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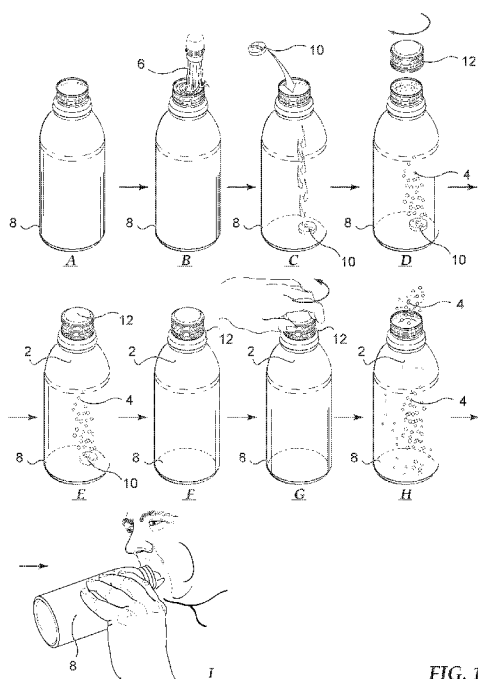


FIG. 1

(57) Abstract: A beverage containing potable water is infused with molecular hydrogen (H₂) at a concentration in excess of 0.75 mmol and a H₂ head pressure of at least 200 kPa. The beverage, together with the H₂ head pressure, may be contained within a sealed metal can. Additionally, the beverage may include a buffering agent for buffering the beverage at a pH of 4.5 or below. The buffering agent may include a food acidulant together with a magnesium salt of such food acidulant. The molar quantity of the magnesium salt exceeds the molar quantity of the molecular hydrogen (H₂) dissolved in the beverage. The canned beverage may be made by filling a can with a beverage that lacks infused molecular hydrogen and then transferring a magnesium tablet into the can. The magnesium tablet includes elemental magnesium, i.e., metallic magnesium. After the magnesium tablet is transferred into the can, the can is then sealed and the elemental magnesium is allowed to react with the water in the beverage so as to evolve molecular hydrogen (H₂) and infuse the beverage therewith. When drinking the beverage, the can is opened and the molecular hydrogen (H₂) head pressure is released. The beverage is then consumed while the molecular hydrogen (H₂) continues to effervesce therefrom.

CANNED BEVERAGE INFUSED WITH MOLECULAR HYDROGEN

Description

Field of Invention

[0001] The invention relates to canned beverages infused with molecular hydrogen (H_2). More particularly, the invention relates to methods for generating molecular hydrogen *in situ* within a beverage and infusing such beverage with molecular hydrogen after the beverage has been introduced into a can and sealed therein.

Background

[0002] A growing number of studies have explored the biological effects and benefits of molecular hydrogen (H_2). In 2007, Ikuroh Ohsawa et al. disclosed that gaseous molecular hydrogen can act as a therapeutic antioxidant. (*Nature Medicine*, 2007, vol. **13**: 688-694) More particularly, Ohsawa disclosed that oxidative stress damage induced in the brain by reperfusion after focal ischemia could be markedly suppressed by inhalation of H_2 gas. The antioxidant activity of gaseous H_2 was attributed to its ability to rapidly diffuse across membranes so as to reach and react with cytotoxic reactive oxygen species in the ischemic brain protecting it against oxidative damage resulting from reperfusion. In 2010, Atsunori Nakao et al. disclosed that hydrogen rich water can act as a therapeutic antioxidant. (*J Clin Biochem Nutr.*, 2010, vol. 46(2): 140–149). More particularly, Nakao disclosed that drinking hydrogen rich water improved levels of oxidative stress markers associated with metabolic syndrome, including obesity, insulin resistance, hypertension and dyslipidemia.

[0003] Various kits have been disclosed for generating hydrogen rich water using elemental magnesium. In 2004, Hidemitsu Hayashi disclosed a “magnesium stick” that could be introduced into a vessel filled with water for generating hydrogen rich water. (US Pat. No. 7,189,330) In 2008, Seiki Shiga disclosed the use of a first case containing elemental magnesium together with a second case containing gypsum for generating hydrogen rich water within a vessel. (US Pat. App. No. 20080311225) After the two cases are introduced into the vessel together with the water, the vessel is then placed into storage for generating molecular hydrogen.

[0004] Various proposals have been made for producing hydrogen rich water using pressured gaseous hydrogen. In 2005, Yoshida Yoshiaki disclosed a method for producing hydrogen rich water wherein raw drinking water is sprayed into a pressure vessel pressurized with gaseous hydrogen. (US Pat. App. No. 20050224996) In 2015, Levy Gail disclosed a method for producing hydrogen rich water wherein raw drinking water is introduced into a pressure vessel and stirred therein while the pressure vessel remains pressured with gaseous hydrogen. (WO 2015175547) In 2015, Igarashi Junichi disclosed a continuous process for producing hydrogen water using pressurized gaseous hydrogen. (WO 2015166967 A1) In 2010, Kato Akira disclosed a process for producing hydrogen water wherein the hydrogen is introduced into the water via a gas permeable membrane. (JP 2010274181)

[0005] In 2010, Robert Stanley Farr disclosed a metal can for containing and dispensing effervescent beverages. (US Pat. App. No. 2006/0201331 A1) The metal can included an actuator for dispensing the beverage. Farr discloses that molecular hydrogen is one of many potential gases that could be contained in his bottle.

[0006] Most canned carbonated beverages are produced by first carbonating the beverage with pressurized CO₂ and then introducing the carbonated beverage into a can and sealing the can. Alternatively, some carbonated beverages, such as beer and root beer, can acquire their carbonation by a process of fermentation, i.e., without the use of pressurized CO₂. Such fermented beverages are made in fermentation vessels and then transferred to individual drinking cans.

[0007] Given the therapeutic benefits of hydrogen rich water, what was needed was a convenient method for generating molecular hydrogen *in situ* within a beverage sealed inside a metal can.

