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Executive Summary

The universal solvent, water, has long been recognized as the ideal cleaning medium, safe for both humans and the environment. However, when surfactants/detergents are dissolved in water, the surface tension is reduced, facilitating an enhanced wetting effect and spreading the cleaning solution across the cleaning surface. The cleaning industry has become more aware of the negative environmental and health ramifications associated with chemical use, there has been a quest for new solutions that achieve the cleaning effect of a surfactant without the adverse side effects inherent with chemical use. The basics of water electrolysis is to apply an electrical charge to water thereby dissolving water's hydrogen and oxygen molecules which generates two species of water; alkaline and acidic. This process allows the two streams of water to be combined to create a powerful cleaning agent before recombining into normal tap water.

What have the studies shown?

1. The test clearly shows that the floor scrubber with the water-electrolysis process dries faster than the scrubber using general cleaner.
2. The floor scrubber using the water-electrolysis process was picking up more dirt from the floor than the scrubber using the general purpose cleaner.
3. Lastly, the test for amounts of TSS in the Tennant T5 walk-behind scrubber using water-electrolysis system was greater 20 out of 28 times as compared to the three other cleaning types with the same scrubber (Scrubber using water, Scrubber using Tennant FaST and Scrubber using a general purpose cleaner).

In conclusion, these findings show a superior cleaning performance using water-electrolysis technology for cleaning applications with many benefits that include; Environmentally friendly, social responsibility, sustainability, health and safety benefits and it is simple, productive and cost effective.

The future is water-electrolysis

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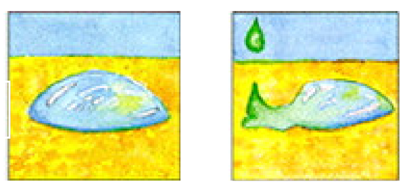
Introduction

Water—the universal solvent—has long been recognized as the ideal cleaning medium, safe for both humans and the environment. By itself, water aggressively attacks most substances it contacts. However, plain water does not always contain the requisite attributes to clean dirt particles from a surface. As a result, cleaning professionals have been forced to augment water with surface active agents, or surfactants, found in all general purpose cleaners and detergents in order to achieve the cleaning performance they desire.

Surfactants, when dissolved in water, improve the cleaning solution's ability to more evenly wet the cleaning surface, penetrate the dirt and lift it from the surface. Surfactants produce this improved wetting effect by lowering the surface tension or interfacial tension between the dirt and the water droplet. Surfactants used in general purpose cleaning have a hydrophilic (water-loving) head that is attracted to water molecules and a hydrophobic (water-hating) tail that repels water and simultaneously attaches itself to oil and grease in dirt. These opposing forces loosen the dirt and suspend it in the water.

As illustrated below, water droplets have a high surface tension that is created by the "sticky-skin" effect within the water's surface layer. As a result, when plain water is applied to the cleaning surface, it tends to maintain its droplet form rather than distributing the liquid evenly across the surface. However, when surfactants are dissolved in water, the surface tension is reduced, facilitating an enhanced wetting effect and spreading the cleaning solution across the cleaning surface.

Surface Tension



Plain Water **Water & Surfactant**

In addition to the wetting effect, surfactant molecules add a charge to the water that helps attract the cleaning solution to the surface of the dirt. This enables the surfactant molecules to surround the dirt particles, break the dirt into smaller particles, keep the dirt particles suspended in the water solution, and prevent the dirty water from re-depositing on the surface.

While the surfactants found in most cleaning chemicals infuse water with a number of valuable attributes, they also present numerous deleterious environmental and health consequences. These include:

- Ground and drinking water contamination
- Chemical residues which can lead to slip and fall incidents and poor indoor air quality
- Injuries resulting from chemical inhalation, ingestion and exposure
- Additional training costs and complexity
- Additional supply chain costs for purchasing and storing chemicals
- Utilization of fossil fuels for chemical production and packaging

As the cleaning industry has become more aware of the negative environmental and health ramifications associated with chemical use, there has been a clamoring for new solutions that achieve the cleaning effect of a surfactant without the adverse side effects inherent with chemical use.

