

Study of Electrochemical Water Reactor Concerning Food Safety in Industrial Food Processing

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Abstract

Context: Water molecule is one of the best known polar molecules in nature, on the grounds that this molecular property gives special importance to its chemical structure and its role in life. Our objective was to investigate cleaning in place with electrochemical water.

Evidence Acquisition: Provided that the water molecule with its oxygen and hydrogen parts does not get completely decomposed, its structure changes in terms of shape and quality. The changed shape will be preserved for long hours and the activation trend for such kind of water molecule will increase.

Methods: This process is called "Electrochemical Activation". The reactor is able to produce two kinds of Catholyte and Anolyte waters. The electrochemical water is produced with different pHs. In the present study, the bacteriostatic and bacteriocidal ability of the anolyte water were studied with respect to four bacterial species including *Staphylococcus aureus*, *Enterobacter*, *Pseudomonas fluorescense*, and *Bacillus cereus*. The effective factor of the natural anolyte included active chlorine and a compound of oxygen (hypochlorous, ozone, and peroxide).

Results: The function range of this natural anolyte has been emphasized for cleaning and sterilizing medical equipment.

Conclusions: Electrochemical water reactor in food safety is important and suitable for cleaning in place and is environmental-friendly.

Keywords: Electrochemical Water, Reactor, CIP, Industrial Food, Food Safety

1. Context

Water molecule is one of the best known polar molecules in nature, on the grounds that this molecular property gives special importance to its chemical structure and its role in life. We can activate water through many essential chemical processes (1, 2).

Water is capable of being activated in two ways of physical transition and filtration through live cells' structure. Activated water is the product of non-chemical molecular interaction technology (3, 4).

The main mission of this technology is based on molecular interactions, direct transmission of the signs of molecular activities to biological systems with the help of activated water. The effect of activated water on complex compositions such as viruses, bacteria and unnatural cells can be explained by physical entity, fundamentality, and electromagnetism such as complex interactions and destructive alternating structure collision (5, 6).

Activated water is highly energetic, mobile, and alive. The results obtained from experiments show that when we drink water, our body system activates the water and thus

activated water is produced. In this way, the body uses the activated water to stabilize a magnetic-protective base (7).

One of the important characteristics of water is precipitating deposits, combining metals or analyzing the precipitated deposits chemically. A similar action of analysis is called EDTA. This complex surrounds the deposits and makes them move towards neutral electrochemical slope and not deposit further. When the activated water is energized in a proper way, it is considered as separator (8).

The catalytic property of activated water exerts effects on the live cell growth so as to accelerate the growth of sea algae and increase the absorption strength of mineral sources in plants. Environment of activated water is not suitable for the growth of non-natural microbes (Pathogens) (9).

2. Methods

Contrary to surface water which is a good environment for pathogenic bacteria, the activated water does not allow the pathogens to multiply.

The experiments on the water activation show the effects of equalization of pH and reduction of the hardness of water. Also, it causes a large reduction in the vast amount of bacteria inside the water and increases electrical transitivity and darkness in water.

These results are obtained because of the existence of free radicals like H^+ , OH^- , Ca^{2+} and Mg^{2+} in part of water that is activated in water structure and contains stronger hydrogen bonds than just the regularly produced water which produces smaller angles.

The main goal of this theory is related to the effect of molecular interactions, direct transmission of the signs of molecular activities to the biological systems with the help of activated water. This transmission takes place during the water activation process (9).

Thus, according to the researches done previously, in the present study it was tried to follow these steps: the neutral anolyte with pH 6 - 7 was studied to clean and sterilize equipment and devices used in meat, sausage, and salami industries. This material is also a suitable substitute for the sterilizing chemicals that pollute the environment.

This kind of produced water is not toxic to human, has no color or smell, and does not cause any corruption and unwanted reaction in the equipment of meat-based food industries. This electrically activated solution helps us get advantage of its two catholyte and anolyte forms. The catholyte has alkali reactions and appears with pH between 7 and 12. It bears soaking and washing qualities for different spots like perforated spots and it easily spreads in such spots. On the other hand, it has the acidic anolyte with pH between 2 and 4 that bears the bacteriocidal property (7, 10).

