A QUANTITATIVE COMPARISON BETWEEN ELECTRO COAGULATION AND CHEMICAL DOSING

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ABSTRACT

Effluents of paint wastewater contain highly toxic compounds and organic biorefractory compounds such as COD and TOC. It harms fish, wild life, contaminates the food chain if poured down a storm drain. So paint wastewater must be needed to discharge after treatment. The characteristics of paint wastewater and efficiency of Electrocoagulation (EC) process by using Al-Al electrode combination and Chemical coagulation process were studied. In EC study, conductivity and current density plays a vital role. The effect of operational parameters such as electrolyte concentration, initial pH and current density was investigated. In chemical coagulation process, the alum dosage levels were calculated by using faraday’s law. When compare with chemical coagulation process, the maximum removal efficiency was obtained for EC process by using Al electrode.

Keywords: EC, Paint Wastewater, Chemical Coagulation, COD Removal Efficiency.

1. INTRODUCTION

Paint is generally considered as a mixture of pigment, binder, solvent, additives. The type and proportion of each component in the mixture characterize the properties of a particular paint. The components of paint also determine the characteristics of the waste generated in its manufacture and use. A convenient method to classify paints is based on their primary solvent for waste reduction and disposal. In this respect, paints can be classified as water based, organic solvent based or powder (dry), without solvent.

The term “water based” refers to coating systems that use water as solvent to some extent. They have advantages over some types of organic solvent based coatings because they generally decrease Volatile Organic Carbon (VOC) emissions, eliminate organic solvents for thinning and
reduce the use of organic solvents for thinning and reduce the use of organic solvents during clean-up (Korbahti and Tanyolac, 2009). Due to the varying degree of chemicals used, the waste water contains appreciable concentrations of BOD, Chemical Oxygen Demand (COD), suspended solids, toxic compounds and color.

The discharge of such colored wastewater into the environment is not only aesthetically displeasing, but impedes light penetration, damages the quality of the receiving streams and may be toxic to treatment processes, to food chain organisms and to aquatic life. For these reasons, the effluent treatment is necessary before their discharge into the environment (Aboulhassan et al., 2006).

There are many different techniques to remove COD, TOC and color from industrial wastewater such as biodegradation, adsorption, membrane filtration, coagulation–floculation, advanced oxidation processes such as ozone, photochemical, Fenton's, electrochemical etc. These technologies take considerable time; require an extensive setup and they are not economically applicable for plants of produced small volume wastewater. These conventional processes generate a considerable quantity of secondary pollutants which pose serious environmental problems. (Akyol, 2012)

Advantages of the EC compared to conventional chemical coagulation include reduced wastewater acidification and salinity, low dosage of coagulant, superior coagulant dispersion and intrinsic electroflotation separation capability. In this study, the feasibility of EC and Chemical coagulation process for the treatment of paint wastewater in terms of COD was investigated. Effects of parameters such as electrolyte and its concentration, initial pH, electrode area, inter-electrode distance, current density and initial concentration of the paint using aluminum electrode were also studied.

2. MATERIALS AND METHODS

2.1 Chemicals and Materials

The water based paint was obtained from the local car showroom in Trichy. The color of water based paint used for the treatment was bluish silver (1H7). Sodium chloride and Sodium sulphate (Merck, 99.9% purity) was utilized as an external electrolyte. Commercially available aluminum plate (99% purity) was used as an electrode.

2.2 EC process

A set of experimental run were carried out to determine the optimum external electrolyte for high COD removal. The experimental setup was shown in Fig. 3.3. 800 ml of sample has taken in the 1 L beaker. It was kept above the magnetic stirrer for continuous agitation. External electrolyte such as NaCl was added to increase the conductivity. The aluminum rod was used as an electrode. The size of rod was 5 cm X 7 cm X 0.7 cm. The electrode was immersed into the sample. Initially electrode area immersed in the sample was 60 cm². The spacing between the anode and cathode was 2 cm. then the electrodes were connected with DC supply. The voltage supply has adjusted by DC supply. The electrolysis process was conducted for 2 hours. The 5 ml of sample were taken for every 10 min. the sample was filtered by using glass filter paper. The pore size of filter paper was 0.45µm. The sample was analyzed to determine the COD by using COD digester.
2.3 Chemical Coagulation

The coagulation tests were carried out using the jar test. The tests involved rapid mixing, followed by slow mixing and sedimentation in a batch process. Five beakers were filled with 500 ml of the real paint wastewater samples, and placed on the floc illuminator and agitated at the preselected speed of rapid mixing at 120 rpm for 10 min. During the rapid mixing, a known dosage of alum was added to each beaker simultaneously. After the rapid mixing, the preselected speed of slow mixing 20 rpm for 20 min was quickly established and when this was completed the beakers were then carefully removed from the floc illuminator and left for the sedimentation phase. After settling, 5 ml of the sample was taken from the middle of each beaker for COD analysis.

3. RESULTS AND DISCUSSIONS

3.1 Study of EC process in paint wastewater by using Al electrode

The experiment was carried out in raw wastewater. The COD removal efficiency was 50 % at the electrolysis time of 45 mins. The conductivity of the sample was around 189 µS. The external electrolyte as NaCl was added to increase the conductivity. When the conductivity increases, current produced also increased.

