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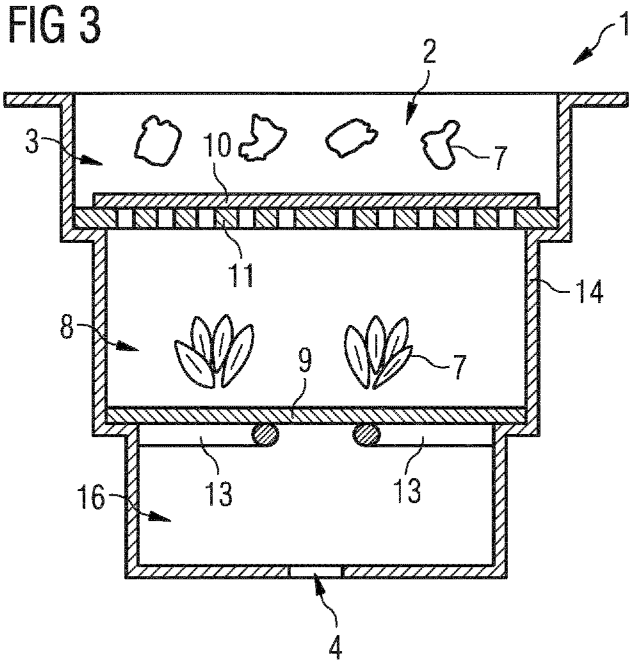
(54) Title: HIGH PRESSURE EXTRACTION CAPSULE

FIG 3



(57) Abstract: A high pressure extraction capsule (1) for single beverage preparation has a porous hydrophobic membrane (5, 10) that acts as a barrier to fluid flow up to a certain pressure and exceeding said pressure allows for extracting the fluid with active ingredients but still acts as a barrier to particles, particularly ground herbs or roots, wherein the pore size of the membrane (5, 10) is bigger than 0.45pm and wherein the hydrophobic membrane (5, 10) is arranged to have a surface tension of less than 40 dynes/cm. Preferably the hydrophobic membrane (5, 10) is arranged to have a surface tension of less than 40 dynes/cm, preferably approx. 30 dynes/cm and to have a pore size in the range from 0.45µm to 10µm, preferably from 0.45µm to 5µm. The capsule (1) comprises an inlet port (2), a compartment (3) for holding a substance with active ingredients like, e.g. ground herbs or roots, an outlet port (4) and a hydrophobic membrane (5, 10) that separates the compartment (3) from the outlet port (4). The hydrophobic membrane (5, 10) can be supported by a non-woven or by support means of the capsule (1). According to another embodiment of the invention the capsule (1) comprises a first compartment (3) and a second compartment (8), wherein the inlet port (2) opens into the first compartment (3) and the second compartment (8) opens out into the outlet port (4), wherein a first membrane (9) separates the second compartment (8) from the outlet port (4), wherein the first compartment (3) is separated from the second compartment (8) by means of a second membrane (10), and wherein the second membrane (10) has a higher water resistance pressure than the first membrane.

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High pressure extraction capsule

Field of the invention

The present invention relates generally to preparing ready-to-drink beverages that have the potential of treating or preventing diseases or enhancing the health of a human. In certain embodiments, the invention discloses a multi-compartment capsule that is capable of extracting active ingredients using high pressure in one compartment and mix that extract with the ingredients of the downstream compartment and extract the downstream ingredients at same or lower pressures in order to provide a freshly mixed extract for consumer use.

Background of the Invention

Herbs have been used in tea bag formats for decades now with claims to improve well-being of consumers. Many customers would select herbs over drugs since they are natural ingredients that usually have no side effects. However, the making of a drink from herbs requires tea bags and some time for preparation of the drink. The herbs in the tea bags are usually dried and preprocessed, which reduces the potential of enhancing the health of the consumer. Furthermore if the tea bag is stored for some time before preparing the drink the taste and health enhancing quality of the herbs degrade as well.

During the past few years there has been a significant increase in devices, methods and capsules used to prepare ready-to-drink beverages. Companies like Nestle and Kourig already have household products in the market that serve consumers hot or cold tea and/or coffee.

Most of the capsules used for ready-to-drink beverages contain a coffee filter or a coarse nonwoven material to retain the ground particles. Membranes have also been incorporated into capsules for various reasons.

For example in WO 2010112353 A1 that focuses on a capsule with filter for preparing a liquid nutritional or food composition, usage of a weak membrane layer is described that will rupture at a given pressure.

In WO 2009092629 A1 a sterilizing grade membrane having a 0.2µm rated pore size and made of polyethersulphone, cellulose acetate or polyamide is used to retain the possible bacteria that are present in the beverage. They also mention that it may be problematic to filter some infant formulas since they contain probiotics; i.e. good bacteria that helps digestion.

The document WO 2008117329 A1 describes a capsule with a perfectly flat top, containing a filter paper at the entrance of the capsule in order to create a homogeneous flow path into the capsule.

However, WO 2010128031 A1 teaches away from such a concept since such a large filter surface at the entrance of the capsule requires a thick and rigid plastic support underneath and those additional parts increases the price of the capsule. Also mentioned is the environmental impact of these additional plastic parts. It is claimed that the filter surface should be much less than the mouth of the capsule to minimize the plastic usage as support. Furthermore the idea of cleaning the incoming water has been introduced in order to increase the quality of the water by filtering it from microorganisms and viruses.

