COD Removal from Textile Wastewater by Electrocoagulation Using Iron Electrodes

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Abstract— This work presents removal of COD (Chemical Oxygen Demand) from Textile wastewater by Electrocoagulation (EC) process using Iron as a sacrificial electrode which is currently used for the purification of many types of water and wastewater. The effecting parameters such as applied voltage, electrolysis time and initial pH are studied to achieve higher removal. The performance of EC process is carried out in batch reactor. In this process, samples are taken out from the batch reactor at regular interval of 20 minutes. Results obtained show that the most effective removal efficiency is achieved at 1 A of applied current at 16V. Moreover, the experimental results also show that the COD removal is strongly influenced by the initial pH. EC is found to be very efficient at pH 9. The highest COD removal efficiency of 93.5% occurred at 16V at electrolysis time of 80 minutes with optimum pH 9. In this study, the EC process is proved effective and is capable in removing COD efficiently.

Key words: Textile wastewater, Electrocoagulation process (EC), Iron electrode, COD, Electrolysis time, pH

I. INTRODUCTION

The Textile industry, particularly in India, nowadays is an important sector of its economy, such as one of the major contributors to the total output of the fast growing Indian industrial sector which is at present revolving around 14%. These Textile dyeing industries consumes large quantities of water and produces large volumes of wastewater. Therefore, with this perspective of growth, more wastewater is expected, i.e., more industries will throw its wastewater in the environment. Furthermore, one of the major challenges facing mankind today is to provide clean water to a vast majority of population around the world. There is an urgent need to develop innovative, more effective and inexpensive technique for treatment of wastewater.

Therefore, it is necessary to treat dye effluents prior to their discharge to the receiving water stream in order to meet the envIronmental regulations. The discharge of dyes in the ecosystem is considered as a major envIronmental concern. Dye effluents, are not only aesthetic pollutants by nature of their colour, but may interfere light penetration in water, thereby disturbing biological activities of aquatic life. The technique used in this experiment is electrocoagulation, which has been a practice for most of the 20th century[2].

Electrocoagulation is the process where an electrical current is introduced into an aqueous medium in an electrochemical cell, usually with an electrode. The destabilization mechanism of the contaminants, particulate suspension, and breaking of emulsions has been described in broad steps and may be summarized as follows:

1) Compression of the diffuse double-layer around the charged species, which is achieved by the interactions of ions generated by dissolution of the sacrificial electrode, due to passage of current through the solution.
2) Charge neutralization of the ionic species present in wastewater, which is caused by the counter ions, produced by the electrochemical dissolution of the sacrificial electrode. These counter ions reduce the electrostatic inter-particle repulsion sufficiently so that the van der Waals attraction predominates, thus causing coagulation. A zero net charge results in the process.
3) Floc formation, and the floc formed as a result of coagulation creates a sludge blanket that entraps and bridges colloidal particles that have not been complexed [3].

The chemical reactions using Iron electrode is as follows [4]:

At anode:

$4Fe(s) \rightarrow 4Fe^{2+}(aq) + 8e-$

$4Fe^{2+}(aq) + 10H_2O(l) + O_2(g) \rightarrow 4Fe(OH)_3(s) + 8H^+(aq)$

At cathode:

$8H^+(aq) + 8e^- \rightarrow 4H_2(g)$

Overall reaction**:**

$4Fe(s) + 10H_2O(l) + O_2(g) \rightarrow 4Fe(OH)_3(s) + 4H_2(g)$

Main aim of the study is to investigate the potential of Electrocoagulation process using four Iron electrodes in bipolar mode in the removal of COD from Textile wastewater. The effect of electrolysis time, pH and applied voltages on electrode is studied for the efficient treatment of Textile wastewater.

II. MATERIAL AND METHODS

A. Analytical measurements

The Textile wastewater used in this study is collected from Textile industry located in Vijayapur and was stored in deep freezer at 4°C with preservatives. The analysis of wastewater is carried out as per Standard Methods [1]. The various characteristics of Textile effluent are shown in Table 1.

