

DESCRIPTION

DEVICE FOR GENERATING HYDROGEN PEROXIDE

FIELD

[0001] Embodiments relates to a device for generating hydrogen peroxide.

BACKGROUND

[0002] These days, there has been an increasing interest in anti-virus measures and bacterial eradication measures due to an epidemic of novel influenza and the like. In response to the request of these bacterial eradication and anti-virus measures, hydrogen peroxide water is sprayed in the form of mist so as to eradicate bacteria. In the water purification and sewage field, there has been developed a technique for supplying hydrogen peroxide to raw water, generating hydroxyl (OH) radicals through ultraviolet (UV) irradiation and ozone diffusion, and performing sterilization using powerful oxidation action of the radicals. In a part of the fields such as effluent processing, hydrogen peroxide water is used.

[0003] In generation of hydrogen peroxide water used for bacterial eradication, conventionally, there has been known a method in which hydrogen peroxide water having a small percent of concentration is diluted. There has been known a device for generating hydrogen peroxide water using an electrolysis method in which a pair of electrode plates is located and inserted in the water so as to face each other, and electrolyzes water that is an electrolytic solution.

CITATION LIST

Patent Literature

[0004] Patent Literature 1: Japanese Patent Application Laid-open No. 2004-10904

Patent Literature 2: Japanese Patent Application Laid-open No. 2007-162033

Patent Literature 3: Japanese Patent Application Laid-open No. 2002-317287

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0005] However, the method in which hydrogen peroxide water having a small percent of concentration is diluted requires time and effort for supplying a medical agent, and is not versatile. The device for generating hydrogen peroxide water using an electrolysis method has a lower generation efficiency of hydrogen peroxide and cannot generate hydrogen peroxide water in high concentration.

Means for Solving Problem

[0006] A device for generating hydrogen peroxide of the embodiments includes an electrolytic cell, a pair of electrodes, and a circulation pipe. The electrolytic cell holds an electrolytic solution. The pair of electrodes is provided in the electrolytic cell and electrolyzes the electrolytic solution. The circulation pipe is connected to the electrolytic cell, and causes oxygen generated from the electrolytic solution that has been electrolyzed in the electrolytic cell to flow into the electrolytic cell.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. 1 is a view illustrating the whole configuration of a device for generating hydrogen peroxide according to a first embodiment;

FIG. 2 is a view illustrating the whole configuration

of a device for generating hydrogen peroxide according to a second embodiment;

FIG. 3 is a view illustrating the whole configuration of a device for generating hydrogen peroxide according to a first comparison example;

FIG. 4 is a view illustrating the whole configuration of a device for generating hydrogen peroxide according to a second comparison example; and

FIG. 5 is experiment results of concentration of generated hydrogen peroxide water according to the embodiment examples and comparison examples.

DETAILED DESCRIPTION

[0008] Embodiments and modifications exemplified below include like components. Hereinafter, like reference signs are assigned to the like components, and overlapped explanation is partially omitted. A part included in the embodiments and modifications can be replaced with the corresponding part in other embodiments and modifications. The configuration, the position, and the like of a part included in the embodiments and modifications are, unless specifically mentioned, the same as those of other embodiments and modifications.

[0009] Hydrogen peroxide water according to the embodiments generates hydrogen peroxide water in high concentration by returning oxygen generated from an electrolytic solution that has been electrolyzed in an electrolytic cell back to the electrolytic solution in the electrolytic cell, and increasing dissolved oxygen concentration of the electrolytic solution.

First Embodiment

[0010] FIG. 1 is a view illustrating the whole configuration of a device 10 for generating hydrogen

peroxide according to a first embodiment. The device 10 for generating hydrogen peroxide includes an electrolytic cell 12, an electrode 14, an electrode 16, a storage tank 18, a raw water pump 20, a circulation pump 22, valves 26 and 28, and pipes 30, 32, 34, 36, 38, and 40. The pipes 30, 34, and 38 are an example of a circulation pipe.

[0011] The electrolytic cell 12 holds an electrolytic solution 80 for generating hydrogen peroxide water by electrolysis. The electrolytic solution 80 is, for example, pure water or salt water. Examples of pure water include tap water. Examples of salt water include a sodium sulfate solution in concentration of 0.05 mol/L.

