

Contribution of Electrochemical Treatment in Treating Textile Dye Wastewater

Usha N. Murthy, Rekha H. B., Mahaveer Devoor

Abstract—The introduction of more stringent pollution regulations, in relation to financial and social pressures for sustainable development, has pressed toward limiting the volumes of industrial and domestic effluents discharged into the environment - as well as to increase the efforts within research and development of new or more efficient wastewater treatment technologies. Considering both discharge volume and effluent composition, wastewater generated by the textile industry is rated as the most polluting among all industrial sectors. The pollution load is mainly due to spent dye baths, which are composed of unreacted dyes, dispersing agents, surfactants, salts and organics. In the present investigation, the textile dye wastewater was characterized by high color, chemical oxygen demand (COD), total dissolved solids (TDS) and pH. Electrochemical oxidation process for four plate electrodes was carried out at five different current intensities, out of which 0.14A has achieved maximum percentage removal of COD with 75% and 83% of color. The COD removal rate in kg COD/h/m² decreases with increase in the current intensity. The energy consumption increases with increase in the current intensity. Hence, textile dye wastewater can be effectively pretreated by electrochemical oxidation method where the process limits objectionable color while leaving the COD associated with organics left for natural degradation thus causing a sustainable reduction in pollution load.

Keywords—Electrochemical treatment, COD, color.

I. INTRODUCTION

TEXTILE manufacturing is one of the largest industrial producers of wastewater; approximately 125–150L of water is used for 1kg of textile product. Textile engineering has a direct connection with all the environmental aspects to be explicitly and abundantly considered. The main reason is that the textile industry plays an important role in the economy of the country like India and it accounts around one third of total export [5]. Textile manufacturing is chemically intensive and contributes about 70% of pollution; the wastewater from textile processing contains processing bath residues from preparation, dyeing, finishing, slashing and other operations and well known with its high chemical oxygen demand, strong color, and large amount of suspended solids, variable pH, salt content and high temperature. These residues cause pollution if not properly treated before discharge to the environment. Dyes and auxiliary chemicals used in textile mills are

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improved to be resistant to environmental influences for better performance. As a result they are hardly removed from wastewater generated during the dyeing processes. In this content, the textile industry is concerned with some pollutants, which might not be suitable to treat with existing treatment technologies. Therefore, the treatment systems combined with physical, chemical and biological methods become inefficient for the effective treatment of industrial textile wastewater due to the wide variation of wastewater characteristics and heavy COD load.

On the other hand, electrochemical oxidation is becoming an alternative wastewater treatment method because many industrial processes produce toxic wastewaters, which are not easily biodegradable and requiring costly physical or physicochemical pretreatments [2]. Increasingly stringent effluent discharge permit limitations have been forced into effect. The textile industry generally has difficulty in meeting wastewater discharge limits.

Many advanced treatments have been studied and electrochemical oxidation has been applied to many kinds of wastewater. It is presented as an effective, selective, economical, and clean alternative for dealing with wastewaters bearing high loads of organic compounds, especially some bio-refractory organic pollutants. Such treatment produces total degradation of compounds to CO₂ and H₂O or at least a considerable decrease in toxicity. A direct anodic process or an indirect anodic oxidation via the production of oxidants such as hydroxyl radicals, ozone, etc. usually destroys the organic and toxic pollutants present in wastewater such as dyes [6]. The present study investigated with stainless steel electrodes as anode and cathode at different current intensities for the removal of COD and color.

II. MATERIALS AND METHODS

A. Sample Collection

Textile processor, a partnership company, established during the year 2005 located at Kumbalagodu, near Kengeri Hobli, Mysore road, Bangalore, India. Textile processor involved in the activity of cotton fabrics processing involving dyeing and printing. The sample for analysis was drawn from dye bath unit of textile industry. The dye bath varies widely in its physical and chemical characteristics. The quantity of sample required for the analysis was taken after thorough mixing, in order to keep the solids in suspension. Container used for sampling was, basically nonreactive in nature along with a proper stopper and a tag bearing details of the type of sample, place, date and time of sampling. This practice was carried out for complete duration of project work.

B. Electrode Preparation

Before each run, electrodes were washed with tap-water, dried at 103°C cooled and weighed. At the end of each run, the electrodes were washed thoroughly with water to remove any solid residues on the surface, dried and reweighed [4].

