

CONTENTS FILLING METHOD, CONTENTS FILLING SYSTEM, AND CONTENTS-FILLED BOTTLE

TECHNICAL FIELD

5 [0001] The present invention relates to a contents filling method, a contents filling system and a contents-filled bottle, and more particularly to a contents filling method, a contents filling system and a contents-filled bottle, which can prevent or reduce oxidation degradation of the contents of a bottle by
10 reducing the initial amount of oxygen in the bottle.

BACKGROUND ART

[0002] There has recently been a demand for reducing the weight of plastic bottles by reducing the amount of plastic
15 materials used for plastic bottles. A reduction in the weight of a plastic bottle, however, leads to a lowering of the strength and the content preservability (oxygen barrier properties) of the bottle.

[0003] A technique that involves blending a material for a plastic bottle with a material having oxygen insulating properties or oxygen absorbing properties to enhance the content preservability (oxygen barrier properties) of the
20 resulting plastic bottle, and a technique for providing a plastic bottle with a multilayer structure to enhance the gas barrier properties (reduce oxidation of contents with time) of the plastic bottle are currently used.

[0004] There also exists a filling (packaging) technique which involves filling contents into a plastic bottle, and thereafter replacing oxygen in the headspace of the bottle with an inert
30 gas to remove the oxygen from the headspace (to reduce the initial oxidation of the contents) (Japanese Patent Laid-Open Publication No. 2008-155943).

[0005] On the other hand, Japanese Patent Laid-Open Publication No. 2002-301441 describes a technique which
35 involves injecting a mixture of an inert gas and cleaning water (rinsing water) into an empty bottle.

[0005] [Patent documents]

Patent document 1: Japanese Patent Laid-Open Publication No. 2008-155943

5 Patent document 2: Japanese Patent Laid-Open Publication No. 2002-301441

DISCLOSURE OF THE INVENTION

[0007] In the method of blowing an inert gas into the headspace of a contents-filled bottle to replace oxygen with the inert gas, as described in Japanese Patent Laid-Open Publication
10 No. 2008-155943, there is a limit on the gas replacement ratio. In particular, some contents entrain the surrounding air upon their filling and generate bubbles, and the bubbles sometimes hardly collapse. When replacing oxygen with an inert gas in
15 the headspace of a bottle filled with such formable contents, oxygen existing in that space (space over the liquid surface) of the headspace which lies outside bubbles, can be replaced with the inert gas, but oxygen existing inside the bubbles cannot be replaced. The oxygen existing inside the bubbles is released
20 into the headspace as the bubbles collapse after a certain amount of time has elapsed, resulting in an increase in the amount of oxygen in the headspace.

[0008] In the method of Japanese Patent Laid-Open Publication No. 2002-301441, on the other hand, injection of an inert gas
25 into a bottle and injection of cleaning water (rinsing water) into the bottle are not carried out in separate steps; a mixture of the rinsing water and the inert gas is sprayed into the bottle. The rinsing water is therefore difficult to drain off and will remain in a mist form on the interior surface of the bottle.

30 [0009] The present invention has been made in view of the above situation. It is therefore an object of the present invention to provide a contents filling method, a contents filling system and a contents-filled bottle, which can prevent or reduce oxidation degradation of the contents of a bottle by reducing the
35 amount of oxygen initially existing in the bottle.

[0010] In order to achieve the object, the present invention

provides a contents filling method for filling contents into a bottle having a mouth portion and a bottle body, comprising: an inert gas replacement step of supplying only an inert gas from the mouth portion into the bottle body to replace the air in the bottle body with the inert gas; and a contents filling step of
5 filling contents from the mouth portion into the bottle body.

[0011] In a preferred embodiment of the present invention, the contents filling method further comprises, before the inert gas replacement step, a sterilization step of sterilizing the interior of the bottle and a rinsing step of supplying rinsing water from the
10 mouth portion into the bottle body.

[0012] In a preferred embodiment of the present invention, the contents filling method further comprises, before the inert gas replacement step, a sterilization step of sterilizing the interior of the bottle by electron beam irradiation.
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[0013] In a preferred embodiment of the present invention, the contents filling method further comprises, after the contents filling step, an inert gas supply step of supplying an inert gas from the mouth portion into the bottle body. [0014] In a preferred embodiment of the present invention, the contents filling method further comprises, after the inert gas supply step, a cap mounting step of mounting a cap to the mouth portion.
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[0015] In a preferred embodiment of the present invention, in the contents filling step, the contents are filled from the mouth portion into the bottle body at a temperature of 5°C to 55°C.
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[0016] In a preferred embodiment of the present invention, the entire process is carried out in a sterile atmosphere.

[0017] In a preferred embodiment of the present invention, in the contents filling step, bubbles containing the inert gas which has been introduced into the bottle body in the inert gas replacement step are generated in the contents which have been filled into the bottle body.
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[0018] In a preferred embodiment of the present invention, the contents consist of a tea beverage, a milk beverage, a coffee beverage, a functional beverage, a vegetable juice or a fruit juice.
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[0019] In a preferred embodiment of the present invention, the time interval between the inert gas replacement step and the contents filling step is 0.5 to 20 seconds.

5 [0020] In a preferred embodiment of the present invention, the bottle body of the bottle includes a body portion and a bottom portion having a petaloid shape.

[0021] In a preferred embodiment of the present invention, the bottle body of the bottle includes a body portion and a bottom portion having a depressed portion, the depth of the depressed portion being 4% to 40% of the outside diameter of the body portion.

[0022] The present invention also provides a contents filling system for filling contents into a bottle having a mouth portion and a bottle body, comprising: an inert gas replacement section for supplying only an inert gas from the mouth portion into the bottle body to replace the air in the bottle body with the inert gas; and a contents filling section, provided downstream of the inert gas replacement section, for filling contents from the mouth portion into the bottle body.