It is also interesting to note that the use of such water is very easy and cost-effective and leads to the thorough sterilization of the instruments and equipment. It is also a good substitute to sterilize meat grinders, cutters, tubs, and packaging tables used in meat industries.

The research was accomplished using acidic anolyte, neutral anolyte, and catholyte. The approach taken was: we washed cutters and knives with the neutral anolyte for two minutes (for this category). For the next category, they were washed with catholyte and sterilized by anolyte. The microbiological experiments demonstrated a reduction in *E. coli* as much as 43 times in comparison with the gauging category.

It is also notable that no *Salmonella* was detected. We obtained great results from the first category where acidic anolyte was used as the sterilizing agent: *E. coli* reduced 100 times and *Salmonella* reduced 600 times. The most apparent results were achieved in the last category where the neutral acid was used for both washing and sterilizing purposes and even a trace of *E. coli* and *Salmonella* did not re-

main.

Washing and sterilizing the meat processing devices by the use of neutral anolyte was even more useful compared to other approaches. Within this method, *Salmonella* did not exist any longer after being washed by the neutral anolyte. Washing and sterilizing the meat processing instruments by neutral anolyte has many advantages in comparison with other approaches (10, 11).

Volume of the poured water on the in-contact surfaces was approximately 300 mL. Therefore, hygiene, health, and sterilization of the meat processing devices can successfully be gained with the help of neutral anolyte (within pHs 6 and 7, normal temperature of 18°C for 2 minutes).

3. Results

3.1. Results Obtained from Activating Samples of Alkaline and Acidic Water

Activating a sample of alkaline water for 15 minutes will change pH from 7.69 to 7.48, which means we are confronting the reduction in alkaline magnitude.

If the duration is 30 minutes, we will observe more reduction in alkaline magnitude representing the change of pH from 7.65 to 7.25. It is important to remember that activating the acidic water sample for 30 minutes will increase the pH from 5.73 to 6.89, which means that the acidic property or magnitude undergoes a considerable reduction.

What is important in this experiment is the fact that through the process of activation, reaching the pH to a balance point is accompanied by the reduction of acidic or alkaline properties. These results are obtained because of the existence of free radicals like H^+ and OH^- in water that is activated in water structure and contains stronger hydrogen bonds compared to just the regular water. The amount of Ca and Mg in water that is activated for 30 minutes will reduce 72% and 18%, respectively. As a result, the hardness of water (Ca and Mg compounds) will reduce up to 45%.

According to these experiments, we noticed a considerable amount of alterations and important reductions in free radicals. This reduction is due to the connection of these free radicals, i.e. Ca^{2+} and Mg^{2+} , to the activated water structure with stronger hydrogen bonds (3, 12, 13).

Furthermore, the movement and transmission of water, which is activated for 30 minutes, is increased 3% and its darkness increases as much as 18%.

These results show that the activation process has induced stronger molecular structures.

The free radicals that increase the molecular structure of the activated water and formation of the deposits which cause more darkness in water are mutually connected.

We also observed a reduction of 44% in bacteria counts after 15 minutes activation of lake water and as a result, the

destruction and elimination of microscopic creatures in activated water, which proved the positive effects of sterilized activated water process (11).

3.2. Biological Effects of Activated Water and Its Sickness Treatment Property

Several experiments were performed on the lymphatic cells by Dr. John Stell in biotechnological laboratory where the transformed cells were polluted by the activated water and some plant complements for the duration of 24 hours.

These experiments continuously showed that the activated water stopped 33% of the metabolism of cancer cells. Also, it was capable of stopping 50% of the metabolism in dogs and 10% in the case of cats. The results gained for cancer cells of the human and dog were shown by the expression of $P > 0.99$.

The amount of cancer cells remaining in other groups was 100%.

This experiment showed the none-poisonous nature of cancer cells compared to their treatment by chemicals. It showed that within the same time duration, it halted the metabolism of normal cells, and the general comparison of these two was related to tumors and normal cells longevity when the chemical treatment was lower than 5%.

Another experiment was designed for the plants to compare a 15-day period of two groups of oil seeds (20 from each group) which were treated by normal and activated water.

