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Electrolytic Sterilization Washing System with CNT Cathode

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Abstract
Background/Objectives: Hydrogen water was developed for health, but recent tests have shown that it has good sterilization and cleaning functions. If you can sterilize and wash fruits and meats without using detergents, you can create new demand.
Methods/Statistical analysis: An electrolysis device using platinum group-coated titanium as an anode and a carbon nanotube (CNT) and a plastic composite as a cathode was made, and the hydrogen water produced therein was used as washing water.
Findings: The pesticides and bacteria were completely removed by washing the crops, fruit, meats, etc. with hydrogen water. The device could be applied to a steaming process to purify contaminated wastewater. In addition, the ginseng was washed to completely remove the pesticides and bacteria.
Improvements/Applications: Its small size makes it possible to produce drinking hydrogen water, and the three-wavelength can wash the car without using detergent. In this case, environmental pollution by wastewater discharge can be prevented.

Keywords: *CNT, electrolysis, sterilization, washing, hydrogen water.*

1. Introduction

Hydrogen water generators have been studied in various ways [1-3]. The good health of hydrogen water has been studied in many ways [4-17]. In general, free radicals are highly oxidizing oxygen produced by biological defense to remove pathogens and foreign substances, which protect the body from pathogens. Generated and about 2% of the inhaled oxygen is converted to free radicals. As such, free radicals are beneficial for the immune function of the human body, but excessive exercise and stress, drinking, inhaling polluted air, excessive intake of acidic foods, harmful chemicals caused by environmental pollution, and ultraviolet rays generate excess free radicals. Excessive free radicals break down the cell membrane or DNA of normal cells and oxidize amino acids to induce protein deterioration, thereby promoting aging, causing various diseases including cancer, and directly oxidizing DNA in human cells It is reported to cause mutations. According to the medical community, active oxygen-related diseases account for about 90% or more. On the other hand, water containing hydrogen, that is, hydrogen water is a water containing abundant hydrogen molecules (H2) having an antioxidant action, characterized in that the particles of the water molecules are generally small, very fast penetration, especially active oxygen, in particular It is the most effective antioxidant that removes hydroxyl radical (OH), which is known to cause DNA and cell damage, and reaches every organ and brain cell of human body. Analyzing the world's four miracle waters, it is noteworthy that it contains more hydrogen than common water. When drinking hydrogen water, active oxygen reacts with hydrogen dissolved in hydrogen water

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to be reduced to water, and the reduced water leaves the body without a secondary reaction. This is called an antioxidant reaction.

Hydrogen has recently attracted great attention due to its various uses, including clean energy sources, and methods for efficiently producing hydrogen have been researched in a variety of countries as well as domestically and globally. Accordingly, the method of producing hydrogen is mainly obtained by steam reforming fossil fuels such as methane gas, and then purified and used. However, recently, in order to overcome the finiteness and environmental problems of fossil fuels, electrolysis of water is performed. It is actively developing and applying the method of using hydroelectric.

As a method of obtaining hydrogen by electrolyzing water, an alkaline aqueous electrolysis method using an aqueous alkaline solution is typical, but such a method requires a purification process due to low hydrogen purity, a separation process for separating oxygen and hydrogen, and an aqueous solution state. It has many disadvantages such as the need for process control that must continuously replenish the electrolyte, corrosion of electrodes and components by aqueous electrolyte, deterioration of hydrogen production efficiency due to low current density, and excessive power consumption due to high voltage.

On the other hand, the recently-received polymer electrolyte electrolytic method has mostly compensated for the shortcomings of the alkaline electrolytic method, and since hydrogen produced by the polymer electrolyte electrolytic method has almost no impurities other than trace amounts of water, no separate purification process is required. In addition, since the electrolyte is a solid phase, management is not necessary, and pure water is used as a source, there is almost no problem of corrosion of the device. Consumption is also low. In order to produce hydrogen in the conventional polymer electrolyte hydroelectrolyte, water is supplied to an anode in which an oxidation reaction occurs to generate oxygen, and hydrogen ions pass through an electrolyte membrane to a cathode, and then through a reduction reaction. Generate hydrogen. At this time, the hydrogen ions passing through the polymer electrolyte membrane are moved to the hydrated state, and as a result, it serves to transport the water molecules to the cathode electrode side, so that water gradually accumulates on the cathode electrode as the water is filled on the cathode electrode side. There is a hassle that must be discharged into the device, and thus the device is complicated and the supply water consumption on the anode electrode side is increased.

