

# Advanced High-Amp Dual Polarity Electrochemistry

Ion Isolation Using Sodium Chloride Electrolyte Injection

Production of Dual Functional Electrochemical Solutions



## Slide 2 — Scientific Context

### Scientific Context

- Electrochemical activation of water has applications in energy systems, water treatment, hydrogen production, and electrochemical synthesis.
- Functional Electrolyzed Water (FEW) systems simultaneously produce oxidizing and reducing streams with distinct redox properties.



Energy Systems



Water Treatment



Hydrogen  
Production



Electrochemical  
Synthesis



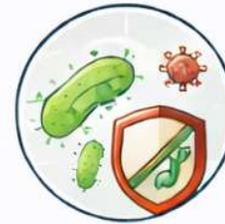
Research has expanded applications into Functional Electrolyzed Water systems, capable of producing oxidizing and reducing streams simultaneously. These systems produce two chemically distinct aqueous solutions with unique redox properties.

## Slide 3 — Problem Statement

### Problem Statement

Modern sanitation systems face challenges:

- Microbial resistance
- Chemical toxicity
- Environmental persistence
- Transport and storage risks



Microbial  
Resistance



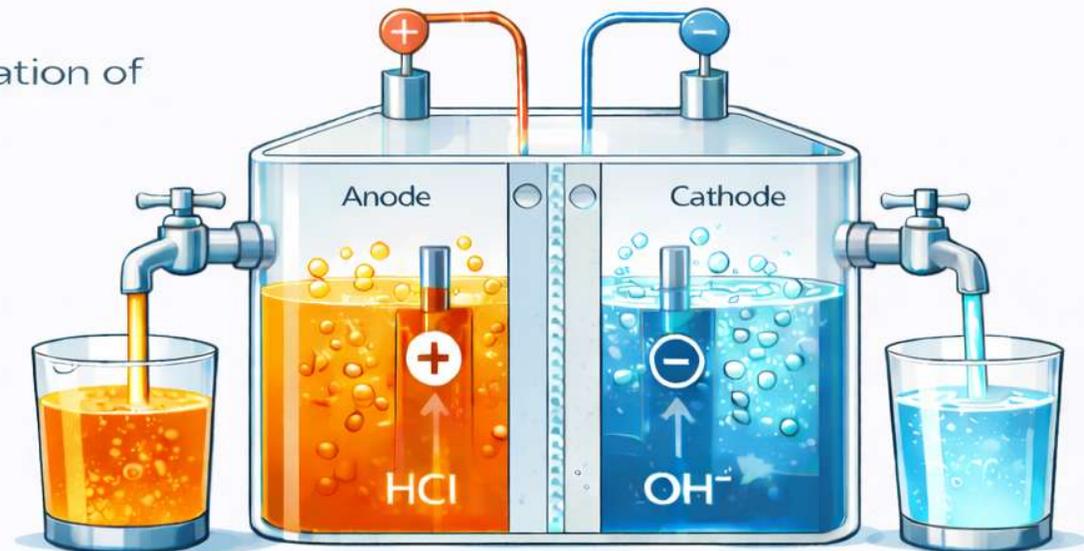
Chemical  
toxicity



Transport  
& storage risks

A solution is the in-situ generation of disinfectant chemistry using electrochemical processes.

Electrochemical activation allows on-demand synthesis of oxidizing agents directly from water and salt.



