AN AEROSOL GENERATING SYSTEM WITH LEAKAGE PREVENTION

The present invention relates to an aerosol generating system. In particular, the present invention relates to an aerosol generating system in which the aerosol-forming substrate is liquid.

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.

The aerosol generating systems of the prior art, including the electrically operated smoking system referred to above, do have a number of advantages, but there is still opportunity for improvement in the design.

According to a first aspect of the invention, there is provided an aerosol generating system for heating a liquid aerosol-forming substrate, the system comprising: a liquid storage portion for storing the liquid aerosol-forming substrate; a capillary wick for conveying the liquid aerosol-forming substrate from the liquid storage portion; and leakage prevention means comprising sealing means between the liquid storage portion and the capillary wick configured to prevent or reduce leakage of the liquid aerosol-forming substrate from the liquid storage portion, wherein the sealing means comprises a sealing ring.

~~there~~ There is also provided an aerosol generating system for heating a liquid aerosol-forming substrate, the system comprising: a liquid storage portion for storing the liquid aerosol-forming substrate; and leakage prevention means configured to prevent or reduce leakage of the liquid aerosol-forming substrate from the liquid storage portion.

The aerosol generating system is arranged to vaporize the aerosol-forming substrate to form the aerosol. The aerosol generating system 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.

An advantage of the invention is that leakage of liquid from the liquid storage portion is prevented or at least substantially reduced. Minimising, or preferably preventing, leakage is important to avoid wastage of the liquid aerosol-forming substrate. Moreover, leakage of the liquid aerosol-forming substrate may create contamination, for example when different aerosol-forming substrates are used consecutively. In addition, liquid aerosol-forming substrate that has leaked out of the liquid storage portion may flow out of the aerosol generating system and

cause inconvenience for the user. For example, the aerosol generating system may become wet or sticky.

The liquid aerosol-forming substrate preferably has physical properties, for example boiling point and vapour pressure, suitable for use in the aerosol generating system. If the boiling point is too high, it may not be possible to vaporize the liquid but, if the boiling point is too low, the liquid may vaporize too readily. The liquid preferably comprises a tobacco-

containing material comprising volatile tobacco flavour compounds which are released from the liquid upon heating. Alternatively, or in addition, the liquid may comprise a non-tobacco material. The liquid may include water, solvents, ethanol, plant extracts, nicotine solutions and natural or artificial flavours. Preferably, the liquid further comprises an aerosol former. Examples of suitable aerosol formers are glycerine and propylene glycol.

An advantage of providing a liquid storage portion is that the liquid in the liquid storage portion is protected from ambient air (because air cannot generally enter the liquid storage portion) and, in some embodiments light, so that the risk of degradation of the liquid is significantly reduced. Moreover, a high level of hygiene can be maintained. The liquid storage portion may not be refillable. Thus, when the liquid in the liquid storage portion has been used up, the aerosol generating system is replaced. The leakage prevention means prevent contamination when the liquid storage portion is replaced. Alternatively, the liquid storage portion may be refillable. In that case, the aerosol generating system may be replaced after a certain number of refills of the liquid storage portion. Preferably, the liquid storage portion is arranged to hold liquid for a pre-determined number of puffs.

In one embodiment, the leakage prevention means comprises a porous plug at least partially located within the liquid storage portion.

Providing a porous plug at least partially within the liquid storage portion minimises the free liquid. This reduces the likelihood that liquid will leak from the liquid storage portion at all. The porous plug may comprise any suitable material or combination of materials which is able to retain the liquid aerosol-forming substrate, but is also inert with respect to the liquid aerosol-forming substrate. The particular preferred material or materials will depend on the physical properties of the liquid aerosol-forming substrate. Examples of suitable materials are a capillary material, for example a sponge or foam material, ceramic- or graphite-based materials in the form of fibres or sintered powders, a foamed metal or plastics material, a fibrous material, for example made of spinned or extruded fibres, such as cellulose acetate, polyester, or bonded polyolefin, polyethylene, terylene or polypropylene fibres, nylon fibres or ceramic. The porous plug may have any suitable shape. Most preferably, however, the porous plug substantially fills the cavity of the liquid storage portion so as to minimise the free liquid.

As mentioned in the first aspect of the invention, ~~The~~ the aerosol generating system ~~may further~~ comprises a capillary wick for conveying the liquid aerosol-forming substrate from the liquid storage portion.