13 germs with the length of 9 cm were created. The control group that was treated with regular water had 7 germs with the length of 4 cm each, which again showed the accelerated growth of plants being watered with activated water (8).

3.3. Important Difference in Water Activation Process and Its Mechanisms

In a situation that the water molecule is divided and analyzed to its oxygen and hydrogen constitutes, its structure will be altered and its active properties will be preserved for many hours. The process for the activation of these kinds of molecules will be accelerated and they will be activated. In general, this process is called electrochemical activation. In cathode, several chemical compounds are regenerated with chemical reactions (the best known is OH^-); hydroxides (ECA) as well as unsolvable or rarely solvable heavy metals are also formed.

Heavy metals (e.g. Hg, Cr, Pb, Ag, Au-Gold, Tu-Tungsten) have high atomic mass.

They exist in water in a very low concentrations but they are very poisonous (7).

The poisonous activities of heavy metals and other metals with lower weights in their ionized form are very obvious.

The above metals are shown with the expression of $\text{Me exp (n}^+)$, in which n represents the number of positive charges; the result is the regeneration of cathode ionized poisonous metals to hydroxides (E Me (OH)n). Metal hydroxides are chemically neutral and are not dangerous for human beings.

If they enter into stomach juice along with water, the acid in juice is not able to ionize them; for this reason, the Emerald Equipment decomposes the poisonous metals in the form of ions, but it is not capable of eliminating them (10, 11).

3.4. Researches on Electrochemical Water

The diversity of main parameters for sea water and other new active parameters as well as pH and EH of both anolyte and catholyte and their combination has been studied along with solidification and evaporation.

The sea water activated bacteria (Anole) were also studied considering the pure tissues of the microorganisms with their special importance for sterilized hygien.

The outcomes of continuous fish breeding process with anode initiated particles, then those related to cathode from activated sea water indicated that the bacterial effect is performed under anole examination and this is when undesirable oxidation processes are hidden by cathode particle examination. This examination acts like anti-oxidation process and restricts the agent for oxidation interactions which release the radicals.

The new strategy called chitin (Poly-N-Steel-D-Glucose Amine) which is generated from chitin that contains the raw material (Sea Alga, Hammarus, Shrimp Shells, Crabs and the rest of Crustacea), is vastly popular. The raw protein material is inside the cathode electrolysis container which is demineralized inside the box (7).

3.5. Nanosecond Evacuation (1/1 Billion Second) Inside Water is Effective for Disinfection

The water disinfection is a simple and effective process for power consumption at KW hour/liter and for this purpose, the number of $5 \times 10 \text{ exp } (-5) \text{ L exp } (-) 10 \text{ exp } (-4)$ counts of special bacteria (*E. coli*) equivalent to per Liter CFU up to $5 \times 7 \text{ Log}$ is considered.

In the past, electro physical approaches were used for water disinfection which depended on the electricity consumption and mechanical energy. They were high strength platforms for producing the light waves of UV, which contained invisible rays of light inside the UV spectrum that scattered UV lamp radio lights and caused the

Table 1. Activity and Infection

Association	Natural Anolyte	Infection
Effective cause	Active chlorine, oxygen compound (hypo chlorous acidazen - peroxide)	1/4 Ammonium antibacterial solution
Activity, %	2 to 0.06	50
Being poisonous	Minimum (Level 4)	Level 3
Applicable areas	Disinfection - cleaning and sterilizing the medical equipment	General sterilizing
Form and shape	Colorless material with little oxidant odor	Clear liquid with special little odor
Dormant life	More than 3 days preserving the destructive behavior	
Registration	Index 95 - 0024	Index 96 - 0025
Factory owner	Research and production of "Ogran" community	Israeli company Y.Y.SL

separation of base material from new chemical material in an environment where there existed no electrical current. At the time of separation of these materials, some sound waves were produced which had an essential role in water disinfection. Normally, many of physical, chemical and biological effects of evacuation inside the water are not distinguished and are unclear. Moreover, the simple applied evacuation systems as well as power and accommodation of produced units are not clarified yet (11).

In the current reports, the explanations for a simple evacuation with high effectiveness are provided in a way that a special design for the electrodes with high nanosecond (1/1 billion second) voltage is used that is poured in water and accompanied by high energy of " $E \leq 0.35$ J".

