A New Direction of Cancer Treatment through the Development of the Anti-Oxidant Function of Hydrogen Water

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***Abstract*—Cancer has a high metastasis rate and recurrence rate, so its incidence rate and mortality rate are not much different. Cancer caused by the deformation and necrosis of cells weakens the human immune system. If an immune system is weakened, a body and cells do not have enough vigor to be recovered; even cancer is removed by a physical operation or treated with the most effective medicine. The researcher saw the solution in the hydrogen water and tried to confirm that an antioxidant was effective in treating cancer or acting as a cancer treatment supplement through a literature review. Furthermore, this study measured pH, ORP (Oxidation Reduction Potential), and electrical conductivity to identify the characteristics of water and evaluated what kind of water is proper as an antioxidant. The antioxidant function of hydrogen water was proved as a nail was rusted less in hydrogen water than in regular water. It was found a new role of antioxidant hydrogen water was an anticancer medicine from these two experiments. Moreover, it was found that hydrogen injected water can act as hydrogen water so the researcher could expect mass production of antioxidant hydrogen water.**

***Index Terms*—hydrogen water, antioxidant, anticancer effects, ORP**

I. Introduction

A. Study Motivation

People drink at least 2 liters of water per day. People intake moisture by eating food, although they do not drink water regularly. It is an essential element to maintain our lives, although it does not have a good taste. Water accounts for 70-80% of our body mass. In addition, the structure of the human body changes every 6 months due to the circulation of water. If so, people may be able to find new efficacy of water, if people pay more attention to the water people drink.

Recently, the researcher ran into a 'the miracle hydrogen water' advertisement on the internet. It says that hydrogen water has an anti-cancer function. People's reactions were skeptical. Some said it was effective and others said it was an outrageous fraud. However, this advertisement reminded the researcher of a recent article the researcher read in a science magazine. This article was about a study in Japan, which evaluated the anti-cancer effects of hydrogen water. The researcher wanted to be a researcher studying cancer and finding a new means to cure cancer. Therefore, the researcher read medical journals when the researcher can. It made the researcher curious so the researcher conducted a literature review on domestic studies evaluating the anti-cancer effects of hydrogen water. However, there were only few studies, unlike advertisements on hydrogen water and hydrogen water makers excessively claimed. There were a few studies regarding the antioxidant effects of hydrogen water.

Cancer is like an unsolved riddle, although science and technology have advanced significantly in the modern society. It is not only because it is hard to detect the onset of cancer but also because cancer easily spreads to other organs, has a high recurrence rate, and shows a high mortality rate. Radiotherapy and physical operation can easily damage the nerve cells of a patient. Young cancer patients have a higher mortality rate than elder cancer patients do because cancer encroaches the vigor of patients. It is necessary to find a means to easily prevent cancer with minimum side effects.

The researcher thought that hydrogen water might be a solution for cancer. Although water is closely related to our life, people do not know much about water. Therefore, it is important to know the components of water and a proper drinking method by accumulating scientific knowledge on water. Particularly, people will be able to utilize water resources in the most effective way by gaining scientific knowledge of the cluster structure of water molecules and making practical approaches. It is because people cannot live without drinking water, although people can survive without food for a while. Water is the most essential and versatile media.

This study paid attention to the potential of water, which is a major component of the human body. Cancer is the main cause of mortality among modern people and water can be a perfect remedy for cancer without a side effect. The researcher focused on the antioxidant function of hydrogen water, a current hot topic. The antioxidant function reduces the amount of active oxygen and prevents cell damage. The researcher was trying to find a connection between hydrogen water and a cancer

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treatment. Moreover, the researcher tried to identify if artificially hydrogen inserted water has an anti-cancer function. If so, the researcher planned to design and manufacture the hydrogen water with anti-cancer function throughout the connection.

B. Study Objectives

Water accounts for more than 80% of a human body, so changing the quality of water in a body means to alter 80% of our body. Water can act as an antioxidant and an antioxidant can prevent the production of malignant cells by resolving active oxygen in a human body. The cause of cancer is the development of malignant cells. The modern people suffer from imbalanced nutrition, poor quality of resting, and much stress due to their busy schedules. These characteristics make the modern people have more active oxygen in their bodies. The increase of active oxygen raises the possibility of cell deformation and necrosis. Cancer, consequently, can occur more easily. It is said that many people find that they have cancer only after cancer proceeds to the phase 3, although more people have a regular health checkup. The fact reflects that the busy lifestyle of modern people restrains them from taking medical checkups. Busier schedule and accordingly nutritional intake require faster movements, thereby active oxygen generation is further enhanced. The inhaled oxygen creates energy in our bodies and reduces to water. This process creates oxygen residue with high oxidation power, which is the process of active oxygen creation. A human body produces active oxygen to defend it from the mold and bacterial infections, which is the positive role of active oxygen. However, too frequent reactions and the increase of active oxygen secretion can cause a problem. Active oxygen efflux can burden blood vessel walls, other organs, and tissues. It directly affects the oxidation of blood.

If so, what is the desired direction of cancer treatment? The technique and precision of cancer cells excision has advanced magnificently, but a physical treatment cannot avoid giving physical damage to a human body due to its medical characteristics. Therefore, the surgical treatment can delay the recovery of patients with low vigor (e.g., elders, children, or patients with metastatic cancer) even if the treatment is localized.

People need a simple tool to cure and prevent cancer. The researcher found a breakthrough from water, which circulates in our body ceaselessly and refurbishes our body every 6 months. People need to understand the strength of hydrogen water, which is considered as a purifying water, over natural water and if it is proper to use it as an antioxidant against cancer. Hydrogen water has a different solubility in oil than regular water. People need to understand this characteristic fully and determine how it can purify harmful elements in our bodies. Based on these understandings, its recommendation should be decided. This will affect the rise of the hydrogen water and the mass production system of antioxidant hydrogen water. It may settle in as the most effective means to prevent cancer with improving the foundation of human body.

C. Study Methods

This study tried to promote the production and circulation of antioxidant functions with hydrogen added water through two experiments.

The first experiment was conducted directly by the researcher. A survey list was created by selecting evaluative components of water, which directly influence a human body. Scientific methods to measure these elements were evaluated and the standard of good water was created. They include pH, ORP, and they have to be examined from various perspectives. The grounds of differences were empirically tested by comparing the clustered water formed by combining hydrogen with regular water and evaluating the manufacturing method of hydrogen water, which may have the most effective health functionality.

The most representative differences between general natural water and hydrogen rich water were solubility in oil and surface tension. Functions to have as an antioxidant were withdrawn by comparing and analyzing them. Based on this, researchers should determine if hydrogen water could be used as an antioxidant.

