ELECTRICALLY HEATED AEROSOL DELIVERY SYSTEM

The invention relates to a cartridge for an aerosol delivery system and to a device configured to receive the cartridge. The invention also relates to an aerosol delivery system for delivering aerosolised medicament, such as nicotine salt particles, to a user comprising a device and a cartridge, in particular to a smoking device for delivering aerosolised nicotine salt particles to a user. The invention further relates to a method of delivering aerosolised medicament, such as nicotine salt particles, to a user.

So-called ‘e-cigarettes’ and other electrically operated smoking systems that vaporise a liquid nicotine formulation to form an aerosol that is inhaled by a user are known in the art. For example, WO 2009/132793 A1 discloses an electrically heated smoking system comprising a shell and a replaceable mouthpiece wherein the shell comprises an electric power supply and electric circuitry. The mouthpiece comprises a liquid storage portion, a capillary wick having a first end that extends into the liquid storage portion for contact with liquid therein, and a heating element for heating a second end of the capillary wick. In use, liquid is transferred from the liquid storage portion towards the heating element by capillary action in the wick. Liquid at the second end of the wick is vaporised by the heating element. The liquid preferably comprises a tobacco-containing material comprising volatile tobacco flavour compounds which are released from the liquid upon heating.

Commercially available e-cigarettes typically require significant power in order to form an aerosol having suitable particle size for delivery to a user.

WO 2008/121610 A1 and WO 2011/034723 A1 disclose devices and methods for delivering nicotine or other medicaments to a subject in which pyruvic acid is reacted with nicotine or other medicaments in the gas phase to form an aerosol of nicotine, or medicament, pyruvate salt particles. At room temperature both pyruvic acid and nicotine are sufficiently volatile to form respective vapours that react with one another to form nicotine pyruvate salt particles. However, pyruvic acid has a greater vapour pressure than nicotine at a given temperature. As a result, the efficiency of the gas phase reaction between the pyruvic acid and the nicotine is highly dependent on the ambient temperature, which can disadvantageously lead to inconsistent nicotine delivery to a user.

It would be desirable to provide an aerosol delivery system that operates with reduced power consumption as compared to commercially available e-cigarettes. It would also be desirable to provide an aerosol delivery system that allows for more consistent nicotine or other medicament delivery per puff as compared to known devices for delivering aerosolised nicotine salt particles.

According to a first aspect, there is provided a cartridge comprising: a first compartment comprising a volatile delivery enhancing compound source; a second compartment comprising a medicament source; a vaporiser for heating the medicament, wherein the vaporiser comprises an electrically operated heater, the heater being connectable to an electric power supply; and a transfer element for conveying the medicament from the second compartment to the vaporiser.

According to a second aspect, there is provided a device configured to receive a cartridge according to any of the preceding claims, the device comprising: an outer housing; a power source; temperature controlling means for controlling the temperature of the first compartment of the cartridge; temperature controlling means for controlling the temperature of the vaporiser for heating a medicament; and electronic circuitry configured to control power to the temperature controlling means from the power source, wherein the electronic circuitry is configured to maintain the first compartment of the cartridge at a temperature of between 30°C and 50°C.

According to a third aspect, there is provided an aerosol delivery system comprising: a device in cooperation with a cartridge, the cartridge comprising a first compartment comprising a volatile delivery enhancing compound source; the cartridge comprising a second compartment comprising a medicament source; the cartridge comprising a vaporiser for heating the medicament, wherein the vaporiser comprises an electrically operated heater, the heater being connectable to an electric power supply; and the cartridge further comprising a transfer element for conveying the medicament from the second compartment to the vaporiser; wherein the device or cartridge further comprises an aerosol forming chamber in fluid communication with the first compartment and the second compartment.

According to a fourth aspect, there is provided a method of delivering aerosolised medicament-containing particles to a user, the method comprising: controlling the temperature of a delivery enhancing compound to between 30°C and 50°C to form a delivery enhancing compound-containing vapour; heating a medicament to a temperature of between 70°C and 100°C to form a medicament-containing vapour; and contacting the delivery enhancing compound-containing vapour with the medicament-containing vapour to form aerosolised medicament-containing particles.

~~According to the invention, there is provided,~~Herein disclosed is a cartridge comprising: a first compartment comprising a volatile delivery enhancing compound source; a second

In preferred embodiments, the first compartment of the cartridge comprises a volatile delivery enhancing compound source and the second compartment of the cartridge comprises a nicotine source. The nicotine source may comprise one or more of nicotine, nicotine base, a nicotine salt, such as nicotine-HCl, nicotine-bitartrate, or nicotine-ditartrate, or a nicotine derivative.

