ISSN 2321-807X
Volume 13 Number3
Journal of Advances in chemistry

ELECTRO COAGULATION TREATMENT ON TANNERY BEAM HOUSE-SOAK LIQUOR BY HYBRID ELECTRODE COMBINATIONS

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ABSTRACT

Waste water released from beam house operation of the soaking process contains different kind of pollutants such as protein, lipids, greases and hairs produce high amounts of Chemical Oxygen Demand and Biological Oxygen Demand. Mainly tannery industries in TamilNadu, India follow solar evaporation pans. The waste water coming from soaking process contains high amount of Chemical Oxygen Demand and chloride concentration. The research work focus on soak processing waste water coming out of the tannery industry by an Electro Coagulation process using different electrodes. The removal efficiency only determined for Chemical Oxygen Demand and compared by different anode/cathode combinations Al/Fe, Fe/Graphite, Pt/Fe and Fe/Zn investigated.

Indexing terms/Keywords

Soak liquor; Electro coagulation; Different electrodes;Chemical Oxygen Demand

Academic Discipline And Sub-Disciplines

Chemistry : Engineering Chemistry, Applied Chemistry, Environmental Science and Engineering

SUBJECT CLASSIFICATION

Environmental Science and Engineering

TYPE (METHOD/APPROACH)

Experimental and study analysis

1.INTRODUCTION

Increasing of population and future needs of an Indian economy, the industries concentrate on opportunities in employment and export products. The number of Industries and the use of pollution creating old methods, direct to escalating ecological pollution. Manufacturing of leather products were produce huge amount of waste water with different concentration of pollutants. The untreated pollutants of tannery waste water create health problems for living things, environmental issues and pollution to the surroundings. Leather collected from a variety of animals like sheep, cattle, pig, etc. Leather is a usual natural creation, but leather product produced by different mechanical and chemical process on raw hides and skins.

The inclusion capability of hides and skins has helped to avoid them from decaying, make them resistant to wetting, and produce bendable and long-lasting properties. Hide or skin is much thicker and softer and contains the hair and oil glands. The waste water generated from the soaking operation is soak-liquor, contains salt soluble proteins and suspended matters. Based on pollution control regulations, the tanneries are required to separate the salt laden in soak liquor and discharge into Solar Evaporation Pans(SEP) in Tamil Nadu. High amount of organic matter, suspended solids, growth of bacteria in soak liquor reduced the rate of evaporation in SEP. Bio-degradation of organic matter in soak liquor creates an obnoxious odor and also impure and not reusable salt obtained in SEP. An alternative treatment is necessary to remove the suspended solids from the soak liquor or before discharging in to a SEP. Number of treatment methods available for the tannery waste water like chemical coagulation [1-3], photo-degradation by Suraiya Jabeen [4] and bio-degradation [5-9]. The electro coagulation process was an effective treatment for various industrial waste water and maximum removal percentage of pollutants obtained by different authors [10-13]. Melanie Asselin et al [14] , explained the effective treatment on slaughterhouse waste water by an electro coagulation process using mono polar and bipolar electrolytic cells.

The electrode material plays an important in electro chemical treatment. Most of the authors have used cheap and effective trivalent nature of electrode materials such as aluminum and iron. The removal rate of COD and energy consumption were analyzed and the results concluded iron electrode is found superior to aluminum by Kobya et al.[15]. Electro coagulation Process for the treatment of textile waste water under combined electrical connections analyzed with titanium electrodes by Ahmed Samir et al.[16]. Zaroual et al.[17] explained aluminum anodes were produced more than 90% removal in 10 minute reaction time, pH 4.2, with 3.53 kWh/m3 of energy consumption for chromium waste water by an electro coagulation process. Espinoza-Quinones et al. [18] determined the optimum treatment condition of EC at pH 7.6 and 30-45 minutes electrolysis time for leather-finishing processes using aluminum electrodes. Mahmoud. [19], explain the anaerobic digestion for segregating tannery soak liquor from the composite tannery waste water. O. Lefebvre, et al.[20] also investigated tannery soak liquor with an aerobic post-treatment by anaerobic digestion. Majouli et.al.[21]

explained micro filtration ceramic membrane process was reducing the COD by 60-65% and TKN by 57-59%. Al/Fe, Fe/Graphite, Pt/Fe and Fe/Zn electrodes are not still compared in detail with tannery industry waste water. The work aimed to compare the treatment of tannery water by electro coagulation using different anode/cathode combinations Al/Fe, Fe/Graphite, Pt/Fe and Fe/Zn. In addition, the performance is explored without alteration of pH in different voltages and electrolysis time.