The second experiment was to evaluate the possibility of relating antioxidation and anticancer treatment by reviewing case studies of foreign specialized research teams. From the existing studies, the possibility of applying the antioxidation function to anticancer treatment was examined. Furthermore, the mass production possibility of hydrogen water was tested.

II. Theoretical Review

A. The Characteristics of Water

Water is the most fundamental compound to support lives. However, it has a rather simple molecular structure. Moreover, it forms an interesting structure by being interconnected with other water molecules and repeating the same pattern. A water molecule is composed of two hydrogen atoms and one oxygen atom and its chemical formula is H_2O. The density of water is around $1g/cm^3$ and the density is highest at 4 ℃ in its liquid form.

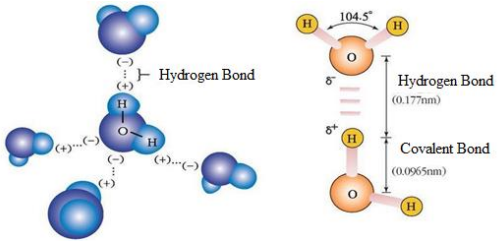

Figure 1. A water molecule and a model showing a hydrogen bond between water molecules.

Hydrogen in water has a partially positive charge and oxygen in it has a partially negative charge. Therefore, the oxygen has an electrical property to attract an electron in the hydrogen. Water, consequently, has a polarity to be influenced by the electric or magnetic force. Water molecules are influenced by electric coupling as well as the binding between hydrogen and oxygen atoms. Due to these characteristics, water has a unique structure.

For example, its boiling point is much higher than other liquid with similar molecular weight. Generally, liquid molecules with similar molecular weights have similar boiling points. However, water has a higher boiling point due to its hydrogen bond "Fig. 1".

Water has stronger surface tension than other liquid owing to the hydrogen bond. Objects having a greater density than water can float because of the high surface tension of water. The surface tension occurs because of the cohesiveness of water created by attraction among water molecules. This surface tension generates a thin elastic surface on water surface and causes the capillary phenomenon. Water, unlike other molecules, has very high surface tension compared to its viscosity. Therefore, a water droplet has the smallest surface area. The surface tension of water enables a water strider to walk on water and people to swim.

B. The Purification Ability of Water

"Reference [1]" Water has high specific heat capacity and to increase the temperature of it, it requires many calories to evaporate. Therefore, it plays an important role in preventing abrupt temperature change of a material or an organism. Water also has self-purification abilities (e.g., diffusion, dilution, and chemical reactions) "Fig. 2".

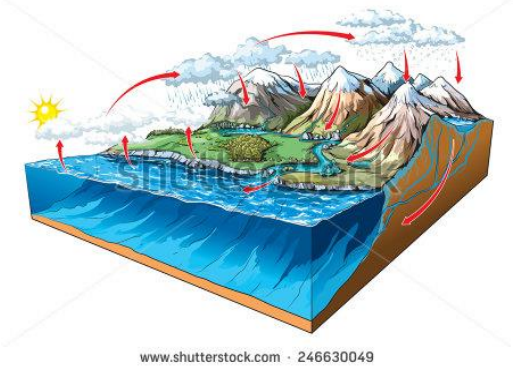

Figure 2. Water circulation process through evaporation and precipitation

Water accounts for approximately 80% of a human body. It is the major component of a body and the most important material to control the body temperature and the metabolism. Two or three days of water fasting can cause dehydration, which can be lethal. It has the same consequence even if other nutrients are supplied but water, because water is the main carrier of nutrients and contributes all biological processes including body temperature control, waste removal, and neurotransmission. For example, IV contains a lot of water additional to specific nutrients. Higher water content means higher absorption.

Therefore, one will experience adverse effects on the physiological metabolism if the water loss due to sweat, breathing, and urine is not properly replenished. Dehydration occurs if one only loses 1% of water in the body. Particularly, water loss increases the concentration of blood to decrease the ability to supply oxygen and nutrients to cells and remove waste, which can cause various diseases.

Water contains various metal compounds including iron, magnesium and calcium and numerous gases such as oxygen and carbon dioxide. It is because oxygen and nitrogen in the atmosphere are dissolved in water and various elements in the earth's crust are included in water. Carbonated water has a large amount of carbon dioxide. It suggests a possibility that industrialization related troubles must be related to water. "Reference [3]" Water is highly influenced by environmental pollution such as heavy metal (e.g., mercury and lead) contamination, environmental hormones, and harmful organic matter due to the industrial wastewater and yellow sand.

Consequently, it is important to identify the chemical substances in water for drinking water safely. The most worrisome factor is the presence of pathogenic bacteria and viruses. The adverse impact of drinking chemical compounds or heavy metal (e.g., mercury and lead) contaminated water slowly appears after an incubation period and it gradually deteriorates health. If people drink water contaminated by bacteria, they can face an immediate and fatal danger such as Norovirus or Tsutsugamushi fever.

"Reference [2]" To prevent this danger, tap water goes through chlorination to remove bacteria preferentially. This process removes bacteria but chlorine ions remain in the water. It is said that chlorine can be removed by a water purifier almost completely. However, it is necessary to analyze if chlorine is properly removed by a purifier and what are the impacts of trace amount of it on a human body.

C. The Potential of Water as an Antioxidant

Water removes contaminants through biological, chemical, and physical processes. The self-purification process of water occurs by activating microbes, plants, and animals living in the water. Organic contaminants entering into water are absorbed by microbes and go through the metabolic activities. Water, naturally, flows and keeps bacteria on the surface to significantly reduce the number of it. The aquatic germ, the strongest germ, inhibits the growth of pathogens.

"Reference [3]" Purified water and tap water are clean water to simply quench people's thirst owing to the chlorine disinfection. It can remove wastes through physical water pressure but it has no use to get rid of active oxygen in a body or problematic wastes. Weak alkali water can eliminate active oxygen and wastes in a body.

Particularly, water allows cells to absorb various essential minerals with maintaining the morphology of them, even if they do not take nutrients physically. It increases the functions of metabolism and enhances the circulation of blood and tissue liquid. Moreover, water dissolves nutrients and can supply the dissolved nutrients to cells in needs. It also discharges unnecessary wastes and properly maintains the pH of blood.

