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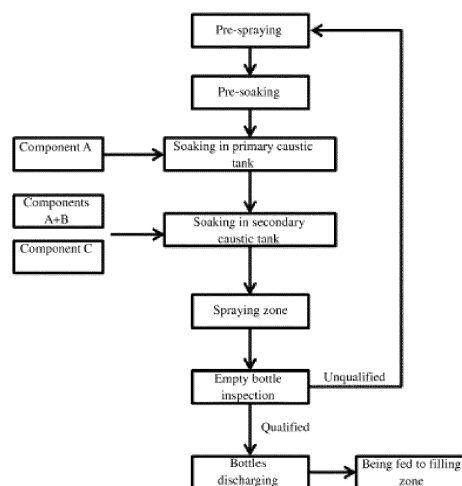
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(54) **CLEANING ADDITIVE AND CLEANING METHOD USING THE SAME**

(57) The present invention discloses a glass bottle cleaning additive and cleaning method for glass bottles, for use in treatment by cleaning glass bottles in a primary caustic tank and a secondary caustic tank, said cleaning additive consisting of a component A, a component B and a component C, wherein the component A contains an organic phosphine chelating agent, the component B contains a peroxide, and the component C contains an antifoaming agent, the component A is added in the primary caustic tank, the component B is selectively added in the primary caustic tank, the component A and the component B are added in the secondary caustic tank, and the component C is selectively added in the primary caustic tank or the secondary caustic tank. The addition amount of the component A is 0.05%-0.5%, the addition amount of the component B is 0.1 %-0.5%, and the addition amount of the component C is 0-0.5%, based on the weight of an caustic solution added in the primary caustic tank or the secondary caustic tank. The caustic solution in said primary caustic tank and said secondary caustic tank is a 1.5%-3% sodium hydroxide solution. The glass bottle cleaning additive and cleaning method for glass bottles of the invention enable a stable and good cleaning effect at a relatively low temperature, usually 50-70°C.



*Fig.1*

**Description**

## TECHNICAL FIELD

5 **[0001]** The invention provides a cleaning additive and a cleaning method using the same, for cleaning glass bottles in a primary caustic tank and a secondary caustic tank, which enables a stable and good cleaning effect at a relatively low temperature.

## BACKGROUND ART

10 **[0002]** In cleaning technologies used for industrial purposes, the selection and treatment processes of cleaning agents are varied respectively for different objects to be cleaned, such as glass bottles, metal containers, plastic cans or rubbers, due to different materials, shapes and different physical and chemical properties of the containers.

15 **[0003]** CIP (also known as Clean In Place) commonly used in the cleaning industry is a safe and automatic cleaning system, and has been widely used in the advanced food, sanitary and pharmaceutical industries. CIP is generally used in the cleaning of large equipment, systems and devices, and is not suitable for the cleaning of small objects, such as glass bottles.

20 **[0004]** Recycled glass bottles are usually cleaned by a bottle cleaning machine with an industrial cleaning temperature generally set at 80°C-90°C and a cleaning rate of 24,000-40,000 bottles per hour. The selection of a cleaning agent has a relatively large influence on the cleaning effect and the cleaning rate. There are a variety of cleaning agents (mainly acids and alkalis) used in the food industry, among which sodium hydroxide and nitric acid are most widely used. In the glass bottle cleaning industry, alkaline cleaning in a caustic tank is generally adopted, with addition of a cleaning additive during the alkaline cleaning process, so as to improve the cleaning effect.

25 **[0005]** Currently, glass bottle cleaning additives include chelating agents and surfactants. The chelating agents mainly include ethylenediaminetetraacetic acid (EDTA), sodium gluconate, gluconic acid, citric acid, lactic acid, sodium phosphate, sodium tripolyphosphate, sodium pyrophosphate, organic phosphine, etc., which are generally used alone or in combination. The surfactants usually are used as nonionic surfactants and antifoaming agents, etc..

30 **[0006]** The key of glass bottle cleaning technologies lies in the thorough removal of labels at the outside of a bottle and removing dirt inside and outside the bottle. The degree of difficulty of the label removal depends largely on the types of glue used during labeling and the degree of weathering of the label. The dirt of glass bottles mainly includes two types of dirt, namely mildew stains, and mud and clay. The mildew stains, mud and clay become very dry in the air, such that they are firmly adhered to the glass bottle, and the mouth of a glass bottle is usually smaller than that of a common container, so that the dirt inside the bottle is very difficult to be removed.

35 **[0007]** Generally, repeated cleaning by a cleaning equipment, or manually repeated rinsing, or an elevated cleaning temperature, is required to realize a good cleaning effect. Generally, when the cleaning temperature is increased by every 10°C, the chemical reaction rate will be increased by 1.5-2.0 times, and the cleaning rate is also increased correspondingly, with a good cleaning effect.

40 **[0008]** Although the increase of the cleaning temperature helps to shorten the cleaning time, or reduce the concentration of a cleaning agent, the energy consumption will be increased correspondingly. Although it is theoretically considered that mould is dried at 82°C, resulting in more difficult removal of the dried dirt, it is actually found in practice of cleaning that the cleaning effect will be better by increasing the temperature, even at 90°C. Therefore, the temperature increase is generally adopted in the cleaning industry to enhance the cleaning effect, and in order to remove carbohydrates, proteins, hard dirt and other contaminants which are difficult to be removed, on a glass surface, the cleaning temperature is generally set at 80°C-90°C, and not lower than 60°C even in special circumstances. However, cleaning at a high

45 temperature results in not only high energy consumption and high cost, but also has many potential safety hazards, increasing the operational risk for operators, and making the working environment severe.

50 **[0009]** To overcome the above disadvantages in the prior art, the invention provides, specially for the cleaning of glass bottles, a novel cleaning additive and a corresponding glass bottle cleaning method, which are particularly suitably for an caustic solution cleaning environment, and achieve the same or better cleaning effect at a relatively low temperature, thus saving energy and reducing the production cost.

## SUMMARY OF THE INVENTION

55 **[0010]** The present invention provides a glass bottle cleaning technology for use in a caustic cleaning environment, and by using the novel cleaning additive and cleaning method of the present invention, the glass bottle cleaning temperature can be reduced to 50°C-70°C, with the same or better cleaning effect, so as to improve the productivity and save energy.

**[0011]** In one aspect, the present invention provides a glass bottle cleaning additive for use in the treatment of cleaning

glass bottles in a primary caustic tank and a secondary caustic tank, said cleaning additive consisting of a component A, a component B and a component C, wherein,  
 the component A contains an organic phosphine chelating agent,  
 the component B contains a peroxide, and  
 the component C contains an antifoaming agent,  
 the component A is added in the primary caustic tank, the component B is selectively added in the primary caustic tank, the component A and the component B are added in the secondary caustic tank, and the component C is selectively added in the primary caustic tank or the secondary caustic tank.

**[0012]** The organic phosphine chelating agent includes, but not limited to, amino trimethylene phosphonic acid (ATMP), 1-hydroxy ethylidene-1,1-diphosphonic acid (HEDP), ethylene diamine tetra(methylene phosphonic acid) sodium (EDTMPs), ethylene diamine tetra(methylene phosphonic acid) (EDTMPA), diethylene triamine penta(methylene phosphonic acid) (DTPMPA), 2-phosphonobutane-1,2,4-tricarboxylic acid (PBTCA), polyhydric alcohol phosphate ester (PAPE), 2-hydroxy phosphonoacetic acid (HPAA), hexamethylene diamine tetra(methylene phosphonic acid) (HDTMPA), polyamino polyether methylene phosphonate (PAPEMP), and bis(hexamethylene triamine penta(methylene phosphonic acid)) (BHMTMPMA).

**[0013]** The organic phosphine chelating agent has the effect of peeling off viscous dirt, and can highly intensively penetrate and disperse mould, mud and clay on glass bottles, so as to effectively remove them. In addition, the organic phosphine chelating agent contained in the cleaning additive of the present invention is non-toxic to human body, promotes the dissolution of dirt, has low corrosion to equipment, and has good dirt inhibition performance.

**[0014]** The component A may also comprise any one or a mixture of two or more of gluconate, gluconic acid, lactic acid, and citric acid, preferably comprising sodium gluconate or gluconic acid.