[0012] The electrodes 14 and 16 are provided in the electrolytic cell 12. More specifically, the electrodes 14 and 16 are provided in the electrolytic solution 80 held in the electrolytic cell 12. The electrodes 14 and 16 are disposed in parallel with a constant space from each other. The electrode 14 is connected to a negative electrode of a direct current (DC) power source 90. The electrode 14 functions as a cathode. The electrode 16 is connected to a positive electrode of the DC power source 90. The electrode 16 functions as an anode. The electrodes 14 and 16 are connected to the DC power source 90 so that polarity can be reversed. In other words, the electrode 14 may function as an anode, and the electrode 16 may function as a cathode. When the DC power source 90 applies a voltage to the electrodes 14 and 16, the electrodes 14 and 16 electrolyze the electrolytic solution 80. A space between the electrodes 14 and 16 is not specifically limited, but the space is preferably, when a voltage of 10 V to 20 V is applied, made about 2 mm to 10 mm.

[0013] The electrodes 14 and 16 have the same shape, and are formed in a rectangular shape of the same size. It is

preferable that the electrodes 14 and 16 have a specific surface area (or reactive area) capable of generating sufficient hydrogen peroxide water. The electrodes 14 and 16 include, for example, carbon. Specifically, it is preferable that the electrodes 14 and 16 be formed by dispersing highly activated carbon black (for example, VulcanXC-72 made by Cabot corporation) on a Teflon (registered mark) dispersing agent and applying the dispersed carbon black on a carbon sheet or pressing the carbon black in a carbon sheet shape and pressing the pressed carbon black in a metal current collector so as to sinter the carbon black, and the like. The electrode 16 may be formed of, for example, a platinum plate, a steel use stainless (SUS) plate, and an insolubilized electrode (dimension stable anode (DSA)).

[0014] The pipe 30 is connected to an upper part of the electrolytic cell 12. The pipe 32 is an example of a discharge pipe. The pipe 32 is connected to the pipe 30 and an outside holding unit 92. The pipes 30 and 32 connect the upper part of the electrolytic cell 12 and the outside holding unit 92 together. The pipes 30 and 32 discharge a part of the electrolyzed electrolytic solution 80 as hydrogen peroxide water 88 from the upper part of the electrolytic cell 12 to the holding unit 92.

[0015] The valve 26 is an example of a pressure adjusting unit. The valve 26 is provided to a middle part of the pipe 32. The valve 26 adjusts pressure and a discharge amount of the discharged electrolytic solution 80 (in other words, the hydrogen peroxide water 88) so that circulation pressure of the electrolytic solution 80 can be made equal to or greater than atmospheric pressure.

[0016] The pipe 30 and the pipe 34 connected to the pipe 30 are connected to the upper part of the electrolytic cell

12 and the storage tank 18. The pipes 30 and 34 connect the electrolytic cell 12 and the storage tank 18 together. The pipes 30 and 34 cause the electrolytic solution 80 including a gas bubbles 84 of oxygen generated from the electrolytic solution 80 that has been electrolyzed by the electrodes 16 and 14 to flow from the upper part of the electrolytic cell 12 into the storage tank 18.

[0017] The pipe 36 connects the storage tank 18 and an outside electrolytic solution supply source 94 together. The raw water pump 20 is provided to a middle part of the pipe 36. The raw water pump 20 supplies the electrolytic solution 80 from the electrolytic solution supply source 94 to the storage tank 18 through the pipe 36.

[0018] The storage tank 18 stores therein the electrolytic solution 80 that is supplied from the outside electrolytic solution supply source 94 and that is supplied to the electrolytic cell 12. The storage tank 18 is provided between the pipes 34 and 38, in other words, to a middle part of the circulation pipe. The storage tank 18 stores therein the electrolytic solution 80 including the gas bubbles 84 of oxygen that has been sent from the electrolytic cell 12 through the pipes 30 and 34.