Basics of Water Electrolysis

Scientist Michael Faraday first discovered the process of water electrolysis in 1859. By applying an electrical charge to water, Faraday was able to dissolve (break apart) water's hydrogen and oxygen molecules. Today, this technique is employed in a wide range of applications, including:

- Conditioning and purifying drinking water (sanitation)
- Vegetable cleaning (sanitation)
- Poultry, meat and seafood cleaning (sanitation)
- Washing machines (cleaning and sanitation)
- Well drilling (soil suspension)
- Electroplating metals onto an other surface
- Producing hydrogen fuel for automobiles—to name just a few applications.

The typical water-electrolysis process generates two species of water: alkaline and acidic. These streams must remain separate in order to prevent them from naturally recombining into normal tap water. Each resultant stream provides a unique set of benefits and utilities, although not every application requires the use of both streams.
As a result, in most of the aforementioned applications, there is a waste stream created during electrolysis that requires disposal

In the remainder of this paper, we will focus on a new innovative process that leverages the underlying water electrolysis process but allows the two streams of water to be combined to create a powerful cleaning agent before recombining into normal tap water. This approach does not compromise the cleaning effect of the alkaline water and allows use of 100 percent of the water. This process combines the two streams together and applies them to the cleaning surface where it remains active for a period of 30-45 seconds, ample time for the water to perform its cleaning action.

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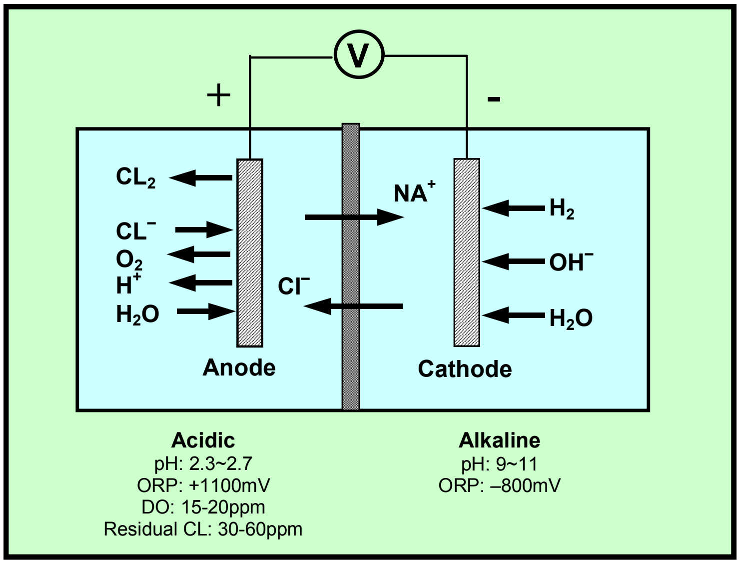
Water Electrolysis (the Chemistry)

The following illustration shows the chemical reaction that occurs when an electrical charge is applied to water



Electrolysis cell have anode and cathode chambers, dividing by microporous semi-permeable wall of membrane or diaphragm type. Electrodes are constructed in titanium and rare metals.

Commonly used dividing walls are prepared from asbestos fibres and ceramic (diaphragm cells) and perfluorinated composite coated from both sides with perfuoro ion exchange resins (membrane cells). Some membranes initially may contain a water-soluble surfactant.

The main difference in membrane and diaphragm cells lies in the manner by which the acidic water and the reduced water are prevented from mixing with each other to ensure generation of pure products (for instance sodium hypochloride).

The electrochemical reactors of both types make possible to carry out unipolar (anodic and/or cathodic) treatment of water with low mineralizing level (0.01 – 0.2 g/l) obtaining by addition of NaCl, KCl, LiCl, ScCl, NaOH, KOH, NaHCO3, Ca(ClO)2, HCl, H2SO4 and other water soluble electrolytes.

The effect of dividing wall on the performance of electrolysis cell is quite complex. Electrochemically, as high concentrations of Cl- and OH- ions without compensation of Na+ and H+ build-up on either side of the membrane, this unstable species can result in complex reactions producing a metastable solution containing a wide variety of a very reactive ions and free radicals (possible reactive ions formed in anodic chamber are H+, H3O+ , OH-, ClO-, HO., ClO., Cl., O., O2. and radicals in cathodic – O2., H3O2.)

