Title: A CAPSULE, A BEVERAGE PREPARATION SYSTEM AND A METHOD FOR FORMING A BEVERAGE

Abstract: A Capsule, a Beverage Preparation System and a Method for forming a Beverage. A capsule (20) comprises a cup-shaped body (21) and a lid (22); the cup-shaped body having a base (23) and a side wall (24). The lid is sealed to the cup-shaped body. The capsule is suitable for insertion into a beverage preparation machine to permit a pressurised liquid to be flowed through the capsule in order to produce a beverage from interaction with the beverage ingredients. The beverage preparation machine may be of the type having an enclosing member adapted to be selectively configurable between an open position to permit insertion of the capsule into the beverage preparation machine and a closed position in which the enclosing member sealingly engages the capsule. The base comprises a plurality of pre-formed openings (70) and a plurality of reinforcing ribs (80) which extend on an inner face (71) of the base. Each pre-formed opening is aligned with one of the plurality of reinforcing ribs such that the reinforcing ribs traverse the pre-formed opening and partially occludes the pre-formed opening.

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A Capsule, a Beverage Preparation System and a Method for forming a Beverage

The present disclosure relates to a capsule, a beverage preparation system and a method for forming a beverage. The beverage preparation system is of the type comprising a beverage preparation machine wherein the capsule is suitable for insertion into the beverage preparation machine to permit a pressurised liquid to be flowed through the capsule in order to produce a beverage from interaction with beverage ingredients contained within the capsule.

Background

Beverage preparation systems which comprise a beverage preparation machine and a capsule containing beverage ingredients are known in the art. One such system is taught in EP1 700548 and is shown in Figure 1. The system comprises a capsule 1 having a thin aluminium cup-like body 4 and a closing foil member 2 and a beverage preparation machine having an enclosing member 9 and a capsule holder 13.

The enclosing member 9 comprises an annular element having a leading edge in the form of an annular rim 5. The leading edge may be provided with a plurality of grooves. An upper end of the enclosing member 9 may be coupled to a supply of water and also comprises one or more perforation elements 14 intended to pierce the base 17 of the capsule 1 in use. The one or more perforation elements 14 may take the form of needles or blades. The one or more perforation elements 14, as illustrated in Figure 1, arranged along a circular path at a radius R₁ from a central longitudinal axis of the enclosing member 9 so that in use the capsule 1 is intended to be perforated also at one or more points along a circular path at radius R₁ from a central longitudinal axis of the capsule 1 (which in use is substantially coincident with the central longitudinal axis of the enclosing member 9).

The capsule holder 13 comprises relief elements 12 which are designed to tear and perforate the closing foil member 2 of the capsule 1. The tearing may
occur due to internal pressurisation of the capsule 1 caused by inflowing water. The relief elements 12 may have any protruding shape able to cause a partial tearing of the foil member 2, e.g. pyramids, needles, bumps, cylinders, or elongated ribs.

The capsule 1 is suitable for insertion into the beverage preparation machine. During or after insertion the one or more perforation elements 14 form one or more apertures in the aluminium base 17 of the capsule 1 to allow water under pressure to enter the capsule in order to interact with ingredients in the capsule to form a beverage which is output for consumption.

The capsule 1 of EP 1700548 is provided with a dedicated sealing member 8 to prevent a by-pass flow of water around the exterior of the capsule in use. The sealing member 8 is in the form of a resilient material attached to a flange of the capsule which is contacted on closure of the enclosing member 9 of the beverage preparation machine.

WO201 2/1 44885 discloses an alternative capsule for use in a system of the general type described in EP 1700548. The capsule is formed with an integral sealing element for interacting with the enclosing member of the beverage preparation machine, wherein the sealing element is at least partially manufactured from a thermoplastic polyolefin such as polypropylene.

WO201 1/061 126 discloses a capsule for the preparation of a beverage. The capsule includes a rim formed from a polymer blend selected to soften on heating. This is said to ensure a seal can be formed without the requirement for a separate rubber sealing ring. It is disclosed that the polymer may contain one or more fillers selected from calcium carbonate, titanium dioxide, fibers, glass beads and combinations thereof.

US201 0/02881 31 discloses a multi-laminate container for use in the preparation of a beverage. The container is formed from a polymer blend and includes calcium carbonate. This is used to scavenge free oxygen and moisture and ensure that beverage ingredients held within remain fresh and unspoiled.

It is an object of the present disclosure to address this problem, tackle the disadvantages associated with the prior art, or at least provide a commercially useful alternative thereto.
A problem that can occur when using capsules formed from a polymeric material, for example polypropylene, in a system of the general type described in EP1 700548 is that the capsule may not be adequately pierced by the one or more perforation elements 14 of the beverage preparation machine. This may be due to the relative resilience to puncturing of the polymeric material compared to aluminium and/or due to relative flexibility of the base of the capsule which may lead to the one or more perforation elements 14 tending to deflect the capsule material rather than puncture it.