[0019] The pipe 38 connects the storage tank 18 and a lower part of the electrolytic cell 12 together. The pipe 38 supplies the electrolytic solution 80 of the storage tank 18 to the lower part of the electrolytic cell 12. The pipe 38 causes the electrolytic solution 80 including the gas bubbles 84 of oxygen that has been sent from the electrolytic cell 12 to the storage tank 18 by the pipes 30 and 34 to flow into the electrolytic cell 12. In other words, the pipes 30, 34, and 38 are connected to the electrolytic cell 12, and function as a circulation pipe that causes oxygen generated from the electrolytic solution

80 that has been electrolyzed in the electrolytic cell 12 to flow into the electrolytic cell 12.

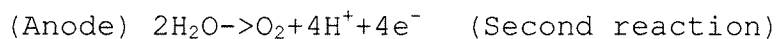
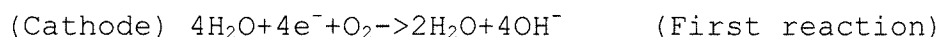
[0020] The circulation pump 22 is an example of a circulation member and a supply unit, and is provided to a middle part of the pipe 38 that is a part of the circulation pipe. The circulation pump 22 applies pressure to the electrolytic solution 80 including oxygen that flows in the pipe 38, and causes the electrolytic solution 80 to flow into the electrolytic cell 12. It is preferable that the circulation pump 22 supply the electrolytic solution 80 to the electrolytic cell 12 with pressure equal to or greater than atmospheric pressure.

[0021] The pipe 40 is an example of an exhaust pipe, and is connected to the upper part of the storage tank 18. The valve 28 is provided to a middle part of the pipe 40. The pipe 40 exhausts, in a gas layer 86 where the gas bubbles 84 of oxygen generated at the electrode 16 of the electrolytic cell 12 is separated into gas and liquid, a part from the upper part of the storage tank 18. The valve 28 adjusts an exhaust gas amount of the gas layer 86 so that circulation pressure of the electrolytic solution 80 can be maintained equal to or greater than atmospheric pressure.

[0022] The following describes operation of the device 10 for generating hydrogen peroxide according to the first embodiment.

[0023] In the device 10 for generating hydrogen peroxide, the DC power source 90 applies a DC voltage to the electrodes 16 and 14. The electrodes 14 and 16 electrolyze the electrolytic solution 80 in the electrolytic cell 12. In electrolysis of water as the electrolytic solution 80 that has been caused by the electrodes 14 and 16 that function as a cathode and an anode, respectively, the

following reaction is advanced.



Furthermore, hydrogen peroxide is secondarily generated by oxidation action of H_2O of the OH^- radicals generated on the electrode 14 side.

[0024] On the electrode 14 side, as the dissolved oxygen concentration of the electrolytic solution 80 indicated on the left side of the first reaction is higher, the reaction is advanced to the right side in a chemical equilibrium manner. On the electrode 16 side, oxygen is generated by the second reaction. Usually, on a surface of the electrode 16, the oxygen concentration becomes supersaturated, and oxygen is discharged as the gas bubbles 84. A part of the gas bubbles 84 is slowly dissolved in the electrolytic solution 80, but most of the remaining gas bubbles 84 are supplied from the electrolytic cell 12 to the storage tank 18 through the pipes 30 and 34.

[0025] In this case, when the electrolytic solution 80 that contacts atmosphere (= air) is supplied to the electrolytic cell 12, atmospheric equilibrium causes the dissolved oxygen concentration of the electrolytic solution 80 to be made about 20%, which is almost the same as that of oxygen partial pressure. By contrast, the device 10 for generating hydrogen peroxide according to the embodiment circulates the electrolytic solution 80 with the gas bubbles 84 through the storage tank 18 and the like, and returns the electrolytic solution 80 to the electrolytic cell 12. In this manner, the device 10 for generating hydrogen peroxide increases the dissolved oxygen concentration of the electrolytic solution 80 in the electrolytic cell 12.