However, in order to prepare the drink from a capsule a liquid, e.g. water, must be injected into the capsule and then remain in the capsule as long as required to extract the active ingredients from the ground herbs and roots. Afterwards, the solution comprising the liquid and the active ingredients must be ejected from the capsule. Usually this requires a device that is capable of holding the capsule and providing the required liquid streams into the capsule and out of the capsule after uptake of the active ingredients. In order to ensure proper preparation of the herb containing beverage the amount and pressure of the liquid must be within predetermined ranges of parameters.

This invention may provide a capsule that allows for easy preparation of beverages with active ingredients from herbs and roots.

Summary of the invention

The present invention provides a novel membrane based capsule design that includes a valve system for ready to drink beverages.

For this, the invention relates to a high pressure extraction capsule for single beverage preparation with a porous hydrophobic membrane that acts as a barrier to fluid flow up to a certain pressure and exceeding said pressure allows for extracting the fluid with active ingredients but still acts as a barrier to particles, particularly ground herbs or roots, wherein the pore size of the membrane is bigger than 0.45µm and wherein the hydrophobic membrane is arranged to have a surface tension of less than 40 dynes/cm, i.e. less than 40 mN/m.

Water intrusion pressure for a membrane is a function of its surface tension and it pore size. Increasing amounts of superhydrophobic chemistry and decreasing the pore size will increase the water intrusion pressure. Therefore, by arranging the membrane to have superhydrophobic characteristics that equals a surface tension of less than 40 dynes/cm will provide for a valve effect that facilitates usage of such membrane in a capsule.

The benefit of such a membrane is four fold. First, the membrane provides for filtration of the ground herbs and roots, which is already known from prior art. Secondly, the membrane provides for retention of bacteria that can potentially be introduced into the drink via the herbs or roots or by the liquid that is used for fabrication of the beverage. Thirdly, the membrane provides resistance to the liquid flow, i.e. water flow, and allows for building up a predetermined pressure to facilitate high pressure extraction of active ingredients of the ground herbs and roots. According to the invention a suitable membrane can be capable of withstanding high pressures, e.g. like more than 100 psi, i.e. more than approx. 690 kPa or 6.9 bar. By adapting the hydrophobic characteristics and the pore size the water resistance pressure can be predetermined to a given value in the range between e.g. 15 psi and more than 100 psi, preferably between 50 psi and 75 psi (i.e. between approx. 130 kPa / 1.3 bar and more than 690 kPa / 6.9 bar, preferably between approx. 345 kPa / 3.5 bar and 517 kPa / 5.2 bar). The membrane then acts like a valve and prevents water from crossing the membrane if the pressure is less than the predetermined water resistance pressure. The water that has been injected into the capsule will remain within the capsule and extract the active ingredients from the ground herbs and roots, resulting in a solution of active ingredients in water. However, if the pressure that is applied to the water upstream of the membrane is increased and exceeds the pressure value of the predetermined water resistance pressure, the membrane becomes permeable for the solution and allows for discharging the solution from the capsule. Fourthly, the hydrophobic membrane enables a user friendly and clean capsule disposal step upon beverage preparation for the end user, i.e. non-drip capsule. When beverage preparation is complete and the water pressure is released, depending on the material and surface tension of the membrane, the membrane becomes hydrophobic again i.e. the membrane valve closes. This property of the membrane enables the upstream accumulated liquid, if any, to be retained in the compartment, preventing a spill during the disposal of the used capsule.

This novel capsule design eliminates the effects of packing density of the ground herbs on extraction pressure build up. Resistance to flow is created by the hydrophobic membrane. Therefore, there is no need for a dense porous structure created by the compacted microparticles of the ground herbs and roots in order to retard the fluid within the capsule for increased uptake of active ingredients.

High permeability is another important characteristic of the membranes used in a ready to drink beverage. A membrane with high permeability only requires coverage of a small area in a capsule and therefore results in low manufacturing cost. There is, however, a trade-off between permeability and water intrusion pressure (pore size) for a hydrophobic filtration membrane. Greater intrusion pressures can be achieved by sacrificing permeability. Therefore the preferred way of increasing water intrusion pressure is manipulating the surface energy i.e. the surface tension of the membrane.

Preferably the hydrophobic membrane is arranged to have a surface tension of less than 35 dynes/cm, more preferably approx. 30 dynes/cm. Such a superhydrophobic membrane can have a large pore size but still act as a valve, i.e. at the same time have a large water resistance pressure. As soon as the water pressure exceeds the predetermined water resistance pressure, the membrane opens and has a high permeability, resulting in a large flow of solution through the membrane and correspondingly short discharge times for emptying the compartment.

For some applications it might be desirable to provide for even more water resistance pressure. The hydrophobic membrane can be arranged to have a surface tension of less than 25 dynes/cm or even less than 20 dynes/cm.

According to an embodiment of the invention the pore size of the hydrophobic membrane ranges from 0.45µm to 10µm, preferably from 0.45µm to 5µm. Pore sizes below 0.45µm reduce the permeability and result in undesired long discharge times. However, pore sizes above 5µm or 10µm will no longer effectively filter the most common bacteria that should not remain in or be added into the beverage.