The present disclosure provides an alternative capsule which may be used, for example, as part of a beverage preparation system of the general type described in EP1 700548 and provides improved compatibility with the one or more perforation elements of such beverage preparation machines.

**Summary of the Disclosure**

In a first aspect the present disclosure provides a capsule for preparing a beverage comprising a cup-shaped body and a lid; the cup-shaped body having a base and a side wall and the lid being sealed to the cup-shaped body;

the capsule being suitable for insertion into a beverage preparation machine to permit a pressurised liquid to be flowed through the capsule in order to produce a beverage from interaction with the beverage ingredients;

the beverage preparation machine being of the type having an enclosing member adapted to be selectively configurable between an open position to permit insertion of the capsule into the beverage preparation machine and a closed position in which the enclosing member sealingly engages the capsule;

wherein the base comprises a plurality of pre-formed openings and a plurality of reinforcing ribs which extend on an inner face of the base;

wherein each pre-formed opening is aligned with one of the plurality of reinforcing ribs such that the reinforcing rib traverses the pre-formed opening and partly occludes the pre-formed opening.

Advantageously, the plurality of pre-formed openings allow entry of liquid, for example hot water, into the capsule in use irrespective of whether the base is additionally pierced in use by the perforation elements of the beverage
preparation machine. This may allow the capsule to be used in a wider range of beverage preparation machines, in particular machines having differing designs of perforation elements.

Advantageously, locating a reinforcing rib so as to partly occlude the pre-formed opening may allow for easier manufacture of the cup-shaped body. Typically, it may be desirable to form the pre-formed opening during moulding (in the case where the cup-shaped body is moulded) by means of a core pin that is sized and shaped to produce the desired pre-formed opening in the moulded article. However, use of core pins to produce openings of small diameter is generally difficult since the core pin itself may be prone to damage and have a short life due to its small dimensions. With the present cup-shaped body, the pre-formed opening can be made larger, allowing use of a larger and stronger core pin, since the reinforcing rib acts to reduce the effective open area of the pre-formed opening. Thus, the co-location of the reinforcing rib and the pre-formed opening combines the benefits of reinforcing the base and allowing easier manufacture.

Additionally, the presence of the reinforcing rib may allow for easier flow of the injected material, in the case where the cup-shaped body is moulded. Typically, for a cup-shaped body of the type described herein, the gate for entry of injected material will be at a centre of the base aligned with the central axis of the base. Thus, injected material will need to flow in the mould radially outwards to form the base and continue to flow onwards to form the side wall. The presence of a core pin (or equivalent) to form a pre-formed opening in the base creates an obstruction that may hinder flow of the injected material into the parts of the mould beyond the core pin. This may be particularly the case in the area immediately downstream of the core pin, i.e. in the 'wake' of the core pin. With the present cup-shaped body, the co-location of the reinforcing rib with the pre-formed opening allows for easier injection moulding since the void in the mould that demarcates the reinforcing rib creates a channel which allows easier flow of the injected material to parts of the mould beyond the location of the pre-formed opening. This benefit is especially found where the reinforcing rib is aligned along the radial direction of the base.
In the following passages different aspects/embodiments are defined in more detail. Each aspect/embodiment so defined may be combined with any other aspect/embodiment or aspects/embodiments unless clearly indicated to the contrary. In particular, any feature indicated as being preferred or advantageous may be combined with any other feature or features indicated as being preferred or advantageous.

Each pre-formed opening and reinforcing rib may define two apertures for fluid entry into the capsule. For example, the two apertures may be on either side of the reinforcing rib. The two side apertures may open laterally into an interior of the capsule. In this way, the water entry into the capsule may have a flow direction with a lateral component. Advantageously, this may lead to better wetting of the beverage ingredients since the water is spread out more evenly across an upper region of the cup-shaped body.

Each reinforcing rib may extend across a diameter of the base. This may provide better reinforcement of the base.

Each reinforcing rib may extend in a continuous manner from the base onto at least an upper portion of the side wall. This may also improve the reinforcement of the base since additional support is obtained from the upper portion of the side wall via the reinforcing rib(s).

Each reinforcing rib may extend down a majority of the length of the side wall.

In one example the capsule comprises two reinforcing ribs which form a cruciform arrangement. Preferably, the capsule comprises four pre-formed openings, two pre-formed openings being aligned with each reinforcing rib.

The capsule may further comprise additional reinforcing ribs which extend along the side wall and/or base. Such additional ribs are ribs additional to the reinforcing ribs that are aligned with one or more of the pre-formed openings.