20 [0023] In a preferred embodiment of the present invention, the contents filling system further comprises a sterilization section, provided upstream of the inert gas replacement section, for sterilizing the interior of the bottle, and a rinsing section, provided upstream of the inert gas replacement section and downstream of the sterilization section, for supplying rinsing water from the mouth portion into the bottle body.

[0024] In a preferred embodiment of the present invention, the contents filling system further comprises a sterilization section, provided upstream of the inert gas replacement section, for sterilizing the interior of the bottle by electron beam irradiation.

30 [0025] In a preferred embodiment of the present invention, the contents filling system further comprises an inert gas supply section, provided downstream of the contents filling section, for supplying an inert gas from the mouth portion into the bottle body.

35 [0026] In a preferred embodiment of the present invention, the

contents filling system further comprises a cap mounting section, provided downstream of the inert gas supply section, for mounting a cap to the mouth portion.

[0027] In a preferred embodiment of the present invention, the
5 bottle body of the bottle includes a body portion and a bottom portion having a petaloid shape.

[0028] In a preferred embodiment of the present invention, the bottle body of the bottle includes a body portion and a bottom portion having a depressed portion, the depth of the depressed
10 portion being 4% to 40% of the outside diameter of the body portion.

[0029] The present invention also provides a contents-filled bottle comprising: a bottle having a bottle body and a mouth portion; and contents filling the bottle body, wherein bubbles
15 containing an inert gas are formed in the contents.

[0030] In a preferred embodiment of the present invention, the bottle body of the bottle includes a body portion and a bottom portion having a petaloid shape.

[0031] In a preferred embodiment of the present invention, the
20 bottle body of the bottle includes a body portion and a bottom portion having a depressed portion, the depth of the depressed portion being 4% to 40% of the outside diameter of the body portion.

[0032] According to the present invention, contents are filled
25 from the mouth portion into the bottle body after supplying an inert gas from the mouth portion into the bottle body and thereby replacing the air in the bottle body with the inert gas. Accordingly, the bottle body can be filled with the inert gas while generating bubbles of the inert gas in the contents. This
30 can reduce the amount of oxygen initially existing in the bottle (the initial total amount of oxygen in the bottle), thereby reducing the initial oxidation degradation of the contents.

[0033] According to the present invention, the rinsing step of supplying rinsing water from the mouth portion into the bottle
35 body is provided before the inert gas replacement step of supplying only an inert gas from the mouth portion into the

bottle body to replace the air in the bottle body with the inert gas. The rinsing water can therefore be effectively removed by the inert gas.

5 [0034] According to the present invention, the inert gas supply step of supplying an inert gas from the mouth portion into the bottle body is provided after the contents filling step. This can replenish the loss of the previously-supplied inert gas from the bottle body during transportation of the bottle, making it possible to reduce the amount of oxygen initially existing in the
10 bottle (the initial total amount of oxygen in the bottle) and more securely prevent the initial oxidation degradation of the contents.

[0035] According to the present invention, the contents are filled from the mouth portion into the bottle body at a
15 temperature of 5°C to 55°C and the entire process is carried out in a sterile atmosphere. Thus, the contents are not subjected to a heating process. This can avoid heat deterioration of the contents.

[0036] According to the present invention, the initial oxidation
20 degradation of the contents can be effectively reduced even when the contents are foamable, such as a tea beverage, a milk beverage, a coffee beverage, a functional beverage, a vegetable juice or a fruit juice.

[0037] Further, according to the present invention, the time
25 interval between the inert gas replacement step and the contents filling step is preferably 0.5 to 20 seconds. The process for filling contents into a bottle can thus be performed at a high rate.

30 BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing the construction of a contents filling system according to an embodiment of the present invention;

FIG. 2 is a schematic diagram showing the rinsing section
35 and the inert gas replacement section of the contents filling system according to the present invention;

FIG. 3 is a flow diagram showing a contents filling method according to an embodiment of the present invention;

FIGS. 4A through 4C are diagrams showing a bottle in the respective steps of the contents filling method according to the present invention;

FIG. 5 is a graph showing comparative data on the initial total amount of oxygen in bottle;

FIG. 6 is a graph showing comparative data on change with time of the total amount of oxygen in bottle;

FIGS. 7A and 7B are diagrams showing a bottle of Example A;

FIGS. 8A and 8B are diagrams showing a bottle of Example B;

FIGS. 9A and 9B are diagrams showing a bottle of Example C; and

FIGS. 10A and 10B are diagrams showing a bottle of Example D.

BEST MODE FOR CARRYING OUT THE INVENTION

[0039] Preferred embodiments of the present invention will now be described in detail with reference to the drawings. FIGS. 1 through 4 are diagrams show an embodiment of the present invention.

[0040] <Contents filling system>

A contents filling system according to an embodiment of the present invention will be described first with reference to FIGS. 1 and 2.

[0041] The contents filling system 10 shown in FIG. 1 is a system for filling contents 43 into a bottle 30 having a mouth portion 31 and a bottle body 32. The contents filling system 10 includes a sterilization section 11, a rinsing section 12, an inert gas replacement section 13, a contents filling section 14, an inert gas supply section 15, and a cap mounting section 16. The sterilization section 11, the rinsing section 12, the inert gas replacement section 13, the contents filling section 14, the inert gas supply section 15, and the cap mounting section 16 are

disposed in this order from the upstream side to the downstream side.

[0042] A first transport mechanism 17 for transporting the bottle 30 from the sterilization section 11 to the rinsing section 12 is provided between the sterilization section 11 and the
5 rinsing section 12. Further, a second transport mechanism 18 for transporting the bottle 30 from the inert gas replacement section 13 to the contents filling section 14 is provided between the inert gas replacement section 13 and the contents filling
10 section 14.