A particular capsule according to the invention comprises an inlet port, a compartment for holding a substance with active ingredients like, e.g. ground herbs or roots, an outlet port and a hydrophobic membrane that separates the compartment from the outlet port. The characteristics of the hydrophobic membrane control the required pressure and the retention period of the liquid within the compartment and therefore the maximum uptake duration for transferring the active ingredients of the ground herbs into the solution.

In order to support the hydrophobic membrane a nonwoven backing can be used. Particularly for membranes with a high water resistance pressure it is advantageous to combine the membrane with a supporting nonwoven that adds to the strength of the membrane.

According to a preferred embodiment of the invention the hydrophobic membrane is supported by a support means of the capsule. Said support means may comprise a web-like support structure or radially inward extending protrusions mounted at side walls of the compartment that extend over the area that is covered by the hydrophobic membrane. Such support means can possess sufficient resisting power to hold the membrane in place and to prevent any damage to the membrane that might be incurred by excess pressure or a high liquid throughput.

In order to enable new possibilities for easy preparation of beverages that contain different ingredients the capsule comprises a first compartment and a second compartment, wherein the inlet port opens into the first compartment and the second compartment opens out into the outlet port, wherein a first membrane separates the second compartment from the outlet port, wherein the first compartment is separated from the second compartment by means of a second membrane, and wherein, preferably but not necessarily, the second membrane has a higher water resistance pressure than the first membrane. A first ingredient that requires high pressure for extracting the active ingredients into solution can be placed in the first compartment and a second ingredient with active ingredients that are best dissolved at lower pressure is placed in the second compartment. Depending on the location of the membrane having higher water resistance pressure, e.g. first or second compartment, the position of the ingredients can also be swapped.

For preparation of the beverage a fluid like, e.g. water, is filled into the capsule. At low pressure the water cannot penetrate the second high pressure membrane and remains in the first compartment. The water extracts the active ingredients that are positioned in the first compartment until the pressure is raised above the predetermined water resistance pressure of the second membrane, e.g. 5 bar. After that the second membrane becomes permeable and allows for the water with the dissolved or extracted active ingredients from the first compartment to flow through the second membrane into the second compartment.

In the second compartment there are substances with active ingredients that efficiently dissolve at a lower pressure, e.g. 0.1 bar. The first membrane that is positioned between the second compartment and the outlet port has a water resistance pressure of e.g. 0.1 bar that is much lower than the water resistance pressure of the second membrane. The solution that permeated from the first compartment only stays for a short duration of time in the second compartment for uptake of the active ingredients in this compartment. The solution that now contains two different active ingredients will then be ejected through the first membrane. The first membrane may be hydrophilic, as it is not necessary for the first membrane to withstand a high pressure of the solution that comes from the first compartment. The pore size of the first membrane can be tailored in order to allow for efficient filtration of the solution before leaving the capsule.

If the beverage shall comprise more than two different active ingredients, the capsule may consist of three or more compartments that are separated from each other by means of membranes.

In a further embodiment of the capsule a flow distributing member is arranged between two adjacent compartments. The flow distributing member enhances turbulences of the water flow through the compartments and supports dissolution of the active ingredients as well as better mixing of the solution within the compartments.

The flow distributing member can be a membrane. The pore size and structure of the membrane can be arranged to enhance flow distributing effects of the membrane.

Additional features and advantages of the invention will be set forth in the detailed description and claims, which follow. Many modifications and variations of this invention can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. It is to be understood that the foregoing general description and the following detailed description, the claims, as well as the appended drawings are exemplary and explanatory only, and are intended to provide an explanation of various embodiments of the present teachings. The specific embodiments described herein are offered by way of example only and are not meant to be limiting in any way.

Brief description of the drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate the presently contemplated embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Figure 1 schematically depicts a cross sectional view of capsule with one compartment, wherein an outlet port is covered by a first porous hydrophobic membrane,

Figure 2 shows a schematic graph representation of the resulting water resistance pressure as a function of the amount of additional crosslinker used for modification of the membrane surface,

Figure 3 schematically depicts a cross sectional view of a capsule with two compartments separated by a second porous hydrophobic membrane,

Figure 4 depicts a partial sectional view of the capsule that is shown in figure 3,

Figure 5 depicts a partial sectional view of the capsule from a different point of view,

Figure 6 depicts an exploded view of the capsule that is shown in figures 3 to 5, and

Figure 7 depicts the capsule with a closing lid.

Description of the embodiments

All publications, patents and patent applications cited herein, whether supra or infra, are hereby incorporated by reference in their entirety to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated by reference.

Before describing the present invention in further detail, a number of terms will be defined. Use of these terms does not limit the scope of the invention but only serve to facilitate the description of the invention.

As used herein, the singular forms “a”, “an”, and “the” include plural referents unless the context clearly dictates otherwise.

For the purposes of this specification and appended claims, all numeric values expressing quantities of ingredients, percentages or proportions of materials, reaction conditions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about”, whether or not the term “about” is expressly indicated.

