(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 289 296 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
13.12.2023 Bulletin 2023/50

(21) Application number: **23177377.1**

(22) Date of filing: **05.06.2023**

(51) International Patent Classification (IPC):
A24F 40/44 *(2020.01)*

(52) Cooperative Patent Classification (CPC):
A24F 40/44; A24F 40/10

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **06.06.2022 CN 202210631709**

(71) Applicant: **BYD Precision Manufacture Co., Ltd.
Shenzhen Guangdong 518116 (CN)**

(72) Inventors:
- **JIN, Qibin
Shenzhen, 518116 (CN)**
- **CHEN, Chaonan
Shenzhen, 518116 (CN)**
- **LU, Yinbo
Shenzhen, 518116 (CN)**
- **TANG, Jianguo
Shenzhen, 518116 (CN)**

(74) Representative: **DehnsGermany Partnerschaft von Patentanwälten
Theresienstraße 6-8
80333 München (DE)**

(54) VAPORIZATION CORE AND ELECTRONIC VAPORIZATION APPARATUS

(57) An electronic vaporization apparatus includes a vaporization core, and the vaporization core includes a porous substrate and a heating element, where the porous substrate includes a liquid absorbing surface and a vaporization surface, and the heating element is arranged on the vaporization surface. The porous substrate is defined to include a liquid penetration portion and a temporary liquid storage portion that are connected, the temporary liquid storage portion is close to the vaporization surface and the temporary liquid storage portion is a portion of a volume of the porous substrate occupied by e-liquid with a maximum vaporizable volume Q_{c1} in an inhalation cycle of the vaporization core. In any inhalation cycle of continuous inhalations, the vaporization core meets: $Q_{cn} \geq Q_{xn} \geq Q_{bn}$, where Q_{cn} represents a volume of e-liquid stored in the temporary liquid storage portion before an n^{th} inhalation cycle starts, Q_{xn} represents a volume of e-liquid actually vaporized during the n^{th} inhalation cycle, and Q_{bn} represents a volume of e-liquid entering the porous substrate during the n^{th} inhalation cycle.

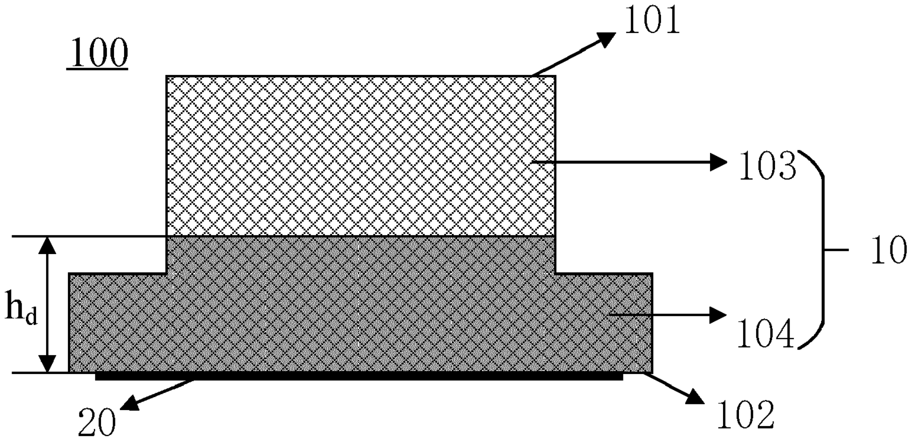

FIG. 1

Description

FIELD

[0001] The present disclosure relates to the field of electronic vaporization apparatus technologies, and in particular, to a vaporization core and an electronic vaporization apparatus.

BACKGROUND

[0002] With the improvement of tobacco consumers' own health awareness and the development of the international tobacco control movement, electronic cigarettes are increasingly popular with consumers. A key device in an electronic cigarette is a vaporization core, and the vaporization core generally includes a porous substrate and a heating element arranged on the porous substrate. When a consumer inhales the electronic cigarette, the porous substrate absorbs e-liquid to the heating element, and under the action of electronic heating of the heating element, the e-liquid may be heated and vaporized to generate vapor. At present, the phenomenon of "e-liquid leakage" or "burnt core" is common in commercially available electronic cigarettes. This seriously affects the use experience of users.

SUMMARY

[0003] In view of the foregoing problems, the present disclosure provides a vaporization core and an electronic vaporization apparatus. The vaporization core can be used in a plurality of continuous inhalation cycles without e-liquid explosion and burnt core.

[0004] A first aspect of the present disclosure provides a vaporization core. The vaporization core includes a porous substrate and a heating element, where the porous substrate includes a liquid absorbing surface and a vaporization surface, and the heating element is arranged on the vaporization surface. The porous substrate is defined to include a liquid penetration portion and a temporary liquid storage portion that are connected, the temporary liquid storage portion is close to the vaporization surface and the temporary liquid storage portion is a portion of a volume of the porous substrate occupied by e-liquid with a maximum vaporizable volume Q_{c1} in an inhalation cycle of the vaporization core.

$$Q_{c1} = V \times \sigma \qquad (1)$$

[0005] In any inhalation cycle of continuous inhalations, the vaporization core meets:

$$Q_{cn} \geq Q_{xn} \geq Q_{bn} \qquad (2)$$

When n≥2,

$$Q_{cn} = Q_{c1} - \sum_{i=1}^{n-1} \frac{f(T_i)}{\rho} + v_b(h) \times S(h) \times \left(\sum_{i=1}^{n-1} T_i + \sum_{i=1}^{n-1} t_i \right) \times \sigma \qquad (3)$$

[0006] V is a volume of the temporary liquid storage portion, in units of cm^3; σ is a porosity of the porous substrate; Q_{cn} represents a volume of e-liquid stored in the temporary liquid storage portion before an n^{th} inhalation cycle starts, Q_{xn} represents a volume of e-liquid actually vaporized during the n^{th} inhalation cycle, and Q_{bn} represents a volume of e-liquid entering the porous substrate during the n^{th} inhalation cycle, where units of Q_{cn}, Q_{c1}, Q_{xn} and Q_{bn} are all mL; i is any integer ranging from 1 to n; $f(T_i)$ represents a function relationship between quality of e-liquid actually vaporized and an inhalation time in an i^{th} inhalation cycle; T_i is a duration of the i^{th} inhalation cycle, in units of s; t_i is an interval time between the i^{th} inhalation cycle and an $(i+1)^{th}$ inhalation cycle, in units of s; $v_b(h)$ is a penetration rate of e-liquid in the porous substrate at a distance h from the vaporization surface, in units of cm/s; and $S(h)$ is a cross-sectional area of the porous substrate at a distance h from the vaporization surface, in units of cm^2.

[0007] During a plurality of continuous inhalation cycles of the foregoing vaporization core, the volume Q_{cn} of e-liquid stored in the temporary liquid storage portion, the volume Q_{xn} of e-liquid consumed by vaporization on the vaporization surface, and the volume Q_{bn} of e-liquid entering the vaporization core can always meet the foregoing relationship, so that there is always an appropriate amount of e-liquid in the vaporization core. This can effectively avoid the phenomenon of burnt core and e-liquid explosion during a plurality of continuous inhalation cycles, so as to significantly improve the use experience of consumers.

