

CATALYTIC COMBUSTION BURNER MADE OF POROUS MATERIAL
WITH OPTIMIZED OPERATING PERFORMANCE AND BOTTLE EQUIPPED
WITH SUCH A BURNER

5 The present invention relates generally to the field
of catalytic combustion, and more precisely to that of
catalytic combustion burners made of porous material.
These burners are used in particular for diffusing
fragrance and/or active substances, for destroying
10 molecules which may or may not be odorous, and/or for
purifying the air.

Such a burner was described, for example, in patent
FR 2610390 in the name of the Applicant. It is especially
intended to receive a wick dipping in a combustible liquid
15 contained in a catalytic combustion bottle, which receives
the burner on its neck. Such a burner (represented
especially in figure 1) is made of a porous material, which
comprises an end piece having, in its upper part, a cavity
emerging to the exterior and, in its lower part, a cavity
20 in which the end of the wick is engaged. The end piece is
extended in its lower part by a sleeve. When functioning,
the combustible liquid conveyed by the wick penetrates the
pores of the porous material of the burner. Some of this
liquid crosses the central zone of the burner and undergoes
25 vaporization therein.

Moreover, the Applicant has developed an SiC-based
ceramic burner such as, for example, those described in
French patents FR2095163B1, FR2905164B1 and FR2905165B1
belonging to the Applicant, to equip catalytic lamps. This
30 type of burner meets numerous performance criteria in terms
of fragrancing, consumption, olfactory quality, emissions,
etc. However, it has the drawback of malfunctioning or
even of going out when it is subjected to strong air

currents such as air conditioning. Certain countries, in which air conditioning is extensively used, are thus confronted with recurring problems of burner extinction when the lamp is placed close to air conditioning, and
 5 therefore cannot use the burners mentioned previously.

In order to overcome the abovementioned drawbacks, the Applicant has developed a catalytic combustion burner made of porous material, comprising:

- an end piece comprising:
 - 10 • a lower part of outside diameter ϕ_1 and delimiting a first cavity of diameter ϕ_2 , this first cavity extending along a main axis and being adapted to receive a wick that is capable of soaking the end piece with a combustible composition, and
 - 15 • an upper part having a peripheral side wall comprising an inner face of essentially frustoconical shape and delimiting a second cavity of depth P, an outer face, an upper face of circular shape and a base, the inner face having
 - 20 a lower end of diameter ϕ_3 greater than ϕ_2 and an upper end of diameter ϕ_4 greater than ϕ_3 , the upper end of the side wall communicating with the atmosphere and the base communicating with the first cavity,
 - 25 • at least a part of said outer face of the peripheral side wall is doped with a catalyst,
 - a sleeve arranged in the extension of the lower part of the end piece and delimiting a third cavity extending the first cavity of the lower part, and
 - 30 - an insert arranged in the first cavity of the end piece and having a surface in contact with the base of the end piece,

the burner being characterized in that the porous material is obtained from a composition comprising, as a percentage of the total weight of this composition, between 0 and 5% of at least one heat-conducting compound, with a
5 thermal conductivity of greater than 60 watts per metre-kelvin, between 30% and 70% of at least one refractory compound, between 2% and 30% of at least one binder, and between 5% and 40% of at least one pore-forming agent, and
in that all of the circular-shaped upper face is also
10 doped with said catalyst.

The catalyst used in the context of the present invention may be, for example, a catalyst based on a metal belonging to groups 9 or 10 of the Periodic Table of the Elements (according to the terminology recommended by the
15 IUPAC).

The insert may be made of the same porous material as the burner. It may also be made of another porous material.

With such a composition, the porous material of the burner according to the invention has a porosity of between
20 57% and 63%, and preferably of about 59%, and interconnections of between 8 and 11 μm .

For the purposes of the present invention, the term "interconnections" means the median diameter of the porous interconnections.

25 Advantageously, at least a part of the inner face of the peripheral side wall may also be doped with said catalyst. This makes it possible to further improve the operating performance in the presence of an air conditioner or ventilation, as shown in the examples hereinbelow.