Accordingly, unless indicated to the contrary, the numerical parameters set forth in the description and in the following specification and attached claims are approximations. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Moreover, all ranges disclosed herein are to be understood to encompass all subranges subsumed therein. For example, a range of “1 to 10” includes any and all subranges between (and including) the minimum value of 1 and the maximum value of 10, that is, any and all subranges having a minimum value of equal to or greater than 1 and a maximum value of equal to or less than 10, e.g., 5.5 to 10.

The terms “optional” or “optionally” mean that the subsequently described event or circumstance may or may not occur, and that the description includes instances where the event occurs and instances where it does not.

The terms “filter medium”, “filter media”, “filtration media”, or “filtration medium” refer to a material, or collection of material, through which a fluid carrying active ingredients for a ready to drink beverage and/or a microorganism contaminant passes, wherein microorganism is deposited in or on the material or collection of material.

The terms “flux” and “flow rate” are used interchangeably to refer to the rate at which a volume of fluid passes through a filtration medium of a given area.

The term “capsule” refers to any container that is capable of holding solids that can be exposed to a fluid flow. Usually a capsule comprises a compartment with an inlet port and an outlet port. According to the present invention a membrane is arranged to act as a barrier between a section within the compartment that holds the substances with active ingredients and the outlet port.

The membranes are prepared from a broad range of polymers and polymer compounds, including thermoplastic and thermosetting polymers. Suitable polymers include, but are not limited to, nylon, polyimide, aliphatic polyamide, aromatic polyamide, polysulfone, cellulose, cellulose acetate, polyether sulfone, polyurethane, poly(urea urethane), polybenzimidazole (PBI), polyetherimide, polyacrylonitrile (PAN), poly(ethylene terephthalate), polypropylene, polyaniline, poly(ethylene oxide), poly(ethylene naphthalate), poly(butylene terephthalate), styrene butadiene rubber, polystyrene, poly(vinyl chloride), poly(vinyl alcohol), poly(vinylidene fluoride), poly(vinyl butylene), polymethylmethacrylate (PMMA), copolymers, derivative compounds and blends and/or combinations thereof.

Non-limiting examples of single or multilayered porous substrates or support means include porous film membranes. Porous film membranes are produced from a variety of thermoplastic polymers, including polyamides, polysulfones, polyvinylidene fluoride, polytetrafluoroethylene, cellulose, cellulose esters, polyacrylonitrile, etc. Methods of producing porous film membranes include solution phase inversion, temperature-induced phase separation (TIPS), vapor-induced phase separation (VIPS), solvent and chemical etching, room temperature and heat-assisted biaxial stretching, and combinations thereof.

Figure 1 schematically depicts one embodiment of the present invention wherein a capsule 1 comprises an inlet port 2 into a compartment 3 within the capsule and an outlet port 4. A high pressure membrane 5 is attached to a bottom 6 of the compartment 3 and covers the outlet port 4, thereby separating the compartment 3 from the outlet port 4. Within the compartment 3 there are ingredients 7 like, e.g. ground herbs and roots.

A fluid, e.g. water, can be injected through the inlet port 2 into the compartment 3. If the fluid is injected with a pressure that is below a predetermined fluid or water resistance pressure of the membrane 5, the fluid cannot exit the compartment 3 and remains within the compartment 3. During this time, the fluid dissolves the solvable active ingredients of the ingredients 7 like e.g. ground herbs and roots and becomes a solution that contains the already solved active ingredients.

If the pressure is increased above the predetermined water resistance pressure of the membrane 5, the membrane 5 becomes permeable and the solution is ejected from the compartment 3 through the membrane 5 and the outlet port 4.

Figure 2 shows the resulting water resistance pressure of a polyethersulfone membrane 5 after surface modification with a 4% hydrophobic Zonyl monomer as a function of the amount of crosslinker used, e.g. hexanedioldiacrylate.

Figure 2 displays that by surface modification the water intrusion pressure of a cast polyethersulfone (PES) membrane can be easily varied from 15 psi to 75 psi, without changing its pore size rating.

The resulting water resistance pressure was determined according to the pressure gauge reading in an apparatus were water is delivered from a pressurized tank into a 47mm stainless steel membrane holder. Pressurized water is applied upstream of the membrane and downstream side is monitored for any water flow. The pressure at which water starts to flow downstream of the membrane is recorded as the water intrusion pressure.

Flux is the rate at which fluid passes through the sample of a given area and was measured by passing deionized water through filter medium samples having a diameter of 47mm ($9.6cm^2$ filtration area). The water was forced through the samples using about 25 in Hg vacuum on the filtrate end via a side arm flask.

Bubble point test provides a convenient way to measure effective pore size. Bubble point is calculated from the following equation:

$$P = \frac{2\gamma}{r}\cos\theta,$$

where P is the bubble point pressure, γ is the surface tension of the probe fluid, r is the pore radius, and θ is the liquid-solid contact angle.

Membrane manufacturers usually assign nominal pore size ratings to commercial membrane filters, which are based on their retention characteristics.

