

Emerging Water & Wastewater Treatment Technologies

Electrocoagulation (EC)

Deer Creek State Park Lodge &
Convention Center
Mount Sterling, Ohio

August 3, 2016



Lagoon Logistics, LLC



Electrocoagulation



Powell Water 50 GPM Unit



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Electrocoagulation

Wastewater Applications

- Industrial Wastewater
 - Aquaculture
 - Cooling Tower
 - Food Processing
 - Production Water
 - Plating
 - Frac Flowback Water
- Agricultural Wastewater
 - Dairies
 - Slaughterhouses
- Mining Wastewater
 - Colloidal Material
 - Heavy Metals
- Municipal
 - Ammonia Removal
 - Phosphorus
 - Disinfection
 - Pharmaceuticals
 - Viruses

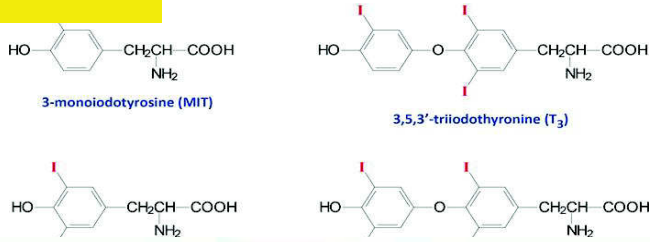


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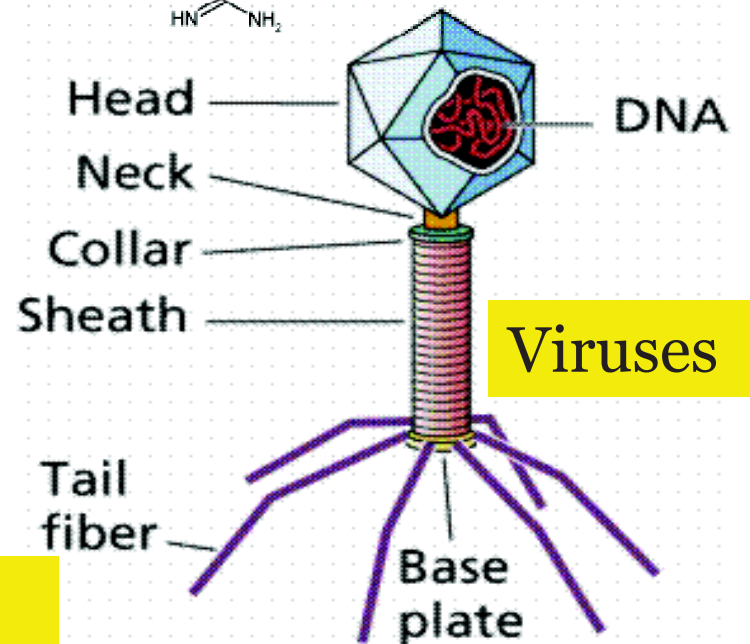
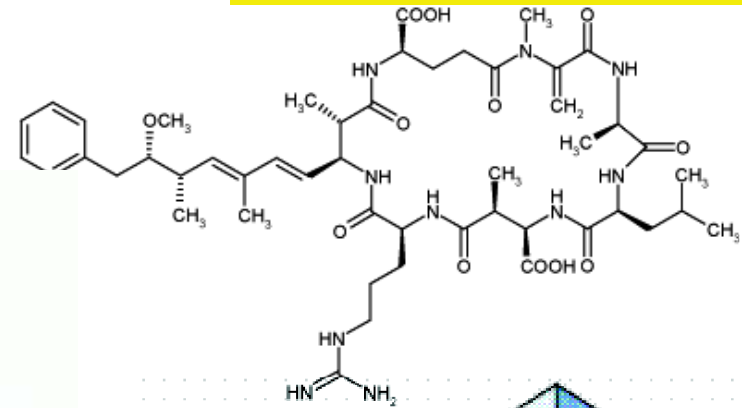