The additional reinforcing ribs preferably do not extend cross that portion of the base designed to be additionally pierced in use by a perforation element of the beverage preparation machine. In this way, the additional reinforcing ribs do not hinder additional piercing of the base.
Where the base of the capsule is intended to be additionally pierced by the perforation elements of the beverage preparation machine, at least a portion of the base designed to be additionally pierced in use may be formed of a thermoplastic polymer, wherein said thermoplastic polymer includes silica particles. By forming at least the portion of the base designed to be pierced in use of a thermoplastic polymer containing silica particles an improved perforation of the base may be promoted. In particular, whilst not wishing to be bound by theory, the behaviour of the portion of the base designed to be pierced in use under loading is understood to be modified by reducing the degree of, or eliminating, plastic yielding prior to fracture of the material. This promotes the formation of larger perforations in the base under the loading of the one or more perforation elements 14 of the beverage preparation machine compared to a thermoplastic polymer without the silica particles. In addition, the nature of the perforations tends to be changed from holes that approximately match the shape of the intruding perforation element (e.g. a round hole produced by a round needle) to slits or openings which propagate further away from the point of contact of the perforation element. The larger perforations may be beneficial in promoting easier admittance of water into the capsule in use.

The silica particles preferably have a particle size D50 of from 5 to 330 microns, more preferably from 40 to 150 microns, and most preferably from 110 to 120 microns. Techniques for measuring particles sizes are well known in the art. Preferably the measurements are taken with laser diffraction, such as the method described in ISO 13320-1. It should be appreciated that one method of forming the silica particles is by a precipitation method and it is known that this can be controlled to arrive at the desired particle size ranges.

Preferably the silica particles have a specific surface area of at least 150 m²/g, preferably of at least 170 m²/g. Specific surface area measurements are well known in the art. Such high surface areas are not observed for some conventional fillers such as fibers or glass beads.

The thermoplastic polymer of at least the base designed to be additionally pierced preferably includes at least 5% by weight silica particles. Preferably the silica particles are present in an amount of from 10% to 30% by weight in the
thermoplastic polymer, more preferably about 15% by weight silica particles. When the level of silica particles is too low, the advantageous pierceability of the base is not observed, whereas when the level is too high, the injection moulding process is adversely affected.

The silica particles used in the present disclosure are formed of silicon and oxygen and will typically be SiO₂, together with any unavoidable impurities. In another embodiment, the silica particles consist essentially of SiO₂. The silica particles preferably comprise substantially pure SiO₂. For example, the silica particles may be at least 90% by weight SiO₂, preferably at least 95% by weight SiO₂, more preferably at least 97% by weight SiO₂, measured following ISO 3262-1 9 based on ignited substance (2h/1 000°C).

Conventional glass beads provide little or no free silica. In contrast, the preferred silica particles used in the present disclosure are capable of providing free silica.

The silica particles may comprise precipitated silica particles. These may be produced by known precipitation techniques, for example from a solution containing silicate salts. In more detail, it is known to prepare precipitated silica by reacting an acidifying agent (for example sulphuric acid, nitric acid or hydrochloric acid) with a silicate of an alkali metal (for example sodium silicate or potassium silicate) to obtain a suspension of precipitated silica. The suspended precipitated silica is then separated and dried to produce a powder of precipitated silica. Precipitated silica particles produced by such processes are generally amorphous in structure and also porous. An example of a preferred precipitated silica is one having one or more of the following characteristics: specific surface area (N₂) of 100 to 600 m²/g, measured by ISO 9277; and/or particle size D50 of 5 to 330 microns, measured by ISO 13320-1 . As already noted, the precipitated silica particles may be SiO₂, together with any unavoidable impurities, or may consist essentially of SiO₂ (preferably may be at least 90% by weight SiO₂, preferably at least 95% by weight SiO₂, more preferably at least 97% by weight SiO₂, measured following ISO 3262-1 9 based on ignited substance (2h/1 000°C).)

A whole of the base may be formed from the thermoplastic polymer containing the silica particles.
Without wishing to be bound by theory, it is considered that the inclusion of the silica particles provides an optimum material for forming the cup-shaped body. In particular, silica particles are sufficiently fine to be readily distributed within the thermoplastic polymer, and have a high specific surface area which allows them to form an integral part of the final polymer. It is considered that this allows the material to rip when pierced and, therefore, allows the provision of a larger hole. Nonetheless, the silica particles do not interfere with the softening of the polymer which may be desirable to allow a good seal to be achieved of a flange. Advantageously, the silica particles can be readily mixed and then injection moulded to form the cup-shaped body. This provides a simple cost-effective one-step method for the formation of the capsule.

A whole of the cup-shaped body may be formed from the thermoplastic polymer containing the silica particles.

The thermoplastic polymer may comprise a polyethylene and/or polypropylene polymer or co-polymer.

In one example, the thermoplastic polymer comprises a high density polyethylene polymer.

In another example, the thermoplastic polymer comprises a low density polyethylene polymer, preferably a linear low density polyethylene polymer (LLDPE).

Alternative thermoplastic polymers that may be used include polypropylene, ABS, polystyrene and blends of any of the preceding polymers.