Summary

[0008] In general terms, the invention relates to beverages (2) with water infused with pressurized molecular hydrogen (H₂) (4), to methods for manufacturing same, to articles of manufacture thereof, and to methods for using same. Optionally, the beverages (2) may be flavored and/or sweetened.

[0009] One aspect of the invention is directed to a beverage (2) comprising potable water (6) having a pressure of at least 200 kPa with molecular hydrogen (H₂) (4) dissolved therein, the molecular hydrogen (H₂) having a concentration in excess of

0.75 mmol. The potable water (6) further including a buffering agent including a food acidulant and a magnesium salt of the food acidulant dissolved in the water (6) for buffering the water at a pH at or below 4.5, the magnesium salt having a molar quantity in excess of the molar quantity of said dissolved molecular hydrogen (H_2). In a preferred embodiment, the dissolved molecular hydrogen (H_2) has a concentration in excess of 1.0 mmol. In another preferred embodiment, the dissolved molecular hydrogen (H_2) has a concentration in excess of 1.5 mmol. In another preferred embodiment, the buffering agent includes a salt of the food acidulant having one or more cations, in addition to magnesium, selected from the group of dietary minerals consisting of calcium, phosphorus, potassium, sulfur, sodium, iron, cobalt, copper, zinc, manganese, molybdenum, iodine, bromine, and selenium. In another preferred embodiment, the beverage (2) further comprises a water soluble vitamin admixed therein, the water soluble vitamin being selected from the group consisting of B₁, B₂, B₃, B₅, B₆, B₇, B₉, B₁₂, and C. In another preferred embodiment, the beverage (2) further comprises a green tea extract admixed therein. In another preferred embodiment, the food acidulant is selected from the group consisting of malic acid, fumaric acid, citric acid, acetic acid, and lactic acid. In another preferred embodiment, the beverage (2) further comprises a sweetening agent admixed therein for sweetening the beverage (2). In another preferred embodiment, the sweetening agent is selected from the group consisting of natural sweeteners and artificial sweeteners. In another preferred embodiment, the beverage (2) further comprises a flavoring agent admixed therein for flavoring the beverage (2). In another preferred embodiment, the beverage (2) further comprises both a flavoring agent and a sweetening agent admixed therein for flavoring and sweetening the beverage (2).

[0010] A second aspect of the invention is directed to a can (8) of pressurized beverage (2). The can of pressurized beverage (2) comprises a sealed metal can (8), a beverage (2) infused with molecular hydrogen (4), described above, and a gaseous phase, including gaseous molecular hydrogen (H_2). More particularly, the beverage (2) is enclosed within the sealed can (8) together with the gaseous phase. The gaseous phase includes gaseous molecular hydrogen (H_2) in equilibrium with the dissolved molecular hydrogen dissolved in the beverage (2), in accordance with Henry's Law. In a preferred embodiment of this second aspect of the invention, the

gaseous molecular hydrogen (H_2) has a partial pressure in excess 100 kPa. In another preferred embodiment, the dissolved molecular hydrogen (H_2) has a concentration in excess of 1.0 mmol. In another preferred embodiment, the gaseous molecular hydrogen (H_2) has a partial pressure in excess 250 kPa. In another preferred embodiment, the can (8) has a burst pressure greater than 250 kPa relative to atmospheric air pressure. In another preferred embodiment, the metal can (8) has an aluminum composition. In another preferred embodiment, the can (8) has a volume between 50 ml and 1000 ml. In another preferred embodiment, the can (8) has a leakage rate of less than 15% / year with respect to the gaseous molecular hydrogen (H_2) therein leaking from the can (8) into atmospheric air. In another preferred embodiment, the molar quantity of magnesium cations (Mg^{2+}) enclosed within the can (8) is not less than the molar quantity of the gaseous molecular hydrogen (H_2) enclosed within the can (8).

[0011] In a broader version of the above second aspect of the invention, the can of pressurized molecular hydrogen (4) infused beverage (2) comprises a sealed metal can (8), a beverage (2), and a gaseous phase including gaseous molecular hydrogen (H_2). The beverage (2) is enclosed within the sealed can (8) and includes potable water (6) having a pressure of at least 200 kPa, dissolved molecular hydrogen (H_2) dissolved in the water with a concentration in excess of 1 mmol, and a buffering agent including a food acidulant and a magnesium salt of the food acidulant dissolved in the water for buffering said water at a pH at or below 4.5. The magnesium salt has a molar quantity in excess of the molar quantity of said dissolved molecular hydrogen (H_2) (4). The gaseous molecular hydrogen (H_2) is enclosed within the sealed can (8) together with the beverage (2) and is in equilibrium with the dissolved molecular hydrogen therein. In a preferred embodiment of this second aspect of the invention, the dissolved molecular hydrogen (H_2) has a concentration in excess of 1.5 mmol.

[0012] A third aspect of the invention is directed to a method for consuming molecular hydrogen (4). In the first step of the method, a can of beverage (2) is opened wherein the can (8) contains both dissolved and gaseous molecular hydrogen (4), the gaseous molecular hydrogen being pressurized and in equilibrium with the dissolved molecular hydrogen. Then, in the second step of the process, the gaseous molecular hydrogen (H_2) (4) is released from the can (8) and depressurized.

Then, in the third step of the process, the beverage (2) is drunk while the dissolved molecular hydrogen (H_2) (4) effervesces from the beverage (2).

