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The Electrocoagulation Process

The Process

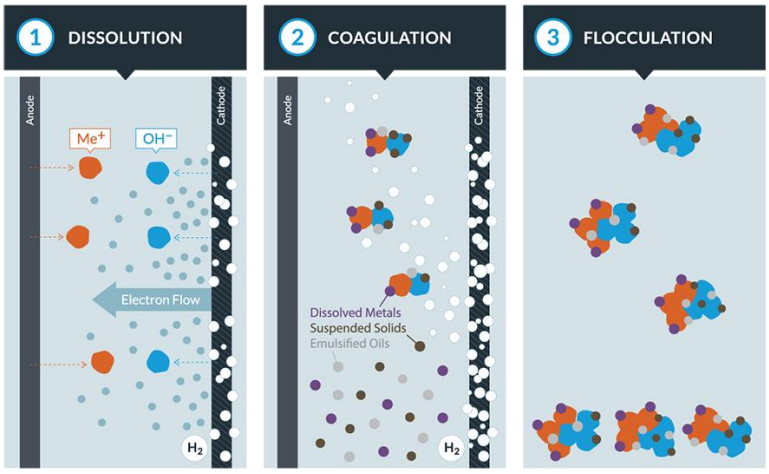
The process is based on the principle of introducing an electric current to various types of electrode/s generating positive ions in an energetic environment that reacts with negative charged species in the water. Correspondingly, positive charged contaminants are destabilized and react with negative charged ions in the reaction chamber (electro-coagulation cell).

The process is applicable in the removal of a diverse range of contaminants. The technology is largely interference free and operates across a broad range of pH (4-9) and conductivity (salinity) solutions. The products of reaction are discharged as a stable and inert flock, that coagulates, then precipitates in solution and easily removed.

Electrocoagulation Technology is the process of destabilizing suspended, emulsified or dissolved contaminants in an aqueous medium by introducing an electrical current into the medium. The electrical current provides the electromotive force to drive the chemical reactions. When reactions are driven or forced, the elements or compounds will approach the most stable state. Generally, this state of stability produces a solid that is either less colloidal and less emulsified (or soluble) than the compound at equilibrium values. As this occurs, the contaminants form hydrophobic entities that precipitate out and can be easily removed by a number of secondary separation techniques.

Stated another way:
"Electrocoagulation Technology utilizes direct current to cause sacrificial electrode ions to remove undesirable contaminants either by chemical reaction and precipitation or by causing colloidal materials to coalesce and then be removed by electrolytic flotation. The electrochemical system has proven to be able to cope with a variety of wastewaters. These waters are paper pulp mill waste, metal plating, tanneries, canning factories, steel mill effluent, slaughterhouses, chromate, lead and mercury-laden effluents, as well as domestic sewage. These wastewaters will be reduced to clear, clean, odourless and reusable water. In most cases, more especially domestic sewage, the treated water effluent will be better than the raw water from which it had originated."

In the EC process, the electrical current is introduced into water via parallel plates constructed of various metals that are selected to optimize the removal process. The two most common plate materials are iron and aluminium. In accordance with Faraday's Law, metal ions will be split off or sacrificed into the liquid medium. These metal ions tend to form metal oxides that electromechanically attract to the contaminants that have been destabilized.



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Electrocoagulation: Application and Benefits

Electrocoagulation is the distinct economic and environmental choice for meeting water treatment discharge standards and compliance requirements. Capital and operating costs are generally recovered by eliminating discharge fees and fines, harvesting resources, and significantly reducing water replacement costs.

SYSTEM CAPABILITIES:

- removes heavy metals as oxides that pass TCLP
- removes suspended and colloidal solids
- breaks oil emulsions in water
- removes fats, oil, and grease
- removes complex organics
- destroys & removes bacteria, viruses & cysts
- processes multiple contaminants

KEY APPLICATIONS:

- Textile and Dye Industry
- Ground water clean-up
- Process rinse and wash water
- Potable water
- Sewage treatment
- Cooling towers
- Radioactive isotope removal
- Pre-treatment for reverse osmosis, ultra-filtration, Nano filtration, photocatalytic
- Water reuse resulting in zero discharge
- Metal recovery
- Influent quality water control
- Industrial waste water

BENEFITS:

- Capital cost significantly less than alternative technologies
- Operating cost significantly less than alternative technologies
- Low power requirements
- Generally no chemical additions
- Metal oxide formation passing TCLP
- Low maintenance
- Minimal operator attention
- Handles a wide variation in the waste stream
- Consistent and reliable results
- Sludge minimization
- Treats multiple contaminants

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Electrocoagulation: General Capabilities

The following well documented lab and field tested results are routinely attained through electrocoagulation.