The electrical evacuation depends on short time high voltage consumptions, low energy strokes, which is a very sophisticated duty for the electrodes.

We came to the conclusion that water disinfection using *E. coli* had been destructive enough.

The evacuation was considered through the operation of voltage strokes for two heavy electrodes with even surfaces. The amino electrodes distance which is filled with small gas bubbles in water is also considered.

The water is quaked with water rings with the speed of 5 cm/s. The connecting strength of standard preserving units is as following:

(The duration of stroke $t \leq 100$ seconds) - (The repetition speed of the stroke $F = 10$ Hz) - (Energy stroke of $E \leq 0.35$ J)

In each stroke with the voltage of 40 KW, the evacuation has a narrow shape which can also be called "String". This narrow channel relates the distance between evacuation and the exit (from one stroke to another in the opposite direction of the electrode surface). This last situation to some extent increases the stability for periodical property of the electrodes. Compared to large usage of needle with an even shape, the application of *E. coli* and its results

were heavily controlled, examined and were experimented on the filled medium size nutrients in a separate container. After 18 - 24 hours of being covered and exposed in the thermostat in the temperature of 37°C, the number of *E. coli* was counted. The number of adjacent cells under the experiment after the release of the energy was diminished (14-16).

3.6. Limitations of Analyzed Live Cells in Electrochemical Activities (ECA)

In similar systems of pH and ORP (getting combined by the oxygen, diminishing the strength), there exists a comparison base for the analyzed live cells (related to animals, plants and bacteria) in the fields currently used. The unnatural compounds of pH and ORP are obtained with the help of the electrochemical activities which occur in active regions. The spread of microbe elimination activities using active chlorine on the material cells in different circumstances has been studied.

Some issues related to different or similar values regarding pH and ORP comparable with the activities of live analyzed cells (animal sperms) and the strength of male sexual cells and the bacteria cells has been examined, which emphasize the connections between them.

There are some factors which are effective in pH and ORP. The pH and ORP fields are only for adding the protective organic acid compounds and sodium bicarbonate or cathode activities (Negative Pole) which are being used.

According to the reports published, the erythrocytes that are analyzed inside many mammals' blood are sensitive to hypochloride and this sensitivity is within their own dormant period.

Regarding the oglea plant cells living activities, the corresponding cells will deform and alter in response to fluctuations (going up and down) in the ORP amount.

The parametric composition of pH and ORP with coordination of electrode references in active anode, which was accessible from the beginning being also used in STEL

plans, bears noticeable characteristics. Like anole processes, these devices have washing abilities for eliminating organic dirt coagulations (9, 14, 17).

Through combination with oxygen, the sterilization activities are decreased but regarding the organic dirt, these products will abolish the effect of disinfection after spending enough time.

The plans for active electrochemical solutions are different from the still analogues and are important because of business problems as well as the plan for special thoughts controlling micro fluoride in human and animal life cycle.

The most common issue is that the Russian market is filled with antibacterial advertisements which are attached on the back of unessential household products. For this reason, the comparative information considering the special facts about Russian chemicals are far from scientific, experimental, and business aspects of the case.

The specifications for synthesized anole neutral activities are stated in STEL disinfection plans. The neutral anole is a sterilizer that creates a wide affected area which indicates the washing composition of the materials and their antibacterial effects get rid of all forms of known microbes (forms like viruses and spores). This substance is also used as a washing sterilizer. The saturated anole, through utilizing the peroxide particles, kills a large amount of microbial cells and disinfects them in a medical endoscope process in a very effective and quick manner (16).

In the vast and healthy living environments, anole environment is produced, because its effective disinfecting washer is not found within the mentioned environment yet.

3.7. Properties for Neutral Anolyte Bacteria of ANK Kind Relating to Hygienic Micro Organisms Industry and Fishing Industry

In the fishing industry, one of the most important issues is searching for the right disinfecting agents which are less poisonous, with minimal cause for sensitivity and allergy and easily movable on the applied surfaces. The boundary for preparation of new permissible disinfecting materials for food industry is extremely limited.

Recently, only some strands in the national economy are being used and are named disinfecting agents.

These solutions which are activated chemicals, contain active chlorine and free radicals with the name of sample neutral cathode and Anole, ANK.