Surface tension is used interchangeably with critical wetting surface tension (CWST) of a porous membrane. CWST is equal to the surface tension of the highest surface tension solution which wet the porous membrane in 2 seconds or less. The test is conducted as follows: One drop from an eye drop type bottle is added to the porous membrane surface and the time to wet, or penetrate the porous surface, is measured. The surface is arbitrary deemed to be wet by the test solution if the penetration of the surface is 2 seconds or less. CWST test solutions are prepared by mixing water and isopropylalcohol in various ratios to achieve surface tensions of 21 - 72 dynes/cm, and by mixing water and sodium chloride in various ratios to achieve surface tensions of 73 - 100 dynes/cm.

In figures 3 to 7 there is shown a capsule 1 with a first compartment 3, a second compartment 8 and a third compartment 16, wherein the inlet port 2 opens into the first compartment 3, the second compartment 8 is between the first compartment 3 and the third compartment 16, and the third compartment 16 opens out into the outlet port 4. A first membrane 9 separates the second compartment 8 from the third compartment 16 and the outlet port 4. The first compartment 3 is separated from the second compartment 8 by means of a second membrane 10. Both compartments 3 and 8 contain ingredients 7 with solvable active ingredients that will be solved by the fluid that streams through the compartments 3 and 8. For some applications it might be advantageous to insert additional ingredients 7 also into the third compartment 16.

The second membrane 10 has a higher water resistance pressure than the first membrane 9. According to the embodiment shown in figures 3 and 4, the second membrane 10 has a water resistance pressure of 5 bar, whereas the first membrane 9 has a water resistance pressure of 0.1 bar. Therefore, the first compartment 3 contains ingredients 7 with active ingredients that require long exposure time or high fluid pressure for effective dissolution. In the second compartment 8 there are ingredients 7 with active ingredients that easily dissolve at low pressure or short exposure times. By way of example, the first compartment 3 may contain ground herbs and roots with active ingredients that are difficult to dissolve, and the second compartment 8 may contain other ground herbs or roots that are easily dissolved. According to another example the first compartment 3 may contain ground coffee, whereas the second compartment 8 contains milk powder. According to yet another example the first compartment 3, the second compartment 8 and the third compartment 16 may contain three different ingredients for a dietary supplement drink.

The second membrane 10 is supported by a support disc 11 with many openings 12 that result in a web-like configuration of the support disc 11. As shown in figure 4, the first membrane 9 may be supported by radially inward extending protrusions 13 that are arranged in order to provide for a flat mounting support for the membrane 9.

It is also possible to support the first membrane 9 by a support disc 11’ that is similar to the support disc 11 for the second membrane 10. The capsule 1 with support discs 11 and 11’ are shown in figures 5 to 7.

For manufacturing the capsule 1 a housing 14 as well as the first membrane 9 and the second membrane 10 are prefabricated. The water resistance pressure of the first membrane 9 differs from the water resistance pressure of the second membrane 10 in a manner that the water resistance pressure of the second membrane 10 is significantly higher than the water resistance pressure of the first membrane 9.

The first membrane 9 is introduced into the housing 14 and mounted above the radially projecting protrusions 13. Afterwards, the also prefabricated support disc 11 is mounted in the housing 14 of the capsule 1 at a distance to the first membrane 9. The second membrane 10 is mounted on top of the support disc 11. The second membrane 10 is at a distance to the first membrane 9 as well as at a distance to the inlet port 3 of the capsule 1. The first membrane 9 then separates the housing 14 of the capsule 1 into the third compartment 16 and the remaining first and second compartment 3 and 8, whereas the second membrane 10 separates the housing 14 of the capsule 1 into the first compartment 3 and the second compartment 8. Of course instead of the radially projecting protrusions 13 an additional support disc can be placed above the outlet port 4, if the first membrane 9 requires such a support.

The capsule 1 can be sealed with a closing lid 15 that is only shown in figure 7. The closing lid 15 may be either rigid or flexible and can be made of any suitable material.

The disclosure set forth above may encompass multiple distinct inventions with independent utility. Although each of these inventions has been disclosed in its preferred form(s), the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense, because numerous variations are possible. The subject matter of the inventions includes all novel and nonobvious combinations and subcombinations of the various

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elements, features, functions, and/or properties disclosed herein. The following claims particularly point out certain combinations and subcombinations regarded as novel and nonobvious. Inventions embodied in other combinations and subcombinations of features, functions, elements, and/or properties may be claimed in applications claiming priority from this or a related application. Such claims, whether directed to a different invention or to the same invention, and whether broader, narrower, equal, or different in scope to the original claims, also are regarded as included within the subject matter of the inventions of the present disclosure.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Patent claims

1. High pressure extraction capsule for single beverage preparation with a porous hydrophobic membrane that acts as a barrier to fluid flow up to a certain pressure and exceeding said pressure allows for extracting the fluid with active ingredients but still acts as a barrier to particles, wherein the pore size of the membrane is bigger than 0.45µm and wherein the hydrophobic membrane is arranged to have a surface tension of less than 40 dynes/cm.

2. High pressure extraction capsule according to claim 1, whereby the particles are ground herbs or roots.

3. High pressure extraction capsule according to either claim 1 or 2, whereby the hydrophobic membrane is arranged to have a surface tension of less than 35 dynes/cm.