[0008] A second aspect of the present disclosure provides an electronic vaporization apparatus, where the electronic vaporization apparatus has the vaporization core according to the first aspect of the present disclosure and a battery connected to the vaporization core (100).

[0009] The inventor of the present disclosure finds in a research process that excessively large e-liquid content in a porous substrate will easily lead to "e-liquid explosion" to cause serious e-liquid leakage, or excessively small e-liquid content in the porous substrate may cause the phenomenon of "burnt core", and consequently vapor has a burnt flavor.

[0010] However, when the electronic vaporization apparatus of the present disclosure works, by controlling the relationship between the volume of e-liquid stored in the temporary liquid storage portion, the volume of e-liquid actually vaporized during a single inhalation cycle, and the volume of e-liquid entering the porous substrate (10) during a single inhalation cycle to be in an appropriate range, the electronic vaporization apparatus can work continuously for a plurality of inhalation cycles without a burnt core and e-liquid explosion, so that the use experience of users is good, and a service life of the electronic vaporization apparatus is long. In addition, vapor generated by the electronic vaporization apparatus has a good taste and high fullness.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is a schematic structural diagram of a vaporization core according to an embodiment of the present disclosure;
. FIG. 2 is a grayscale image from a perspective of a vaporization core according to Embodiment 1 of the present disclosure;
FIG. 3 is a vaporization quality-time function curve of e-liquid of a vaporization core measured in Embodiment 1 of the present disclosure; and
FIG. 4 is a grayscale image of a vaporization core from a perspective of a vaporization core according to Embodiment 3 of the present disclosure.

DETAILED DESCRIPTION

[0012] At present, most of electronic vaporization apparatuses on the market have the problems of "e-liquid explosion" and "burnt core". The "e-liquid explosion" is due to accumulation of excessive e-liquid on a vaporization surface in a short time. This causes the e-liquid on the vaporization surface to be overboiled during heating, and sound similar to "oil explosion" sound that is generated when water drops into a deep fryer occurs. In addition, when "e-liquid explosion" happens, extra e-liquid will splash into a vaporization cavity of the electronic vaporization apparatus, causing e-liquid to accumulate in the vaporization cavity, which seriously affects the use experience of consumers and causes waste of e-liquid. The "burnt core" is due to dry heating of a heating element on the vaporization surface. This produces a burnt smell and will also seriously affect the use experience of consumers. To resolve the foregoing problem, an embodiment of the present disclosure provides a vaporization core.

[0013] Specifically, the following describes the technical solutions of the present disclosure in detail with reference to the accompanying drawings.

[0014] Referring to FIG. 1, the vaporization core 100 includes a porous substrate 10 and a heating element 20, where the porous substrate 10 includes a liquid absorbing surface 101 and a vaporization surface 102, and the heating element 20 is arranged on the vaporization surface 102. The porous substrate 10 is defined to include a liquid penetration portion 103 and a temporary liquid storage portion 104.The liquid penetration portion 103 and the temporary liquid storage portion 104 are connected, the temporary liquid storage portion 104 is close to the vaporization surface 102 and the temporary liquid storage portion 104 is a portion of a volume of the porous substrate 10 occupied by e-liquid with a maximum vaporizable volume Q_{c1} in an inhalation cycle of the vaporization core 100.

$$Q_{c1} = V \times \sigma \quad (1)$$

[0015] In any inhalation cycle of continuous inhalations, the vaporization core 100 meets:

$$Q_{cn} \geq Q_{xn} \geq Q_{bn} \quad (2)$$

When n≥2,

$$Q_{cn} = Q_{c1} - \sum_{i=1}^{n-1} \frac{f(T_i)}{\rho} + v_b(h) \times S(h) \times \left(\sum_{i=1}^{n-1} T_i + \sum_{i=1}^{n-1} t_i \right) \times \sigma \quad (3)$$

[0016] V is a volume of the temporary liquid storage portion 104, in units of cm^3; σ is a porosity of the porous substrate 10; Q_{cn} represents a volume of e-liquid stored in the temporary liquid storage portion 104 before an n^{th} inhalation cycle starts, Q_{xn} represents a volume of e-liquid actually vaporized during the n^{th} inhalation cycle, and Q_{bn} represents a volume of e-liquid entering the porous substrate 10 during the n^{th} inhalation cycle, where units of Q_{cn}, Q_{xn} and Q_{bn} are all mL; i is any integer ranging from 1 to n; $f(T_i)$ represents a function relationship between quality of e-liquid actually vaporized and an inhalation time in an i^{th} inhalation cycle; T_i is a duration of the i^{th} inhalation cycle, in units of s; t_i is an interval time between the i^{th} inhalation cycle and an $(i+1)^{th}$ inhalation cycle, in units of s; $v_b(h)$ is a penetration rate of e-liquid in the porous substrate 10 at a distance h from the vaporization surface 102, in units of cm/s; and $S(h)$ is a cross-sectional area of the porous substrate 10 at a distance h from the vaporization surface 102, in units of cm^2.

[0017] It should be noted that, all the e-liquid vaporized during the i^{th} inhalation cycle comes from the e-liquid that has been stored in the temporary liquid storage portion 104 before the i^{th} inhalation, and the e-liquid entering the porous substrate 10 during the i^{th} inhalation cycle will be vaporized in the $(i+1)^{th}$ inhalation cycle.

[0018] The following describes definitions of the temporary liquid storage portion 104 and Q_{c1} in detail:
A portion of a volume of the porous substrate 10 occupied by e-liquid with a maximum vaporizable volume Q_{c1} in an inhalation cycle of the vaporization core 100 is defined as the temporary liquid storage portion 104. That is, e-liquid with a maximum vaporizable volume in one inhalation is located on an upper liquid surface in the vaporization core 100, and an entire space encircled by a plane at a distance h_d from the upper liquid surface to the vaporization surface 102, the vaporization surface 102, and a part of side walls of the porous substrate 10 is the temporary liquid storage portion 104 (that is, a height of the temporary liquid storage portion is h_d, and reference may be made to FIG. 1). Naturally, an entire space encircled by a plane of the upper liquid surface of the e-liquid, the liquid absorbing surface 101, and a part of side walls of the porous substrate 10 is the liquid penetration portion 103.

[0019] It may be understood that, for each vaporization core, a value of Q_{c1} is fixed. In addition, the volume of the temporary liquid storage portion 104 may be calculated by a mathematical formula according to a value of h_d and a structural feature of the vaporization core. It may be understood that a critical condition for burnt core is that: During a single inhalation, the maximum vaporizable volume Q_{c1} of the e-liquid in the temporary liquid storage portion 104 is equal to a volume Q'_{x1} of e-liquid actually consumed by the inhalation, that is, a position of a liquid surface of the e-liquid when the single inhalation ends exactly overlaps with the vaporization surface 102. If Q_{c1} is less than Q'_{x1}, burnt core occurs.