In this study, we report how to utilize hydrogen water for sterilization and washing by using CNT composite material as cathode of hydrogen generator. The hydrogen water generator proposed in this study maintains chlorine concentration at 5ppm and has excellent antibacterial and bactericidal effect. Does not use any chemicals and does not generate ozone. It removes odor causing bacteria and has deodorizing effect and protects skin by using hydrogen water. Effective for reducing greenhouse gas and energy.

2. CNT electrode

2.1. CNT Raw Material

Carbon nanotubes (CNTs) are allotropees of carbon with cylindrical nanostructures. Interesting electronic properties of carbon nanotubes have generally shown hope for new electrode materials, particularly in the field of batteries under test as cathodes for lithium ion batteries. Interesting electrical properties of carbon nanotubes generally show them their potential in the field of batteries, experimenting with new electrode materials, especially cathodes. This is due to the fact that it is close to the only metallic lithium potential observed so far by graphite-based composites such as carbon nanotubes, and requires a relatively high reversible capacity suitable for

irreversible capacity.

CNT is known to have 100 times the tensile strength of steel, 1000 times the electrical conductivity of copper wire, and 6000W / mK of thermal conductivity. Since the specific surface area of the nanostructure (1 to several tens of nanometers in diameter) and the apparent density were about 0.02 to 0.05g/cc, it was difficult to add a certain amount of CNTs when compounding with a polymer material. To increase the dispersibility of CNTs, oil-based CNT dispersants are used. In this case, the oil used as a dispersant in the continuous high temperature environment of more than 60℃ during product molding is released to the surface of the product to weaken the adhesion between the CNT particles, the problem is also raised electrical resistance. Acrylic anionic resin dispersion is prepared by mixing 5-10% by weight of water-dispersible acrylic anion resin and 90-95% by weight of distilled water. In the process of mixing CNT and water dispersible acrylic anion resin, CNT 98.56~99.4% by weight is mixed with water dispersible acrylic anion resin 0.6-1.44% by weight (solid content basis). CNT pellet containing 98.56 ~ 99.4% by weight of CNT mixed with 0.6~1.44% by weight of water-dispersible acrylic anion resin (based on solids), 39.8 ~ 74.8% by weight of polypropylene resin, styrene-ethylene-butylene-styrene (SEBS) 5 to 35% by weight, consisting of 0.2% by weight antioxidant. As a result, a metal-free electroconductive CNT composite material for injection molding with surface resistance of 0.37~0.91Ω/□, volume resistivity 0.007~0.009Ω/cm, electromagnetic shielding 1.5GHz is applied. Since CNTs are contained in a high content and excellent in CNT dispersion, a CNT composite material having a high level of electrical conductivity having a surface electrical resistance of 1Ω/□ or less is provided. CNT composite material is suitable for injection molding because of its excellent dimensional stability. Since the CNT composite material is excellent in electrical conductivity without using a metal, there is an advantage that it can be used without fear of corrosion in place of a conventional metal product. Therefore, it is useful to use as electrolytic electrode material in place of metal material. Figure 1 shows an example of a three-ply CNT structure.