[0026] In addition, the device 10 for generating

hydrogen peroxide has retention time of the electrolytic solution 80 including the gas bubbles 84 elongated by providing the storage tank 18 to a middle part of the circulation path of the electrolytic solution 80. In this manner, the gas bubbles 84 are further dissolved in the electrolytic solution 80. Nitrogen dissolved in the electrolytic solution 80 that has been supplied from the electrolytic solution supply source 94 to the storage tank 18 is exhausted based on Charles's law by dissolving the gas bubbles 84 in the electrolytic solution 80. Thus, the dissolved oxygen concentration in the electrolytic solution 80 is increased for partial pressure of the gas bubbles 84 from oxygen generated by the electrode 16.

[0027] Exhausted nitrogen and oxygen that is not dissolved in the electrolytic solution 80 are separated from the electrolytic solution 80, and become the gas layer 86 on the upper part of the storage tank 18. The valve 28 exhausts a part of the gas layer 86 while adjusting an exhaust gas amount so that circulation pressure of the electrolytic solution 80 can be maintained equal to or greater than atmospheric pressure.

[0028] The valve 26 discharges the electrolytic solution 80 having higher concentration of hydrogen peroxide water as the hydrogen peroxide water 88 to the outside while adjusting a discharge amount so that circulation pressure of the electrolytic solution 80 can be maintained equal to or greater than atmospheric pressure.

[0029] At the electrode 14 functioning as a cathode, inorganic ions such as calcium that are dissolved in the electrolytic solution 80 are secondarily generated as side reaction by the following third reaction. The generated inorganic ions cause deterioration in the electrode 14.



In the device 10 for generating hydrogen peroxide, when the electrodes 14 and 16 are formed of the same material and are formed in the same shape, polarity of the electrodes 14 and 16 can be regularly reversed. In other words, the electrode 16 is connected to a negative electrode of the DC power source 90, and the electrode 14 is connected to a positive electrode of the DC power source 90. In this manner, the electrode 16 functions as a cathode, and the electrode 14 functions as an anode. The device 10 for generating hydrogen peroxide dissolves, as indicated in fourth reaction, inorganic ions such as calcium that have been deposited on the electrode 14 functions as an anode in the electrolytic solution 80, and discharges the dissolved inorganic ions with the electrolytic solution 80 to the outside. After that, the electrode 14 functioning as an anode advances the second reaction and generates oxygen, and the electrode 16 functioning as a cathode generates the first reaction. In this manner, the device 10 for generating hydrogen peroxide can advance the above-mentioned reaction while regenerating the electrode 14 the polarity of which has been reversed from a cathode to an anode and extending life thereof.

(Anode: Immediately after polarity reverse) $\text{Ca} > \text{Ca}^{2+} + 2\text{e}^-$ (Fourth reaction)

[0030] As described above, the device 10 for generating hydrogen peroxide according to the first embodiment includes the pipes 30 and 34 that cause the electrolytic solution 80 to flow from the electrolytic cell 12 into the storage tank 18. The device 10 for generating hydrogen peroxide causes the electrolytic solution 80 including many of the gas bubbles 84 of oxygen that has been electrolyzed in the electrolytic cell 12 by the electrodes 14 and 16 to flow from the electrolytic cell 12 into the storage tank 18

and the electrolytic solution 80 to be circulated so as to increase the dissolved oxygen concentration of the electrolytic solution 80 in the storage tank 18. The device 10 for generating hydrogen peroxide can supply the electrolytic solution 80 having high dissolved oxygen concentration to the electrolytic cell 12, so as to advance the first reaction to the right and increase concentration of hydrogen peroxide. For example, the device 10 for generating hydrogen peroxide can generate the hydrogen peroxide water 88 having concentration from several 10 ppm to several 100 ppm.

[0031] The device 10 for generating hydrogen peroxide includes the storage tank 18. The device 10 for generating hydrogen peroxide can store the electrolytic solution 80 flowing from the electrolytic cell 12 into the storage tank 18, dissolve the gas bubbles 84 of oxygen in the electrolytic solution 80, and increase the dissolved oxygen concentration. Thus, the device 10 for generating hydrogen peroxide can advance the first reaction to the right, and generate the hydrogen peroxide water 88 in higher concentration.

[0032] The device 10 for generating hydrogen peroxide includes the circulation pump 22, and can maintain pressure of the electrolytic solution 80 flowing in the pipe 38 equal to or greater than atmospheric pressure. Thus, the device 10 for generating hydrogen peroxide can increase the dissolved oxygen concentration in the electrolytic solution 80.