[0020] Therefore, assuming that burnt core occurs when inhalation is continuously and uniformly performed for T_h, a height at the vaporization surface 102 is recorded as 0:

$$h_d = \int_0^{T_h} v_b(h)dt \quad (4)$$

and

$$Q_{c1} = V \times \sigma = Q'_{x1} \quad (5)$$

[0021] In the foregoing relational expressions, $v_b(h)$ refers to a penetration rate of the e-liquid in the porous substrate 10 at a height h from the vaporization surface 102, which is closely related to e-liquid viscosity, a temperature of the e-liquid in the porous substrate 10, and a porous structure (pore size distribution and a porosity σ) of the porous substrate 10, and can be measured by an e-liquid penetration experiment of the vaporization core. In addition, for an existing vaporization core, σ is a known parameter, or σ may also be measured by experiments.

[0022] Moreover, Q_{c1} at this time is equal to Q'_{x1}, Q'_{x1} may be calculated by a function relationship between the quality of the e-liquid actually vaporized and the inhalation time T_h. The foregoing function relationship may also be measured by early-stage experiments, values of T_h and h_d may be calculated with reference to formula (4) and formula (5), so as to determine the maximum vaporizable volume Q_{c1} of the e-liquid in an inhalation cycle and the volume V of the temporary liquid storage portion 104.

[0023] It may be understood that when $n \geq 2$, Q_{cn} is an amount of e-liquid stored in the temporary liquid storage portion 104 after the vaporization core 100 works continuously for (n-1) cycles, that is, formula (3) may be obtained by adding the total volume Q_{c1} of the e-liquid in the temporary liquid storage portion 104 before a first cycle starts and a total volume $v_b(h)\times S(h)\times\left(\sum_{i=1}^{n-1}T_i+\sum_{i=1}^{n-1}t_i\right)\times\sigma$ of e-liquid entering the porous substrate during the (n-1) cycles (during the interval time period *ti* between two adjacent inhalation cycles, due to the action of inertia, some e-liquid is also inhaled into the porous substrate 10), and reducing a total volume $\sum_{i=1}^{n}Q_{xi}$ of e-liquid actually vaporized during the (n-1) cycles: When n≥2,

$$Q_{cn}=Q_{c1}-\sum_{i=1}^{n-1}\frac{f(T_i)}{\rho}+v_b(h)\times S(h)\times\left(\sum_{i=1}^{n-1}T_i+\sum_{i=1}^{n-1}t_i\right)\times\sigma$$

[0024] E-liquid entering the porous substrate 10 during an i^{th} inhalation cycle will be vaporized during an $(i+1)^{th}$ inhalation cycle. It may be understood that, a critical condition for "e-liquid explosion" occurring in the vaporization core 100 is that:

[0025] A volume Q'_{b1} of the e-liquid entering the porous substrate 10 is equal to the total volume Q'_{x1} of the e-liquid actually vaporized. After the inhalation cycle ends, a total volume of e-liquid in the vaporization core 100 is Q_{c1}-Q'_{x1}+Q'_{b1} , and this value is equal to the capacity Q_{c1} of the temporary liquid storage portion 104. If $Q'_{x1} < Q'_{b1}$, then $Q_{c2} > Q_{c1}$. In this case, e-liquid will overflow to the liquid penetration portion 103. However, excessive e-liquid inside the porous substrate 10 will cause the e-liquid to accumulate on the vaporization surface 102 in a short time, resulting in "e-liquid explosion". Therefore, in order to ensure that e-liquid explosion will not occur in the vaporization core 100 in any cycle in a plurality of continuous inhalation cycles, it is necessary to meet $Q_{xn} \geq Q_{bn}$.

[0026] In summary, before each inhalation cycle starts, the temporary liquid storage portion 104 is controlled to contain a sufficient amount of e-liquid, so that the volume Q_{xn} of e-liquid vaporized in each inhalation is less than or equal to the volume Q_{cn} of the e-liquid stored in the temporary liquid storage portion 104. This can effectively avoid the phenomenon of "burnt core". By controlling the volume Q_{xn} of e-liquid entering the vaporization core 100 in each inhalation to range from Q_{bn} to Q_{cn}, it may be ensured that there is a sufficient amount of e-liquid in the temporary liquid storage portion 104 before a next inhalation cycle starts, and there will be no phenomenon of "e-liquid explosion" caused by extra e-liquid penetrating into the vaporization surface 102 in a short time, thereby significantly improving the use experience of consumers. In addition, a service life of the vaporization core 100 can further be prolonged.

[0027] In some implementations of the present disclosure, Q_{bn} meets the following relational expression: $Q_{bn} = v_b(h)\times S(h)\times T_n\times\sigma$ (formula 6); where $v_b(h)$ is a penetration rate of e-liquid in the porous substrate 10 at a distance h from the vaporization surface 102, in units of cm/s; and $S(h)$ is a cross-sectional area of the porous substrate 10 at a distance h from the vaporization surface 102, in units of cm^2.

[0028] In some implementations of the present disclosure, Q_{xn} meets the following relational expression: $Q_{xn}=\frac{f(T_n)}{\rho}$; where $f(T_n)$ represents a function relationship between quality of vaporized e-liquid and an inhalation time, ρ is a density of the e-liquid, in units of mg/mL. $f(T_n)$ may be measured through early-stage experiments. In some cases, the quality of the e-liquid actually vaporized by the vaporization core at different time points is measured to obtain a relationship curve between the quality of the e-liquid actually vaporized and a time. A function relationship of $f(T_n)$ may be calculated by function fitting. Then, and the density of the used e-liquid is substituted, to calculate Q_{xn} of the vaporization core 100.

[0029] In some implementations of the present disclosure, t_i meets the following relational expression: $t_i\leq\frac{Q_{cn}-Q_{xn}+Q_{bn}}{\upsilon_b(h)}$. Generally, if a user continuously performs inhalation, a duration of a single inhalation generally ranges from 2.0s to 2.5s, and an interval time between two adjacent inhalations generally requires a specific duration, for example, falling within a range of greater than 0s and less than or equal to 1s. By limiting t_i to be within the foregoing range, it is convenient to define whether a plurality inhalation actions performed by the user are continuous inhalations.

[0030] In some implementations of the present disclosure, t_i is less than or equal to 0.6s.

[0031] In some implementations of the present disclosure, T_i is less than or equal to 3s. Generally, when a consumer uses an electronic vaporization apparatus to inhales e-liquid, a single inhalation time needs to be not greater than 3s to obtain a comfortable use experience.

[0032] In some implementations of the present disclosure, n is less than or equal to 15. In this case, the vaporization core 100 will not encounter the phenomenon of burnt core in no more than 15 continuous inhalation cycles.