**[0015]** Generally, the organic phosphine chelating agent is used to dissolve and disperse dirt on glass bottles, and has strong dispersion and dissolution effects to mould, mud and clay on glass bottles in a caustic environment, but has weak complexing power for metal ions, such as calcium, magnesium, iron ions etc.; however, gluconate, gluconic acid, lactic acid, citric acid or a mixture thereof is per se a chelating agent, has relatively strong complexing power for calcium, magnesium and iron salts, but has low removing power for other dirt. After adding a component such as gluconate or gluconic acid, the overall chelating effect of the component A is significantly enhanced. Therefore, when treating severely polluted glass bottles, any one or a mixture of two or more of gluconate, gluconic acid, lactic acid, and citric acid can be selectively added in the component A.

**[0016]** The present invention also comprises a component B containing a peroxide, and said peroxide comprises, but not limited to, one or any combination of hydrogen peroxide, sodium peroxide, sodium percarbonate, sodium perborate, magnesium peroxide, calcium peroxide, barium peroxide, potassium peroxide, chlorine dioxide, peracetic acid, peroctanoic acid and ozone water. Said peroxide is preferably one or any combination of sodium percarbonate, sodium perborate and hydrogen peroxide. Alternatively, said peroxide is preferably one or any combination of magnesium peroxide, calcium peroxide and barium peroxide.

**[0017]** In the food industry, peroxides are usually used for food sterilization and disinfection, but have never been used as a cleaning additive for glass bottles. The present inventor found that, in a glass bottle cleaning process, the use of peroxides as part of a cleaning additive formulation in combination with other formulations can synergistically achieve a good cleaning effect.

**[0018]** Generally, the mouth of a glass bottle is relatively small, so it is difficult to obtain a mechanical force for effective stirring inside the bottle to remove dirt, and there is a need for manual rinsing or repeated flushing by equipment, which results in a reduction in productivity. Since the cleaning additive of the present invention is used in combination with the caustic solution in a caustic tank, the peroxide will release oxygen gas when encountering the caustic solution, to generate bubbles in the cleaning solution, and the bubbles continuously generated in the solution will promote the stirring in the solution, resulting in a larger mechanical force in the glass bottle to break dirt and reduce the adsorption force between the dirt and the glass bottle, so as to make it easier to flush away and peel off the dirt. At the same time, the peroxide has the effects of oxidizing and decomposing organic dirt, to make it easier to clean away dirt inside and outside the glass bottle. After adding the component B containing the peroxide, the cleaning additive of the present invention has a better cleaning effect as compared to an ordinary glass bottle cleaning additive, and hence can achieve a cleaning effect that is the same as or better than the prior art at a relatively low temperature.

**[0019]** In addition, these peroxides used in the present invention are relatively stable and low in cost, and generate substances after decomposition which have no toxicity and side effects, achieving high safety and practical value when used in the glass bottle cleaning technology of the present application in the food industry. The component B is generally added in the secondary caustic tank, to save cost, and can be added in the primary caustic tank when treating severely polluted glass bottles.

**[0020]** The cleaning additive of the present invention also comprises a component C, and the component C contains an antifoaming agent, to provide an antifoaming effect in the cleaning process. The antifoaming agents include, but not limited to, silicone polyether, fatty alcohol polyether, ethylenediamine polyether antifoaming agents or any combination

thereof. Other antifoaming agents commonly used in the art may also be selected.

**[0021]** In the glass bottle cleaning, the bubble release of the component B containing the peroxide in the solution may enhance the generation of foams in a bottle cleaning machine, and dirt carried by the glass bottle may also generate foams; in the production, the generated bubbles help enhance the mechanical force for cleaning, whereas at the same time, the generation of excessive foams should be controlled, because

1. excessive foams may lead to insufficient contact between the glass bottle and the cleaning solution, to reduce the cleaning efficiency;
2. excessive foams may increase the difficulty in cleaning, lead to the prolonging of the subsequent spray cleaning procedure, and impose the risk of residue of the cleaning solution;
3. excessive foams will overflow from the bottle cleaning machine, to influence the sanitary condition of the site of production.

**[0022]** Therefore, after applying the component B of the present invention, if there is the phenomenon of excessive foams, the component C containing the antifoaming agent can be added to the secondary caustic tank to inhibit the occurrence of the above harmful phenomenon. If there is no generation of excessive foams, the component C needs not to be added. Technicians can determine to add a proper amount of the component C according to the condition at the site.

**[0023]** Because the cleaning additive of the present invention takes into account and utilizes the synergistic action of the peroxide and the antifoaming agent, the same or better cleaning effect as compared with the prior art is realized at a relatively low temperature (50-70°C) while greatly increasing the glass bottle cleaning effect (oxidation and enhanced mechanical force), and simultaneously the negative effect caused by excessive foams can be eliminated.

**[0024]** The antifoaming agent of the present invention is preferably a mixture of a polyether-siloxane polymer, polyoxypropylene polyoxyethylene fatty alcohol ether and polyoxypropylene polyoxyethylene ethylenediamine ether at a ratio of 1-3:6:9, preferably 1:2:3. Alternatively, the antifoaming agent of the present invention is a mixture of a non-alkyl terminated fatty alcohol alkoxyl polymer, an alkyl terminated fatty alcohol alkoxyl polymer and polyoxypropylene polyoxyethylene ethylenediamine ether at a ratio of 3-5:6:9, preferably 1:2:3. The non-alkyl terminated fatty alcohol alkoxyl polymer, and the alkyl terminated fatty alcohol alkoxyl polymer are generally methyl terminated C4-C18 fatty alcohol polyalkoxyl compounds.

**[0025]** The silicone antifoaming agent can form a low surface energy film in a medium, allowing air bubbles to be continuously broken and move to form larger bubbles, so as to realize antifoaming, and the silicone antifoaming agent also has a significant foam inhibition effect, and can prevent the generation of foams while breaking foams. However, the silicone antifoaming agents have poor compatibility and are difficult to be emulsified. A polyoxyethylene fatty alcohol ether is an effective polymer antifoaming agent, and can enter the foam bimolecular film, to lead to local reduction of the surface tension in the film while keeping a relative large surface tension at the rest part of the film, so as to break foams; however, as an antifoaming agent, the emulsified particles thereof must be greater than 50 μm, otherwise it can only accelerate the generation of foams or have a stabilization effect on foams and thus have certain disadvantages in its particular production and application. The preferable antifoaming agent of the present invention combines the silicone and the polyoxyethylene fatty alcohol ether, to eliminate their respective disadvantages through the synergistic action, and achieve a good antifoaming effect by using the two at the same time.

**[0026]** Each component of the cleaning additive of the present invention can be added in different caustic tanks separately, and based on the weight of the caustic solution added in the primary caustic tank or secondary caustic tank, the addition amount of the component A is 0.05%-0.5%, the addition amount of the component B is 0.1%-0.5%, and the addition amount of the component C is 0%-0.5%. The caustic solution in the primary caustic tank and the secondary caustic tank is generally a 1.5%-3% sodium hydroxide solution.

**[0027]** The component A containing the organic phosphine chelating agent can highly intensively penetrate and disperse mould, mud and clay on glass bottles, to effectively peel off viscous dirt; after the dirt is dispersed, the component B containing the peroxide can perform oxidation more effectively, to decompose organic dirt that is difficult to be removed, and on the other hand facilitate the component A containing the organic phosphine chelating agent in further peeling off the dirt, so as to make the glass bottle cleaning in the subsequent procedure easier. Meanwhile, since the peroxide contained in the cleaning additive of the present invention releases oxygen gas under the action of the caustic solution in the caustic tank, to generate bubbles in the cleaning solution, the bubbles continuously generated in the solution increase the stirring in the solution, resulting in a larger mechanical force to break dirt and reduce the adhesion force between the dirt and the glass bottle, so as to make it easier to flush away the dirt. With the synergistic action of the peroxide and the antifoaming agent, the present invention realizes the same or better cleaning effect as compared with the prior art at a relatively low temperature while greatly increasing the glass bottle cleaning effect (oxidation and enhanced mechanical force), and eliminates the negative effect caused by excessive foams simultaneously.

**[0028]** The selection of the components of the cleaning additive of the present invention is obtained by the present

inventor through many experiments, which components act in a synergistic and stable way, to effectively clean glass bottles at a relatively low temperature (generally, 50°C-70°C), effectively remove labels on recycled glass bottles, and achieve a significant cleaning effect (even better than that achieved by a conventional method at 80°C) on glass bottles containing severe mildew stains, mud or clay dirt. Generally, an caustic solution at a high temperature has stronger corrosivity, and in the cleaning process, it may easily cause labels to be broken in the caustic tank, leading to difficult removal of the labels, and a stronger corrosion to glass bottles. Therefore, with the cleaning additive of the present invention, low-temperature cleaning can be realized, which facilitates the complete peeling off of labels, facilitates the cleaning and maintenance of the caustic tank, and reduces the corrosion to glass bottles.

