as a piston-type element. The advancement mechanism may be configured as a screw-type element. The advancement mechanism may translate rotational movement into lateral movement.

The cavity opening of the aerosol-generating article 500 abuts the heating element 622 when the aerosol-generating article 500 is received into the receptacle 610 of the aerosol-generating device 600. The heating element 622 is disposed proximate to the cavity opening 515. The aerosol-forming substrate 511 of the aerosol-generating article 500 is a nicotine formulation according to the invention that may flow into and through the mesh layer of the heating element 622.

Air may flow into the receptacle 610 aerosol-generating device 600 and entrain the volatized aerosol components from the heated aerosol-forming substrate 511 and through the aerosol-generating device 600 via an air channel 650 and to the consumer.

FIG. 2 is a schematic sectional view of a spring-loaded aerosol-generating article 500. The aerosol-generating article 500 includes a body 512 defining a cavity 510 having a cavity opening 515. The aerosol-forming substrate 511 is disposed in the cavity 512. The heating element 622 is disposed proximate to the cavity opening 515. The body 512 includes a closed end portion 551 that may be a fixed support. A spring element 517 biases a movable rigid base 513 to the spring support 551 fixed to the body 512. The aerosol-forming substrate 511 is a nicotine formulation according to the invention.

FIG. 3 is a schematic sectional view of a "lip-stick" advance mechanism aerosol-generating article 500. The aerosol-generating article 500 includes a body 512 defining a cavity 510 having a cavity opening 515. The aerosol-forming substrate 511 is disposed in the cavity 512. The heating element 622 is disposed proximate to the cavity opening 515. The body 512 includes a ring or rotation element 551 that is coupled to the movable rigid base 513 and translates rotational movement into lateral movement via a spiral or helical groove 514. Pins (not shown) couple the rigid base 513 to the spiral or helical groove 514 to provide the lateral movement of the aerosol-forming substrate 511. The aerosol-forming substrate 511 is a nicotine formulation according to the invention.

In alternative embodiments (not shown), the aerosol-generating system may comprise an automatic mechanism to move or advance the aerosol-forming substrate 511 toward the heating element 622. In such alternative embodiments, the controller 653 of the aerosol-generating device 600 may activate an actuator or advancement mechanism on either the aerosol-generating article 500 or the aerosol- generating device 600 to advance the aerosol-forming substrate 511 and rigid base 513 toward the heating element 622 upon detecting that the heating element 622 is not in contact the aerosol-forming substrate 511.

Examples

Three nicotine formulations according to the invention that have a viscosity at 25°C of greater than or equal to about 100 Pa·s (Examples A, B and C) were prepared having the compositions and viscosities shown in Table 2.

Example		A	B	C
Nicotine (% by weight)		2	2	2
Water (% by weight)		6	6	6
Vegetable Glycerine (% by weight)	polyhydric alcohol	91	68	91.5
Propylene Glycol (% by weight)	polyhydric alcohol	0	23	0
Sodium Stearate (% by weight)	metal salt	1	1	0.5
Viscosity (Pa s)		3366	225	185

Table 2

Three nicotine formulations according to the invention that are solid at 25°C (Examples D, E and F) were prepared having the compositions shown in Table 3.

Example		D	E	F
Nicotine (% by weight)		2	2	2
Water (% by weight)		4	5	0
Vegetable Glycerine (% by weight)	polyhydric alcohol	85	68	88
Propylene Glycol (% by weight)	polyhydric alcohol	0	15	0
Sodium Stearate (% by weight)	metal salt	8	10	5
Sodium Alginate (% by weight)	metal salt	0	0	5
Lactic Acid	organic acid	1	0	0

Table 3

Each of the nicotine compositions was prepared by:

(1) heating the one or more polyhydric alcohols to a temperature of between about 100°C and about 120°C using a hotplate stirrer;

(2) adding a fine powder of the one or more metal salts to the one or more polyhydric alcohols, 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 nicotine to the mixture, while stirring constantly; and

(5) pouring the heated mixture into a mold and then allowing the mixture to cool and congeal to form the nicotine composition.

As shown in Table 2, inclusion of less than or equal to about 1 percent by weight of metal salt (sodium stearate) results in nicotine formulations having a viscosity at 25°C of greater than or equal to about 185 Pa s.

As shown in Table 3, inclusion of greater than or equal to about 8 percent by weight of metal salt (sodium stearate and sodium alginate) results in nicotine formulations that are solid at 25°C.

CLAIMS:

1. A nicotine formulation for use in an aerosol-generating system, the nicotine formulation comprising one or more water-miscible polyhydric alcohols, wherein the nicotine formulation has a water-miscible polyhydric alcohol content of greater than or equal to about 40 percent by weight, wherein the nicotine formulation is solid at 25°C or has a viscosity at 25°C of greater than or equal to about 100 Pa·s, wherein the one or more water-miscible polyhydric alcohols comprise glycerine and propylene glycol, and wherein the ratio of the weight percent glycerine content to the weight percent propylene glycol content of the nicotine formulation is greater than or equal to about 1.5.