[0013] A fourth aspect of the invention is directed to a method for transforming a first aqueous beverage substantially lacking infused molecular hydrogen (H_2) into a second beverage infused with molecular hydrogen (H_2) (4). In the first step of the method, a metal can (8) is filled with the first aqueous beverage. Then, in the second step of the process, a tablet (10) with elemental magnesium is transferred into the metal can (8) for contacting the first aqueous beverage therein. The tablet (10) has a density greater than the density of the first aqueous beverage. Then, in the third step of the process, the metal can (8) is sealed for confining the first aqueous beverage therein together with the tablet (10). And then, in the fourth step of the process, molecular hydrogen (H_2) is generated within the sealed metal can (8) by reacting the elemental magnesium with water in the first aqueous beverage confined therein. The first aqueous beverage is transformed into the second beverage having infused molecular hydrogen (H_2) by the generation of molecular hydrogen (H_2) (4) in the fourth step. In a preferred mode of this fourth aspect of the invention, in the first step, not less than 90% of the volume of the metal can (8) is filled with the first aqueous beverage. In another preferred mode, the tablet (10) sinks within the first aqueous beverage during the second step. In another preferred mode, the can (8) is sealed in the third step so as to have a leakage rate of less than 15% / year with respect to the loss of gaseous molecular hydrogen (H_2) enclosed therein. In another preferred mode, the generation of molecular hydrogen (H_2) (4) in the fourth step generates sufficient molecular hydrogen (H_2) to produce the second beverage with a concentration of dissolved molecular hydrogen (H_2) therein in excess of 1 mmol. In yet another preferred mode, the generation of molecular hydrogen (H_2) in the fourth step generates sufficient molecular hydrogen (H_2) to produce a partial pressure of gaseous molecular hydrogen (H_2) within the sealed metal can (8) in excess 130 kPa.

Brief Description of Drawing

[0014] Figures 1 A-I illustrate a sequence for making and consuming a canned beverage (2) infused with molecular hydrogen (4), wherein the can (8) employs a screw top (12).

[0015] Figures 2 A-I illustrate an alternative sequence for making and consuming a canned beverage (2) infused with molecular hydrogen (4), wherein the can (8) employs a pull tab (14).

[0016] Figure 3 illustrates a graph depicting the solubility of molecular hydrogen in water as a function of temperature.

[0017] Figure 4 illustrates a graph depicting a relationship that theoretically predicts the upper limit of the partial pressure H_2 that can be achieved from use of the hydrogen infusion method disclosed herein, as a function of the starting volume of the air gap within the can (8).

The "Air" Gap and Pressure Calculation

[0018] A sealed can (8) of hydrogen infused beverage (2) will include an "air" gap between the top of the beverage (2) and the top of the interior of the can (8). This air gap will have a pressure that exceeds atmospheric pressure. The composition of the air gap will include gases that have been introduced to the can (8), preferably molecular hydrogen or an inert gas, in combination with the molecular hydrogen gas that has been generated therein, as described below.

[0019] The gas pressure within this air gap is determined by the interior volume of the can (8), the quantity of beverage (2) introduced into the can (8), and the quantity of hydrogen generating material (e.g., elemental magnesium) introduced into the can (8). Introducing too much beverage (2) or too much hydrogen generating material into the can (8) may cause the resultant gas pressure to exceed the pressure rating of the sealed can (8) and should be avoided.

[0020] A calculation of the resultant gas pressure within a sealed can (8) of hydrogen infused beverage (2) may be made by applying the above variables to the Ideal Gas Law, in combination with Henry's Law and the Law of Conservation of Mass. The calculation, together with useful estimates for the input factors, is described below.

Chemical Generation of Molecular Hydrogen

[0021] In a preferred embodiment, the molecular hydrogen is generated by the addition of elemental magnesium (Mg) to a sealed container containing an aqueous beverage (2). The elemental magnesium reduces water within the aqueous beverage (2) to produce molecular hydrogen according to following reaction:



[0022] Reaction (1) occurs in a closed vessel having a constant volume. However, the pressure within the reaction vessel increases as the gaseous molecular hydrogen (g) is generated. The enthalpy of Reaction (1), at constant volume, is equal to the change in the internal energy (ΔE) of the reacting system. The enthalpy of Reaction (1) is large. Given that Reaction (1) occurs in the presence of a large excess of water, that it has a large enthalpy, and that the reaction is allowed to proceed for days or months, i.e., the reaction time includes the storage period after the beverage (2) is made, Reaction (1) is substantially quantitative and goes to completion. Substantially all the elemental magnesium is converted to magnesium hydroxide (Mg(OH)_2), with a stoichiometry of 1:1.

[0023] The reaction is initiated by introducing the elemental magnesium into a container containing the aqueous beverage (2). After the magnesium is introduced into the container, the container is promptly sealed while the elemental magnesium sinks to the bottom of the beverage (2). The elemental magnesium then reduces water to form molecular hydrogen (H_2) and magnesium hydroxide (Mg(OH)_2). A portion of the molecular hydrogen (H_2) remains dissolved in the beverage (aq) and a portion effervesces to form gaseous molecular hydrogen (g). Magnesium hydroxide has a low solubility in water but is also capable of forming a suspension. Accordingly, a small portion of the magnesium hydroxide remains dissolved in the beverage as a solute (aq) and a larger portion of the magnesium hydroxide forms an aqueous suspension within the beverage (2).

Law of Conservation of Mass

[0024] Law of Conservation of Mass states that mass is neither created nor destroyed in a chemical reaction. In other words, the mass of any one element at the beginning of a reaction will equal the mass of that same element at the end of the reaction.

[0025] Given that the Reaction (1) goes substantially to completion and that the magnesium reactants and products have a stoichiometry of 1:1, each mole of elemental magnesium will produce one mole of magnesium hydroxide. Accordingly, the molar quantity of magnesium hydroxide produced by the reaction of equation (1)

is substantially identical to the molar quantity of elemental magnesium added to the reaction mixture, viz.:

$$n_{Mg} = n_{Mg(OH)2}$$

where (n_{Mg}) is the molar quantity of the reactant elemental magnesium added to the reaction mixture and ($n_{Mg(OH)2}$) is the molar quantity of the product magnesium hydroxide.

[0026] However, Reaction (1) also has a stoichiometric ratio of 1:1 with respect to the two products, i.e., magnesium hydroxide and molecular hydrogen. Accordingly, each mole of elemental magnesium will also produce one mole of molecular hydrogen.