Preferably the thermoplastic polymer consists of the polymer and the silica particles. Accordingly, preferably in one example the base which may be additionally pierced consists of high density polyethylene polymer and silica particles. In another example, preferably the base which may be additionally pierced consists of low density polyethylene and silica particles. As will be appreciated, there may be unavoidable impurities present in the thermoplastic polymer. However, preferably these will form less than 1 wt% of the polymer, more preferably less than 0.1 wt% thereof.

A whole of the cup-shaped body may be formed from the thermoplastic polymer.
A whole of the cup-shaped body may be formed as a single injection moulding. This may have the advantage of allowing fast and cost-efficient manufacture of the capsules. Preferably the cup-shaped body is formed as a single layer of material. That is, the body is preferably not formed as a laminate structure.

Preferably the concentration by weight of silica particles in the thermoplastic polymer is substantially constant. Thus, if the thermoplastic polymer includes 20% by weight of the silica particles, then this concentration of 20% by weight is substantially constant throughout, for example, the cup-shaped body.

Alternatively, the concentration by weight of silica particles in the thermoplastic polymer may be greater in the portion of the base designed to be pierced in use than in the rest of the cup-shaped body. That is, the concentration in the portion of the base designed to be pierced in use may be 20% by weight, whereas the remainder of the cup-shaped body may have, for example, less or substantially no silica particles. In one embodiment, the concentration by weight of silica particles in the thermoplastic polymer may decrease across the cup-shaped body away from the portion of the base designed to be pierced in use. This decrease may be linear and or variable. For example, the ratio of the concentration by weight of silica particles in the portion of the base designed to be pierced in use to the concentration by weight of silica particles in a flange or the outer limit of the cup-shaped body may be at least 2:1, and preferably up to from 10:1.

The portion of the base designed to be pierced in use may have a wall thickness in the range of 0.30 to 0.50 mm.

The cup-shaped body may further comprise a flange at an end of the side wall opposite the base.

The flange may comprise a sealing element located on an upper side of the flange. The sealing element may be intended for facilitating the production of a fluid-tight engagement of the capsule with the enclosing member in use.
The sealing element may comprise a portion having a substantially triangular cross-section with two sides that extend from the upper side of the flange.

An outer of the two sides of the sealing element may comprise a straight side and an inner of the two sides may comprise a side having a straight portion distal an apex of the sealing element and a convex upper portion proximate the apex of the sealing element. This design is advantageous in being compatible with venting apertures in the mould tools.

The flange may further comprise a cavity on a lower side of the flange and/or a peripheral portion that is directed downwards. The cavity may improve the mouldability of the capsule flange.

The lid may be formed from aluminium, an aluminium alloy or a laminate comprising at least one layer formed from aluminium or an aluminium alloy. Alternatively, another, suitably ductile material could be utilised. The lid may optionally comprise one or more lines or points of pre-weakness to promote tearing in use. Alternatively, the lid may comprises one or more pre-formed openings so as to act as a filter irrespective of whether the lid is further torn or punctured in use by the beverage preparation machine.

Prior to insertion, the capsule may have a maximum diameter of from 35 to 38 mm, preferably 37 mm.

Prior to insertion, the capsule may have a height of from 25 to 31 mm, preferably between 27 and 28 mm.

The capsule may form a single-use, disposable element.

The capsule may contain a beverage ingredient or mixture of beverage ingredients. As a non-limiting example, the beverage ingredient may comprise roasted ground coffee.

The present disclosure also provides a beverage producing system comprising:

- a capsule as described above and containing beverage ingredients; and
- a beverage preparation machine;
the beverage preparation machine having an enclosing member adapted to be selectively configurable between an open position to permit insertion of the capsule into the beverage preparation machine and a closed position in which the enclosing member sealingly engages the capsule;

the beverage preparation machine further comprising one or more perforation elements which in use perforate the base of the capsule in addition to the pre-formed openings of the base to facilitate entry of liquid into the capsule.

The present disclosure also provides a method for preparing a beverage comprising the steps of:

- providing a capsule as described above;
- providing a beverage preparation machine having an enclosing member;
- configuring the enclosing member into an open position;
- inserting the capsule into the beverage preparation machine;
- closing the enclosing member so as to sealingly engage the enclosing member with the capsule;
- flowing a pressurised liquid through the one or more pre-formed openings and through the capsule to produce a beverage from interaction with the beverage ingredients; and
- outputting the beverage for consumption.

The method may further comprise the step of during or after closure of the enclosing member, forming one or more perforations in the base of the capsule in addition to the one or more pre-formed openings.

Forming the one or more perforations in the base of the capsule may comprise forming one or more slits in the base of the capsule. The one or more slits may be orientated radially. The one or more slits may have a length substantially greater than their width.

**Brief Description of the Drawings**

Examples of the present disclosure will now be described in more detail, for exemplary purposes only, with reference to the accompanying drawings, in which:
Figure 1 is a cross-sectional view of a prior art beverage preparation system as disclosed in EP1 700548.