Oxidizing  
Medium

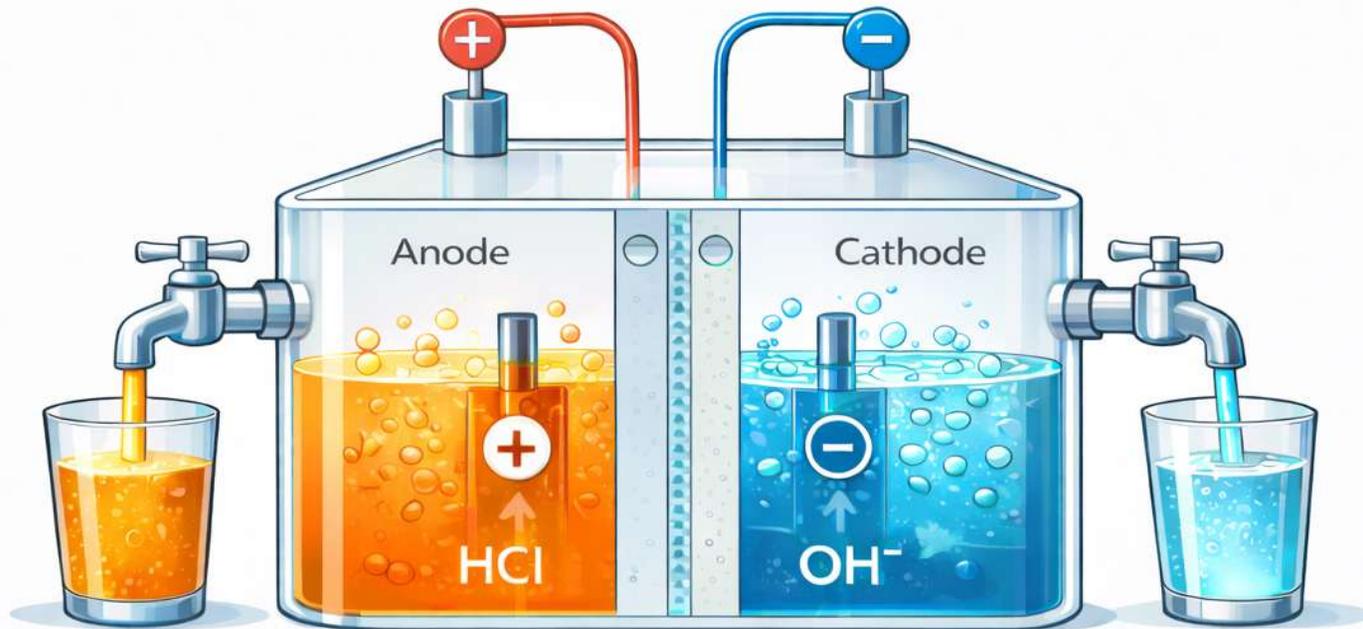
In-situ Electrochemical Activation

Reducing  
Medium

## Slide 4 - Discussion objective - separating ionic species

### Discussion Objective

- Communicate the **high-amp dual-polarity** electrochemical system capable of:
- generating oxidizing and reducing streams
- producing two **functional chemical solutions** simultaneously



Acidic Oxidizing  
Solution HCl

Alkaline Reducing  
Solution OH<sup>-</sup>

## Slide 5 — Fundamental Electrochemical Reaction

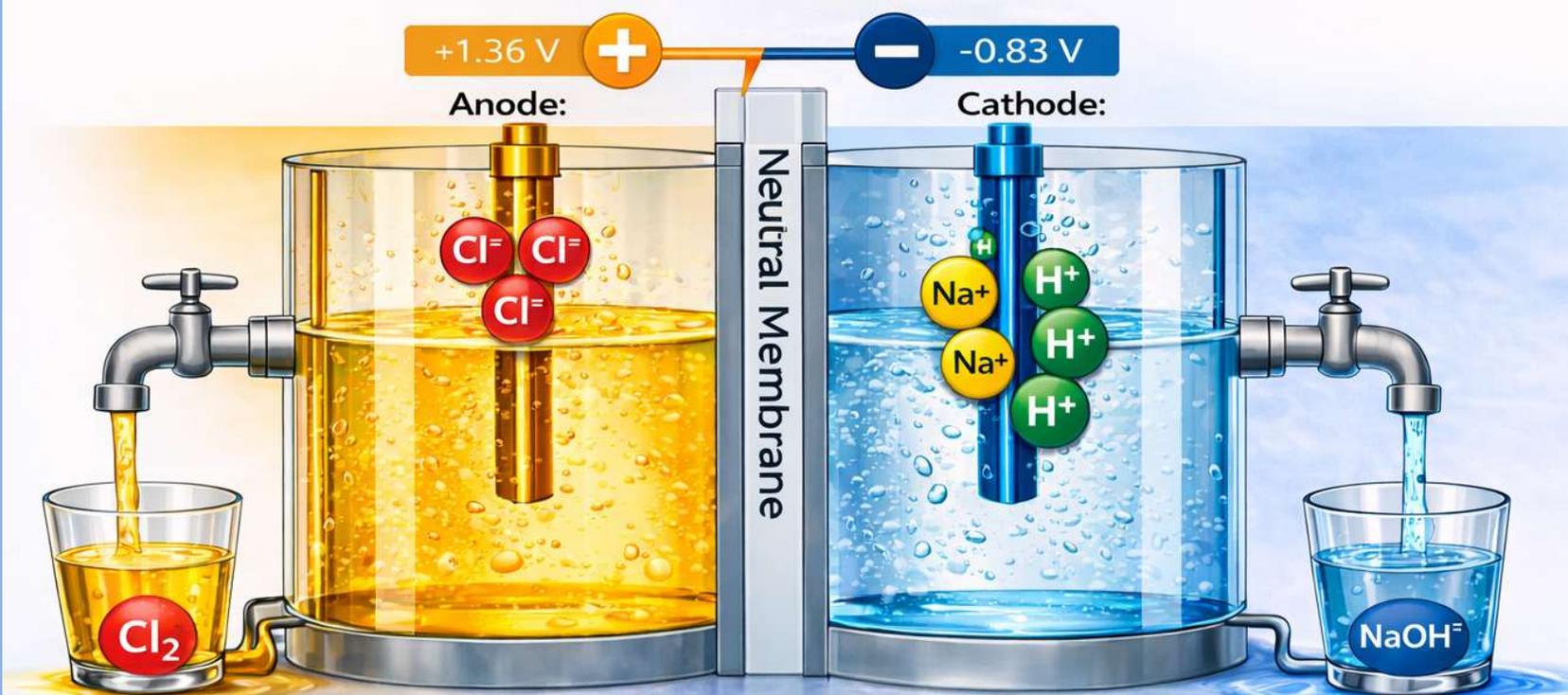
### Fundamental Electrochemical Reaction

Primary water electrolysis reaction:



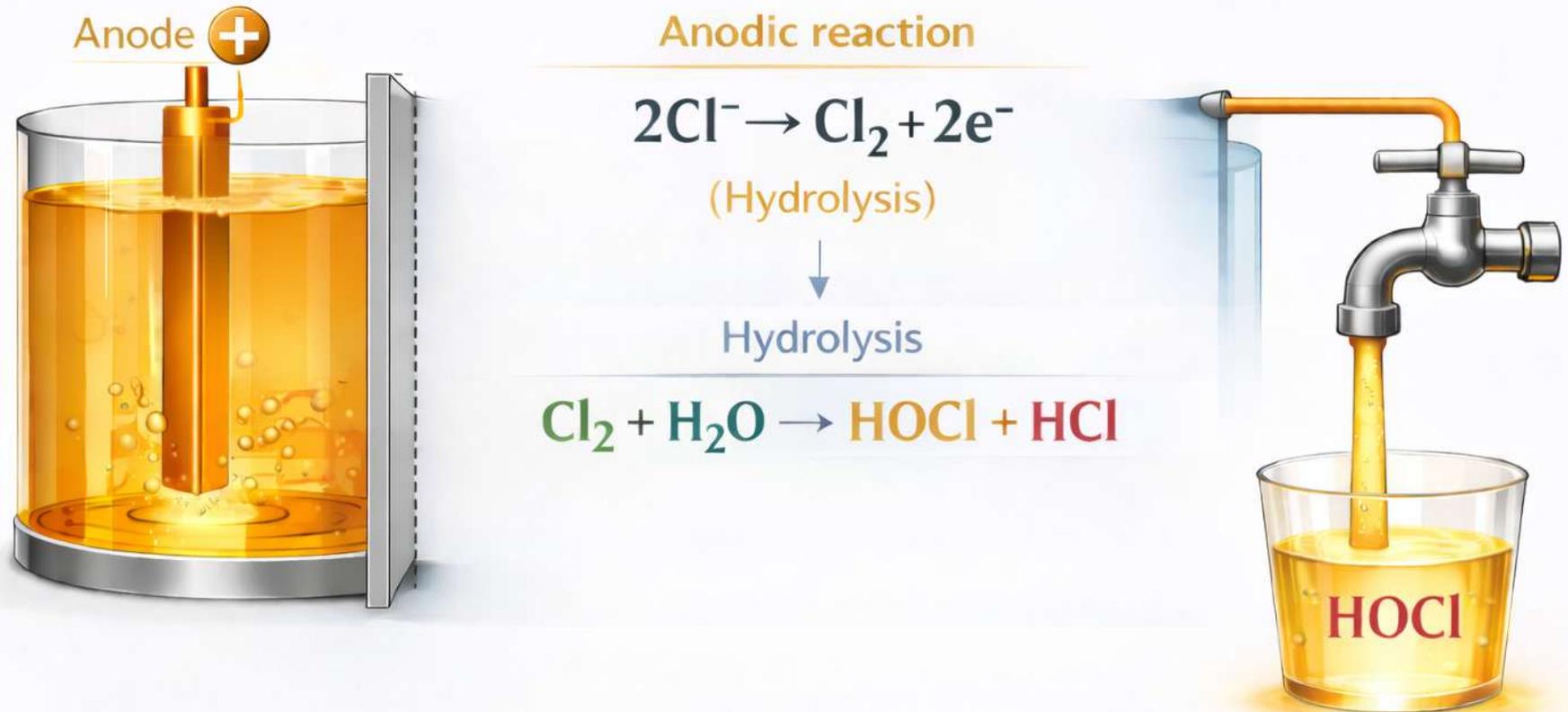
In the presence of chloride ions:

Additional electrochemical pathways become active



**Energy Transfer:** The reaction is highly exothermic; the ionization energy of Na is 5.14 eV, and the electron affinity of Cl is 3.62 eV.

## Electrochemical Chloride Oxidation



Hypochlorous acid becomes the **primary antimicrobial oxidant** species.

## Slide 7 — Cathodic Reduction resulting chemistry

### Cathodic Reduction

#### Cathode reaction



- Resulting chemistry
- sodium hydroxide formation
- Hydrogen evolution
- Negative oxidation reduction potential