4. High pressure extraction capsule according to claim 3, whereby the surface tension is approx. 30 dynes/cm.

5. High pressure extraction capsule according to claim 4, whereby the surface tension is less than 25 dynes/cm.

6. High pressure extraction capsule according to claim 5, whereby the surface tension is approx. 20 dynes/cm.

7. High pressure extraction capsule according to any of the preceding claims, whereby the pore size of the hydrophobic membrane ranges from 0.45µm to 10µm.

8. High pressure extraction capsule according to claim 7, whereby the pore size of the hydrophobic membrane ranges from 0.45μm to 5μm.

9. High pressure extraction capsule according to any of the preceding claims, whereby the capsule comprises an inlet port, a compartment for holding a substance with active ingredients, an outlet port and a hydrophobic membrane that separates the compartment from the outlet port.

10. High pressure extraction capsule according to claim 9, whereby the substance is ground herbs or roots.

11. High pressure extraction capsule according to any of the preceding claims, whereby the hydrophobic membrane is supported by a nonwoven.

12. High pressure extraction capsule according to any of the preceding claims, whereby the hydrophobic membrane is supported by a support means of the capsule.

13. High pressure extraction capsule according to any of the preceding claims, whereby the capsule comprises a first compartment and a second compartment, wherein the inlet port opens into the first compartment and the second compartment opens out into the outlet port, wherein a first membrane separates the second compartment from the outlet port, wherein the first compartment is separated from the second compartment by means of a second membrane.

14. High pressure extraction capsule according to any of the preceding claims, whereby the second membrane has a higher water resistance pressure than the first membrane.

15. High pressure extraction capsule according to any of the preceding claims, whereby the first membrane has a higher water resistance pressure than the second membrane.

16. High pressure extraction capsule according to any of the preceding claims, whereby the capsule comprises three or more compartments that are separated from each other by means of membranes.

17. High pressure extraction capsule according to any of claims 13 to 16, whereby a flow distributing member is arranged between two adjacent compartments.

18. High pressure extraction capsule according to claim 17, whereby the flow distributing member is a membrane.

FIG 1

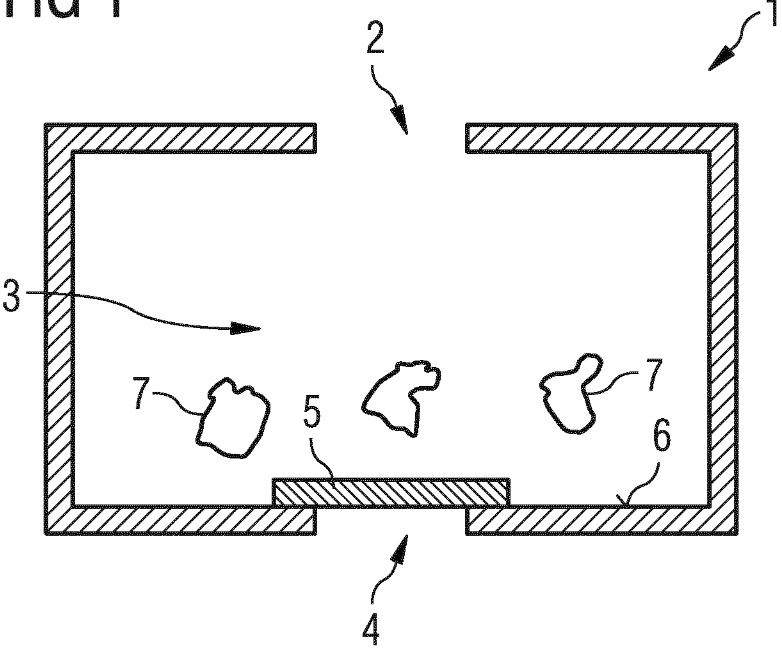
1
2
3
7
5
7
6
4

FIG 2

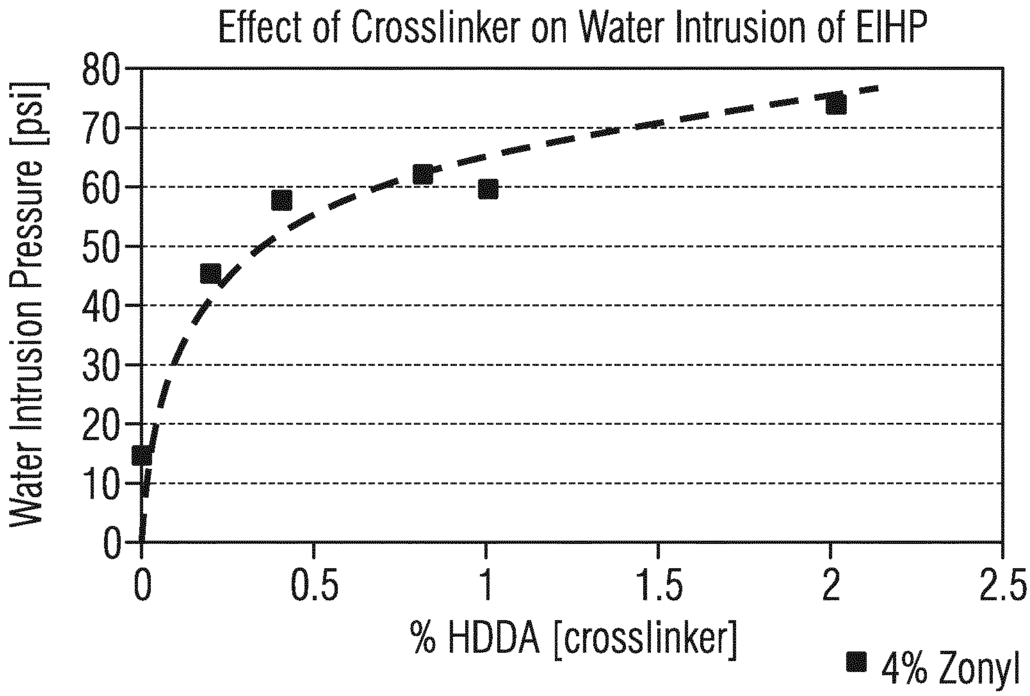
Effect of Crosslinker on Water Intrusion of EIHP
Water Intrusion Pressure [psi]
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
% HDDA [crosslinker]
4% Zonyl