Electrocoagulation Water Applications

Hormones



Microcystin LR



Radiation



Powell Water Electrocoagulation System Components



Reaction Chamber

Power Source

Outlet

PLC

Intake

Metal Skid



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- **Plates** are placed vertically within the **patented** reaction chamber
- Direct **current** is applied to the **first and last blade**
- Untreated water is introduced into the bottom of the chamber
- Water is dispersed **evenly** as it **moves upward** through the blades
- **Water conducts electricity throughout** the chamber



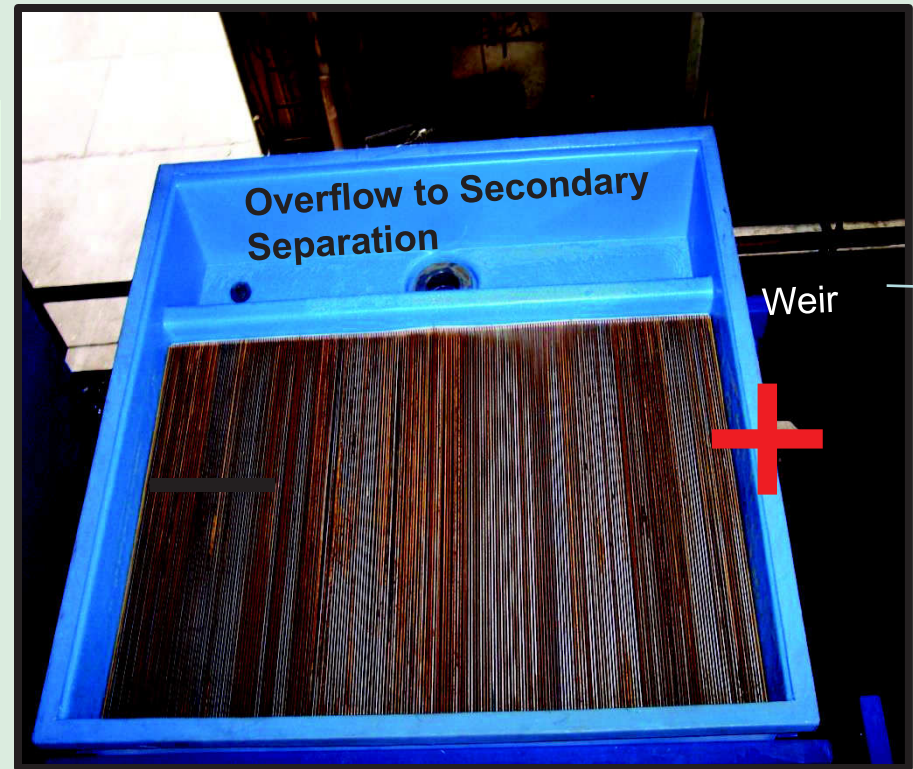
Treated Water Sample



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- Metal **blades react** to the **current** by **releasing charged metal ions**
- **This electron flooded** water **neutralizes** charged **particles**, making constituents **coagulate** and thus separable (**precipitate**)
- Electron flooded / treated **water overflows** to **secondary separation** such as lamella or other clarifiers
- Heavy **metals precipitate** into acid-resistant **oxide** sludge that passes the Toxic Classification Leaching Procedure (TCLP), making the sludge **non-hazardous**



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Sludge Comparison

Sludge from Powell Water EC:

- Is in the pH 6-7 range
- metals in non-hazardous form as oxides
- does not leach at ambient landfill pH
- passes EPA TCLP and California Title 22 STLC and TTLC leach tests
- 83% less solids than lime softening per EPA
- hydrophobic – 76% improvement infiltration rate

Sludge from Chemical Coagulation:

- is in caustic pH range
- metals in form of hydroxides
- metals can become soluble in the neutral pH range – leaching potential
- Large volumes
- Hydrophilic – difficult to dewater



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EC Handles mixed waste streams at the same time (colloids + metals + FOG + TSS, BOD, bacteria, viruses, endocrine disrupters, pharmaceuticals, cyanotoxins, etc.)