If water is promoted as an antioxidant, its strength is to intake various minerals without side effects and repulsion. It will be especially beneficial to patients suffering from a digestion problem or a bronchial problem as well as senior patients with difficulty in eating. Water accelerates

the peristaltic movement to prevent the waste accumulation in intestines, so drinking plenty of water significantly reduces the occurrence of urinary system problems (e.g., urinary bladder inflammation, kidney cancer, and prostate cancer) and is effective in breast cancer prevention. Some argued that chronic fatigue and low vigor could be a result of water deficiency due to dehydration, as well as low blood sugar. Senior citizens tend to have gradually lower recognition of the dehydration phenomenon because the functionality of the thyroid system is deteriorated, as people get older. Senior citizens do not usually recognize dehydration on time so they do not supply enough water in time. Consequently, senior citizens have more wrinkles and much higher probability to suffer from various diseases including diabetes and high blood pressure. Dr. Hoit MacCathy at the National Institute of Health of the USA said, "at least 1/3 of modern disease is due to imbalanced mineral levels due to incorrect fluid intake". Insufficient fluid reduces the elasticity or strength of muscle, causes chronic fatigue, erectile dysfunction, cardiovascular disorder, and mental disorder, and produces edema.

After drinking water, it reaches the bloodstream in 30 seconds, the brain tissue and genitals in 1 minute, skin in 20 minutes, and internal organs such as liver, heart, and kidney in 20 minutes. It takes only 30 minutes to directly affect all parts of a body. One can absorb 20-30% of water requirement indirectly through bathing in a hot spring, taking a shower, steaming with hot towel, and taking a sitz bath. However, the most effective way is to drink water. Therefore, adding minerals with known anticancer effects in water will create promptly effective anti-cancer solution.

Potassium (K) improves the function of a heart, sodium (Na) balances acid and alkali and adjusts osmotic pressure, calcium (Ca) is effective in osteoporosis prevention, blood coagulation chronic gastritis, fatigue recovery, growth and development of osteoarthritis, and metabolism. Magnesium (Mg) maintains body pH and facilitates blood clotting. Ge strengthens anti-cancer and immune functions. SO_4 is effective in chronic cholecystitis, diabetes, gout, and excitement alleviation.

"Reference [4]" People pursued water sanitization, but people look for safe water as people suspect outflow of chemical substances into the water supply as a byproduct of industrialization. It makes water purification a common lifestyle. People now pursue healthy water, since well-being became the most important trend. As more studies on well-being are conducted, more attentions are given to the medi-care water. Many researchers are actively studying the Korean natural bedrock groundwater. Researchers will be able to produce water with antioxidant efficacy by mixing previously mentioned elements and it will be the best means to prevent cancer.

III. Anticancer Efficacy of Hydrogen Water

This study observed the type and content of hydrogen in 'the miracle hydrogen water', a hot topic, and its effects on a human body. Hydrogen water is named after the new concept of hydrogen ion (H). French 'Lourdes Le Izumi', Mexican 'Torakote water', German 'Norudenau water', and Indian 'Nadana well' are famous. Since they are famous, hydrogen water from them is relatively expensive. Hydrogen water has caught attention for its antioxidant function. "Reference [1]" People will be able to manufacture water with a better antioxidation function by observing strengths and weaknesses of hydrogen water.

It will require a comparison among hydrogen water products manufactured by the different manufacturing methods. The difference of manufacturing process will be observed by comparing hydrogen water containing hydrogen and hydrogen water created by forcibly injecting hydrogen.

This study used OPR index, the reduction potential of hydrogen, to determine the quantity of hydrogen. The reduction potential index indicates the degree of antioxidation and it can determine whether hydrogen water is an effective antioxidant or not. Moreover, pH measurement was used to decide the degree of water ionization and alkali. Based on hydrogen content, alkali, and mineral, water quality index will be created. "Reference [5]" This study will contribute to making more effective antioxidant drinking water by actively applying hydrogen content, alkali, and mineral.

A. Analysis on the Function of Hydrogen Water

Three chemical properties were measured in this experiment, which are pH, ORP using an oxidation-reduction potentiometer, and conductivity. The ORP index, hydrogen reduction potential, was used to determine the quantity of hydrogen. ORP is closely related to the antioxidant capability of a material, so it is important to compare the ORP values. To prove the antioxidative characteristic of hydrogen water, a nail and iron power corrosion experiment and a fish survival test were conducted. Moreover, pH measurement was used to decide the degree of hydrogen ionization and the degree of alkali water. The solubility of medicine by surface tension, a physical property, was compared.

Acidity stands for the hydrogen ion concentration and it shows that higher hydrogen ion make it more acidic by using a chemical formula: pH= -log[H+]. Seven is neutral. Over seven represents basic or alkaline. Researchers can determine if a solution is acidic or basic by the color of an indicator (e.g., litmus paper). However, it is not suitable to decide the precise acidity of water. Therefore, pH was measured pH values by time with an electric pH meter to improve the accuracy.

"Reference [6]" ORP allows researchers to predict the contents of chemical reaction by ORP, which indicates the strength of a material to lose an electron (oxidation) or gain an electron (reduction). The oxidation-reduction potential was measured by the potential generation after adding a non-reactive electrode in solution in the redox reversible equilibrium state. In other words, it indicate the potential difference between an electrode and the solution when a non-corrosive electrode (e.g., platinum) is emerged into a solution containing bother oxidants and reductants (for example, Fe^{3+} ion and Fe^{2+} or oxygen and

water). It cannot be measured directly, so it is estimated from the difference between its read with the measurement of a standard hydrogen electrode. E_0 means the standard redox potential and it is stable at a given temperature. Higher E_0 value means that it is a stronger oxidant. On the other hands, negative E_0 value means reductant or antioxidant. The negative ORP value was considered an important factor.

Electrical conductivity means how well electricity flows and it is also called specific conductivity. Electrical conductivity measures the capability of one material to flow electricity while specific conductivity stands for a conductivity of a unit length or unit area of a material at a specific temperature. Specific conductivity is a synonym of volume electrical conductivity and it is a reciprocal of volume resistivity (electrical resistivity). The unit of electrical conductivity is mho or Siemens: 1mho = 1Siemen. The unit of electrical resistivity is Ohm (Ω). Therefore, water with 1μS electrical conductivity has 1,000,000Ω or 1MΩ electrical resistivity. Electrical conductivity is estimated by measuring electric current of two special electrode plates. Electrical conductivity is closely related to the quantity of total dissolved solids (TDS) in water. The electrical conductivity of the water increases as the quantity of charge ion in water raises. As electrical conductivity increases with higher ion concentration in water, electrical conductivity is an important measure indicating ion concentration in water. The electrical conductivity value was an important factor determining the quality of water since it represented the quantity of total mineral ions in water. Alkaline electrolysis is used to measure electrical conductivity by employing electrolyte alkaline solution (NaOH, KOH) and separating produced gas through the diaphragm between anode and cathode. In alkaline electrolysis, the reaction of each electrode is the same as follows.

$$\text{Cathode}: 2H_2O + 2e^- \rightarrow 2OH^- + H_2 \quad (1)$$

$$\text{Anode}: 2OH^- \rightarrow H_2O + 2e^- + 1/2O_2 \quad (2)$$

An environment-friendly method was used, which progresses a chemical reaction through electrolysis. It does not produce harmful substances since it uses electron (electric energy) instead of chemicals when converting harmful chemical compounds to less harmful substances. It is a technique to be used for manufacturing antioxidant drink later. The quantity of produced chemical as a result of electrolysis is proportional the quantity of applied electricity. It is found by Faraday and it is called as the Faraday's Law relates to the electrolysis.