30 Advantageously, the depth P of the second cavity may be between 2 and 8 mm, preferably between 6 and 7.5 mm and better still about 7 mm.

Advantageously, the lower end of the inner face may be terminated with a counterbore of diameter ϕ_3 , communicating with the first cavity.

For the purposes of the present invention, the term
5 "counterbore" means cylindrical machining made around a piercing communicating with the first cavity of the lower part of the end piece.

By virtue of the presence of the counterbore and also of the nature and porosity of the porous material of which
10 the burner is made, the operating performance in the presence of air conditioning is further improved.

Advantageously, the outside diameter ϕ_1 of the lower part of the end piece may be between 14 and 17 mm, preferably between 15 and 16 mm and better still about
15 15.6 mm.

Advantageously, the porous material is obtained from a composition comprising, as a percentage of the total weight of said composition, between 0.5% and 2% of said heat-conducting compound, between 40% and 70% of said
20 refractory compound, between 5% and 25% of said binder, and between 8% and 35% of at least one pore-forming agent.

The composition of the porous material according to the invention especially comprises a heat-conducting compound and a refractory compound.

25 As heat-conducting compound that may be used in the porous material of the burner according to the invention, use may advantageously be made of silicon carbide, preferably present in a proportion of 1% by weight relative to the total weight of said composition. The percentage of
30 heat-conducting compound (between 0 and 5%, and preferably about 1%) is optimized so as to obtain ideal operating characteristics.

As refractory compound, use will preferably be made of a refractory compound with a thermal conductivity below the thermal conductivity of said heat conductor. Advantageously, said refractory compound may be chosen
5 from the group constituted by alumina, silica, mullite, zirconia and cordierite, and mixtures thereof. The refractory material is preferably mullite. The mullite may, for example, be replaced or mixed with alumina, silica, zirconia, cordierite, or a mixture thereof. Silica
10 is preferably introduced into the composition of the invention as a mixture with another refractory compound. In addition to its good mechanical behaviour at high temperature, the refractory compound plays a main role as insulator in the porous material obtained from the
15 composition according to the invention.

Besides the heat-conducting compound and the refractory compound, the composition of the porous material according to the invention comprises a binder and a pore-forming agent.

20 For the purposes of the present invention, the term "binder" means a mineral compound which allows sintering at a temperature of less than or equal to 1100°C.

The binder is advantageously a glass with a variable percentage of silica, more particularly an oxide-based
25 plain glass, for example including about 70% of silica and about 30% of calcium and sodium oxides, or a special glass including oxides of various elements such as boron or phosphate, for example a borosilicate glass.

The binder improves the formability, gives the raw
30 mechanical cohesion of a piece and makes it possible to obtain a porous and mechanically strong material. The binder is chosen in particular from low-temperature-sintering compounds, i.e. compounds that allow sintering

of the composition in which they are included at this temperature, of less than or equal to 1100°C. For example, during the temperature rise during sintering of the composition of the invention, the glass softens and wets
5 the particles of heat-conducting compound. A vitreous phase is thus obtained. Next, during the temperature fall, the particles are bonded together during the solidification of the vitreous phase.

As pore-forming agent that may be used in the porous
10 material of the burner according to the invention, any pore-forming compound (natural or synthetic) whose particle size is governed and controlled, especially during its manufacture and its storage, may advantageously be chosen. For example, polymethyl methacrylate (PMMA) may
15 advantageously be used as pore-forming agent. This agent may advantageously be present in a proportion of from 18% to 30% by weight relative to the total weight of said composition. The pore-forming agent allows the formation of pores during the sintering of the composition according
20 to the invention.

Thus, preferentially, the porous material may be made from a composition of the order of 1% of silicon carbide, between 60% and 70% of mullite, between 5% and 15% of glass, and about 18% to 30% of PMMA.

25 With such a composition, the porous material of the burner according to the invention has a porosity of about 60%, and interconnections of about 9.5 μm .

Advantageously, said sleeve of the burner may have a length of between 10 and 20 mm, and preferably about 14
30 mm. As illustrated in the examples, it is possible to achieve good performance qualities in terms of resistance to air conditioning with a burner according to the

invention having a sleeve length that may be as short as 12 mm.

