



EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.01.2023 Bulletin 2023/01

(51) International Patent Classification (IPC):
B65D 41/34 ^(2006.01) **B65D 55/16** ^(2006.01)

(21) Application number: **21182602.9**

(52) Cooperative Patent Classification (CPC):
B65D 55/16; B65D 41/3447; B65D 2401/30

(22) Date of filing: **29.06.2021**

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

• **Borealis AG**
1020 Vienna (AT)

(72) Inventor: **BHAGAT, Suraj**
Abu Dhabi (AE)

(74) Representative: **Dehns**
St. Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(71) Applicants:
• **Abu Dhabi Polymers Company Limited**
(Borouge) LLC
Abu Dhabi (AE)

(54) **BOTTLE CLOSURE ASSEMBLY**

(57) A bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end

joined to the cap, and a lower end joined to the retaining ring, wherein as the cap is unscrewed it separates from the retaining ring but remains connected to said retaining ring via the connecting portions; and wherein, in the open configuration, the cap can be oriented such that the cap and retaining ring define an angle of at least 150°, especially at least 180°.

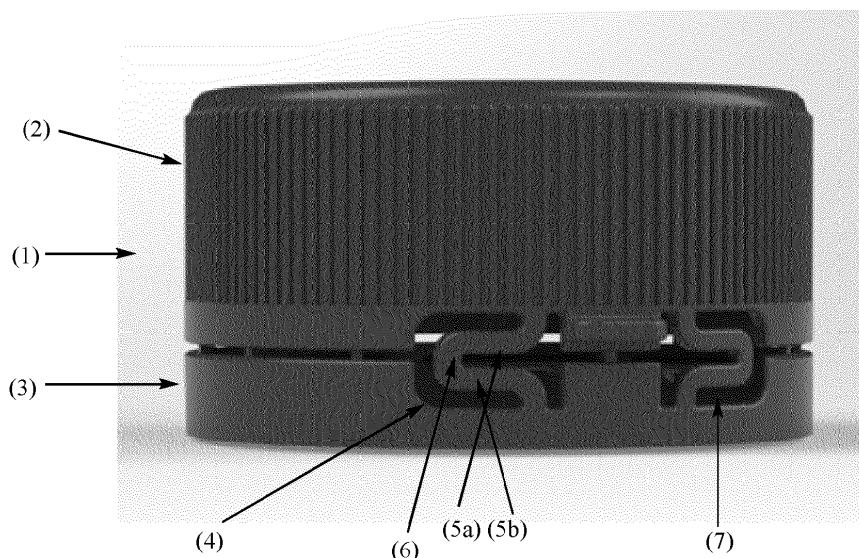


Figure 1

Description

[0001] The present invention concerns a bottle closure assembly, e.g. one made using a polyethylene composition, having a cap or closure portion, two tethering portions, and a retaining ring. In use, the cap can be unscrewed and then bent back to create at least a 180° angle with the retaining ring whilst still remaining attached thereto via the two tethers.

Background

[0002] Caps or closures are small components of rigid packaging. HDPE is commonly used to prepare caps for the likes of juices, dairy products, carbonated soda drinks and water bottles. The manufacture of simple one-piece caps or closures for bottles using high density polyethylene compositions is well known to persons skilled in the art. Bottle closure assemblies often incorporate a retaining ring (also known as a tamper evident band) which is present on the neck of the bottle and to which the cap is attached, before opening, via a plurality of frangible connections. The retaining ring remains attached to the neck of the bottle at all times. When the bottle cap is unscrewed these connections are broken allowing the cap to be completely removed from the bottle.

[0003] Being so small, these caps are often discarded once the drink has been opened or consumed. Being so small also makes them difficult to recycle. Caps often end up as litter and hence the industry is looking for ways to prevent littering and maximise the opportunity for recycling.

[0004] In some solutions, the cap is attached to the retaining ring via a stronger, non frangible connection that does not break during the cap opening operation. This connection therefore secures the cap to the retaining ring even after the cap has been removed from the bottle opening.

[0005] US2019/0168935 describes a cap assembly comprising a cap portion, a tether portion, and a retaining means portion where the tether portion connects at least one point on the cap portion. In use therefore, the cap remains attached to the retaining ring thus preventing it being thrown away and causing litter.

[0006] WO2019/207148 describes a tamper-evident closure comprising a cap and a retaining ring connected to the cap by a plurality of bridges at least one of which is non-frangible.

[0007] JP2011173600 describes a bottle closure assembly in which the cap is connected to the retaining ring via C shaped connectors that expand around an expansion point. The connectors are such that the expansion points are adjacent each other. In use, the cap remains attached to the retaining ring and appears to snag on the retaining ring after the cap is unscrewed and bent back to allow access to the bottle neck.

[0008] These solutions suffer from the problem that the tethered cap interferes with drinking from the bottle. One problem with tethering caps to the bottle is that these obstruct the bottle opening when the consumer is trying to drink the contents. The cap may also rub on the consumer's face which consumers find irritating. The consumer will often then try to remove the cap from the retaining ring (perhaps by twisting it off) thus defeating the purpose of the tether.

[0009] If the cap is attached via a long single tether, it can also be challenging to reseal the bottle as the tether interferes with the reclosing process or orients the cap in an awkward way.

[0010] The present inventors sought to tether the cap to the retaining ring to minimise littering of the small components. The tethered cap becomes therefore an integrated part of the container and can be recycled possibly with the container.

[0011] They also sought to avoid the problem of the cap interfering with drinking from the bottle. The inventors have devised a solution in which the cap can be oriented (e.g. via unscrewing the cap and then bending the cap back in a plane perpendicular to the bottle neck) such that the cap forms an angle of 150° or more, such as 180° or more, with the retaining ring. The tethers between the retaining ring or bottle and the cap are sufficiently long that the cap does not snag on the retaining ring as it is bent away from the bottle neck. In the fully open orientation therefore, there is preferably a gap between the cap and the retaining ring.

[0012] In this way, the cap is so far from the neck of the bottle that it does not interfere with drinking from the bottle.

Summary of Invention

[0013] Viewed from one aspect the invention provides a bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end joined to the cap, and a lower end joined to the retaining ring, wherein as the cap is unscrewed it separates from the retaining ring but remains connected to said retaining ring via the connecting portions; and

wherein, in the open configuration, the cap can be oriented such that the cap and retaining ring define an angle of at least 150°, especially at least 180°.