[0043] The sterilization section 11 is to sterilizes the interior of the bottle 30 with a disinfectant 40 ejected in a mist form, linearly or in a fountain-like manner. Hydrogen peroxide water or peracetic acid, for example, can be used as the disinfectant
15 40. Instead of the use of the disinfectant 40, it is possible to use in the sterilization section 11 an electron beam sterilization method (hereinafter also referred to as EB sterilization) without the use of the disinfectant 40.

[0044] The rinsing section 12 is to supply rinsing water 41 from the mouth portion 31 into the bottle body 32 of the bottle 30 whose interior has been sterilized in the sterilization section 11. The rinsing water 41 is, for example, warm water (sterilized
20 water) e.g. at about 25°C to 80°C. When the EB sterilization method is used in the sterilization section 11, the rinsing section 12 may not necessarily be provided and, in that case, the use of water and electricity in the manufacturing process can be
25 reduced.

[0045] The first transport mechanism 17, located between the sterilization section 11 and the rinsing section 12, is configured
30 to invert the bottle 30 so that the mouth portion 31 faces downward.

[0046] The inert gas replacement section 13 is to supply only an inert gas 42 from the mouth portion 31 into the bottle body 32 of the bottle 30, whose interior has been rinsed in the
35 rinsing section 12, to replace the air in the bottle body 32 with the inert gas 42. Though various gases can be used as the

inert gas 42, it is particularly preferred to use nitrogen (N_2). The amount of the filling inert gas 42 is preferably larger than the volume of the bottle 30. In the inert gas replacement section 13, the bottle 30 is still held with the mouth portion 31 downward. The bottle 30 becomes filled with the inert gas 42 by thus replacing the air (oxygen) in the bottle 30 with the inert gas 42.

[0047] The constructions of the rinsing section 12 and the inert gas replacement section 13 will now be described in greater detail with reference to FIG. 2.

[0048] As shown in FIG. 2, the rinsing section 12 and the inert gas replacement section 13 are disposed on a distributor 50. The distributor 50 includes a fixed section 51 and a rotational section 52 which rotates in a certain direction on the fixed section 51. A plurality of upwardly-projecting nozzles 53 are coupled to the rotational section 52. By the rotation of the rotational section 52, the bottle 30 rotates in the certain direction together with each nozzle 53 inserted into the mouth portion 31. For convenience sake, FIG. 2 schematically shows only part of the distributor 50.

[0049] The rinsing section 12 includes a rinsing water tank 59 in which the rinsing water 41 is housed, a rinsing water supply pipe 54 connected to the rinsing tank 59, and a rinsing water supply space 55 connected to the rinsing water supply pipe 54. The rinsing water supply space 55 is formed in the fixed section 51, and communicates with those rinsing nozzles 53 which have moved to above the rinsing water supply space 55 by the rotation of the rotational section 52. Thus, the rinsing water 41 is supplied from the rinsing water tank 59 into the bottle 30 via the rinsing water supply pipe 54, the rinsing water supply space 55 and each nozzle 53, to clean the interior of the bottle 30.

[0050] On the other hand, the inert gas replacement section 13 includes an inert gas tank 56 in which the inert gas 42 is housed, an inert gas supply pipe 57 connected to the inert gas tank 56, and an inert gas supply space 58 connected to the inert gas

supply pipe 57. The inert gas supply space 58 is formed in the fixed section 51, and communicates with those rinsing nozzles 53 which have moved to above the inert gas supply space 58 by the rotation of the rotational section 52. Thus, the inert gas 42 is supplied from the inert gas tank 56 into the bottle 30 via the inert gas supply pipe 57, the inert gas supply space 58 and each nozzle 53, to replace the air in the bottle 30 with it.

[0051] Referring again to FIG. 1, the contents filling section 14 for filling contents 43 from the mouth portion 31 into the bottle body 32 of the bottle 30 is provided downstream of the inert gas replacement section 13. In the contents filling section 14, the contents 43 are filled into the bottle 30 filled with the inert gas 42. The contents 43 may be various types of beverages; however, a foamable liquid, such as a tea beverage, e.g. green tea, a milk beverage, e.g. milk, a coffee beverage, a functional beverage, a vegetable juice or a fruit juice, is preferred.

[0052] The second transport mechanism 18, located between the inert gas replacement section 13 and the contents filling section 14, is configured to again invert the bottle 30 so that the mouth portion 31 faces upward.

[0053] The inert gas supply section 15 is provided downstream of the contents filling section 14. The inert gas supply section 15 is to supply an inert gas 42 from the mouth portion 31 into the bottle body 32 of the bottle 30 to fill the space over the liquid surface of the contents 43 (space 32a over the liquid surface) in the bottle body 32 with the inert gas 42. As with the inert gas which is supplied in the inert gas replacement section 13, nitrogen (N_2), for example, can be used as the inert gas 42. The inert gas supplied in the inert gas supply section 15 may be a gas of a different type from the inert gas supplied in the inert gas supply section 13. The amount of the filling inert gas 42 used in the inert gas supply section 15 is preferably equal to or larger than the sum of the volume of bubbles 43a and the volume of the space 32a over the liquid surface. The "space 32a over the liquid surface" herein refers to a space formed over the liquid surface of the contents 43 in the bottle

body 32 and excluding the bubbles 43a generated in the contents 43. Thus, the gas contained in the bubbles 43a and the space 32a over the liquid surface corresponds to the gas in the headspace of the bottle after it comes on the market.

- 5 [0054] The cap mounting section 16, provided downstream of the inert gas supply section 15, is to mount a cap 33 to the mouth portion 31 of the bottle 30 to hermetically close the bottle 30.