2.EXPERIMENTAL

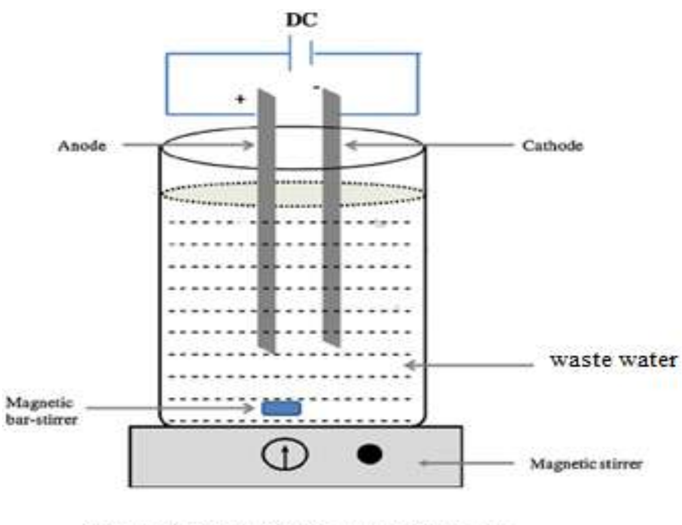
The sample was collected at organized tannery industrial region located at Naripallam in Erode District, India and important parameters analyzed as quickly as possible. All the pollutant parameters were analyzed as per the Standards Methods (APHA-AWWA-WPCF) for the examination of water and wastewater and methods are reported in the literature [22] and the observed values were tabulated in Table-1.

Table 1. Physical and chemical parameters of tannery soak liquor

Parameters	**(mg/L)**
Turbidity (NTU units)	490
Color (NTU units)	1150
Total dissolved solids	7577
COD	6466
BOD	3926
pH	6.36
Chloride	173

Electro coagulation process investigated in soak liquor with iron electrode, aluminum electrode, graphite electrode and zinc electrode. The anode and cathodes were taken in the same dimension (6cm×6cm×1mm). Electrodes were connected to the positive and negative terminals of the DC power supply (fig.1). An experiment carried out with different voltages (15V, 18V, 20V, 22V) and different electrolysis time (15, 20, 25, 28, 30 minutes) for each electrode combination with 3cm electrode.