[0033] The device 10 for generating hydrogen peroxide includes the pipe 40 that is connected to the upper part of the storage tank 18 and the valve 28. The device 10 for generating hydrogen peroxide can exhaust the gas layer 86 on the upper part of the storage tank 18 through the pipe

40 and the valve 28 while maintaining pressure applied to the electrolytic solution 80 that has been stored in the storage tank 18 equal to or greater than atmospheric pressure. Thus, the device 10 for generating hydrogen peroxide can increase dissolved oxygen concentration in the electrolytic solution 80.

[0034] The device 10 for generating hydrogen peroxide includes the pipe 30 connected to the upper part of the electrolytic cell 12, the pipe 32, and the valve 26. The device 10 for generating hydrogen peroxide can discharge the electrolytic solution 80 (or the hydrogen peroxide water 88) of the electrolytic cell 12 through the pipes 30 and 32, and the valve 26 while maintaining pressure applied to the electrolytic solution 80 of the electrolytic cell 12 equal to or greater than atmospheric pressure.

Second Embodiment

[0035] FIG. 2 is a view illustrating the whole configuration of a device 110 for generating hydrogen peroxide according to a second embodiment. The device 110 for generating hydrogen peroxide includes the electrolytic cell 12, the electrodes 14 and 16, a gas-liquid separation tank 118, a raw water pump 120, a compressor 122, valves 126 and 128, pipes 130, 132, 134, 136, 138, and 140, and a diffuser tube 142. The pipes 130, 134, and 138 are an example of the circulation pipe.

[0036] The pipe 132 connects a lower part of the gas-liquid separation tank 118 and the outside holding unit 92. The valve 126 is provided to a middle part of the pipe 132. The pipe 132 discharges the electrolyzed electrolytic solution 80 as the hydrogen peroxide water 88 from the upper part of the electrolytic cell 12 to the holding unit 92. The valve 126 adjusts a discharge amount of the hydrogen peroxide water 88 so that pressure of the

discharged electrolytic solution 80 can be made equal to or greater than atmospheric pressure.

[0037] The pipe 134 connects the upper part of the electrolytic cell 12 and the gas-liquid separation tank 118. The 134 causes the electrolytic solution 80 including the gas bubbles 84 of oxygen that has been electrolyzed by the electrodes 16 and 14 to flow from the upper part of the electrolytic cell 12 into the gas-liquid separation tank 118.

[0038] The gas-liquid separation tank 118 is provided between the pipes 138 and 134, to a middle part of the circulation pipe. The gas-liquid separation tank 118 holds the electrolytic solution 80 that has been electrolyzed in the electrolytic cell 12 with the gas bubbles 84 of oxygen. The gas-liquid separation tank 118 separates the electrolytic solution 80 into a liquid phase 180 that is discharged as the hydrogen peroxide water 88 and a gas layer 186 including oxygen that has been generated at the electrode 16 of the electrolytic cell 12.

[0039] The pipe 130 is connected to an upper part of the gas-liquid separation tank 118. The pipe 140 is connected to a middle part of the pipe 130. In other words, the pipe 140 is an example of a branch pipe, and branches from the pipe 130 that is a part of the circulation pipe. The pipe 140 is connected to the outside, and exhausts the gas layer 186 in the gas-liquid separation tank 118. The valve 128 is provided to a middle part of the pipe 140. The pipes 130 and 140 exhaust a part from the gas layer 186 that has been separated into gas and liquid from the upper part of the gas-liquid separation tank 118. The valve 128 adjusts an exhaust gas amount of the gas layer 186 so that circulation pressure of the electrolytic solution 80 can be maintained equal to or greater than atmospheric pressure.

[0040] The pipe 136 connects the electrolytic cell 12 and the outside electrolytic solution supply source 94 together. The raw water pump 120 is provided to a middle part of the pipe 136. The raw water pump 120 is an example of a supply unit, and directly supplies the electrolytic solution 80 from the electrolytic solution supply source 94 to the gas-liquid separation tank 118 through the pipe 136. It is preferable that the raw water pump 120 supply the electrolytic solution 80 to the electrolytic cell 12 with pressure equal to or greater than atmospheric pressure.