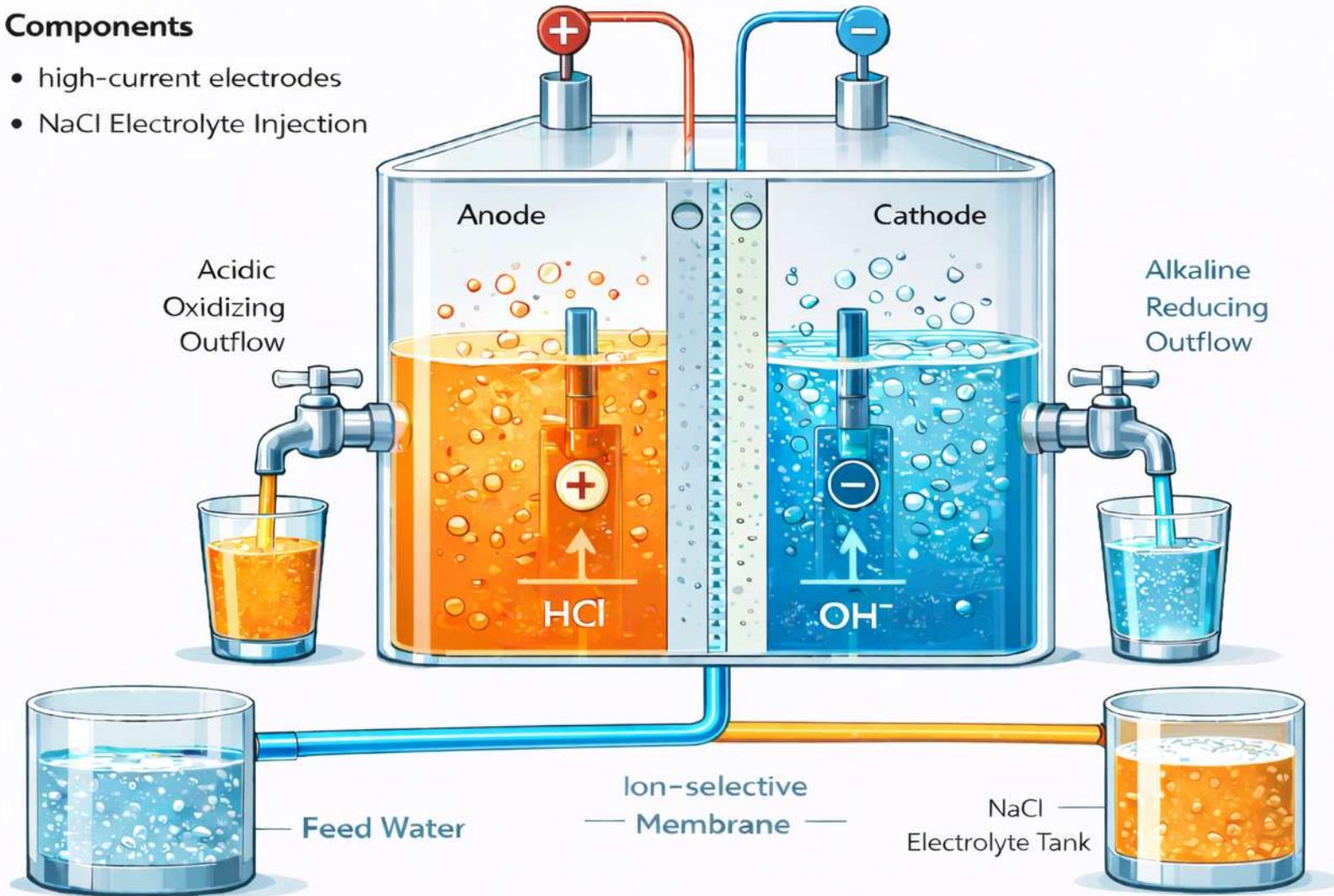
Produces alkaline conditions and hydrogen evolution, resulting in sodium hydroxide formation.

## Slide 8 Electrochemical Cell Architecture Components:

### Electrochemical Cell Architecture

#### Components

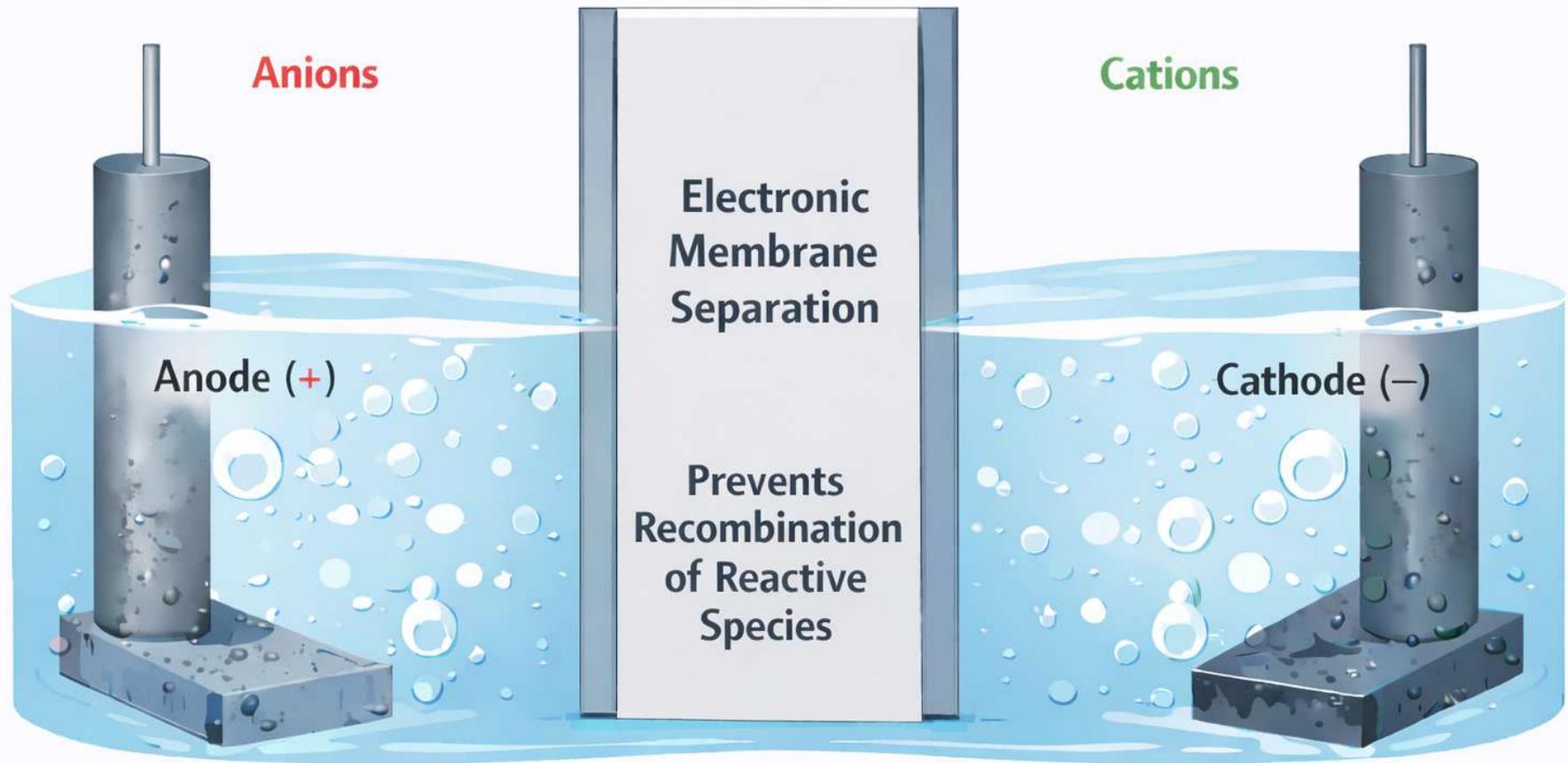
- high-current electrodes
- NaCl Electrolyte Injection