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ELECTROCOAGULATION - EC

Removal Mechanisms

Fe (or Al) ions AND electrons are introduced into the aqueous solution

- **Oxidation/reduction reactions**
- **Emulsion breaking** - FOG
- **Halogen complexing** – Pesticides, Herbicides
- **Bleaching by oxygen ions** - dyes, cyanides, bacteria, viruses, endocrine disruptors, biohazards, etc.
- **Seeding** – Complex metal ions
- **Electron flooding** - bacteria, cysts, and viruses



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Powell Water EC Optimization

Controlled by:

- **Blade type**
- **Amperage density**
- **Voltage**
- **Flow rate**
- **Process time (residence)**
- **Conductivity of water**
- **pH**
- **Filtration technique**



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EC Does ...

- **Efficiently remove constituents between 2nd and 17th column on periodic chart**
- **Not use a large quantity of electricity**
 - **Typically 2-7 kWh/1,000 gallons**
- **Not require clean power**
 - **Only low voltage PLC and computer requires uninterrupted power source (UPS)**
 - **battery can be used**
 - **Easier to operate in countries with poor electric grid**



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Microsystin LR – Celina, OH



67.1 ug/l Raw Sample
2.2 ug/l EC Treated

Municipal Sewage from POTW Discharge Water:

<u>(002-156)</u>	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
BOD (mg / l)	1,050	14	99% +
TSS (mg / l)	4,620	7	99% +
Bacteria (cfu)	110,000,000	2,700	99% +
<u>(002-187)</u>	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
BOD (mg / l)	500	19	96%
TSS (mg / l)	3,245	14	99% +
<u>(006-646)</u>	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
BOD (mg / l)	3,345	510	84%
TSS (mg / l)	16,500	165	99%
Volatile Solids	12,300	126	99%



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Vanderbilt Study

Municipal Sewage from POTW Discharge Water:

	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
COD	490	26	94.7%
Suspended Solids	73	7	90.4%
Total Hardness	127	11	91.3%
Alkalinity	267	11	95.8%
pH	6.88	7.02	
BOD₅	220	9	95.9%
Coliform	318,000/ml	0	99% +
Phosphates	38	0	99% +



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Wastewater Facility
Hydro, OK



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Food Processing Industry: Chicken Processing Plant

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>%Removal</u>
BOD₅ (Total)	4,328	480	89%
BOD₅ (Soluble)	303	39	87%
TSS	3,367	83	97%



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Food Processing Industry: Fish Processing and Packaging Plant

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>% Removal</u>
BOD₅	40,500	750	98.1%
TSS	33,667	107	99.7%
FOG	3,047	12.1	99.7%



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Salmon Farm - Chile



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Food Processing Industry: Salad Dressing Production Plant Water

	<u>Raw (mg / l)</u>	<u>Treated</u>	<u>% Removal</u>
BOD₅	8,223	752	91.0%
TSS	14,528	86	99.4%
FOG	18,165	28	99.8%



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Metal Plating Client MO



<u>Analyte</u>	<u>(mg/l)</u>	<u>Raw</u>	<u>Post EC</u>	<u>% Reduction</u>
Chromium (Cr) Total		37.9	0.10	99+
Chromium (Cr) hex		21.0	<0.05	99+
Zinc (Zn)		18.1	0.16	99+