FIG 3

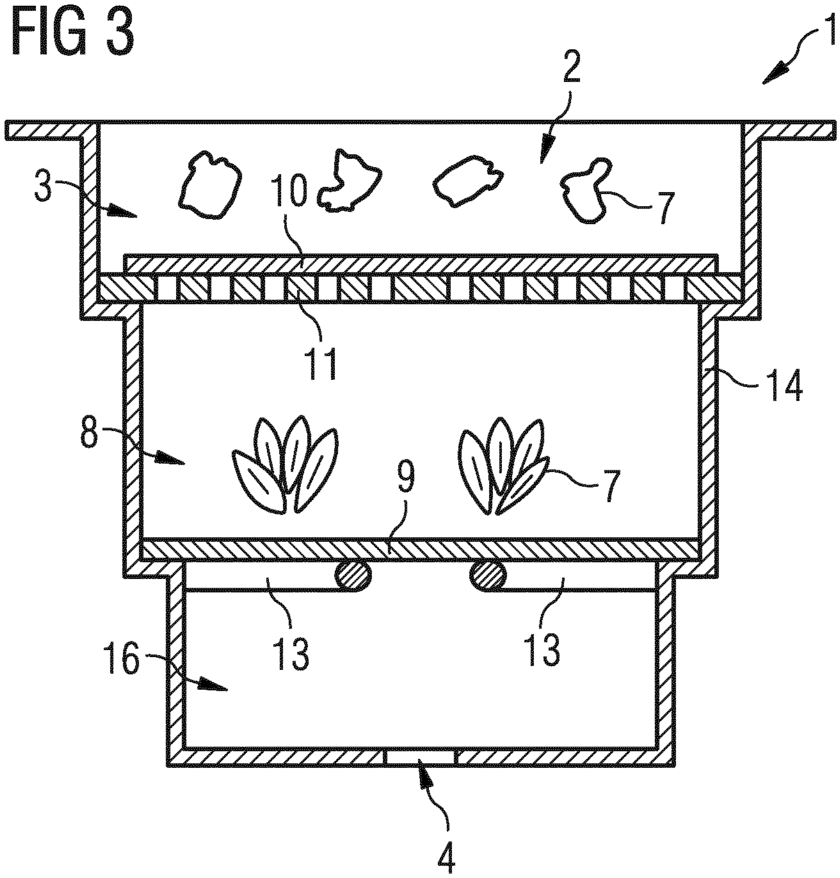

FIG 4

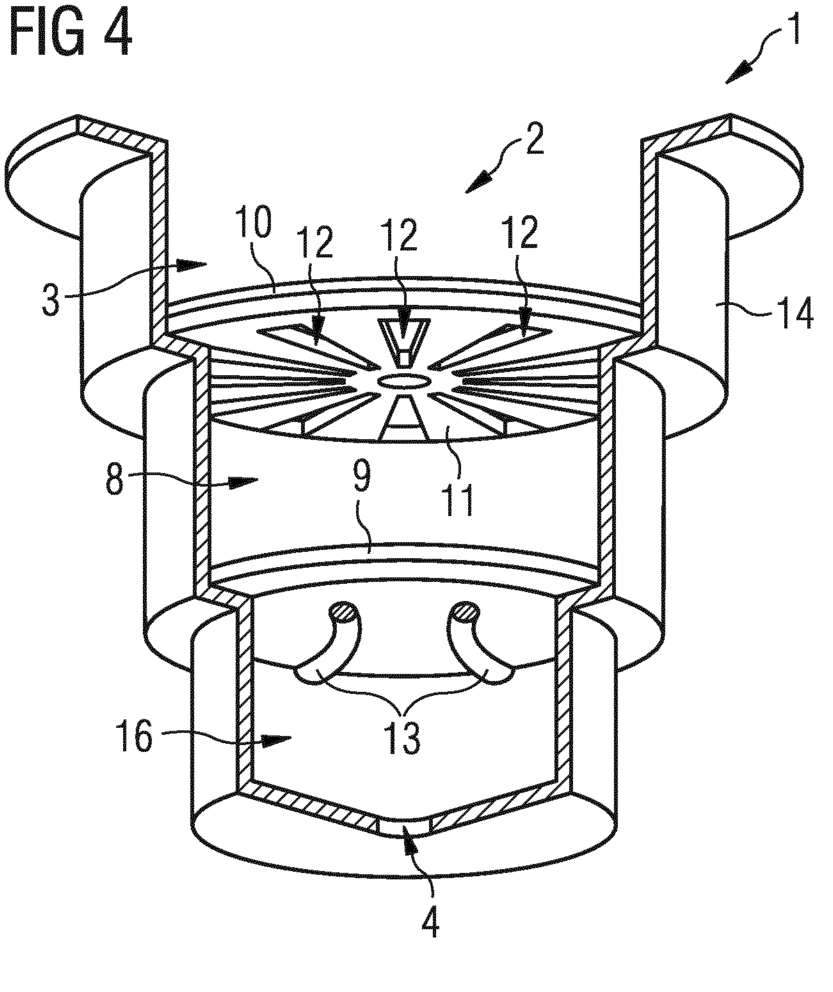