[0033] In some specific embodiments, when the duration of each inhalation cycle is 3s, the interval time between every two adjacent inhalation cycles is 0.6s, and when inhalation is continuously performed for 15 cycles, the vaporization core 100 will not encounter the phenomenon of burnt core and e-liquid explosion.

[0034] In some implementations of the present disclosure, the porosity σ of the porous substrate 10 ranges from 40% to 60%. For example, the porosity of the porous substrate 10 may be 40%, 45%, 50%, 55%, or 60%. By controlling the porosity of the porous substrate 10, not only the total volume of the e-liquid entering the porous substrate 10 during each inhalation cycle may be directly controlled, but also a transmission rate of the e-liquid in the liquid penetration portion 103 and the temporary liquid storage portion 104 may be changed, so that Q_{bn} of the vaporization core 100 may be further controlled to be in a suitable range, and the e-liquid can be transmitted to the vaporization surface 102 faster and better, thereby achieving a fast and excellent vaporization effect and ensuring that the vaporization core 100 does not encounter burnt core and e-liquid explosion.

[0035] In some specific embodiments, the porosity σ of each part inside the porous substrate 10 may be the same or different. This parameter may be determined according to a shape and a size of the porous substrate and an actual use requirement.

[0036] In some implementations of the present disclosure, the volume V of the temporary liquid storage portion 104 ranges from 0.01 cm^3 to 0.2 cm^3. In some specific embodiments, V ranges from 0.01 cm^3 to 0.1 cm^3. For example, V may be 0.01 cm^3, 0.02 cm^3, 0.03 cm^3, 0.04 cm^3, 0.05 cm^3, 0.1 cm^3, 0.15 cm^3, or 0.2 cm^3. By controlling each size of the porous substrate 10 and the porous structure and distribution of the porous substrate 10, V may be controlled in the foregoing range, thereby ensuring that a suitable amount of e-liquid may be provided by the vaporization core 100 during each inhalation cycle for vaporization and ensuring that there is no burnt core and e-liquid explosion, so as to improve the inhalation experience of users.

[0037] In some implementations of the present disclosure, Q_{c1} ranges from 0.004 cm^3 to 0.12 cm^3. In some specific embodiments, Q_{c1} ranges from 0.004 cm^3 to 0.06 cm^3. For example, Q_{c1} may be 0.004 cm^3, 0.005 cm^3, 0.006 cm^3, 0.007 cm^3, 0.008 cm^3, 0.009 cm^3, 0.01 cm^3, 0.05 cm^3, 0.06 cm^3, 0.07 cm^3, 0.08 cm^3, 0.09 cm^3, 0.1 cm^3, or 0.12 cm^3. Controlling Q_{c1} in the foregoing range helps control the vaporization core 100 to provide a suitable amount of e-liquid during each inhalation cycle, so that a user can obtain a good use experience.

[0038] In some implementations of the present disclosure, the penetration rate $v_b(h)$ of the e-liquid in the porous substrate 10 at the distance h from the vaporization surface 102 ranges from 0.01 cm/s to 0.2 cm/s. In some specific embodiments, the penetration rate $v_b(h)$ of the e-liquid in the porous substrate 10 at the distance h from the vaporization surface 102 ranges from 0.01 cm/s to 0.1 cm/s. For example, $v_b(h)$ may be 0.01 cm/s, 0.02 cm/s, 0.03 cm/s, 0.04 cm/s, 0.05 cm/s, 0.1 cm/s, 0.15 cm/s, or 0.2 cm/s. Controlling the penetration rate $v_b(h)$ of each part of the porous substrate 10 in the foregoing range helps control the total volume Q_{bn} of the e-liquid entering the porous substrate 10 in each inhalation cycle to be in a suitable range and helps ensure a suitable transmission rate of the e-liquid in the porous substrate 10, so that the e-liquid may enter the temporary liquid storage portion 104 within an expected time, thereby ensuring that the vaporization core 100 does not encounter e-liquid explosion and burnt core during a plurality of continuous inhalation cycles and helping convert the e-liquid into vapor with a delicate taste, so as to improve the inhalation experience of users.

[0039] In the present disclosure, $v_b(h)$ of the porous substrate 10 at different heights h from the vaporization surface 102 may be the same or different. $v_b(h)$ may gradually decrease in a penetration direction of the e-liquid, or may first remain unchanged and then decrease, or may be changed in gradient.

[0040] In some implementations of the present disclosure, the liquid absorbing surface (101) and the vaporization surface (102) are arranged opposite to each other, and in a direction perpendicular to an extension direction from the liquid absorbing surface (101) to the vaporization surface (102), a maximum cross-sectional area of the liquid penetration portion 103 is smaller than a maximum cross-sectional area of the temporary liquid storage portion 104. The maximum cross-sectional area of the liquid penetration portion 103 is smaller than the maximum cross-sectional area of the temporary liquid storage portion 104. This helps further control the volume of the e-liquid entering the temporary liquid storage portion 104 from the liquid penetration portion 103 per unit time, thereby better avoiding the phenomenon of "e-liquid explosion".

[0041] In some implementations of the present disclosure, in the direction perpendicular to the extension direction from the liquid absorbing surface (101) to the vaporization surface (102), the porous substrate (10) includes a cross-section, and a cross-sectional area of the porous substrate 10 first remains unchanged and then increases in the extension direction from the liquid absorbing surface 101 to the vaporization surface 102. In this case, a longitudinal section of the porous substrate (the longitudinal section is parallel to the extension direction from the liquid absorbing surface 101 to the vaporization surface 102 of the porous substrate) is in a "step shape". This helps control the e-liquid in the temporary liquid storage portion 104 to continuously and uniformly penetrate onto the vaporization surface 102, so that a consumer can obtain a better use experience.

[0042] In some implementations of the present disclosure, in the direction perpendicular to the extension direction from the liquid absorbing surface (101) to the vaporization surface (102), the porous substrate (10) includes a cross-section, and the cross-sectional area of the porous substrate 10 gradually increases in the extension direction from the liquid absorbing surface 101 to the vaporization surface 102. In this case, a shape of the porous substrate 10 may be a prism. This can also help control the e-liquid in the temporary liquid storage portion 104 to continuously and uniformly penetrate onto the vaporization surface 102, so that a consumer can obtain a better use experience.

[0043] In the present disclosure, a shape of the longitudinal section of the porous substrate(the longitudinal section is parallel to the extension direction from the liquid absorbing surface 101 to the vaporization surface 102 of the porous substrate 10) may be an inverted "T", a trapezoid, or an irregular pattern including a plurality of trapezoids or rectangles, a side wall of the porous substrate 10 (which refers to a portion of the porous substrate 10 between the liquid absorbing surface 101 and the vaporization surface 102, and the side wall connects the liquid absorbing surface 101 to the vaporization surface 102) may be a plane or a curved surface, and shapes of the liquid absorbing surface 101 and the vaporization surface 102 are not specifically limited. The liquid absorbing surface 101 and the vaporization surface 102 may be arranged opposite to each other. A person skilled in the art may select according to an actual production requirement.