Hydrogen generating apparatus at the above electrolytes does not have the electrical conductivity of water. Therefore, it requires being reacted in an electrolyte such as KOH or H_2SO_4, which make the pH of water basic. Thus, hydrogen and oxygen could be acquired by electrolyzing tap water with using an electrolysis device.

1) Comparing acidity

This experiment showed the pH dynamics after hydrogen injection. pH graph revealed that pH increased after hydrogen injection "Fig. 3" and it became basic with 1 – 1.5 pH increase "Fig. 4". It is natural of alkali ion water to be basic due to the presence of OH^- ion. However, pH increased due to hydrogen dissolution and it suggested that hydrogen ions reacted with water molecules to have a different water structure compared to regular water. The following figure revealed the phenomenon of turning water to basic condition due to the reaction of water and hydrogen. A possibility was found to form a trace amount of H ion by reacting water and hydrogen. It means that the reaction of hydrogen and water create a structure of water "Fig. 5", which is very different from the general water. Therefore, it was expected that the hydrogen water's characteristics related to surface tension and solubility of oil are associated with this fact.

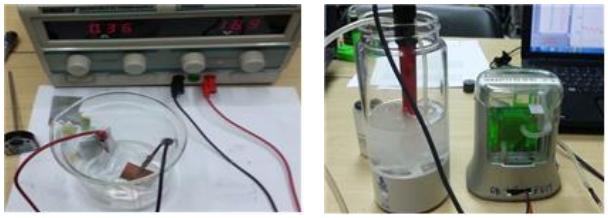

Figure 3. The electrolysis process of water by using a power supply and electrodes (left). Hydrogen water production device (right).

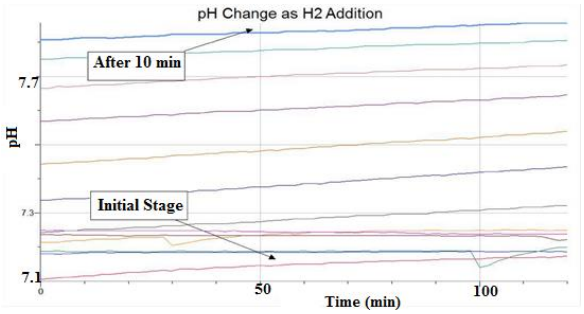

Figure 4. Hydrogen injection and pH dynamics

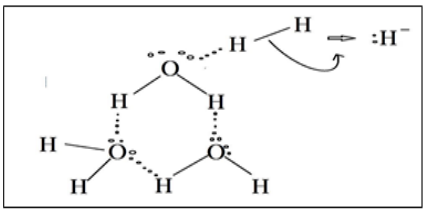

Figure 5. Example showing the possibility of forming hydrogen atom or hydrogen anion by contacting hydrogen and water

2) Changes in ORP after injecting hydrogen

"Reference [7]" It could maintain low ORP value due to dissolved hydrogen. However, hydrogen escapes to the atmosphere unless hydrogen is injected more. Therefore, it is important to evaluate the adsorption process by the type of water for preserving hydrogen water extensively. The dynamics of ORP for 10 minutes after hydrogen injection and ORP value at 10 hours after blocking hydrogen were compared to understand the hydrogen dissolution and adsorption processes in various liquid forms (i.e., distilled water, purified water, tap water, green tea, and carbonated beverages).

Water close to actual antioxidant was estimated by evaluating the reduction potential identified from previously experiments. ORP values of various vitamins, green tea, and chemical reductants, having antioxidation characteristics, were compared to determine if ORP value could be a characteristic of antioxidation.

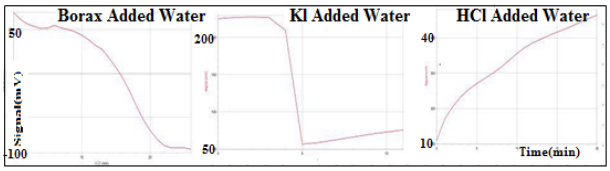

Figure 6. ORP measurements of various reductants and oxidants (Borax, KI, and HCl from the left to right)

It showed that reductants (i.e., borax solution and Kl solution) had low ORP value and acid solution (i.e., HCL) had high value. Vitamin C, known as an antioxidant, also revealed a low ORP value but it was about +50mV, which was far less than that of hydrogen water (-500mV) "Fig. 6".

This experiment was conducted to decide what would be the most effective water type for manufacturing hydrogen water when hydrogen was injected in water. Target water types commonly determine the price of mass produced drinks. They are purified water, water from a water purifier, Kangwon-do Pyeongchang water, Jeju Island Samdasu, tap water, Evian, and deep-sea water. ORP was observed by inserting a piece of magnesium, used to manufacture hydrogen water, and it decreased to -200mV. Hydrogen was injected at 60ml/min to water from a water purifier with using an electrolyte type hydrogen generating apparatus.

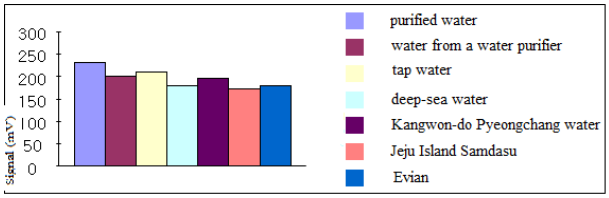

Figure 7. Reduction potential measurement experiment with using a Vernier ORP meter.

Purified water showed the best effect of hydrogen injection. The solubility of hydrogen in water is very low. However, many scientists expect that the trace amount of hydrogen will decrease the reduction of water drastically and water can behave as an antioxidant "Fig. 7". Injecting hydrogen to water makes its reduction potential below -500mV in 10 minutes. This water has the highest reduction potential of any type of water.

Water with lower redox potential is good water. Jeju Samdasu showed the lowest redox potential. It was +300mV, high value, for oxygen rich water or carbon dioxide rich water but hydrogen water showed a very low value of -500mV.

The results could be interpreted that purer water absorbed hydrogen faster while impurities in solution would slow hydrogen absorption or prevent it "Fig. 8". On the other hand, a medium in water can adsorb hydrogen to maintain ORP value for a long time and charcoal or zeolite are found to hold hydrogen for a long time "Fig. 9".

