



## TREATMENT OF INDUSTRIAL EFFLUENT BY ELECTRO-COAGULATION METHOD

<sup>1</sup>Prasanna, N., <sup>2</sup>Manivasagan, V., <sup>2</sup>Pandidurai, S. & <sup>1</sup>Sundaram, T.T.

<sup>1</sup>Department of Chemistry, Adhiyamaan College of Engineering, Hosur – 635 109, Tamilnadu

<sup>2</sup>Department of Biotechnology, Adhiyamaan College of Engineering, Hosur – 635 109, Tamilnadu

### ABSTRACT

Electrocoagulation (EC) is becoming a popular and promising process to be used for the treatment of industrial effluent. The removal of COD from industrial effluent by EC using Aluminium and stainless steel electrode material was investigated in this paper. Several working parameters, such as current density, initial concentration of solution and operating time were studied in an attempt to achieve a higher removal capacity. The effluent is obtained from a pharmaceutical industry and the objective of the study is to reduce the COD before it is discharged into the water bodies. The results show that the effluent wastewater had a quality that exceeded the direct discharge standard. Aluminum and stainless steel electrodes were found to be effective in the reduction of COD. The removal efficiencies of COD were more than 90 %. In addition, the experimental results also show that the electro coagulation can neutralize pH of wastewater. A value of 7.33 pH was obtained through the experiment.

**KEYWORD** - Pharmaceutical effluent, electro coagulation, Aluminum, stainless steel

### INTRODUCTION

An increasing world population with growing industrial demands has led to the situation where the protection of the environment has become a major issue and crucial factor for the future development of industrial processes, which will have to meet the requirements of sustainable development. One of the major problems faced by human race today is to provide clean water to the vast majority of population all around the world. Electrocoagulation is a proven to treat waste water and remove most contaminants/pollutants from water (Aboulhassan *et al.*, 2006). It removes suspended solids, emulsified hydrocarbons and many dissolved organic compounds, heavy metals (including chromium, cadmium, gold, platinum, radio nuclides) and arsenic, bacteria, algae, larvae *etc.*, from water for re-use/discharge (Antoni Sanchez Ferrer *et al.*, 2003) The process may also be used to protect reverse osmosis elements, membrane filters, ion exchange columns from fouling. The process is continuous flow and is low in energy consumption (Balasubramanian *et al.*, 2005) with fresh water sources as rivers, canals and estuaries *etc.* limited and those available being polluted by indiscriminate discharge of industrial pollutants and other processes, making fresh water much cherished commodity now a days. The widening gap between demand and supply of water comes in the way of sustainable development. Recycling and reusing the waste water that leads to reduction of fresh water consumption and for treating difficult waste waters, there is an urgent need to develop innovative, more effective and inexpensive technique of waste water treatment (Balasubramanian *et al.*, 2011) Electrochemical treatment is one such technique which can either be used as main treatment scheme or as a hybrid technique. It can also be used as a pretreatment scheme for difficult waste waters for which feasible technologies are not available. Treatment of these waste

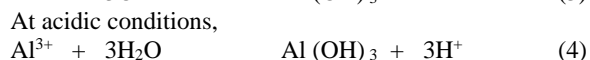
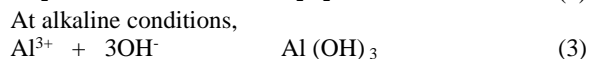
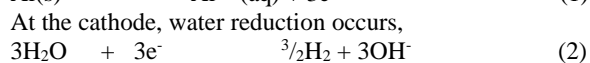
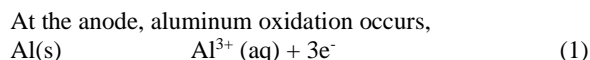
waters may require segregation of wastewater streams at source and pretreatment prior to addition to other wastewaters for treatment and disposal. Here, objective of the pre-treatment is to make the wastewater compatible for mixing with other wastewaters and to improve the treatability of the overall wastewater of the industrial unit. Pharmaceutical waste is one of the major complex and toxic industrial wastes. As mentioned earlier. It has been reported that because of the seasonal use of many products, production within a given pharmaceutical plant often varies throughout the year, which changes the characteristics of wastewater by season. Hence, it is difficult to generalize the characteristics of the effluent discharged from these industries (Chandra Moul *et al.*, 2014) Fermentation plants generally produce extremely strong and highly organic wastes, whereas synthetic organic chemical plants produce wastes that are strong, difficult to treat, and frequently inhibitory to biological systems (Roppola Katri, 2009). The production of antitoxins and vaccines by biological plants generates wastewater containing very high BOD (biochemical oxygen demand), COD (chemical oxygen demand), TS (total solids), colloidal solids, toxicity, and odor. Electrochemistry offers promising approaches for the prevention of pollution problems in the process industry. The inherent advantage is its environmental compatibility, due to the fact that the main reagent, the electron, is a 'clean reagent' (Mehmet Kobya, 2003). The strategies include both the treatment of effluents and waste and the development of new processes or products are less harmful effects, often denoted as process-integrated environmental protection.