[0014] This angle is measured between the upper surface of the retaining ring and the lower surface of the cap. It will

be appreciated that the lower surface of the cap, having been bent back through 180 degrees is uppermost.

[0015] Viewed from another aspect the invention provides a bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end joined to the cap, and a lower end joined to the retaining ring, wherein as the cap is unscrewed it separates from the retaining ring but remains connected to said retaining ring via the connecting portions; and

wherein, in the open configuration, the cap can be oriented such that the cap and retaining ring define an angle of at least 150°, especially at least 180°; and

wherein an underside of the cap is provided with a projection having a cam face for cooperating with the bottle opening.

[0016] Viewed from another aspect the invention provides a bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end joined to the cap, a lower end joined to the retaining ring, and first and second tilting portions disposed between upper and lower ends and joined at an expansion point,

wherein said first and second tilting portions are substantially parallel in the closed configuration and wherein in the closed configuration the first and second tilting portions of the first connecting portion extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the second connecting portion, and wherein in the closed configuration the first and second tilting portions of the second connecting portion extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the first connecting portion,

and wherein, in use, as the cap is unscrewed it separates from the retaining ring but remains connected thereto via the connecting portions which expand to accommodate movement of the cap away from the retaining ring.

[0017] Viewed from another aspect the invention provides a bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end joined to the cap, a lower end joined to the retaining ring, and first and second tilting portions disposed between upper and lower ends and joined at an expansion point,

wherein said first and second tilting portions are substantially parallel in the closed configuration and wherein in the closed configuration the first and second tilting portions of the first connecting portion extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the second connecting portion, and wherein in the closed configuration the first and second tilting portions of the second connecting portion extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the first connecting portion,

wherein, in use, as the cap is unscrewed it separates from the retaining ring but remains connected thereto via the connecting portions which expand to accommodate movement of the cap away from the retaining ring; and

wherein an underside of the cap is provided with a projection having a cam face for cooperating with the bottle opening.

[0018] Viewed from another aspect the invention provides a bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end joined to the cap, a lower end joined to the retaining ring, and first and second tilting portions disposed between upper and lower ends and joined at an expansion point,

wherein an underside of the cap is provided with a projection having a cam face for cooperating with the bottle opening.

[0019] Viewed from another aspect the invention provides a bottle comprising a bottle closure assembly as hereinbefore defined.

Detailed Description of Invention

[0020] The present invention relates to a bottle closure assembly which comprises a cap and a retaining ring tethered to the cap via two connecting portions. Preferably there are two connecting portions only. In one embodiment, the invention also describes a bottle comprising a bottle closure assembly of the invention.

[0021] The bottle closure assembly is applied to the neck of a bottle to close it and hence seal the bottle. The neck of the bottle and the bottle closure assembly are provided with male and female screw threads to enable this. During manufacturing, the bottle closure assembly is therefore screwed onto the bottle neck.

[0022] The term "closed configuration" describes the situation where the bottle cap assembly is fully screwed onto the bottle. The term "open configuration" describes the situation where the cap is fully unscrewed and bent back away from the bottle neck to allow the consumer to readily drink from the bottle.

[0023] The retaining ring is attached to the cap via two non frangible tethers called connecting portions herein but before the cap is first unscrewed, a plurality of frangible tethers may almost be present connecting the cap to the retaining ring. These frangible tethers are designed to break when the cap is unscrewed during the bottle opening process as is well known in the art. These frangible tethers also provide evidence that the cap has not been tampered with.

[0024] On unscrewing, the cap begins to separate from the retaining ring. The retaining ring remains attached to the neck of the bottle at all times. Whilst the retaining ring might rotate, it does not detach or move up or down the bottle neck. Often the neck of the bottle is provided with a flange that prevents the retaining ring from becoming detached or moving up the bottle neck. The bottle closure assembly of the invention is typically circular in cross section. The bottle closure assembly may have a diameter if 1.5 to 5.0 cm.

[0025] The bottle closure assembly comprises two non frangible connectors called the first and second connecting portions herein. These connect the cap to the retaining ring where the connecting portions connect two points on the cap to two points on the retaining ring.

[0026] The connecting portions are designed so that in use the cap can be unscrewed and then bent back to create an angle of at least 150° between the retaining ring and the cap, such as at least 180°. In order to allow such angles to be created, it is preferred if the cap is distanced from the retaining ring in its open configuration. In particular, it is preferred that the cap does not touch the retaining ring in the open configuration.

[0027] If the connecting portions between the cap and retaining ring are short then as the cap is bent back, the top and/or sides of the cap might make contact the retaining ring or the bottle itself, e.g. the neck thereof. This can prevent the desired 180° angle being achieved as the retaining ring, which might project from the bottle neck, or the bottle itself prevents the cap being bent back further.

[0028] It is therefore preferred if the connecting portions between the cap and retaining portion are sufficiently long that the cap is distanced from (i.e. does not make contact with) the retaining ring or bottle neck when the cap bent back and away from the bottle.

[0029] The cap does not therefore interfere when the consumer drinks from the bottle. Moreover, as the cap is still connected to the retaining ring via two connecting portions, the cap is readily returned to the bottle neck to reseal it.

[0030] Each of the connecting portions comprises an upper end joined to the cap, and a lower end joined to the retaining ring. It is preferred if the upper end of the first connecting portion connects to the cap at a location directly above where the lower end of the connecting portion connects to the retaining ring. In the closed configuration therefore, the upper and lower ends preferably lie on a vertical line.

[0031] The same applies to the second connecting portion.

[0032] In a preferred embodiment, first and second tilting portions are disposed between upper and lower ends of the connecting portions and joined at an expansion point. Each connecting portion therefore contains an upper end, first tilting portion, expansion point, second tilting portion and a lower end (in that order).

[0033] It is preferred that in the closed configuration, the first and second tilting portions are substantially parallel however it will be appreciated that the tilting portions may also form a < or > shape. The acute angle between tilting portions is preferably less than 45 degrees.

[0034] In the closed configuration, the first and second tilting portions are preferably substantially parallel to the top of the neck of the bottle. The words substantially parallel imply parallel to within 10°.

[0035] The first and second tilting portions preferably positioned in parallel and the first tilting portion is positioned directly above the second tilting portion. The two tilting portions should be the same length therefore. The tilting portions are essentially symmetrical about the expansion point.

[0036] Also, in the closed configuration the first and second tilting portions of the first connecting portion preferably extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the second connecting portion.

[0037] The connecting portions are therefore a mirror image of each other where the mirror is regarded as being placed exactly between the two connecting portions.