3.1.1 Determination of NaCl concentration

The initial COD concentration of paint wastewater was 1000 mg/L. The experimental conditions maintained were spacing 2 cm, area of electrode dipped in sample 60 cm², voltage supplied 10V. The results obtained by adding the external electrolyte NaCl in different concentration were shown in Fig. 3.1. The concentration of NaCl electrolyte was varying like 200 mg/L, 300 mg/L, and 400 mg/L. It explains that, by increasing the electrolyte concentration, the COD removal also increased. The maximum COD removal of 57.12 % was achieved with 400 mg/L concentration in 10 min. The addition of NaCl contributes chloride ions to the solution. It removes the insulating layer formed by Ca²⁺ and Mg²⁺ on electrode (Raghavacharya, 1997; Wong. H. M., 2002).
3.1.2 Determination of Optimum pH

The initial condition to carried out the process were the initial COD concentration of sample 1000 mg/L, NaCl concentration 300 mg/L, area of electrode immersed in sample 60 cm², spacing between the electrodes 2 cm, voltage applied 10 V. The Fig. 3.2 shows the COD removal for various pH. The pH was varying like 5, 6, 7, 8 and 9. For pH 6, 76% of maximum removal efficiency was observed at 10 min. At pH 5, Al³⁺ is transformed into soluble monomeric species such as Al(OH)₂⁺, Al(OH)⁻² and Al(OH)₂ (Bensadok et al., 2008). So the optimum pH for the process is considered as 6.

3.1.3 Determination of Optimum Current Density

The condition maintained for the process were the initial COD concentration of sample 1000 mg/L, NaCl concentration 300 mg/L, pH 6 area of electrode immersed in sample 60 cm² and spacing of electrode 2 cm. Fig. 3.3 shows the variation in COD removal when changing the voltage supplied for electrolysis process. The voltage was varying like 6 V, 8 V, 10 V and 12 V. The amount
of current density determines the coagulant dosage and size of the bubble production. It affects the growth of flocs (Adoum et al., 2004). An increase in removal efficiency of 73% from 31.3% was observed when the current density was increased from 1.333 mA/cm² (6 V) to 3.667 mA/cm² (12 V) at 10 min. So 12 V is considered as the optimum voltage for this study.

3.1.4 Determination of Effect of Initial Concentration of Paint Wastewater

The condition maintained for the process were the NaCl concentration 300 mg/L, pH 6, area of electrode immersed in sample 60 cm² and spacing of electrode 2 cm, voltage supplied 12 V. The Fig. 3.4 shows the variation in COD removal when changing the initial COD concentration of paint wastewater. The initial COD concentration of paint wastewater was varying like 1000 mg/L, 2000 mg/L, 3000 mg/L and 5000 mg/L. Removal efficiency decreased when increasing the initial concentration. The maximum COD removal efficiency for 1000 mg/L was 73% in 10 min. In high concentrations, insufficient hydroxyl and metal ions production on the electrodes are the reason for less removal efficiency (Sengil and Ozacar, 2009).
3.2 Chemical Coagulation
The removal efficiency of paint wastewater without supplying current was studied by using chemical coagulation process. To compare the results with Al electrode alum was used as a chemical coagulant. The alum concentration was calculated by using Faraday’s law. For maximum removal, the optimum conditions like alum dosage concentration and initial pH were studied. The results obtained were given below.

3.2.1 Determination of Alum Dosage
The initial COD concentration of the sample was 1000 mg/L and pH was 7. To analyze the effect of alum dosage, the dosage concentration was varying like 0.6 g/L, 1.2 g/L, 1.8 g/L, 2.4 g/L and 3 g/L respectively. The variation of COD removal for different alum dosage is shown in Fig. 3.5. The COD removal efficiency was increased by increasing the alum dosage. The maximum COD removal efficiency of 66 % was observed for the dosage concentration of 3 g/L. The dosage concentration of 3 g/L was considered as optimum dosage.

![Fig. 3.5: Variation of removal efficiency for various alum dosages](image)

3.3 Comparison of EC and Chemical Coagulation
Fig. 4.31 shows the comparison of COD removal efficiency by chemical coagulation and EC by Al electrodes. The maximum removal efficiency achieved by EC process using Al electrode was 73 %. When compare with chemical coagulation process, electrocoagulation process giving the maximum removal efficiency. So EC process using Al electrode was considered as the most preferable method for treatment of water based paint wastewater.

4. CONCLUSION
The fundamental physical separation processes are different for chemical dosing and EC, with settling being the key removal path in the former case. In EC, however, the dominant removal path is determined by the applied current. At low currents, settling dominates. As the current increases, so the pollutant fraction that is removed by flotation increases, although the coagulant appears to be used less effectively. Experimental data support the hypothesis that the increased bubble densities associated with higher currents are removing flocs of coagulant from solution. The mechanism of coagulant delivery is a key difference between chemical dosing and EC performance. In the alum dosing studied here, coagulant addition is a discrete event with the system. By comparing
the EC and chemical coagulation process results, helps to conclude that EC process giving the maximum removal efficiency. So EC process is considered as the suitable process for treatment of water based paint wastewater.

REFERENCES