Physical - primary methods are referred to physical or physical-chemical unit Operations (*e.g.*) filtration, adsorption, air flotation, flocculation and sedimentation.

Biological secondary referred to biological operations *e.g.* aerobic, anaerobic and activated sludge.

Chemical - advanced or tertiary referred to chemical or to combinations of all three *e.g.* Thermal oxidation (combustion), Chemical oxidation, Ion exchange, Chemical precipitation, incineration. The use of conventional water and wastewater treatment processes becomes increasingly challenged with the identification of more and more contaminants, rapid growth of population and industrial activities, and diminishing availability of water resources (Magdalena Vankova, 2011).

When aluminum is used,  $Al^{3+}$  ions are produced in water, which forms soluble monomeric and polymeric hydroxo-metal complexes. The main reactions occurring at electrodes during electrolysis are as follows:



Electrochemical reactions at the electrodes produce very fine  $H_2$  and  $O_2$  gas bubbles and highly chemically reactive hydroxyl  $OH^-$  and superoxide  $HO_2^-$  radicals. The gas bubbles promote the flotation of coagulated solids and coalesced hydrocarbons *etc.* The hydroxyl and superoxide radicals cause precipitation of hydroxides of heavy metals and breakdown of many soluble organic molecules. (Deshpande, A. M., Satyanarayan, S., 2011) Removal and destruction of pollutant species can be carried out directly or indirectly by electrochemical oxidation reduction processes in an electrochemical cell without continuous feed of redox chemicals (Stasinakis, A. S. 2008) In addition, the high selectivity of many electrochemical

processes helps to prevent the production of unwanted by-products, which in many cases have to be treated as waste.

### MATERIALS & METHODS

Raw effluent was collected from a pharmaceutical industry. The samples were checked for some initial parameters such as TSS, TDS, pH, BOD and COD and then treatment was done. The studies were exercised in a lab-scale batch system, which was composed of a 1000 ml electrolysis cell, a power supply, a magnetic stirrer.

#### Experimental Setup

Electro-coagulation reactor consists of an electrolytic cell with an anode and a cathode. Electrocoagulation cells consist of pairs of parallel metal plate electrodes separated by a few millimeters with a low voltage applied at high current densities. Oxidation will cause the anode material to undergo electrochemical corrosion, whereas the cathode will be subjected to passivation, when the cell is connected to an external power source. But, since electrodes with large surface area are required for a workable rate of metal dissolution, the afore-mentioned arrangement is generally not suitable for the treatment of pollutant liquid medium. This requirement can be satisfied by use of electrodes either in parallel or series connections. The conductive metal plates are commonly known as ‘sacrificial electrodes’. The sacrificial electrodes may be made up of the same or of different materials as anode. Electrical current was applied by a constant current voltage controlled DC Power Supply (Model L1606, Aplab) with maximum output current and voltage of 6 A and 16 V, respectively. Sodium chloride was used as a supporting electrolyte and the experiment was performed at ambient temperature of about  $25^\circ C - 27^\circ C$ . The reactor was placed on a magnetic stirring block in order to keep its contents well mixed during the experiment. The amount of metal dissolved is dependent on the quantity of electricity passed through the electrolytic solution.