A subject of the present invention is also a catalytic combustion bottle, which is suitable for containing a combustibile liquid and for receiving on its neck a catalytic combustion burner receiving a wick which is soaking in said liquid, characterized in that said bottle is equipped with a burner according to the invention as defined previously.

Other characteristics and advantages of the invention will emerge clearly from the detailed description that is made thereof hereinbelow, as a guide and with no limitation whatsoever, with reference to the attached drawings, in which:

- figure 1 represents schematically a cross section of a first example of a burner that may be used in the context of the present invention;
- figure 2 is a schematic front view of a bottle equipped with one of the combustion burners represented in figure 1, on the one hand, and in figures 5 and 6, on the other hand;
- figures 3 and 4 represent, respectively, a view in side perspective and a top view of an insert that may be used in the burner according to the invention;
- figure 5 represents schematically a cross section of a second example of a burner that may be used in the context of the present invention;
- figure 6 is a perspective view of the burner illustrated in figure 5;
- figures 7 to 18 are IR thermographs produced to show the impact of air conditioning on a burner according to the invention, on the one hand, and on a control

burner not having any catalyst on the circular zone 5c;

- figure 19 illustrates the protocol for measuring by infrared camera the impact of air conditioning on the temperature of the burner during functioning.

The technical characteristics common to these two figures are each designated by the same reference numeral in the figures concerned.

Figures 1, 5 and 6 show two examples of burners that may be used in the context of the present invention. These two examples of burner each comprise, on the one hand, an end piece 1 with a lower part 1a and an upper part 1b, and, on the other hand, a sleeve 7 arranged in the extension of the lower part 1a of the end piece 1.

As more particularly regards the end piece 1, it comprises:

- the lower part 1a of outside diameter ϕ_1 and delimiting a first cavity 2 of diameter ϕ_2 , this first cavity 2, which extends along a main axis 3, being adapted to receive a wick that is capable of soaking the end piece 1 with a combustible composition, and
- an upper part 1b having a peripheral side wall 5 comprising an inner face 5a of essentially frustoconical shape and delimiting a second cavity 6 of depth P, an outer face 5b of essentially cylindrical shape (but frustoconical at its base) and of diameter ϕ_5 , an upper face 5c and a base 5d communicating with the first cavity.

The inner face 5a has a lower end 61 of diameter ϕ_3 greater than ϕ_2 and an upper end 62 of diameter ϕ_4 greater than ϕ_3 , the upper end 62 of the side wall 5 communicating with the atmosphere and the lower end 61 being connected

to the base 5d. The first 2 and second 6 cavities communicate together.

As more particularly regards the sleeve (also known as the barrel) 7, it is arranged in the extension of the lower part 1a of the end piece 1. It delimits a third cavity 2' extending the first cavity 2 of the lower part 1a. This sleeve is constituted of the same porous material as the end piece.

Figures 5 and 6 schematically show, respectively, a schematic cross section and a view in perspective of a second burner example, which differs from the first burner example in that, in the second burner example, the lower end 61 of the inner face 5a terminates with a counterbore 18 of diameter ϕ_3 , communicating with the cavity 2. In the first burner example represented in figure 1 (without counterbore), the inner face 5a is entirely frustoconical between its two ends 61 and 62.

The two burner examples (represented in figures 1, 5 and 6) each comprise an insert 8 arranged in the second cavity 6 of the end piece 1 and having a surface 8a in contact with said base 5d of the end piece.

In addition, at least a part of their outer face 5b is doped with a catalyst, for example based on a metal belonging to groups 9 or 10 of the Periodic Table of the Elements (according to the terminology recommended by the IUPAC).

When the first burner example does not comprise any catalyst on its face 5c, it is used as control in the tests of behaviour with respect to air conditioning (designated hereinbelow by the reference 1C).

When the first burner example does not comprise any catalyst doping its face 5c, it is used as first burner example according to the invention in the tests of

behaviour with respect to air conditioning (designated hereinbelow by the reference 1).

The second burner example comprises a catalyst doping its face 5c, and is used as second burner example according to the invention in the tests of behaviour with respect to
5 air conditioning (designated hereinbelow by the reference 2).