[0038] In the closed configuration, the first and second tiling portions may be at an angle of about 45 to 90° to the upper and lower ends of the connecting portion which attach to the cap and retaining ring respectively. Ideally, the first and second tiling portions may be at an angle of about 90° to the upper and lower ends of the connecting portion which attach to the cap and retaining ring respectively

[0039] The first and second tilting portions are preferably the same length. The first and second tilting portions are preferably between 2.0 and 12.0 mm in length.

[0040] In the closed configuration therefore the first and second tilting portions of the second connecting portion extend from the upper and lower ends of the second connecting portion in a direction circumferentially away from the first and second tilting portions of the first connecting portion. The expansion points of the two connecting portions are therefore

circumferentially far apart. In contrast the upper and lower ends of the first and second connecting portions are closer.

[0041] It is preferred therefore if the distance from the two expansions points is greater than the distance from the upper end of the first connecting portion to the upper end of the second connecting portion.

[0042] It is preferred therefore if the distance from the two expansions points is greater than the distance from the lower end of the first connecting portion to the lower end of the second connecting portion.

[0043] In one embodiment the upper ends of the first and second connecting portions may be between 0.5 and 1.0 cm apart.

[0044] In one embodiment the lower ends of the first and second connecting portions may be between 0.5 and 1.0 cm apart.

[0045] In one embodiment the expansion point of the first and second connecting portions may be between 0.75 and 1.5 cm apart.

[0046] In order to accommodate the connecting portions, it may be an indentation needs to be made in both the retaining ring and cap, e.g. as clearly shown in figure 1.

[0047] In use, as the cap is unscrewed it separates from the retaining ring but remains connected thereto via the connecting portions which expand around the expansion point to accommodate movement of the cap away from the retaining ring. The first and second tilting portions of said first and second connecting portions are therefore pulled apart. The tilting portions move from a substantially parallel orientation (lying on top of each other) to a substantially linear orientation. The two tilting portions may thus be arranged linearly separated by the expansion point.

[0048] In this configuration, the cap can then be bent back to create an angle of at least 150° with the retaining ring. The lower ends of the connecting portions therefore act as a hinge to allow the cap to be bent away from the bottle neck and retaining ring.

[0049] A key aspect of the invention is that the expansion points of the connecting portion are circumferentially distanced apart. In this way, the lower and upper ends of the connecting portions are comparatively closer together than if the expansion portions had been oriented in the other direction.

[0050] Having the ends of the connecting portions close to each other on both the cap and retaining ring gives the whole bottle closure assembly more flexibility. It also makes bending the cap through 150° or more, easier. The further apart the connecting portions are from each other on the retaining ring, the harder it is to bend the cap through the requisite angle. As the retaining ring is circular, the further apart the connecting portions, the more the retaining ring protrudes between the lower ends of the connecting portion. That makes it more likely that the cap snags on the retaining ring before fully opening. By orienting the connecting portions in the way defined herein, we minimise the gap between the lower ends of the connecting portions and hence maximise the opening angle.

[0051] As there are two tethering connections between retaining ring and cap, the cap cannot be twisted such that, for example, the cap faces downwards. The connecting portions ensure that in the open configuration, the underside of the cap faces upwards and can readily be returned to the bottle neck.

Guide Flange

[0052] In one embodiment, the underside of the cap is preferably provided with a flange. The top surface of the flange is provided with a cam face. The flange is preferably extends radially outwards towards the edge of the cap. There is however a gap between the end of the flange and the cap wall to allow the bottle neck to pass through. The flange may extend radially from the centre of the cap although this is not essential.

[0053] The cam face is preferably such that the larger protrusion is nearer the centre of the cap. The lowest protrusion occurs at the end of the flange nearest the cap wall.

[0054] In one embodiment there may be two flanges which are conveniently 180° apart (i.e. opposite). One or both flanges is preferably provided with a cam. The cam on both such flanges is preferably such that the flange protrudes further from the underside of the cap nearer the centre of the cap.

[0055] The cam face defines a curved surface which helps to return the cap to the bottle neck during the closing operation. As the cap is replaced, the cam face guides the cap back onto the bottle neck.

[0056] This flange prevents interference between the cap and the neck of the bottle and enables smooth opening and closing of the bottle. The flange acts as a guide in this operation.

[0057] The underside of the cap may also be provided with a circular projecting portion adapted to fit just inside the top of the bottle to aid the closing process. The circular projection typically only extends 1 to 3 mm from the underside of the cap and can be seen in figure 3c. Such a circular projecting portion has a diameter just less than the internal diameter of the top of the bottle to guide the cap onto the bottle in the initial closing process or subsequent reclosing processes. The flange is present within the circular portion and there will typically be a small gap between the circular projecting portion and the flange, e.g. 0.5 to 1.0 mm gap.

High Density Polyethylene (HDPE)

[0058] The bottle closure assembly of the invention is preferably prepared using high density polyethylene. In one embodiment therefore, a bottle closure assembly of the invention comprises at least 80 wt% HDPE, such as at least 90 wt% HDPE. It will be appreciated that all parts of the bottle closure assembly are preferably prepared from the same material as the bottle closure assembly is prepared in a single moulding process.

[0059] The bottle closure assembly of the invention can be prepared in a conventional injection moulding or compression moulding process. Preferably an injection moulding process is used.

[0060] Any HDPE used to prepare a bottle closure assembly of the invention should have good mechanical properties e.g. in terms of FNCT and tensile modulus with excellent processability and aspect, e.g. in terms of high tip and angel hair.

[0061] The HDPE used is preferably a multimodal high density ethylene polymer and may be an ethylene homopolymer or an ethylene copolymer. By ethylene copolymer is meant a polymer the majority by weight of which derives from ethylene monomer units. The comonomer contribution preferably is up to 10% by mol, more preferably up to 5 % by mol. Ideally however there are very low levels of comonomer present in the polymers of the present invention such as 0.1 to 2 mol%, e.g. 0.1 to 1 mol%.

[0062] The other copolymerisable monomer or monomers are preferably C3-20, especially C3-10, alpha olefin comonomers, particularly singly or multiply ethylenically unsaturated comonomers, in particular C3-10-alpha olefins such as propene, but-1-ene, hex-1-ene, oct-1-ene, and 4-methyl-pent-1-ene. The use of -1-hexene and 1-butene is particularly preferred. Ideally there is only one comonomer present.

