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Electrochemical Degradation of Textile Dye Wastewater Using Stainless Steel Electrode

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Abstract: ***The last decades the request for environmental conditions has increased dramatically, the biological threats can be expressed in every aspect of the daily life. The efficiency of electrochemical oxidation technique depending on many factors such as material of electrode used, composition of electrolyte, electrical energy density, mass transfer and electrolysis time. This technique has many advantages such as safety, effectiveness of current density, selectivity, less operational cost and environmental safety. In this investigation, the degradation operation by electrochemical oxidation was performed using stainless steel as anode and cathode to treating textile dye wastewater contain of procion red mx5b dye. The effects of operating conditions such as current density, effect of initial dye concentration and effect of pH on the degradation operation was studied at optimistic condition. We concluded from our results that electrochemical degradation can used as pretreatment and we finding this technique are effective to treat our electrolyte.***

Keywords: Degradation, Textile Dye Wastewater, Electrochemical Oxidation, Batch Reactor, Stainless Steel Electrodes, UV Spectrophotometer, Electrolysis Time.

1. Introduction

Textile industry plays a vital role in the economy of many countries. Textile industry considers oldest and largest industry existing around the word. The gross domestic product of some countries like Sri Lanka, Vietnam and Mauritius increasing by textile industry growing where this industry play important role to provide functions for people whom didn't have special skills. The textile industry is the only industry that has generated huge employments after agriculture in India. This industry in India offers direct employment to over 35 million in the country. Moreover, another 54.85 million people are involved in its allied activities [1].

The chemicals and water will be consumed with large amount in wet process of textile industry where to produce 1 kg of textile we consume about 200 L of water. The usage of water in textile industry is mainly in two operations which are chemicals employment onto the fibers and final products rinsing [2].

Textile dye included the major unit operations which are as follows:

Desizing, Scouring, Mercerising, Bleaching, Dyeing, Printing, Finishing.

Many methods can be used to treat the textile effluents such as physical, chemical and biological methods. The simple and cheap method can be applied to remove colour and organic pollutants from textile wastewater is Biological method. Some pollutants producing from textiles industry cannot remove by biological operation and cannot treat by traditional methods such as refractory pollutants, this pollutant will remain in waste water. The other disadvantage of conventional biological process to treating textile wastewater is most commercial dyes are toxic to the organisms which are used in this technique. So, other methods must be used such as physical and chemical methods. [3]

In electrochemical oxidation the many factors are important such as electrolysis time, pH and concentration of electrolyte and anode material which is important factor. The temperature does not have effect on output of direct oxidation. The electrochemical model consists of anode and cathode, where those electrodes must be immersed in the electrolyte (synthetic solution) which is connected to electrical loop. Electrical circuit contains source of current and control device, where the electrical energy used to impact a chemical change. In this technique, the oxidation and reduction processes occurring at the electrolyte interface and at electrodes. [4]

The reduction processes occurs at the cathode electrode and the oxidation processes occurs at the anode electrode. The maintaining of the current flow continuous is by the electrons flow which producing from electrical source. The solution must be an electrolyte to permit the current to flow by the motion of its ionic charged species. Different factors are important to get high efficiency of electro chemical oxidation process and the important impact on the process is type of electrolyte which play main role in the formation of oxidizing species during the process. [5]

2. Specifications and Experimental Procedure

- **Electrochemical Oxidation Reaction**

For the electrochemical oxidation reaction reactor system contain the stainless steel (18 cm × 2.4 cm × 0.1 cm) as an anode and (18 cm × 2.4 cm × 0.2 cm) as a cathode were placed 6cm apart which were attached to DC supply.

The steps of supplied energy to an electrode during the process are as following:

1) The electro active particle is transported from the solution to the surface of electrode.
2) The electro active particle is adsorbed on the electrode surface.

3) The electron transfer occurs between the electrode and the bulk solution.
4) The reacted particle is either deposited at the surface of electrode or transported to the Solution (desorption).

The DC power supply was used to provide the electric energy required during the electrolysis. The magnetic stirrer was used in electrical cell to keep the solution well mixed.

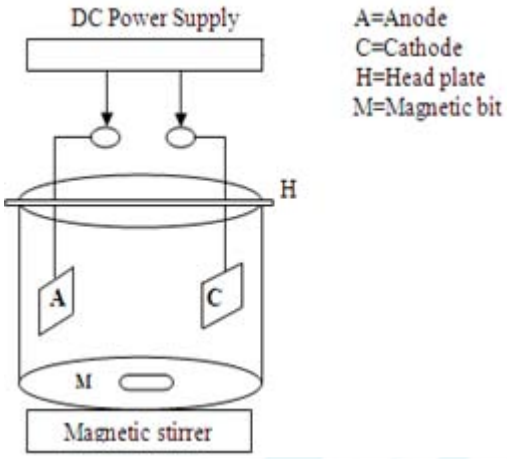


Figure 1: The schematic diagram of the experimental setup

In this study, we studied the effect of voltage, initial dye concentration and pH on the degradation of procion red mx5b dye. Different densities of current were used to study the performance of the electrochemical Cell. The electrochemical cell has a volume of 1000 ml. For each experiment 1 liter of aqueous dye solution was prepared. The duration of each experiment was 60 minutes and every experiment was batch process. The removal of colour was calculated by drawn of samples every 15 minutes. We have to remove the sediments from the surface of electrode, therefore prior each experiment electrodes were dipped into dilute HCl for few minutes and after that washed with distilled water. 1 gm of common salt was added as a supporting electrolyte. The electrical energy used to heating the water must be calculated to prevent any wasting of energy .The current effect on process efficiency depending on current density supplied.