**[0029]** In another aspect, the present invention provides a glass bottle cleaning method by using the cleaning additive of the present invention to clean glass bottles, comprising the steps of:

- (i) adding the component A containing an organic phosphine chelating agent to an caustic solution of a primary caustic tank, selectively adding the component B to the primary caustic tank, and mixing them thoroughly; adding the component A containing the organic phosphine chelating agent and the component B containing a peroxide to an caustic solution of a downstream secondary caustic tank, and mixing them thoroughly;
- (ii) immersing glass bottles in the primary caustic tank, to sufficiently contact with the mixed solution in the primary caustic tank;
- (iii) transferring and immersing the glass bottles into the downstream secondary caustic tank after they have left the primary caustic cleaning tank, to sufficiently contact with the mixed solution in the secondary caustic tank, and selectively adding the component C containing an antifoaming agent; and
- (iv) moving the glass bottles out of the secondary caustic tank, and subjecting them to spray cleaning.

**[0030]** In cleaning steps (i)-(iii), the temperatures in the primary caustic tank and the secondary caustic tank can be set and maintained in a range of 50°C-80°C, or in a range of 50°C-70°C.

**[0031]** The cleaning method of the present invention comprises, before step (i), pre-spraying, pre-soaking and pre-heating the glass bottles, to remove surface dirt that is easy to be removed and facilitate the subsequent cleaning steps.

**[0032]** In the cleaning process, technicians can determine whether there is a need for adding an effective amount of the component C containing the antifoaming agent, to perform antifoaming treatment, according to whether there is generation of foams. The component B is generally added in the secondary caustic tank, but may also be added in the primary caustic tank when treating severely contaminated glass bottles, to enhance the cleaning effect.

**[0033]** Generally, when cleaning the glass bottles in the primary caustic tank, foams may be generated due to the dissolution and dispersion of dirt, and technicians can determine whether there is a need for adding the component C containing the antifoaming agent to the primary caustic tank, to perform antifoaming treatment, according to the condition of foams.

**[0034]** When performing a spraying treatment to the glass bottles, there is usually a need for gradually reducing the temperature for spray cleaning of the glass bottles, in order to prevent breakage of the glass bottles due to non-uniform heating.

**[0035]** In the cleaning process, a step for removing the peeled off labels from the primary caustic tank and the secondary caustic tank may be also included. Therefore, with a low-temperature treatment, the cleaning method of the present invention is advantageous in keeping the integrity of labels, so as to facilitate the removal of the peeled off labels by label removing equipment, such as a label remover, and consequently, facilitates the cleaning and maintenance of a caustic tank.

**[0036]** Meanwhile, the caustic solution and the components A, B and C are consumed in a certain amount after cleaning for a certain time, and a corresponding concentration monitoring is performed to help the technicians to determine whether there is a need for feed supplementation, to keep an proper concentration of the cleaning solution, as so to realize continuous cleaning and achieve a stable cleaning effect.

**[0037]** In another aspect, the present invention also provides a glass bottle cleaning system using the glass bottle cleaning additive of the present invention to clean glass bottles, said cleaning system comprising:

- a primary caustic tank;
- a secondary caustic tank located downstream;
- a spray cleaning device located downstream of the secondary caustic tank;
- a glass bottle conveying device for conveying glass bottles among the parts of the glass bottle cleaning system.

**[0038]** The caustic solution in the primary caustic tank and the secondary caustic tank is generally a 1.5%-3% sodium hydroxide solution, and the temperatures in the primary caustic tank and the secondary caustic tank are set at 50°C-80°C, or at 50°C-70°C.

**[0039]** The cleaning system of the present invention also comprises a pretreatment device located upstream of the

primary caustic tank for pre-spraying, pre-soaking and pre-heating; a concentration monitoring system for monitoring the concentrations of the caustic solution and the components A, B and C; and corresponding feeding devices. The cleaning system of the present invention also comprises a label remover connected to the primary caustic tank and the secondary caustic tank respectively, for removing the peeled off labels in time.

**[0040]** The terms "primary caustic tank" and "secondary caustic tank" used in the present invention both refer to a container for accommodating a caustic solution, and the differences between the "primary caustic tank" and the "secondary caustic tank" are that the secondary caustic tank is located downstream of the primary caustic tank, and the secondary caustic tank can comprise one or more independent caustic tanks.

**[0041]** The advantages of the present invention are that, through using the glass bottle cleaning additive and cleaning method of the present invention, the operating temperature of the cleaning equipment is reduced, thereby making the operation safer and more comfortable, the equipment wear and tear is reduced at low temperature, with the consumption of cooling water and energy consumption being reduced, and the low-temperature treatment is advantageous in prolonging the service life of recycled glass bottles and in the cleaning and maintenance of the equipment.

1. A glass bottle cleaning additive for use in treatment by cleaning glass bottles in a primary caustic tank and a secondary caustic tank, said cleaning additive consisting of a component A, a component B and a component C, wherein

the component A contains an organic phosphine chelating agent,

the component B contains a peroxide, and

the component C contains an antifoaming agent,

the component A is added in the primary caustic tank, the component B is selectively added in the primary caustic tank, the component A and the component B are added in the secondary caustic tank, and the component C is selectively added in the primary caustic tank or the secondary caustic tank.

2. The cleaning additive according to 1, characterized in that said organic phosphine chelating agent is selected from one of amino trimethylene phosphonic acid, 1-hydroxy ethylidene-1,1-diphosphonic acid, ethylene diamine tetra(methylene phosphonic acid) sodium, ethylene diamine tetra(methylene phosphonic acid), diethylene triamine penta(methylene phosphonic acid), 2-phosphonobutane-1,2,4-tricarboxylic acid, polyhydric alcohol phosphate ester, 2-hydroxy phosphonoacetic acid, hexamethylene diamine tetra(methylene phosphonic acid), polyamino polyether methylene phosphonate and bis(hexamethylene triamine penta(methylene phosphonic acid)), or any combination thereof.

3. The cleaning additive according to 1 or 2, characterized in that said component A further contains gluconate, gluconic acid, lactic acid, citric acid or a mixture thereof.

4. The cleaning additive according to 1 or 2, characterized in that said peroxide is selected from one of hydrogen peroxide, sodium peroxide, sodium percarbonate, sodium perborate, magnesium peroxide, calcium peroxide, barium peroxide, potassium peroxide, chlorine dioxide, peracetic acid, peroctanoic acid and ozone water, or any combination thereof.

5. The cleaning additive according to 4, characterized in that said peroxide is selected from one of sodium percarbonate, sodium perborate and hydrogen peroxide, or any combination thereof.

6. The cleaning additive according to 4, characterized in that said peroxide is selected from one of magnesium peroxide, calcium peroxide and barium peroxide, or any combination thereof.

7. The cleaning additive according to 1 or 2, characterized in that said antifoaming agent is selected from silicone polyethers, fatty alcohol polyethers, ethylenediamine polyethers or any combination thereof.

8. The cleaning additive according to 7, characterized in that said antifoaming agent is a mixture of a polyether-siloxane polymer, polyoxypropylene polyoxyethylene fatty alcohol ether and polyoxypropylene polyoxyethylene ethylenediamine ether.

9. The cleaning additive according to 8, characterized in that the ratio of polyether-siloxane polymer to polyoxypropylene polyoxyethylene fatty alcohol ether to polyoxypropylene polyoxyethylene ethylenediamine ether in said antifoaming agent is 1-3:6:9.

10. The cleaning additive according to 8, characterized in that the ratio of polyether-siloxane polymer to polyoxy-

propylene polyoxyethylene fatty alcohol ether to polyoxypropylene polyoxyethylene ethylenediamine ether in said antifoaming agent is 1:2:3.

11. The cleaning additive according to 7, characterized in that said antifoaming agent is a mixture of a non-alkyl terminated fatty alcohol alkoxyl polymer, an alkyl terminated fatty alcohol alkoxyl polymer and polyoxypropylene polyoxyethylene ethylenediamine ether.

12. The cleaning additive according to 11, characterized in that the ratio of non-alkyl terminated fatty alcohol alkoxylate polymer to alkyl terminated fatty alcohol alkoxylate polymer to polyoxypropylene polyoxyethylene ethylenediamine ether in said antifoaming agent is 3-5:6:9.

13. The cleaning additive according to 11, characterized in that the ratio of non-alkyl terminated fatty alcohol alkoxylate polymer to alkyl terminated fatty alcohol alkoxylate polymer to polyoxypropylene polyoxyethylene ethylenediamine ether in said antifoaming agent is 1:2:3.