[0027] Accordingly, the molar quantity of molecular hydrogen (H_2) produced by the reaction of equation (1) is substantially identical to the molar quantity of elemental magnesium added to the reaction mixture, viz.:

$$n_{Mg} = n_{H2} \quad \text{(Equation 1)}$$

where (n_{Mg}) is defined above and (n_{H2}) is the molar quantity of the product molecular hydrogen.

[0028] However, the product molecular hydrogen will exist within the reaction vessel in two phases, i.e., a gaseous phase ($n_{H2 \text{ gaseous}}$) and an aqueous phase (dissolved within the water) ($n_{H2 \text{ aqueous}}$).

[0029] Accordingly, Equation (1) may be restated as follows:

$$n_{Mg} = n_{H2 \text{ gaseous}} + n_{H2 \text{ aqueous}}$$

And finally, the molar quantity of molecular hydrogen dissolved in the aqueous phase is equal to the molar quantity of elemental magnesium added to the reaction mixture minus the molar quantity of molecular hydrogen in the gaseous phase:

$$n_{H2 \text{ aqueous}} = n_{Mg} - n_{H2 \text{ gaseous}} \quad \text{(Equation 2)}$$

Conservation of Volume

[0030] The volume of the “air” gap within the can (8) may be calculated from the total interior volume (V_T) of the can (8) and from the volume of solid and liquid inputs

introduced into the can (8). The total interior volume (V_T) of the sealed can (8) may be provided by its manufacturer or may be measured directly. After the can is sealed, its total interior volume may be considered to be fixed. Optionally, if there is measurable expansion of the can when its contents are pressurized and if this expansion factor is known, the interior volume (V_T) of the can may be treated as a function of pressure.

[0031] Prior to sealing the can, a beverage, not yet infused with hydrogen, is loaded into the can, together with a solid tablet (10) of hydrogen generating material. Preferably, this loading process is performed under a “loading atmosphere,” preferably either an inert gas or molecular hydrogen, so that space not occupied within can by the beverage (2) and any solid objects therein is occupied by the “loading atmosphere” gas. Once the can is sealed, this “loading atmosphere” gas forms the initial air gap.

[0032] The interior volume of the sealed can is initially occupied by the elemental magnesium in tablet (10) or other form, the beverage (2), and a gas. In other words, the sealed can contains a solid phase, a liquid phase and a gas phase. Immediately after the can is sealed, the elemental magnesium tablet (10) therein is still largely intact, i.e., it has not yet dissolved or started to react with the aqueous component of the beverage (2).

[0033] The solid and liquid phases are each substantially incompressible. Their combined volume is determined by the quantity of solid and liquid material introduced into the can. Their combined volume is approximately the same whether the tablet (10) [0001] is dissolved within the liquid phase or has not yet been dissolved.

[0034] Shortly after the can is sealed, the tablet (10) will begin to dissolve within the beverage (2) and to react with the water therein to generate molecular hydrogen, according to Reaction 1. Some of the newly generated molecular hydrogen will remain dissolved in the beverage (2) and some will effervesce and join the gas phase.

[0035] Since the total interior volume of the can is fixed and since the solid/ liquid phase is considered incompressible, the total volume occupied by the gas phase

within the sealed can must also remain fixed. These relationships with respect to the "Conservation of Volume" may be summarized by the following equation:

$$V_T = V_L + V_G,$$

where (V_T) is the total interior volume of the sealed can; (V_L) is the combined volume of the liquid/solid phase; and (V_G) is the volume of the gaseous phase. The above equation may be rearranged to calculate the volume of the gas phase:

$$V_G = V_T - V_L \quad (\text{Equation 3})$$

Henry's Law

[0036] Henry's Law states that the amount of dissolved gas in a liquid is proportional to its partial pressure in the gas phase. The proportionality factor is called Henry's Law constant (H), viz.:

$$H = c_{aq}/c_G \quad (\text{Equation 4})$$

where c_{aq} is the concentration of a gas (e.g., molecular hydrogen) in the aqueous phase and c_G is the concentration of the same gas in the gas phase.

[0037] In the molecular hydrogen infused beverage of the present invention, before a can of beverage is opened, the gas above the drink is almost pure molecular hydrogen at a pressure higher than atmospheric pressure. The beverage itself contains dissolved molecular hydrogen. When the can is opened, this gas escapes, giving a characteristic hiss. Because the partial pressure of molecular hydrogen above the aqueous based beverage is now much lower, some of the dissolved molecular hydrogen comes out of the beverage as bubbles, i.e., the beverage effervesces. If the beverage (2) is left in the open, the concentration of molecular hydrogen in the beverage will come into equilibrium with the molecular hydrogen in the air, and the beverage will go "flat".

[0038] The aqueous solubility of molecular hydrogen is less than the aqueous solubility of carbon dioxide. For example, at 77°F, Henry's Law constant (H) for molecular hydrogen in water is 1.9×10^{-2} . In contrast, at the same temperature, Henry's Law constant (H) for carbon dioxide in water is 8.3×10^{-1} . Accordingly, in order to achieve a concentration of dissolved gas comparable to carbonated drinks, containers holding beverages infused with molecular hydrogen must have a gas pressure higher than the pressure conventionally employed for carbonated drinks.

[0039] Returning to Equation 4, since concentrations are defined as moles per volume, Henry's Law constant (H) may be restated as follows:

$$H = c_L/c_G = (n_{aq}/V_{aq}) / (n_{gas}/V_{gas}) \quad (\text{Equation 5})$$

where n_{aq} is the moles of gas (molecular hydrogen) in the aqueous phase; V_{aq} is the volume of the aqueous phase; n_{gas} is the moles of gas (molecular hydrogen) in the gaseous phase; and V_{gas} is the volume of the gaseous phase.