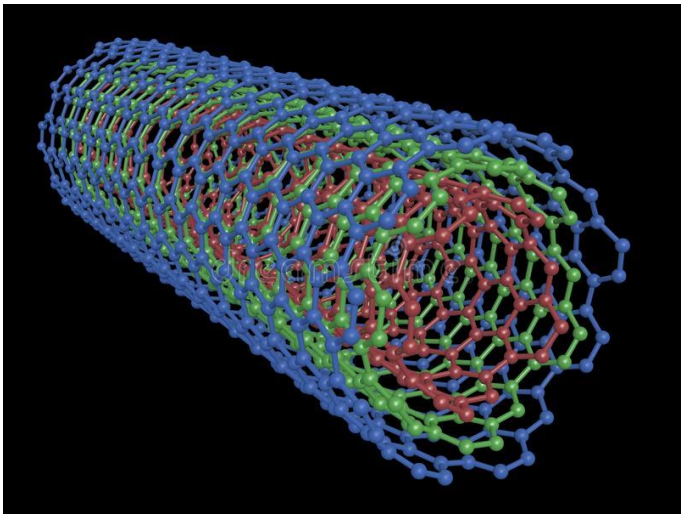

Figure 1. An example of CNT model.

2.2. Cathode production

Instead of using platinum group coated titanium as the anode, the cathode was made of CNT composite plastics. CNT plastic composites improve the electrical conductivity while compensating for the disadvantages of easily

being broken when using other materials. CNTs are known to have tensile strength of 100 times that of steel, electrical conductivity of 1000 times that of copper wire, and thermal conductivity of 6000W/mK. However, the specific surface area is large and the apparent density is 0.02~0.05 by nano structure (diameter of 1~10nm). Since it is about g / cc, it is difficult to add more than a certain amount of CNT when compounding with a polymer material. In order to increase the dispersibility of the CNT, an oil-based CNT dispersant may be used. In this case, the oil used as the dispersant may escape to the surface of the product in a continuous high temperature environment of 60°C or higher to weaken the adhesion between the CNT particles. This raises the problem of increasing the electrical resistance.

CNT plastic composite material is a process of preparing an acrylic anionic resin dispersion by mixing a water-dispersible acrylic anion resin and a distilled water of the urethane characteristics prepared by adding castor oil; Spraying the acrylic anion resin dispersion onto the CNT to mix the CNT and the water-dispersible acrylic anion resin; Controlling the moisture of the CNT and water-dispersible acrylic anion resin mixture prepared in the above process;

Extruding the CNT and the water dispersible acrylic anion resin mixture to pelletize the mixture; And compounding the CNT pellets prepared in the above process with a polypropylene resin and a thermoplastic elastomer to pelletize them. This CNT composite material is a metal-free electrical conductor with excellent chemical resistance and less than 1Ω/□ of surface electrical resistance. Figure 2 shows the structure of the positive and negative plates combined.

Figure 2. Combined structure of assembled anode and cathode.

2.3. Comparison of Metal Electrodes and CNT Electrodes

The metal electrode is damaged by the redox reaction during the electrolysis process, thereby reducing the efficiency. It is also expensive to use platinum. In comparison, the use of CNT-based plastic composites increases the surface area for the reaction and is inexpensive. Table 1 compares the properties of the metal electrode and the CNT electrode.

Table 1.Comparoson of CNT electrode and metal electrode

division	CNT electrode	Metal electrode
Electriysis	non diaphragm	non diaphragm
Electrode catalyst	CNT	Pt, Ir, Ru coated Ti(5μm)
electrolyte	self catalyzed role	electrolyte needed

Property	• Bipolar-oxidation, reduction (electron emission and migration possible) • Nonchemical characteristic • Current density (1,000 times compared with copper) • Self-catalyzed role in distilled water • Minimize to H2O clusters • Maximize the specific surface area	•Platinum catalyst - High precious metals - Low safety when using basic (NaCl) (-) poles - very expensive • Iridium-coated catalyst on titanium electrode plate - Maximizing oxygen / chlorine production - Strengthen corrosion resistance - Minimize pollution when using (+) pole

CNC electrodes have several advantages over ordinary metal electrodes, and Table 2 shows the performance of the hydrogen water produced by the device.