B. Experimental Set Up

The study consists of lab-scale batch system, which is composed of an electrolysis cell, a power supply system and a magnetic stirrer unit. The electrolysis cell made of borosil glass beaker with an effective volume of 1L and with bipolar electrodes in parallel connection. The Iron cathode and Iron anode consist of pieces of Iron electrodes of size 10cm × 5cm × 1mm separated by a space of 1 cm and dipped in the wastewater. The electrodes are connected to the positive and negative terminals of the DC power supply (Range 30V/2A) as shown in Fig 1. In this study, an individual effect of Cell Voltage and applied pH and Electrolysis time is studied. Each experiment is of batch operation, for every regular interval of 20 minutes samples were drawn and COD concentrations are measured. At the

end of each experimental (i.e. after electrocoagulation) run, the sample is transferred into another beaker and kept undisturbed for 30 minutes in order to allow the flocs that formed during electrocoagulation to settle down.

Sl.no	Characteristics	unit	Textile wastewater
1	pH	-	9
2	Color	-	Indigo blue
4	Conductivity	mS/cm	22.2
5	Alkalinity	mg/L	550
6	Total dissolved solids	mg/L	3000
7	Suspended solids	mg/L	200
8	Total solids	mg/L	3200
9	BOD_5@20°C	mg/L	599
10	COD	mg/L	1400
11	Chlorides	mg/L	324
12	Nitrate	mg/L	15
13	Sulphate	mg/L	11.6
14	Phosphate	mg/L	22

Table 1: Characterization of Textile wastewater

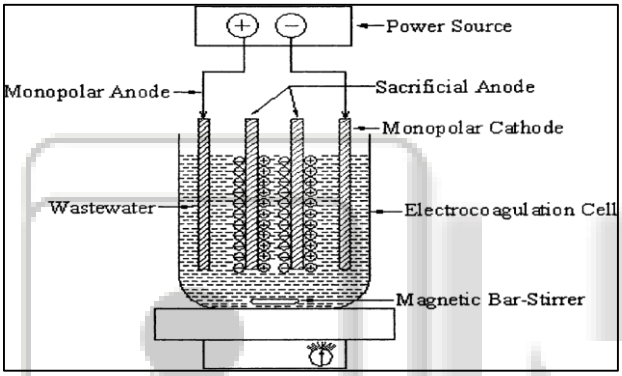

Fig. 1: Experimental Set Up

III. RESULTS AND DISCUSSION

A. *Effect of Electrolysis Time*

The effect of electrolysis time is investigated in the range 0 to 120 minutes with sample pH 9 as shown in Fig. 2, there is rapid increase in COD removal efficiency till 80 minutes of duration and later on approaches constant value. The maximum COD removal efficiency of 60% at 8V and 72.1% at 10V for Iron is achieved in 80 minutes of electrolysis duration which is considered as optimum electrolysis duration for further studies.