The separating wall can be described in terms of thickness, tortuosity, porosity, pore size distribution and resultant permeability of the structure. For a given set of cell operating conditions, the membrane parameters, and especially their uniformity across the active area, determine the electrical energy usage of the cell and quality of the products.

The physical and chemical characteristics of the anolyte and cathalyte, forming at anodic and cathodic compartments accordingly, are determined by current magnitude, volume feeding of aqueous medium and its mineral content.

Acidic Output Stream

The acidic side of the water cell has a higher concentration of hydrogen ions than the input water, thus having a lower pH level than the input water. Repeatable experimentation has shown that the pH levels range from approximately 2.2 to 6.0. This degree of change in the pH levels is a result of the alkalinity levels (mainly carbonate and bicarbonate concentrations) in the input water. The acidic side has been shown to possess a significant potential for sanitizing or disinfecting, several split stream products are registered devices with the EPA.

Alkaline Output Stream

The alkaline side of the water cell has a lower concentration of hydrogen ions than the input water, thus having a higher pH level than the input water. Repeatable experimentation has shown that the pH levels range from approximately 8 to 11. This degree of change in the pH levels is a result of the alkalinity levels in the input water. This degree of change, however, is far less than that from the acidic output stream. The alkaline side has been shown to have no known sanitizing potential.

Repeated experimentation by Aspen Research Corporation—an independent St. Paul, Minnesota-based contract research and development company—has shown that the alkaline output stream offers significant surfactant-mimicking behavior.

Current scientific literature describes several theories as to why the alkaline output water can hydrate soils faster, disperse food-based oils and greases, and remove stains better that plain tap water. Nearly all these published theories emphasize the reactive properties of diatomic hydrogen species; that is, the changes that occur in the hydrogen bonding of the water are caused by the concentration of positive ions “clusters”—or the interaction of these two phenomena. While pH levels can have an effect, most scientists agree that pH-level contributions are minor when compared to oxidation, reduction, and hydrogen bonding.

This new water electrolysis technology mixes the acidic and alkaline output streams at the output of the water cell and then uses this blended stream to perform daily cleaning activities. The mixed streams have consistently shown significant surfactant-mimicking behavior over a 45-second period. After this period, the output water is essentially deactivated and returned to plain water containing the recovered dirt.

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How It Works

The device performing the water electrolysis contains two distinct but critical elements or stages.

1st Stage

In the first stage, a bubble generator infuses the tap water with oxygen, producing millions of micro bubbles. This is accomplished by having two wire-mesh electrodes placed close to each other. The small radius of the wires in the mesh ensures very small bubbles. The smaller sizes of these bubbles allow the gases in the bubbles to be more soluble in the water at a high rate, which is due to the large surface area of the bubbles. The resultant water is rich in dissolved oxygen and has low ppm (parts per million) levels of both peroxides and other reactive species that are formed through oxidation or reduction reactions.

This stage performs several key functions in the overall cleaning process: provides a cleaning boast, maintains separation between the alkaline and acidic water species, and helps carry the dirt particles away from the cleaning surface.

2nd Stage

In the second stage, the oxygenated water passes through membranes and is subjected to an electrical charge. This charge is where the two unique output streams, alkaline and acidic, are created. The membranes allow ions to migrate through, thus resulting in a separation of the chemical species. Near the positive electrode (anode), hydrogen ions and oxidized species are formed. Negatively charged ions in the water, such as chloride and carbonates, are attracted to the positively charged electrode. The resulting water from this electrode is acidic. This acid is caused by the water's hydrogen ions, by the water being rich in species with oxidizing potential, and by the water's excess of negatively charged ions. Near the negative electrode (cathode), hydroxide ions and reduced species are formed. Positively charged ions in the water, such as sodium and potassium, are attracted to the negatively charged electrode. The resulting water from this electrode is alkaline. This alkalinity is caused by the water's hydroxide ions, by the water being rich in species with reducing potential, and by the water's excess of positively charged ions.