14. The cleaning additive according to any one of 1-13, characterized in that the addition amount of the component A is 0.05%-0.5%, the addition amount of the component B is 0.1%-0.5%, and the addition amount of the component C is 0-0.5%, based on the weight of an caustic solution added in the primary caustic tank or the secondary caustic tank.

15. The cleaning additive according to 14, characterized in that the caustic solution in said primary caustic tank and said secondary caustic tank is a 1.5%-3% sodium hydroxide solution.

16. A cleaning method for glass bottles, by using a cleaning additive of any one of 1-15 to clean glass bottles, comprises the following steps:

(i) adding the component A containing an organic phosphine chelating agent to an caustic solution of a primary caustic tank, selectively adding therein the component B, and mixing them thoroughly; adding the component A containing an organic phosphine chelating agent and the component B containing a peroxide to the caustic solution of a downstream secondary caustic tank, and mixing them thoroughly;

(ii) immersing glass bottles in the primary caustic tank, to sufficiently contact with a mixed solution in the primary caustic tank;

(iii) transferring and immersing the glass bottles into the downstream secondary caustic tank after they have left the primary caustic tank, to sufficiently contact with a mixed solution in the secondary caustic tank, and selectively adding the component C containing an antifoaming agent; and

(iv) moving the glass bottles out of the secondary caustic tank, and subjecting them to spray cleaning.

17. The cleaning method according to 16, characterized in that in said steps (i)-(iii), the temperatures in the primary caustic tank and the secondary caustic tank are 50°C-80°C.

18. The cleaning method according to 17, characterized in that in said steps (i)-(iii), the temperatures in the primary caustic tank and the secondary caustic tank are 50°C-70°C.

19. The cleaning method according to 16 or 17, characterized in that said method comprises treatments of pre-spraying, pre-soaking and pre-heating the glass bottles before step (i).

20. The cleaning method according to 16 or 17, characterized in that said method comprises selectively adding the component C containing an antifoaming agent to the primary caustic tank to carry out an antifoaming treatment during step (ii).

21. The cleaning method according to 16 or 17, characterized in that in step (iv), the temperature for spray cleaning of the glass bottles is reduced gradually.

22. The cleaning method according to 16 or 17, characterized in that said method further comprises a step of removing peeled off labels from the primary caustic tank and the secondary caustic tank, a step of monitoring the concentrations of the components A, B and C and the caustic solution, and a feeding step for supplementing the components A, B and C and the caustic solution.

23. A cleaning system for glass bottles which employs a glass bottle cleaning additive of any one of 1-15 to clean

glass bottles, said cleaning system comprising:

- a primary caustic tank;
- a secondary caustic tank located downstream;
- a spray cleaning device located downstream of the secondary caustic tank; and
- a glass bottle conveying device for conveying glass bottles among the parts of the cleaning system for glass bottles.

24. The cleaning system according to 23, characterized in that the temperatures in the primary caustic tank and the secondary caustic tank are set at 50°C-80°C.

25. The cleaning system according to 24, characterized in that the temperatures in the primary caustic tank and the secondary caustic tank are set at 50°C-70°C.

26. The cleaning system according to 23, characterized in that the caustic solution in said primary caustic tank and said secondary caustic tank is a 1.5%-3% sodium hydroxide solution.

27. The cleaning system according to 23, characterized in that said cleaning system comprises a pretreatment device for pre-spraying, pre-soaking and pre-heating, located upstream of the primary caustic tank.

28. The cleaning system according to 23, characterized in that said cleaning system comprises feeding devices and concentration monitoring devices for the caustic solution and the components A, B and C, and further comprises a label remover connected to the primary caustic tank and the secondary caustic tank respectively for removing the peeled off glass bottle labels.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0042]

Figure 1 is a schematic flow chart illustrating the cleaning glass bottles procedure according to one embodiment of the present invention.

Figure 2 is a schematic diagram of comparison of the average mildew stain removal rate achieved by cleaning at 60°C according to one embodiment of the present invention with those achieved by cleaning at 60°C and 80°C according to prior art.

Figure 3 is a schematic diagram of comparison of the average mud and clay removal rate achieved by cleaning at 60°C according to one embodiment of the present invention with those achieved by cleaning at 60°C and 80°C according to prior art.

Figure 4 is a schematic diagram of comparison of the average label removal time achieved by cleaning at 60°C according to one embodiment of the present invention with those achieved by cleaning at 60°C and 80°C according to prior art.

## DETAILED DESCRIPTION

[0043] In general, the cleaning effect is influenced by the following four factors:

### Cleaning agent and concentration thereof

[0044] The selection of a cleaning agent relates to the type of dirt and the material of a surface to be cleaned. For different materials, it is required to select a suitable cleaning agent which not only improves the cleaning effect but also prevents an object being cleaned from corrosion. In the meantime, an increase in the concentration of a cleaning agent can shorten cleaning time properly or compensate for the insufficiency of a cleaning temperature. However, the increase in the concentration of a cleaning agent leads to an increase in cleaning cost; moreover, the increase in concentration may not necessarily improve the cleaning effect effectively, and sometimes may even lead to the prolongation of cleaning time.

### Cleaning time

[0045] The longer the cleaning time with a cleaning agent is, the better the cleaning effect is. However, the prolongation



of cleaning time means a reduction of productivity and an increase of production cost. If the cleaning time is shortened blindly, it will be possible that a desired cleaning effect cannot be achieved. Therefore, it is required to determine a proper cleaning time according to actual conditions in industrial applications.

#### 5 Cleaning temperature

[0046] The cleaning temperature refers to a temperature at which a cleaning agent is kept during a cleaning cycle, which temperature should be kept constant during the cleaning process. If sodium hydroxide is used, the temperature is generally 80°C-90°C; if nitric acid is used, the temperature is generally 60°C-80°C. The increase of the cleaning temperature can help to shorten the cleaning time or reduce the concentration of a cleaning agent, but corresponding energy consumption will be increased.

#### Mechanical cleaning force

[0047] Generally, a certain flow rate of a cleaning agent is ensured during cleaning to improve the turbulence of the fluid, so as to enhance an impact force of the cleaning agent, such that a certain mechanical action may be generated in the cleaning process, thus resulting in a good cleaning effect.

[0048] By means of the synergistic action of its components, the cleaning additive of the present invention enhances the mechanical cleaning force and the cleaning effect over the same cleaning time without increasing the concentration, and can achieve the same or better cleaning effect at a relatively low temperature.

[0049] The cleaning additive and cleaning method of the present invention also take full account of the following factors, that is, it needs to remove a label wholly to prevent the label from becoming pulp, to prevent ink and colors on the label from being dissolved, to reduce the possibility of foaming in the cleaning process and to avoid a harmful sticking reaction.

[0050] Particular embodiments mentioned and described below in the present invention are only used for illustration and detailed description of technical solutions of the present invention, but not intended to limit the scope of protection of the present invention.

[0051] The cleaning additive of the present invention can be used with existing bottle cleaning machine equipment, such as a single-end bottle cleaning machine system or a double-end bottle cleaning machine system, without the need for a specific cleaning equipment, and thus has a wide extent of application.

[0052] Figure 1 illustrates a schematic flow chart of low-temperature cleaning carried out by using the cleaning additive of the present invention in an existing bottle cleaning machine system. During cleaning, glass bottles are fed in from an inlet of the bottle cleaning machine system, wherein each of the bottles is loaded into a corresponding bottle box or other similar conveyors, wetted by way of pre-spraying, pre-soaking, pre-heating, etc., by a pretreatment device, with part of loose dirt flushed away, and then enters a primary caustic tank. A caustic solution is added into the primary caustic tank in advance, which caustic solution is usually a sodium hydroxide solution at a concentration of 1.5%-3%. To the primary caustic tank is added a component A containing an organic phosphine chelating agent (such as HEDP) at a concentration of 0.05%-0.5%, based on the weight of the caustic solution in the primary caustic tank. In case that the contamination of glass bottles is very severe, 0.1%-0.5% of a component B containing a peroxide (such as sodium percarbonate) can also be added to the primary caustic tank. The cleaning temperature of the primary caustic tank is set and kept in a range of 50°C-70°C during the cleaning process. In the primary caustic tank, the glass bottles contact with the caustic solution and the cleaning additive sufficiently, so that most of labels are peeled off there, and are carried away by a label removing device (such as a label removing chain belt). Dirt, such as mould, mud and clay and so on, is also dispersed and dissolved under the action of the cleaning solution in the primary caustic tank.