2. A nicotine formulation according to claim 1 or 2 comprising one or more metal salts.

3. A nicotine formulation according to claim 2 wherein the one or more metal salts are selected from the group consisting of metal alginates, metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates.

4. A nicotine formulation according to claim 3 wherein the one or more metal salts are selected from the group consisting of metal benzoates, metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates.

5. A nicotine formulation according to claim 4 wherein the one or more metal salts are selected from the group consisting of metal cinnamates, metal cycloheptanecarboxylates, metal levulinates, metal propanoates, metal stearates and metal undecanoates, preferably wherein the one or more metal salts are selected from the group consisting of metal cinnamates, metal cycloheptanecarboxylates, metal stearates and metal undecanoates.

6. A nicotine formulation according to claim 5 wherein the one or more metal salts comprise metal stearates.

7. A nicotine formulation according to claim 2 or 3 wherein the one or more metal salts comprise sodium stearate.

8. A nicotine formulation according to any one of claims 2 to 7 wherein the nicotine formulation has a metal salt content of between about 0.5 percent by weight and about 15 percent by weight

9. A nicotine formulation according to any one of claims 1 to 7 comprising one or more polymers selected from the group consisting of polyvinyl acetate (PVA), polyvinyl alcohol (PVOH), polyethylene glycol (PEG), polyglycolic acid (PGA), polylactic acid (PLA), polydioxanone (PDO), polycaprolactone (PCL), polyethylene (PE) and low density polyethylene (LDPE).

10. A nicotine formulation according to any one of claims 1 to 9 comprising water.

11. A nicotine formulation according to claim 10 having a water content of less than or equal to about 10 percent by weight.

12. A nicotine formulation according to any one of claims 1 to 11 comprising one or more organic acids, wherein the nicotine formulation has an organic acid content of between about 0.5 percent and about 4 percent by weight.

13. A nicotine formulation according to any one of claims 1 to 13, wherein the nicotine formulation has a viscosity at 25°C of greater than or equal to about 10 Pa·s.

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

15. An aerosol-generating system comprising:
a nicotine formulation according to any one of claims 1 to 13; and
an atomiser configured to generate an aerosol from the nicotine formulation.