Figure 1 : Schematic diagram of electro coagulation process

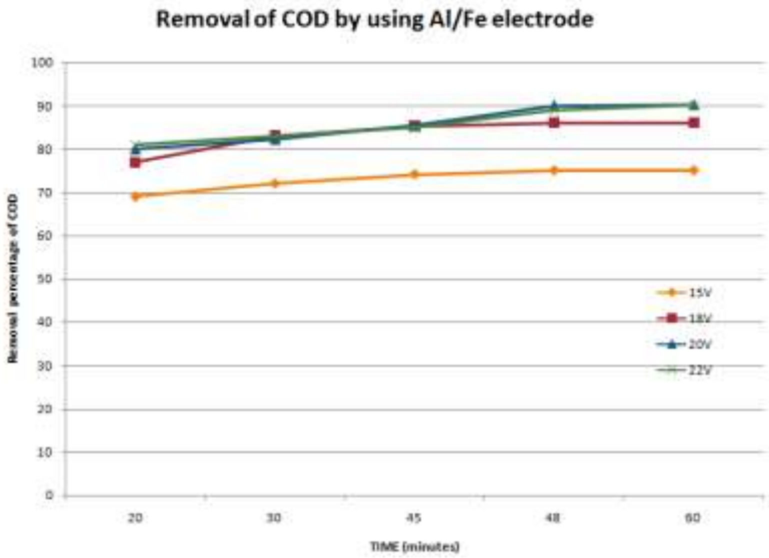


Schematic diagram of electrocoagulation process

3.RESULTS AND DISCUSSION

The performance of electro coagulation process depends on many factors such as an electrode material, electrolysis time, current density, pH, etc. pH or conductivity not adjusted in the EC process in tannery soak liquor. Removal efficiency, increased with increasing electrolysis time in all electrode combinations. The removal rate of COD in various electrolysis time and different voltages with Al/Fe electrode was shown in Figure 2. Aluminum and Iron combination, COD concentration fall from 6466mg/lit to 643 mg/lit. Aluminum anode produces best results in EC, an operation time of 48 min for maximum 90% removal of COD. The use of iron anode, no removal can be observed beyond 48 min and maximum COD removal is 64.5% with Graphite cathode and 71% with zinc cathode. In Fe/Graphite electrodes COD can reduce 65.5 % of removal at 22V, 60 minutes electrolysis time. This type electrode removes 50-65% of COD in soak liquor. Compare with Fe/Graphite electrodes Fe/Zn removes above 50% in 20 minutes, 15V. Removal efficiency steadily increases with increasing time and voltage in Fe/Zn electrode combinations. EC process investigated using Pt/Fe electrode combination removes a considerable amount of COD (nearly 50%), but is not effective in tannery waste water.

Figure 2: Removal efficiency of COD by Al/Fe



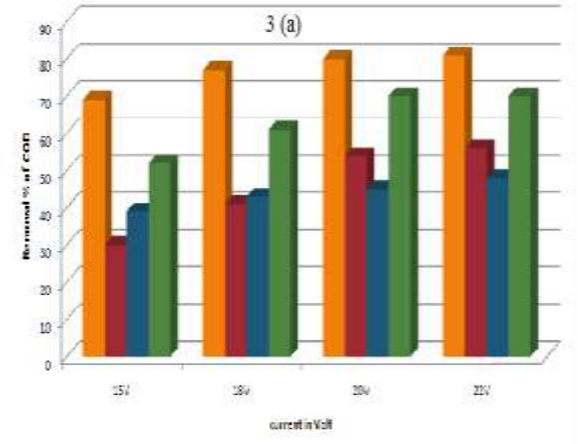
It is very clear, comparing these electrode combinations again Al/Fe electrodes again proven best results in electro coagulation process. Electrochemical reactions of anode and cathode mention in **Table 2.** The obtained results of COD removal efficiency in EC process with different electrolysis time by various electrode combinations shown in **figure 3.** The same point can be explained by Zaroual et al [23] and Fuat Ozyonar et al [24*]* concluded in his report for aluminum electrode combinations produce high removal efficiency and low energy consumption.

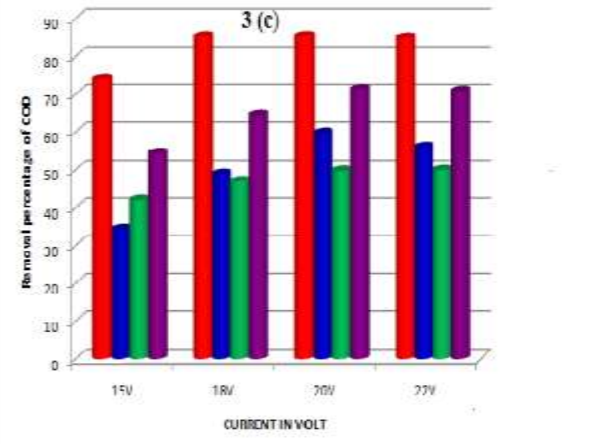
Table 2. Electro chemical reactions during the process