[0063] It is preferred if the polymer of the invention is a copolymer and therefore comprises ethylene and at least one comonomer. Ideally that comonomer is 1-butene.

[0064] The polymer of the invention is preferably multimodal and therefore comprises at least two components. The polymer of the invention preferably comprises

- (A) a lower molecular weight first ethylene homo- or copolymer component, and
- (B) a higher molecular weight second ethylene homo- or copolymer component.

[0065] It is generally preferred if the higher molecular weight component has an Mw of at least 5000 more than the lower molecular weight component, such as at least 10,000 more.

[0066] The HDPE of the invention is preferably multimodal. Usually, a polyethylene composition comprising at least two polyethylene fractions, which have been produced under different polymerisation conditions resulting in different (weight average) molecular weights and molecular weight distributions for the fractions, is referred to as "multimodal". Accordingly, in this sense the compositions of the invention are multimodal polyethylenes. The prefix "multi" relates to the number of different polymer fractions the composition is consisting of. Thus, for example, a composition consisting of two fractions only is called "bimodal".

[0067] The form of the molecular weight distribution curve, i.e. the appearance of the graph of the polymer weight fraction as function of its molecular weight, of such a multimodal polyethylene will show two or more maxima or at least be distinctly broadened in comparison with the curves for the individual fractions.

[0068] For example, if a polymer is produced in a sequential multistage process, utilising reactors coupled in series and using different conditions in each reactor, the polymer fractions produced in the different reactors will each have their own molecular weight distribution and weight average molecular weight. When the molecular weight distribution curve of such a polymer is recorded, the individual curves from these fractions are superimposed into the molecular weight distribution curve for the total resulting polymer product, usually yielding a curve with two or more distinct maxima.

[0069] The HDPE preferably has an MFR₂ of 15.0 g/10 min or less, preferably 10.0 g/10min or less. The polymer preferably has a minimum MFR₂ of 0.1 g/10min, such as 0.2 g/10 min. The MFR₂ preferably is in the range of 0.2 to 10 g/10min.

[0070] The density of the HDPE is preferably 940 kg/m³ or more. More preferably, the HDPE has a density of 945 kg/m³ or more, still more preferably is 950 kg/m³ or more, still more preferably is 952 kg/m³ or more, and most preferably is 954 kg/m³ or more.

[0071] Furthermore, the density of the HDPE is preferably 970 kg/m³ or lower, and more preferably is 965 kg/m³ or lower. An ideal density range is 940 to 960, preferably 950 to 960 kg/m³.

[0072] Preferably, the HDPE has a tensile modulus of at least 900 kPa, more preferably at least 910 kPa.

[0073] Preferably, the HDPE has a SHI 1/100 of 10 or less, such as 2 to 10.

[0074] Preferably, the HDPE has an eta₀ of 2000 to 30000 Pas.

[0075] The HDPE preferably has an environmental stress crack resistance measured as FNCT (2% Arkopal 6.0 MPa, 50°C) of 30 h or more, more preferably 35 h or more such as 40 to 100 hrs.

[0076] The HDPE preferably has an environmental stress crack resistance measured as ESCR (10% Igepal F50) of 50 to 1000 hrs.

[0077] The HDPE preferably has a molecular weight distribution Mw/Mn, being the ratio of the weight average molecular weight Mw and the number average molecular weight Mn, of 10 or more, more preferably of 12 or more, still more preferably of 14 or more.

[0078] The HDPE preferably has an Mw/Mn of 30 or below, more preferably of 25 or below.

[0079] As noted above, the HDPE preferably comprises a lower molecular weight component (A) and a higher molecular weight component (B). The weight ratio of fraction (A) to fraction (B) in the composition is in the range 30:70 to 70:30, more preferably 35:65 to 65:35, most preferably 40:60 to 60:40. In some embodiments the ratio may be 45 to 55 wt% of fraction (A) and 55 to 45 wt% fraction (B), such as 45 to 52 wt% of fraction (A) and 55 to 48 wt% fraction (B). It has been found however that the best results are obtained when the HMW component is present at the same percentage or even predominates, e.g. 50 to 54 wt% of the HMW component (B) and 50 to 46 wt% fraction (A).

[0080] Fractions (A) and (B) may both be ethylene copolymers or ethylene homopolymers, although preferably at least one of the fractions is an ethylene copolymer. Preferably, the polymer comprises an ethylene homopolymer and an ethylene copolymer component.

[0081] Where one of the components is an ethylene homopolymer, this is preferably the component with the lower weight average molecular weight (Mw), i.e. fraction (A). An ideal polymer is therefore a lower molecular weight homopolymer component (A) with a higher molecular weight component (B), ideally an ethylene butene higher molecular weight component.

[0082] The lower molecular weight fraction (A) preferably has an MFR₂ of 10 g/10min or higher, more preferably of 50 g/10min or higher, and most preferably 100 g/10min or higher.

[0083] Furthermore, fraction (A) preferably, has an MFR₂ of 1000 g/10 min or lower, preferably 800 g/10 min or lower, and most preferably 600 g/10min or lower.

[0084] The weight average molecular weight Mw of fraction (A) preferably is 10 kD or higher, more preferably is 20 kD or higher. The Mw of fraction (A) preferably is 90 kD or lower, more preferably 80 kD or lower, and most preferably is 70 kD or lower.

[0085] Preferably, fraction (A) is an ethylene homo- or copolymer with a density of at least 965 kg/m³.

[0086] Most preferably, fraction (A) is an ethylene homopolymer. If fraction (A) is a copolymer, the comonomer is preferably 1-butene. The comonomer content of fraction (A), if it is a copolymer, is preferably very low, such as less than 0.2 mol%, preferably less than 0.1 mol%, especially less than 0.05 mol%. A further preferred option therefore, is for fraction (A) to be a homopolymer or a copolymer with a very low comonomer content, such as less than 0.2 mol%, preferably less than 0.1 mol%, especially less than 0.05 mol%. The higher Mw fraction (B) is then preferably a copolymer.

[0087] The higher molecular weight fraction (B) preferably has an Mw of 60 kD or higher, more preferably of 100 kD or higher. Furthermore, fraction (B) preferably has an Mw of 500 kD or lower, more preferably of 400 kD or lower.

[0088] Preferably, fraction (B) is an ethylene homo- or copolymer with a density of less than 965 kg/m³.

[0089] Most preferably, fraction (B) is a copolymer. Preferred ethylene copolymers employ alpha-olefins (e.g. C3-12 alpha-olefins) as comonomers. Examples of suitable alpha-olefins include but-1-ene, hex-1-ene and oct-1-ene. But-1-ene is an especially preferred comonomer.