Figure 2 is a perspective view from above of a capsule according to the present disclosure;

Figure 3 is a side view of the capsule of Figure 2;

Figure 4 is a cross-sectional view through the capsule of Figure 2;

Figure 5 is an enlarged view of a portion of Figure 2;

Figure 6 is an enlarged view of a portion of Figure 4;

Figure 7 is an enlarged plan view of a portion of the capsule of Figure 2;

Figure 8 is a view from below of the capsule of Figure 2 with a lid of the capsule removed in order to show internal detail;

Figure 9 is an enlarged view of a portion of Figure 4;

Figure 10 is a cross-sectional view of the capsule of Figure 2 in a beverage preparation machine; and

Figure 11 is a schematic perspective view of a perforation element from a prior art Nespresso® U beverage preparation machine.

Detailed Description

Figure 2 illustrates a first embodiment of capsule 20 according to the present disclosure which may be used with a beverage preparation machine to produce a beverage. The capsule 20 and the beverage preparation machine together define a beverage preparation system.

The capsules of the present disclosure may be used, for example, with a beverage preparation machine of the general type shown in Figure 1, described in brief above and in more detail in EP1 700548. However, they may also be used in other beverage preparation machines and, in the following description, reference to features of a beverage preparation machine of the general type described in EP1 700548 is by way of example only.

The enclosing member 9 and the capsule holder 13 in the closed position together define a receptacle 30 for holding the capsule 20 during a dispensing operation.
In addition, the beverage preparation machine may comprise conventional elements which are not illustrated in the accompanying drawings and which are well known in the art of beverage preparation machines. For example, the beverage preparation machine may comprise either a facility for storing water, such as an internal reservoir, or a facility for connection to an external supply of water, such as mains water. A pump or equivalent may be provided for supplying the water in a pressurised state to the capsule 20. The water will typically be supplied at a pressure of up to 9 to 14 bar. A heater may be provided for heating the water to a desired temperature. The heater may heat the water in the reservoir (where present) or may heat the water on-demand as it passes through a conduit or over a thermoblock to the receptacle 30.

As shown in Figures 2 to 9, the capsule 20 comprises a cup-shaped body 21 and a lid 22. The cup-shaped body 21 has a base 23 at one end of the cup-shaped body 21 and a side wall 24 which extends from base 23 and terminates at an open end 25 which may be closed off in use by the lid 22.

The cup-shaped body 21 and the lid 22 together enclose a beverage ingredient chamber 29 which may be filled with a beverage ingredient or mixture of beverage ingredients (not shown in the drawings for reasons of clarity). As a non-limiting example, the beverage ingredient may comprise roasted ground coffee.

The side wall 24 may have a generally frusto-conical form with a basal end of the side wall 24 having a smaller diameter than the open end 25.

The base 23 may have a generally convex dome-shaped form as viewed from the exterior of the capsule.

The side wall 24 may be provided with decorative embossing. As an example, the decorative embossing may comprise a pictorial representation of coffee beans 51. As shown in Figures 4 to 7, the side wall 24 may be thin walled. The side wall 24 may have a wall thickness in the range of 0.30 to 0.50 mm.

The base 23 may define an inlet end of the capsule 20 and the lid 22 may define an outlet end of the capsule 20.

The capsule 20 may further be provided with a flange 26 at the open end 25. The flange 26 may extend outwardly from the side wall 24 and define an
upper side 27 and a lower side 28. A bottom of the flange 26 may define an end
face 61 of the cup-shaped body 21, as most clearly seen in Figure 9.

As shown in Figure 9, a sealing element 40 may be provided on the upper
side 27 of the flange 26. The sealing element 40 may comprise a portion 41
having a substantially triangular cross-section with two sides that extend from the
upper side 27 of the flange 26. An outer side 42 of the sealing element 40 may
have a straight side. An inner side 43 may have a straight portion 44 distal an
apex 46 of the sealing element 40 and a convex upper portion 45 proximate the
apex 46 of the sealing element 40.

The sealing element 40 may be spaced from the side wall 24 so as to
define a gulley 49 there between. The apex 46 may be distanced radially 1.0 mm
from the side wall 24.

The gulley 49 may have a gulley floor 60 at a first height above the end
face 61 of the capsule 20 at the open end 25. The thickness of the flange 26 in
line with the gulley 49 may be 0.62 mm.

The apex 46 of the sealing element 40 may rise above the gulley floor 60
to a second height above the end face 61. The height of the apex 46 may be 0.70
mm higher than the height of the gulley floor 60 and 1.32 mm above the end face
61.

The flange may comprise a peripheral portion 63 lying outside the sealing
element 40 at a third height above the end face 61. The third height may be
greater than the first height but less than the second height. The third height may
be 0.98 mm. The peripheral portion 63 may extend outwardly substantially
parallel to the end face 61 and terminate with an edge region 64 that is directed
downwards away from the base 23.

The lower side 28 of the flange 26 may comprise a cavity 47 underneath
the peripheral portion 63 of the flange 26.