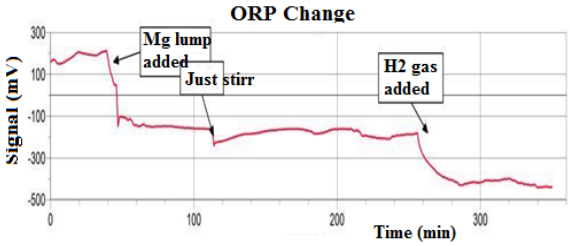

Figure 8. It shows that reduction potential decreases much more under the use of an electrolyte hydrogen generator than under the hydrogen production by a magnesium stick.

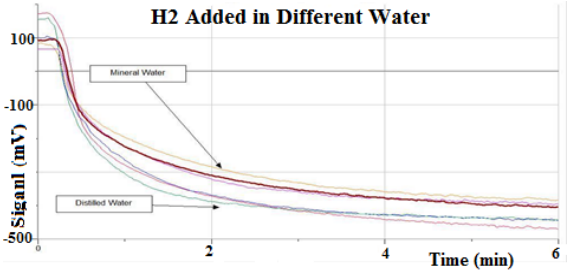

Figure 9. ORP curves comparing the hydrogen absorption effects in mineral water and distilled water.

"Reference [8]" When charcoal was mixed with water, ORP value decreased. It indicated that charcoal could behave as a reducing agent. When hydrogen was injected in the charcoal colloid, ORP value decreased as it did in the previous experiment, but it decreased slower than regular water. The speed of hydrogen escape was slower than regular water as well. It revealed that it is effective in preserving hydrogen water.

3) Testing the role of antioxidant through nail and iron power corrosion experiment

The actual effects of this ORP value can be found by a corrosion experiment of nail and iron power. It is necessary to conduct an experiment to identify how well solutions containing various gases dissolve metals, so people can make water closer to antioxidant water. There is a proposition that reductant water with low ORP can prevent rusting. The reduction potential of hydrogen water was examined by comparing the degree of rusting between hydrogen dissolved water and regular water when iron nails are emerged in two types of solution.

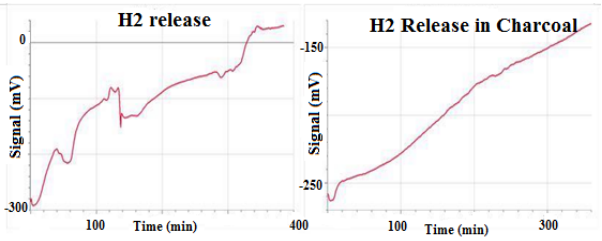

Figure 10. Comparing the changes in ORP after stopping hydrogen injection (left: regular water, right: water with charcoal)

When the reduction reaction of hydrogen-injected water is explained, oxidation means binding with oxygen. Oxidation process is identical with the aging process and

decomposition "Fig. 10, Fig. 11". When iron reacts with oxygen in water, it becomes ferrite oxide (Fe_2O_3).

Iron (Fe) + Oxygen (O_2) ----- Ferrite oxide (Fe_2O_3)

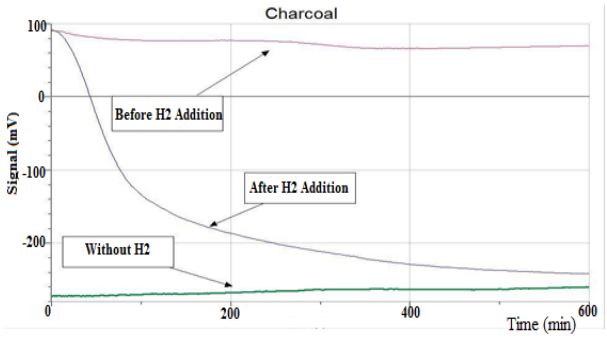

Figure 11. ORP changes before and after hydrogen injection and that of water with charcoal

Water contains oxygen and water with carbon dioxide corrodes iron nail faster due to acidity. However, corrosion takes place slowly in hydrogen water, it is due to reduction reaction of hydrogen.

Reducing water did not prevent oxidation completely but it slowed down rusting process by testing the notion that water with low ORP could prevent rusting. When rusting of nail was compared, nail in the hydrogen dissolved water showed much less rusting than that in regular water "Fig. 12".

Figure 12. An experiment comparing corrosiveness of iron nails in solutions mixed with various gases

4) Fish survival test to prove the antioxidative activity of hydrogen water

- Prepare nine goldfish raised in the same conditions.
- Prepare three transparent cups and place 3 fish in each cup.
- Injecting hydrogen, produced by a hydrogen generating apparatus, at 60ml/min in to one of the cups.
- Compare the growth and survival of gold fish contained in one cup with 1g of Mg and one cup filled with regular water.

Fish were raised in hydrogen water, regular water, and magnesium induced hydrogen water and their activity and growth were compared to find the difference in survivorship. No difference was found for a week. However, fish were most active in hydrogen water. It was expected that fish would survive longer in magnesium water and hydrogen water, if hydrogen water with oxidant function were good for health. It will be observed continually "Fig. 13".

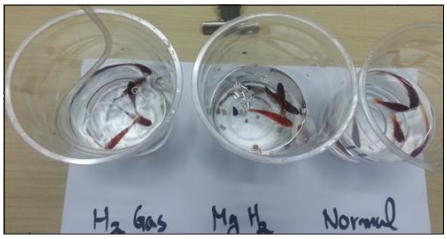

Figure 13. Survival experiment of fish under different conditions (hydrogen gas injection, magnesium metal insertion, and regular water from left to right)

5) Comparison between hydrogen water and regular water – Comparing solubility of oil and surface tension

It was to confirm the common sense idea that hydrogen water has better cleansing power. It can be identified by measuring the solubility of oil and surface tension. Surface tension varies by the mineral contents, so it should be measured. Vegetable oil was dissolved in hydrogen water and distilled water and a droplet was placed on a sheet of oilpaper. Contact angles were observed.

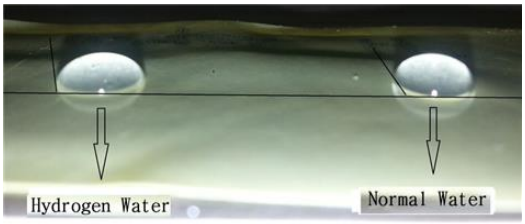

Figure 14. Comparing the surface tension according to the differences in contact angles.

Surface tension of water is affected by mineral contents and temperature "Fig. 14". In this experiment, hydrogen injected water tended to dissolve oil better. When the contact angles were compared, it showed that hydrogen water had slightly lower surface tension. The solubility was distinctively different between hydrogen water and regular water, when it was compared after shaking with vegetable oil. As shown in the following figure, it was clear in hydrogen water and alkali water with NaOH while it was blurry opaque in regular water "Fig. 15".