As ANK is not widely used in fishing industry yet, the purpose for this study is:

1- The bacterial experiment of ANK for the existence of defined hygienic bacteria inside pure tissues and having the albumin charge which are both impurities of albumin

properties - (blood, the remains of albumin fish, jelly material, etc.)

2- The description of small active chlorine in ANK which induces the effects of some bacteria on the hygienic well-known bacteria.

The abilities for anole bacteria in four well-known bacteria (the Huygens) were studied. The below chains called micro organism examiner are used:

- *Staphylococcus aureus* 906, *Enterobacter Cloaceae*

- *Pseudomonas fluorescens*, *Bacillus cereus* BKM 687

The 3-day bacteria cultures are used in this experiment which were multiplied on the FDA.

5 milliliters of fish stew water (FEB) were injected inside a U-shape tube for 72 hours at the temperature of 37°C. *S. aureus*, *E. lbaceae*, *Bacillus cereus*, and *P. fluorescens* were placed in the thermostat. Like the experimental surfaces, materials are widely used in Fish breed processing industry such as sand planes - plastic mobile sheets - alloyed plastic, and steel (1, 18).

9 mL of salt solution was added to 1 mL of fish stew culture after 3 days.

2 mL of this suspension was used in a 7.5×7.5 cm cube.

Without any temperature, the container was dried out for 2 hours. The examination of the surface was performed with distributing the Anole ANK in 2 mL portions per cubic meter.

After the multiplications at the room temperature for 40 minutes, the damp area of the examined surface was dried with 2 strips of cotton.

The strips were placed inside 20 mL of salt solution containing 1 mL of hyposulfite 0.1 N and mixed completely for 1 - 2 minutes (4, 13).

Then, the reduction happened and was injected over the surface of FPA. In experiments with organic charge instead of the salted solution, 9 mL of FPA was added to 1 mL of bacterial suspension.

The performance of bacterial reactions ANK as compared to the quantity of the multipliable cells in the controllable experiment was measured. The assumption was that the positive effect of the experiment should not have been less than 2 Logarithm of the reduction in multipliable cells with respect to the control.

With regards to the general form of the bacteria, gene factors "Enterobacter" are mostly found in fish products. These factors are not only the main cause of animal waste liquids, but also carry some of fish diseases like Piscine (7).

For this reason, with the application of the bacteria of ANK, the chain *Enterobacter cloaceae* is separated from sea products. The resulted actions of the ANK bacteria in a 3-day culture of *Enterobacter cloaceae* are shown in Table 2.

Table 3 indicates that the number of multipliable *E. cloaceae* is clearly sloped (up to $3\log_{10}$) in the applica-

Table 2. Action Results for the ANK Bacteria Related to the *E. cloacae* Culture on the Stone and Sandy Plane After 40 Minutes of Contact

Number of Cells That Can Multiply, CFU/mL			Stone Material	ANK, CL, Mg/l
After the examination is washed	Washed without examination	Used from the sample future wash		
4.2×10^2	No Protein - 2.6×10^2	3.5×10^6	The Stone Plane - Sandy	250
1.6×10^3	Protein- 2.5×10^3			

tion step and when drying over the experimented material (stony sandy plane).

The ANK bacteria without organic charge, which indicates the decreasing number of cells of $2\log_{10}$, have very effective multiplication property (4).

In the existence of organic charge, the effect of ANK bacteria (active chlorine density is 250 mg/L) is ignorable and its amount is 35% of the initial count of bacteria.

Therefore, we can conclude that the planted surfaces with *E. CBG* (the *E. coli* bacteria group) 250 mg/L ANK and the higher density of active chlorine are effective in succeeding the sterilized stone and sandy planes.

The gene agents/factors of *Pseudomonas* are generally in water, on fish and its products.

The vastest kinds of these genes are *Pseudomonas Fluorescens* actually (P.F) in the study of the ANK bacteria activities (19).

The findings of this study for the evaluation of the effect of ANK over a 3-day culture of *P. fluorescens* adjacent to the albumin impurities which are indicated in chart 2 are gathered together.

Table 3 shows in the applied process of drying over the stone planes, the amount of $2\log_{10}$ reduction in the number of multipliable cells in the bacteria suspension has been seen.