This architecture enables spatial separation of oxidation and reduction chemistry.

## Slide 9 — Ion Migration Mechanism

### Ion Migration Mechanism Under Applied Electric Field



**Two Independent Chemical Environments**

Under applied electric field: Cations → migrate toward the cathode - Anions → migrate toward the anode

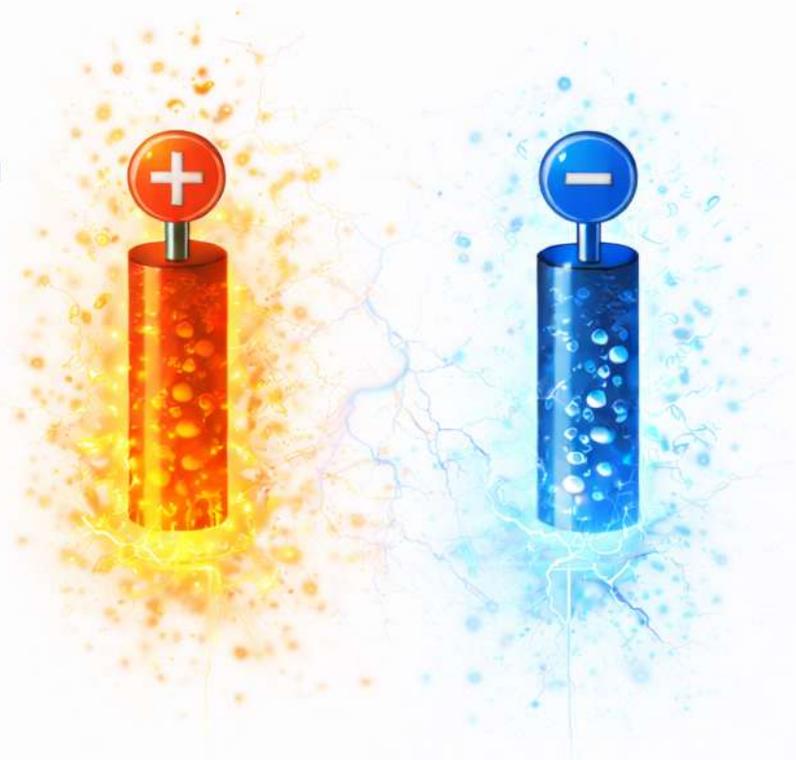
## Electrochemical Operating Parameters

Key variables affecting system performance:

- Current density
- Electrode material
- Electrolyte concentration
- Flow rate
- Membrane selectivity

High-amperage operation increases:

- reaction kinetics
- ionic flux
- oxidant production



## Formation of Dual Functional Streams

Electrochemical activation produces two distinct outputs:

 Anode chamber produces  
**Acidic oxidizing** solution

Cathode chamber produces  
**Alkaline reducing** solution



Electrolysis therefore transforms a single feed water stream into two electro-chemically different solutions.

## Oxidizing Stream Characteristics (Anolyte)

### Chemical Characteristics

Typical Parameters:

pH  
**2 – 6.5**

ORP  
**+900 to +1200 mV**

### Active Reactive Species



Hydroxyl



Chlorine



Hydrochloric  
Acid



Ozone



Hydrogen  
Peroxide



Hypochlorous  
Acid

Provides **strong antimicrobial activity**.



## Slide 13 — Alkaline Stream Characteristics(Catholyte)

### Alkaline Stream Characteristics (Catholyte)

#### Chemical Characteristics

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Typical Parameters:

pH  
**7.4 ~ 12**

ORP Negative Potential  
**-850**

Major Species:

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These properties create a **high-efficiency cleaning solution**.