0.05%-0.5% of a component A containing an organic phosphine chelating agent (such as ATMP) and 0.1%-0.5% of a component B containing a peroxide (such as hydrogen peroxide) are added to a downstream secondary caustic tank, said concentrations being based on the weight of the caustic solution in the secondary caustic tank. The glass bottles enter the secondary caustic tank along the conveyor. In the secondary caustic tank, the labels, which have not been peeled off completely, are further peeled off here and then are carried away from the bottle cleaning machine system. The dirt on the glass bottles is completely dispersed and dissolved in the secondary caustic tank under the action of the cleaning solution.

[0053] Due to the addition of the component B containing peroxide and the action of the caustic solution in the secondary caustic tank, bubbles are generated, which enhance the mechanical force for cleaning glass bottles. During the cleaning process, technicians can adjust the addition amount of a component C according to an on-site foam condition in the bottle cleaning machine system, and the addition concentration may be 0-0.5%, based on the weight of the caustic solution in the caustic tank.

[0054] Subsequently, the bottles enter a spraying zone after they have left the secondary caustic tank. After spraying hot water, spraying warm water and spraying cold water, the temperature of the glass bottles per se is reduced gradually, and the dirt inside and outside the bottles and the cleaning solution adhered on the bottles are flushed away. Finally,

the cleaned bottles exit from an outlet of the bottle cleaning machine. They can be fed to a filling zone for packing of beer or other drinks.

[0055] In addition, it is usually required to detect the cleanness of cleaned glass bottles between the bottle cleaning machine and the filling zone. Empty bottle inspection rate (EBIR) is an important index for evaluating the cleaning effect and quality of recycled bottles. An empty bottle inspector (EBI) uses a technique of detecting the bottle body, the bottle bottom and the bottle mouth via a high-resolution camera over 360 degrees, and compares them with a standard bottle, so as to screen out unqualified bottles. High empty bottle inspection rate will influence the working efficiency of subsequent procedures, such as a procedure of filling beer or a beverage, etc. Therefore, the productivity can be improved effectively by improving the cleaning efficiency of recycled bottles and reducing the empty bottle inspection rate (EBIR).

[0056] With the component A containing an organic phosphine chelating agent, which can highly intensively penetrate and disperse mould, mud and clay on glass bottles, being added in the primary caustic tank, viscous dirt can be peeled off effectively; after the dirt is dispersed, with the component B containing a peroxide being added to the secondary caustic tank, oxidation can be carried out more effectively, to decompose organic dirt that is difficult to be removed, and on the other hand to help the component A containing an organic phosphine chelating agent in the caustic tank further peel off dirt, so that it is easier to clean the glass bottles in subsequent procedures. In the meantime, since the peroxide component B contained in the cleaning additive of the present invention releases oxygen gas under the action of the caustic solution in the caustic tank, bubbles are generated in the cleaning solution, and the bubbles continuously generated in the solution increase the stirring in the solution, resulting in a larger mechanical force, thereby breaking the dirt, reducing the adsorption force between the dirt and the glass bottle, so as to make it easier to flush away the dirt. Meanwhile, the present invention employs the synergistic action between the peroxide component B and the antifoaming agent component C, which achieves the same or better cleaning effect at a relatively low temperature (50°C-70°C) while remarkably increasing the cleaning effect of glass bottles (oxidation and enhanced mechanical force), and at the same time, also takes account of the potential negative influence that the peroxide possibly results in excessive foams.

[0057] In addition, those skilled in the art can determine the addition amount of each components of the cleaning additive according to factors such as the degree of contamination of glass bottles, the nature of contaminants, cleaning process, etc., and a generally desired cleaning effect can be achieved with an addition amount within a concentration range defined in the present invention, whereas there is no need to use too much cleaning additive, which leads to the increase of cleaning cost.

[0058] During the cleaning process, the concentration of caustic solution and the concentration of cleaning additive in the caustic tank reduce continually, so there is a need for technicians to detect the concentrations periodically and supplement them in time, or to supplement the alkali and additive by a specific adding equipment, in order to hold a certain concentration for ensuring the cleaning effect.

[0059] The glass bottle cleaning additive and cleaning method of the present invention can realize effective cleaning of recycled bottles at a relatively low temperature. The reduction of cleaning temperature can save energy without doubt, improve the operational environment, and also further promote the cleaning effect substantially. Apparently, a caustic solution at a high temperature has a stronger negative influence on the breaking of the labels per se or the dissolution of ink on the labels, whereas the cleaning technology at a low temperature overcomes this shortcoming. Thus, it is more advantageous for cleaning and maintenance of the cleaning equipment itself. Moreover, data from experiments showed that the glass bottle cleaning additive of the present invention has an obvious effect on cleaning glass bottles severely contaminated by mildew stains, mud or clay, even exceeding the cleaning effect of prior art at 80°C.

[0060] In order to further describe the advantageous effects of the cleaning additive and the low-temperature cleaning technology of the present invention, the following comparison tests were carried out by the applicant by simulating on-site cleaning conditions in the laboratory.

#### Experiment 1: mildew stain removal test

[0061] All tests employed recycled glass bottles of the same type from the same factory at the same time and with similar degrees of mildew stain contamination. Each set of tests employed 8 samples of recycled bottles of the type, and the mildew stain level for each glass bottle was observed and recorded. The situation with severest mildew stains was defined as level 5, whereas the situation without mildew stains was defined as level 0. The mildew stain levels of each glass bottle before and after cleaning were recorded. Specific processes of the tests were as follows:

##### Control test I for mildew stain cleaning

#### [0062]

- 1) Selecting recycled glass bottles with similar mildew stain degrees, recording the initial states of mildew stains and evaluating the mildew stain level of each glass bottle;

2) Preparing two cleaning solutions with tap water, each of which cleaning solutions contained a 2% sodium hydroxide solution and 0.2% of a cleaning additive Stabilon BPU, a bottle cleaning additive product with a relatively good mould removal performance from Ecolab Company;

3) Heating the two cleaning solutions and holding them at a temperature of 60°C, taking two glass bottles and soaking them in the first cleaning solution firstly, taking out the bottles after they had been soaked for 7 minutes, and then pouring out the solution from the bottles completely;

4) Placing the glass bottles in the second cleaning solution, then taking out the bottles after they had been soaked for 3 minutes, and pouring out the solution from the bottles completely;

5) Flushing the interior and the exterior of the bottles with warm water and cold water in sequence; and

6) Staining the bottles with methylene blue, then observing and recording the mildew stain levels after cleaning.

Table 1: Mildew stain levels of glass bottles after cleaning at 60°C by prior art

Glass bottle number	Mildew stain level before cleaning	Mildew stain level after cleaning
1a	5	5
1b	5	5
1c	5	3
1d	5	5
1e	4	4
1f	4	4
1g	4	2
1h	4	4

#### Control test II for mildew stain cleaning

**[0063]** Said control test I was repeated except that the cleaning temperature was set at 80°C, giving the following data:

Table 2: Mildew stain levels of glass bottles after cleaning at 80°C by prior art

Glass bottle number	Mildew stain level before cleaning	Mildew stain level after cleaning
2a	5	4
2b	5	2
2c	5	5
2d	5	2
2e	5	2
2f	5	3
2g	5	1
2h	5	1

#### Control test III for mildew stain cleaning

**[0064]** Said control test I was repeated except that a formulation A of the cleaning additive of the present invention without a peroxide was used to replace the cleaning additive Stabilon BPU in the above test, wherein the formulation A was a mixture of 15% sodium gluconate, 15% amino trimethylene phosphonic acid and 70% water, and the following data was obtained :

Table 3. Mildew stain levels after cleaning at 60°C by using the formulation A of the cleaning additive of the present invention without adding peroxide

Glass bottle number	Mildew stain level before cleaning	Mildew stain level after cleaning
3a	4	3
3b	5	3
3c	5	2
3d	5	3
3e	5	2
3f	5	5
3g	5	3
3h	5	3

Mildew stain cleaning test IV using the cleaning additive of the present invention

**[0065]**

- 1) Selecting recycled glass bottles with similar mildew stain degrees, recording the initial states of mildew stains and evaluating the mildew stain level of each glass bottle;
- 2) Preparing two cleaning solutions with tap water, the first cleaning solution of which contained a 2% sodium hydroxide solution and 0.2% of the formulation A; and the second cleaning solution contained a 2% sodium hydroxide solution and a total concentration of 0.2% of the formulation A and a formulation B; wherein the formulation A was a mixture of 15% sodium gluconate, 15% amino trimethylene phosphonic acid and 70% water, and the formulation B was a 50% hydrogen peroxide solution;
- 3) Heating the two cleaning solutions and holding them at a temperature of 60°C, taking two glass bottles and soaking them in the first cleaning solution, taking out the bottles after 7 minutes, and then pouring out the solution from the bottles completely;
- 4) Placing the glass bottles in the second cleaning solution, then taking out the bottles after they had been soaked for 3 minutes, and pouring out the solution from the bottles completely;
- 5) Flushing the interior and the exterior of the bottles with warm water and cold water in sequence; and
- 6) Staining the bottles with methylene blue, and then observing and recording the mildew stain levels after cleaning.

