A Case Study Evaluating Effluent Quality Following Chemical and Electrochemical Precipitation for Metals Removal from Acid Mine Drainage Water

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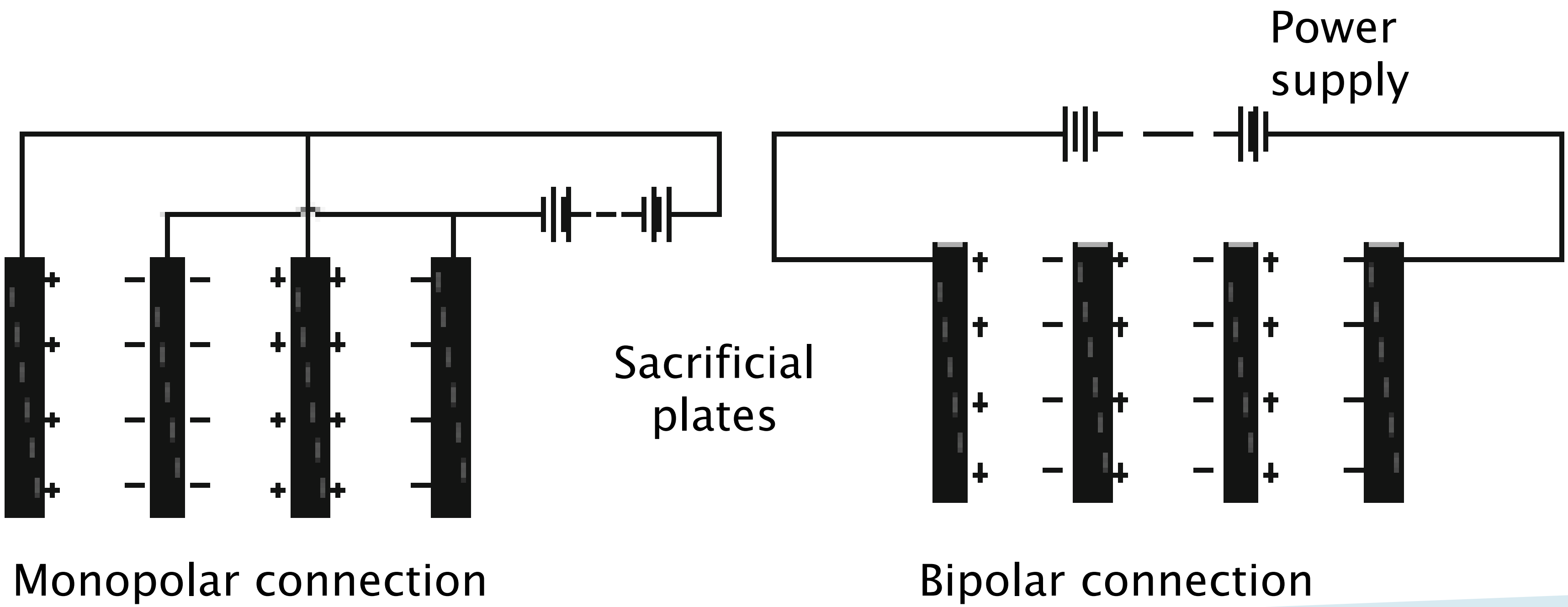
Overview

- What is electrocoagulation?
- History of electrocoagulation: Old technology with a new beginning
- Why is electrocoagulation important for our future?
- Comparison of conventional chemical precipitation and electrochemical precipitation for metals reductions.