[0090] Where herein features of fractions (A) and/or (B) are given, these values are generally valid for the cases in which they can be directly measured on the respective fraction, e.g. when the fraction is separately produced or produced in the first stage of a multistage process. However, the composition may also be and preferably is produced in a multistage process wherein e.g. fractions (A) and (B) are produced in subsequent stages. In such a case, the properties of the fractions produced in the second step (or further steps) of the multistage process can either be inferred from polymers, which are separately produced in a single stage by applying identical polymerisation conditions (e.g. identical temperature, partial pressures of the reactants/diluents, suspension medium, reaction time) with regard to the stage of the multistage process in which the fraction is produced, and by using a catalyst on which no previously produced polymer is present. Alternatively, the properties of the fractions produced in a higher stage of the multistage process may also be calculated, e.g. in accordance with B. Hagström, Conference on Polymer Processing (The Polymer Processing Society), Extended Abstracts and Final Programme, Gothenburg, August 19 to 21, 1997, 4:13.

[0091] Thus, although not directly measurable on the multistage process products, the properties of the fractions produced in higher stages of such a multistage process can be determined by applying either or both of the above methods. The skilled person will be able to select the appropriate method.

[0092] A multimodal (e.g. bimodal) HDPE as hereinbefore described may be produced by mechanical blending two or more polyethylenes (e.g. monomodal polyethylenes) having differently centred maxima in their molecular weight distributions. The monomodal polyethylenes required for blending may be available commercially or may be prepared using any conventional procedure known to the skilled man in the art. Each of the polyethylenes used in a blend and/or the final polymer composition may have the properties hereinbefore described for the lower molecular weight component, higher molecular weight component and the composition, respectively.

[0093] Preferably, the multimodal HDPE may be produced by polymerisation using conditions which create a multimodal (e.g. bimodal) polymer product, e.g. using a catalyst system or mixture with two or more different catalytic sites,

each site obtained from its own catalytic site precursor, or using a two or more stage, i.e. multistage, polymerisation process with different process conditions in the different stages or zones (e.g. different temperatures, pressures, polymerisation media, hydrogen partial pressures, etc).

[0094] Preferably, the multimodal (e.g. bimodal) composition is produced by a multistage ethylene polymerisation, e.g. using a series of reactors, with optional comonomer addition preferably in only the reactor(s) used for production of the higher/highest molecular weight component(s) or differing comonomers used in each stage. A multistage process is defined to be a polymerisation process in which a polymer comprising two or more fractions is produced by producing each or at least two polymer fraction(s) in a separate reaction stage, usually with different reaction conditions in each stage, in the presence of the reaction product of the previous stage which comprises a polymerisation catalyst. The polymerisation reactions used in each stage may involve conventional ethylene homopolymerisation or copolymerisation reactions, e.g. gas-phase, slurry phase, liquid phase polymerisations, using conventional reactors, e.g. loop reactors, gas phase reactors, batch reactors etc. (see for example WO97/44371 and WO96/18662).

[0095] Polymer compositions produced in a multistage process are also designated as "in-situ" blends.

[0096] Accordingly, it is preferred that fractions (A) and (B) are produced in different stages of a multistage process.

[0097] Preferably, the multistage process comprises at least one gas phase stage in which, preferably, fraction (B) is produced.

[0098] Further preferred, fraction (B) is produced in a subsequent stage in the presence of fraction (A) which has been produced in a previous stage.

[0099] It is previously known to produce multimodal, in particular bimodal, olefin polymers, such as multimodal polyethylene, in a multistage process comprising two or more reactors connected in series.

[0100] Preferably, the main polymerisation stages of the multistage process for producing the composition according to the invention are such as described in EP 517 868, i.e. the production of fractions (A) and (B) is carried out as a combination of slurry polymerisation for fraction (A)/gas-phase polymerisation for fraction (B). The slurry polymerisation is preferably performed in a so-called loop reactor. Further preferred, the slurry polymerisation stage precedes the gas phase stage.

[0101] Optionally and advantageously, the main polymerisation stages may be preceded by a prepolymerisation, in which case up to 20 % by weight, preferably 1 to 10 % by weight, more preferably 1 to 5 % by weight, of the total composition is produced. The prepolymer is preferably an ethylene homopolymer (High Density PE). At the prepolymerisation, preferably all of the catalyst is charged into a loop reactor and the prepolymerisation is performed as a slurry polymerisation. Such a prepolymerisation leads to less fine particles being produced in the following reactors and to a more homogeneous product being obtained in the end.

[0102] The polymerisation catalysts include coordination catalysts of a transition metal, such as Ziegler-Natta (ZN), metallocenes, non-metallocenes, Cr-catalysts etc. The catalyst may be supported, e.g. with conventional supports including silica, Al-containing supports and magnesium dichloride based supports. Preferably the catalyst is a ZN catalyst, more preferably the catalyst is silica supported ZN catalyst.

[0103] The Ziegler-Natta catalyst further preferably comprises a group 4 (group numbering according to new IUPAC system) metal compound, preferably titanium, magnesium dichloride and aluminium.

[0104] Suitable HDPEs are available commercially.

[0105] The bottle closure assembly may be prepared from a composition in which HDPE is combined with minor quantities of additives such as pigments, nucleating agents, antistatic agents, fillers, antioxidants, etc., generally in amounts of up to 10 % by weight, preferably up to 5 % by weight.

[0106] Optionally, additives or other polymer components can be added during the compounding step in the amount as described above. The bottle closure assembly is preferably at least 90 wt% of the HDPE, such as at least 95 wt%.

[0107] In one embodiment, the bottle closure assembly consist essentially of the HDPE. The term consists essentially of means that the HDPE is the only "non additive" polyolefin present. It will be appreciated however that such a polymer may contain standard polymer additives some of which might be supported on a polyolefin (a so called masterbatch as is well known in the art). The term consists essentially of does not exclude the presence of such a supported additive.

[0108] The bottle cap assembly of the invention is preferably 5g or less, such as 4 g or less in weight, such as 3.0 g or less, e.g. less than 2.0 g, such as 0.5 to 3.0 g.

Brief Description of the Figures

[0109] Figure 1 shows a bottle closure assembly (1) in its closed configuration. A cap (2) is connected to a retaining ring (3) via a plurality of frangible links which will break when the cap is opened.