[0055] <Contents filling method>

- 10 A contents filling method according to an embodiment of the present invention will now be described with reference to FIGS. 1, 3 and 4A through 4C. The contents filling method of this embodiment is carried out by using the above-described contents filling system 10 (FIG. 1).

- 15 [0056] First, the interior of an empty bottle 30 is sterilized with the disinfectant 40 in the sterilization section 11 (sterilization step) (step S1 in FIG. 3). As described above, hydrogen peroxide water or peracetic acid, for example, can be used as the disinfectant 40. Instead of the use of the disinfectant 40, it is possible to use the above-described EB sterilization method in the sterilization step without the use of the disinfectant 40. The interior of the bottle 30 is thus sterilized in the sterilization section 11.

- 20 [0057] Next, the sterilized bottle 30 is inverted by the first transport mechanism 17 so that the mouth portion 31 faces downward, and is transported to the rinsing section 12. In the rinsing section 12, the rinsing water 41 is supplied from the mouth portion 31 into the bottle body 32 of the bottle 30 (rinsing step) (step S2 in FIG. 3). The disinfectant 40, etc. remaining in the bottle 30 is removed by cleaning the interior of the bottle 30 with the rinsing water 41. When the EB sterilization method is used in the sterilization step, the rinsing section 12 may not necessarily be provided because of no use of the disinfectant 40. Even when the EB sterilization method is used in the sterilization step, however, the rinsing step may be provided in order to remove foreign matter remaining in the
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bottle 30.

[0058] Thereafter, the bottle 30, held with the mouth portion 31 downward, is transported to the inert gas replacement section 13. In the inert gas replacement section 13, only the inert gas 42 is supplied from the mouth portion 31 into the bottle body 32 of the bottle 30 to replace the air in the bottle body 32 with the inert gas 42 (inert gas replacement step) (step S3 in FIG. 3). This step also has the advantage that the rinsing water 41 remaining in the bottle body 32 can be effectively removed by ejecting the inert gas 42 into the bottle body 32 from below.

[0059] Next, the bottle 30 filled with the inert gas 42 is inverted by the second transport mechanism 18 so that the mouth portion 31 faces upward, and is transported to the contents filling section 14. In the contents filling section 14, the contents 43 are filled from the mouth portion 31 into the bottle body 32 of the bottle 30 (contents filling step) (step S4 in FIG. 3, FIG. 4A). The filling contents 43 have been subjected to a liquid treatment (deaeration) step to control the concentration of dissolved oxygen.

[0060] In the contents filling step, the contents 43 entrain the surrounding gas upon their filling, generating a large number of bubbles 43a inside and on the surface of the contents 43 which have been filled into the bottle body 32 of the bottle 30. In this embodiment, the inert gas 42 has been filled into the bottle body 32 in the inert gas replacement step. Therefore, the bubbles 43a containing the inert gas 42 are generated in the contents 43. Further, the inert gas 42 is taken into the contents 43.

[0061] As described above, in this embodiment the contents 43 preferably consist of a foamable liquid, such as a tea beverage, e.g. green tea, a milk beverage, e.g. milk, a coffee beverage, a functional beverage, a vegetable juice or a fruit juice. Because of the high effect of preventing the initial oxidation of the contents 43 according to this embodiment, a liquid whose taste or color is changeable by oxidation degradation, as typified by

green tea, is very suitable. The contents filling method of this embodiment is also effective for a liquid containing a large amount of milk component, which is likely to bubble upon their filling and the bubbles hardly collapse.

- 5 [0062] After the contents filling step, the bottle 30 is transported to the inert gas supply section 15. In the inert gas supply section 15, an inert gas 42 is supplied from the mouth portion 31 into the bottle body 32 of the bottle 30 (inert gas supply step) (step S5 in FIG. 3, FIG. 4B). The space 32a over
10 the liquid surface in the bottle body 32 is thus filled with the inert gas 42. This can replenish the loss of the previously-supplied inert gas 42 during transportation of the bottle 30 from the inert gas replacement section 13 to the inert gas supply section 15 via the contents filling section 14.
- 15 [0063] After the inert gas supply step, the bottle 30 is transported to the cap mounting section 16. In the cap mounting section 16, the cap 33 is mounted to the mouth portion 31 of the bottle 30 to obtain a contents-filled bottle 35 (cap mounting step) (step S6 in FIG. 3, FIG. 4C).
- 20 [0064] The hermetically-closed contents-filled bottle 35 comprises the bottle 30 having the bottle body 32 and the mouth portion 31, and the contents 43 which have been filled into the bottle body 32 of the bottle 30. The space 32a over the liquid surface in the bottle body 32 is filled with the inert
25 gas 42 and, in addition, the bubbles 43a containing the inert gas 42 are formed (FIG. 4C). Therefore, the amount of oxygen initially existing in the bottle 30 (the initial total amount of oxygen in the bottle) is controlled at a very low level.
- 30 [0065] In this embodiment, the entire process from the sterilization step to the cap mounting step is carried out in a sterile atmosphere, and the contents 43 are filled from the mouth portion 31 into the bottle body 32 of the bottle 30 at a temperature of 5°C to 55°C, e.g. at room temperature (5°C to 35°C). The process is thus carried out by a so-called sterile
35 filling method.
- [0066] A difference between the sterile filling method as used in