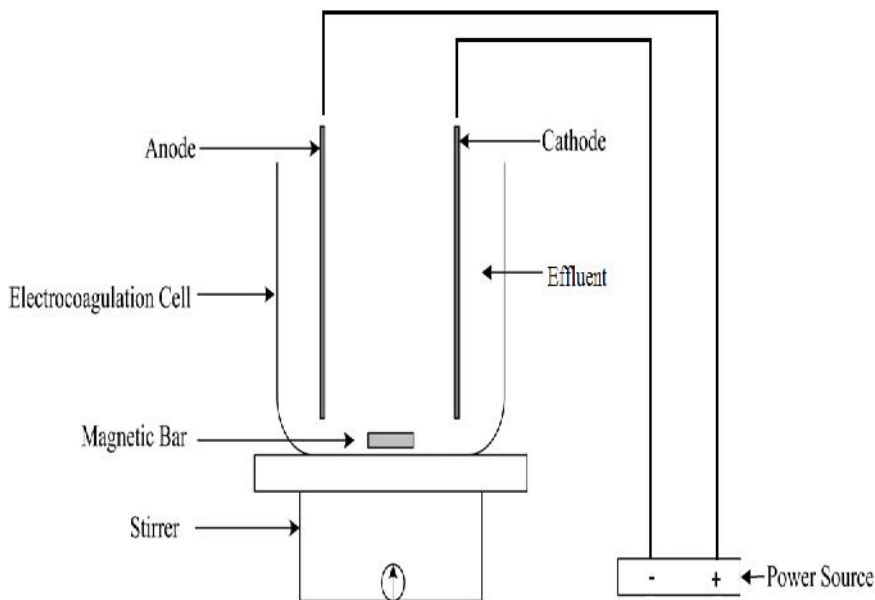


FIGURE 1: Schematic diagram of batch reactor

## ANALYSIS PERFORMED

### CHEMICAL OXYGEN DEMAND (COD)

In order to determine the extent of degradation of the effluent chemical oxygen demand (COD) was measured. The COD as the name implies is the oxygen requirement of a sample of oxidation for organic and inorganic matter. COD is generally considered as the oxygen equivalent of the amount of organic matter oxidizable by potassium dichromate. The organic matter of the sample was oxidized with a known excess of potassium dichromate in a 50% sulfuric acid solution. The excess dichromate was titrated with a standard solution of ferrous ammonium sulfate solution. COD of all samples were determined by the dichromate closed reflux method using thermo reactor.

### Biological oxygen demand (BOD)

Analysis of biochemical oxygen demand (BOD) was done by Winkler's Method. Samples were prepared by dissolving 12.5 ml sample in 274.5 ml distilled water. The initial dissolved oxygen of the sample was measured using digital Dissolved oxygen meter (DO meter). Then the sample was kept in incubator for 5 days at 120°C. After 5 days the final dissolved oxygen was found.

## RESULTS & DISCUSSIONS

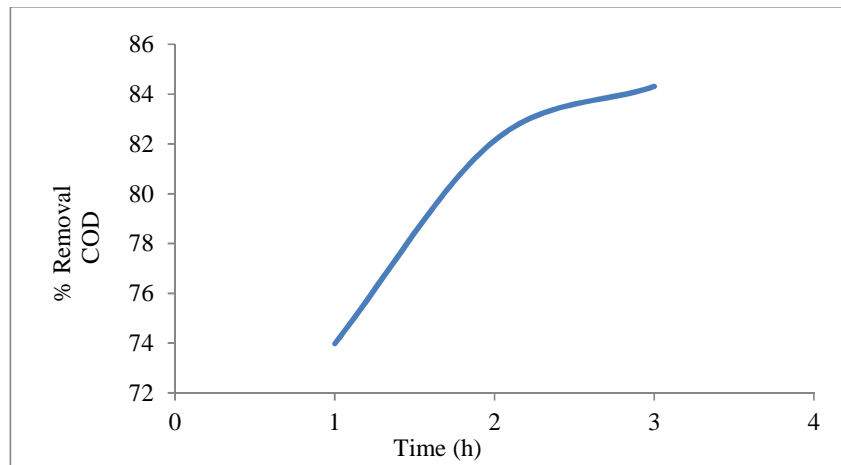
### Effect of Operating Time

The operating time has a significant effect on the COD removal. When the operating time was varied from 60 minutes to 180 minutes, it was found that the efficiency of COD removal increased with increase in operating time. Considering the cases varied in the study, the maximum removal was found at the contact time of 180 minutes. The maximum removal at 180 minutes operating time was 90.5 % COD.

