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Effect of pH and Electrolysis Time on Removal of Reactive Black B dye by Electrochemical Treatment

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***Abstract* -The electrochemical treatment was an effective technique in dye processing and it can be enforced to remove color from dye solution. An Experimental setup was made for electrochemical treatment of synthetically prepared Reactive Black B dye in batch mode operation using aluminum electrodes. Based on probability the operating parameters such as pH, Concentration, Electrolysis time, Retention time were determined from which the color removal efficiency (CRE) is optimized. The maximum color removal efficiency of Reactive black B dye was achieved at 98.23% for the concentration of 10mg/l.**
Keywords: **Reactive Black B, Aluminum, Color, pH, Efficiency**

I. INTRODUCTION

Textile industries are one of the major areas that have an importance throughout the world. However, off recent, the industry has been the epicenter of a massive pollution problem, worldwide. Mainly, pollution in the textile waste water comes from the dyeing and finishing processes. Before water is released into the nearest water body it is essential that it is treated properly in order to ensure that there is significant reduction in the level of pollutants. Releasing the untreated colored water can cause the environmental severe effects surface and subsurface water bodies. The dye can be classified as Acid, Direct, Azoic, Sulphur, Reactive, Basic, Vat, and metal complex dyes [1].More than 3600 textile dyes are being manufactured by the various industries today. The textile industries use 8000 and above chemicals in various processing including printing and dyeing [19]. The Decolonization is achievable using one or combination of the Adsorption, Filtration, and Precipitation, Chemical degradation, Photo degradation and biodegradation methods. The Electrochemical color removal from waste water occurs by a combination of adsorption and chemical reduction. In electrocoagulation no more coagulant has been added so the salinity of treated wastewater should be controlled.

Electrocoagulation is compact and effective method to treat various wastewaters like as textile dye water [2], landfillleachate [13],Tannerywastewater [6], oil and water emulsion [12], this experimental study deals with the electrochemical treatment of synthetically prepared Reactive Black B dye from aluminum electrodes.

A. Electrocoagulation mechanism

Three main processes occurring in the Electrocoagulation process like as;

1. Electrolytic Reaction at the electrode surface,
2. Formation of coagulants in the aqueous phase,
3. Adsorption of soluble and colloidal pollutants on coagulants, and removed by sedimentation or flotation [16],

Anode:

$$Al \rightarrow Al_3 + 3e^-$$

Cathode:

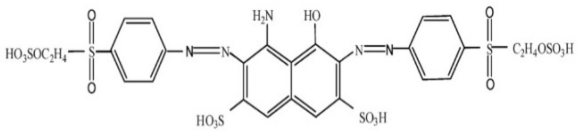
$$3H_2O + 3e \rightarrow 3/2H_2 + 3OH^-$$

Generally textile wastewater containing chlorine components, which may cause further reaction, occurs in the electrocoagulation process. During the electrocoagulation presents of chlorine atoms oxidizing the organic components in wastewater and increase the color removal efficiency.

$$2Cl+Cl_2+2e^-$$

The cathode has been electrochemically affected by OH^- ions due to release of H_2 gases in the solution. H_2 gas generation rate it depends up on the pH of the solution (Picard et al., 2000). $Al_{(aq)}^{3+}$ and OH^- ions generated by reactions (1) and (2) and it forms monomeric specious as $Al(OH)_2^+$, $Al(OH)_2^+$, $Al(OH)_4^-$ $A_{l2}(OH)_{24}^+$, $Al(OH)_4$and polymeric specious such as $A_{l6}(OH)_{15}^{3+}$, $Al_7(OH)_{17}^{4+}$,$A_{l8}(OH)_{20}^{4+}$, $Al_{13}O_4(OH)_{24}^{7+}$ and $Al_{13}(OH)_{34}^{5+}$ which finally transforms into $Al(OH)_3$ according to complex precipitation kinetics[11]. Two major mechanisms is involved in the electrocoagulation process such as precipitation and adsorption, those mechanisms have been depends on the pH of the solution. Flocculation in lower pH range considered as precipitation and higher range is considered as the adsorption [15].

TABLE I CHARACTERISTICS OF REACTIVE BLACK B DYE

Dye	Reactive Black B
Appearance	Powder
Color	Black
Odor	None
Dye group	Anionic
λmax	591nm
Structure  Chemical structure of dye-Reactive Black B (RBB)	

II. MATERIALS AND METHEDOLOGY

Reactive Black B dye was purchased from Indian dyes Tirupur, It is water soluble anionic dye used for dyeing silk, woolen and nylon in textile industries. The general characteristics and structures[11] of dye is listed in below Table 1.The experiment carried out effect of pH, Concentration, Electrolysis time, Retention time with synthetically prepared Reactive Black-B dye. The experiment was studied under batch mode operation in 500ml beaker shown in fig 1. Two electrodes were used. Both the electrodes are made of aluminum connected to monopolar series. This electrode was connected to DC variable power supply providing 0 – 30 V (0-5 ampere) potentiometric power supply.