Water treatment approaches

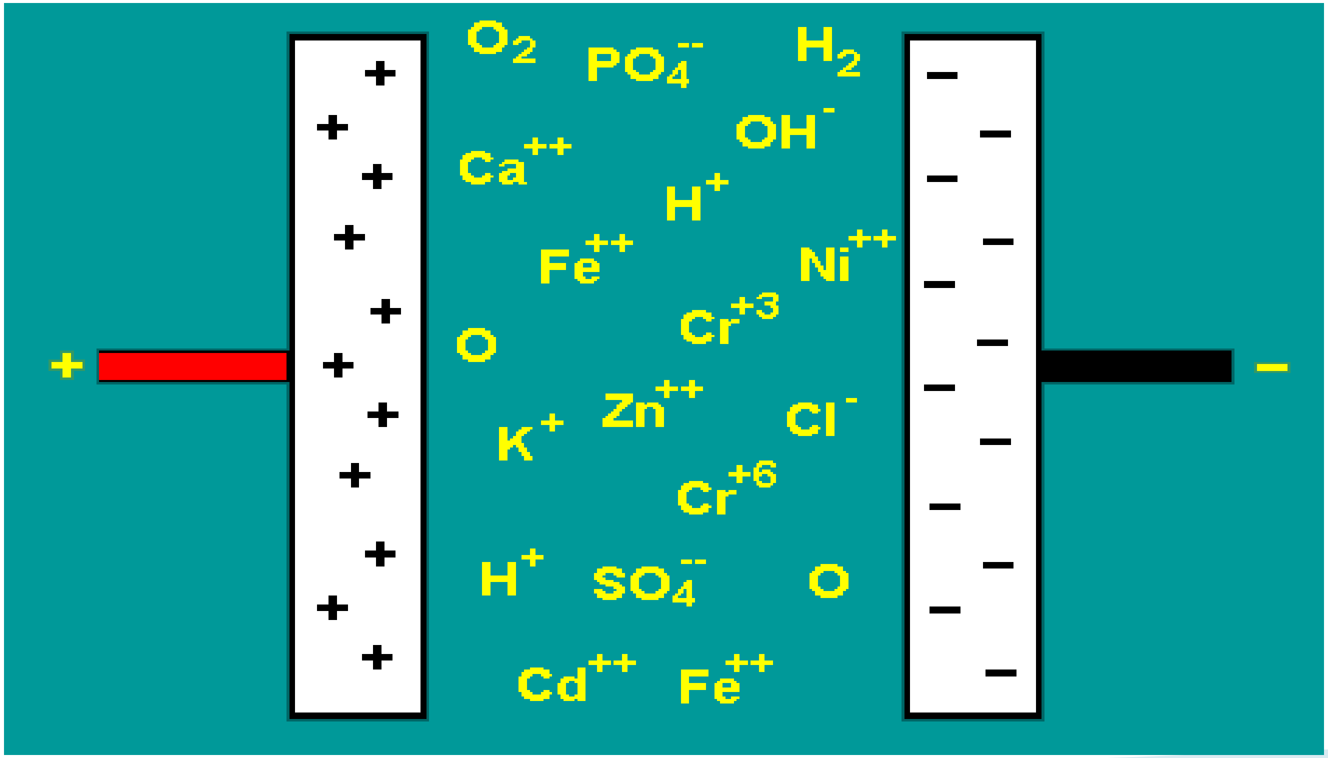
- Physical
- Biological
- Chemical
- Electrochemical

Electrochemical treatment cell



Huijuan Liu, Xu Zhao, and Jiuhui Qu. 2010.
Electrocoagulation in Water Treatment

Ion Reactions



Electrocoagulation History

- 1906 – Dieterich Patent
- Bilge Water Treatment
- 1980’s – Revival
- 1988 – Article in *Products Finishing* Magazine
- 2000’s – KASELCO Patents
- 2010 – Textbook describing the process
- 2010’s – Rapid expansion of companies in market

General Benefits

- Reduced treatment cost
- Reduced chemical usage
- Reduced sludge generation
- Simple operation
- Broad spectrum of treatment
- Cleaner effluent
  - Less salt in discharge
  - Lower concentration of contaminants

What about scalability?
Reactor Sizes & Capacities (Nominal)

- Sur-Flo Reactors
  - 2.5 GPM
  - 10 GPM
  - 25 GPM
  - Link Multiple Units (100 GPM)
- Hi-Flo Reactors
  - 25 GPM
  - 100 GPM
  - 200 GPM
  - 400 GPM
  - 600 GPM
  - 800 GPM
  - 1200 GPM

Fixed installations

Mobile installations

Why is electrocoagulation important for our future?