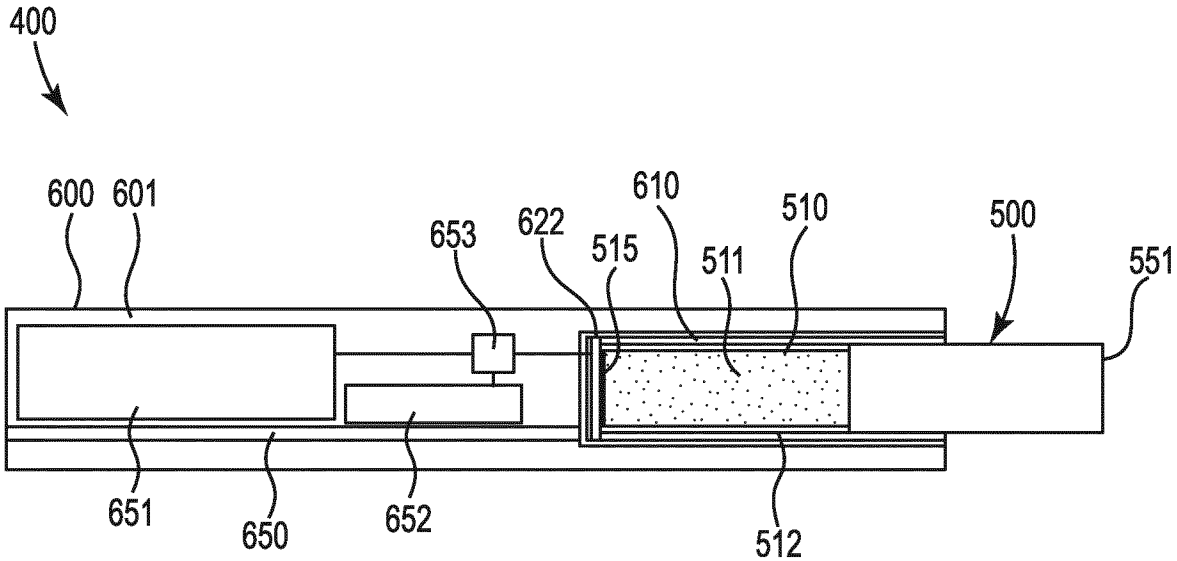

Fig. 1

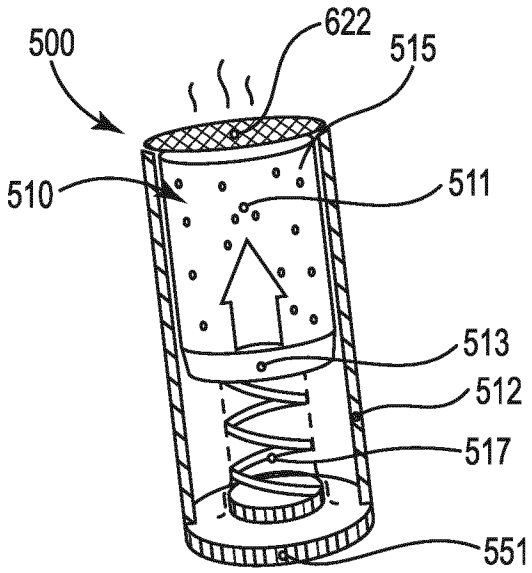

Fig. 2

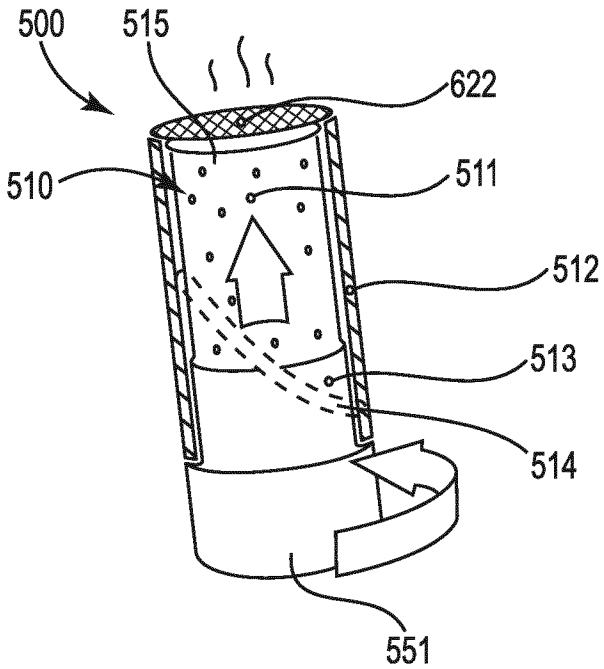

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/086109

A. CLASSIFICATION OF SUBJECT MATTER
INV. A24B15/167 A24F40/20 A24B15/16
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A24B A61K A61M A24F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018/199617 A1 (IODICE BIANCA [US]) 19 July 2018 (2018-07-19) paragraph [0018]; claims 1-8; examples paragraph [0024] - paragraph [0026]	1-15
Y	US 5 105 836 A (GENTRY JEFFERY S [US] ET AL) 21 April 1992 (1992-04-21) column 8, line 4 - line 7; example 14	1-3, 10-14
A	US 5 240 016 A (NICHOLS WALTER A [US] ET AL) 31 August 1993 (1993-08-31) column 4, line 22 - line 45; example 1	1-15
A	US 2007/023056 A1 (CANTRELL DANIEL V [US] ET AL) 1 February 2007 (2007-02-01) paragraph [0090]	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 February 2020	06/03/2020

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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2015/084544 A1 (JUUL LABS INC) 11 June 2015 (2015-06-11) claims -----	1-3, 10-14

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/086109

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2018199617 A1	19-07-2018	EP 3351121 A1	25-07-2018
		US 2018199617 A1	19-07-2018
US 5105836 A	21-04-1992	CA 2026537 A1	30-03-1991
		CN 1050494 A	10-04-1991
		EP 0419981 A2	03-04-1991
		JP H03180165 A	06-08-1991
		KR 910005794 A	27-04-1991
		US 5105836 A	21-04-1992
US 5240016 A	31-08-1993	EP 0509657 A1	21-10-1992
		JP H05153946 A	22-06-1993
		US 5240016 A	31-08-1993
US 2007023056 A1	01-02-2007	AT 451024 T	15-12-2009
		EP 1909604 A1	16-04-2008
		JP 5007305 B2	22-08-2012
		JP 2009502194 A	29-01-2009
		US 2007023056 A1	01-02-2007
		WO 2007015735 A1	08-02-2007
WO 2015084544 A1	11-06-2015	AU 2014357622 A1	16-06-2016
		AU 2020200425 A1	13-02-2020
		CA 2932464 A1	11-06-2015
		CN 105979805 A	28-09-2016
		EP 3076805 A1	12-10-2016
		JP 2016539645 A	22-12-2016
		KR 20160093717 A	08-08-2016
		UA 118686 C2	25-02-2019
		US 2016302471 A1	20-10-2016
		US 2020022400 A1	23-01-2020
		WO 2015084544 A1	11-06-2015