this embodiment and a hot pack filling method will now be described. The sterile filling method is characterized in that filling of the contents 43 is carried out at 5°C to 55°C. Accordingly, the amount of gas in the bubbles 43a and in the space 32a over the liquid surface upon filling of the contents 43 is approximately equal to the volume of the headspace of the product (contents-filled bottle 35) after it comes on the market. [0067] In the case of the hot pack filling method, on the other hand, contents are filled into a bottle at a high temperature of not less than 85°C. Therefore, the headspace of the bottle is full of a vapor upon filling of the contents, and the concentration of oxygen in the headspace is low. The volume of the headspace greatly decreases as the temperature of the contents reaches room temperature. In general, the lower the temperature is, the higher is the solubility of a gas in a liquid. [0068] Thus, in the sterile filling method as used in this embodiment, the concentration of dissolved oxygen in the contents 43 is likely to be high due to entrainment of air upon filling of the contents 43, compared to the hot pack filling method. In addition, because of the large space 32a over the liquid surface, the total amount of oxygen in the bottle 30 is likely to be large. Accordingly, especially when the sterile filling method is employed, reducing the amount of oxygen initially existing in the bottle 30 (the initial total amount of oxygen in the bottle) is effective to prevent oxidation of the contents 43. [0069] In this embodiment the production (transportation) rate of contents-filled bottles 35 is preferably 100 to 2000 bpm (bottle per minute). The "bpm" herein refers to the number of bottles 30 transported per minute. The time interval between the inert gas replacement step (step S3 in FIG.3) and the contents filling step (step S4 in FIG. 3) is preferably 0.5 to 20 seconds. [0070] A synthetic resin material, such as polyethylene terephthalate (PET), polypropylene (PP) or polylactic acid (PLA), can be used as a material for the bottle 30. A preferable shape

of the bottle 30 will be described in detail later.

[0071] As described hereinabove, according to this embodiment, the contents 43 are filled from the mouth portion 31 into the bottle body 32 of the bottle 30 after supplying the inert gas 42 from the mouth portion 31 into the bottle body 32 and thereby replacing the air in the bottle body 32 with the inert gas 42. Accordingly, the bottle body 32 can be filled with the inert gas 42 while generating bubbles 43a of the inert gas 42 in the contents 43. This can reduce the initial total amount of oxygen in the bottle 30 (the sum of the amount of oxygen existing in the space 32a over the liquid surface, the amount of oxygen existing inside the bubbles 43a and the amount of dissolved oxygen in the contents 43 immediately after the production of the contents-filled bottle), thereby reducing the initial oxidation degradation of the contents 43. For instance, in the case of an about 500 ml bottle 30, the initial total amount of oxygen in the bottle can be controlled at a level of not more than 2.0 cc.

[0072] According to this embodiment, the rinsing water 41 is supplied from the mouth portion 31 into the bottle body 32 of the bottle 30 (rinsing step) before only the inert gas 42 is supplied from the mouth portion 31 into the bottle body 32 to replace the air in the bottle body 32 with the inert gas 42 (inert gas replacement step). The rinsing water 41 can therefore be effectively removed by the inert gas 42.

[0073] According to this embodiment, the inert gas supply step of supplying the inert gas 42 from the mouth portion 31 into the bottle body 32 is provided after the contents filling step. This can replenish the loss of the previously-supplied inert gas 42 from the bottle body 32 during transportation of the bottle 30, making it possible to more securely prevent the initial oxidation degradation of the contents 43.

[0074] According to this embodiment, the contents 43 are filled from the mouth portion 31 into the bottle body 32 at a temperature of 5°C to 55°C and the entire process steps are carried out in a sterile atmosphere (sterile filling method). Thus, unlike the hot pack filling method, the contents 43 are not

subjected to a heating process. This can avoid heat deterioration of the contents 43.

[0075] According to this embodiment, there is no need for significant alteration of facilities which use the conventional sterile filling method. Thus, no significant cost is needed for the facility alteration.

[0076] Further, according to this embodiment, the production (transportation) rate of contents-filled bottles 35 is preferably 100 to 2000 bpm (bottle per minute), and the time interval between the inert gas replacement step and the contents filling step is preferably 0.5 to 20 seconds. The process for filling the contents 43 into the bottle 30 can thus be performed at a high rate.

[0077] [Examples]

15 Examples of the present invention will now be described with reference to FIGS. 1, 3, 5 and 6.

[0078] [Example 1]

Using the contents filling system 10 shown in FIG. 1, a contents-filled bottle 35 (Example 1) was produced by the contents filling method shown in FIG. 3. Contents 43 were filled into a bottle 30 at room temperature in a sterile atmosphere (sterile filling method). A PET bottle having a volume of 500 ml was used as the bottle 30, and the bottle 30 was transported at 900 bpm.

25 [0079] First, the interior of the bottle 30 was sterilized with hydrogen peroxide water as a disinfectant (sterilization step), and then rinsing water was supplied from the mouth portion 31 into the bottle body 32 (rinsing step). Subsequently, 550 ml of nitrogen gas as an inert gas was supplied from the mouth portion 31 into the bottle body 32 to replace the air in the bottle body 32 with the nitrogen gas (inert gas replacement step). Next, the contents 43, consisting of green tea, was filled from the mouth portion 31 into the bottle body 32 (contents filling step). The concentration of oxygen in the green tea before the filling was 1.4 ppm. The temperature of the green tea upon the filling was 30.2°C.

[0080] Next, nitrogen gas as an inert gas was supplied from the mouth portion 31 into the bottle body 32 (inert gas supply step), and thereafter a cap 33 was mounted to the mouth portion 31, whereby the contents-filled bottle 35 of Example 1 was obtained.

5 The volume of the headspace of the bottle 35 was 20 ml.

[0081] The initial total amount of oxygen in bottle (beverage-derived oxygen amount + headspace-derived oxygen amount) was measured for the thus-obtained contents-filled bottle 35 (Example 1). The initial total amount of oxygen in
10 bottle was calculated according to the following formula, using the measured values of the concentration of oxygen in the headspace (%), the volume of the headspace, the amount of the filling contents and the concentration of dissolved oxygen in the contents (%):

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$$\text{(Initial total amount of oxygen in bottle)} = \text{(Concentration of oxygen in the headspace)} \times \text{(Volume of the headspace)} + \text{(Amount of the filling contents)} \times \text{(Concentration of dissolved oxygen in the contents)}.$$

[0082] As a result, the initial total amount of oxygen in bottle
20 was found to be 1.5 cc (beverage-derived oxygen amount 0.4 cc + headspace-derived oxygen amount 1.1 cc) (see FIG. 5). The beverage-derived oxygen amount includes the amount of dissolved oxygen in the green tea, and the headspace-derived oxygen amount includes the amount of oxygen existing in the
25 space 32a over the liquid surface and the amount of oxygen existing in the bubbles 43a.

