ECOTREAT

COPPER-SILVER IONIZATION

A Technical Overview

OVERVIEW

ECOTREAT Copper-Silver Ionization

is an innovative and sustainable disinfection solution for potable water systems. It's designed to quickly destroy Legionella and other waterborne pathogens and achieve long-term prevention without creating harmful byproducts or damaging plumbing equipment.

Why copper-silver ionization?

- ✓ Highly effective regardless of water temperature or complexity of plumbing system
- ✓ Outperforms chemical and oxidative alternatives in controlling waterborne pathogens
- ✓ Provides complete system disinfection within 48 hours
- ✓ Does not dissipate rapidly in hot water for lasting protection

Bactericidal Properties

- Kill Mechanism
- Historical Uses

ECO

- Equipment Overview

Science of Ionization

- **Ohm's Law**
  - Amperage
  - Resistance and Conductivity
  - Voltage
  - Power

BACTERICIDAL PROPERTIES

Copper (Cu2+ Ion)

- The 3-dimensional structure of proteins can be altered by copper, so that the proteins can no longer perform their normal functions. The result is inactivation of bacteria or viruses (1)
- Copper complexes form radicals that inactivate viruses. (2,3)
- Copper may disrupt enzyme structures, and functions by binding to sulfur- or carboxylate-containing groups and amino groups of proteins. (4)
- Copper facilitates deleterious activity in superoxide radicals. Repeated redox reactions on site-specific macromolecules generate OH- radicals, thereby causing "multiple hit damage" at target sites. (5,6)
- Copper can interact with lipids, causing their peroxidation and opening holes in the cell membranes, thereby compromising the integrity of cells. This can cause leakage of essential solutes, which in turn, can have a desiccating effect. (7)
- Copper damages the respiratory chain in E. coli cells (8) and is associated with impaired cellular metabolism. (9)

BACTERICIDAL PROPERTIES

Copper (Cu2+ Ion)

- Microbes require copper-containing enzymes to drive certain vital chemical reactions. Excess copper, however, can affect proteins and enzymes in microbes, thereby inhibiting their activities. Researchers believe that excess copper has the potential to disrupt cell function both inside cells and in the interstitial spaces between cells, probably acting on the cells' outer envelope. (11)
- Elevated copper levels inside a cell causes oxidative stress and the generation of hydrogen peroxide. Under these conditions, copper participates in the so-called Fenton-type reaction — a chemical reaction causing oxidative damage to cells. (11)
- Excess copper causes a decline in the membrane integrity of microbes, leading to leakage of specific essential cell nutrients, such as potassium and glutamate. This leads to desiccation and subsequent cell death. (11)
- While copper is needed for many protein functions, in an excess situation (as on a copper alloy surface), copper binds to proteins that do not require copper for their function. This "inappropriate" binding leads to

BACTERICIDAL PROPERTIES

Silver (Ag+ Ion)

- It is thought that silver atoms bind to thiol groups (-SH) in enzymes and subsequently cause the deactivation of enzymes. (12)
- The silver-catalyzed formation of disulfide bonds can lead to changes in protein structure and the inactivation of key enzymes, such as those needed for cellular respiration (13)
- Condensation of DNA occurs as a protective measure in order to protect the genetic information of the cell , however condensation of DNA could also prevent cell replication by preventing the DNA from being accessed by transcriptional enzymes such as DNA polymerase. (14)
- In one way or another, all of the effected proteins play a role in energy and ATP production for the cell, so the decreased expression of any one of these proteins could lead to cell death. (15)

"Kill Mechanism"

Synergistic Effect

- Copper works from the outside of the cell by distorting the cell wall leading to increased permeability.
- This increased permeability permits silver to penetrate the cell and cause protein denaturation and enzyme inactivation.
- The result of this multi-phase attack is cell "lysis" or death.

Historical Uses

- Copper was used to line water vessels as far back as the Egyptian Civilization, while silver was used in a similar capacity during the height of the Greek and Persian Empires.
- Countless other references are made throughout history as to the effectiveness of copper and silver in combatting various infections and diseases.
- NASA first used copper and silver ionization in the 1960's to disinfect the water supply aboard spacecraft without chemicals.
- In the 1980's testing was performed that demonstrated the effectiveness of copper silver ionization against Legionella.

ECO

Equipment Overview

CONTROLLER

FLOW CELL

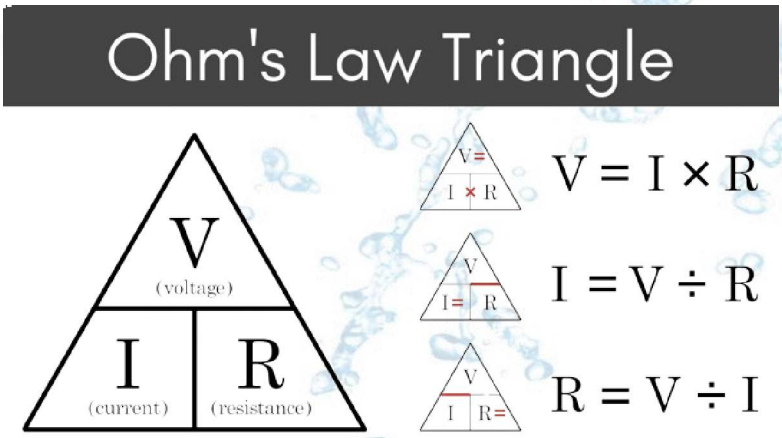
FLOW METER

SCIENCE OF IONIZATION

- The controller takes in AC power (either 120V or 220V) and then converts the power to DC for the ionization process.
- The Ionization process is a direct application of Ohm's Law.

- Voltage (V) = Resistance (R) * Current (I)

  - Ohm's Law dictates that to pass current through a given material one must overcome the resistance of that material by applying a specific amount of voltage.
  - The Controller is essentially a current generator. Current is directly proportional to ion production.
  - The Controller automatically adjusts its voltage output between 0 and 100 Volts to maintain a specific amount of output current dictated by a control mechanism.
  - So, if a control mechanism chooses the current and the controller sets the voltage, what controls the resistance?



Power

- Often times our competitors will offer control systems with different output capabilities then our own.
  - Power (watts) = Current (amps) x Voltage (volts)
  - Maximum power will often be used to mask true output capabilities.
  - If competitor claims 1000-Watt Output capability with current output of 20 amps, how much voltage can they accommodate? 50 Volts