[0110] First connecting portion (4) has tilting portions (5a) and (5b) connected via an expansion point (6). The tilting portions are parallel in the closed configuration. Second connecting portion (7) has the same features but in mirror image.

[0111] In order to accommodate the connecting portions the cap and retaining ring have an indentation.

[0112] In Figure 2, the thread within the bottle closure can be seen along with the flange (10) which aids the resealing

of the bottle.

[0113] In Figures 3a-d, a bottle opening process is shown. In Figure 3a, the cap is shown on a bottle in closed form. The cap is connected to the retaining ring via a plurality of frangible bridges. The first connecting portion has tilting portions connected via an expansion point as described in Figure 1. The tilting portions are parallel in the closed configuration. Second connecting portion has the same features but in mirror image.

[0114] In Figure 3b, the cap has been unscrewed and is separated from the retaining ring which remains on the bottle. The tilting portions extend thus allowing the cap to be separated from the top of the bottle. The cap remains attached to the retaining ring.

[0115] Figure 3c shows the unscrewed cap in cross section showing the position of the flange and the circular projecting portion adapted to fit the inside of the bottle top. There is a small gap between the circular projecting portion and flange.

[0116] The cap can then be bent back on itself. This is shown in Figure 3d. The lower ends of the connecting portion function as a hinge to allow the cap to be bent back. In Figure 3d, the cap is bent fully back to form an angle of 180 degrees between the cap and retaining ring.

[0117] When the bottle is closed, the cam face on the flange guides the cap into the correct position to enable the resealing operation. The connectors compress around the expansion point and return to the C shape closed configuration.

Examples

[0118] HDPEs suitable for use in the invention include:

Sr no	Material	Density	Melt Flow Rate (190°C/2.1 6kg)	Tensile Modulus (1mm/min)	ESCR (10% Igepal- F50)	FNCT (2% Arkopal, 6.0Mpa, 50°C)	SHI 1/100	ETA 0
AST M/ISO Standards		ISO 1183	ISO 1133	ISO 527-2	ASTM D1693-B	ISO 16770		Pas
1	BorPure™ MB6561	955 kg/m³	1.5 g/10min	920 MPa	400 Hours	40 Hours	6.8	11,971
2	BorPure™ MB6562	955 kg/m³	1.5 g/10min	920 MPa	400 Hours	40 Hours	7.2	12,260
3	BorPure™ MB5568	956 kg/m³	0.8 g/10min	1000 MPa	750 Hours	65 Hours	7.9	24,165
4	BorPure™ MB5569	956 kg/m³	0.8 g/10min	1000 MPa	750 Hours	65 Hours	7.8	23,849
5	BorPure™ MB7581	958 kg/m³	4.0 g/10min	1100 MPa	40 Hours	NA	5.7	4,154
6	Borstar® FB5600	960 kg/m³	0.7 g/10min	1100/1650 MPa	72 Hours	NA	7.0	25,492

[0119] These HDPEs can be conveniently injection moulded to form the bottle closure assemblies of the invention.

Claims

1. A bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring; each of the connecting portions comprises an upper end joined to the cap, and a lower end joined to the retaining ring, wherein as the cap is unscrewed it separates from the retaining ring but remains connected to said retaining ring via the connecting portions; and wherein, in the open configuration, the cap can be oriented such that the cap and retaining ring define an angle of at least 150°, especially at least 180°.

2. A bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring;
5 each of the connecting portions comprises an upper end joined to the cap, a lower end joined to the retaining ring, and first and second tilting portions disposed between upper and lower ends and joined at an expansion point, wherein an underside of the cap is provided with a projection having a cam face for cooperating with the bottle opening.
3. A bottle closure assembly comprising a cap, a retaining ring, and first and second connecting portions connecting the cap to the retaining ring, the cap being provided with a male thread configured to reversibly engage a female thread on a bottle opening, the retaining ring being configured to engage a bottle neck and where the connecting portions connect two points on the cap to two points on the retaining ring;
10 each of the connecting portions comprises an upper end joined to the cap, a lower end joined to the retaining ring, and first and second tilting portions disposed between upper and lower ends and joined at an expansion point,
15 wherein said first and second tilting portions are substantially parallel in the closed configuration and wherein in the closed configuration the first and second tilting portions of the first connecting portion extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the second connecting portion, and wherein in the closed configuration the first and second tilting portions of the second connecting portion extend from the upper and lower ends in a direction circumferentially away from the first and second tilting portions of the first connecting portion,
20 wherein, in use, as the cap is unscrewed it separates from the retaining ring but remains connected thereto via the connecting portions which expand to accommodate movement of the cap away from the retaining ring; and wherein an underside of the cap is provided with a projection having a cam face for cooperating with the bottle opening.
- 25 4. A bottle closure assembly as claimed in claim 1 to 3 which comprises a polyethylene composition.
5. A bottle closure assembly as claimed in claim 1 to 4 which comprises a HDPE.
6. A bottle closure assembly as claimed in claim 1 to 5 which comprises a multimodal HDPE.
- 30 7. A bottle closure assembly as claimed in any previous claim comprising a HDPE having an MFR₂ of 0.2 to 10 g/10min, and a density of 940 to 960 kg/m³.
8. A bottle closure assembly as claimed in any previous claim comprising one more of:
35 a HDPE having an SHI 1/100 of not more than 10;
eta zero (Pas) of 30000 or less;
ESCR F50 of 50-1000 hrs.;
FNCT at least 40 hrs.
- 40 9. A bottle closure assembly as claimed in any previous claim weighing 5.0 g or less, preferably 3.0 g or less, especially 1.5 g or less.
10. A bottle closure assembly as claimed in any preceding claim wherein before the cap is first unscrewed a plurality of frangible bridges connect said cap to the retaining ring.
- 45 11. A bottle closure assembly as claimed in any preceding claim wherein, in use, as the cap is unscrewed it separates from the retaining ring and the first and second tilting portions of said first and second connecting portions are pulled apart.
- 50 12. A bottle closure assembly as claimed in any preceding claim wherein the lower ends of the connecting portions act as a hinge.
13. A bottle closure assembly as claimed in any preceding claim wherein after unscrewing the cap, it can be rotated through an angle of at least 150° such as 180° whilst remaining connected to the retaining ring.
- 55 14. A bottle comprising a bottle closure assembly as claimed in any preceding claim.