[0083] [Example 2]

A contents-filled bottle 35 (Example 2) was produced in the same manner as in Example 1 except that the contents 43
30 were filled into the bottle 30 at a lower temperature to generate the bubbles 43a in a larger amount [the percentage of the volume of bubbles 43a in the headspace volume (also called bubble ratio) was 18%]. The initial total amount of oxygen in bottle was measured for the contents-filled bottle 35 (Example
35 2) in the above-described manner, and was found to be 1.0 cc (beverage-derived oxygen amount 0.4 cc + headspace-derived

oxygen amount 0.6 cc) (see FIG. 5).

[0084] [Comparative Example 1]

A contents-filled bottle (Comp. Example 1) was produced in the same manner as in Example 1 except that after the
5 rinsing step, 550 ml of sterilized air, instead of nitrogen gas, was supplied from the mouth portion 31 into the bottle body 32, and that the inert gas supply step was not carried out. The initial total amount of oxygen in bottle was measured for the
10 contents-filled bottle (Comp. Example 1) in the above-described manner, and was found to be 5.0 cc (beverage-derived oxygen amount 1.0 cc + headspace-derived oxygen amount 4.0 cc) (see FIG. 5).

[0085] [Comparative Example 2]

A contents-filled bottle (Comp. Example 2) was produced
15 in the same manner as in Example 1 except that after the rinsing step, 550 ml of sterilized air, instead of nitrogen gas, was supplied from the mouth portion 31 into the bottle body 32. The initial total amount of oxygen in bottle was measured for the
20 contents-filled bottle (Comp. Example 2) in the above-described manner, and was found to be 2.5 cc (beverage-derived oxygen amount 0.5 cc + headspace-derived oxygen amount 2.0 cc) (see FIG. 5).

[0086] [Comparative Example 3]

A contents-filled bottle (Comp. Example 3) was produced
25 in the same manner as in Example 1 except that the contents-filling process was carried out not by the sterile filling method but by the hot pack method. The initial total amount of oxygen in bottle was measured for the contents-filled bottle
30 (Comp. Example 3) in the above-described manner, and was found to be 1.7 cc (beverage-derived oxygen amount 0.4 cc + headspace-derived oxygen amount 1.3 cc) (see FIG. 5).

[0087] The results show that the initial total amount of oxygen in bottle can be controlled at a level less than 2.0 cc for the contents-filled bottles 35 of Examples 1 and 2 (1.5 cc and 1.0 cc, respectively). The measured values are less than or equal to the value (1.7 cc) for the contents-filled bottle (Comp. Example

3) which was produced in the same manner but using the hot pack filling system (see FIG. 5). On the other hand, the initial total amount of oxygen in bottle is more than 2.0 cc for the contents-filled bottles of Comp. Examples 1 and 2 (5.5 cc and 2.5 cc, respectively).

[0088] Change with time of the total amount of oxygen in bottle was examined in comparison of the contents-filled bottles 35 of Examples 1 and 2 with the contents-filled bottles of Comp. Examples 1 to 3 (FIG. 6). The results show that due to permeation of oxygen through the bottle wall, the total amount of oxygen in bottle gradually increases with time (upward-sloping lines in the graph of FIG. 6) for both of the contents-filled bottles 35 of Examples 1 and 2 and the contents-filled bottles of Comp. Examples 1 to 3. Further, the differences in the total amount of oxygen in bottle between these bottles remain approximately constant even after a long period of time has elapsed. The data obtained thus demonstrates that controlling the initial total amount of oxygen in bottle at a low level is effective to prevent oxidation degradation of the contents.

[0089] [Bottle construction]

A bottle construction suited for use in the contents filling method and the contents filling system of this embodiment will now be described with reference to FIGS. 7 through 10.

[0090] As described above, according to this embodiment, the contents 43 are filled from the mouth portion 31 into the bottle body 32 of a bottle 30 (contents filling step) after supplying the inert gas 42 from the mouth portion 31 into the bottle body 32 and thereby replacing the air in the bottle body 32 with the inert gas 42 (inert gas replacement step).

[0091] Further, as described above, a large number of bubbles 43a are generated in the contents 43 due to entrainment of the surrounding gas upon filling of the contents 43. The bubbles 43a contain the inert gas 42 inside. Therefore, the larger the total volume of the bubbles 43a (hereinafter also referred to as bubble volume), the more the amount of oxygen, existing in the

space 32a over the liquid surface in the bottle body 32, can be relatively reduced. Because the inert gas 42 in the bubbles 43a is not replaced with the external oxygen till the cap mounting step, the amount of oxygen existing in the bottle 30 (initial total
5 amount of oxygen in bottle) can be kept at a low level. It has been found by the present inventors that the bubble volume is susceptible to the shape of the bottom 30, especially the shape of the bottom of the bottle 30.

[0092] Bottles (Examples A to D) usable in this embodiment will
10 now be described with reference to FIGS. 7 through 10.

[0093] [Example A]

FIGS. 7A and 7B show a bottle 30 (30a) suited for use in the contents filling method and the contents filling system of this embodiment (Example A). FIG. 7A is a perspective view of
15 the bottle of Example A, and FIG. 7B is a cross-sectional view (taken along the line VII-VII of FIG. 7A) of the bottom of the bottle of Example A.