[0041] The pipe 130 and the pipe 138 connected to a middle part of the pipe 130 connect the upper part of the gas-liquid separation tank 118 and the electrolytic cell 12. The pipe 138 is connected to the lower part of the electrolytic cell 12 at a lower part than the diffuser tube 142. The pipes 130 and 138 cause the gas layer 186 on the upper part of the gas-liquid separation tank 118 to flow into the electrolytic cell 12.

[0042] The compressor 122 is an example of a circulation member, and is provided to a middle part of the pipe 138 that is a part of the circulation pipe. The compressor 122 applies pressure to gas of the gas layer 186 including oxygen of the gas-liquid separation tank 118 that flows in the pipes 130 and 138, and causes the gas of the gas layer 186 to flow from the gas-liquid separation tank 118 into the electrolytic cell 12.

[0043] The diffuser tube 142 is an air diffuser that has, for example, a round shape, a plate shape, and the other shape. The diffuser tube 142 is provided to a lower part of the electrolytic cell 12. The diffuser tube 142 disperses, through the pipes 134, 130, and 138 and the gas-liquid separation tank 118, gas of the gas layer 186 including oxygen that flows into the electrolytic cell 12

in the electrolytic cell 12, and diffuses the dispersed gas as the gas bubbles 84.

[0044] The device 110 for generating hydrogen peroxide according to the second embodiment causes the compressor 122 to send gas of the oxygen-rich gas layer 186 that includes oxygen generated at the electrode 16 and has been separated into gas and liquid at the gas-liquid separation tank 118 to the electrolytic cell 12. The device 110 for generating hydrogen peroxide can increase the dissolved oxygen concentration of the electrolytic solution 80 in the electrolytic cell 12, advance the first reaction to the right, and generate the hydrogen peroxide water 88 in higher concentration.

[0045] Specifically, the device 110 for generating hydrogen peroxide having the sufficiently large electrolytic cell 12 and the electrodes 14 and 16 generates the sufficiently oxygen-rich gas bubbles 84 in the electrolytic cell 12, and has a contact time of the electrode 14 with the gas bubbles 84 of oxygen elongated so as to dissolve the gas bubbles 84 having high oxygen concentration in the electrolytic solution 80. Simply by sending gas including the gas bubbles 84 of oxygen in the gas-liquid separation tank 118 to the electrolytic cell 12 as described above, this kind of device 110 for generating hydrogen peroxide can generate the hydrogen peroxide water 88 having sufficiently high concentration, for example, from several 10 ppm to several 100 ppm.

[0046] In addition, the device 110 for generating hydrogen peroxide includes the diffuser tube 142 that diffuses oxygen as gas bubbles 84 supplied to the electrolytic cell 12 as the gas in the electrolytic cell 12. The device 110 for generating hydrogen peroxide can further enhance contact of the gas bubbles 84 with the electrode 14,

and can further improve the concentration of the hydrogen peroxide water 88.

[0047] Because the valve 128 exhausts gas of the gas layer 186 while adjusting an exhaust gas amount and pressure through the pipes 130 and 140, dissolved nitrogen due to chemical equilibrium of atmospheric contact in the electrolytic solution 80 that has been supplied from the outside electrolytic solution supply source 94 to the electrolytic cell 12 can be easily exhausted from the gas layer 186 in the gas-liquid separation tank 118. Similarly to the device 10 for generating hydrogen peroxide according to the first embodiment, the device 110 for generating hydrogen peroxide can further advance the first reaction to the right with chemical equilibrium, and can improve the concentration of generated hydrogen peroxide water.

[0048] Other effects according to the second embodiment are almost the same as those of the first embodiment.

[0049] The following describes an experiment for proving effects of the embodiments described as above.

[0050] FIG. 3 is a view illustrating the whole configuration of a device 210 for generating hydrogen peroxide according to a first comparison example. FIG. 4 is a view illustrating the whole configuration of a device 310 for generating hydrogen peroxide according to a second comparison example. The following describes the device 210 for generating hydrogen peroxide according to the first comparison example and the device 310 for generating hydrogen peroxide according to the second comparison example as compared with the embodiments.