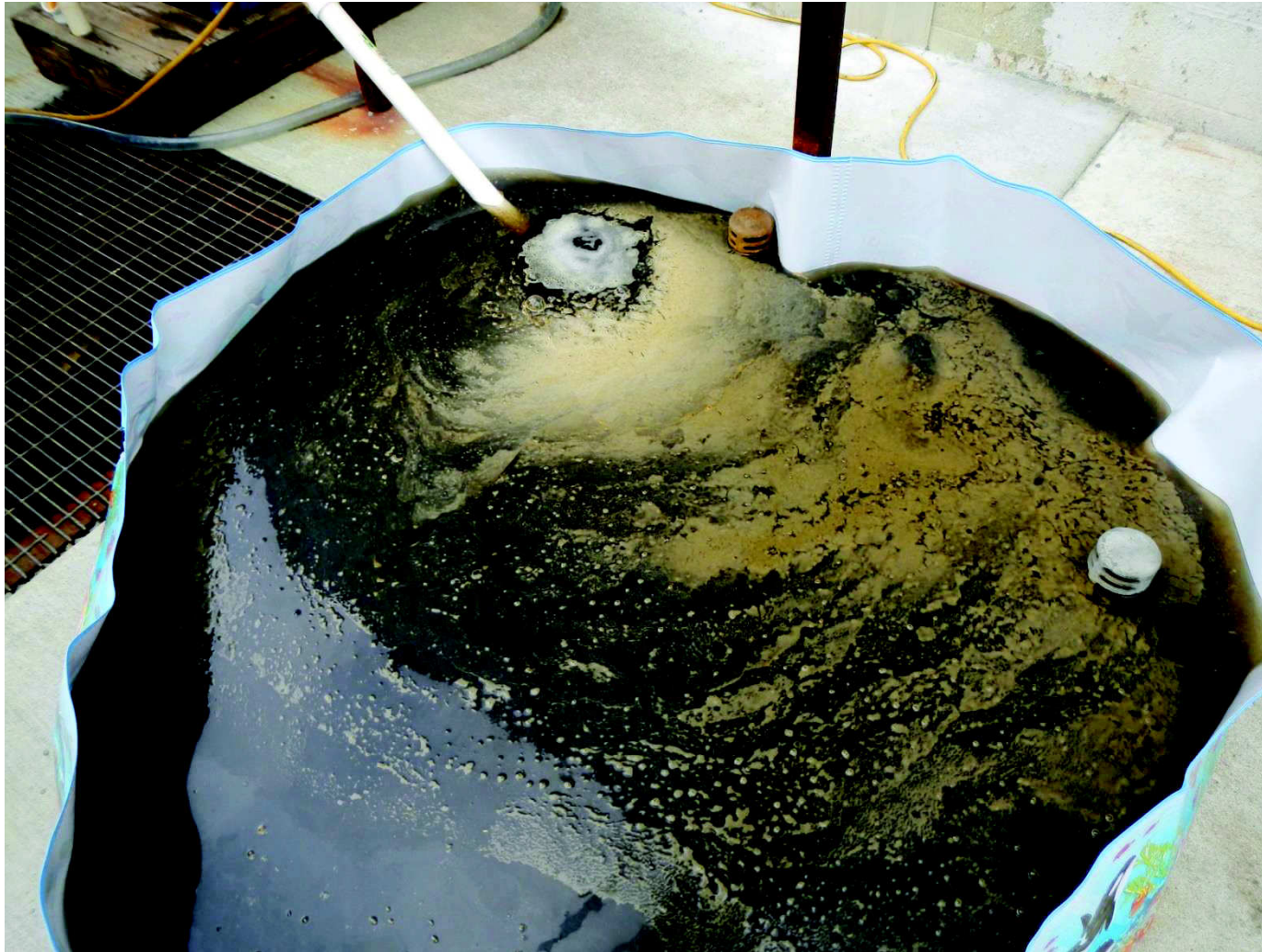
3 gpm EC Operation



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Treated Effluent



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Successful Result



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Results – Lead & Other Metals

Lead mining operation client in Missouri.