## Functional Chemistry

### Acidic stream

- oxidizing
- antimicrobial
- biofilm disruption
- Porous surface sanitizer



### Alkaline stream

- degreasing
- organic matter breakdown and removal
- porous surface cleaner



## Sequential Treatment Mechanism



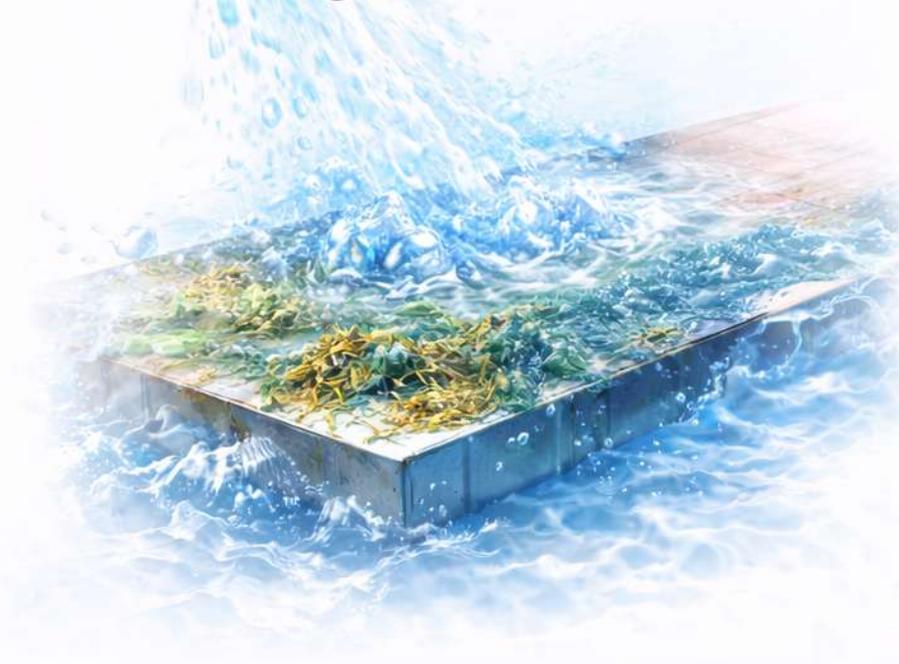
### Step 1

Alkaline solution removes organic contamination



### Step 2

Acidic oxidizing solution destroys microorganisms



Sequential treatment significantly enhances microbial reduction efficiency.

## Experimental Validation

**Electrolysis** performed using NaCl electrolyte solutions

Controlled electrochemical activation electrolyzed water has demonstrated effectiveness observed on fresh produce surfaces against pathogens such as:



Electrolysis performed using NaCl electrolyte solutions.

## Raw Well Water – Source Composition



### Raw Well Water – Source Composition

#### Baseline Ionic Composition

- pH: 7.58
- EC: 0.67 mS/cm
- Hardness: 318.65
- Major ions (ppm):
  - K** K: 41.63
  - Mg** Mg: 52.76
  - Ca** Ca: 140.40
  - Na** Na: 66.40
  - Cl** Cl: 74.15
  - S** S: 85.74

Baseline ionic composition before electrochemical separation.

## Electrochemical Separation – Alkaline Stream (UH)



### Alkaline Stream – UH

#### Key measured characteristics

- pH: 11.55
- EC: 4.48 mS/cm
- Hardness: ~0
- Key ions (ppm):
  - K 1403.32
  - Mg 11.58
  - Ca 53.01
  - Na 66.39
  - Cl 347.39
  - S 55.18

Alkaline reducing stream generated by cathodic reactions

## Electrochemical Separation – **Acidic Stream** (UL)

### Acidic Stream – UL

#### Key measured characteristics

- pH: 2.40
- EC: 4.03 mS/cm
- Hardness: 244.19
- Key ions (ppm):
  - K** 1208.67
  - Mg** 51.35
  - Ca** 11.52
  - Na** 72.38
  - Cl** 373.08
  - S** 11.93

Acidic oxidizing stream enriched in chloride species.

## Slide 20 — Electrochemical Output

### Comparison of Water Streams Before and After Electrochemical Separation

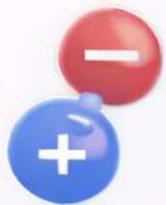


Parameter	Raw Well Water	Alkaline Stream (UH)	Acidic Stream (UL)
pH	7.58	11.55	2.40
EC (mS/cm)	0.67	4.48	4.03
Hardness	318.65	0.00	244.19
K	41.63	1403.32	1208.67
Mg	52.76	11.58	51.35
Ca	140.40	53.01	111.52
Na	66.40	66.39	72.38
Cl	74.15	347.39	373.08
S	85.74	55.18	111.93

Comparative ionic composition of water streams before and after electrochemical separation.

Measured alkaline stream pH 11.55 ~ Measured acidic stream pH 2.40  
This confirms effective electrochemical ion separation.

## Mechanistic Model



### Ion Migration

Ions move toward the electrodes



### Oxidation of Chloride

Chloride ions lose electrons



### Reduction of Water

Water molecules gain electrons



### Formation of Reactive Chlorine Species

Electrochemical reactions produce reactive chlorine species

This process transforms simple saline water into two functional chemical products.

## Slide — The Ionic Transport Mechanism

### Ionic Transport Mechanism

- Electrochemical activation produces both dissolved ionic oxidant and reductive species
- These single dissolved ions and gases travel with single H<sub>2</sub>O molecules (acidic as +1) (basic as -1)
- Aquaporin membrane channels facilitate transport enabling deep penetration into microbial cells and biofilms