[0040] In turn, Equation (5) may be solved for n_{aq} and restated as follows:

$$n_{aq} = H \cdot n_{gas} \cdot (V_{aq}/V_{gas}) \quad (\text{Equation 6})$$

Henry's Law and Law of Conservation of Mass Combined

[0041] Equating the expressions for n_{aq} in equations 2 and 6, i.e., $n_{aq} = n_{aq}$, yields the following expression:

$$n_{Mg} - n_{gas} = H \cdot n_{gas} \cdot (V_{aq}/V_{gas}) \quad (\text{Equation 7})$$

[0042] Solving Equation 7 for n_{gas} gives the following expression:

$$n_{gas} = n_{Mg} / (1 + (H \cdot (V_{aq}/V_{gas}))) \quad (\text{Equation 8})$$

Ideal Gas Law

[0043] The ideal gas law is stated as follows:

$$P_{gas} = n_{gas} RT / V_{gas} \quad (\text{Equation 9})$$

where P_{gas} is the pressure of a gas; n_{gas} is the molar quantity of a gas; R is the gas constant; T is the temperature; and V_{gas} is the volume of the gas.

Can Pressure

[0044] If one knows the volume of a can (8), the volume of beverage within the can, the temperature of the can, and the quantity of elemental magnesium added to the can, one is able to calculate the pressure within the can resulting from the evolution of molecular hydrogen within such sealed can in accordance with the chemical reaction described in Reaction 1.

[0045] Combining equations 8 and 9 provides the following expression:

$$P_{gas} = n_{Mg} RT / [(1 + (H \cdot (V_{aq}/V_{gas}))) \cdot V_{gas}] \quad (\text{Equation 10})$$

[0046] And finally, combining equations 3 and 10 provides the following expression:

$$P_{gas} = n_{Mg} RT / [V_T - V_{aq} \cdot (1 + H)] \quad (\text{Equation 11})$$

[0047] Can pressure (P_{gas}) from Equation 11 as a function of can volume and beverage volume is plotted in Figure 4. As one can see from Equation (11), can pressure increases linearly with the quantity of elemental magnesium added to the beverage. As one can see from both Equation (11) and from the plot in Figure 4, can pressure increases asymptotically as the beverage volume approaches the can volume.

Example 1: Flavored H₂ Water

Water	500 ml (final volume)
Malic Acid	400 mg
Sucrose	200 mg
Fumaric Acid	100 mg
Lemon Lime natural flavor	100 mg
Stevia	40 mg
Magnesium	60 mg

[0048] The above solid ingredients, including the elemental magnesium, are mixed with one another and compressed to form a tablet (10). The water (6) is then filled into an open-top can (8) having a fill volume of 525 ml, as illustrated in Figures 1 and 2. Sufficient water is put into the open-top can (8) so that when subsequently, the tablet (10) is added to the can, the final volume will be 500ml, leaving an unfilled air gap of 5% of the volume of the can. The tablet (10) is then inserted into the can. The open-top can is sealed as soon as possible after the tablet is inserted therein either by means of screwing on a cap (12) onto the cone top (Fig. 1) or sealing the can with a lid (16) having a pull tab (14), stay tab, or the equivalent (Fig. 2). After the can is sealed, the elemental magnesium within the tablet (10) reacts with the water (6) by reduction to form molecular hydrogen (4) and magnesium hydroxide Mg(OH)₂.

The $\text{Mg}(\text{OH})_2$ then reacts with the food acidulants, viz., malic acid and fumaric acid to form a buffer with magnesium malate and fumarate salts. The buffer acts to stabilize the pH of the flavored water having a pH of less than 4.5. Part of the evolved molecular hydrogen remains dissolved in the flavored water and, at the completion of the magnesium reduction, forms a solute with a concentration in excess of 1.0 mmolar H_2 . The remaining evolved molecular hydrogen forms a gaseous phase, which pressurizes the sealed can (8). During storage, the dissolved and gaseous phases of the molecular hydrogen achieve an equilibrium with a dimensionless Henry's constant of 1.9×10^{-2} at 298.15 K to form the flavored H_2 water.

Example 2: Sports H₂ Water

Water	500 ml
Malic Acid	400 mg
Sucrose	200 mg
Fumaric Acid	100 mg
Lemon Lime natural flavor	100 mg
Magnesium	60 mg
Stevia	40 mg
Sodium Citrate	100 mg
Potassium Citrate	100 mg

[0049] The protocol for making a sports H_2 water is similar to the method for Example 1, except the composition of the tablet (10) includes the above solid ingredients.

Example 3: Energy H₂ Water

Water	500 ml
Malic Acid	400 mg
Sucrose	200 mg

Fumaric Acid	100 mg
Lemon Lime natural flavor	100 mg
Magnesium	60 mg
Stevia	40 mg
Green tea extract	120 mg
Vitamin B12	1 mg

[0050] The protocol for making an energy H₂ water is similar to the method for Example 1, except the composition of the tablet (**10**) includes the above solid ingredients.

What is claimed is:

1. A beverage comprising:
 - potable water having a pressure of at least 200 kPa;
 - dissolved molecular hydrogen (H_2) dissolved in said water with a concentration in excess of 0.75 mmol;
 - a buffering agent including a food acidulant and a magnesium salt of the food acidulant dissolved in said water for buffering said water at a pH at or below 4.5, the magnesium salt having a molar quantity in excess of the molar quantity of said dissolved molecular hydrogen (H_2).
2. A beverage according to claim 1 wherein:
 - said dissolved molecular hydrogen (H_2) having a concentration in excess of 1.0 mmol.
3. A beverage according to claim 2 wherein:
 - said dissolved molecular hydrogen (H_2) having a concentration in excess of 1.5 mmol.
4. A beverage according to claim 1 wherein:
 - said buffering agent including a salt of the food acidulant having one or more cations, in addition to magnesium, selected from the group of dietary minerals consisting of calcium, phosphorus, potassium, sulfur, sodium, iron, cobalt, copper, zinc, manganese, molybdenum, iodine, bromine, and selenium.
5. A beverage according to claim 1 further comprising:
 - a water soluble vitamin admixed with said water, said water soluble vitamin being selected from the group consisting of B₁, B₂, B₃, B₅, B₆, B₇, B₉, B₁₂, and C.
6. A beverage according to claim 1 further comprising:
 - a green tea extract admixed with said water.