C. Experimental Setup

The reactor used is made up of perspex material having a capacity of two liter. The dimensions were planned in such a way that it offers a higher electrode area to the smallest volume in all possible arrangements of the electrodes and it is nonreactive with textile wastewater. The batch experimental set up was used for the electrochemical oxidation studies and is schematically depicted in Fig 1. The dimensional characteristics of the experimental set up and electrical assembly is shown in Table I. The electrolysis was carried out under optimized conditions at different current intensities. Each experiment was of batch operation with duration of 180 min. For every 30 minutes samples were drawn and analyzed for COD, color, pH, and temperature.

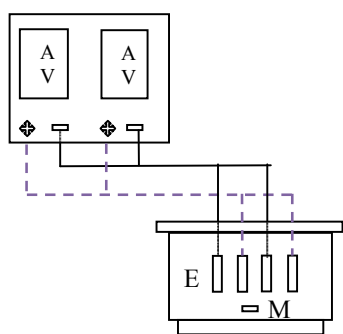


Fig. 1 Experimental setup, E=electrodes, M=magnetic bit

TABLE I
DIMENSIONAL CHARACTERISTICS OF EXPERIMENTAL SETUP

Sl no	Parameters	Results
1	Reactor type	Batch mode
2	Volume	2 L
3	Electrode	5 x 5 cm ²
4	Plate arrangement	Independent
5	DC dual power supply	Testronix-35 D, 0-10A, 0-15V / New Bio Scientific. Co. 0-3A, 0-15V
6	Reactor size	16cmX11cmX14cm

D. Analysis

The pH measurements were made using Elico pH meter (LI 120). The chemical oxidation demand of the effluent sample was determined by closed reflux method, using COD digestion apparatus Model ET 108, Lovibond. The absorption spectra of the samples were recorded to measure color on Elico scanning mini spectrophotometer (SL 177), recording the spectra over 340nm to 1000nm range. The characteristics of industrial effluent were determined according to APHA standard methods. All the reagents used were of analytical grade.

To estimate the color removal, the disappearance of the absorbance peaks of the solution was monitored. Percent of

color removal was calculated as per equation 1 and notations are given below,

$$\text{Color Removal (\%)} = \frac{[Abs_0 - Abs_t]}{Abs_0} \times 100 \quad (1)$$

where,
Abs₀ = Initial absorbance of the raw sample (390nm)
Abs_t = Absorbance of the treated samples at regular intervals.
The percentage COD removal was calculated using (2).

$$\text{COD Removal (\%)} = \frac{[COD_0 - COD_t]}{COD_0} \times 100 \quad (2)$$

where,
COD₀ = COD in mg/L before treatment.
COD_t = COD removed in mg/L at regular intervals during treatment.

III. RESULTS AND DISCUSSIONS

Electrochemical oxidation process was carried out for five different current intensities i.e. 0.1A, 0.14A, 0.24A, 0.28A and 0.33A. The percentage of removal of COD and color w. r. t different current intensities are shown in Figs. 2 and 3 respectively.

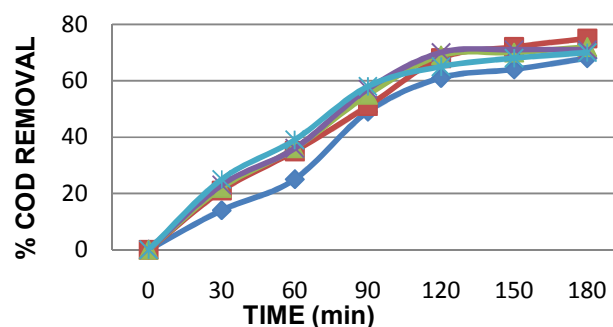


Fig. 2 Percentage removal of COD at different current densities
◇ 0.1A, □ 0.14A, △ 0.24A, × 0.28A, * 0.33A

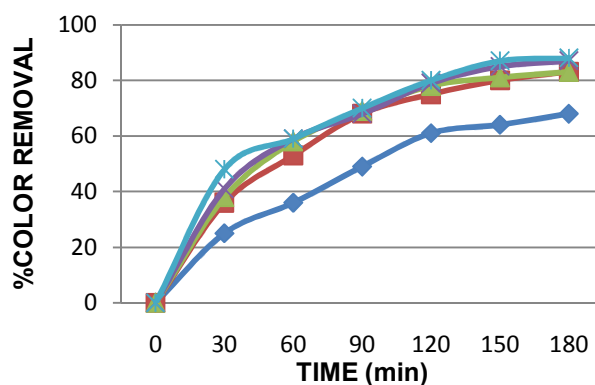


Fig. 3 Percentage removal of color at different current densities
◇ 0.1A, □ 0.14A, △ 0.24A, × 0.28A, * 0.33A