In order to test the catalytic functioning in the presence of air conditioning of the burners represented in
10 figures 1, 5 and 6, these burners were placed in a catalytic combustion bottle 20, represented in figure 2.

Such a bottle 20 contains during functioning a combustible liquid 30. The burner 10 (either the burner according to the invention as represented in figure 5, or
15 the prior art burner represented in figure 1, each equipped with an insert as represented in figure 3) is installed in the neck 50 of the bottle (for example with the aid of a metallic seat placed in the neck 50). A wick 40 is received inside the cavities 2 and 2' of the burner 10, this
20 catalytic combustion wick 40 receiving a wick (40) which is soaking in the liquid 30. The bottle 20 may be a bottle of any shape having a neck 50 into which is fitted the burner 10. The combustible liquid 30 is usually an alcohol, for example isopropyl alcohol, or any other suitable
25 combustible liquid that is compatible with the legislation in force in this field. In particular, this combustible must be such that its vaporization and its catalytic combustion do not give off any unpleasant odour. The combustible liquid 30 may also comprise a fragranced
30 material and/or an active material. The wick 40 is any known wick, for example a wick made of cotton, or a wick made of mineral material, for example made of mineral fibres.

During functioning, the combustible liquid 30 in the bottle 20 rises in the wick 40 by capillary action and penetrates the pores of the porous material of the burner, which, when it has been preheated, ensures its catalytic
5 combustion.

The examples that follow illustrate the invention, in connection with the figures, without, however, limiting the scope thereof.

In these examples, unless otherwise indicated, all
10 the percentages and parts are expressed as mass percentages.

EXAMPLES

15 Compounds included in the composition of the porous materials used:

- heat-conducting compound: silicon carbide,
- refractory compound: mullite,
- binder: glass,
- 20 • pore-forming agent: polymethyl methacrylate (PMMA).

Compositions of the porous material:

The burners used in the examples are made by dry pressing
25 from compositions C1 and C2 below indicated in table 1. For each of these compositions, the porosity of the ceramic structure and the median diameter of the interconnections have been indicated in table 1.

30

Table 1

Composition	Mullite (%)	SiC (%)	Glass (%)	PMMA (%)	Porosity (%)	Interconnection diameter (µm)
c1	64	5	10	21	58% to 60% at 975°C	9
c2	66.5	1	11.5	21	60.2% at 1050°C	9.5
c3	67	0.5	11.5	21	58,9	-

Catalysts

The catalyst used (whether on parts 5a, 5b or 5c of the burner) is a metal belonging to groups 9 or 10 of the Periodic Table of the Elements.

Burners used:10 As comparative example:

Burner 1C (represented in figure 1), the outer face 5b of which is doped with a catalyst impregnating it, the burner 1C being constituted of a porous material obtained from composition C1.

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As examples according to the invention:

- o burner 1 (also represented in figure 1 and comprising the insert represented in figures 3 and 4) identical to burner 1C, except for its face 5c which is doped with the same catalyst as that of the outer face 5b, burner 1 also being constituted of a porous material obtained from composition C1.
- o burner 2 (represented in figures 5 and 6 and comprising the insert represented in figures 3 and 4), the outer face 5b and the upper face 5c of which are doped with the same catalyst which impregnates them, burner 2

being constituted of a porous material obtained from composition C2.

- o burner 3 (represented in figures 5 and 6 and comprising the insert represented in figures 3 and 4), the outer face 5b and the upper face 5c of which are doped with the same catalyst which impregnates them, burner 3 being constituted of a porous material obtained from composition C3.

During functioning, when the burner is equipped with a catalyst in its circular peripheral part 5c, the part of the combustible liquid which reaches this part 5c undergoes catalytic combustion thereat, which keeps this part at a high temperature.

Bottle used: the one shown in figure 2 for burners 1C, 1 and 2.

Wick used: cotton wick (for burner 3, two different wicks were tested).

Combustible liquid used: isopropyl alcohol.