Comparing Aqueous Cleaners

Beginning in the fall of 2006 and continuing for several months, controlled laboratory cleaning trials of this new water-electrolysis process were performed and evaluated by Aspen Research. In addition, numerous field trials of this process were performed at customer sites using automatic powered floor scrubbers. The ability of the water-electrolysis process to clean multiple soil types on multiple surfaces—from vinyl tiles and sealed concrete—was tested and evaluated against general-purpose cleaners. These tests consistently demonstrated that the water-electrolysis process cleaned as well as or better than industry-accepted general-purpose cleaners. Also, when compared to the general-purpose cleaners, customers noted that the water-electrolysis process provided a number of significant benefits:

- Removed more dirt from the floor
- Reduced unpleasant odor in the scrubber's recovery tanks
- Left no residue on a highly polished floor
- Dried more quickly

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The picture below illustrates how this process facilitates a faster dry time than general cleaners. In this test, two new floor scrubbers—one using an industry-accepted general cleaner and the other using water electrolysis —were run side by side. It is clearly visible that the floor scrubber on the right, with the water-electrolysis process, dries faster than the scrubber on the left using the general cleaner.

During these same trials, water collected from the recovery tanks of both floor scrubbers (as shown below) clearly revealed that the floor scrubber using the water-electrolysis process was picking up more dirt from the floor than the scrubber using the general-purpose cleaner.

Water-Electrolysis Process **General Cleaner**

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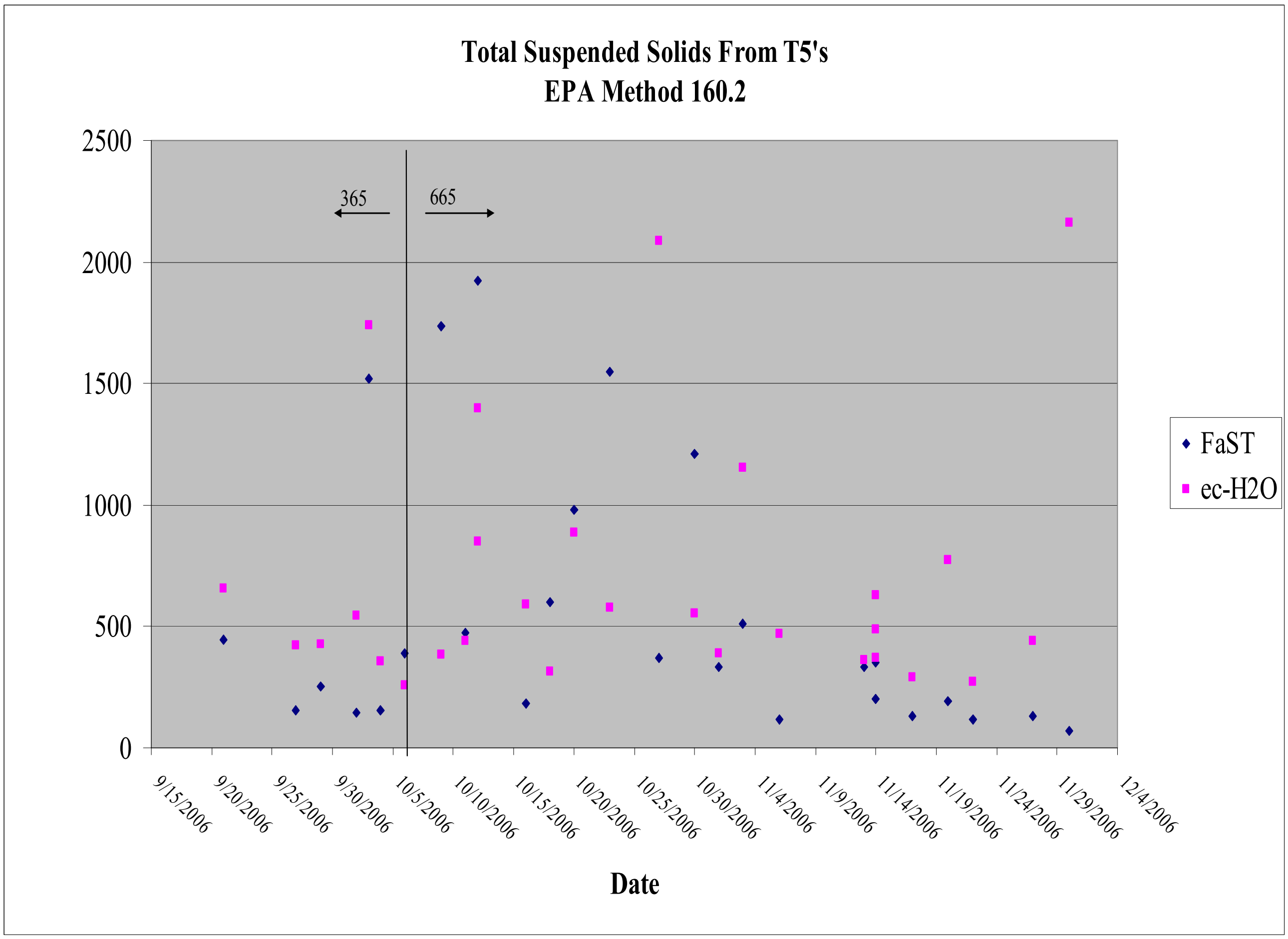
In another test during the same trial, water samples were taken to compare the Total Suspended Solids (TSS) from the collection tanks. Samples were collected from four walk-behind scrubbers: one using the water-electrolysis process (ec-H2O), one using water, one using Tennant FaST (Foam Activated Scrubbing Technology) and one using a general purpose cleaner. The TSS measured from the water from the collection tanks on the scrubbers measures the mass of solids in the water. This corresponds to the amount of dirt being removed from the floor. Twenty-eight sets of water samples were collected and tested. The amount of TSS in the T5 using water-electrolysis system was greater 20 out of 28 times, as indicated in the chart below.