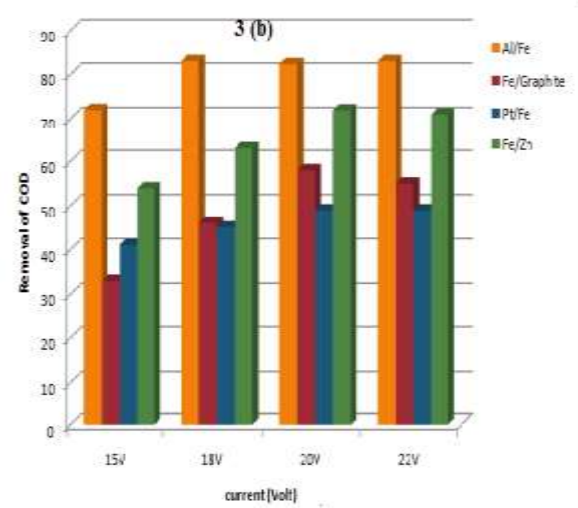
Electrodes	Aluminum Electrode	Iron Electrode
Anode reactions	$Al \rightarrow Al^{3+} + 3e$ $2Al + 6H_2O + 2OH^- \rightarrow 2Al(OH)^{4-} + 3H_2$	$4Fe(s) \rightarrow 4Fe_2^+(aq) + 8e^-$ $4Fe_2(aq) + 10H_2O(l) + O_2(g) \rightarrow Fe(OH)_3(s) + 8H^+(aq)$
Cathode reactions	$3H_2O + 3e \rightarrow 3/2H_2 + 3OH^-$	$8H^+_{(aq)} + 8e^- \rightarrow 4H_2(g)$
Overall reactions	$2Al_{(s)} + 6H_2O_{(l)} \rightarrow 2Al(OH)_3(s) + 3H_2(g)$	$4Fe_{(s)} + 10H_2O(l) + O_2(g) \rightarrow Fe(OH)_{3(s)} + 4H_2(g)$
Source: (Kobya et al., 2003: Zaroual et al., 2006)		

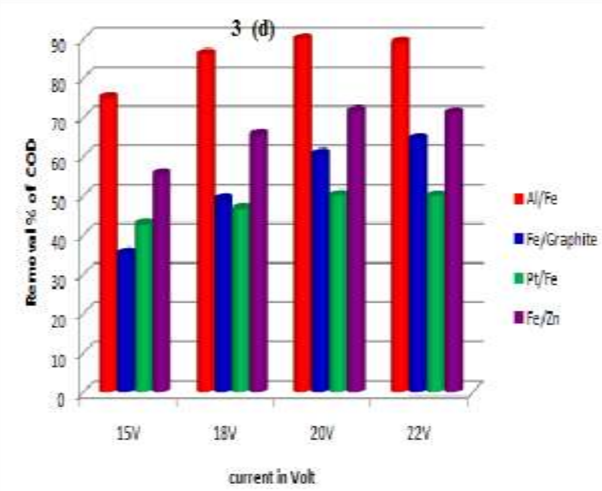
Aluminum anode material requires lower oxidation potential, but using an iron anode, produce black color to the water after the process. The further Electro Coagulation process was continued with Al/Fe electrode combination with different pH at 20V, 45 minutes of electrolysis time for the removal of COD. Turbidity and chloride also analyzed with similar operational condition showed in **figure 4**.

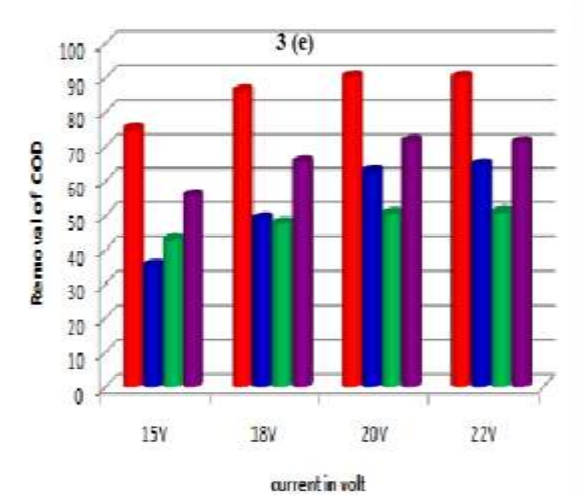
Figure 3 : EC process with different electrolysis time by various electrode combinations











