AN AEROSOL GENERATING DEVICE WITH AIR FLOW NOZZLES

The present invention relates to an aerosol generating device for heating an aerosol-forming substrate. Particularly, but not exclusively, the present invention relates to an electrically operated aerosol generating device for heating a liquid aerosol-forming substrate.

WO-A-2009/132793 discloses an electrically heated smoking system. A liquid is stored in a liquid storage portion, and a capillary wick has a first end which extends into the liquid storage portion for contact with the liquid therein, and a second end which extends out of the liquid storage portion. A heating element heats the second end of the capillary wick. The heating element is in the form of a spirally wound electric heating element in electrical connection with a power supply, and surrounding the second end of the capillary wick. In use, the heating element may be activated by the user to switch on the power supply. Suction on a mouthpiece by the user causes air to be drawn into the electrically heated smoking system over the capillary wick and heating element and subsequently into the mouth of the user.

It is an object of the present invention to improve the generation of aerosol in an aerosol generation device or system.

According to one aspect of the invention, there is provided an aerosol generating device comprising: a vaporizer for heating an aerosol-forming substrate; a plurality of air flow vents; and at least one air outlet, the air flow vents and the air outlet being arranged to define an air flow route between the air flow vents and the air outlet; and wherein each of the plurality of air flow vents is an air inlet vent arranged to direct air towards the vicinity of the vaporizer and substantially perpendicular to the longitudinal axis of the device so as to manage particle size in the aerosol.

According to another aspect of the invention, there is provided a cartridge comprising: a storage portion for storing an aerosol-forming substrate; a vaporizer for heating the aerosol-forming substrate; a plurality of air flow vents; and at least one air outlet, the air flow vents and the air outlet being arranged, to define an air flow route between the air flow vents and the air outlet; wherein each of the plurality of air flow vents is an air inlet vent arranged to direct air towards the vicinity of the vaporizer in a direction across the surface of the vaporizer and substantially perpendicular to the longitudinal axis of the cartridge so as to manage particle size in the aerosol.

The aerosol generating device and cartridge cooperate to provide an aerosol generating system for heating an aerosol-forming substrate. The cartridge or aerosol generating device may comprise a storage portion for storing the aerosol-forming substrate. The vaporizer may be contained in the aerosol generating device. The vaporizer may also be contained in the cartridge. The plurality of air flow vents may be provided in either the aerosol generating device

or in the cartridge, or some of the plurality of air flow vents may be provided in the aerosol generating device and other of the plurality of air flow vents may be provided in the cartridge. The air outlet may be provided in either the aerosol generating device or in the cartridge or, if more than one air outlet is provided, one or more air outlets may be provided in the aerosol generating device and one or more air outlets may be provided in the cartridge.

According to another aspect of the invention, there is provided an aerosol generating system comprising: a vaporizer for heating an aerosol-forming substrate; a plurality of air flow vents; and at least one air outlet, the air flow vents and the air outlet being arranged to define an air flow route between the air flow vents and the air outlet; wherein each of the plurality of air flow vents is an air inlet vent arranged to direct air towards the vicinity of the vaporizer in a direction substantially perpendicular to the longitudinal axis of the system so as to manage particle size in the aerosol, wherein the air flow vents direct the air towards the vicinity of the vaporizer in more than one direction wherein each of the air flow vents has a diameter of less than or approximately equal to 0.4 mm.

For all aspects of the invention, the storage portion may be a liquid storage portion. For all aspects of the invention, the aerosol forming substrate may be a liquid aerosol forming substrate. The aerosol-forming substrate may contain nicotine. The aerosol-forming substrate may be adsorbed, coated, impregnated or otherwise loaded onto a carrier or support.

The aerosol-forming substrate may alternatively be any other sort of substrate, for example, a gas substrate or a gel substrate, or any combination of the various types of substrate. The aerosol-forming substrate may be a solid substrate.