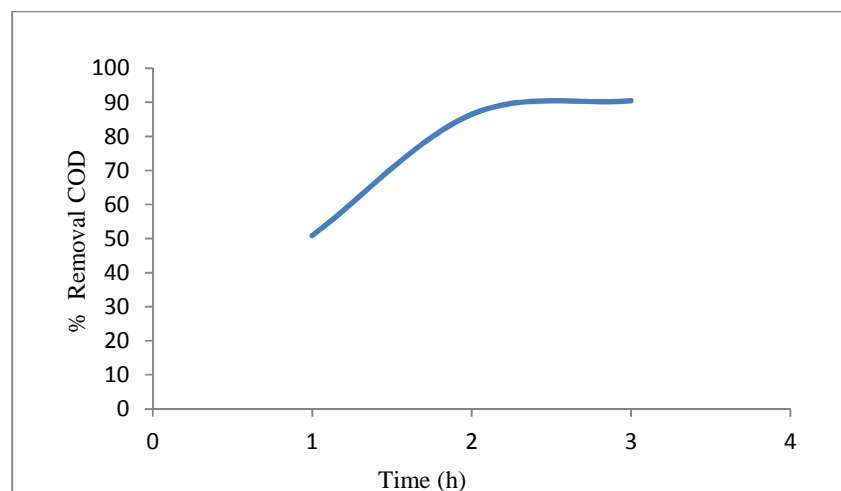
On the other hand, to explore the effect of the operating time on the pH value, the initial pH of solution was kept constant at 5.7. That the pH value increases as the time of electro-coagulation process is increased. This happened because of the OH<sup>-</sup> ion accumulates in aqueous solution during the process. The increase of pH in acidic condition was attributed to hydrogen evolution at cathodes.

### Effect of varying current density

Waste suspensions may have a range of dissolved ionic species that change the ionic strength and hence the conductivity of the suspensions. This, in turn, changes the current at constant applied voltage. Therefore, the effect of increasing current density on the COD removal efficiency was studied at constant voltage by adding appropriate amounts of NaCl to the solution.



**FIGURE 2:** Effect of time on COD removal percentage for current density of 0.05 A / dm<sup>2</sup> for 100 ml dilution solution

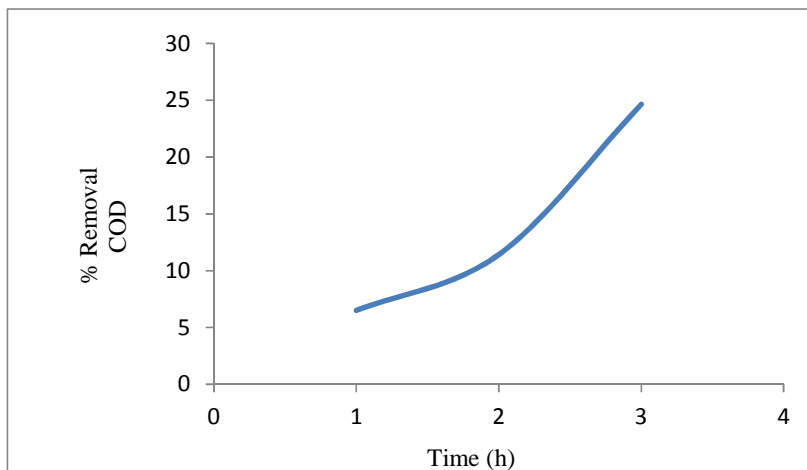


**FIGURE 3:** Effect of time on COD removal percentage for current density of 8 mA / dm<sup>2</sup> for 100 ml dilution solution