As shown in the above picture, when oil is dropped on water, hydrogen water showed opaque film on the surface indicating mixing tendency. However, it did not mix at all on regular water due to surface tension "Fig. 16". Due to this phenomenon, hydrogen water exists as fine particle water. It was considered that hydrogen water is more active than regular water. Hydrogen water will help a body absorb antioxidant material, dissolved in it, and it will provide anticancer effects. Moreover, antioxidant materials will not accumulate in a body.

Figure 15. Solubility test after mixing with vegetable oil

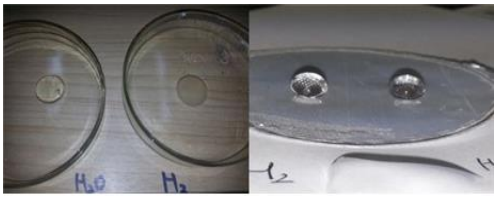

Figure 16. Comparing the changes of oil on hydrogen water and regular water (left) and surface tension (right).

6) Experiment comparing the dissolved phase of pills in hydrogen water and distilled water

Add Tylenol (a painkiller) to hydrogen water, hydrogen was produced by a hydrogen generating apparatus for 10 minutes and injected in water, and distilled water. It was observed after 10 minutes "Fig. 17". It was almost completely dissolved in similar pace or faster in hydrogen water. Electrical conductivity was measured to compare the dissolved quantity. It was 12ppm and 6ppm for hydrogen water and distilled water, respectively, which indicated that it was dissolved more in hydrogen water "Fig. 18, Fig. 19".

Figure 17. Solubility observation experiment after producing hydrogen for 10 minutes (left) and applying pain painkiller pill (right)

Figure 18. Ion residue in hydrogen water (left) and distilled water (right) after dissolving XX for 10 minutes.

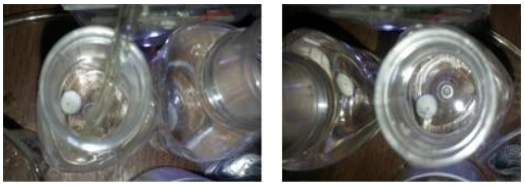

Figure 19. Dissolved phase in hydrogen water (left) and distilled water (right) after dissolving aspirin for 5 minutes.

However, it was found from an experiment that acidic aspirin tablet was dissolved much faster in hydrogen water. It was considered that aspirin was rapidly melted at the initial stage due to neutralization because hydrogen water is alkaline. Ion residue for 10 minutes in the following graph suggested that solubility due to chemical reaction was the dominant process rather than surface tension "Fig. 20".

The experiment, consequently, proved that surface tension of basic hydrogen water could enhance the solubility of acidic pill. However, medicine can be weak basic or weak acidic. Sometimes, a medicine can be dissociated and ionized according to pH. Ion type has low-fat solubility and nonionic type has high-fat solubility. Therefore, the absorption rate is high with nonionic type. The drug absorption rate, consequently, highly depends on the dissociation rate. Weak acidic medicine and weak basic medicine have lower dissociate rate at low pH (acid) and high pH (base), respectively. Lower dissociation increases the proportion of nonionic type to boost absorption. It means that hydrogen water can be advantageous or disadvantageous conditions to dissociate medicine. Further discussion is needed to determine if hydrogen water can increase the bioavailability, which means the proportion of administered medicine circulating in a body without changing its form, when taking an anticancer medicine.

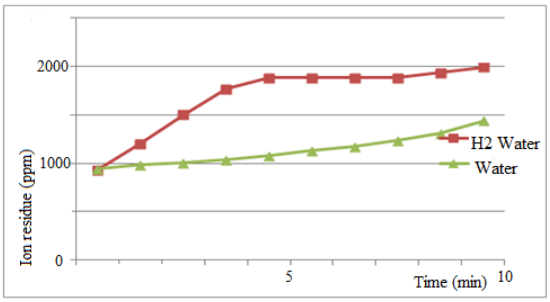

Figure 20. The dynamics of ion residue (ppm) in hydrogen water and distilled water during dissolving aspirin

IV. Anticancer Efficacy of an Antioxidant Material

A. The Development of Science and the Growth of Cancer

Chemicals causing cancer were not found until 200 years ago. Even after the discovery, it was determined that the impact was insignificant. Dr. Hill of the USA found the carcinogen in 1761 for the first time. He claimed that the incidence of nasal cavity cancer was abnormally high with people using snuff and tobacco contained more than one carcinogen. Subsequently, Mr. Port, a physician of the United Kingdom, found that chimneysweepers have higher testicular cancer possibility due to chemicals in chimney soot. It was clear that some chemicals could induce cancer.

As the new chemical industry emerged in the late 1800s, many workers were exposed to the high concentrations of toxic substances. Perkin found 2-naphthylamine in 1856 during an attempt to synthesize quinine from coal tar. The naphthylamine advanced the aniline dye industry in one hand. On the other hand, it made people exposed to the first carcinogenesis chemical substance. It has long incubation time (15-30 years) from the first exposure to the cancer occurrence. It calmed the genetic difference theory of cancer occurrence. The naphthylamine causes bladder cancer. Workers are in contact with it for a long time without recognizing the danger of it due to its long incubation period and large quantity of it accumulated in bodies.

Radiotherapy is used to treat cancer but, paradoxically, the radioactive often induces cancer. Rachel Carson, the author of Silent Spring and an earth biologist, cited the work of Dr. Otto Heinrich Warburg, who was a biochemist of Max Planck Institute in Germany and studied the origin of a cancer cell. Radioactive and chemicals kill cancer cells and cause cancer at the same time. It is because radioactivity damages the cell respiration process. Dr. Carson emphasized, "A cancer cell already breathes in the wrong way, so another damage on cancer kills it. However, a normal cell encounters breathing problem for the first time, so it survives to cause another malignant disease."

The problem is that environmental contaminations and damaged cells cause troubles in the body. Water flows everywhere from the sky to the earth owing to its characteristics. Therefore, it naturally contains various chemicals including magnesium, iron, and calcium. In the past, people sit water for a long time to remove impurities or purified water with charcoal or stone. However, these primitive ways could not eliminate infectious pathogens in water. Modern science advanced purifying technique and researchers can produce a large quantity of pure water through a chemical process.

B. *Experiment Testing the Anticancer Efficacy of Anticancer Material*

"Reference [9]" Colon cancer is caused and influenced by dietary factors. Therefore, dietary therapy is important in anticancer treatment. Dietary habit and environmental pollution cause problems in protein metabolism and these problems cause cancer. Nicolas Gonzalez, an immunologist and MD, was interested in the William Kelly therapy, who mentioned the relationship between cancer and a dietary therapy. He reviewed the records of 50 patients, who were treated by the therapy, for 5 years. His review revealed that more than ten patients treated with this therapy survived, which was a high complete recovery rate at that time. Gonzalez applied this therapy to patients with pancreas cancer and confirmed that it increased the survival rate.