The effect of ANK bacteria (350 CL- mg/L) is noticeable and is added to the $6\log_{10}$ reduction of initial bacteria count (17).

Overall, we can conclude that in a case of *P. fluorescens* and existence of albumin impurities, ANK with a density of 350 CL- mg/L can be used for sterilizing stone-sandy plate surfaces.

Staphylococcus with the title of experiment *Staphylococcus aureus* with 906 chains is very credible and recommended in evaluation of sterilizers' effectiveness.

The effect of ANK action against *S. aureus* with 906 chains over several surfaces is indicated in Table 3.

3.8. Sand Culture 72 Hours at 30°C

The given parameters indicate that the quantity of multipliable cells *S. aureus* bacteria suspension diminishes as soon as using the culture over the experimented material and the surface becomes dry over the sandy-stony plate

which is bilateral, over the plastic up to $2\log_{10}$ CFU/mL, over Steel Alloy up to 3 - $110 \log_{10}$ /mL.

4. Discussion

The reduction of oxygen level in the water is directly related to the increase of temperature and altitude from the sea level that should be noticed. We can use Emerald Machines to do some fine adjustments (20).

The amount of minerals inside the water is extremely variable and in some waters could be changed enormously. These changes even in a short period of time can cause irreversible consequences inside the breeding workhouses specially the breeding of Trout fish (18).

To prevent this, we can use different electrolysis phases within the Emerald Equipments to analyze water (12).

The slow current of swamps, sewage muddy water, spring and wells usually contain less oxygen, have low pH, and high amount of free CO_2 . Using the water purification techniques and with suitable production we can eliminate these problems (11, 13).

The connected values in ORP in clarification strategy, the cathodic activated water and the internal environment of living creatures should be seriously noticed. These values regarding the shapes and forms are very similar to each other and this resemblance induces the electrical balance in biological liquids in the body of the living creatures and also the water we drink. This matter specially in breeding the aquatic creatures in different systems, traditional, academic, etc., should be prioritized, since these creatures are very sensitive to water alterations and the smallest change in either the composition or the environment temperature could lead to their disease and ultimately their mortality. For example, we can use the clarification strategy to prevent or even cure some of bacterial diseases in the breeding of fish (2, 6, 9).

4.1. Conclusion

The active water is considered outside the system because of its physical and physiological properties. This result of alterations is activated to form the molecules,

Table 3. The Effectiveness of the Action of ANK Bacteria Related to the *P. fluorescens* Over the Surface of Stone-Sand After 40 Minutes Contact

After the examination is washed	Number of Cells That Can Multiply, CFU/mL		Stone Material	ANK, CL-,Mg/I
	Washed without examination	Used from the sample future wash		
< 5	No Protein - 2.4×10^6	3.2×10^8	The Stone Plane - Sandy	350

stronger hydrogen bonds and lengthier molecular structures. The living organisms are not capable of consuming lots of energy to metabolize and diminish this water. Therefore, all body organs and muscles receive a large amount of water molecular structure which are of activated water and provide the needed information in order to achieve a healthier condition and solving the problems (5, 20).

Different experiments have shown the poisonous and fatal effects of some elements like Copper, Zinc, and Mercury on various kinds of fish species. The poisonous activity of some of heavier metals and other metals with lower atomic mass in an ionized form is obvious. The activation of cathodic water inside the Emerald Equipment isolates the poisonous metals in ionized forms but does not completely eliminate them.

Furthermore, instead of using chemical matters like antiseptics and antibiotics in traditional ways, we can use the activated chemical solutions inside the preservative Tuna foods specially the Trout Eggs and other related kinds (21).

The effective factor of the natural anolyte includes active chlorine and a compound of oxygen (hypochlorous, ozone, and peroxide). The function range of this natural anolyte has been emphasized for cleaning and sterilizing medical equipment.

At the end, the use of anodic and cathodic water produced by the reactor may be an efficient method for decontamination (sanitization) of food processing factories such as meat and dairy factories; this method does not pose any pollution threat for the environment.

Future research can focus on discovering best CIP (cleaning in place) doses for elimination of snard food-borne bacteria.

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Footnote

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