7. A beverage according to claim 1 wherein:
said food acidulant being selected from the group consisting of malic acid, fumaric acid, citric acid, acetic acid, and lactic acid.
8. A beverage according to claim 1 further comprising:
a sweetening agent admixed with said water for sweetening said water.
9. A beverage according to claim 8 wherein:
said sweetening agent being selected from the group consisting of natural sweeteners and artificial sweeteners.
10. A beverage according to claim 1 further comprising:
a flavoring agent admixed with said water for flavoring said water.
11. A beverage according to claim 10 further comprising:
a sweetening agent admixed with said water for sweetening said water.
12. A can of pressurized beverage comprising:
a sealed metal can;
a beverage according to claim 1, said beverage being enclosed within said sealed can; and
a gaseous phase including gaseous molecular hydrogen (H_2) enclosed within said sealed can together with said beverage and in equilibrium with said dissolved molecular hydrogen therein.
13. A can of pressurized beverage according to claim 12 wherein:
the gaseous molecular hydrogen (H_2) having a partial pressure in excess 100 kPa.
14. A can of pressurized beverage according to claim 12 wherein:
said dissolved molecular hydrogen (H_2) having a concentration in excess of 1.5 mmol.

15. A can of pressurized beverage according to claim 14 wherein:
the gaseous molecular hydrogen (H_2) having a partial pressure in excess 200 kPa.
16. A can of beverage according to claim 12 wherein:
said can having a burst pressure greater than 200 kPa relative to atmospheric air pressure.
17. A can of beverage according to claim 12 wherein:
said metal can having an aluminum composition.
18. A beverage according to claim 12 wherein:
said can having a volume between 50 ml and 1000 ml.
19. A can of beverage according to claim 12 wherein:
said can having a leakage rate of less than 15% / year with respect to the gaseous molecular hydrogen (H_2) therein leaking from said can into atmospheric air.
20. A can of beverage according to claim 12 wherein:
the molar quantity of magnesium cations (Mg^{2+}) enclosed within said can being not less than the molar quantity of the gaseous molecular hydrogen (H_2) enclosed within said can.
21. A can of pressurized beverage infused with molecular hydrogen comprising:
a sealed metal can;
a beverage enclosed within said sealed can, said beverage including:
potable water having a pressure of at least 200 kPa;
dissolved molecular hydrogen (H_2) dissolved in said water with a concentration in excess of 0.75 mmol; and
a buffering agent including a food acidulant and a magnesium salt of the food acidulant dissolved in said water for buffering said water at a pH at

or below 4.5, the magnesium salt having a molar quantity in excess of the molar quantity of said dissolved molecular hydrogen (H_2); and a gaseous phase including gaseous molecular hydrogen (H_2) enclosed within said sealed can together with said beverage and in equilibrium with said dissolved molecular hydrogen therein.

22. A can of pressurized beverage according to claim 21 wherein:
said dissolved molecular hydrogen (H_2) having a concentration in excess of 1.5 mmol.
23. A method for consuming molecular hydrogen comprising the following steps:
Step A: opening a can of beverage containing both dissolved and gaseous molecular hydrogen (H_2), the gaseous molecular hydrogen being pressurized and in equilibrium with the dissolved molecular hydrogen; then
Step B: releasing and depressurizing the gaseous molecular hydrogen; and then
Step C: drinking the beverage therein while the dissolved molecular hydrogen (H_2) effervesces from the beverage.
24. A method for transforming a first aqueous beverage substantially lacking infused molecular hydrogen (H_2) into a second beverage infused with molecular hydrogen (H_2), the method comprising the following steps:
Step A: filling a metal can with the first aqueous beverage;
Step B: transferring a tablet with elemental magnesium into the metal can for contacting the first aqueous beverage therein, the tablet having a density greater than the first aqueous beverage; then
Step C: sealing the metal can for confining the first aqueous beverage therein together with the tablet; and then
Step D: generating molecular hydrogen (H_2) within the sealed metal can by reacting the elemental magnesium with water in the first aqueous beverage confined therein;
whereby said generation of molecular hydrogen (H_2) in said Step D within the sealed metal can transforming the first aqueous beverage to the second beverage having infused molecular hydrogen (H_2).

25. A method according to claim 24, wherein:
in said Step A, not less than 90% of the volume of the metal can being filled with the first aqueous beverage.
26. A method according to claim 24, wherein:
in said Step B, the tablet sinking within the first aqueous beverage.
27. A method according to claim 24, wherein:
in said Step C, the sealed metal can having a leakage rate of less than 15% / year with respect to the loss of gaseous molecular hydrogen (H_2) enclosed therein.
28. A method according to claim 24, wherein:
in said Step D, said generation of molecular hydrogen (H_2) generating sufficient molecular hydrogen (H_2) to produce the second beverage with a concentration of dissolved molecular hydrogen (H_2) therein in excess of 1 mmol.
29. A method according to claim 24, wherein:
in said Step D, said generation of molecular hydrogen (H_2) producing a partial pressure of gaseous molecular hydrogen (H_2) within the sealed metal can in excess 100 kPa.

