



ELECTROCHEMICAL DECOLORIZATION OF DIRECT BLACK TEXTILE DYE WASTEWATER

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ABSTRACT

Electrochemical decolorization of direct black textile dye was studied in the presence of sodium hydroxide (NaCl). Electrochemical cell occupy about 1 liter of working electrolyte supplied with graphite electrodes for both anode and cathode was constructed for this purpose. Decolorization percent, treatment time, power consumption, and pH were studied as a function of the applied voltage and salt concentration. Results show that decolorization increase with increasing salt concentration and applied voltage. Best decolorization of 86% can be achieved after 17 min at 7 volt and 5 g/l salt concentration. Further decolorization can be achieved but this will be accompanied with a sharp increase in power consumption. No significant decrease in pH value was observed at the end of each experiment.

KEYWORDS: Dye removal, decolonization, direct black, electrochemical, wastewater.

7 %86

17 \ 5

INTRODUCTION

Dyes used in textile industries were considered to be one of pollution sources, not because the color of thrown wastewater only but because that these dyes contain usually toxic compound that can effect the environment. The removal of dyes is therefore was considered to be a challenge for both the textile industry and the wastewater treatment.

There are many methods used to treat wastewaters containing dyes. Such methods classified as biological methods, physicochemical methods, adsorption, membrane filtration and ozonation. However, in recent years, attention was increased to the use of electrochemical techniques for the treatment of wastewater. Electrochemical technologies such as electrooxidation, electrocoagulation, and electrofloatation have been

widely used in water and wastewater treatment and several applications have been studied (Christos Comninellis and Guohua Chem, 2010). The electrochemical degradation of some synthetic and actual dye effluents over some electrodes had been studied by many authors (Efthalia Chatzisyneon *et al*, 2006, M. Fatima Esteves, 2004). Electrocoagulation includes the electrochemical formation of coagulants usually using aluminum and iron electrodes, adsorption of soluble or colloidal pollutants on coagulants, and removal by sedimentation and floatation (Peter K. Holt *et al*, 2004; Fatih Ilhan *et al*, 2008). In each of the methods there is some degree of removal and combining with other treating methods, high decolorization and oxidation of some dyes can be achieved (Tak-Hyun Kim *et al*, 2002).

Pollutants destruction in the presence of NaCl was studied by many authors (Comninellis and Nerini, 1995) and seems to be attractive in the destruction of different dyes in many types of electrochemical reactors (Karuppan Muthukumar *et al*, 2004; Raghu and Ahmed, 2008; Raghu and Ahmed, 2007) since it is of low cost, availability, easy to handle without problems. The purpose of this study is to investigate the electrochemical removal efficiency (decolorization) of Direct Black dye from textile wastewater in the presence of NaCl in an electrochemical reactor.

EXPERIMENTAL WORK

Electrochemical Cell and Equipment

Electrochemical experiments were conducted in electrochemical cell made of glass material with dimensions of 10 cm height x 15 cm width x 10 cm depth, filled by 1 liter of working electrolyte (dye solution containing NaCl) during each run. Graphite electrodes were mounted at the long side ends and magnetic stirring was applied to maintain the pH constant along the cell. Farnell stabilized power supply (model L30E, UK) was used to apply the electric current and two digital multimeters (model DT9205A, China) were used to measure voltage and current. pH measurements was achieved using Thermo Fisher Scientific portable pH meter (model Orion 3 star, USA) and Dye concentration was measured

spectrophotometrically using Labomed Inc. spectrophotometer (model Spectro SC, USA).

Dye Preparation

Direct black textile dye solution of 10 mg/liter (10 ppm) concentration was prepared in simulation to that effluent discharged by the State Company for Textile Industries (Kadhmia, Baghdad). This was suggested to be the normal effluent dye concentration discharged by the company (Rasha H. Salman, 2010).

Decolorization Measurement

NaCl up to 10 g/l was added to the reaction cell to improve decolorization efficiency. Samples were taken from the reaction cell during the experiment for spectrophotometrically measurement at wavelength of 566 nm and expressed in terms of concentration. pH was taken at the beginning and end of the experiment. All measurement and experiments were conducted at 28-30°C temperature range.

RESULTS AND DISCUSSION

Effect of Applied Voltage on Decolorization Percentage

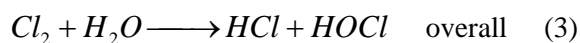
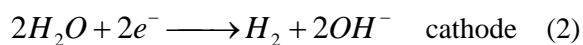
Figs. 1-3 show the effect of increasing the applied voltage on the decolorization percent, treatment time, and the power consumed at different salt concentrations. Samples were taken for analysis and the effective treatment time was taken just when there is no significant improvement in removal efficiency. It is clear that there is a direct relationship between the applied voltage and decolorization percent and power consumed; as the potential increases, power consumption and decolorization also increases for a given salt concentration. Also, decolorization can be achieved at reduced effective treatment times as the potential increases which may give the attention to work at some optimum point (Maria A. Sanroman *et al*, 2004).