[0044] In some implementations of the present disclosure, the heating element 20 includes, but is not limited to, any one of a heating film, a heating sheet, a heating circuit, or a heating net.

[0045] In some implementations of the present disclosure, a material of the porous substrate 10 includes, but is not limited to, at least one of a porous ceramic and an e-liquid guiding cotton. The porous substrate 10 may be a porous ceramic, or the porous substrate 10 may be an e-liquid guiding cotton, or the porous substrate 10 is formed by a porous ceramic and an e-liquid guiding cotton together.

[0046] An embodiment of the present disclosure further provides an electronic vaporization apparatus, where the electronic vaporization apparatus has the vaporization core 100 according to the embodiments of the present disclosure and a battery connected to the vaporization core (100).

[0047] When the electronic vaporization apparatus works, e-liquid is led onto the heating element arranged on the electronic vaporization apparatus through the porous substrate, and vapor may be evaporated when the heating element heats the e-liquid. Due to the use of the foregoing vaporization core, when the electronic vaporization apparatus works for a plurality of inhalation cycles, there is no burnt core and e-liquid explosion, so that a user has a good use experience, and a service life of the electronic vaporization apparatus is long. In addition, the vapor generated by the electronic vaporization apparatus has a good taste and high fullness.

[0048] The following describes in detail the technical solutions of the present disclosure with reference to specific embodiments.

Embodiment 1

[0049] Embodiment 1 provides a vaporization core, and for a grayscale image from a perspective of the vaporization core, reference may be made to FIG. 2.

[0050] The vaporization core is in a shape of an inverted T, which includes a liquid absorbing surface and a vaporization surface that are arranged opposite to each other, and a heating element is arranged on the vaporization surface. The liquid absorbing surface is arranged on an upper surface of a porous substrate(a surface with a small maximum cross-sectional size, where the cross-section is a cross-section perpendicular to an extension direction from the liquid absorbing surface to the vaporization surface), and the vaporization surface is arranged on a lower surface of the porous substrate(a surface with a large maximum cross-sectional size, where the cross-section is a cross-section perpendicular to the extension direction from the liquid absorbing surface to the vaporization surface). The vaporization core includes a temporary liquid storage portion with a volume of V (the temporary liquid storage portion is an entire space encircled by a plane at a distance h_d from the vaporization surface, the vaporization surface, and a side wall of the porous substrate, and a liquid penetration portion is a portion of the porous substrate excluding the temporary liquid storage portion). That is, a volume of the porous substrate occupied by e-liquid with a maximum vaporizable volume Q_{c1} in an inhalation cycle of the vaporization core is V. A size of the liquid absorbing surface of the vaporization core is 4.8 mm×2.2 mm, a size of the vaporization surface is 8.0 mm×3.0 mm, a thickness size h_1 of an upper rectangle is 2.5 mm, and a thickness size h_2 of a lower rectangle is 0.8 mm. The heating element is a metal heating wire arranged on the vaporization surface in a screen-printing manner. A porosity σ of the porous substrate is 58%, and a density ρ of the used e-liquid is 1.1 mg/mL.

[0051] A vapor inhalation collection test is carried out on the foregoing vaporization core to obtain results of the vapor inhalation collection test at different times shown in FIG. 3. After further fitting, a function relationship between a vaporization amount of the e-liquid and an inhalation time is obtained as $\mathrm{Q_{xn}} = \frac{f(T_n)}{\rho} = \frac{0.781 \times \mathrm{T}^2}{1.1} = 0.71T^2$ (formula 7), and a penetration rate of the e-liquid in the porous substrate is measured according to an e-liquid penetration test as 2.8×10^{-2} cm/s. In addition, a critical condition of burnt core is that: A position of a liquid surface of e-liquid when a single inhalation ends exactly overlaps with the vaporization surface. That is, assuming that burnt core occurs when inhalation is continuously and uniformly for T_h, a height at the vaporization surface 102 is recorded as 0:

$$Q_{c1} = V \times \sigma \quad (1)$$

$$h_d = \int_0^{T_h} v_b(h)dt \quad (4)$$

and

$$v_b(h) \times T_h = T_d \quad (8)$$

[0052] The measured result is respectively substituted into formulas (1), (4) and (8), then:

$$\left[8.0\times3.0\times0.8+\left(4.8\times2.2\right)\times\left(h_d-0.8\right)\right]\times0.58=0.71T_h^2$$

$$0.28\times T_h = h_d$$

[0053] It is calculated that $h_d=1.23\times10^{-1}$ cm, and T_h=4.53s. It may be calculated that $V=21.8596\times10^{-3}$ cm^3 according to h_d.

[0054] Then, $Q_{bn} = v_b(h)\times S(h)\times T_n\times\sigma$ (formula 6). Therefore, when a duration T_i of each single inhalation cycle is 3s, the foregoing value is respectively substituted into formulas (1), (6), and (7), and Q_{c1}, Q_{x1}, and Q_{b1} are respectively calculated as 12.67×10^{-3} mL, 6.39×10^{-3} mL, and 5.14×10^{-3} mL, meeting $Q_{c1} \geq Q_{x1} \geq Q_{b1}$.

[0055] When the vaporization core is continuously inhaled twice and an interval time t_1 between a second inhalation cycle and a first inhalation cycle is 0.6s, the value is substituted into formula (3)

$$Q_{cn} = Q_{c1} - \sum_{i=1}^{n-1}\frac{f(T_i)}{\rho} + v_b(h)\times S(h)\times\left(\sum_{i=1}^{n-1}T_i + \sum_{i=1}^{n-1}t_i\right)\times\sigma$$

, it is calculated that Q_{c2}=12.44×10-3 mL, and Q_{x2} and Q_{b2} are respectively 6.39×10^{-3} mL and 5.14×10^{-3} mL, also meeting $Q_{c2} \geq Q_{x2} \geq Q_{b2}$.

[0056] When the vaporization core is continuously inhaled for 15 times and an interval time t14 between a 15th inhalation cycle and a 14th inhalation cycle is also 0.6s (T_{15}=3s, and t14=0.6s), Q_{c15} may be calculated as 9.45×10^{-3} mL according to formula (3), and Q_{x15} and Q_{b15} are respectively calculated as 6.39×10^{-3} mL and 5.14×10^{-3} mL, meeting $Q_{c15} \geq Q_{x15} \geq Q_{b15}$. Therefore, when inhalation is continuously performed for 15 times, the vaporization core still does not encounter burnt core and e-liquid explosion.

Embodiment 2

[0057] Embodiment 2 provides a vaporization core, a structural feature and a size of the vaporization core are the same as those of Embodiment 1. The porosity σ of the porous substrate is 40%, and the density ρ of the used e-liquid is 1.1 mg/mL.