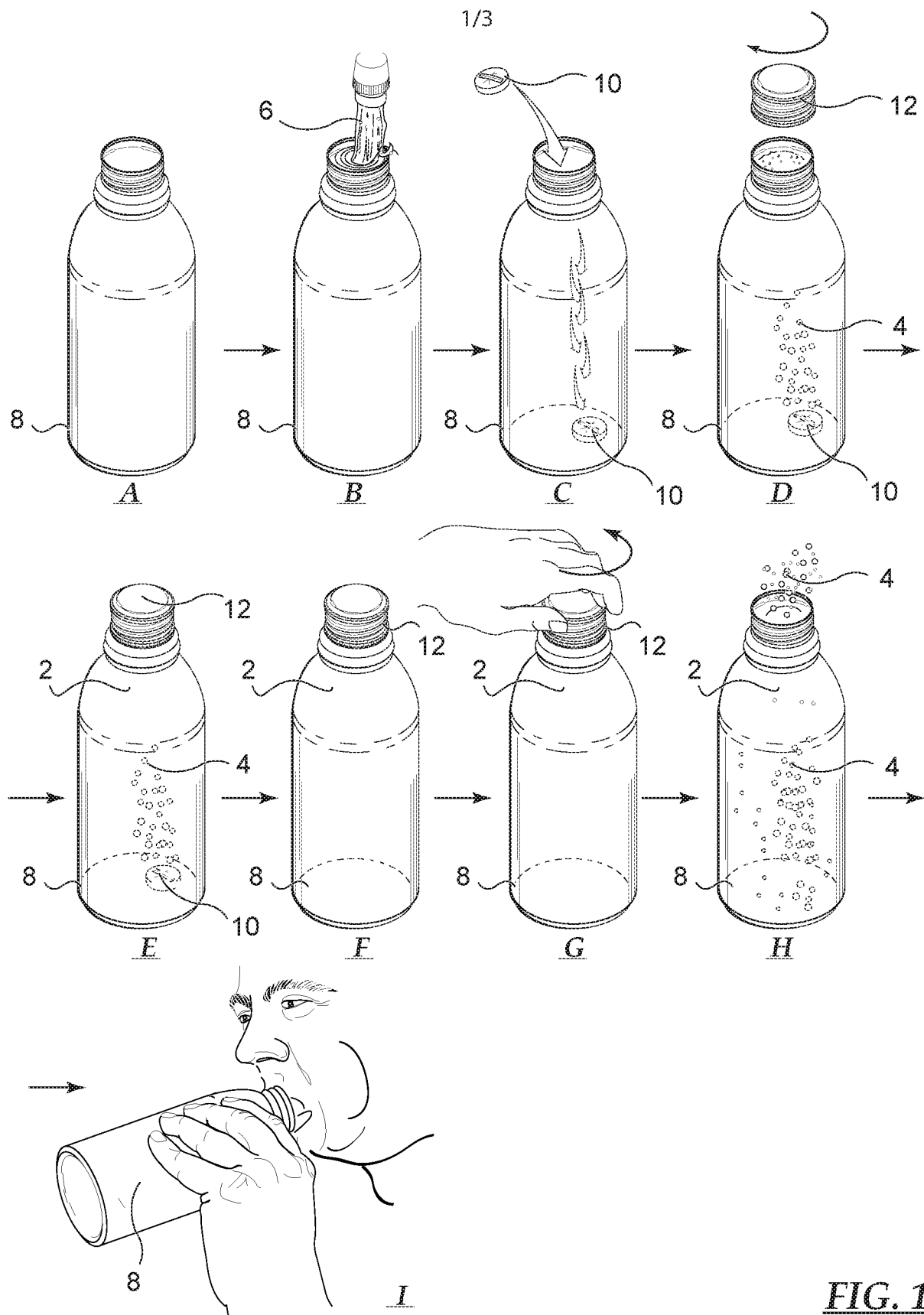
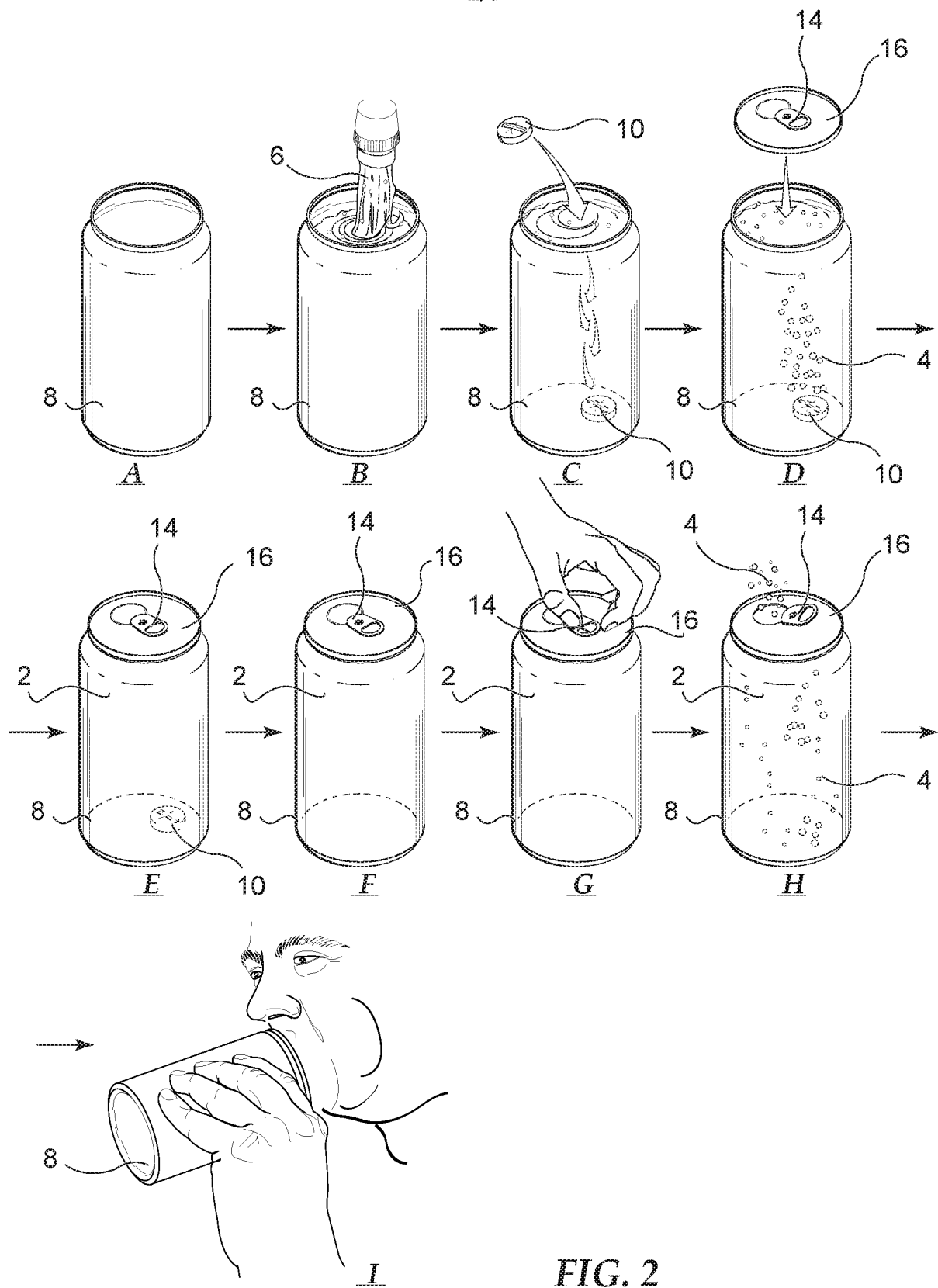