As shown in Figures 2 to 4 and 8, the base 23 is provided with a plurality
of pre-formed openings 70 and a plurality of reinforcing ribs 80 which extend on
an inner face 71 of the base. Each pre-formed opening 70 is a through aperture
that extends through the thickness ti of the base 23 as shown most clearly in the
enlarged views of Figures 5 and 6. However, each pre-formed opening 70 is
aligned with one of the plurality of reinforcing ribs 80 such that the reinforcing rib 80 traverses the pre-formed opening 70 as shown in Figures 5 and 7 and consequently at least partly occludes the pre-formed opening 70. Consequently, each pre-formed opening 70 and reinforcing rib 80 defines two apertures 73, 74 for fluid entry into the capsule 20. The two apertures 73, 74 are located on either side of the reinforcing rib 80 as shown in Figures 5 and 7. The presence of the reinforcing rib 80 that extends across at least a portion of the bottom of the pre-formed opening 70 results in the two apertures 73, 74 opening generally laterally into the interior of the capsule. In other words, the reinforcing rib 80 prevents at least the majority of the incoming water entering the capsule 20 from entering in a direction parallel to the longitudinal axis of the cup-shaped body 21 but rather deflects and diverts a majority of the water laterally. This may help to spread the incoming water more evenly across the upper region of the beverage ingredient chamber 29 resulting in improved mixing with the beverage ingredient.

In the example shown, there are two reinforcing ribs 80 present and each one extends across a diameter of the base 23 as shown in Figure 8. In addition, it is preferred that each reinforcing rib 80 also extends in a continuous manner from the base 23 onto at least an upper portion of the side wall 24 as shown in Figure 4 and 8. In a more preferred example, as illustrated, each reinforcing rib 80 extends down a majority of the length of the side wall 24. The two reinforcing ribs 80 may form a cruciform arrangement as shown in Figure 8. Preferably they intersect one another perpendicularly.

Thus, in the illustrated example, the base 23 is provided with four pre-formed openings 70, with two pre-formed openings 70 being aligned with each reinforcing rib 80.

The combined thickness \( t_2 \) of the base 23 and the reinforcing rib 80 is shown in Figure 6. The thickness \( (t_2 + t_i) \) of the reinforcing rib 80 may be two or more, preferably three or more times the thickness \( t_i \) of the base 23.

As shown in Figures 2, 4 and 8, the base 23 may comprise an annular region 90 including a portion of the base 23 which in use is aligned with the positioning of the one or more perforation elements 14 of the beverage preparation machine. For example, Figure 11 illustrates a typical perforation
element used in a Nespresso® U beverage preparation machine which has three perforating tips.

Thus, this annular region 90 of the base 23 is potentially subject to additional piercing by the one or more perforation elements 14 of the beverage preparation machine. Preferably, the pre-formed openings 70 are located in this annular region 90 and more preferably are located so as to lie on a circular path that encompasses the initial contact points of tips of the perforation elements 14 in use. Thus, as will be described below, one or more of the tips of the perforations elements 14 may make initial contact with one of the pre-formed openings 70.

The capsule 20 may further comprise, as shown in Figures 4 and 8, additional reinforcing ribs 85 which extend along the side wall 24 and preferably continuously up onto an outer peripheral portion of the base 23. Preferably, these additional reinforcing ribs 85 do not extend cross the annular region 90 of the base 23 designed to be potentially additionally pierced in use by the perforation elements 14 of the beverage preparation machine.

The lid 22 may be formed from aluminium, an aluminium alloy or a laminate comprising at least one layer formed from aluminium or an aluminium alloy. Alternatively, another, suitably ductile material could be utilised.

In the illustrated example, at least the annular region 90 of the base 23 is formed of a thermoplastic polymer containing silica particles.

The whole of the base 23 may be formed of the thermoplastic polymer containing silica particles.

More preferably, a whole of the cup-shaped body 21 may be formed of a single material, i.e. the thermoplastic polymer containing silica particles.

The silica particles may have a particle size D50 as measured by laser diffraction in accordance with ISO 13320-1 in the range of 5 to 330 microns.

In one example, the silica particles may have a particle size D50 in the range of 40 to 150 microns. In another example the silica particles may have a particle size D50 in the range of 110 to 120 microns.

The silica particles may comprise substantially pure SiO₂. The silica particles may be in the form of precipitated silica.
A non-limiting example of suitable silica particles is the precipitated silica Sipernat® 22 manufactured by Evonik Industries AG of Hanau, Germany. Other examples, also manufactured by Evonik Industries AG of Hanau, Germany, include Sipernat® 609, Sipernat® 2200, Sipernat® 680 and Sipernat® 303.

The thermoplastic polymer for use with the silica particles may comprise a polyethylene and/or polypropylene polymer or co-polymer. The thermoplastic polymer may comprise a blend of thermoplastic polymers. In one example the thermoplastic polymer may comprise a high density polyethylene polymer.