Preferably, the capillary wick is arranged to be in contact with liquid in the liquid storage portion. Preferably, the capillary wick extends into the liquid storage portion. In that case, in use, liquid is transferred from the liquid storage portion by capillary action in the capillary wick. In one embodiment, liquid in one end of the capillary wick is vaporized to form a supersaturated vapour. The supersaturated vapour is mixed with and carried in the air flow. During the flow, the vapour condenses to form the aerosol and the aerosol is carried towards the mouth of a user.

The liquid aerosol-forming substrate has physical properties, including surface tension and

viscosity, which allow the liquid to be transported through the capillary wick by capillary action.

The capillary wick may have a fibrous or spongy structure. The capillary wick preferably comprises a bundle of capillaries. For example, the capillary wick may comprise a plurality of fibres or threads or other fine bore tubes. The fibres or threads may be generally aligned in the longitudinal direction of the aerosol generating system. Alternatively, the capillary wick may comprise sponge-like or foam-like material formed into a rod shape. The rod shape may extend along the longitudinal direction of the aerosol generating system. The structure of the wick forms a plurality of small bores or tubes, through which the liquid can be transported by capillary action. The capillary wick may comprise any suitable material or combination of materials. Examples of suitable materials are capillary materials, for example a sponge or foam material, ceramic- or graphite-based materials in the form of fibres or sintered powders, foamed metal or plastics material, a fibrous material, for example made of spinned or extruded fibres, such as cellulose acetate, polyester, or bonded polyolefin, polyethylene, terylene or polypropylene fibres, nylon fibres or ceramic. The capillary wick may have any suitable capillarity and porosity so as to be used with different liquid physical properties. The liquid has physical properties, including but not limited to viscosity, surface tension, density, thermal conductivity, boiling point and vapour pressure, which allow the liquid to be transported through the capillary device by capillary action. The physical properties of the liquid aerosol-forming substrate may also affect the leakage behaviour.

In a preferred embodiment, the aerosol generating system comprises a porous plug at least partially located within the liquid storage portion and a capillary wick for conveying the liquid aerosol-forming substrate from the liquid storage portion. In that case, the porous plug and capillary wick may comprise the same material or different materials. Preferably, the capillary wick is arranged to extend into the porous plug which is inside the liquid storage portion. Preferably, the capillary wick extends into substantially the centre of the porous plug. The capillary wick and porous plug are preferably in contact, as this provides for good transfer of liquid. The capillary wick and porous plug may be provided as a single integral capillary member, partially located within the liquid storage portion to retain liquid, and partially extending out of the liquid storage portion to convey the liquid aerosol-forming substrate by capillary action. Alternatively, the capillary wick and porous plug may be separate.

As mentioned in the first aspect of the invention, ~~If~~ the aerosol generating system comprises a capillary wick~~,~~ and the leakage prevention means ~~may~~ comprises sealing means between the liquid storage portion and the capillary wick. Such sealing means, particularly in combination with a porous plug, provide improved leakage prevention.

In one embodiment, the sealing means comprises sealing material substantially surrounding the capillary wick. Preferably, the capillary wick is located partially inside the liquid storage portion for contact with the liquid in the liquid storage portion. In that case, preferably,

the sealing means comprises sealing material at the junction between the liquid storage portion and the capillary wick. As mentioned in the first aspect of the invention, ~~The~~ the sealing means ~~may be~~ is in the form of a sealing ring.

The sealing means may be particularly important if a porous plug at least partially located within the liquid storage portion is provided and the capillarity of the porous plug is different from the capillarity of the capillary wick. In that case, a capillarity or capillary strength gradient will form between the porous plug in the liquid storage portion and the capillary wick, which may force liquid to move from the liquid storage portion towards the capillary wick.

In a preferred embodiment, the sealing means is created by placing the wick into an injection mould and injecting an appropriate sealing material around the capillary wick. When the capillary wick is placed in the liquid storage portion, the sealing means is positioned at the junction between the liquid storage portion and the capillary wick.

The sealing means preferably substantially seals any gap between the liquid storage portion and the capillary wick. Thus, if any liquid does begin to leak out of the liquid storage portion, the sealing means will prevent any liquid, or reduce the amount of liquid, which exits the liquid storage portion and capillary wick. If the sealing means is provided in addition to a porous plug, any liquid which does escape the porous plug may be contained by the sealing means.