Table 2. Performance test

Test	Contents	Inspection standard	Measures
Bactericidal power	Escherichia coli	13000CFU/mL	Removal rate>99.9%
	Staphylococcus aureus	10000CFU/mL	Removal rate>99.9%
	Salmonella	12000CFU/mL	Removal rate>99.9%
	Pseudomonas aeruginosa	15000CFU/mL	Removal rate>99.9%
	Staphylococcus aureus	10000CFU/mL	Removal rate>99.9%
	Legionella	600000CFU/mL	Removal rate>99.9%
	Vibrio bacteria	500000CFU/mL	Removal rate>99.9%
Pesticide removal	Diazinon	0.0596 mg / ℓ	0.00 / ℓ
	Phenyrrothione	0.1169 mg / ℓ	0.00 / ℓ
	Pyration	0.1742 mg / ℓ	0.00 / ℓ

3. Electrolytic Sterilization Cleaning System Using CNT Electrode

3.1. Prototype design

A hydrogen water generator using a CNT electrode was designed. When water is first introduced and electricity is passed, hydrogen ions

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and hydroxyl ions are formed, resulting in sterilization, antibacterial and deodorizing functions. Figure 3 shows the design conceptual diagram.

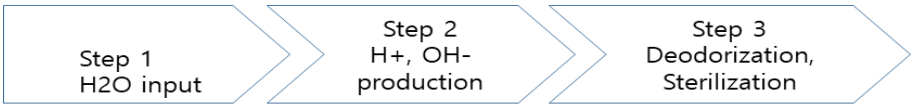

Figure 3. Prototype Design Concept.

3.2. Prototype production

A hydrogen water generator was fabricated by combining a DC power supply, a platinum-plated titanium anode, and a CNT cathode plate. Figure 4 shows a hydrogen water generator that can be easily used on a laboratory scale and shows the experiment of washing 5 year old ginseng. It could be cleaned without the use of chemicals. Recently, fast growing hydroponic cultivation has been implemented due to the increase in demand for ginseng. Hydrogen water was used for hydroponic cultivation. Figure 4 shows a hydrogen water generator that can produce 100 tonnes of hydrogen water per day. This equipment can be used in large scale sterilization facilities such as laver factories and swimming pools. Figure 5 shows the equipment of the hydrogen water generator.

Figure 4. Laboratory scale Hydrogen Water Generator.

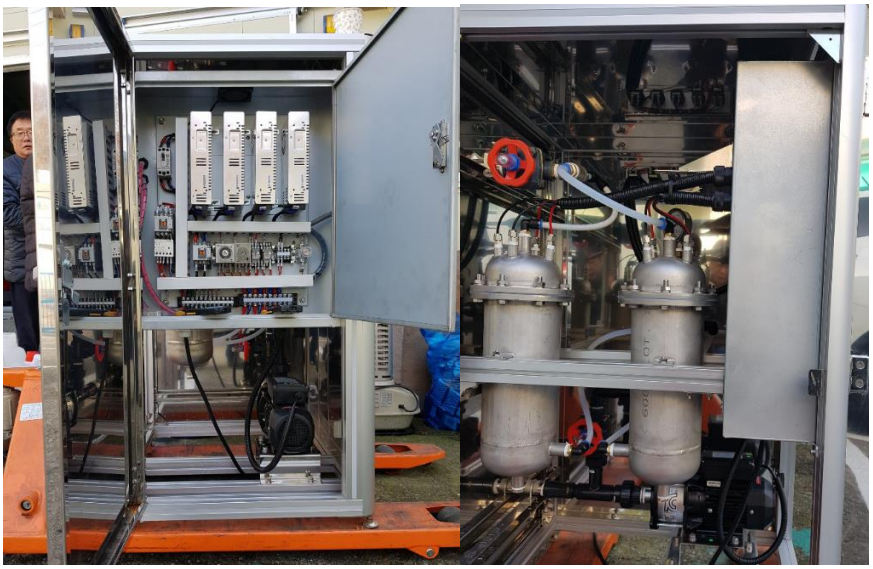

Figure 5. Hydrogen water generator using CNC electrode (Left: electric device, right: hydrogen water generator)