The nicotine source may comprise natural nicotine or synthetic nicotine.

The nicotine source may comprise pure nicotine, a solution of nicotine in an aqueous or non-aqueous solvent or a liquid tobacco extract.

The nicotine source may further comprise an electrolyte forming compound. The electrolyte forming compound may be selected from the group consisting of alkali metal hydroxides, alkali metal oxides, alkali metal salts, alkaline earth metal oxides, alkaline earth metal hydroxides and combinations thereof.

For example, the nicotine source may comprise an electrolyte forming compound selected from the group consisting of potassium hydroxide, sodium hydroxide, lithium oxide, barium oxide, potassium chloride, sodium chloride, sodium carbonate, sodium citrate, ammonium sulfate and combinations thereof

In certain embodiments, the nicotine source may comprise an aqueous solution of nicotine, nicotine base, a nicotine salt or a nicotine derivative and an electrolyte forming compound.

Alternatively or in addition, the nicotine source may further comprise other components including, but not limited to, natural flavours, artificial flavours and antioxidants. Preferably, the second compartment comprises a liquid medicament source. Preferably, the second compartment is configured to hold between about 50 microlitres and about 150 microlitres of the liquid medicament, more preferably about 100 microlitres of the liquid medicament

The liquid medicament has a boiling point suitable for use in an aerosol delivery system as described herein: if the boiling point is too high, the vaporiser will not be able to vaporise the liquid medicament. The liquid medicament also has physical properties that allow the medicament to be conveyed by the transfer element from the second compartment to the vaporiser. Preferably, the liquid medicament has physical properties, including viscosity, that allow the liquid medicament to be conveyed through the transfer element from the second compartment to the vaporiser by capillary action.

The vaporiser is preferably located downstream of the first compartment such that air drawn through the cartridge passes through the first compartment before passing over the vaporiser.

~~The~~ As shown in the first and third aspect, the vaporiser preferably comprises an

electrically operated heater, the heater being connectable to an electric power supply. The heater preferably comprises at least one heating element configured to heat the medicament to form a medicament-containing vapour. The

Preferably, the first compartment is substantially sealed prior to first use of the cartridge. For example, the first compartment may comprise one or more seals that may be punctured, or otherwise opened on first use of the cartridge.

As described above, the volatile delivery enhancing compound interacts with the medicament in the gas phase to form medicament-containing particles. Where the volatile delivery enhancing compound is an acid, and the medicament source is a nicotine source, the acid interacts with the nicotine in the gas phase to form nicotine salt particles. Preferably, the Mass Median Aerodynamic Diameter of the nicotine salt particles is less than about 6 microns. The Mass Median Aerodynamic Diameter of the nicotine salt particles may be less than about 1 micron. Preferably, the Mass Median Aerodynamic Diameter of the nicotine salt particles is between about 0.5 microns and about 5 microns.

The cartridge may further comprise a third compartment. Preferably, the third compartment is downstream of the second compartment. Where the cartridge comprises an aerosol forming chamber, the third compartment is preferably downstream of the aerosol forming chamber. The third compartment may comprise a flavour source. Alternatively or in addition, the third component may comprise a filtration material capable of removing at least a portion of any unreacted volatile delivery enhancing compound mixed with aerosolised medicament-containing particles drawn through the third compartment. The filtration material may comprise an adsorbent, such as activated carbon. As will be appreciated, any number of additional compartments may be provided as desired. For example, the cartridge may comprise a third compartment comprising a filter material and a fourth compartment downstream of the third compartment comprising a flavour source.

Preferably, the cartridge comprises an opaque outer housing. This advantageously reduces the risk of degradation of the volatile delivery enhancing compound and medicament due to exposure to light.

~~According to a further aspect of the invention, there is provided~~Herein disclosed is a device configured to receive a cartridge as described herein. The device comprises: an outer housing; a power source; temperature controlling means for controlling the temperature of the first compartment of the cartridge; and electronic circuitry configured to control power to the controlling means from the power source; wherein, the electronic circuitry is configured to maintain the first compartment of the cartridge at a temperature of between about 30°C and about 50°C.

In a preferred embodiment, the controlling means comprises a heater for heating the first compartment of the cartridge.