[0058] Similarly, a vapor inhalation collection test is carried out on the foregoing vaporization core, after fitting, a function relationship between a vaporization amount of the eliquid and an inhalation time is obtained as

$$Q_{xn} = \frac{f(T_n)}{\rho} = 0.50T^2$$

, and a penetration rate of the e-liquid in the porous substrate is measured according to an e-liquid penetration test as 2.5×10^{-2} cm/s. The measured result is respectively substituted into formulas (1), (4), and (8), then:

$$\left[8.0\times3.0\times0.8+\left(4.8\times2.2\right)\times\left(h_d-0.8\right)\right]\times0.4=0.50T_{\mathrm{h}}^{2}$$

$$0.25\times T_{\mathrm{h}}=h_d$$

[0059] It is calculated that h_d=1.04×10^{-1} cm, and T_h=4.17s. That is, the temporary liquid storage portion is an entire space encircled by a plane at a height of 1.04×10^{-1} cm from the vaporization surface, the vaporization surface, and the side wall of the porous substrate. It may be calculated that the volume of the temporary liquid storage portion V=21.7344×10^{-3} cm^3 according to h_d=1.04×10^{-1} cm, the duration T_i of each single inhalation cycle is 3s, and Q_{c1}, Q_{x1}, and Q_{b1} are respectively 8.71×10^{-3} mL, 4.51 ×10^{-3} mL, and 3.17×10^{-3} mL, meeting $Q_{c1} \geq Q_{x1} \geq Q_{b1}$.

[0060] When inhalation is continuously performed twice and the interval time t_1 between the second inhalation cycle and the first inhalation cycle is 0.6s, Q_{c2}, Q_{x2}, and Q_{b2} are respectively obtained as 8.43×10^{-3} mL, 4.51 × 10^{-3} mL, and 3.17× 10^{-3} mL, also meeting $Q_{c2} \geq Q_{x2} \geq Q_{b2}$.

[0061] When inhalation is continuously performed for 15 times (T_{15}=3s, and t_{14}=0.6s), Q_{c15}, Q_{x15}, and Q_{b15} are respectively obtained as 4.84×10^{-3} mL, 4.51×10^{-3} mL, and 3.17×10^{-3} mL, meeting $Q_{c15} \geq Q_{x15} \geq Q_{b15}$. Therefore, when inhalation is continuously performed for 15 times, the vaporization core still does not encounter burnt core and e-liquid explosion.

Embodiment 3

[0062] Embodiment 3 provides a vaporization core, and the vaporization core is in a shape of a prism (as shown in FIG. 4). The size of the liquid absorbing surface of the vaporization core is 5.0 mm×4.0 mm, the size of the vaporization surface is 10.0 mm×4.0 mm, and a thickness h of a trapezoid is 5.0 mm. The longitudinal section of the vaporization core is an isosceles trapezoid, and a width of the isosceles trapezoid at a height of h_3 is (10-h_3). The heating element is a metal heating wire arranged on the vaporization surface in a screen-printing manner. The porosity σ of the porous substrate is 58%, the density ρ of the used e-liquid is 1.1 mg/mL, and the penetration rate of the e-liquid in the porous substrate is 1.8×10^{-2} cm/s. After fitting, a function relationship between a vaporization amount of the e-liquid and an inhalation time is obtained as $Q_{\mathrm{xn}}=\frac{f(T_{\mathrm{n}})}{\rho}=0.95T^2$. The measured result is respectively substituted into formulas (1), (4), and (8), then:

$$\left[\left(10\text{-}h_d\right)+10\right]\times\frac{h_d}{2}\times4=0.95T_{\mathrm{h}}^{2}$$

$$0.18T_h=\mathrm{h}_d$$

[0063] It is calculated that h_d=1.28×10^{-1} cm, and T_h=7.09s. That is, the temporary liquid storage portion is an entire space encircled by a plane at a height of 1.28×10^{-1} cm from the vaporization surface, the vaporization surface, and the side wall of the porous substrate, and the volume of the temporary liquid storage portion V=47. 8217 × 10^{-3} cm^3. When the duration T_i of each single inhalation cycle is 3s, Q_{c1}, Q_{x1}, and Q_{b1} are respectively calculated as 27.741×10^{-3} mL, 8.55×10^{-3} mL, and 6.26×10^{-3} mL, meeting $Q_{c1} \geq Q_{x1} \geq Q_{b1}$.

[0064] When inhalation is continuously performed twice and the interval time t_1 between the second inhalation cycle and the first inhalation cycle is 0.6s, Q_{c2}, Q_{x2}, and Q_{b2} are respectively obtained as 27.61×10^{-3} mL, 8.55×10^{-3} mL, and 6.26×10^{-3} mL, also meeting $Q_{c2} \geq Q_{x2} \geq Q_{b2}$.

[0065] When inhalation is continuously performed for 15 times (T_{15}=3s, and t_{14}=0.6s), Q_{c15}, Q_{x15}, and Q_{b15} are respectively obtained as 25.97×10^{-3} mL, 8.55×10^{-3} mL, and 6.26×10^{-3} mL, meeting $Q_{c15} \geq Q_{x15} \geq Q_{b15}$. Therefore, when inhalation is continuously performed for 15 times, the vaporization core still does not encounter burnt core and e-liquid explosion.

Embodiment 4

[0066] Embodiment 4 provides a vaporization core, a structural feature and a size of the vaporization core are the same as those of Embodiment 3. The porosity σ of the porous substrate is 58%, the density ρ of the used e-liquid is 1.1

mg/mL, and the penetration rate of the e-liquid in the porous substrate is 0.011 cm/s. After fitting, a function relationship between a vaporization amount of the e-liquid and an inhalation time is obtained as $Q_{xn} = \frac{f(T_n)}{\rho} = 0.65T^2$, and the measured result is respectively substituted into formulas (1), (4), and (8), then:

$$\left[(10\text{-}h_d) + 10\right] \times \frac{h_d}{2} \times 4 = 0.78T_h^2$$

$$0.11T_h = h_d$$

[0067] It is calculated that $h_d = 7.18 \times 10^{-1}$ cm, and $T_h = 6.53$s. That is, the temporary liquid storage portion is an entire space encircled by a plane at a height of 7.18×10^{-1} cm from the vaporization surface, the vaporization surface, and the side wall of the porous substrate, and the volume of the temporary liquid storage portion $V = 23.168 \times 10^{-3}$ cm^3. When the duration T_i of each single inhalation cycle is 3s, Q_{c1}, Q_{x1}, and Q_{b1} are respectively 16.06×10^{-3} mL, 5.85×10^{-3} mL, and 3.83×10^{-3} mL, meeting $Q_{c1} \geq Q_{x1} \geq Q_{b1}$.

[0068] When inhalation is continuously performed twice and the interval time t_1 between the second inhalation cycle and the first inhalation cycle is 0.6s, Q_{c2}, Q_{x2}, and Q_{b2} are respectively obtained as 15.35×10^{-3} mL, 5.85×10^{-3} mL, and 3.83×10^{-3} mL, also meeting $Q_{c2} \geq Q_{x2} \geq Q_{b2}$ Q_{b15}.