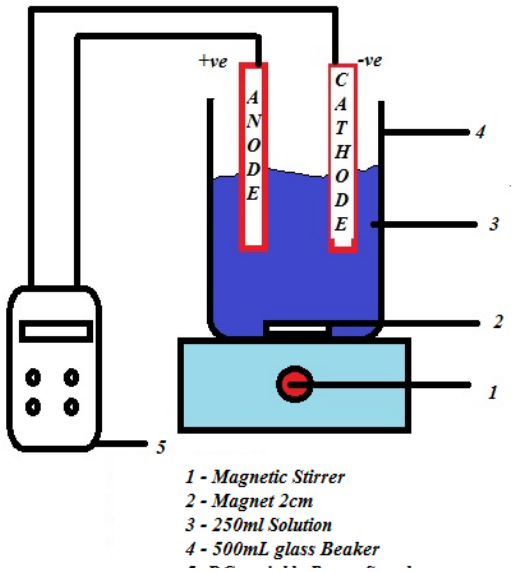


Fig. 1 Electrocoagulation reactor

The solution in the beaker was agitated by magnetic stirrer having a dimension of 2cm, for maintaining uniform concentration. The dimensions of anode and cathode are 10cm x 5cm x 0.1cm (Length x Breadth x Thickness) and it is submerged into 4.5cm in the solution, and the submerged area of the electrode surface is 22.5cm2. The spacing between the two electrodes was maintained at 3cm. The agitation speed of the magnetic stirrer was maintained at 300rpm and current density was maintained 1.5ampere. After the process, the impurities in the electrodes were removed by dipping the electrode in 100ml of 0.1mole HCL. The solid surface of the electrode was then thoroughly washed and air dried before weighing. pH of the Reactive Black B dye was adjusted by adding Sodium hydroxide (NaOH) 0.1N and Hydrochloric acid (HCL) 0.1M respectively. Conductivity of the solution was changed by adding necessary amount of sodium chloride. The dye concentration was analyzed by using double beam UV spectrophotometer and the wavelength of the dye was fixed as 591nm[1].

*Calibration:*The calibration curve was prepared from 0-50mg/l at every 5mg/l of the solution and it based on the above mentioned wavelength based absorbance value and it shown fig 2. The colour removal efficiency was calculated using the following equation

$$CRE = \frac{Co - Ci}{Co} \times 100$$

Where,
CRE=colour removal efficiency,
Co = Final Concentration,
Ci = Initial Concentration

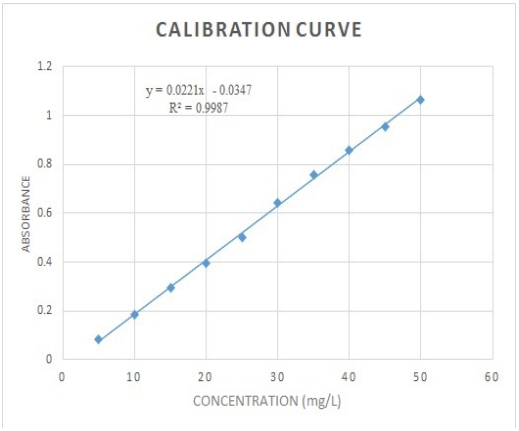


Fig. 2 Calibration Curve

III. RESULTS AND DISCUSSION

A. Effect of pH

The colour removal of the solution was carried out using the pH variation of 4, 7 and 9 respectively. For pH is 2,4,7,9 and 11 the colour removal efficiency was obtained as 69.31%, 87.69%, 97.39%, 98.16% and 98.23% respectively as mentioned in fig 3. When pH lies between 4-9 the electrodes generate Al^{3+} and OH^- ions leading monomeric and polymeric reactions forming complex state of $A_{l3}(OH)_3$ resulting higher removal efficiency. In order to increase the pH of sample higher amount of NaoH is added that produce salinity henceforth neutral pH of 7 is adopted in this experiment.

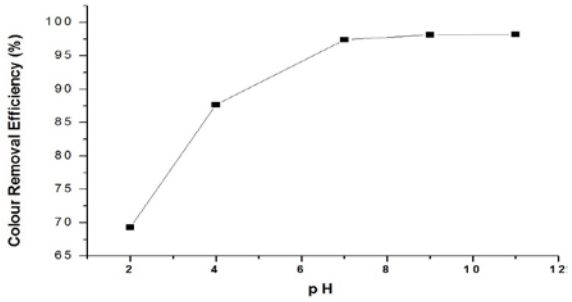


Fig.3 Electrolysis time = 30 minutes, Retention time = 150 minutes, Concentration = 10 mg/L.

B. Electrolysis time

Electrolysis time is the main parameter in electrocoagulation, which represents the cost of power consumption when adopting pilot scale set-up. The colour removal efficiency depends on generation of Al_3^+ and OH^- ions.Al_3^+ ions

production was determined by the Electrolysis time. Different Electrolysis time was carried out between 5-30 minutes and CRE was monitored for every 5 minutes interval of time. When electrolysis time was between 5-15 minutes the Colour removal efficiency was achieved to 30-60%.At the end of 30 minutes colour removal efficiency was attained to be 98.23% that was mentioned in figure 4.

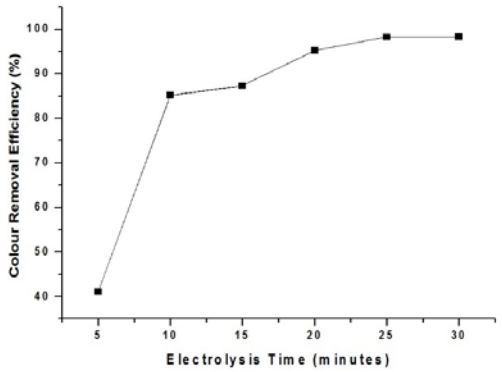


Fig. 4 pH = 7, Retention time = 150 minutes, Concentration = 10 mg/L.

IV. CONCLUSION

The experimental setup is highly suitable for treating the synthetically prepared Reactive black B dye. The maximum colour removal efficiency of 98.23% was achieved at pH 11, concentration of 10 mg/L, electrolysis time of 30 minutes and retention time of 150 minutes. Further research will be carried out on Effect of concentration, Retention time, Electrical conductivity, and Current Density.

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