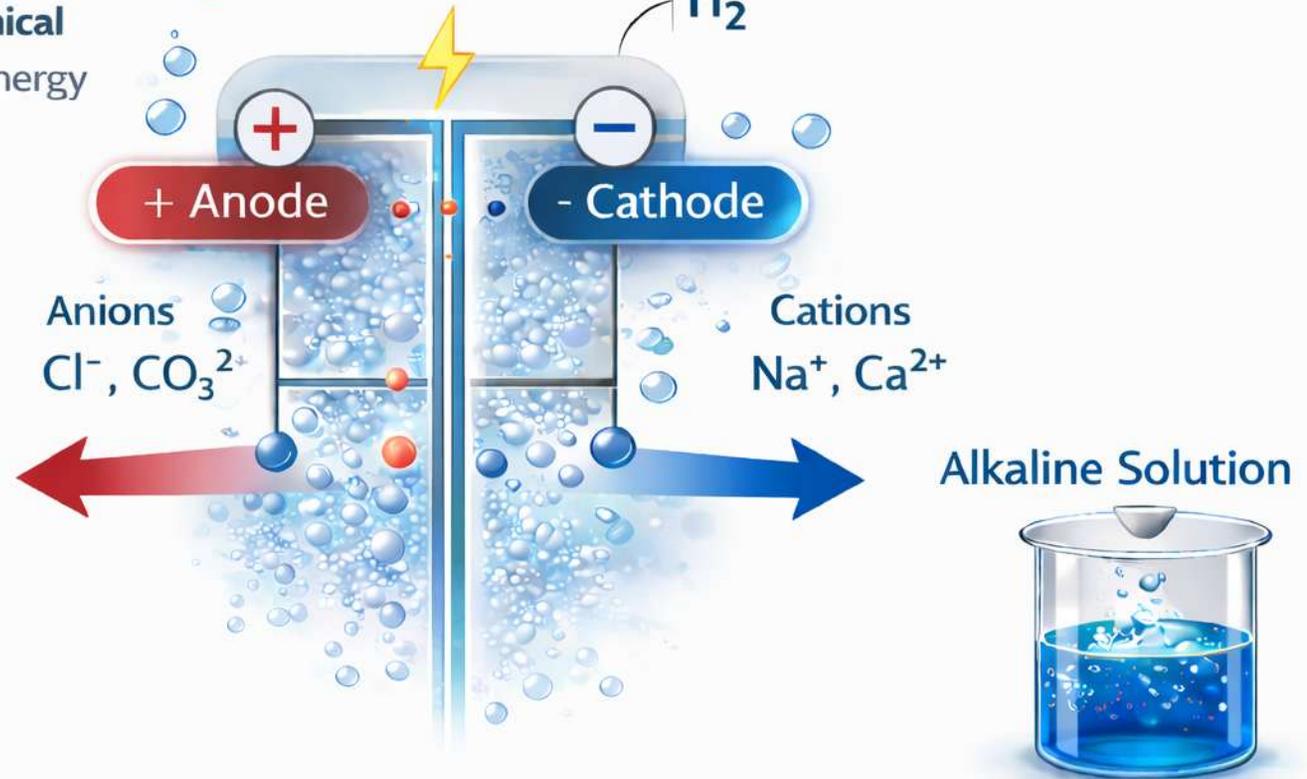


The electrochemically generated oxidizing ions exist in dissolved form and move with water molecules through biological aquaporin channels. This ionic transport mechanism allows rapid penetration into microbial cells and biofilms, improving antimicrobial effectiveness compared with conventional disinfectants.

# Electrolysis of Water

## ELECTROLYSIS OF WATER

Electrolysis is an **electrochemical** process by which electrical energy is used to promote chemical reactions in a conducting solution with electrodes, producing functional water with distinct properties.



$\text{pK}_a = 2.4$   
 $\text{pH} = 2.4$



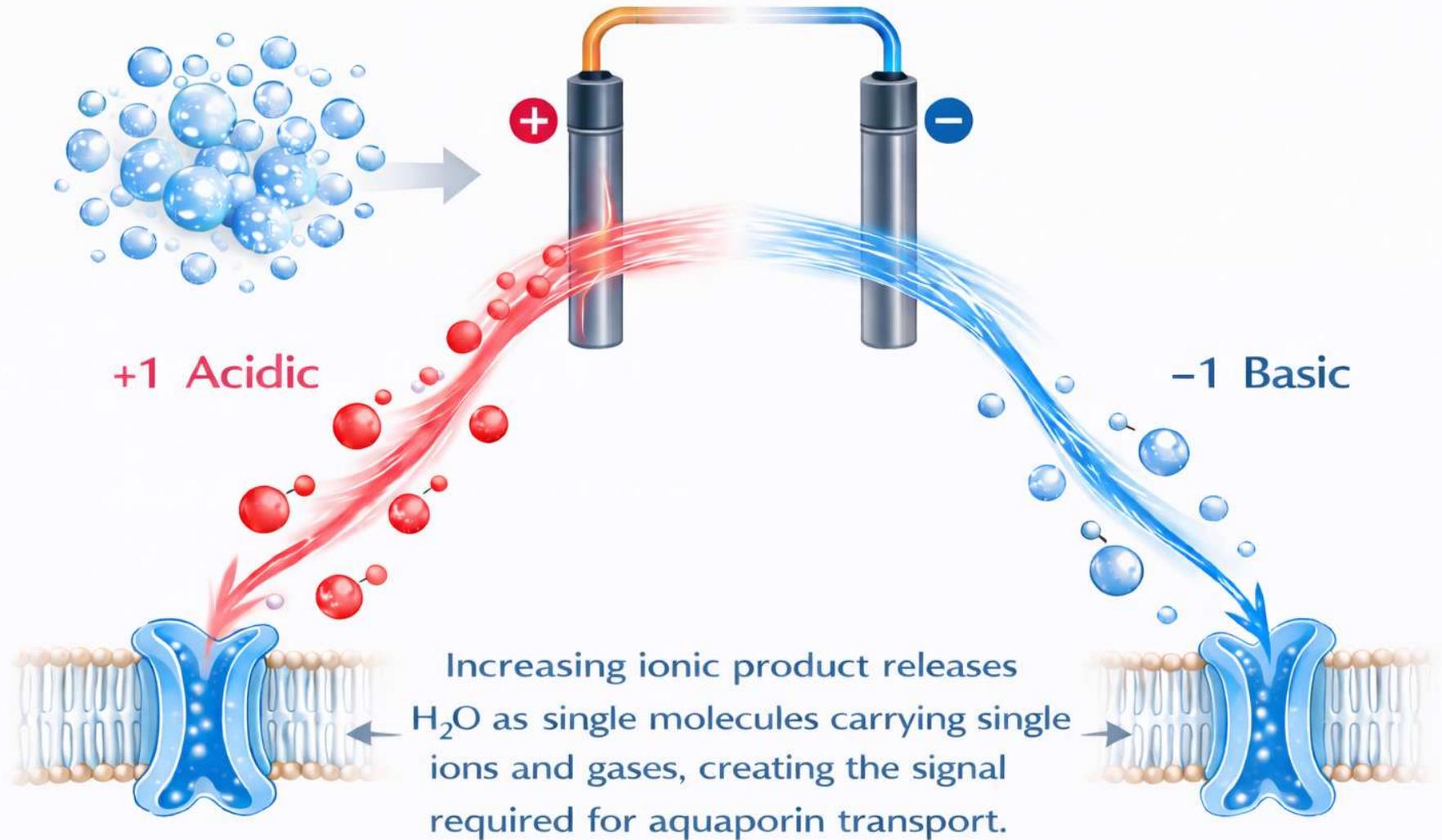
$\text{pK}_w = 7.0$ ,  $\text{pH} = 7.0$