FIG. 1

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FIG. 2

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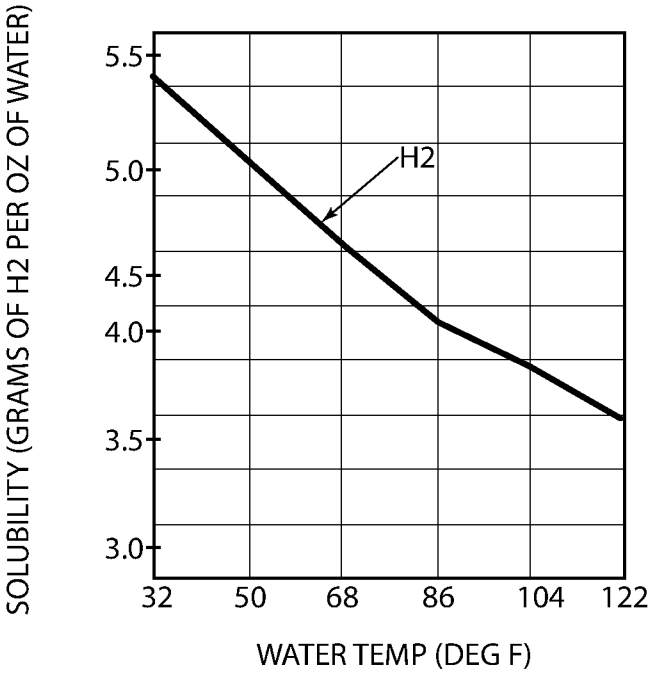


FIG. 3

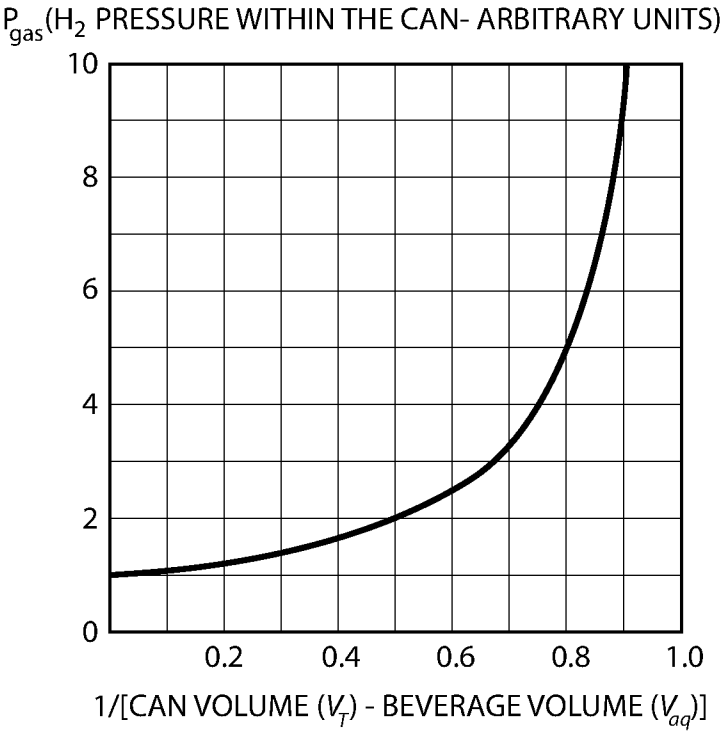


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 17/30894

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A23L 2/38, A23L 29/00, A61K 31/185, A61K 33/06, A61K 47/02, C02F 1/68 (2017.01)

CPC - A23L 2/38, A23L 2/54, A23L 3/3409, A23L 3/34095, A23L 29/00, A23L 29/015, A47G 19/2233, A47G 19/2255, A47J 31/467, A61K 31/185, A61K 9/0095, A61K 33/06, A61K 47/02, B65D 65/46, B65D 81/20, B65D 85/804, C01F 5/26, C02F 1/68, C02F 1/688, C02F 2103/026, C02F 2201/006

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012/0087990 A1 (SHIGA) 12 April 2012 (12.04.2012), Fig. 4; Table 4; para [0009], [0022], [0025], [0034], [0039], [0041], [0043], [0045], [0049], [0051], [0053], [0071], [0074], [0075], [0087], [0110], [0120]	1-23, 27, 28
Y	US 2002/0162458 A1 (FARR et al.) 07 November 2002 (07.11.2002), para [0002], [0010], [0011], [0015], [0020], [0022], [0024], [0028], [0039], [0041]	1-29
Y	US 2005/0121399 A1 (HAYASHI et al.) 07 June 2007 (07.06.2007), Fig. 2; para [0007], [0011], [0016], [0017], [0019]	24-29
Y	US 2007/0128104 A1 (HAYASHI et al.) 07 June 2007 (07.06.2007), para [0022]-[0054]	1-29
Y	WO 2015/029099 A1 (HIROAKI et al.) 05 March 2015 (05.03.2015), English Abstract only	1-29

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

17 July 2017

Date of mailing of the international search report

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