The vaporizer of the aerosol generating device or system is arranged to heat the aerosol-forming substrate to form a supersaturated vapour. The supersaturated vapour is mixed with and carried in the air flow from the plurality of air flow nozzles towards the air outlet. The vapour condenses to form an aerosol, which is carried towards the air outlet into the mouth of a user. The aerosol generating device or cartridge may further comprise an aerosol forming chamber in the air flow route between the plurality of air flow nozzles and the air outlet. The aerosol forming chamber may assist or facilitate the generation of the aerosol. The aerosol generating device may include the aerosol-forming substrate or may be adapted to receive the aerosol-forming substrate. As known to those skilled in the art, an aerosol is a suspension of solid particles or liquid droplets in a gas, such as air.

Each air flow vent comprises a small aperture, orifice or hole. Each air flow vent may also comprise a nozzle. The small size of the aperture, orifice or hole results in a high velocity air flow through the air flow vent or vent or nozzle. This is because air flow speed may be increased by decreasing the cross sectional area of the air flow path, so as to take advantage of the Venturi effect. That is, the velocity of the air flow increases as the cross sectional area

decreases and the air flow through a constricted cross section increases in speed. Each air flow vent or nozzle is arranged to propel, drive or force high velocity air towards the vicinity of the vaporizer. For the cartridge, the air flow vent or nozzles direct the air towards the vicinity of the vaporizer in more than one direction. For the device, the air flow vent or nozzles direct the air towards the vicinity of the vaporizer in more than one direction. The high speed air flow affects the cooling rate of the supersaturated vapour which affects the formation of the aerosol. This, in turn, affects the mean particle size and the particle size distribution of the aerosol. Preferably, the distance between the air flow vent or nozzles and the vaporizer is small. This improves control of the air flow velocity, since there is little opportunity for deceleration of the incoming air or the formation of complex turbulence patterns in the air flow. Because the air flow vent or nozzles direct the air towards the vicinity of the vaporizer in more than one direction, the air flow in the vicinity of the vaporizer is relatively homogeneous. Moreover, the cooling rate on all sides of the vaporizer is substantially equal, which results in a small particle size distribution of the aerosol.

Thus, the invention provides a number of advantages. First, the increased cooling rate results in a smaller mean droplet size in the aerosol. This results in a better sensory experience for the user. Second, the homogeneous air flow results in a smaller range of particle sizes in the aerosol. This results in a more consistent aerosol, which results in a more consistent experience for the user. Third, by increasing the cooling rate, the process of producing the aerosol is accelerated. This means that the aerosol generating device and cartridge can be made smaller, since a reduced air flow length is required for the aerosol formation. The invention allows all three advantages to be realised. Moreover, high velocity air flow may also reduce the amount of condensation that is able to form within the aerosol generating device and cartridge, particularly within the aerosol forming chamber. Formation of condensation may affect liquid leakage from the aerosol generating device and cartridge. Thus, a further advantage of the invention is that it can be used to reduce liquid leakage.

In one embodiment, the air flow vent or nozzles comprise air inlet vents or nozzles. That is to say, the air flow vent or nozzles provide the first (furthest upstream) conduit for ambient air to be drawn into the aerosol generating device or cartridge. In that embodiment, preferably the length of the air inlet vent or nozzles is minimised, so that ambient air is drawn as directly as possible from outside the aerosol generating device or cartridge towards the vicinity of the vaporizer. This improves control of the air flow velocity, since there is little opportunity for deceleration of the air flow or for the creation of complex turbulence patterns. In that embodiment, preferably the air inlet vent or nozzles are provided in a housing of the aerosol generating device or cartridge.

Alternatively, however, the air flow vent or nozzles may not comprise air inlet vent or nozzles. In that embodiment, conduits further upstream of the air flow vent or nozzles provide inlets for ambient air to be drawn into the aerosol generating device or cartridge. The air flow vent or nozzles simply channel the air towards the vicinity of the vaporizer at a high velocity. This allows control of the velocity in the vicinity of the vaporizer, whilst also allowing the invention to be compatible with various designs of aerosol generating device or cartridge or system.

In one embodiment, at least one of the air flow vent or nozzles includes a deviating portion. The crooked portion may comprise a crooked or angled portion. The deviating portion may be curved. The deviating portion may be provided in one, some or all of the air flow vent or nozzles. This is particularly advantageous if the air flow vent or nozzles comprise air inlet vent or nozzles, and particularly if the air flow vent or nozzles are provided in a housing of the aerosol generating device or cartridge. It may then be possible for a user to see the vaporizer or other components in the aerosol generating device or cartridge and potentially access and tamper with the vaporizer or other components. Including a deviating portion in the air flow vent or nozzles prevents access to the internal components of the aerosol generating device or cartridge or system.