[0094] The bottle 30 (30a) shown in FIGS. 7A and 7B has a mouth portion 31 and a bottle body 32. The bottle body 32
20 includes a body portion 21 and a bottom portion 22 having a petaloid shape and connecting with the body portion 21. The bottom portion 22 has five legs 23 circumferentially arranged at equal intervals. The outside diameter (body diameter) of the body portion 21 is 55 mm to 70 mm, preferably 60 mm to 70
25 mm.

[0095] [Example B]

FIGS. 8A and 8B show a bottle 30 (30b) suited for use in the contents filling method and the contents filling system of this embodiment (Example B). FIG. 8A is a perspective view of
30 the bottle of Example B, and FIG. 8B is a cross-sectional view (taken along the line VIII-VIII of FIG. 8A) of the bottom of the bottle of Example B.

[0096] The bottle 30 (30b) shown in FIGS. 8A and 8B has a mouth portion 31 and a bottle body 32. The bottle body 32
35 includes a body portion 21 and a bottom portion 24 having a depressed portion 25 in the center and connecting with the body

portion 21. The outside diameter (body diameter) of the body portion 21 is 55 mm to 70 mm, preferably 60 mm to 70 mm.

[0097] The bottle 30b has the inwardly depressed portion 25 in the center of the bottom portion 24. The depressed portion 25 includes an inwardly-inclined tapered peripheral wall 26, and a generally star-shaped central recess 27 provided at the upper end of the peripheral wall 26. The depth of the depressed portion 25, i.e. the distance Hb from the lowest portion 28 to the deepest portion of the depressed portion 25, is 4 to 40%, preferably 10 to 30%, of the body diameter. If the distance Hb is smaller than 4% of the body diameter, the volume of the bubbles 43a cannot be made sufficiently large. If the distance Hb exceeds 40% of the body diameter, on the other hand, stability in the forming of the bottle may be low, making the shaping of the bottom portion 24 difficult.

[0098] [Example C]

FIGS. 9A and 9B show a bottle 60 usable in the contents filling method and the contents filling system of this embodiment (Example C). FIG. 9A is a perspective view of the bottle of Example C, and FIG. 9B is a cross-sectional view (taken along the line IX-IX of FIG. 9A) of the bottom of the bottle of Example C.

[0099] The bottle 60 shown in FIGS. 9A and 9B has a mouth portion 31 and a bottle body 32. The bottle body 32 includes a body portion 21 and a bottom portion 61 having a recess 62 and connecting with the body portion 21. The recess 62 has a plurality of stepped portions 63, 63. The outside diameter (body diameter) of the body portion 21 is 55 mm to 70 mm. The depth of the recess 62, i.e. the distance Hc from the lowest portion 64 to the deepest portion of the recess 62, is 4% to 15% of the body diameter.

[0100] [Example D]

FIGS. 10A and 10B show a bottle 70 usable in the contents filling method and the contents filling system of this embodiment (Example D). FIG. 10A is a perspective view of the bottle of Example D, and FIG. 10B is a cross-sectional view

(taken along the line X-X of FIG. 10A) of the bottom of the bottle of Example D.

[0101] The bottle 70 shown in FIGS. 10A and 10B has a mouth portion 31 and a bottle body 32. The bottle body 32 includes a body portion 21 and a bottom portion 71 having a recess 72 and connecting with the body portion 21. The outside diameter (body diameter) of the body portion 21 is 55 mm to 70 mm. The depth of the recess 72, i.e. the distance Hd from the lowest portion 73 to the deepest portion of the recess 72, is 4% to 15% of the body diameter.

[0102] [Examples]

Working examples for the bottles shown in FIGS. 7 through 10 will now be described.

[0103] First, the bottles shown in FIGS. 7 through 10 were prepared (referred to as bottle 30a of Example A, bottle 30b of Example B, bottle 60 of Example C, and bottle 70 of Example D, respectively). The bottles 30a, 30b, 60, 70 have the interior volume of 500 ml and have the same shape except the bottom portions. Next, a contents-filled bottle was produced for each bottle in the following manner.

[0104] [Example A]

A contents-filled bottle 35 (Example A) was produced using the bottle 30a of Example A, shown in FIGS. 7A and 7B. Specifically, using the contents filling system 10 shown in FIG. 1, the contents-filled bottle 35 (Example A) was produced by the contents filling method shown in FIG. 3. Contents 43 were filled into the bottle 30a at room temperature in a sterile atmosphere (sterile filling method). A PET bottle having a volume of 500 ml was used as the bottle 30a, and the bottle 30a was transported at 600 bpm.

[0105] First, the interior of the bottle 30a was sterilized with hydrogen peroxide water as a disinfectant (sterilization step), and then rinsing water was supplied from the mouth portion 31 into the bottle body 32 (rinsing step). Subsequently, 600 ml of nitrogen gas as an inert gas was supplied from the mouth portion 31 into the bottle body 32 to replace the air in the bottle

body 32 with the nitrogen gas (inert gas replacement step). Next, the contents 43, consisting of green tea, was filled from the mouth portion 31 into the bottle body 32 (contents filling step). The concentration of oxygen in the green tea before the
5 filling was 1.4 ppm. The temperature of the green tea upon the filling was 30.2°C.

[0106] Next, nitrogen gas as an inert gas was supplied from the mouth portion 31 into the bottle body 32 (inert gas supply step), and thereafter a cap 33 was mounted to the mouth portion 31,
10 whereby the contents-filled bottle 35 of Example A was obtained. The volume of the headspace of the bottle 35 was 20 ml.

[0107] The bubble volume and the initial total amount of oxygen in bottle were measured for the thus-obtained contents-filled bottle 35 (Example A). As a result, the bubble
15 volume was found to be 3.6 cc, and the initial total amount of oxygen in bottle was found to be 1.4 cc.

