Wastewater Made Clear with Green Technology

Presentation - Wastewater Made Clear with Green Technology

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Introduction

Electrocoagulation (EC) is the scientific discipline of utilizing electricity as the electromotive force to drive chemical reactions in a solution, suspension, or emulsion. A special form of direct current is introduced into the aqueous stream as it passes between predetermined electrodes in the electrocoagulation module. This energy from the electricity is the engine or driving force to shift the equilibrium of a reaction to less than equilibrium levels, thus providing a mechanism for removing dissolved, suspended or emulsified molecules, elements or ions to very minute levels in an aqueous stream.

Background

Electrochemical treatment can precipitate dissolved heavy metals by a combination of oxidation reduction reaction that in many cases produces oxide crystals that are very stable. Hexavalent chromium is reduced to trivalent chromium and removed as a precipitate. Copper, Lead, Zinc, Nickel and other metals are oxidized into oxide crystal form and can sometimes be concentrated and removed from the sludge stream to be recycled. Some metals require an anion to be present to form a precipitate such as calcium, magnesium, molybdenum, and others. Many times this anion may already be present in the waste stream, but if not, it can generally be added very easily. These heavy metallic crystals can be a positive nucleus to attract the electron rich hydroxide floc and colloidal solids into a settleable precipitate. This precipitate can then be separated in a settling pond or in a clarifier after some of the heavy metals are classified and concentrated.

Electrocoagulation will break colloidal suspensions, which allows the precipitation and removal of suspended particles. The excess of electrons causes the colloidal particles to attract to a sacrificed metallic cation, which comes from the electrodes as the electric current passes through the electrode in accordance with Faraday's Law. This metallic cation acts as a nucleus to attract the electron laden colloidal particles together into a floc precipitate. This generates a larger heavier floc, which can then be separated by a secondary separation process such as settling, clarification or centrifugation.

Electrocoagulation will break oil emulsions and release the tied up emulsified oil to float to the surface where it can be skimmed off with a vacuum and recovered if viable. Oil becomes emulsified as shearing action from pumps or chemicals cause an open or broken bond in the hydrocarbon chain, which then attaches itself with a weak bond to the water molecule. Even though this is a weak bond, it is a protected bond and consequently very difficult to break by conventional means. As the electricity passes through the water being treated, electrons and energy are available as well as hydrogen ions or protons from the electrolysis of the water itself, and oxygen or hydroxide ions as a chemical feed stock for reaction completion. These subsequent reactions cause the weak bond to be broken and the oils to return to being a complete molecule and the emulsion is broken. At this point the oil again becomes hydrophobic and generally floats to the surface due to differences in specific gravity.

The Process

Electrochemical treatment is generally used on industrial waste streams to allow the reuse or discharge of an industrial waste stream. The process uses electricity rather than expensive, dangerous, and sometimes toxic chemicals to remove contaminants. Electrochemical treatment can be a pretreatment for other processes such as reverse osmosis, or a polish treatment for traditional treatment processes.

How Does EC Technology Work?
Electrocoagulation is the process of destabilizing suspended, emulsified or dissolved contaminants in aqueous medium by introducing a direct electrical current into the medium. The electrical current provides 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 or less emulsified (or soluble) than the compound at equilibrium values. As this occurs, the contaminants form hydrophobic entities that precipitate and can easily be removed by a number of secondary separation techniques. Electrocoagulation neutralizes ions and particle charges, thereby allowing contaminants to precipitate. Colloids are then destabilized and aggregated and subsequently removed by sedimentation or filtration.

Under current wastewater treatment methods, a cocktail of chemicals is needed to treat large amounts of wastewater producing increased amounts of solids, which increase production costs and can create environmental problems when they are ultimately disposed. The negative impact on the environment is high using existing treatment methods.

Electrocoagulation can often neutralize ions and particle charges, thereby allowing contaminants to precipitate. Colloids can be destabilized and aggregated and subsequently be removed by sedimentation or filtration. The amount of solids is substantially much less and environmentally friendly.

This technology has been proven as one the most effective methods to treat large amounts of wastewater. The range of treatment is between 300 liters/hour to 600,000 liters/hour, depending on the site-specific requirements.

For a range of wastewater treatment needs, electrocoagulation technology is a viable option. The technology itself has been successfully used for decades. The need for increased usage now is to help preserve and reuse our natural water resources. Droughts, natural disasters, municipal water needs and shale gas recovery will continue to put increased strain on our water resources and existing treatment facilities.

For states in the western United States, electrocoagulation technology has had positive environmental impact while solving many existing concerns of wastewater and frack fluid treatment. States such as Texas, Wyoming and Colorado have successfully used EC technology for the treatment of a wide-range of industrial wastewater – including frack water.

Results

Analytical testing has been done on a wide range of waste streams including municipal water, animal/dairy waste, and drilling/hydraulic fracturing fluids. The following table reflects some results on raw and EC treated water from a hydraulic fracturing site located in Texas.

Constituents	Units	Raw	Treated	% reduction
Calcium, Ca	mg/L	3,000	4.04	99.9
Magnesium, Mg	mg/L	637	0.78	99.9
Sodium, Na	mg/L	13,100	64.4	99.5
Potassium, K	mg/L	313	2.56	99.2
Iron, Fe (total)	mg/L	23	0.02	99.9
Bicarbonate, HCO_3	mg/L	490	20	95.9
Chloride, Cl	mg/L	28,000	97	99.7
Sulfate, SO_4	mg/L	141	0.404	99.7
Sulfide, S	mg/L	0.65	0.020	96.9
Boron, B	mg/L	19.8	1.91	90.4
Barium, Ba	mg/L	2.89	0.0032	99.9
Silica, SiO_2	mg/L	65.6	0.546	99.2
Strontium, Sr	mg/L	249	0.261	99.9
Totals (Sum)		46,042	171.93	99.6
Total Dissolved Solids	mg/L	53,400	202	99.6
Calculated Hardness,$CaCO_3$	mg/L	10,100	13.3	99.9
Total Alkalinity	mg/L	490	20	95.9
Sodium Chloride, (total)	mg/L	41,100	161.4	99.6
Sodium, Na (Calculated)	mg/L	13,100	64.4	99.5
pH		6.14	7.3	

Conclusions

Electrocoagulation is a technology that can be used in a variety of processes, is a "green" technology and may also produce beneficial by-products. Results indicate that water from a waste stream can be cleaned to most required discharge limits or reuse levels.

Acknowledgements

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Figure 1: The above picture was taken of an electrocoagulation system that was being used in a dam resurfacing project in Colorado.

Figure 2: The electrocoagulation system can be set up in remote areas or incorporated into an existing process.

Figure 3: The EC system was set up to treat water that had been used in the resurfacing of a dam. The water was recycled for reuse.

Figures 1, 2, and 3 were taken at the Homestake Dam, Colorado.