In one embodiment, the air flow vent or nozzles are arranged, when the device is in use with the cartridge to direct the air towards the vicinity of the vaporizer in a direction across the surface of the vaporizer. This air flow direction may be advantageous as it provides a high velocity air flow generally parallel to the surface of the vaporizer. This may increase the speed of the process of vaporization. In addition, in some embodiments, this air flow direction creates a swirling air flow, that is to say, a twisting, rotating or spiralling air flow, in the vicinity of the vaporizer. This has been found to increase the cooling rate, which decreases the mean particle size in the aerosol. In addition, if the vaporizer comprises a heater, directing the air across the surface of the vaporizer, rather than directly onto the vaporizer reduces unnecessary cooling of the heater. In one embodiment, the flow nozzles are arranged to direct the air along a path spaced a predetermined distance from the surface of the vaporiser rather than directly at the vaporiser. This prevents the high speed air from significantly cooling the vaporiser but rapidly cools vapour that has moved away from the vaporiser. This improves the efficiency of the aerosol generating device.

Since the air flow vent or nozzles direct the high velocity air in more than one direction, the air may be directed across the surface of the vaporizer at more than one portion of the vaporizer. This increases the likelihood of substantially equal cooling on all sides of the vaporizer, which leads to consistent aerosol formation. This also enhances the swirl effect of the air flow, which increases the cooling rate.

Alternatively, the air flow vent or nozzles may be arranged to direct the air towards the vicinity of the vaporizer directly onto the surface of the vaporizer. This air flow direction may be directed substantially perpendicular to the surface of the vaporizer. This air flow direction may be advantageous because it increases the cooling rate, which decreases the mean particle size in the aerosol.

Since the air flow vent or nozzles direct the high the high velocity air in more than one direction, the air may be directed onto more than one portion of the vaporizer. This increases the cooling rate and also increases the likelihood of substantially equal cooling on all sides of the vaporizer.

The air flow vent or nozzles may direct the high velocity air towards the vicinity of the vaporizer in any other desired direction or directions. For example, the air flow vent or nozzles may direct the air in the longitudinal direction of the aerosol generating device or cartridge. Moreover, each air flow vent or nozzle may direct the air in its own respective direction. For example, one air flow vent or nozzle may direct the high velocity air across the surface of the vaporizer and another air flow vent or nozzle may direct the air directly onto the surface of vaporizer.

Any suitable number of air flow vent or nozzles may be provided. The air flow vent or nozzles may have any suitable cross sectional area or diameter which results in the desired air flow velocity in the vicinity of the vaporizer. The vent or nozzles' cross sectional area and diameter will also affect the resistance to draw. The vent or nozzles may have the same or different cross sectional areas and diameters. The vent or nozzles may also have any desired cross sectional shape and the vent or nozzles may have the same or different cross sectional shapes. Advantageously, as mentioned in one of the above aspects of the invention, each of the air flow vents has a diameter of less than or approximately equal to 0.4 mm. This provides high speed, directed air flow. In one embodiment, for a flow rate of 27.5 millilitres per second through the air outlet, the air flow velocity through each of the air flow vents is between 10 and 30 meters per second. The separation of the air flow vent or nozzles and the vaporizer may be set according to the desired cooling rate in the aerosol generating device. The vent or nozzle-vaporizer separation may also affect the resistance to draw. The vent or nozzles may be separated from the vaporizer by the same or different distances. The air flow vent or nozzles may direct the air flow in any direction which results in the desired air flow patterns in the aerosol generating device or cartridge. The vent or nozzles may direct the air flow in the same or in different directions.