$\text{pK}_b = 11.8$   
 $\text{pH} = 11.8$

Slide 24 — Increase Ionic Product, maximize delivery potential

## Increasing Ionic Product for Aquaporin Delivery



# Slide 25 — Advantages for AG Pesticide Products – Acidic Isolation with 6.45 Ionic Product – Optimize delivery

## Why Glyphosate Overuse Happens — and How to Fix It

### Typical Farm Mixing Water



- Glyphosate binds to minerals
- Leaf burn, poor absorption
- Incomplete plant kill

- Glyphosate binds to minerals
- Leaf burn, poor absorption
- Incomplete plant kill

**5x**  
LABEL RATE

**3x**  
SPRAY CYCLES

**\$**  
HIGHER COST

### Dual Polarity Electrochemistry



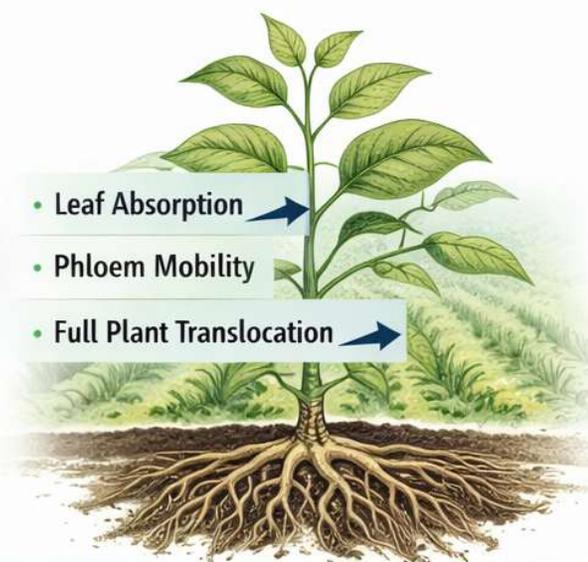
Molecular Separation

Stabilized Ionic Water

### BONUS

- pH 11.8 Alkaline Cleaner
- Neutralizes Pesticide Residues
- Safer Tank Maintenance

### Optimized Glyphosate Delivery



- Leaf Absorption
- Phloem Mobility
- Full Plant Translocation
- 1 Application Instead of 3
- Label-Rate Dosage
- Longer Weed Control
- Lower Environmental Impact



Example of a well known and worldwide used product. Change the medium for mixing, change the game

### System Advantages



#### On-site Generation

Produces solutions directly at the point of use



#### Reduced HazMat Transport

Minimizes the need to transport and store hazardous chemicals



#### Lower Environmental Impact

Decreases the carbon footprint and reduces chemical waste



#### Rapid Antimicrobial Action

Kills harmful microorganisms quickly and effectively



This scalable electrochemical architecture transforms simple saline water into two functional chemical products.

## Application Areas

Food Safety Sanitation



Agricultural Pathogen Control



Industrial Surface Cleaning



Medical Sterilization



Porous Surface Disinfection



This process transforms simple saline water into two functional chemical products.

## Conclusion



High-amp electrochemical activation enables:

- ✓ efficient ionic separation
- ✓ controlled redox chemistry
- ✓ generation of oxidizing and reducing solutions



The electrochemically generated ionic oxidants are transported with water through aquaporin channels, enabling rapid penetration and enhanced antimicrobial activity.

This technology provides a dual-product electrochemical platform for sanitation and cleaning systems.

## Slide 29 — Continuing Optimization Advancements

### Continuing Optimization Advancements



Integration with Smart Control Systems



This PP is by: Paul E. Seaver PBSWC Inc. with a little help from AI, thanks for checking it out



# Advanced Energy Transfer

DISCOVER WATERS TRUE POTENTIAL

*By Palm Beach Springs Water Company*

ADVANCED POWER FROM ANOTHER WORLD

Membrane Separation with Electrolyte Injection is 1 of the many systems available through AET