The percentage removal of COD for 0.1A, 0.14A, 0.24A

0.28A and 0.33A was 68%, 75%, 72%, 71%, and 70% respectively, and similarly color removal was 65%, 83%, 83%, 87%, and 88% respectively. The maximum increase in COD removal and color removal was seen from 90 to 120min for all the current intensities. The trend of COD reduction with electrolysis time remains same for all the current intensities adopted in the present investigation. Also from Fig. 3 it can be ascertained that decolorization increases with increase in electrolysis time and current intensity because, when the current intensity increases, the efficiency of ion production on the anode and cathode increases. Therefore there is an increase in the floc production in the solution and hence the improvement in the efficiency of color removal [3]. From the results it was observed that percentage removal of COD and color for a current intensity of 0.14A found to be maximum with removal of 75% COD and 83% color. During the process there is an increase in temperature. The Increase in the temperature is mainly due to the electrolytic dissociation (Arrhenius Ionic Theory), and it has been established the influent pH is an important operating factor influencing the performance of electrochemical process [1]. The effluent pH would increase for acidic influent but decreases for alkaline influent. This is one of the advantages of this process. The increase of pH at acidic condition was attributed to hydrogen evolution of cathodes. But besides hydrogen evolution, the formation of OH⁻ ions near the anode would release H⁺ leading to decrease of pH.

From Figs. 2 and 3 it can be observed that current intensity of 0.14A for four plate electrodes can be considered as optimum current intensity w.r.t. other current intensities in terms of percentage COD removal, color removal, energy consumption and anodic consumption and characteristics related to the same are shown in Table II.

TABLE II

RESULTS OF VARIOUS PARAMETERS FOR CURRENT INTENSITY OF 0.14A

Sl no	Parameters	Results
1	COD removal %	75
2	Color removal %	83
3	Energy consumption (Wh/kg COD)	291.66
4	COD removal rate (kg COD h ⁻¹ A ⁻¹ m ⁻²)	2.057
5	Anode consumption (g/m ² /h)	19.02

IV. CONCLUSIONS

Electrochemical oxidation process for four plate electrodes was carried out for five different current intensities, out of which 0.14A has achieved maximum percentage removal of COD with 75% and 83% of color. For all the applied current maximum removal efficiency of COD and color occurred at duration of 120 minutes. Therefore, current intensity of 0.14 A is optimum with a percentage removal of COD (68%) and color (75%) for electrolysis duration of 120 minutes. The COD removal rate in kg COD/h/m² decreases with increase in the current intensity. The energy consumption increases with increase in the current intensity. Hence, finally it can be concluded that textile dye wastewater can be effectively pretreated by electrochemical oxidation method where the

process limits objectionable color while leaving the COD associated with organics left for natural degradation thus causing a sustainable reduction in pollution load.

REFERENCES

- [1] Chen Guohua, "Electrochemical Technologies in Wastewater Treatment", *Separation and Purification Technology*, 2004, 31.
- [2] K Bahadir Korbahti, Abdurrahman Tanyolac, "Electrochemical Treatment of Simulated Textile Wastewater with Industrial Components and Levafix Blue CA reactive dye", *j.haz mat*, 2006, pp 422-31.
- [3] N Daneshvar, Ashassi Sorkhabi, H, M B Kasiri, "Decolorization of Dye Solution Containing Acid Red 14 by Electrocoagulation with a Comparative Investigation of Different Electrode Connections", *Haz Materials*, 2004, B112, pp.55-62.
- [4] O T Can, Bayramoglu, M Kobya , "Decolorization of Reactive Dye Solution by Electrocoagulation Using Aluminum Electrodes" *Ind. Eng. Chem Res*, 2003, V (42), 3391-3396.
- [5] Subrata Das, "Textile Effluent Treatment, and A Solution to the Environmental Pollution" 2000.
- [6] Xuejun Chen, Zhemin Shen, Xiaolong Zhu, Yaobo Fan, Wenhua Wang, "Advanced Treatment of Textile Wastewater for Reuse Using Electrochemical Oxidation and Membrane Filtration", 2005, ISSN 378-4738, *Water SA Vol. 31 No. 1*

Dr. Usha N. Murthy- presently serving as Professor in Civil Engineering Department, Bangalore University has about 31 years of Teaching and Research experience and has guided 02 students for Ph.D degree and more than 50 practical oriented Dissertation topics at PG level and is currently guiding about 05 Ph.D students. She has about 65 technical papers in various National and International conference and about 15 Journal papers and associated with KSCST projects, CPCB and KSPCB organizations. She has successfully completed all the confidential tasks assigned by the University.

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