The use of such a device in combination with a cartridge according to the invention, advantageously allows for more consistent aerosol generation and medicament delivery per puff. By configuring the device to maintain the first compartment of the cartridge at a

temperature of between about 30°C and about 50°C, the effect of environmental conditions on aerosol generation and medicament delivery per puff can be mitigated.

Alternatively or in addition, the device may comprise a heater for heating ambient air drawn through the device to a temperature of between about 30°C and about 50°C before it passes through the first compartment of the cartridge.

~~According to a yet further aspect of the invention, there is provided~~Herein disclosed is an aerosol delivery system. The aerosol delivery system comprises: a device as described herein in cooperation with a cartridge as described herein. The device or cartridge comprises a first compartment comprising a volatile delivery enhancing compound. The device or cartridge comprises a second compartment comprising a medicament source. The device or cartridge comprises a vaporiser for heating the medicament. The device or cartridge further comprises a transfer element for conveying the medicament from the second compartment to the vaporiser. The device or cartridge further comprises an aerosol forming chamber in fluid communication with the first compartment and the second compartment. In use, the medicament reacts with the volatile delivery enhancing compound in the gas phase in the aerosol forming chamber to form aerosolised medicament-containing particles.

Preferably, the device or the cartridge further comprises a mouthpiece in fluid communication with the aerosol forming chamber. Preferably, the mouthpiece is part of the cartridge.

The mouthpiece may comprise any suitable material or combination of materials. Examples of suitable materials include thermoplastics that are suitable for food or pharmaceutical applications, for example polypropylene, polyetheretherketone (PEEK) and polyethylene.

Preferably, the cartridge is not refillable. Thus, when the medicament in the second compartment of the cartridge has been used up, the cartridge is replaced.

In certain embodiments, the device as well as the cartridge may be disposable.

Advantageously, all elements of the device which are potentially in contact with the volatile delivery enhancing compound or the medicament are changed when the cartridge is replaced. This avoids any cross-contamination in the device between different mouthpieces and different cartridges, for example cartridges comprising different volatile delivery enhancing compounds or medicaments.

The medicament in the second compartment may be advantageously protected from exposure to oxygen (because oxygen cannot generally enter the second compartment via the capillary wick or other transfer element) and in some embodiments light, so that the risk of degradation of the medicament is significantly reduced. Therefore, a high level of hygiene can be maintained. Also, the risk of the vaporiser becoming clogged with the medicament may be advantageously significantly reduced by replacing the cartridge at suitable intervals.

The outer housing of the device may be formed from any suitable material or combination of materials. Examples of suitable materials include, but are not limited to, metals, alloys, plastics or composite materials containing one or more of those materials. Preferably, the outer housing is light and non-brittle.

The aerosol delivery system and device are preferably portable. The system aerosol delivery system may have a size and shape comparable to a conventional smoking article, such as a cigar or cigarette.

~~According to a yet further aspect of the invention, there is provided~~Herein disclosed is a method of delivering aerosolised medicament-containing particles to a user. The method comprises: controlling the temperature of a volatile delivery enhancing compound to between about 30°C and about 50°C to form a delivery enhancing compound- containing vapour; heating a medicament source to a temperature of between about 70°C and about 100°C form a medicament-containing vapour; and contacting the delivery enhancing compound-containing vapour with the medicament-containing vapour to form aerosolised medicament-containing particles.

In a preferred embodiment, the step of controlling the temperature of the delivery enhancing compound may include heating the delivery enhancing compound.

As will be appreciated, a number of factors influence the formation of the medicament-containing particles. In general, in order to control the medicament delivery it is important to control the vaporisation of the medicament and the volatile delivery enhancing compound. It is also important to control the relative quantities of the medicament and the volatile delivery enhancing compound. In the preferred embodiment, where the volatile delivery enhancing compound is an acid and the medicament source is a nicotine source, the molar ratio of acid to nicotine in the aerosol forming chamber is about 1:1. The use of acid or ammonium chloride as a delivery enhancing compound has been found to approximately double the delivery rate of nicotine to a user for equivalent power supplied to the vaporiser.

The vaporisation of the volatile delivery enhancing compound is controlled by the concentration of the volatile delivery enhancing compound in the first compartment, and by the exchange surface area of volatile delivery enhancing compound in the first compartment. The vaporisation of the volatile delivery enhancing compound may be controlled by heating the first compartment of the cartridge or by heating ambient air drawn through the device before it passes through the first compartment of the cartridge. In preferred embodiments where the first compartment comprises pyruvic acid, preferably about 60 micrograms of pyruvic acid is vaporised per puff.

