Electrolyzed Water as a Novel Sanitizer in the Food Industry: Current Trends and Future Perspectives

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VP TECHNICAL AND R&D
RADICAL WATERS – CITREX CHILE
A NEW ECO-SANITISER

- Electrochemically Activated Water (ECA) – or Electrolyzed Water (EW)
  - Disinfectant - Anolyte (HOCl) and Detergent - Catholyte (NaOH)
- Produced on-site from regular water and salt
- Popular due to simplicity of production
- Actively used in a number of applications in:
  - Agriculture
  - Medical sterilization
  - Food sanitation
  - Livestock Management
  - Other fields
    - antimicrobial techniques
History

• Developed in Russia, used in Japan since the 1980’s in medical institutions for disinfection.
• Use expanded into livestock management and agriculture.
• Electrolyzed Reduced Water (ERW or Catholyte) 1931 - agriculture + medical
• 1966 Ministry of health declared Catholyte effective in treating:
  – Diarrhoea, indigestion, hyperacidity and antacid and home use.
• Technological advances > popularity – better equipment available
• ECA Anolyte became a promising non-thermal disinfectant
HOW ECA IS MADE

**Acidic Electrolyzed Water (AEW)**
**Electrolyzed Oxidizing Water (EOW)**
**Anolyte**
- Hypochlorous acid (HOCl)
- Hypochlorite ion (OCl⁻)
- Hydrochloric acid (HCl)
- Oxygen Gas (O₂)
- Chlorine Gas (Cl₂)
  - pH 2-3
  - ORP >1100mV

**NEW Neutral Electrolyzed Water**
  - pH 7-8
  - ORP 750-900mV

**SAEW Slightly Acidic EW**
  - pH 5-6.5
  - ORP >850mV

**Basic Electrolyzed Water (BEW)**
**Electrolyzed Reduced Water (ERW)**
**Alkaline Electrolyzed Water (AIEW)**
**Catholyte**
- Sodium Hydroxide (NaOH)
- Hydrogen Gas (H₂)
  - pH 10-13
  - ORP -800 to -900mV
TYPES OF ECA-PRODUCING SYSTEMS

• Many systems for producing ECA available worldwide
  – Two main types – with and without diaphragms (pH differences),
  – single/dual stream
• AEW, NEW and SAEW (Anolyte) – powerful sanitizer
• BEW (Catholyte) – remove dirt and grease – strong reducing potential
• Brine, flow rate, voltage, amperage, available chlorine concentration
• Physiochemical properties of ECA varies depending on:
  – Concentration of sodium chloride (NaCl)
  – Current
  – Time of electrolysis
  – flow of water
BASIC PROPERTIES OF ECA

• Antimicrobial efficacy Influenced by pH, ORP and FAC

HOCl 80 times more effective than CLO⁻
BASIC PROPERTIES OF ECA

• Other factors having an influence on properties of ECA
  – current
  – water flow rate
  – salt concentration
  – storage conditions
  – electrolyte
  – electrode material
  – water temperature
  – water hardness
# ADVANTAGES AND DISADVANTAGES

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Environmentally friendly – Salt, water, electricity</td>
<td>High Initial cost of equipment</td>
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<td>Returns to original state after use.</td>
<td>Tendency to lose its antimicrobial potential quickly</td>
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<td>Safety – Humans and the environment</td>
<td>Reduction in concentration of chlorine over time</td>
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<td>On-site production</td>
<td>Pungent chlorine gas formation at pH &lt;5</td>
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<td>Broad-spectrum antimicrobial</td>
<td>Phytotoxicity, irritation and corrosion - Acidic Anolyte</td>
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<td>No microbial resistance</td>
<td>Reduction in efficacy – storage and organic matter</td>
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<td>Sensory quality of food products not affected</td>
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<td>Cost effective – cost 0.04 $/L</td>
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ANTIMICROBIAL MECHANISM FOR ZERO TOLERANCE

- Active chlorine species (Cl₂, HOCl and OCl⁻) inactivation of micro.
- Oxidants – reactive oxygen species (O₃ and H₂O₂) also contribute.
- HOCl – neutral charge – diffuse through cell
- HOCl attack on out outer membrane (A) and
- Also inside the cell (B) and (C)
- OCl⁻ unable to penetrate cell membrane
- Antimicrobial activity due to:
  - Inhibition of enzyme activity
  - Damage to membrane and DNA
  - Membrane transport capacity
APPLICATION OF ECA – IN-VITRO

• Anolyte strong antimicrobial activity in vitro avg. of >6 log CFU/ml
  – Variety of bacteria. Also effective against yeast, mould, spores.
• Foodborne pathogens – different sensitivities towards Anolyte
• Rahman et al (2010): increase in CT – reduction in log CFU/ml
  – 1 min – significant, 3, 5, 10 min – not significant reduction
• Factors influence antimicrobial activity
  – ORP, pH, FAC, and Temperature
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<th>Microorganisms</th>
<th>EW type</th>
<th>Exposure time (min)</th>
<th>Reduction (log CFU/mL)</th>
<th>Chlorine conc. (ppm)</th>
<th>pH</th>
<th>ORP (mV)</th>
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REPLACING CHEMICALS IN FOOD INDUSTRY

• Beverages – CIP
  – Water, CSD, Beer

• Fruit and Vegetables
  – Applied via dipping, spraying, soaking, washing during processing

• Poultry and Meat
  – Direct, fogging, CIP/COP, Equipment, water

• Seafood and Fish
  – Pre-processing, direct, CIP/COP, equipment, water, ice
APPLICATION OF ECA – OTHER

• Agriculture
  – Growth promotion, antifungal, disinfecting greenhouses, packing houses
  – Hydroponics – control of biofilm

• Livestock
  – Replacing antibiotics, increase FCR, fogging and sanitation of barns and houses

• Hospitality
  – Metal/plastic, cutlery, plates, glasses, cutting boards in the kitchen
  – Other areas and water supply - legionella

• Hospitals
  – Hard surfaces, equipment
  – Scopes, infectious waste
FUTURE PERSPECTIVES

• ECA approved by US regulators
  – Green and sustainable solution for home/industry use
  – Recently (USDA) approved ECA in organic products
• EU Biocides Regulation 528/2012 (EU BPR)
• Growing trend for commercialization
• In future – most industry likely to start using ECA
  – Simplicity, environmentally friendly, human safety aspect, efficacy, etc.
• Not sufficient knowledge – more advertisement required
• Over the next 10 years most food plants will start using ECA
CONCLUSIONS

• ECA Anolyte exhibits strong bactericidal, virucidal and fungicidal effects
• Already operational in various sectors
• Acidic Anolyte – corrosive and affects organoleptic properties some foods
  – Solved with introduction and development of slightly acidic and neutral Anolyte.
• Combination of multiple techniques (hurdle enhancement) – advantages:
  – Micro reduction, enhanced shelf-life, food quality maintenance.
• Various factors govern the efficacy of ECA
  – Monitored and managed during production and application
• Advanced and dynamic ECA systems – overcome challenges
  – Available through RW-CITREX CHILE
THANK YOU