[0051] In the device 210 for generating hydrogen peroxide according to the first comparison example, an electrolytic solution 280 is supplied by a raw water pump 220 from the outside to an electrolytic cell 212 through a

pipe 236. An electrode 214 is connected to a negative electrode of a DC power source 290, and functions as a cathode. The electrode 216 is connected to a positive electrode of the DC power source 290, and functions as an anode. When the DC power source 290 applies a voltage to the electrodes 214 and 216, the electrodes 214 and 216 electrolyze the electrolytic solution 280. Hydrogen peroxide water 288 with oxygen generated at the electrode 216 is discharged to the outside through a pipe 232. Because oxygen is discharged together with the hydrogen peroxide water 288, the electrode 214 cannot obtain a sufficient contact time with oxygen. Due to chemical equilibrium of atmospheric contact of the supplied electrolytic solution 280 and oxygen partial pressure of air, the device 210 for generating hydrogen peroxide cannot advance the first chemical reaction to the right in a chemical equilibrium manner and increase the concentration of the hydrogen peroxide water 288.

[0052] When the electrode 216 functioning as an anode is formed of an inexpensive material such as SUS, a surface of the electrode 216 is flat, the electrode area is smaller, and activity generating hydrogen peroxide water is reduced. Thus, the concentration of hydrogen peroxide water cannot be increased by reversing the polarity of the electrodes 214 and 216, and depositing and removing calcium and the like.

[0053] The device 310 for generating hydrogen peroxide according to the second comparison example further includes a diffuser tube 342 provided to a lower part of the electrolytic cell 212, a pipe 338 connected to a supply source of oxygen, and a compressor 322 provided to a middle part of the pipe 338.

[0054] In the device 310 for generating hydrogen

peroxide, the compressor 322 supplies oxygen to the electrolytic cell 212 at a lower part than the diffuser tube 342 through the pipe 236. As compared with the device 210 for generating hydrogen peroxide, the device 310 for generating hydrogen peroxide can increase the dissolved oxygen concentration of the electrolytic solution 280 in the electrolytic cell 212. However, in the device 310 for generating hydrogen peroxide, oxygen that cannot be dissolved in the electrolytic solution 280 supplied from the outside and oxygen generated at the electrode 216 are discharged with the hydrogen peroxide water 288. Thus, in the device 310 for generating hydrogen peroxide, even though effective use of oxygen cannot be sufficiently made, cost is increased in order to install a device for generating oxygen for supplying oxygen or a device for supplying oxygen such as an oxygen tank.

[0055] The device 10 for generating hydrogen peroxide according to first embodiment is defined as a first embodiment example, and the device 110 for generating hydrogen peroxide is defined as a second embodiment example.

Conditions of the experiment are as follows:

Voltage of DC power supply applied to electrodes: 10 V

Current flowing into electrodes: 100 mA

Conductive time: 60 minutes

Electrolytic solution: Tap water

[0056] A Pt (platinum) plate is used as the electrode 216 functioning as an anode according to the first and second comparison examples. A carbon electrode is used as the electrode 16 functioning as an anode according to the first and second embodiment examples. Carbon electrodes are used as the electrodes 14 and 214 functioning as a cathode. The size of the electrodes 14, 16, 214, and 216 is 2 cm × 4 cm. The space between the electrodes 14 and 16,

and between the electrodes 214 and 216 is 10 mm.

[0057] After the experiment is made based on these conditions, the concentration of generated hydrogen peroxide water is measured using a pack test from the potassium iodide method. FIG. 5 is the experiment results of the concentration of generated hydrogen peroxide water according to the embodiment examples and comparison examples.

[0058] As illustrated in FIG. 5, when the first embodiment example and first comparison example where oxygen is not supplied are compared with each other, it turns out that hydrogen peroxide water in high concentration can be generated in the first embodiment example as compared with the first comparison example. When the second embodiment example and second comparison example where oxygen is supplied and diffused are compared with each other, it turns out that hydrogen peroxide water in high concentration can be generated in the second embodiment example as compared with the second comparison example. Specifically, in the case where oxygen is supplied, it turns out that a difference in the concentration of generated hydrogen peroxide water is larger.