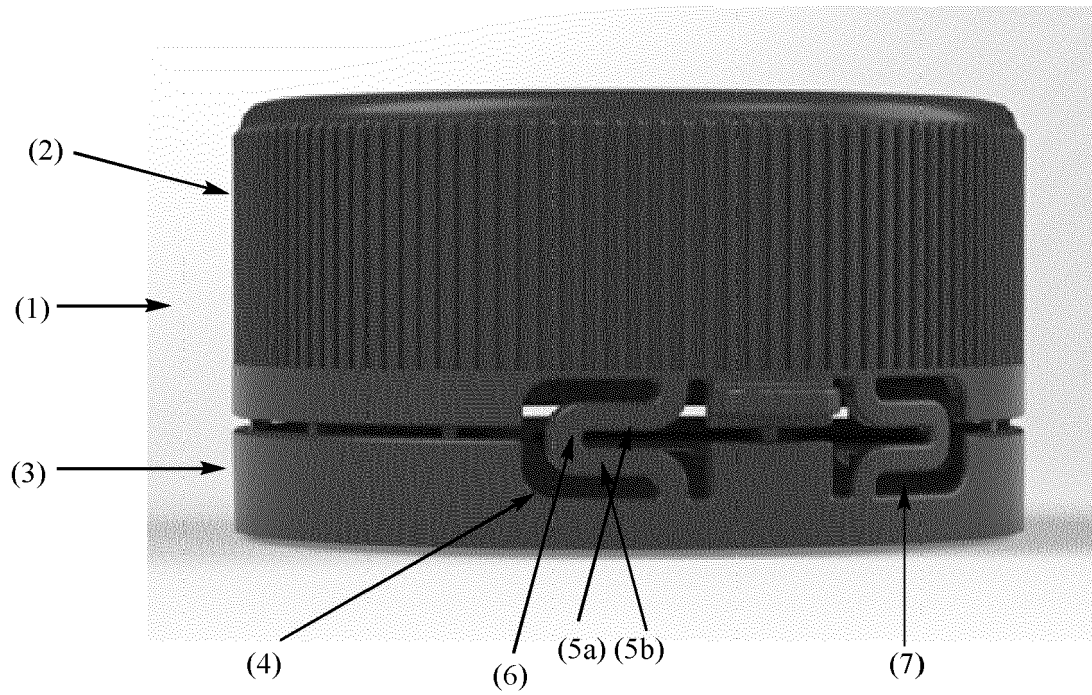


Figure 1

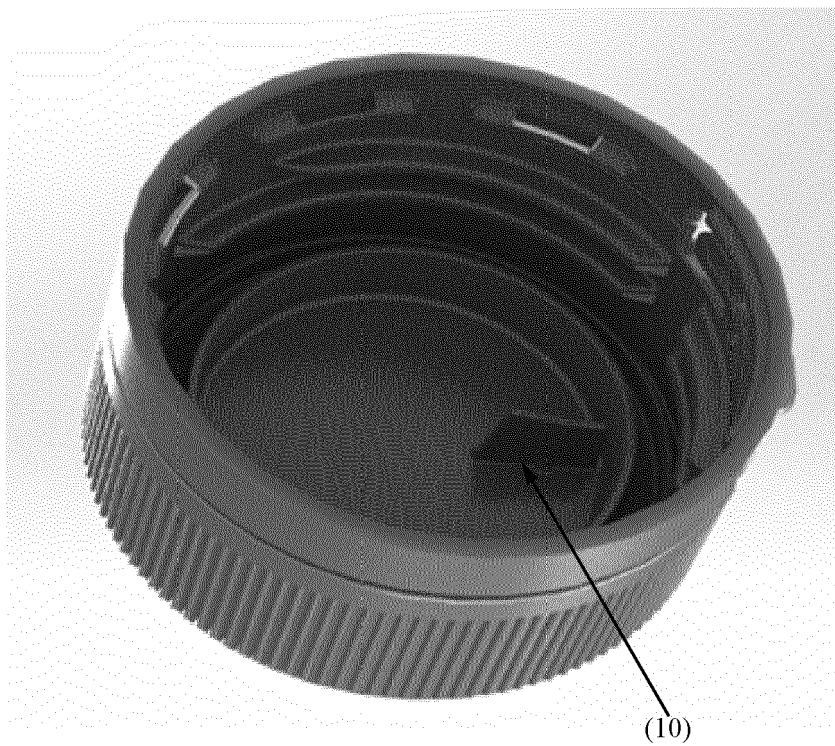


Figure 2

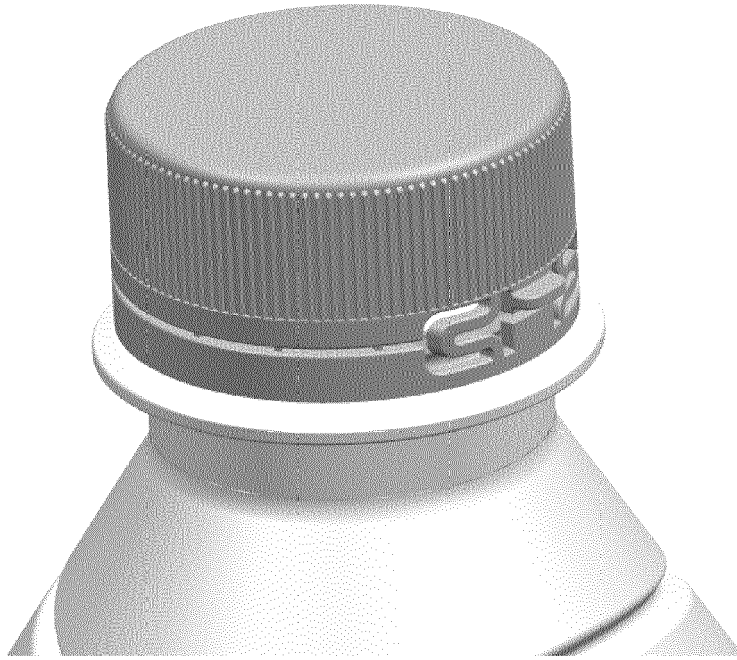


Figure 3a

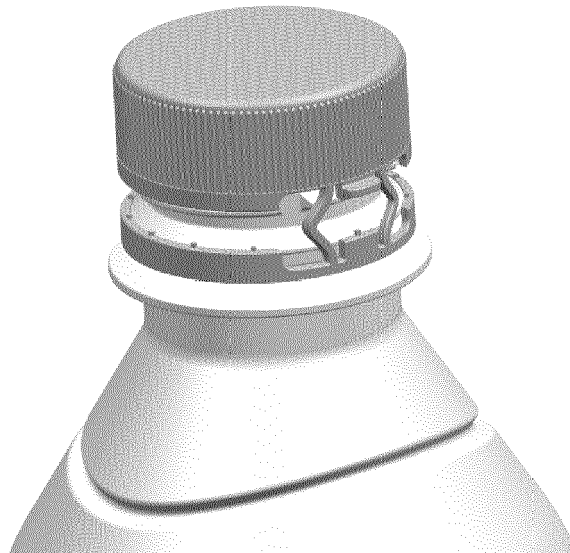


Figure 3b

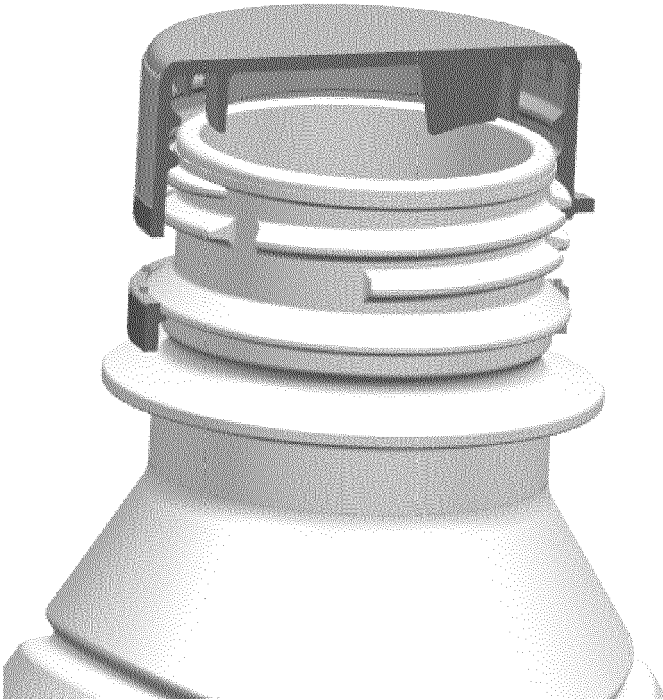


Figure 3c

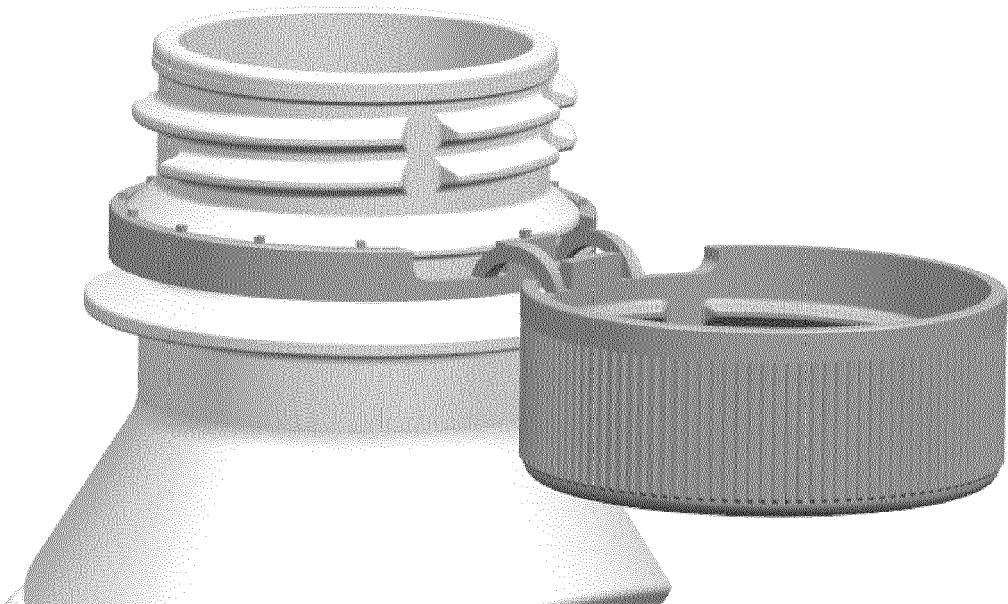


Figure 3d



EUROPEAN SEARCH REPORT

Application Number

EP 21 18 2602

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2021/068058 A1 (HUSKY INJECTION MOLDING SYSTEMS LTD [CA]) 15 April 2021 (2021-04-15) * abstract; figures 1,6a,7 * * page 15, line 13 - line 17 * -----	1,4-10, 12-14	INV. B65D41/34 B65D55/16
X,D	JP 2011 173600 A (CROWN CORK JAPAN) 8 September 2011 (2011-09-08) * figures 1,4,5 * -----	2-12,14	
X	WO 2020/227813 A1 (HUSKY INJECTION MOLDING SYSTEMS LTD [CA]) 19 November 2020 (2020-11-19) * abstract; figures 1-3,7-9 * -----	1-14	
X	WO 2021/018772 A1 (BERICAP GMBH & CO KG [DE]) 4 February 2021 (2021-02-04) * abstract; figures 4,7 * -----	1,4-10, 12-14	
X	US 2020/399036 A1 (DAI KEITH H [TW]) 24 December 2020 (2020-12-24) * abstract; figures 1,7,8 * -----	2,4-12, 14	TECHNICAL FIELDS SEARCHED (IPC) B65D
1 The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 2 December 2021	Examiner Tempels, Marco
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 21 18 2602

5

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

02-12-2021

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2021068058 A1	15-04-2021	EP 3880578 A1	22-09-2021
		WO 2021068058 A1	15-04-2021
JP 2011173600 A	08-09-2011	JP 5590913 B2	17-09-2014
		JP 2011173600 A	08-09-2011
WO 2020227813 A1	19-11-2020	CA 3137383 A1	19-11-2020
		CN 111924311 A	13-11-2020
		CN 212797893 U	26-03-2021
		EP 3880577 A1	22-09-2021
		WO 2020227813 A1	19-11-2020
WO 2021018772 A1	04-02-2021	NONE	
US 2020399036 A1	24-12-2020	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 20190168935 A [0005]
- WO 2019207148 A [0006]
- JP 2011173600 B [0007]
- WO 9744371 A [0094]
- WO 9618662 A [0094]
- EP 517868 A [0100]

Non-patent literature cited in the description

- **B. HAGSTRÖM.** *Conference on Polymer Processing (The Polymer Processing Society), Extended Abstracts and Final Programme*, 19 August 1997, vol. 4, 13 [0090]