Tests and measurements

1) Porosity (%) and Diameter D of the interconnections

The open porosity of the porous material constituting the burner is measured by mercury intrusion into the material of a Micromeritics Autopore IV 9510 brand porosimeter. This measurement is taken at a maximum pressure of 414 MPa approximately, which corresponds to a minimum detectable pore size of about 0.0035 μm .

Method and operating protocol:

The measurement of the porosity by mercury intrusion is based on the principle of penetration of an unreactive liquid into a porous material, by immersing said material in the liquid and increasing the pressure isostatically. Mercury, which does not react with the majority of materials, is furthermore an ideal liquid due to the high value of its contact angle, it does not wet the majority of materials.

From this measurement, the pore size is determined in terms of the diameter D in μm (interconnection diameter), then penetrated, which is inversely proportional to the applied pressure, P , according to the Washburn equation:

15

$$D = \frac{-4\gamma \cos\theta}{P}$$

with: γ : surface tension of mercury,
 $\gamma = 0.00485 \text{ N/cm}$ (485 dynes/cm).
 θ : contact angle of mercury, $\theta = 140^\circ$

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2) Operating characteristics of the burners installed on the bottle in the presence of an air conditioner at 18°C with ventilation

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The test protocol is represented in figure 19. It consists globally in measuring, by infrared (IR) thermograph using an IR thermal camera, the temperature on each of the burners tested, placed at a reasonable distance from an air conditioner (the power of which is 800 W in the context of the tests performed). These measurements are compared, for each burner tested (control 1C and

30

according to the invention 1 and 2), with measurements taken without ventilation.

The thermographs produced are detailed below:

- Burner 1C:

- 5 • without air conditioning: figures 7 and 8;
- with air conditioning: figure 9 (measurement taken on the side opposite the air conditioning) and figure 10 (measurement taken on the side facing the air conditioning);

- Burner 1:

- without air conditioning: figures 11 and 12;
- 15 • with air conditioning: figure 13 (measurement taken on the side opposite the air conditioning) and figure 14 (measurement taken on the side facing the air conditioning);

- Burner 2:

- without air conditioning: figures 15 and 16;
- 20 • with air conditioning: figure 17 (measurement taken on the side opposite the air conditioning) and figure 18 (measurement taken on the side facing the air conditioning).

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When the measurement is taken on the side of the burner that is opposite the flow of air coming from the air conditioner, said air flow has little impact on the temperature measured on this side of the burner, as shown
 30 by comparison of figures 7 and 9 (burner 1C), figures 11 and 13 (burner 1 according to the invention), and figures 15 and 17 (burner 1 according to the invention). This temperature decreases very little for burners 1 and 2

according to the invention, and slightly more for the control burner 1.

This is not likewise the case when the measurement is taken on the side of the burner facing the air conditioner:
 5 burners 1 and 2 according to the invention show better resistance than the control burner 1C, as shown by comparison of figures 7 and 10 (drastic drop for the control burner), that of figures 11 and 14, and finally that of figures 15 and 18. It is considered that when the
 10 temperature measured at a given place on the catalyst is below 300°C, said catalyst has a high likelihood of extinguishing rapidly.

The temperatures measured are collated in Table 2 below:

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Table 2

	Temperature measurement without air conditioning			Temperature measurement with air conditioner	
	Side	Top		Side opposite the air conditioner	Side facing the air conditioner
	Face 5b	Face 5c	Centre		
Burner 1C	535°C	460°C	283°C	413°C	157°C
Burner 1	559°C	521°C	313°C	443°C	327°C
Burner 2	553°C	537°C	339°C	486°C	379°C
Burner 3 (test wick 1)	546°C	559°C	347°C	483°C	404°C
Burner 3 (test wick 2)	556°C	532°C	336°C	523°C	411°C

These tests show that the presence of a catalyst on the circular zone 5c of the burner makes it possible to maintain the temperature of the burner when it is subjected to a strong air current such as, for example, that emitted
5 by a portable air conditioner, both for an SiC content of 1% and for an SiC content of 0.5%. This catalyst allows thermal conduction of the heat to the burner zone, which, when subjected to an air current, does not ultimately become unprimed.