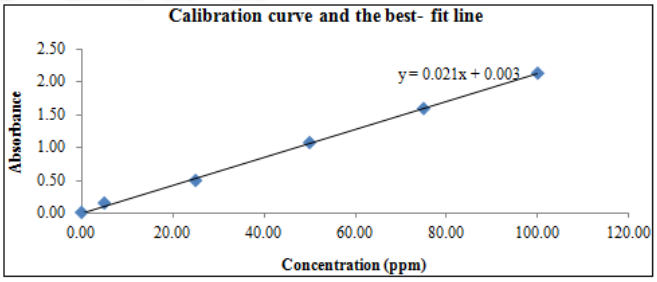
- **Analysis**

Solution pH measured by using the pH meter Labline Auto Digital. The DC power supply for the electrochemical oxidation was supplied by (Testronix 32C DC power). UV Spectrophotometer was used for the analysis of absorbance (LABINDIA UV 3000^{+}).

- **Calibration Curve and Best Fit-Line**

We prepare our known samples with concentrations of 5, 25, 50, 75 and 100 mg / liter (ppm). We measure their absorbance. Our results are shown in the table below.

Concentration (ppm)	Absorbance
0	0
5	0.14
25	0.49
50	1.07
75	1.59
100	2.13



- **Determining the Percentage of Decolourization (Color Removal Ratio)**

Color Removal Ratio Calculated as Follows**:**
Absorption (%) = [(Initial absorbance of the raw sample - Absorbance of the treated samples) / Initial absorbance of the raw sample)*100]

$$abs(\%) = \frac{abs(i) - abs(t)}{abs(i)} x100$$

Where, **abs (%)** = Absorbance in percentage, **abs (i)** = Initial absorbance of the raw sample,
Abs (t) = Absorbance of the treated samples at regular time intervals.

3. Result and Discussion

- **Effect of Voltage**

The experiment was carried out at five different voltages 5, 10,15,20,25 at 5 ppm dye concentration. It is clear that the degradation is increases as the voltage increases. The 25v was the optimized voltage.

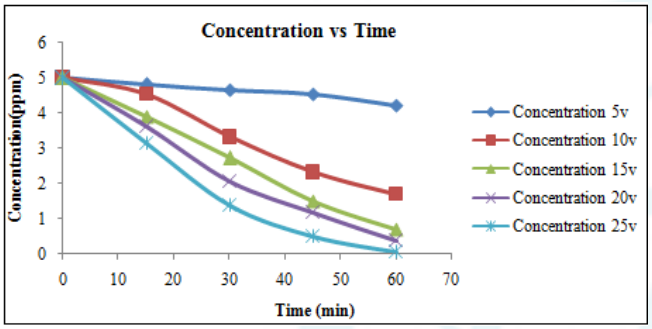


Figure 2: Concentration Vs Time (Effect of Voltage)

- **Effect of Initial Dye Concentration**

Effect of initial dye concentration shows the significant effect on degradation. Effect of initial dye concentration was carried out at optimized voltage i.e. 25 v. the dye concentration varied from 2 to 11 ppm.

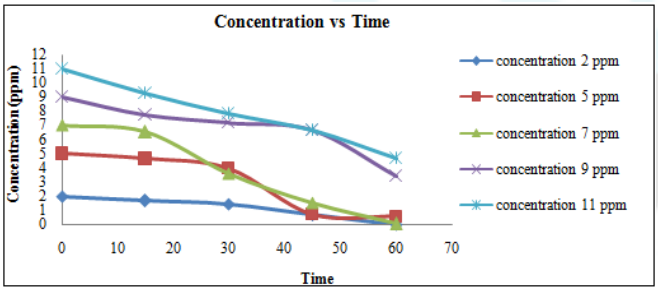


Figure 3: Concentration vs time (effect of initial dye concentration)

- **Effect of pH**

In this study the solution pH varied from 2 to 12 at 5 ppm dye concentration. In this study pH did not show any considerable effect on degradation of procion red mx5b dye.

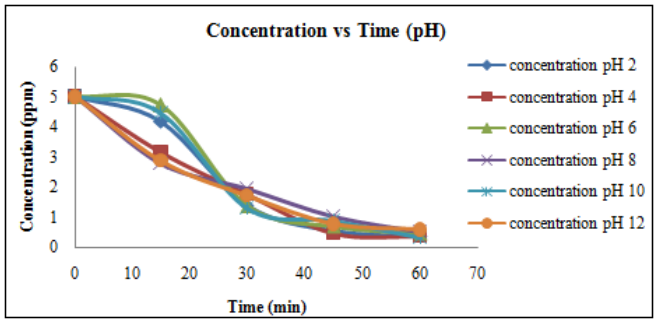


Figure 4: Concentration Vs Time (Effect of pH)

4. Conclusion

A study for decolorization/degradation of procion red mx-5b dye was investigated using electrochemical oxidation. This technology of treatment was used for 60 minutes to remove the colour of procion red mx5b dye from synthetic effluent and the electrodes used as anode and cathode were from stainless steel material. The results of the present studied showed the electrochemical oxidation could be the effective treatment for the decolourization of procion red mx5b dye. From the study we proposed that the electrochemical degradation could be the best solution for the effective treatment of textile wastewater.

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