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4. Application

4.1. Natural food sterilization and washing

Hydrogen water spray keeps the air inside the plant clean. When spraying hydrogen water, it is possible to remove not only the leaves on the top of the plant but also the fungus inhabiting the back of the leaves. Increases immunity to various vegetables, fruits and vegetables of plant factory vulnerable to environmental changes. Spraying hydrogen water or spraying directly on leaves can increase the growth rate by 20-30%. Plants convert the carbon dioxide in the air and water absorbed from the roots into solar energy, making oxygen and glucose (carbohydrates) and using it as a nutrient source. When spraying hydrogen water or giving hydrogen water, hydrogen removes bacteria from various plant surfaces, hydrogen water smaller than plant cell wall size (25㎛) penetrates, expands water and pores, and absorbs carbon dioxide in the air and osmotic pressure on roots in the ground. Speed up growth by increasing nutrient absorption. Sterilization and antibacterial washing with hydrogen water and spraying on slaughter equipment and surrounding facilities removes fishy odor and suppresses germs that may occur in the slaughterhouse. Hydrogen spray spraying keeps plant air clean. When spraying hydrogen water, sterilization, antibacterial and deodorization are possible. Injecting hydrogen water into the slaughtered meat delays oxidation and drying, thus maintaining freshness.

Electrolysis of brine to maintain the chlorine concentration of 0.2 ~ 0.4ppm can suppress the bacteria generated in algae and increase the growth rate. It replaces sulfuric acid and hydrochloric acid, and eco-friendly farming is possible. By electrolysis instead of chemicals, sterilization and antibacterial action can be performed, and NaCl can be electrolyzed to maintain free residual chlorine concentration 0.4 ~ 0.6ppm and total residual chlorine 1.0ppm in the pool. It dissolves algae, moss and foreign substances on the floor to prevent slipping. By using NaCl, wastewater can be reduced by eco-friendly sterilization water. Clean water can be used by decomposing waste products or foreign substances in water. By suppressing germs in the surroundings and air, sterilization is possible in addition to disinfection. Figure 6 shows the washing of pork with hydrogen water. You can see that the blood of pork is effectively removed.

Figure 6. Pork washing scene using hydrogen water

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4.2. Debris removal technology after steaming

In general, the laver processing process is carried out the process of forming and drying the raw chopped to a certain shape of a certain thickness after being collected from the sea to use a raw water in this process, which generates a large amount of waste water. Therefore, if the waste water can be purified again and used again, a large amount of water consumption can be reduced, so that the plant can be operated economically. The conventional laver forming apparatus and dried laver production apparatus having the same can reuse the raw water, but since there is no filtration and water purification process, the wastewater used in the laver molding process is reused as it is, so that by-products contained in the wastewater in the laver molding process are substantially included. It cannot be reused and is inefficient even if reused. The wastewater purification device generated in the steaming process has the effect of saving energy by reusing the water generated in the steaming process. In addition, the manufacturing cost can be reduced by reusing water, and the seaweed taste is different depending on the water used in the seaweed processing process. The seaweed taste is improved by using clean water that passes through the water purification process and lamellar bed and processing seaweed. It works. In the case of using a filter, the filter needs to be changed periodically, which causes cost burden. Hydrogen water uses a decomposition method to purify waste water, so there is no additional cost. Figure 7 is an experimental procedure to purify the wastewater from the laver process A small amount of experiment yielded good results.

(a) (b) (c)

Figure 7. Purification test using hydrogen water during laver production (a: seaweed residue, b: seaweed residue filtrate, c: treatment left(before) right(after))

5. Conclusion

A hydrogen water generator using a platinum group coated titanium and a CNT plastic composite as a cathode were fabricated. Electrolyzed water devices with CNT plastic composites were fabricated to produce hydrogen water and applied to washing and sterilization. Pesticides on fruits, etc. were effectively removed, and pork was washed to effectively remove bacteria. A small amount of wastewater from the laver plant could be effectively treated. In addition, the water in the pool can be sterilized and purified without the use of chemicals. You can wash your car without using detergent. In this case, wastewater, which causes environmental pollution, can be reduced, thereby reducing environmental conservation and economic costs.

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