[0059] FIG. 5 illustrates that hydrogen peroxide water in high concentration can be generated in the first and second embodiment examples where carbon electrodes are used as the electrodes 14 and 16 as compared with the first and second comparison examples where the Pt electrode is used as the electrode 216 and a carbon electrode is used as the electrode 214.

[0060] In addition, when a DC current is defined as 400mA and the conditions other than the DC current are defined as above, in the second embodiment example where

oxygen is diffused and carbon electrodes are used as the electrodes 14 and 16, the concentration of hydrogen peroxide water of four times or higher can be achieved. By contrast, in the first embodiment example where oxygen is not diffused, the concentration of hydrogen peroxide water is not largely changed even though a DC current is defined as 400mA.

[0061] The shape, the number, the disposition, the connection relation, and the like of the embodiments described above may be modified as appropriate. Each of the embodiments may be combined with each other.

[0062] For example, the diffuser tube 142 in the second embodiment may be provided to the first embodiment.

[0063] The embodiments according to the present invention have been described, but these embodiments have been presented by way of example only and are not intended to limit the scope of the invention. These new embodiments may be embodied in a variety of other forms, and various omissions, substitutions, and changes may be made without departing from the spirit of the invention. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the invention.

CLAIMS

1. A device for generating hydrogen peroxide, the device comprising:

an electrolytic cell that holds an electrolytic solution;

a pair of electrodes that is provided in the electrolytic cell and electrolyzes the electrolytic solution; and

a circulation pipe that is connected to the electrolytic cell and causes oxygen generated from the electrolytic solution that has been electrolyzed in the electrolytic cell to flow into the electrolytic cell.

2. The device for generating hydrogen peroxide according to claim 1, further comprising:

a circulation member that is provided to a middle part of the circulation pipe, and applies pressure to the oxygen flowing in the circulation pipe and causes the oxygen to flow into the electrolytic cell.

3. The device for generating hydrogen peroxide according to claim 1 or 2, further comprising:

a storage unit that is provided to a middle part of the circulation pipe, and stores therein the electrolytic solution flowing with the oxygen.

4. The device for generating hydrogen peroxide according to claim 3, further comprising:

an exhaust pipe that is connected to an upper part of the storage unit; and

a valve that is provided to a middle part of the exhaust pipe.

5. The device for generating hydrogen peroxide according to claim 1, further comprising:

a gas-liquid separation unit that is provided to a middle part of the circulation pipe, holds the electrolyzed electrolytic solution with the oxygen, and separates the electrolytic solution into a gas layer including the oxygen and a liquid phase; and

a circulation member that is provided to a middle part of the circulation pipe, and applies pressure to the gas layer including the oxygen and causes the gas layer to flow into the electrolytic cell.

6. The device for generating hydrogen peroxide according to claim 5, further comprising:

a branch pipe that branches from a middle part of the circulation pipe, and exhausts the gas layer in the gas-liquid separation unit; and

a valve that is provided to a middle part of the branch pipe.

7. The device for generating hydrogen peroxide according to any one of claims 1 to 6, further comprising:

a supply unit that supplies the electrolytic solution to the electrolytic cell with pressure equal to or greater than atmospheric pressure.

8. The device for generating hydrogen peroxide according to any one of claims 1 to 7, further comprising:

a discharge pipe that discharges the electrolyzed electrolytic solution; and

a pressure adjusting unit that is provided to a middle part of the discharge pipe and adjusts pressure of the discharged electrolytic solution.

9. The device for generating hydrogen peroxide according to any one of claims 1 to 8, wherein each of the pair of electrodes includes carbon and has the same shape.

10. The device for generating hydrogen peroxide according to any one of claims 1 to 9, wherein the pair of electrodes is connected to a direct current power source, so that polarity thereof is reversible.

11. The device for generating hydrogen peroxide according to any one of claims 1 to 10, further comprising:

a diffuser member that diffuses the oxygen flowing into the electrolytic cell through the circulation pipe.