Table 4. Mildew stain levels after cleaning at 60°C by using the cleaning additive (formulation A + formulation B) of the present invention

Glass bottle number	Mildew stain level before cleaning	Mildew stain level after cleaning
4a	4	0
4b	5	2
4c	5	0
4d	4	0
4e	5	1
4f	5	1
4g	4	0
4h	4	0

**[0066]** After completion of the experiments, mildew stain removal rates were obtained from the data obtained in tables 1-4 above according to a computing equation for mildew stain removal rate, and mean values of the 8 bottles were plotted to obtain figure 2.

$$\text{mildew stain removal rate\%} = \frac{\text{mildew stain level before cleaning} - \text{mildew stain level after cleaning}}{\text{mildew stain level before cleaning}} \times 100\%$$

[0067] As shown in tables 1-4 or figure 2, it is evident that the mildew stain removal rate for cleaning at 80°C by a conventional method is higher than that at 60°C under identical conditions, indicating that the increase of temperature improves the cleaning effect significantly. It is evident that the mildew stain removal effect by using a single component of the cleaning additive of the present invention (without adding a peroxide) is not as good as that by using the cleaning additive of the present invention under the synergistic action of its components. Lastly, the mildew stain removal rate obtained by cleaning at 60°C using the cleaning additive of the present invention is still higher than that obtained by the conventional method at 80°C. Therefore, the cleaning additive of the present invention can achieve a better cleaning effect at a relatively low temperature.

#### Experiment 2: Mud and clay removal test

[0068] All tests employed recycled glass bottles of the same type from the same factory at the same time and with severe mud and clay contamination. Each set of tests employed 8 samples of recycled bottles of the type. During the experiments, the situation with severest mud and clay was defined as level 5, whereas the situation without mud and clay was defined as level 0, and the mud and clay levels of each glass bottle before and after cleaning were recorded.

#### Control test I for mud and clay cleaning

#### [0069]

- 1) Selecting recycled glass bottles with similar mud and clay degrees, recording the initial states of mud and clay and evaluating the mud and clay levels of each glass bottle;
- 2) Preparing two cleaning solutions with tap water, each of which cleaning solutions contained a 2% sodium hydroxide solution and 0.2% of a cleaning additive Stablon HP, a bottle cleaning additive product with a relatively good mud and clay removal performance from Ecolab Company;
- 3) Heating the two cleaning solutions and holding them at a temperature of 60°C, taking two glass bottles and soaking them in the first cleaning solution firstly, taking out the bottles after they had been soaked for 7 minutes, and then pouring out the solution from the bottles completely;
- 4) Placing the glass bottles in the second cleaning solution, then taking out the bottles after they had been soaked for 3 minutes, and pouring out the solution from the bottles completely;
- 5) Flushing the interior and the exterior of the bottles with warm water and cold water in sequence;
- 6) Observing and recording the mud and clay levels after cleaning.

Table 5: Mud and clay levels of glass bottles after cleaning at 60°C by prior art

Glass bottle number	Mud and clay level before cleaning	Mud and clay level after cleaning
5a	4	2
5b	5	4
5c	5	5
5d	5	2
5e	5	2
5f	4	4
5g	4	3
5h	4	2

Control test II for mud and clay cleaning

**[0070]** The above mud and clay cleaning test was repeated except that the cleaning temperature was set at 80°C, and the following data in table 6 was obtained:

Table 6: Mud and clay levels of glass bottles after cleaning at 80°C by prior art

Glass bottle number	Mud and clay level before cleaning	Mud and clay level after cleaning
6a	5	3
6b	5	4
6c	5	1
6d	5	2
6e	5	2
6f	5	1
6g	5	0
6h	5	0

Control test III for mud and clay cleaning

**[0071]** The above mud and clay cleaning test I was repeated except that a formulation C of the cleaning additive of the present invention without a peroxide was used to replace the cleaning additive Stablon HP in the above test, wherein the formulation C was a mixture of 20% lactic acid, 10% 2-phosphonobutane-1,2,4-tricarboxylic acid and 70% water, and the following data was obtained:

Table 7: Mud and clay levels after cleaning at 60°C by using the formulation C of the cleaning additive of the present invention without adding peroxide

Glass bottle number	Sand level before cleaning	Sand level after cleaning
7a	5	3
7b	5	4
7c	5	2
7d	5	3
7e	5	2
7f	5	3
7g	3	1
7h	3	2

Mud and clay cleaning test IV using the cleaning additive (formulation C + formulation D) of the present invention:**[0072]**

- 1) Selecting recycled glass bottles with similar mud and clay degrees, recording the initial states of mud and clay and evaluating the mud and clay levels of the bottles;
- 2) Preparing two cleaning solutions with tap water, the first cleaning solution of which contained a 2% sodium hydroxide solution and 0.2% of the formulation C; and the second cleaning solution contained a 2% sodium hydroxide solution and a total concentration of 0.2% of the formulation C and a formulation D; wherein the formulation C was a mixture of 20% of lactic acid, 10% of 2-phosphonobutane-1,2,4-tricarboxylic acid and 70% of water, and the formulation D was 50% sodium percarbonate;
- 3) Heating the two cleaning solutions and holding them at a temperature of 60°C, taking two glass bottles and soaking them in the first cleaning solution, taking out the bottles after 7 minutes, and then pouring out the solution from the bottles completely;

- 4) Placing the glass bottles in the second cleaning solution, then taking out the bottles after they had been soaked for 3 minutes, and pouring out the solution from the bottles completely;  
 5) Flushing the interior and the exterior of the bottles with warm water and cold water in sequence;  
 6) Observing and recording the mud and clay levels after cleaning.

Table 8. Mud and clay levels after cleaning at 60°C by using the cleaning additive of the present invention

Glass bottle number	Mud and clay level before cleaning	Mud and clay level after cleaning
8a	3	0
8b	3	0
8c	5	0
8d	5	1
8e	5	2
8f	5	0
8g	5	0
8h	5	1

[0073] After completion of the experiments, mud and clay removal rates were obtained from the data obtained in tables 5-8 above according to a computing equation for mud and clay removal rate, and mean values of the 8 bottles were plotted to obtain figure 3.

$$\text{mud and clay removal rate}\% = \frac{\text{mud and clay level before cleaning} - \text{mud and clay level after cleaning}}{\text{mud and clay level before cleaning}} \times 100\%$$

[0074] As shown in tables 5-8 or figure 3, it is evident that the mud and clay removal rate for cleaning at 80°C by a conventional method is higher than that at 60°C under identical conditions, indicating that the increase of temperature improves the cleaning effect significantly. It is evident that the mud and clay removal effect by using a single component of the cleaning additive of the present invention (without adding a peroxide) is not as good as that by using the cleaning additive of the present invention under the synergistic action of its components. Lastly, the mud and clay removal rate obtained by cleaning at 60°C using the cleaning additive of the present invention is still higher than that obtained by the conventional method at 80°C. Therefore, the cleaning additive of the present invention can achieve a better cleaning effect at a relatively low temperature.

### Experiment 3: Label removal test

[0075] All tests employed recycled glass bottles from the same factory at the same time and with an identical wear degree of labels. Each set of tests employed 8 samples of recycled bottles of the type, and the label removal time of each glass bottle was observed and recorded.

#### Control test I for label removal

#### [0076]

- 1) Selecting recycled bottles with intact neck labels, front labels and back labels, and recording the initial states of the labels;
- 2) Preparing two cleaning solutions with tap water, each of which cleaning solutions contained a 2% sodium hydroxide solution and 0.2% of a cleaning additive Stablon BPU, which commercially available bottle cleaning additive is regarded as a bottle cleaning additive with a relatively good mould removal, label removal and mud and clay removal performance in the market; if the label removal time for the present low-temperature cleaning technology in the laboratory is equivalent to or shorter than that at 80°C by using the Stablon BPU, the low-temperature cleaning method can satisfy the requirements for label removal in industrial production;

3) Heating the two cleaning solutions and holding them at a temperature of 60°C, taking two glass bottles and soaking them in the first cleaning solution, and starting the timing;

4) Taking out the bottles after they had been soaked for 7 minutes, and then pouring out the solution from the bottles completely; placing the glass bottles in the second cleaning solution, and soaking them until all labels had been peeled off; and

5) Recording the time when the neck labels, the front labels and the back labels were peeled off, respectively.