FIG 5

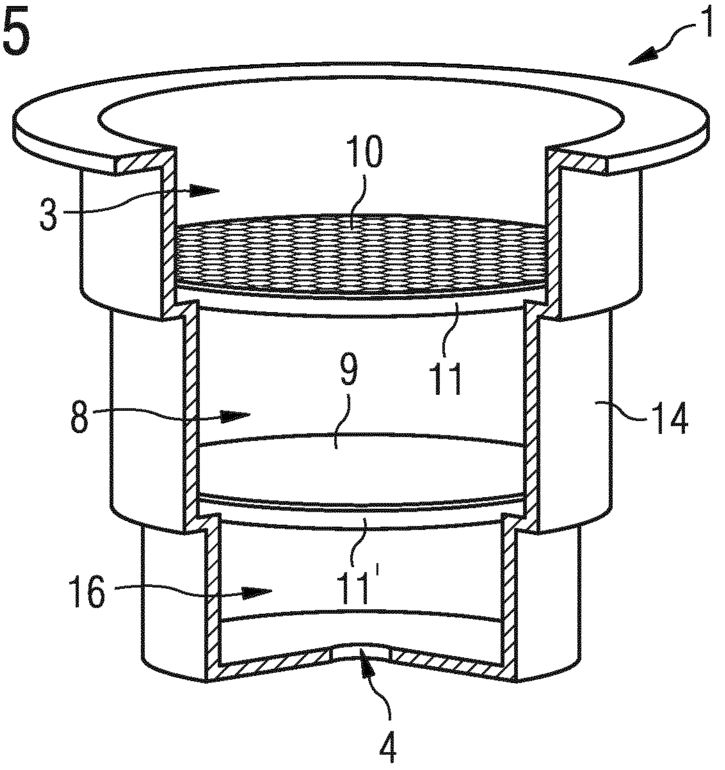

FIG 6

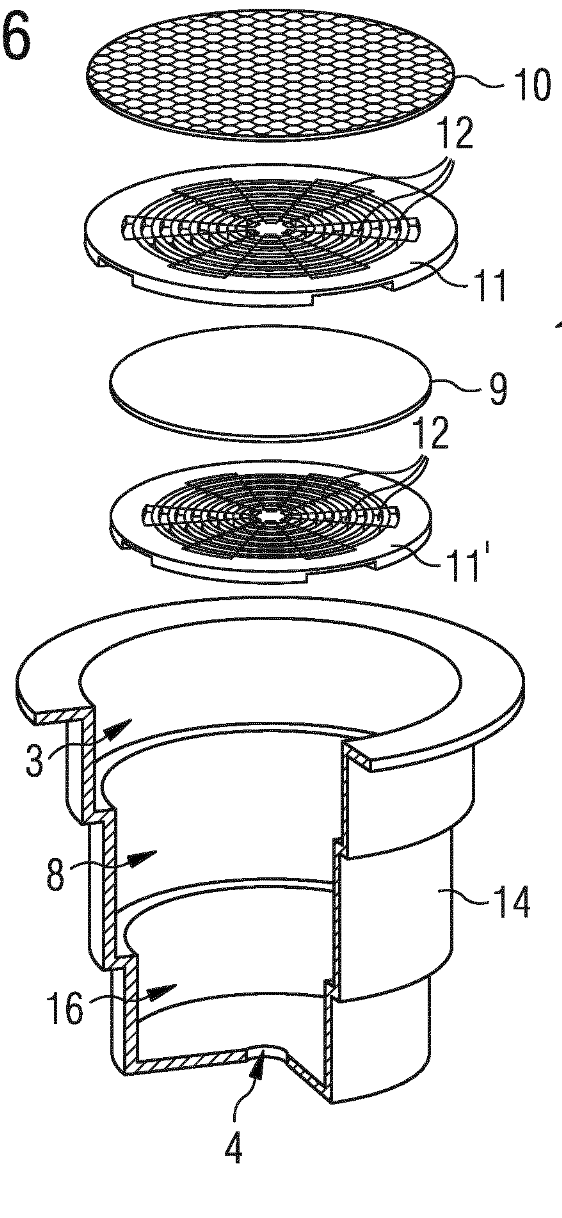

FIG 7