The air flow vent or nozzles may be arranged in any suitable pattern which results in the desired cooling rate. Preferably, the air flow vent or nozzles are arranged symmetrically with respect to the vaporizer. This results in a homogenous air flow around the vaporizer, which

results in a consistent cooling rate and hence a consistent particle size in the aerosol. Preferably, the air flow vent or nozzles are arranged symmetrically with respect to the longitudinal axis of the aerosol generating device or cartridge. The vent or nozzles may be arranged in a plurality of sets of vent or nozzles. Each set may be longitudinally spaced from other sets. However, one, two, three, four or more sets of longitudinally spaced vent or nozzles

CLAIMS

1. An aerosol generating device comprising:

a vaporizer for heating an aerosol-forming substrate;

a plurality of air flow vents; and

at least one air outlet, the air flow vents and the air outlet being arranged to define an air flow route between the air flow vents and the air outlet; and

wherein each of the plurality of air flow vents is an air inlet vent arranged to direct air towards the vicinity of the vaporizer in a direction across the surface of the vaporizer and substantially perpendicular to the longitudinal axis of the device so as to manage particle size in the aerosol.

2. An aerosol generating device according to claim 1, wherein the air inlet vents direct the air in more than one direction.

3. An aerosol generating device according to claim 1 or claim 2, wherein at least one of the air flow vents includes a deviated portion.

4. An aerosol generating device according to any preceding claim, comprising a housing, wherein the air inlet vents are formed in the housing to allow ambient air to be drawn from outside of the device through the air inlet vents.

5. An aerosol generating device according to any preceding claim, wherein each of the air inlet vents has a diameter of less than or approximately equal to 0.4 mm.

6. An aerosol generating device according to any preceding claim, wherein, for a flow rate of 27.5 millilitres per second through the air outlet, the air flow velocity through each of the air inlet vents is between 10 and 30 meters per second.

7. An aerosol generating device according to any preceding claim, further comprising:

a storage portion for storing the aerosol-forming substrate; and

an elongate capillary body for conveying the aerosol-forming substrate from the storage portion towards the vaporizer, the capillary body having a first end extending into the storage portion and a second end opposite the first end, wherein the vaporizer is arranged to heat the aerosol-forming substrate in the second end of the capillary body.

8. An aerosol generating device according to any preceding claim, further comprising an secondary air inlet and an air flow sensor for measuring air flow through the air inlet, wherein a secondary air flow route is defined between the secondary air inlet and the air outlet.

9. A cartridge comprising:

a storage portion for storing an aerosol-forming substrate;

a vaporizer for heating the aerosol-forming substrate;

a plurality of air flow vents; and

at least one air outlet,

the air flow vents and the air outlet being arranged to define an air flow route between the air flow vents and the air outlet;

wherein each of the plurality of air flow vents is an air inlet vent arranged to direct air towards the vicinity of the vaporizer in a direction across the surface of the vaporizer and substantially perpendicular to the longitudinal axis of the cartridge so as to manage particle size in the aerosol.

10. A cartridge according to claim 9, wherein the air inlet vents direct the air in more than one direction.

11. A cartridge according to claim 9 or claim 10, comprising a housing, wherein the air inlet vents are formed in the housing to allow ambient air to be drawn from outside of the device through the air inlet vents. .

12. A cartridge according to any one of claims 9 to 11, wherein each of the air inlet vents has a diameter of less than or approximately equal to 0.4 mm. .

13. A cartridge according to any one of claims 9 to 12 wherein, for a flow rate of 27.5 millilitres per second through the air outlet, the air flow velocity through each of the air inlet vents is between 10 and 30 meters per second.

14. A cartridge according to any one of claims 9 to 13, wherein the vaporizer comprises an electric heater for heating the aerosol-forming substrate, the electric heater being connectable to an electric power supply.

15. An aerosol generating system comprising:

a vaporizer for heating an aerosol-forming substrate;

a plurality of air flow vents; and

at least one air outlet,

the air flow vents and the air outlet being arranged to define an air flow route between the air flow vents and the air outlet;

wherein each of the plurality of air flow vents is an air inlet vent arranged to direct air towards the vicinity of the vaporizer in a direction substantially perpendicular to the longitudinal axis of the system so as to manage particle size in the aerosol, wherein the air flow vents direct the air towards the vicinity of the vaporizer in more than one direction, wherein each of the air flow vents has a diameter of less than or approximately equal to 0.4 mm.