- Water reuse
- Dissolved solids become suspended solids
  - Therefore, physical separation is possible
- Limit chemical addition
- Removes a broad spectrum of industrial pollutants

Example applications

- Textile and Other Dyes
- Mixed Metals and Organics
- Oil & Grease
- Bacteria/solids – Sewage Plants
- Arsenic Removal
- Metals in Mine Water
- Plating Operations
- Die Casting
- Flowback/Produced water
- Desalination

Acid Mine Stream 1

Effluent Water Quality

Test	pH (S.U.)	Conductivity (µS/cm)
CaOH	6.92	1,661
NaOH	6.79	2,030
EC Test 1	7.75	1,535
EC Test 2	8.17	1,400

Conventional Chemical Treatment

Electrochemical Treatment

Constituent	Raw (mg/L)	CaOH (mg/L)	NaOH (mg/L)	EC Test 1 (mg/L)	EC Test 2 (mg/L)
Aluminum	57.4	<0.1	<0.1	0.103	<0.1
Arsenic	<0.02	<0.02	<0.02	<0.02	<0.02
Barium	<0.02	<0.02	<0.02	<0.02	<0.02
Boron	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01
Calcium	84.5	311	94.9	278	258
Chromium	0.0223	<0.02	<0.02	<0.02	<0.02
Copper	0.252	<0.02	<0.02	<0.02	<0.02
Iron	17.7	<0.2	<0.2	<0.2	<0.2
Lead	<0.02	<0.02	<0.02	<0.02	<0.02
Magnesium	60.6	48.5	65.6	32.5	28.9
Manganese	10.8	5.89	10	0.68	0.238
Molybdenum	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	1.02	0.144	0.955	<0.02	<0.02
Potassium	1.21	3.19	2.85	10.1	10.1
Selenium	<0.02	<0.02	<0.02	<0.02	<0.02
Silicon	23.6	2.98	8.63	<2	<2
Silver	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	3.05	4.0	243	3.62	3.42
Strontium	0.315	0.402	0.316	0.364	0.339
Zinc	1.71	<0.05	0.5	<0.05	<0.05

Acid Mine Stream 2

Effluent Water Quality

Test	pH (S.U.)	Conductivity (μS/cm)
CaOH	6.96	2,050
NaOH	7.07	2,200
EC Test 1	8.07	1,881
EC Test 2	8.16	1,610

Conventional Chemical Treatment

Electrochemical Treatment

Constituent	Raw (mg/L)	CaOH (mg/L)	NaOH (mg/L)	EC Test 1 (mg/L)	EC Test 2 (mg/L)
Aluminum	42.1	<0.1	<0.1	<0.1	<0.1
Arsenic	<0.02	<0.02	<0.02	<0.02	<0.02
Barium	<0.02	<0.02	<0.02	<0.02	<0.02
Boron	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01
Calcium	120	248	139	229	221
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02
Copper	0.129	<0.02	<0.02	<0.02	<0.02
Iron	1.42	<0.2	<0.2	<0.2	<0.2
Lead	<0.02	<0.02	<0.02	<0.02	<0.02
Magnesium	80.6	84.5	85.5	62.1	28.8
Manganese	24.6	23.6	23.2	4.1	0.53
Molybdenum	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	1.21	0.991	0.969	<0.02	<0.02
Potassium	3.94	9.38	5.55	7.67	12.4
Selenium	<0.02	<0.02	<0.02	<0.02	<0.02
Silicon	15.6	4.6	4.59	<2	<2
Silver	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	16.5	18.3	162	18.7	14
Strontium	0.35	0.396	0.347	0.403	0.329
Zinc	2.01	0.285	0.281	<0.05	<0.05

Summary

- Calcium and sodium hydroxide chemical precipitation will reduce aluminum and iron concentrations in acid mine drainage water.
- Conventional chemical treatment has limited success for reducing additional metals at a neutral pH range.
- Calcium hydroxide paired with EC will reduce aluminum and iron to low level detection limits; additional metal reductions in magnesium, manganese, nickel, silicon, and zinc.
- Calcium hydroxide and EC provides lower conductivity effluent water compared to conventional chemical metal precipitation.
- Calcium hydroxide and EC does not require the addition of salts for metals precipitation.