A non-limiting example of a suitable thermoplastic polymer is Eraclene MS 80 U HDPE manufactured by Polimeri Europa S.p.A. of Milan, Italy.

In another example the thermoplastic polymer may comprise a low density polyethylene polymer, for example a linear low density polyethylene (LLDPE).

A non-limiting example of a suitable thermoplastic polymer is M500026 LLDPE manufactured by Saudi Basic Industries Corporation (SABIC) of Riyadh, Saudi Arabia.

The thermoplastic polymer may comprise greater than 5% by weight silica particles. Preferably the thermoplastic polymer comprises from 10% to 30% by weight silica particles. More preferably the thermoplastic polymer comprises 15% by weight silica particles.

The thermoplastic polymer may be compounded by heating in a suitable vessel, for example a barrel, and adding the silica particles in one or more portions as the base thermoplastic polymer passes along the heated vessel. The thermoplastic polymer is then extruded and pelletised.

The cup-shaped body 21 may be formed by injection moulding. Preferably a whole of the cup-shaped body 21 is formed as a single injection moulding. This allows for simpler and more rapid manufacture.

Figure 10 shows the capsule 20 being used in the beverage preparation machine. The enclosing member 9 is first moved into the open position and the capsule 20 is inserted into a location in between the capsule holder 13 and the enclosing member 9. The enclosing member 9 is then closed so as to sealingly engage the enclosing member 9 with the capsule 20. A fluid-tight seal between the annular rim 5 of the enclosing member 9 and the flange 26 of the capsule 20
is formed. In particular, the annular rim 5 of the enclosing member 9 is at least partially received in the gulley 49 and contacts and seals against the inner side 43 of the sealing element 40 and/or the gulley floor 60.

During closure of the enclosing member the annular region 90 of the base 23 is potentially subject to additional piercing by the one or more perforation elements 14 of the beverage preparation machine. The tips of the perforation elements 14 may contact a solid portion of the base 23 and may form an additional opening(s) therein. Alternatively, or in addition, one or more of the tips of the perforations elements 14 may make initial contact with one of the pre-formed openings 70 as shown in Figure 10. In this case, the perforation element 14 may enlarge the pre-formed opening 14 and/or may cause the base 23 to deflect inwardly at this point while maintaining a clear passage for inflowing water through the two apertures 73, 74 and/or may break through the reinforcing rib 80.

Water is then flowed into the capsule 20 through the pre-formed openings 70 and, in addition, any additional perforations produced in the base 23 by the perforations element 14. A beverage is thus produced from the interaction of the water with the beverage ingredients. During this step internal pressurisation of the beverage ingredient chamber 29 causes the lid 22 to be deformed outwardly against the relief elements 12 of the capsule holder 13 resulting in at least partial tearing of the lid 22 which opens up an exit path from the capsule 20 for the beverage.

The beverage is then output for consumption.

According to the present disclosure, by preferably forming at least the annular region 90 of the base 23 of a thermoplastic polymer containing silica particles an improved additional perforation of the base 23 is promoted. In particular, whilst not wishing to be bound by theory the behaviour of the annular region 90 under loading is understood to be modified by reducing the degree of, or eliminating, plastic yielding prior to fracture of the material. This results in the formation of larger perforations in the base 23 under the loading of the one or more perforation elements 14 of the beverage preparation machine compared to the thermoplastic polymer without silica particles. In addition, the nature of the perforations tends to be changed from holes that approximately match the shape
of the intruding perforation element (e.g. a round hole produced by a round needle) to slits or openings which propagate further away from the point of contact of the perforation element.

The larger additional perforations are beneficial in promoting easier admittance of water into the capsule 20 in use.

Although preferred examples of the disclosure have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the scope of the disclosure or of the appended claims.
Claims:

1. A capsule for preparing a beverage comprising a cup-shaped body and a lid; the cup-shaped body having a base and a side wall and the lid being sealed to the cup-shaped body;
   the capsule being suitable for insertion into a beverage preparation machine to permit a pressurised liquid to be flowed through the capsule in order to produce a beverage from interaction with the beverage ingredients;
   the beverage preparation machine being of the type having an enclosing member adapted to be selectively configurable between an open position to permit insertion of the capsule into the beverage preparation machine and a closed position in which the enclosing member sealingly engages the capsule;
   wherein the base comprises a plurality of pre-formed openings and a plurality of reinforcing ribs which extend on an inner face of the base;
   wherein each pre-formed opening is aligned with one of the plurality of reinforcing ribs such that the reinforcing rib traverses the pre-formed opening and partly occludes the pre-formed opening.

2. The capsule of claim 1, wherein each pre-formed opening and reinforcing rib define two apertures for fluid entry into the capsule.

3. The capsule of claim 2, wherein the two apertures are on either side of the reinforcing rib.

4. The capsule of claim 2 or claim 3, wherein the two side apertures open laterally into an interior of the capsule.

5. The capsule of any preceding claim, wherein each reinforcing rib extends across a diameter of the base.
6. The capsule of any preceding claim, wherein each reinforcing rib extends in a continuous manner from the base onto at least an upper portion of the side wall.