Results in ug/L

<u>Analyte</u>	<u>Raw</u>	<u>Post EC</u>	<u>% Reduction</u>
Cadmium (Cd) Total	36	0.15	99+
Copper (Cu) Total	3	ND	99+
Lead (Pb) Total	1,285	0.64	99+
Zinc (Zn) Total	6,675	13.0	99+



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Mining Results: Minute Constituent Removal (3 different mines)

<u>Constituent</u>	<u>Raw</u>	<u>Post EC</u>	<u>% Removal</u>
	mg/L	mg/L	
Copper	0.0068	<0.0019	72
Zinc	0.42	<0.001	99+
Cadmium	0.00392	<0.00006	98
Lead	0.00732	<0.00003	99+
Silver	<0.00003	<0.00003	
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Zinc	0.15	<0.001	99+
Cadmium	0.00082	<0.00006	93
Lead	0.00171	<0.00003	98
Copper	0.798	0.002	99 +
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Cadmium	0.1252	0.004	96.8
Lead	0.59	0.0032	99 +
Silver	0.0081	0.0006	92.6

Biologicals			
Contaminant	Before	After	% Removal
Bacteria	110,000,000 cfu	2,700 cfu	99+
Coliform	318,000,000 cfu	ND (<1) cfu	99+
E. coli	>2,419.2 mpn	ND (<0.01) mpn	99+
Enterococcus	83 mpn	ND (<10) mpn	82
Total Coliform	>2,419.2 mpn	ND (<0.1) mpn	99+

Dyes			
Contaminant	Before (NTU)	After (NTU)	% Removal
Ref. 006-691	125.1	12.1	90
Ref. 006-692	129.4	2.2	98
Ref. 006-854	68.30	0.68	99+
Ref. 006-851	2,340	4.5	99+

Hydrocarbons			
Contaminant	Before (mg/l)	After (mg/l)	% Removal
Benzene	90.1	0.3590	99+
Ethyl Benzene	428	0.372	99+
MP-Xylene	41.6	0.057	99+
MTBE	21.58	0.0462	99+
O-Xylene	191	0.416	99+
PCB	0.0007	ND (<0.0001)	85
Petroleum Hydrocarbons	72.5	ND (<0.2)	99+
Toluene	28,480	0.227	99+

Nutrients			
Contaminant	Before (mg/l)	After (mg/l)	% Removal
Ammonia	49	19.4	60
Nitrate	11.7	2.6	77
Nitrite	21	12	42
Nitrogen TKN	1,118.88	59.08	94
Phosphate	28	ND (0.2)	99+
Potassium	200	110	45
Sulfate	104	68	34

Pesticides			
Contaminant	Before (mg/l)	After (mg/l)	% Removal
Aldrin	0.063	ND (0.001)	98
Chlorpyrifos	5.87	ND (0.03)	99+
Cypermethrin	1.3	0.07	94
DDT	0.261	0.002	99+
Diazinon	34	0.21	99+
Lindane	0.143	ND (0.001)	99+
Propetamphos	80.87	0.36	99+

Metals / Minerals			
Contaminant	Before (mg/l)	After (mg/l)	% Removal
Aluminum	224	ND (0.7)	99+
Arsenic	0.076	ND (<0.002)	97
Barium	0.014	ND (<0.001)	93
Boron	4.86	1.41	70
Cadmium	0.125	ND (<0.004)	96
Calcium	1,321	21.4	98
Chromium	139.	ND (<0.1)	99+
Cobalt	0.1238	0.0214	82
Copper	0.7984	ND (<0.0020)	99+
Cyanide (free)	723	ND (<0.02)	99+
Fluoride	1.1	0.415	62
Gold	5.72	1.38	75
Iron	68.34	0.19	99+
Lead	0.59	0.0032	99+
Magnesium	13.15	0.04	99+
Manganese	1.061	0.018	98
Mercury	0.72	ND (<0.003)	98
Molybdenum	0.35	0.029	91
Nickel	183	0.07	99+
Platinum	4.4	0.68	84
Selenium	68	38	44
Silicon	21.07	ND (0.10)	99+
Silver	0.0081	0.0006	92
Tin	0.213	ND (<0.020)	90
Vanadium	0.262	ND (<0.002)	99+
Zinc	221	0.140	99+