A study was conducted on 30,000 subjects at Linxiang, China, by a joint study of the Cancer Research Institute of China and the USA. They concluded that there was a close relationship between antioxidant components in food and incidence of cancer. A group took representative antioxidant materials (e.g., beta-carotene, vitamin E, and selenium) had 9% lower mortality rate than a group did not take those materials. Particularly, it also decreased the mortality rate due to stomach cancer by 21%. Moreover, there was a difference in cancer occurrence.

Moreover, there were several epidemiological studies on large populations in Finland, Swiss, and Hawaii. All results indicated that food with rich antioxidant was effective in preventing endometrial cancer, breast cancer, cervical cancer, lung cancer, and esophageal cancer. As study results of nutritionists were announced, antioxidants became popular to the public. However, antioxidant was rarely used for cancer treatment in South Korea. Bristol Cancer Help Center at UK actively utilizes antioxidant materials such as vitamins, minerals, and herb extracts in addition to mental treatments for a holistic treatment method. This combined treatment is an effort to prevent active oxygen in a body for restraining cell deformation and necrotic cells. It prevents cancer occurrence as well as cure cancer.

1) Study methods and study results

Six 6 week-old mice were purchased and fed with regular diet for one week to be adapted to the cage. They were randomly divided into two groups of three. It was to test the effects of antioxidants to treat cancer. All mice were injected with DMH, a colon cancer carcinogen, from the 1st week to the 5th week twice a week to their left and right thigh alternatively. Total 150mg of DMHwas injected per mouse.

DMH is activated in a liver and moved to colon via blood. Various materials passing through colon affect cell proliferation and a dietary factor is the most influential for the onset of colon cancer. Therefore, a dietary therapy should be accompanied with an anticancer treatment for treating colon cancer. To proceed colon cancer rapidly, 3mg/100μ of cyclooxygenase-2 (COX-2) enzyme was injected to the abdominal cavity after two weeks.

"Reference [10]" Anticancer treatment is followed. Mice of both A and B groups were treated with a radioactive therapy instead of a physical therapy. It is a popular anticancer therapy because it removes cancer cells selectively without an operation. It is advantageous to treat a local area with cancer. Ionizing radiation is used to treat cancer and it is a high-energy radiation inducing the ionization of a material. It affects DNA directly or indirectly and kills cells. A cell radiated by radiation cannot perform cell division due to DNA damage and die. It treats cancer with this principle. However, it has side effects of nausea, vomiting, mental and physical fatigue, and the loss of appetite as well as weakens an immune system by destroying surrounding cells.

People usually take radiotherapy for 5-7 weeks, but radiotherapy was conducted on both A and B group mice for 2-3 weeks considering the body size. Green tea hydrogen water was administered for group B. The mice of group B was also fed with green tea hydrogen water. To examine the status of the tissue, tissue around large intestine was excided and dehydrated. The change of tissue was compared with an optical microscope. To evaluate the effects of green tea hydrogen water, an analysis was conducted with a gas chromatography (Hewlett Packard Model 5890). Each fatty acid was compared with the standard fatty acid.

This study was to enhance the antioxidation function of water by using hydrogen water, which has amplified purifying capability. Hydrogen was injected in green tea, which contains catechin, a representative antioxidant. "Reference [11]" The manufacturing process of green tea hydrogen is as follows. Commercially available green tea was used. It was brewed for 15 minutes at 5% concentration. Hydrogen was injected in the coldly chilled green tea. Artificial hydrogen injector was used as the previous experiment. It was to promote the hydrogen production at home or commercial place.

2) The potential of hydrogen water from experimental results

Analysis on study results showed that tumor occurrence was lower at the group B (39%), green tea hydrogen water treated, than group A (56%). The total number of tumor and the number of tumor per mouse was smaller in the group B as well. Group B also had much less large tumor (7-9mm) in large intestine in than group A had "Table I".

TABLE I. THE SIZE OF TUMOR AND CANCER INCIDENCE RESULTS OF TESTED MICE

	Size of Tumor (mm)		
Groups	1-3	4-6	7-9
Group A	11	7	4
Group B	4	3	1

Disease incident rate in mice and spread rate (1-3:group A/4-6:group B)					
1	2	3	4	5	6
5	7	4	-	2	1

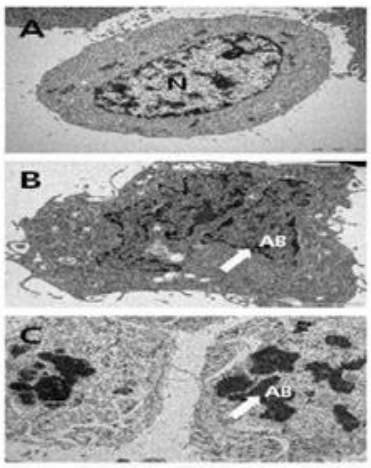

Figure 21. A: Normal tissue / B: A cell of a mouse with colon cancer (group B treated with green tea hydrogen water)/ C: A cell of a mouse with colon cancer (group A)

Normal cells at colonic mucosa are circular shapes and well divided to each other, so they were not transferred to other cells. However, observed cells were elongated irregularly. Therefore, the fractionation of cells was ruptured and they were transformed into the metastatic cancer cells. The proliferation of cells progressed less in the green tea hydrogen water "Fig. 21". The results of t his study proved the anticancer effects of green tea hydrogen water, which was known to have an antioxidation function.

V. POPULARIZING THE ANTIOXIDANT HYDROGEN WATER – THE MEASURE OF CANCER PREVENTION AND TREATMENT

Hydrogen water is good at dissolving oil and has low surface tension. Therefore, it has high mineral contents. This study evaluated the potential of hydrogen water to be water with antioxidant function and tried to form a foundation for circulating it to the public. The antioxidant is a material to prevent the aging of body due to active oxygen. SOD, vitamin E and C, beta-carotene, and selenium are representative antioxidants. People take vitamin E and C, beta-carotene from vegetables and selenium from mineral. SOD naturally exists in our body and it plays a defensive function against the external toxin. However, SOD is not produced in a body after 35-40. A human body starts to experience aging and subsequent diseases, consequently, because it does not produce antioxidants to remove toxic active oxygen. Therefore, people need a replacement for SOD, an antioxidant enzyme. Hydrogen is the smallest atom so it can travel every inch of our body via capillary vessel to remove toxic active oxygen.

A. Antioxidant Hydrogen Water as an Anticancer Medicine

Acid wastes accumulate in a body for years due to the acidification of the blood. Cells at a location where the wastes are accumulated die to have cancer occurred. The cause of this acidification is active oxygen. Active oxygen acidifies blood and kills some cells with deforming others to cause cancer.