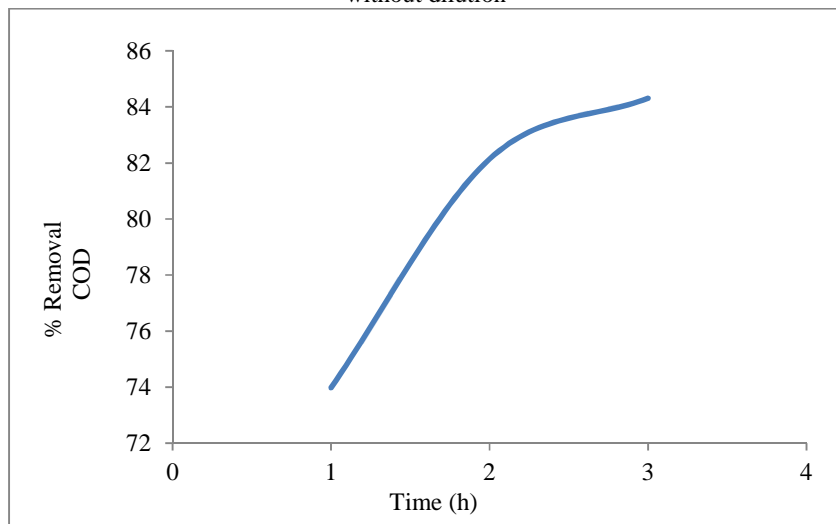
**Effect of supporting electrolyte concentration**

As expected, the conductivity of suspensions increased linearly with increasing NaCl concentration. An increase in conductivity decreased the ohm drop between

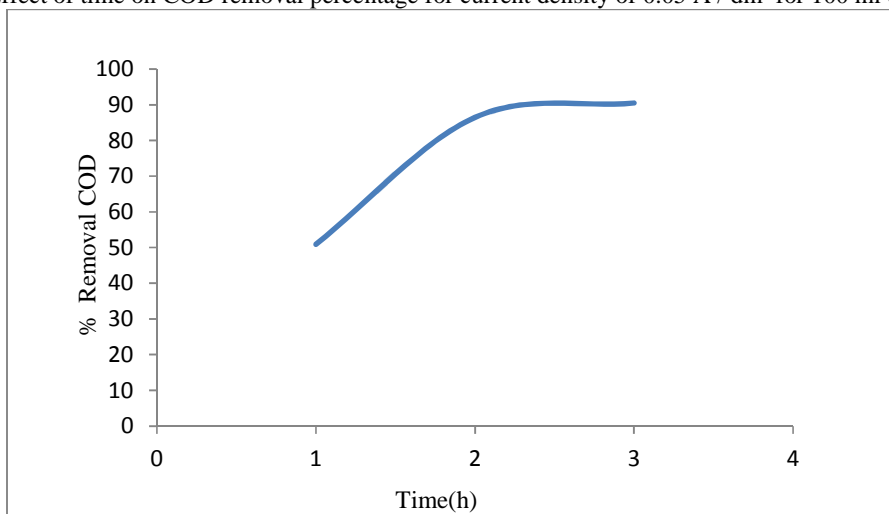
electrodes and therefore more aluminum ions could be produced at the same energy input. Also, the formation of  $(AlCl_3)^{2+}$  ions is expected to promote chemical dissolution  $(Al + 3 H_2O \rightarrow Al(OH)_3 + 3/2 H_2)$  of electrodes.



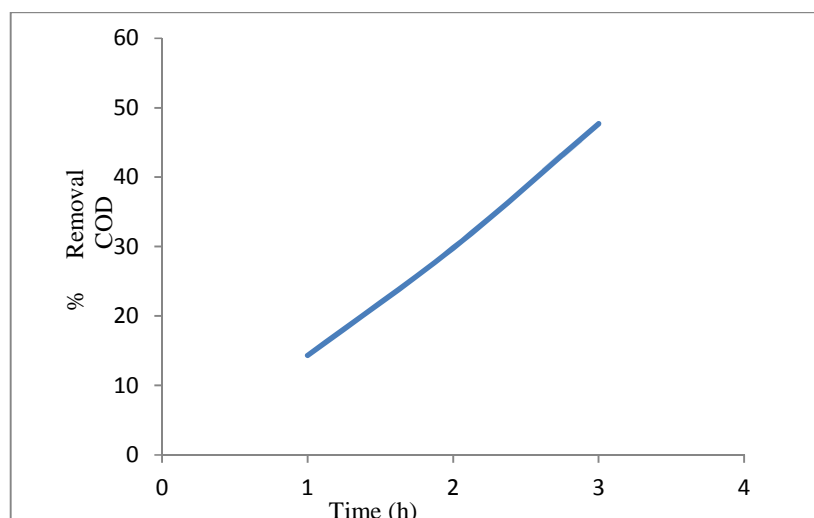
**FIGURE 4:** Effect of time on COD removal percentage for current density of  $0.05 A / dm^2$  for the effluent solution without dilution