7. The capsule of any preceding claim, wherein each reinforcing rib extends down a majority of the length of the side wall.

8. The capsule of any preceding claim, comprising two reinforcing ribs which form a cruciform arrangement.

9. The capsule of claim 8, comprising four pre-formed openings, two pre-formed openings being aligned with each reinforcing rib.

10. The capsule of any preceding claim, further comprising additional reinforcing ribs which extend along the side wall and/or base, and preferably the additional reinforcing ribs do not extend cross that portion of the base designed to be additionally pierced in use by a perforation element of the beverage preparation machine.

11. The capsule of any preceding claim, wherein at least a portion of the base designed to be additionally pierced in use is formed of a thermoplastic polymer, wherein said thermoplastic polymer includes silica particles.

12. The capsule of claim 11, wherein the silica particles have a particle size D50 of from 5 to 330 microns, preferably 40 to 150 microns, and preferably the silica particles have a specific surface area of at least 150 m²/g, preferably of at least 180 m²/g.

13. The capsule of any of claims 11 to 12, wherein the thermoplastic polymer comprises at least 5% by weight silica particles, preferably from 10% to 30% by weight silica particles, more preferably about 15% by weight silica particles.
14. The capsule of any of claims 11 to 13, wherein the silica particles are at least 90% by weight SiO₂, preferably at least 95% by weight SiO₂, more preferably at least 97% by weight SiO₂.

15. The capsule of any of claims 11 to 14, wherein the silica particles are precipitated silica particles.

16. The capsule of any preceding claim, wherein the cup-shaped body of formed of a thermoplastic polymer comprising a polyethylene and/or polypropylene polymer or co-polymer.

17. The capsule of claim 16, wherein the thermoplastic polymer comprises a high density polyethylene polymer and/or comprises a low density polyethylene polymer, preferably a linear low density polyethylene polymer (LLDPE).

18. The capsule of any of the preceding claims, wherein the cup-shaped body consists of high density polyethylene polymer and silica particles or consists of low density polyethylene polymer and silica particles.

19. The capsule of any preceding claim, wherein a whole of the cup-shaped body is formed from a thermoplastic polymer, and preferably a whole of the cup-shaped body is formed as a single injection moulding.

20. The capsule of any preceding claim, wherein a whole of the cup-shaped body is formed from a single layer of thermoplastic polymer.

21. The capsule of any preceding claim, wherein the portion of the base designed to be additionally pierced in use has a wall thickness in the range of 0.30 to 0.50 mm.
22. The capsule of any preceding claim, wherein the cup-shaped body further comprises a flange at an end of the side wall opposite the base, and preferably the flange comprises a sealing element located on an upper side of the flange.

23. The capsule of claim 22, wherein the sealing element comprises a portion having a substantially triangular cross-section with two sides that extend from the upper side of the flange, and preferably an outer of the two sides of the sealing element comprises a straight side and an inner of the two sides comprises a side having a straight portion distal an apex of the sealing element and a convex upper portion proximate the apex of the sealing element.

24. A beverage producing system comprising:
   a capsule as claimed in any preceding claim and containing beverage ingredients; and
   a beverage preparation machine;
   the beverage preparation machine having an enclosing member adapted to be selectively configurable between an open position to permit insertion of the capsule into the beverage preparation machine and a closed position in which the enclosing member sealingly engages the capsule;
   the beverage preparation machine further comprising one or more perforation elements which in use perforate the base of the capsule in addition to the pre-formed openings of the base to facilitate entry of liquid into the capsule.

25. A method for preparing a beverage comprising the steps of:
   - providing a capsule as claimed in any of claims 1 to 23;
   - providing a beverage preparation machine having an enclosing member;
   - configuring the enclosing member into an open position;
   - inserting the capsule into the beverage preparation machine;
   - closing the enclosing member so as to sealingly engage the enclosing member with the capsule;
- flowing a pressurised liquid through the one or more pre-formed openings and through the capsule to produce a beverage from interaction with the beverage ingredients; and
- outputting the beverage for consumption.

26. The method of claim 25, further comprising the step of during or after closure of the enclosing member, forming one or more perforations in the base of the capsule in addition to the one or more pre-formed openings, and preferably forming the one or more perforations in the base of the capsule comprises forming one or more slits in the base of the capsule.

27. The method of claim 26, wherein the one or more slits are orientated radially, and preferably the one or more slits have a length substantially greater than their width.
FIG. 5

FIG. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. B65D85/804

ADD.

According to International Patent Classification (IPC) or both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbol)

B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

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"A" document member of the same patent family

Date of the actual completion of the international search

22 October 2015

Date of mailing of the international search report

02/11/2015

Name and mailing address of the ISA

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Authorized officer

Brochado Garganta, M
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