Operation	% Removal
BOD	90 +
TSS (Clay, Coal, Silt, etc.)	99 +
Fats, oil and Grease in Water	93 - 99 +
Water in sludge	50 - 80 +
Heavy Metal Removal	95 - 99 +
Phosphate Removal	93 +
Bacteria, Viruses & Cysts	99.99 +

SPECIFIC EXAMPLES

Contaminant	Source	Raw mg/L	Treated	% Removal
Aluminium	Can Mfg.	224.00	0.690	99.70 % +
Arsenic	Steam Cleaner	0.30	<0.010	96.70 % +
Barium	Steam Cleaner	8.00	<0.100	98.70 % +
Calcium	Cooling Tower	1,321.00	21.400	98.40 %
Cadmium	Electroplating	31.00	0.340	98.90 %
Chromium	Condenser Wash	139.00	<0.100	99.90 % +
Cobalt	Steam Cleaner	0.13	<0.050	62.00 % +
Copper	Electroplating	287.00	0.480	99.80 %
Iron	Acid Mine	151.00	0.570	99.60 %
Lead	Manufacturing	8.21	0.230	97.20 %
Magnesium	Ammunition Plant.	6.40	<0.100	98.50 %
Magnesium	Ammunition Plant.	0.29	0.050	83.20 %
Mercury	Steam Cleaner	0.01	<0.002	66.60 % +
Molybdenum	Steam Cleaner	0.18	0.040	80.60 %
Nickel	Manufacturing	185.00	0.200	99.90 %
Silicon	Acid Mine	21.70	0.100	99.50 %
Vanadium	Steam Cleaner	0.23	<0.010	95.60 % +
Zinc	Plating	221.00	0.140	99.90 %
BOD	Fish Process	40,500.00	750.000	98.10 %
TSS	Municipal POTW	5,620.00	25.000	99.60 %
FOG	Food Process	18,165.00	28.000	99.90 % +
Bacteria	Municipal POTW	110MM	2,200.000	99.99 % +

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Operational Cost Comparison

An example, taken from an extensive US document on electrocoagulation, hence the imperial units, is an EC system with operational requirements of:

- Reduce Ni from 25 to < 2.38 mg/L
- Reduce Cr from 210 to < 1.71 mg/L
- Flow rate of 100 GPM (30,000,000 GPY)

Operating Cost	Chemical Coagulation	Electrocoagulation
Per 1,000 gallons	$14.18	$1.69
Per year	$425,400.00	$50,700.00

The estimated yearly operating cost saving using electrocoagulation in place of chemical coagulation is $374,700 per year. This does not include labour, transportation or disposal costs.

Chemical precipitation in wastewater treatment involves the addition of chemicals to alter the physical state of dissolved and suspended solids and to facilitate their removal by sedimentation. The chemicals used in wastewater treatment include Alum, Ferric Chloride, Ferric Sulphate, Ferrous Sulphate, and Lime.

The inherent disadvantages associated with most chemical unit processes (activated carbon adsorption is an exception) is that they are additive processes. (Metcalf & Eddy, Wastewater Engineering Treatment Disposal Reuse, Third Edition, page 301- 303). This problem is eliminated in the electrocoagulation process. These chemicals are not only expensive, but, more importantly, the net increase in the dissolved constituents in the wastewater render it impractical or impossible to reuse.

Electrocoagulation uses electricity to precipitate dissolved and suspended solids. The total dissolved solids in the liquid usually decrease by 27 to 60 percent. This enables the water to be reused in many applications, such as steam cleaning operations. Reuse of the water provides a major advantage because this eliminates all EPA and POTW discharge concerns, to say nothing of the replacement costs of the water itself.

Electrocoagulation produces a cleaner water than either chemical precipitation or sedimentation (Wastewater Engineering, page 488). As discharge requirements become more stringent, electrocoagulation will become essential.