Organics			
Contaminant	Before (mg/l)	After (mg/l)	% Removal
BOD ₅	1,050	14	98
NTU	35.38	0.32	99+
TSS	1,560	8	99+

Radioisotopes			
Contaminant	Before	After	% Removal
Americium-241	71.99 pCi/l	0.57 pCi/l	99+
Plutonium-239	29.85 pCi/l	0.29 pCi/l	99+
Radium	1093 pCi/l	0.10 pCi/l	99+
Uranium	0.13 mg/l	0.0002 mg/l	99+

Abbreviations

mg/l = milligrams per liter or parts per million
pCi/l = picocuries per liter
cfu = colony forming unit
mpn = most probable number
NTU = nephelometric turbidity units
ND = not detectable at the reporting limit

THANK YOU!

Local Ohio Powell Water Representative

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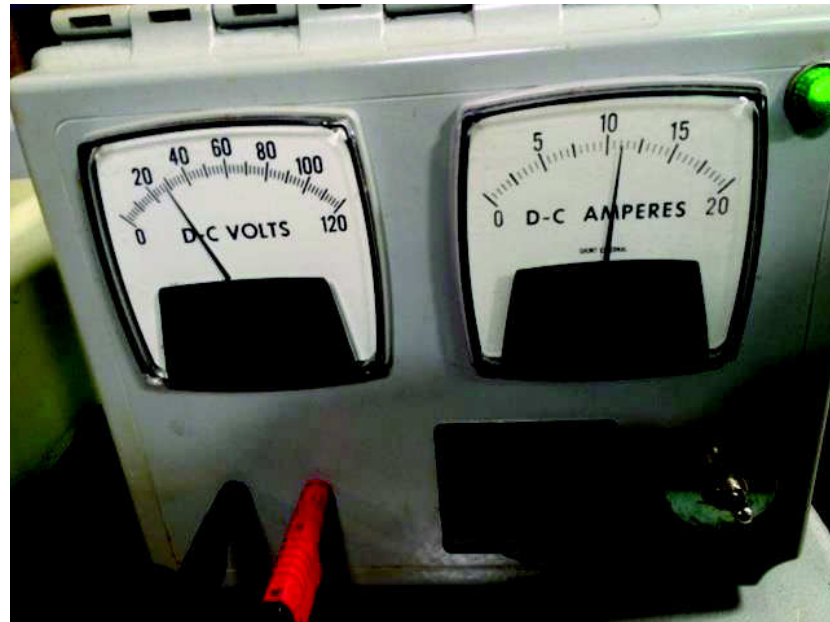
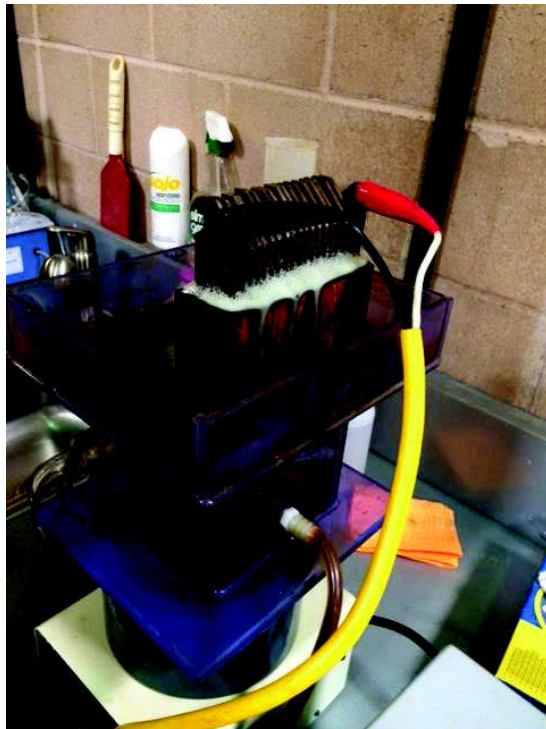
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Electrocoagulation Demo



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