Table 9: Label removal time (second) of glass bottles during cleaning at 60°C by prior art

Glass bottle number	Neck label removal time (second)	Front label removal time (second)	Back label removal time (second)
9a	1320	260	600
9b	683	264	600
9c	890	247	600
9d	720	1074	720
9e	905	287	600
9f	932	500	720
9g	887	461	720
9h	895	300	600

#### Control test II for label removal

**[0077]** The above test was repeated except that the cleaning temperature was set at 80°C, and the following data in table 10 was obtained:

Table 10: Label removal time of glass bottles during cleaning at 80°C by prior art

Glass bottle number	Neck label removal time (second)	Front label removal time (second)	Back label removal time (second)
10a	430	300	1800
10b	405	290	365
10c	358	205	255
10d	264	197	243
10e	345	200	590
10f	335	278	298
10g	315	190	245
10h	379	176	521

#### Control test III for label removal

**[0078]** The above control test I for label removal was repeated except that a formulation E of the cleaning additive of the present invention without a peroxide was used to replace the cleaning additive Stabilon BPU in said test, wherein the formulation E was a mixture of 25% citric acid, 5% 1-hydroxy ethylidene-1,1-diphosphonic acid and 70% water, and the following data was obtained:



Table 11: Label removal time of glass bottles during cleaning at 60°C by using the formulation E of the cleaning additive of the present invention without adding a peroxide

Glass bottle number	Neck label removal time (second)	Front label removal time (second)	Back label removal time (second)
11a	315	438	488
11b	278	281	720
11c	433	150	325
11d	400	253	778
11e	379	429	720
11f	446	293	720
11g	510	369	307
11h	516	302	720

Label removal test IV using the cleaning additive of the present invention:

**[0079]**

- 1) Selecting recycled bottles with intact neck labels, front labels and back labels, and recording the initial states of the labels;
- 2) Preparing two cleaning solutions with tap water, the first cleaning solution of which contained a 2% sodium hydroxide solution and 0.2% of the formulation E; and the second cleaning solution contained a 2% sodium hydroxide solution and a total concentration of 0.2% of the formulation E and a formulation F; wherein the formulation E was a mixture of 25% citric acid, 5% hydroxy ethylidene diphosphonic acid and 70% water, and the formulation F was 50% sodium perborate;
- 3) Heating the two cleaning solutions and holding them at a temperature of 60°C, taking two glass bottles and soaking them in the first cleaning solution, and starting the timing;
- 4) Taking out the bottles after they had been soaked for 7 minutes, and then pouring out the solution from the bottles completely; placing the glass bottles in the second cleaning solution, and soaking them until all labels had been peeled off; and
- 5) Recording the time when the neck labels, the front labels and the back labels are peeled off, respectively.

Table 12: Label removal time of glass bottles during cleaning at 60°C by using the cleaning additive (formulation E + formulation F) of the present invention

Glass bottle number	Neck label removal time (second)	Front label removal time (second)	Back label removal time (second)
12a	600	445	445
12b	600	411	451
12c	423	423	600
12d	410	410	570
12e	600	454	328
12f	439	308	600
12g	294	294	350
12h	519	280	335

**[0080]** After completion of the experiments, mean values of removal time for the neck labels, the front labels and the back labels were respectively calculated according to the data obtained in tables 9-12 above, and a maximum value of the mean values was taken as the time required for all the three labels to be peeled off totally, with results being shown in figure 4.

[0081] As shown in tables 9-12 or figure 4, it is evident that the label removal time when cleaning at 80°C by a conventional method is shortened obviously, compared to that at 60°C under identical conditions, indicating that the increase of temperature improves the cleaning effect significantly. It is evident that the label removal time when cleaning by using a single component of the cleaning additive of the present invention (without adding a peroxide) is obviously longer than that by using the cleaning additive of the present invention under the synergistic action of its components. Lastly, the label removal time when cleaning at 60°C using the cleaning additive of the present invention is shorter than that performed at 80°C by the conventional method. Therefore, the cleaning additive of the present invention can achieve a better cleaning effect at a relatively low temperature.

## Claims

1. A cleaning method for glass bottles, by using a cleaning additive, said cleaning additive consisting of a component A, a component B and a component C, wherein
  - the component A contains an organic phosphine chelating agent,
  - the component B contains a peroxide, and
  - the component C contains an antifoaming agent,
 to clean glass bottles, comprises the following steps:
  - (i) adding the component A containing an organic phosphine chelating agent to an caustic solution of a primary caustic tank, selectively adding therein the component B, and mixing them thoroughly; adding the component A containing an organic phosphine chelating agent and the component B containing a peroxide to the caustic solution of a downstream secondary caustic tank, and mixing them thoroughly;
  - (ii) immersing glass bottles in the primary caustic tank, to sufficiently contact with a mixed solution in the primary caustic tank;
  - (iii) transferring and immersing the glass bottles into the downstream secondary caustic tank after they have left the primary caustic tank, to sufficiently contact with a mixed solution in the secondary caustic tank, and selectively adding the component C containing an antifoaming agent; and
  - (iv) moving the glass bottles out of the secondary caustic tank, and subjecting them to spray cleaning.
2. The cleaning method according to claim 1, **characterized in that** in said steps (i)-(iii), the temperatures in the primary caustic tank and the secondary caustic tank are 50°C-80°C.
3. The cleaning method according to claim 2, **characterized in that** in said steps (i)-(iii), the temperatures in the primary caustic tank and the secondary caustic tank are 50°C-70°C.
4. The cleaning method according to claim 1 or 2, **characterized in that** said method comprises treatments of pre-spraying, pre-soaking and pre-heating the glass bottles before step (i).
5. The cleaning method according to claim 1 or 2, **characterized in that** said method comprises selectively adding the component C containing an antifoaming agent to the primary caustic tank to carry out an antifoaming treatment during step (ii).
6. The cleaning method according to claim 1 or 2, **characterized in that** in step (iv), the temperature for spray cleaning of the glass bottles is reduced gradually.
7. The cleaning method according to claim 1 or 2, **characterized in that** said method further comprises a step of removing peeled off labels from the primary caustic tank and the secondary caustic tank, a step of monitoring the concentrations of the components A, B and C and the caustic solution, and a feeding step for supplementing the components A, B and C and the caustic solution.
8. A cleaning system for glass bottles which employs a glass bottle cleaning additive, said cleaning additive consisting of a component A, a component B and a component C, wherein
  - the component A contains an organic phosphine chelating agent,
  - the component B contains a peroxide, and

the component C contains an antifoaming agent, to clean glass bottles, said cleaning system comprising:

a primary caustic tank;  
a secondary caustic tank located downstream;  
a spray cleaning device located downstream of the secondary caustic tank; and  
a glass bottle conveying device for conveying glass bottles among the parts of the cleaning system for glass bottles.