[0069] When inhalation is continuously performed for 15 times (T_{15}=3s, and t_{14}=0.6s), Q_{c15}, Q_{x15}, and Q_{b15} are respectively obtained as 6.23×10^{-3} mL, 5.85×10^{-3} mL, and 3.83×10^{-3} mL, meeting $Q_{c15} \geq Q_{x15} \geq Q_{b15}$. Therefore, when inhalation is continuously performed for 15 times, the vaporization core still does not encounter burnt core and e-liquid explosion.

[0070] It should be noted that the foregoing descriptions are exemplary implementations of the present disclosure, and a person of ordinary skill in the art may make various improvements and refinements without departing from the principle of the present disclosure. All the improvements and refinements shall fall within the protection scope of the present disclosure.

Claims

1. A vaporization core (100), wherein the vaporization core (100) comprises:

a porous substrate (10), the porous substrate (10) comprising a liquid absorbing surface (101) and a vaporization surface (102); and
a heating element (20), the heating element (20) being disposed on the vaporization surface (102), wherein:

the porous substrate (10) comprises a liquid penetration portion (103) and a temporary liquid storage portion (104), the liquid penetration portion (103) and the temporary liquid storage portion (104) are connected, the temporary liquid storage portion (104) is close to the vaporization surface (102), and the temporary liquid storage portion (104) is a portion of a volume of the porous substrate (10) occupied by e-liquid with a maximum vaporizable volume Q_{c1} in an inhalation cycle of the vaporization core (100);
wherein,

$$Q_{c1} = V \times \sigma \quad (1)$$

in any inhalation cycle of continuous inhalations, the vaporization core (100) meets:

$$Q_{cn} \geq Q_{xn} \geq Q_{bn} \quad (2)$$

when n≥2,

$$Q_{cn} = Q_{c1} - \sum_{i=1}^{n-1} \frac{f(T_i)}{\rho} + v_b(h) \times S(h) \times \left(\sum_{i=1}^{n-1} T_i + \sum_{i=1}^{n-1} t_i \right) \times \sigma \quad (3)$$

V is a volume of the temporary liquid storage portion (104), in units of cm^3; σ is a porosity of the porous substrate (10); Q_{cn} represents a volume of e-liquid stored in the temporary liquid storage portion (104) before an n^{th} inhalation cycle starts, Q_{xn} represents a volume of e-liquid actually vaporized during the n^{th} inhalation cycle, and Q_{bn} represents a volume of e-liquid entering the porous substrate (10) during the n^{th} inhalation cycle, wherein units of Q_{cn}, Q_{c1}, Q_{xn} and Q_{bn} are all mL; i is any integer ranging from 1 to n; $f(T_i)$ represents a function relationship between quality of e-liquid actually vaporized and an inhalation time in an i^{th} inhalation cycle; T_i is a duration of the i^{th} inhalation cycle, in units of s; t_i is an interval time between the i^{th} inhalation cycle and an $(i+1)^{th}$ inhalation cycle, in units of s; $v_b(h)$ is a penetration rate of e-liquid in the porous substrate (10) at a distance h from the vaporization surface (102), in units of cm/s; and $S(h)$ is a cross-sectional area of the porous substrate (10) at a distance h from the vaporization surface (102), in units of cm^2.

2. The vaporization core (100) according to claim 1, wherein Q_{bn} meets the following relational expression: $Q_{bn} = v_b(h) \times S(h) \times T_n \times \sigma$.

3. The vaporization core (100) according to claim 1, wherein Q_{xn} meets the following relational expression: $Q_{xn} = \frac{f(T_n)}{\rho}$, wherein ρ is a density of the e-liquid, in units of mg/mL.

4. The vaporization core (100) according to claim 1, wherein t_i meets the following relational expression:

$$t_i \leq \frac{Q_{cn} - Q_{xn} + Q_{bn}}{\upsilon_b(h)}$$

.

5. The vaporization core (100) according to claim 1, wherein Q_{c1} ranges from 0.004 cm^3 to 0.12 cm^3.

6. The vaporization core (100) according to claim 1, wherein σ ranges from 40% to 60%.

7. The vaporization core (100) according to claim 1, wherein $v_b(h)$ ranges from 0.01 cm/s to 0.2 cm/s.

8. The vaporization core (100) according to claim 1 or 4, wherein t_i is less than or equal to 0.6s.

9. The vaporization core (100) according to claim 1, wherein n is less than or equal to 15.

10. The vaporization core (100) according to claim 1, wherein T_i is less than or equal to 3s.

11. The vaporization core (100) according to claim 1, wherein the liquid absorbing surface (101) and the vaporization surface (102) are arranged opposite to each other, and wherein in a direction perpendicular to an extension direction from the liquid absorbing surface (101) to the vaporization surface (102), a maximum cross-sectional area of the liquid penetration portion (103) is smaller than a maximum cross-sectional area of the temporary liquid storage portion (104).

12. The vaporization core (100) according to claim 11, wherein in the direction perpendicular to extension direction from the liquid absorbing surface (101) to the vaporization surface (102), the porous substrate (10) has a cross-section: and wherein an area of the cross-section of the porous substrate (10) gradually increases in the extension direction from the liquid absorbing surface (101) to the vaporization surface (102), or the area of the cross-section of the porous substrate (10) first remains unchanged and then increases in the extension direction from the liquid absorbing surface (101) to the vaporization surface (102).

13. An electronic vaporization apparatus, comprising:

the vaporization core (100) according to any one of claims 1 to 12; and a battery connected to the vaporization core (100).