The vaporisation of the medicament may be controlled through the power supplied to the vaporiser and through the properties of the transfer element for conveying the medicament to the vaporiser.

Claims:

1. A cartridge comprising:

a first compartment comprising a volatile delivery enhancing compound source;

a second compartment comprising a medicament source;

a vaporiser for heating the medicament, wherein the vaporiser comprises an electrically operated heater, the heater being connectable to an electric power supply; and

a transfer element for conveying the medicament from the second compartment to the vaporiser.

2. A cartridge according to claim 1 further comprising an aerosol forming chamber in fluid communication with the first compartment and the second compartment.

3. A cartridge according to claim 2 further comprising at least one air inlet upstream of the first compartment and at least one air outlet downstream of the aerosol forming chamber, the at least one air inlet and the at least one air outlet being arranged to define an air flow pathway extending from the at least one air inlet to the at least one air outlet via the first compartment, the vaporiser and the aerosol forming chamber.

4. A cartridge according to claim 1, 2 or 3, wherein the transfer element comprises a capillary material for conveying the medicament from the second compartment to the vaporiser by capillary action.

5. A cartridge according to claim 4, wherein the capillary material is a capillary wick having a first portion extending into the second compartment and a second portion adjacent to the vaporiser.

6. A cartridge according to any one of the preceding claims, wherein the second compartment comprises a sorption element with the medicament sorbed thereon.

7. A cartridge according to any one of the preceding claims, wherein the medicament comprises pure nicotine, a nicotine solution or a liquid tobacco extract.

8. A cartridge according to any one of the preceding claims, wherein the first compartment comprises a sorption element with the volatile delivery enhancing compound sorbed thereon.

9. A cartridge according to any of the preceding claims, wherein the volatile delivery enhancing compound comprises an acid selected from the group consisting of 3-methyl-2-

oxovaleric acid, pyruvic acid, 2-oxovaleric acid, 4-methyl-2-oxovaleric acid, 3-methyl-2-oxobutanoic acid, 2-oxooctanoic acid and combinations thereof.

~~10. A cartridge according to any one of the preceding claims, wherein the vaporiser comprises an electrically operated heater, the heater being connectable to an electric power supply.~~

~~11~~10. A device configured to receive a cartridge according to any of the preceding claims, the device comprising:

an outer housing;

a power source;

temperature controlling means for controlling the temperature of the first compartment of the cartridge;

temperature controlling means for controlling the temperature of the vaporiser for heating a medicament; and

electronic circuitry configured to control power to the temperature controlling means from the power source,

wherein the electronic circuitry is configured to maintain the first compartment of the cartridge at a temperature of between ~~about~~ 30°C and ~~about~~ 50°C.

~~12~~11. A device according to Claim ~~11~~10, wherein the electronic circuitry is configured to maintain the temperature of the medicament at a temperature of between ~~about~~ 70°C and ~~about~~ 100°C.

~~13~~12. An aerosol delivery system comprising:

a device in cooperation with a cartridge, the ~~device or~~ cartridge comprising a first compartment comprising a volatile delivery enhancing compound source;

the ~~device or~~ cartridge comprising a second compartment comprising a medicament source;

the ~~device or~~ cartridge comprising a vaporiser for heating the medicament, wherein the vaporiser comprises an electrically operated heater, the heater being connectable to an electric power supply; and

the ~~device or~~ cartridge further comprising a transfer element for conveying the medicament from the second compartment to the vaporiser;

wherein the device or cartridge further comprises an aerosol forming chamber in fluid communication with the first compartment and the second compartment.

~~14~~13. An aerosol delivery system according to claim 12, wherein the device or the cartridge further comprises a mouthpiece in fluid communication with the aerosol forming chamber.

~~15~~14. A method of delivering aerosolised medicament-containing particles to a user, the method comprising:

controlling the temperature of a delivery enhancing compound to between ~~about~~ 30°C and ~~about~~ 50°C to form a delivery enhancing compound-containing vapour;

heating a medicament to a temperature of between ~~about~~ 70°C and ~~about~~ 100°C to form a medicament-containing vapour; and

contacting the delivery enhancing compound-containing vapour with the medicament-containing vapour to form aerosolised medicament-containing particles.