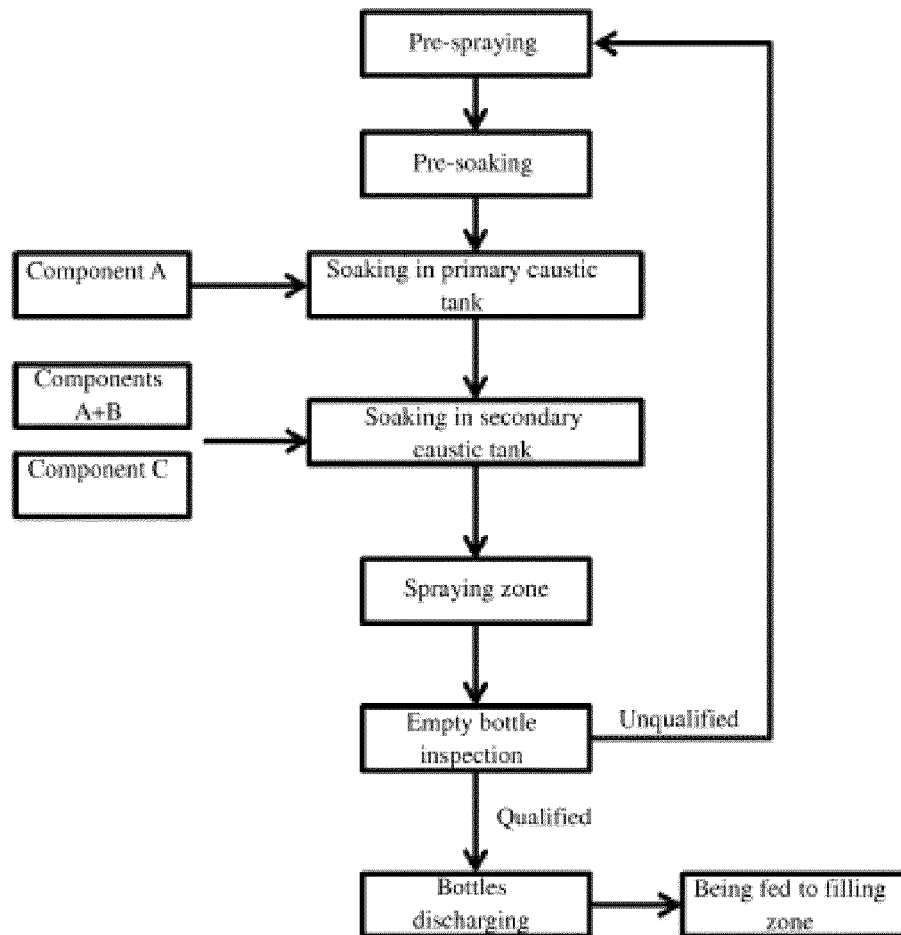
9. The cleaning system according to claim 8, **characterized in that** the temperatures in the primary caustic tank and the secondary caustic tank are set at 50°C-80°C.

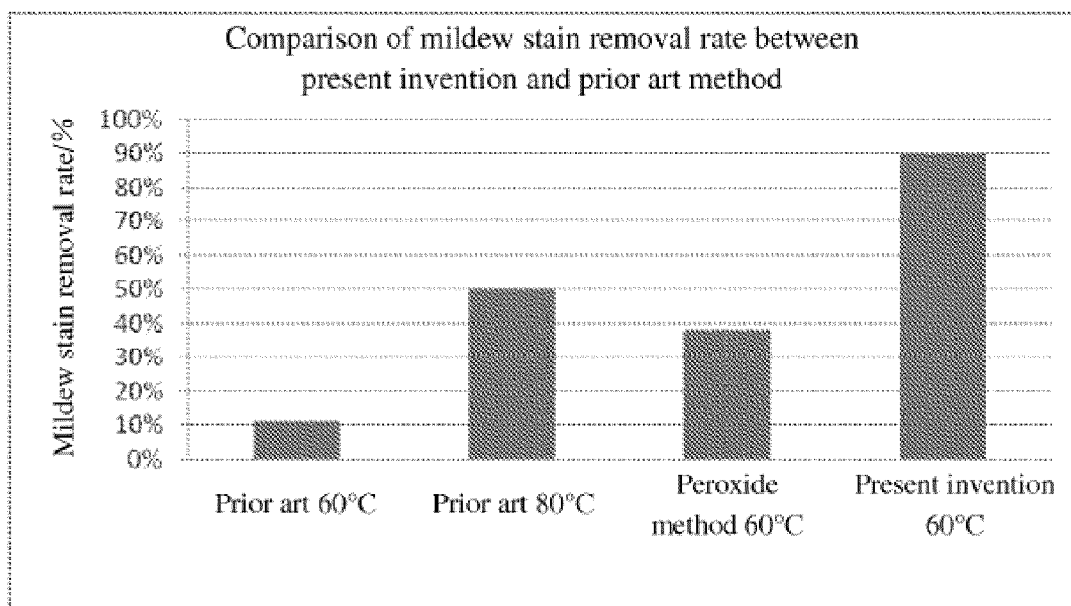
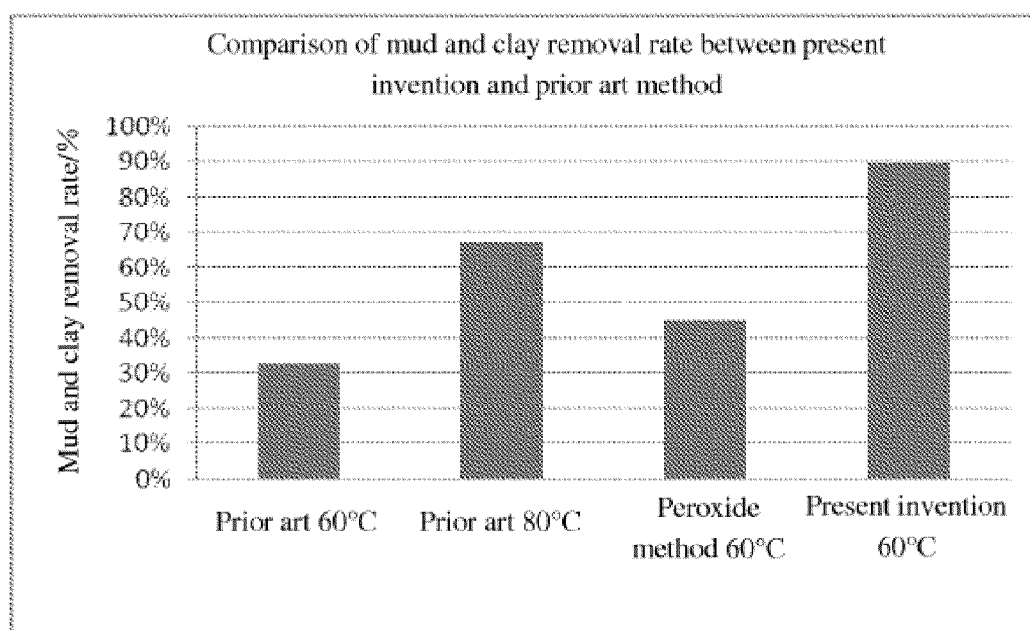
10. The cleaning system according to claim 8, **characterized in that** the temperatures in the primary caustic tank and the secondary caustic tank are set at 50°C-70°C.

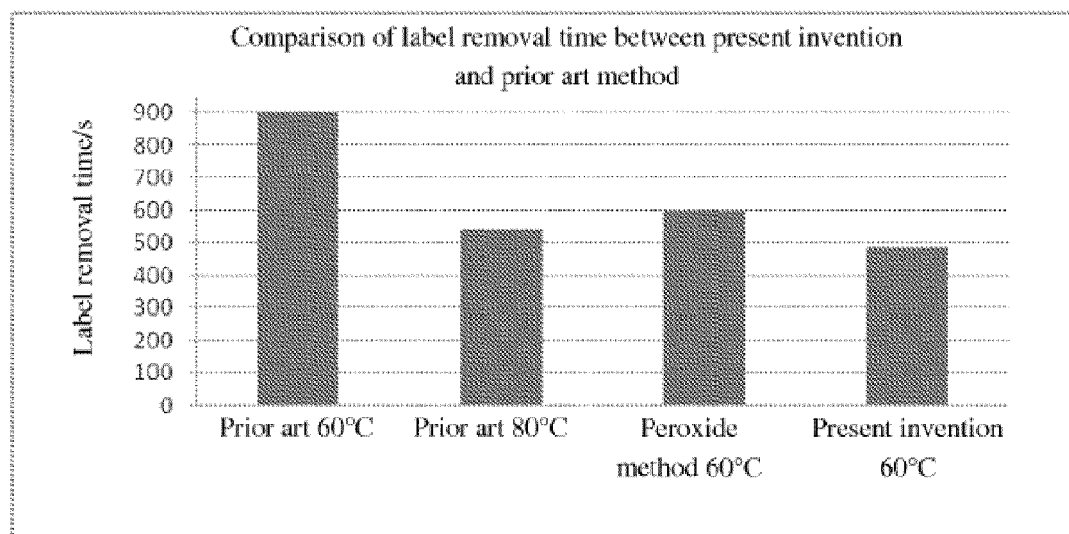
11. The cleaning system according to claim 8, **characterized in that** the caustic solution in said primary caustic tank and said secondary caustic tank is a 1.5%-3% sodium hydroxide solution.

12. The cleaning system according to claim 8, **characterized in that** said cleaning system comprises a pretreatment device for pre-spraying, pre-soaking and pre-heating, located upstream of the primary caustic tank.

13. The cleaning system according to claim 8, **characterized in that** said cleaning system comprises feeding devices and concentration monitoring devices for the caustic solution and the components A, B and C, and further comprises a label remover connected to the primary caustic tank and the secondary caustic tank respectively for removing the peeled off glass bottle labels.

*Fig.1*

*Fig. 2**Fig. 3*



*Fig. 4*