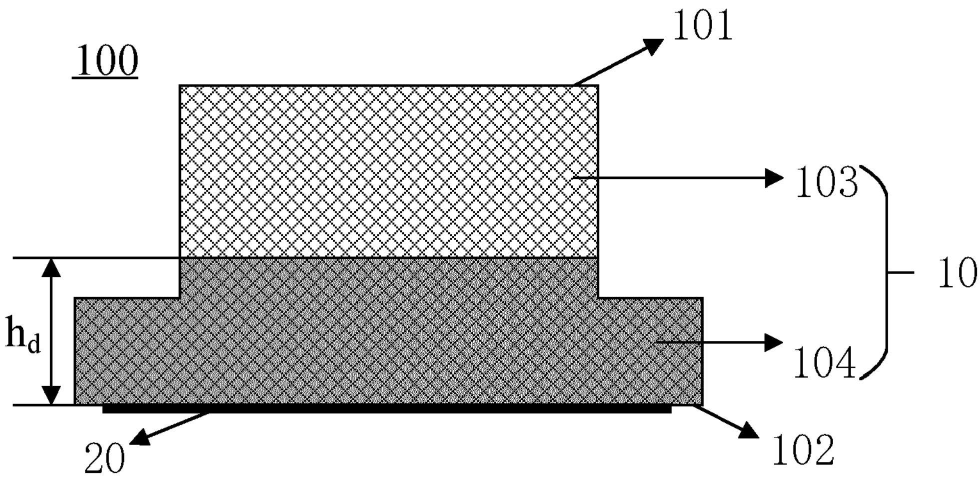

FIG. 1

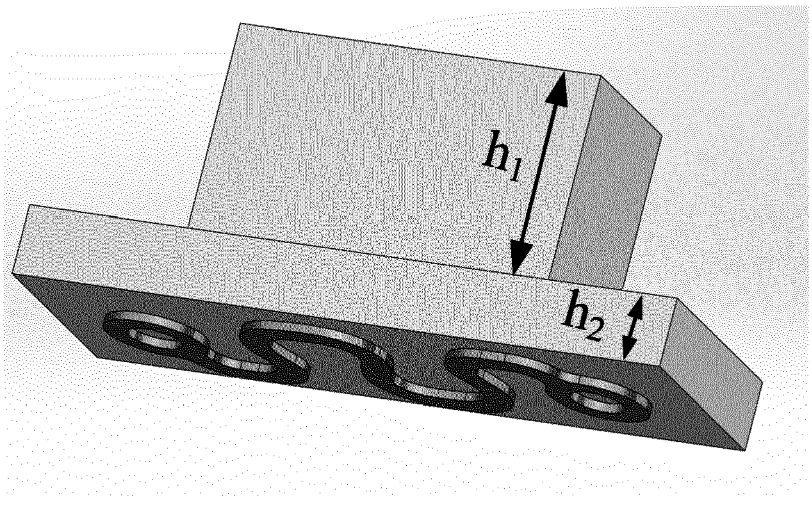

FIG. 2

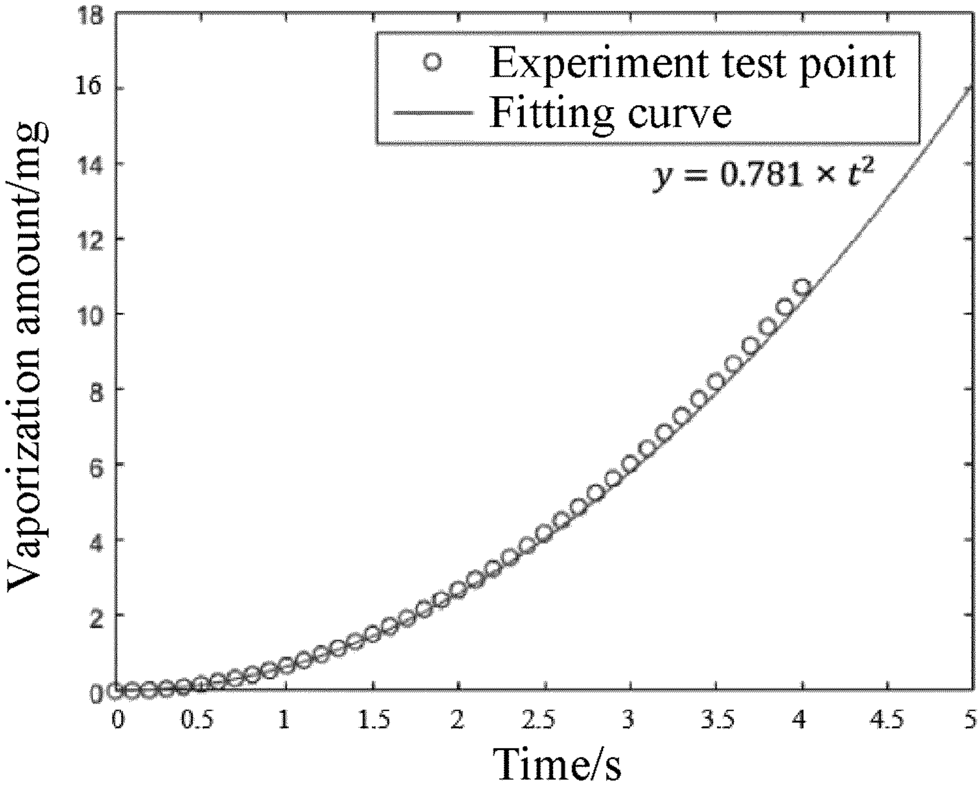
Experiment test point
Fitting curve
$y = 0.781 \times t^2$
Vaporization amount/mg
Time/s
0
2
4
6
8
10
12
14
16
18
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

FIG. 3

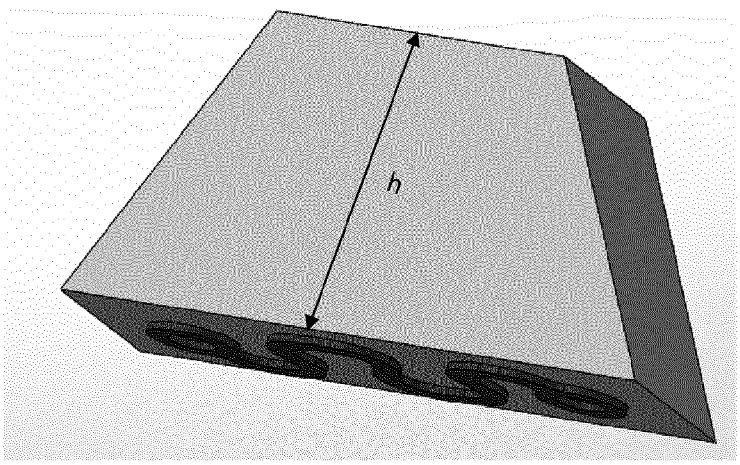
h

FIG. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 17 7377

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2022/042654 A1 (SHENZHEN SMOORE TECHNOLOGY LTD [CN]) 3 March 2022 (2022-03-03) * the whole document * -----	1-13	INV. A24F40/44
A	WO 2021/217292 A1 (SHENZHEN SMOORE TECHNOLOGY LTD [CN]) 4 November 2021 (2021-11-04) * the whole document * -----	1-13	
A	US 2022/125113 A1 (PENG XIAOFENG [CA] ET AL) 28 April 2022 (2022-04-28) * paragraphs [0035] - [0038] * * figures 1-3 * -----	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

A24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	11 October 2023	Cabrele, Silvio

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 17 7377

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-10-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2022042654 A1	03-03-2022	CN 112315027 A	05-02-2021
		EP 4205572 A1	05-07-2023
		JP 2023539321 A	13-09-2023
		US 2023276852 A1	07-09-2023
		WO 2022042654 A1	03-03-2022
WO 2021217292 A1	04-11-2021	EP 4136992 A1	22-02-2023
		US 2023057645 A1	23-02-2023
		WO 2021217292 A1	04-11-2021
US 2022125113 A1	28-04-2022	AU 2020328016 A1	31-03-2022
		BR 112022002608 A2	03-05-2022
		CA 3150799 A1	18-02-2021
		CN 112385898 A	23-02-2021
		CO 2022002643 A2	21-06-2022
		EP 4005421 A1	01-06-2022
		GB 2601968 A	15-06-2022
		IL 290587 A	01-04-2022
		JP 2022544957 A	24-10-2022
		KR 20220056857 A	06-05-2022
		US 2022125113 A1	28-04-2022
		WO 2021027338 A1	18-02-2021

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82