**FIGURE 5:** Effect of time on COD removal percentage for current density of  $0.05 A / dm^2$  for 100 ml dilution solution



**FIGURE 6:** Effect of time on COD removal percentage for current density of  $8 mA / dm^2$  for 100 ml dilution solution



**FIGURE 7:** Effect of COD removal percentage for current density of 8 mA / dm<sup>2</sup> for without solution

### CONCLUSION

The removal efficiencies of COD from industrial effluent were experimentally done by electrocoagulation technique. The processes were measured in the batch studies of a single stirred apparatus. Aluminum and stainless steel plate electrodes were used in this work and were set at distance of 50 mm in the cylindrical glass cell (volume 1000 ml). The results show that the COD removal efficiency is as high as 90.5 % for electro-coagulation process with current of 1.8A. At this optimal condition the pH of the solution remains 7.33, so that the water does not have any problem of safety. In general, the results obtained from the graphs of operating time, indicates that the electro-coagulation technology can enhance the removal of COD. It means that this technology can improve the quality of effluent water that is discharged from the industries.

### REFERENCES

- Aboulhassan Baudu, M., Souabi, S. and Yaacoubi, A. (2006) Removal of surfactant from industrial wastewater by coagulation flocculation process. *Int. J. Environ. Sci. Tech.*, 3 (4): 327-332, 2006 ISSN: 1735- 1472.
- Antoni Sanchez Ferrer, Nora San Sebastian Mart inez, Josep Figuls Fernández, Xavier Font Segura (2003) Pre-oxidation of an extremely polluted industrial waste water by the Fenton's reagent. *Journal of Hazardous Materials B101*, 315–322.
- Balasubramanian N., Rajkumar, D. and Palanivelu, K. (2005) Combined electrochemical degradation and activated carbon adsorption treatments for wastewater containing mixed phenolic compounds. *J. Environ. Eng. Sci.* 4: 1–9.
- Balasubramanian, V., Praveen, K., Radha, C. (2011) Electrochemical Treatment of Plating Effluent: Kinetics and Statistical Modelling. *Arch. Environ. Sci.* (2011), 5, 17-24.
- Chandra Moul, P., Jayarama Reddy S. and Venkata Mohan, S. (2004) Electrochemical processes for the remediation of wastewater and contaminated soil: emerging technology. *Journal of scientific & Industrial Research*. Vol. 63, January 2004, pp 11- 19.
- Deshpande, A. M., Satyanarayan, S. (2011) Toxicity evaluation of through fish bioassay raw bulk drug industry wastewater after electrochemical treatment. *Iran. J. Environ. Health. Sci. Eng.*, 2011, Vol. 8, No. 4, pp.
- Magdalena Vankova (2011) Biodegradability analysis of pharmaceuticals used in developing countries; screening with OxiTop®-C 110 Tampere University of Applied Science Degree Program in Environmental Engineering.
- Meenakshi Bhargav, Nidhi Sharma, and Rajeev Jain (2004) Electrochemical degradation of erythrosine in pharmaceuticals and food product industries effluent. *Journal of Scientific & Industrial Research*. Vol. 64, March 2005, pp. 191- 197.
- Mehmet Kobya, Mahmut Bayramoglu, and Orhan Taner Can (2003) Treatment of textile effluents waste waters by electrocoagulation using iron and aluminum electrodes. *Journal of Hazardous Materials*, B100, 163- 178.
- Roppola Katri (2009) Environmental applications of manometric-respirometric methods, *Acta Univ. Oul. A 527*
- Stasinakis, A.S. (2008) Use of selected advanced oxidation processes (AOPs) for wastewater treatment. *Global Nest Journal*, Vol 10, No 3, pp 376- 385.