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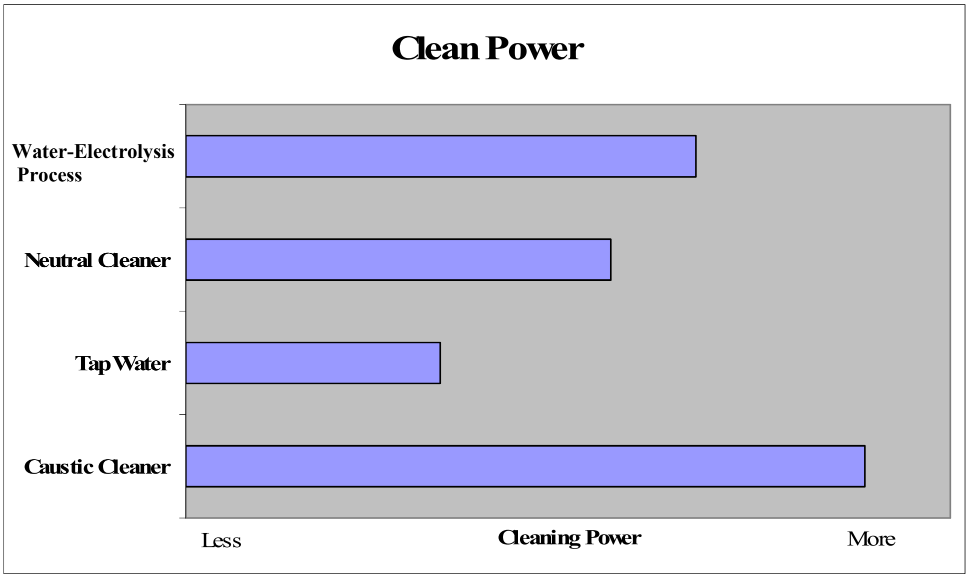
The bar graph below contains test results comparing cleaning performance using electrolyzed water versus other types of cleaning agents. As the graph shows, the water-electrolysis method consistently cleaned as well as and, more often, better than general-purpose cleaners.



In addition to the superior cleaning performance using water-electrolysis technology for cleaning applications presents an array of benefits:

Environmentally Friendly and Socially Responsible

- Eliminates chemical disposal
- Eliminates chemical packaging and shipping
- Reduces chemical production
- Eliminates transportation of chemicals
- Uses up to 70% less water than conventional scrubbers

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Health and Safety

- Eliminates chemical splashing
- Eliminates accidental ingestion
- Eliminates Indoor Air Quality issues
- Eliminates handling of heavy chemical containers
- Reduces slips and falls

Simple, Productive, Cost Effective

- Reduces chemical related training
- Eliminates measuring/mixing of chemicals
- Eliminates purchase of general purpose scrubbing chemicals
- Reduces need for burnishing