[0108] [Example B]

A contents-filled bottle 35 (Example B) was produced in the same manner as in Example A except for using the bottle
20 30b shown in FIGS. 8A and 8B. The bubble volume and the initial total amount of oxygen in bottle were measured for the contents-filled bottle 35 (Example B), and the bubble volume was found to be 3.4 cc, and the initial total amount of oxygen in bottle was found to be 1.5 cc.

25 [0109] [Example C]

A contents-filled bottle (Example C) was produced in the same manner as in Example A except for using the bottle 60 shown in FIGS. 9A and 9B. The bubble volume and the initial
30 total amount of oxygen in bottle were measured for the contents-filled bottle (Example C), and the bubble volume was found to be 2.1 cc, and the initial total amount of oxygen in bottle was found to be 2.0 cc.

[0110] [Example D]

A contents-filled bottle (Example D) was produced in the same manner as in Example A except for using the bottle 70
35 shown in FIGS. 10A and 10B. The bubble volume and the

initial total amount of oxygen in bottle were measured for the contents-filled bottle (Example D), and the bubble volume was found to be 0.8 cc, and the initial total amount of oxygen in bottle was found to be 2.4 cc.

- 5 [0111] The results thus indicate that compared to the bottles 60, 70 of Examples C and D, the bottles 30a, 30b of Examples A and B each have a shape which promotes the generation of bubbles 43a of the inert gas 42, leading to a relatively low initial total amount of oxygen in the contents-filled bottles 35 of
- 10 Examples A and B. In particular, the bottles 30a, 30b of Examples A and B each have a fairly large recessed portion in the bottom portions 22, 24. It is, therefore, conceivable that bubbling is more likely to occur upon filling of the contents 43, and the generation of a large volume of bubbles 43a can control
- 15 the initial total amount of oxygen in bottle at a low level. On the other hand, in the case of a bottle having a flat bottom, a turbulent flow of a filling liquid is less likely to be produced and, therefore, bubbling is less likely to occur. Thus, the effect of reducing the initial total amount of oxygen in bottle is low.
- 20 Conversely, in the case where the bottom portion of a bottle has a petaloid shape (Example A) or the bottom portion has a depressed portion (Example B), a turbulent flow is likely to be produced upon filling of contents because of the complicated bottom shape, resulting in the generation of a large amount of
- 25 bubbles full of nitrogen gas. The bottles 60, 70 of Examples C and D have a certain effect of reducing the initial total amount of oxygen in bottle, though the effect is relatively low.

CLAIMS

1. A contents filling method for filling contents (43) into a bottle (30) having a mouth portion (31) and a bottle body (32), comprising: an inert gas replacement step of supplying only an inert gas (42) from the mouth portion (31) into the bottle body (32) to replace the air in the bottle body (32) with the inert gas (42); a contents filling step of filling contents (43) from the mouth portion (31) into the bottle body (32); and an inert gas supply step of supplying an inert gas (42) from the mouth portion (31) into the bottle body (32), after the contents filling step.

2. The contents filling method according to claim 1, further comprising, before the inert gas replacement step, a sterilization step of sterilizing the interior of the bottle (30) and a rinsing step of supplying rinsing water (41) from the mouth portion (31) into the bottle body (32).

3. The contents filling method according to claim 1, further comprising, before the inert gas replacement step, a sterilization step of sterilizing the interior of the bottle (30) by electron beam irradiation.

4. The contents filling method according to claim 1, further comprising, after the inert gas supply step, a cap mounting step of mounting a cap (33) to the mouth portion (31).

5. The contents filling method according to claim 1, wherein in the contents filling step, the contents (43) are filled from the mouth portion (31) into the bottle body (32) at a temperature of 5°C to 55°C.

6. The contents filling method according to claim 1, wherein the entire process is carried out in a sterile atmosphere.

7. The contents filling method according to claim 1, wherein in the contents filling step, bubbles (43a) containing the inert gas (42) which has been introduced into the bottle body (32) in the inert gas replacement step are generated in the contents (43) which have been filled into the bottle body (32).

8. The contents filling method according to claim 1, wherein the time interval between the inert gas replacement step and the contents filling step is 0.5 to 20 seconds.

9. A contents filling system (10) for filling contents (43) into a bottle (30) having a mouth portion (31) and a bottle body (32), comprising: an inert gas replacement section (13) for supplying only an inert gas (42) from the mouth portion (31) into the bottle body (32) to replace the air in the bottle body (32) with the inert gas (42); a contents filling section (14), provided downstream of the inert gas replacement section (13), for filling contents (43) from the mouth portion (31) into the bottle body (32); and an inert gas supply section (15), provided downstream of the contents filling section (14), for supplying an inert gas (42) from the mouth portion (31) into the bottle body (32).

10. The contents filling system (10) according to claim 9, further comprising a sterilization section (11), provided upstream of the inert gas replacement section (13), for sterilizing the interior of the bottle (30), and a rinsing section (12), provided upstream of the inert gas replacement section (13) and downstream of the sterilization section (11), for supplying rinsing water (41) from the mouth portion (31) into the bottle body (32).

11. The contents filling system (10) according to claim 9, further comprising a sterilization section (11), provided upstream of the inert gas replacement section (13), for sterilizing the interior of the bottle (30) by electron beam irradiation.

12. The contents filling system (10) according to claim 9, further comprising a sterilization section (11), provided upstream of the inert gas replacement section (13), for sterilizing the interior of the bottle (30), a rinsing section (12), provided upstream of the inert gas replacement section (13) and downstream of the sterilization section (11), for supplying rinsing water (41) from the mouth portion (31) into the bottle body (32), and a cap mounting section (16), provided downstream of the inert gas supply section (15), for mounting a cap (33) to the mouth portion (31).