The sealing means may comprise any suitable sealing material or combination of sealing materials. The material may be the same material or a different material as the material of the liquid storage portion.

Preferably, the aerosol generating system is electrically operated. The electrically operated aerosol generating system may further comprise an electric heater for heating the liquid aerosol-forming substrate.

The electric heater may comprise a single heating element. Alternatively, the electric heater may comprise more than one heating element for example two, or three, or four, or five, or six or more heating elements. The heating element or heating elements may be arranged appropriately so as to most effectively heat the aerosol-forming substrate.

The at least one electric heating element preferably comprises an electrically resistive material. Suitable electrically resistive materials include but are not limited to: semiconductors such as doped ceramics, electrically “conductive” ceramics (such as, for example, molybdenum disilicide), carbon, graphite, metals, metal alloys and composite materials made of a ceramic material and a metallic material. Such composite materials may comprise doped or undoped ceramics. Examples of suitable doped ceramics include doped silicon carbides. Examples of suitable metals include titanium, zirconium, tantalum and metals from the platinum group. Examples of suitable metal alloys include stainless steel, Constantan, nickel-, cobalt-, chromium-, aluminium- titanium- zirconium-, hafnium-, niobium-, molybdenum-, tantalum-, tungsten-, tin-, gallium-, manganese- and iron-containing alloys, and super-alloys based on

nickel, iron, cobalt, stainless steel, Timetal®, iron-aluminium based alloys and iron-manganese-aluminium based alloys. Timetal® is a registered trade mark of Titanium Metals Corporation,

The housing may comprise any suitable material or combination of materials. Examples of suitable materials include metals, alloys, plastics or composite materials containing one or more of those materials, or thermoplastics that are suitable for food or pharmaceutical applications, for example polypropylene, polyetheretherketone (PEEK) and polyethylene. Preferably, the material is light and non-brittle.

In one particularly preferred embodiment, the aerosol generating system further comprises: a first end having a mouthpiece; a second end opposite the first end; an electric power supply and electric circuitry arranged in the second end; a capillary wick for conveying the liquid aerosol-forming substrate from the liquid storage portion, the capillary wick having a first end extending into the liquid storage portion and a second end opposite the first end; and an electric heater, connected to the electric power supply, for heating the liquid aerosol-forming substrate in the second end of the capillary wick; wherein the liquid storage portion, capillary wick and electric heater are arranged in the first end of the aerosol generating system.

Preferably, the aerosol generating system is portable. The aerosol generating system may be a smoking system and may have a size comparable to a conventional cigar or cigarette. The smoking system may have a total length between approximately 30 mm and approximately 150 mm. The smoking system may have an external diameter between approximately 5 mm and approximately 30 mm.

Preferably, the aerosol generating system is an electrically operated smoking system.

According to a second aspect of the invention, there is provided a cartridge for storing a liquid aerosol-forming substrate, for use with an aerosol generating system for heating the liquid aerosol-forming substrate, the cartridge comprising:a container for storing the liquid aerosol-forming substrate; a capillary wick for conveying the liquid aerosol-forming substrate from the liquid storage portion; and leakage prevention means comprising sealing means between the liquid storage portion and the capillary wick configured to prevent or reduce leakage of the liquid aerosol-forming substrate from the container, wherein the sealing means comprises a sealing ring.

~~there~~ There is also provided a cartridge for storing a liquid aerosol-forming substrate, for use with an aerosol generating system for heating the liquid aerosol-forming substrate, the cartridge comprising: a container for storing the liquid aerosol-forming substrate; and leakage prevention means configured to prevent or reduce leakage of the liquid aerosol-forming substrate from the container. The cartridge may be used with the aerosol generating system of the first aspect of the invention.

In one embodiment, the leakage prevention means comprises a porous plug at least partially located within the container. The properties of such a porous plug have already been discussed.

As mentioned in the second aspect of the invention, ~~The~~ the cartridge ~~may further~~ comprises a capillary wick for conveying the liquid aerosol-forming substrate from the container. The properties of such a capillary wick have already been discussed.

As mentioned in the second aspect of the invention, ~~If the cartridge comprises a capillary wick,~~ the leakage prevention means ~~may~~ comprises sealing means between the container and the capillary wick. The properties of such sealing means have already been discussed.

The cartridge may further comprise an electric heater for heating the liquid aerosol-forming substrate, the electric heater being connectable to an electric power supply in the aerosol generating system. The properties of such an electric heater have already been discussed.