CLAIMS

1. Catalytic combustion burner (10) made of porous material, comprising:
- 5 - an end piece (1) comprising:
- a lower part (1a) of outside diameter ϕ_1 and delimiting a first cavity (2) of diameter ϕ_2 , said first cavity (2) extending along a main axis (3) and being adapted to receive a wick that is capable of soaking the end piece (1) with a combustible composition, and
 - 10 • an upper part (1b) having a peripheral side wall (5) comprising an inner face (5a) of essentially frustoconical shape and delimiting a second cavity (6) of depth P, an outer face (5b), an upper face (5c) of circular shape and a base (5d), said inner face (5a) having a lower end (61) of diameter ϕ_3 greater than ϕ_2 and an upper end (62) of diameter ϕ_4 greater than ϕ_3 , the upper end (62) of said side wall (5) communicating with the atmosphere and said lower end (61) of said base (5d) communicating with said first cavity (2),
 - 15 • at least a part of said outer face (5b) of said peripheral side wall (5) is doped with a catalyst,
- 20 - a sleeve (7) arranged in the extension of said lower part (1a) of the end piece (1) and delimiting a third cavity (2') extending said first cavity (2) of said lower part (1a), and
- 25 - an insert (8) arranged in said second cavity (2) of the end piece (1) and having a surface (8a) in contact with said base (5d) of the end piece,
- 30 said burner being characterized in that said porous material is obtained from a composition comprising, as a

percentage of the total weight of said composition, between 0 and 5% of at least one heat-conducting compound, with a thermal conductivity of greater than 60 watts per metre-kelvin, between 30% and 70% of at least one refractory compound, between 2% and 30% of at least one binder, and between 5% and 40% of at least one pore-forming agent, and in that all of said circular-shaped upper face (5c) is doped with said catalyst.

10 2. Burner (10) according to Claim 1, in which at least a part of said inner face (5a) of said peripheral side wall (5) is doped with said catalyst.

 3. Burner (10) according to Claims 1 or 2, in which the lower end (61) of said inner face (5a) terminates with a counterbore (18) of diameter $\phi 3$, communicating with said cavity (2).

 4. Burner (10) according to any one of the preceding claims, in which the depth P of said second cavity (6) is between 2 and 8 mm, preferably between 6 and 7.5 mm and better still about 7 mm.

 5. Burner (10) according to any one of Claims 1 to 4, according to which said porous material is obtained from a composition comprising, as a percentage of the total weight of said composition, between 0.5% and 2% of said heat-conducting compound, between 40% and 70% of said refractory compound, between 5% and 25% of said binder, and between 8% and 35% of at least one pore-forming agent.

 6. Burner (10) according to any one of Claims 1 to 5, in which the heat-conducting compound is silicon carbide,

preferably present in a proportion of 1% by weight relative to the total weight of said composition.

7. Burner (10) according to any one of Claims 1 to 6,
5 in which each said refractory compound is chosen from the group constituted of alumina, silica, mullite, zirconia and cordierite, and mixtures thereof, and preferably mullite.

10 8. Burner (10) according to any one of Claims 1 to 7, in which said binder is a mineral compound which allows sintering at a temperature of less than or equal to 1100°C, preferably a glass, and better still a borosilicate glass.

15 9. Burner (10) according to any one of Claims 1 to 8, in which the pore-forming agent is polymethyl methacrylate (PMMA), which is preferably present in a proportion of from 18% to 30% by weight relative to the total weight of said composition.

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10. Burner (10) according to any one of Claims 6 to 9, according to which said porous material is obtained from a composition comprising, as a percentage of the total weight of said composition, about 1% of silicon carbide,
25 between 60% and 70% of mullite, between 5% and 15% of glass, and between 18% and 30% of PMMA.

11. Burner (10) according to Claim 10, in which said sleeve (7) has a length of between 10 and 20 mm, and
30 preferably about 14 mm.

12. Catalytic combustion bottle (20), which is suitable for containing a combustible liquid (30) and for

receiving on its neck (50) a catalytic combustion burner
(10) receiving a wick (40) which is soaking in said liquid
(30), characterized in that said bottle (20) is equipped
with a burner (10) as defined according to any one of
5 Claims 1 to 11.