Removal percentage of cod in different electrode combinations

3 (a) - Reaction time 20 minutes

3 (b) - Reaction time 30 minutes

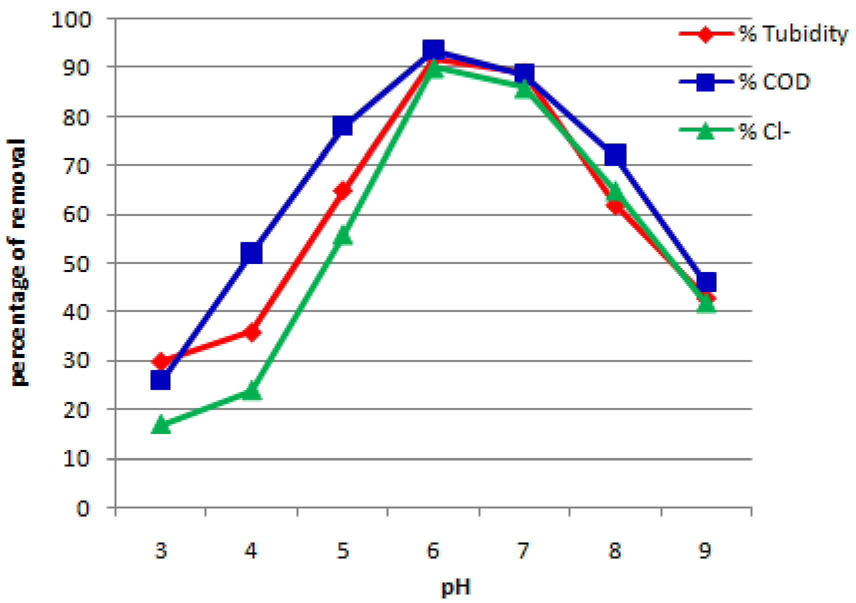
3 (c) - Reaction time 45 minutes

3 (d) - Reaction time 48 minutes

3 (e) - Reaction time 60 minutes

The removal of pollutants in wastewater depends on pH in waste water. At pH 6 to 7 the removal efficiency of COD attained 93.5%, 89-92% of turbidity and 90% of chloride. Based on these results EC processes suitable for removal of pollutants in soak liquor at 20 V in 45 minutes of reaction time and pH range from 6-7. The raw water pH is already 6.3, so without alteration of pH the EC process can be carried out in soak water. Reaction time directly professional to pH value, because due to OH^- ion accumulation in aqueous solution during the process. The rate of removal obtained higher at near neutral pH. The amphoteric behavior of $Al(OH)_3$ does not precipitate at very low pH. In acidic condition H_2 evolution take places at cathodes and formation of Al $(OH)_3$ near at the anode would release H^+ leading to decrease of pH. In addition, there is also O_2 evolution reaction leading to pH decrease. pH decreases at alkaline conditions, due to the formation of soluble $Al(OH)_4$ and this condition useless for removal of COD, BOD in soak water.

Figure 4: Electro coagulation process with Al/Fe electrode combination with different pH at 20V, 45 minutes



Based on removal efficiency, the economic study can be calculated only for the combination of Al/Fe hybrid electrode, includes chemical, electrode, energy consumption and sludge disposal. The disposal cost for the residual sludge, including transportation and charges for waste disposal was evaluated at 0.23$kg^{-1} of dry residue by assuming that these residues were not considered as hazardous material. Treated water should be free from color and all other impurities. The recycled water reused in liming and tanning process, during the EC process the salt content does not increase compared to SEP. The main advantage of EC is much higher color, COD, BOD, turbidity and chlorine removal and possibility to conduct the process without adjusting pH at room temperature.

4.CONCLUSION

The results obtained in this work confirmed that the characteristics of water and combined electrode strongly influenced the performance of electrochemical treatment. It is possible to design an electro coagulation treatment for soak-liquor to optimize the operational conditions to maximize the removal efficiency and minimize the sludge production and consumption of energy and the electrode.. It has been concluded that Electro coagulation is capable of having high efficiency inexpensive and quicker than SEP. The sludge produced by the Electro coagulation process used for agricultural fertilizer or used as a raw material for the production of bio-gas.

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