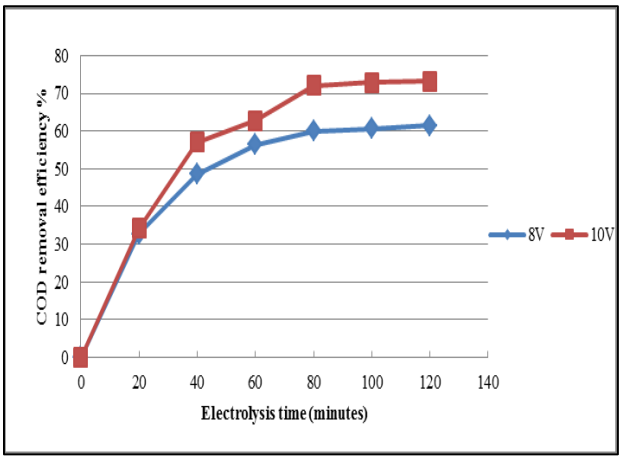

Fig. 2: Effect of Electrolysis Time at pH 9

B. *Effect of pH*

To examine its effect, individual experiments are conducted at varying wastewater pH of 6, 7, 8, 9 and 10 for electrolysis time of 80 minutes at 10V. Fig. 3 shows the COD removals for different pH as a function of treatment time for Iron electrode. The maximum COD reduction using Iron plate electrodes is found to be 390 mg/L that is 72.1% COD removal at pH 9.It was ascribed to an amphoteric behavior of Fe(OH)3 which leads to soluble cations $Fe3+$, $Fe(OH)2+$ (at acidic pH) and to monomeric anions $Fe(OH)4-$, $Fe(OH)63-$ (at alkaline pH). It is well known that these species are not usefull for water treatment. For these reasons the Electrocoagulation process is conducted at optimum pH 9.

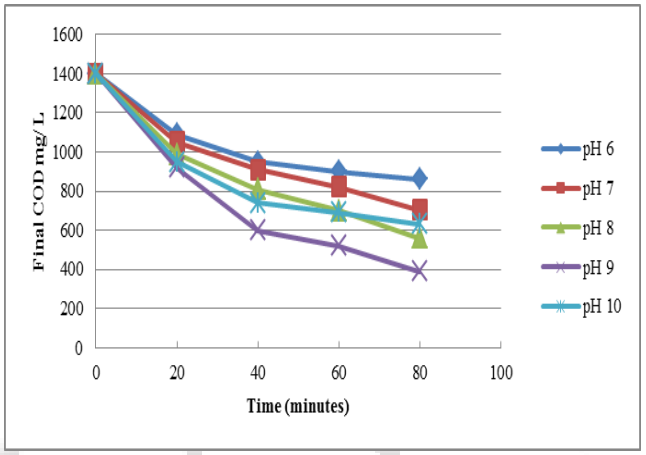

Fig. 3: Effect of pH at 10V

C. *Effect of Applied Voltage*

To investigate the effect of applied voltage on COD, EC process is carried out at 10V, 12V, 14V and 16V voltages at 1A current. Based on previous experiments 80 minutes of electrolysis time and pH 9 is maintained. Fig. 4 shows the maximum reduction of 90mg/L COD is found at 16V that is 93.5% of COD removal efficiency. This is ascribed to the fact that at higher voltage the amount of Iron oxidization increases, resulting in a greater amount of precipitate for the removal of pollutants. In addition, it is demonstrated that bubbles density increases and their size decreases with increasing current density resulting in a greater upwards flux and a faster removal of pollutants.

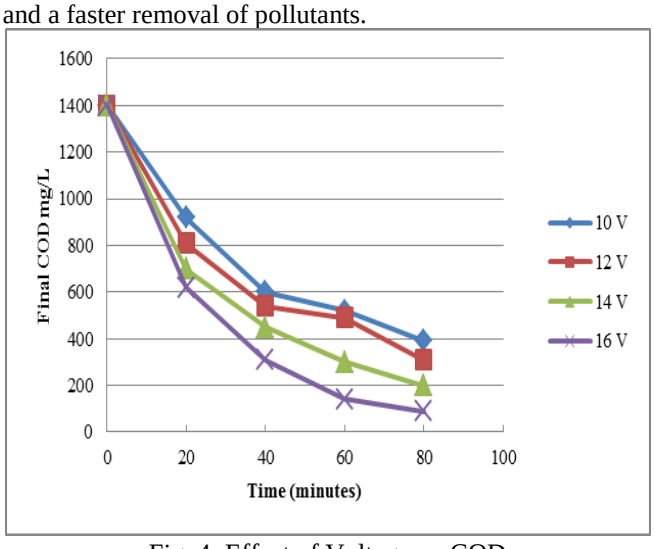

Fig. 4: Effect of Voltage on COD

IV. CONCLUSION

In this study the effect of operational conditions such as electrolysis time, pH and applied voltage is examined. The result showed that at optimum electrolysis time of 80 minutes and at optimum pH 9 condition, the Iron electrodes showed the maximum COD removal efficiency of 93.5% at optimum voltage of 16V. Thus, EC technology with Iron as electrodes in bipolar system could be an attractive alternative for the treatment of Textile wastewater.

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