The onset of cancer exacerbates stress due to active oxygen. As shown, stress due to acidification precedes cancer. Hydrogen is a beneficial antioxidant and it prevents or alleviates cancer. A study from Kagoshima Graduate School of Medical Science Research Institute of Japan, hydrogen water inhibits colorectal cancer owing to 5-FU. When hydrogen water was administered to mice inoculated with Colon-26 cancer cells, their survival rate increased. Hydrogen waster, particularly, fortified the existing immune system and induced an anticancer function. Hydrogen water with higher hydrogen concentration showed better antioxidant and anticancer abilities. Researchers concluded that highly concentrated hydrogen water was effective in preventing the onset and spread of colorectal cancer.

It showed that enhanced antioxidant function of hydrogen water is the necessity of hydrogen water to be an anticancer medicine. If so, how can people enhance its antioxidant capability?

There are three requirements for hydrogen water to be an anticancer medicine. Hydrogen in water should be absorbed to perform antioxidant function. Therefore, hydrogen water should have high dissolved hydrogen and hydrogen should be dissolved for a long time. Hydrogen is sensitive to the temperature and it escapes from water when it exceeds 50 degrees in Celsius. Therefore, it should not be influenced by the chances in temperature.

To remove active oxygen, it should contain the best antioxidants such as hydrogen sulfide, sodium sulfite, aluminum hydride, lithium, and borohydride. However, they are toxic to cells, so it is impossible to directly apply them to a human body. Medicine or laser can be used to remove active oxygen with minimum application. However, a low dose may not be able to penetrate into cells, where DNA exists. If not, it does not have much use. Rather, there is a high possibility that it is deteriorated because toxicity spreads to other parts of a

body. On the other hand, hydrogen is the smallest antioxidant so it can be delivered to a damaged cell via blood vessel easily. Tablet takes time to be dissolved and absorbed, but it is advantageous of hydrogen water to be absorbed more easily and quickly in a liquid form.

Therefore, it is necessary to dissolved previously mentioned antioxidant materials into hydrogen water to enhance anticancer effects. Hydrogen water removes active oxygen and helps absorb other materials. There is an advantage that it is not accumulated in a body even excessive amount is taken. It is a very important advantage because accumulation of a medicine can cause side effects to patients and elders. When a person takes hydrogen water more than a certain degree persistently for 6 months, it can change the tissue and fluid completely. Hydrogen water can enhance an immune system of a patient with cancer and prohibit the possibility of cancer spread by changing the components of a body.

B. Hydrogen Water, for Its Popularization

Literature review and the results provided researchers the foundation of hydrogen water's antioxidant function; which could enhance the efficacy of an anticancer medicine and the occurrence of cancer. It suggested a possibility to utilize hydrogen water as supplementary cancer therapeutics. Further, it implies that hydrogen water can prevent cancer and treat cancer patients, who do not digest well.

There are about 400 publications proving the effects of hydrogen water including articles in the Nature Medicine. However, no study evaluated the effects of hydrogen water with an enhanced antioxidant function. The domestic hydrogen water market is at its beginning stage. There are a few manufacturers for a hydrogen water producer but customers can access to limited information. However, as the power of hydrogen water is publicized, an automation market for mass-producing hydrogen water is being developed. This study revealed that it is possible to produce hydrogen water by injecting hydrogen in addition to world famous natural hydrogen water fountains in France, Germany, and Mexico.

"Reference [12]" Water with an antioxidant function will prevent cancer and people will be able to produce water effective in cancer treatment by influxing various minerals. Radiotherapy and a physical operation are used to treat cancer. However, they are temporary measures and have a high risk of a side effect. Therefore, if researchers can develop cancer medicine water, it will be easy for elder or young patients to take and help doctors to treat patients quickly.

There are hydrogen injection instruments in the market but they are not publicized yet. The skepticism of people contributed to some degree because the effects of hydrogen water are overly advertized. To overcome the skepticism, more studies on the effects and potentials of hydrogen water should be conducted as the researcher did. Furthermore, it will require a more solid vision for the development of hydrogen water with an anticancer function by increasing an antioxidation function.

IV. CONCLUSION

The researcher observed the physical and chemical characteristics of water. Furthermore, the researcher conducted an experiment to test the differences between hydrogen water and regular water and evaluate the suitability of hydrogen water as an antioxidant and the possibility of development. Hydrogen water was basic and became reduced water with very low reduction potential (-500mV or less). An iron nail was rusted less in hydrogen water compared to a regular water. The possibilities of hydrogen water are endless and it is advantageous to be distributed to the public.

When hydrogen water is compared with oxygen water, hydrogen water has lower OPR value and basic. However, oxygen water had positive ORP value to make it acidic. Researchers can predict the reaction of body to these materials chemically. In conclusion, hydrogen reduced water can inhibit the acidification in a body and maintain a body basic.

The reduction of hydrogen, so called antioxidation reaction, can delay aging or the growth of pathogens, if it occurs in a body. It naturally contributes to the dream of life extension. Active oxygen acidifies cells in a human body. It weakens a cell to decrease its immune function.

Antioxidants should be taken regularly to remove active oxygen. This study tried to prove a method to dissolve hydrogen, known to be effective in antioxidation, in water. Hydrogen water is advertised as miracle water. However, it was not known if machine injected hydrogen was as effective as natural hydrogen water and, even if it is not as good as the natural hydrogen water, it had an antioxidation effect.

The researcher tried to pursue hydrogen water development, which can be used to prevent and cure cancer. Hydrogen water with an antioxidation function can reduce the toxicity of other antioxidant materials owing to its small atom size. Moreover, it has an advantage of penetrating deeply. If people can produce water injected with antioxidants and hydrogen, it will prevent cancer and inhibit the onset and spread of cancer: even for organs cannot be reached or treated easily. Cancer is a major of human mortality and aging of cells reduce the vigor of a body to increase the possibility of its onset. Therefore, people need to have a proper treatment on cancer and it should be applicable to the elder, the young, and people with declined immune function.

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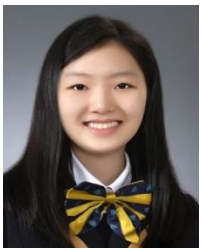

Jiyun Kim was born on January 8, 1998 in Busan, South Korea. In 2003 she went to Michgan, United States to study abord and was given early admission to 1st grader in Angel elementary school. She came back to South Korea 2 years later. In 2011 she was admitted to Chungshim International Academy (middle school) to be taught only in English in Gapyung, South Korea. The competitive rate was 17-to-1. Now she is studying in Natural Science Department, Hankuk Academy of foreign studies in Yongin, South Korea.