From **Figs. 1-3**, the best operating point was suggested to be at 7 volt and 5 g/l salt concentration (maximum possible dye removal with low power consumption). This gives about 86% decolorization percent in 17 min. It is



possible to achieve higher decolorization in lower times (100% decolorization can be achieved virtually) but this should be accomplished at high power consumption rates. Power consumption start to increase gradually and linearly at 3 g/l salt concentration at all voltage ranges but it increases exponentially at higher salt concentrations and especially in the region when the voltages move from 7 to 10 volt.

The use of NaCl in the reaction cell will generate chlorine gas from the chloride ions at the anode electrode surface as indicated by equations 1-3. Chlorine gas then will react with the OH^- generated from the hydrolysis of water at the cathode surface to give hypochlorate. In this process, mixing is required to increase the reaction extent. This will enables the hypochlorate to spread along the cell and not to reside near the anode which will cause long treatment time and more power consumption as compared if mixing exists.



The role of hypochlorate was reported by Vlyssides (Vlyssides et al, 1999) and it seems to be responsible for the oxidation of dye and the rate of decolorization was affected directly by the rate of production of hypochlorate. This was also confirmed in this study.

Effect of Salt Concentration

The effect of different salt concentrations up to 10 g/l on decolorization percent were shown in **Figs. 4-7**. Normalized concentrations were used in these plots which give the dye concentration divided by the initial concentration. It should be noted that no decolorization was detected in the absence of NaCl in all applied voltage ranges. The decolorization percent increases as NaCl concentration increases. It seems that decolorization starts after the addition of NaCl and this was achieved after 7 min at 3 volt. This time were reduced with increasing the applied voltage for a given amount of salt.

The profiles obtained indicate that a minimum amount of NaCl was needed to start decolorization and there an optimum amount of NaCl which should be selected to overcome the problem of increasing the salinity of the treated wastewater. Also, the study indicates that there is no need to add salt continuously to the working solution since NaCl was not consumed during the electrochemical process as shown in equation (1).

Effect of Electrodecolorization Process on pH

As the reaction proceeds, generation of gas bubbles was observed at the surface of the electrodes due to the electrolysis of water in which oxygen gas was generated at the anode and hydrogen gas and hydroxyl ions were generated at the cathode. Therefore the pH increases near the anode and decreased near the cathode. So that, mixing is important to make the pH of the cell constant. pH was measured at the beginning and at the end of the experiment. Recorded values indicates that pH does not affected significantly during the experiments and it just moves to a lower values (acidic direction) with a maximum of 0.5 from that value at the beginning of the experiment. This is evident that production of H^+ ions is greater than OH^- ions resulting in a shift of pH to the acidic region.

CONCLUSIONS

1. Electrochemical decolorization of Direct Black dye can be effectively performed in electrochemical techniques to treat effluents containing this dye such that found in textile industry with high percentage of decolorization.
2. The use of salt in the process relies on the formation hypochlorate which seems to be a good oxidant for this type of dye.
3. Cell applied voltage affect the decolorization percent and treatment time, but power consumption should be taken in consideration in order to achieve lower cost treatment.
4. Electrochemical decolorization process of Direct Black dye does not affect the pH significantly.

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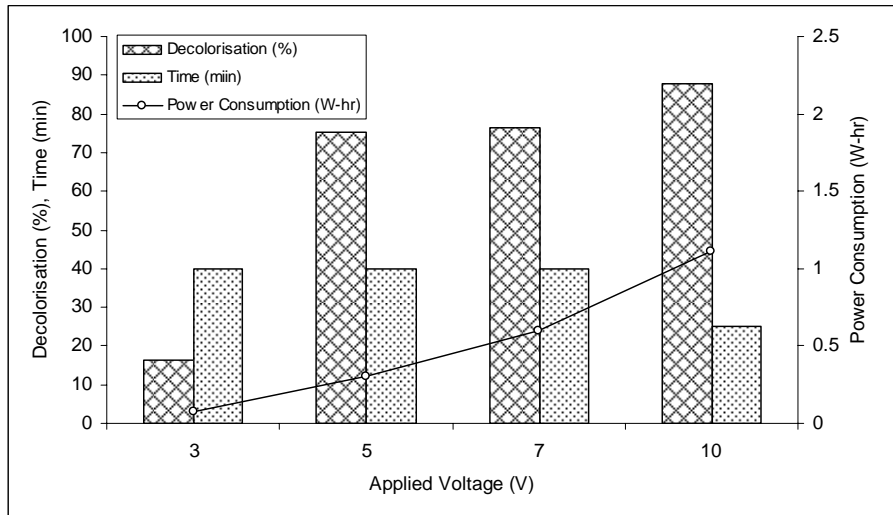


Fig.1 Effect of the applied voltage on removal percentage, treatment time, and power consumed with NaCl concentration of 3 g/l

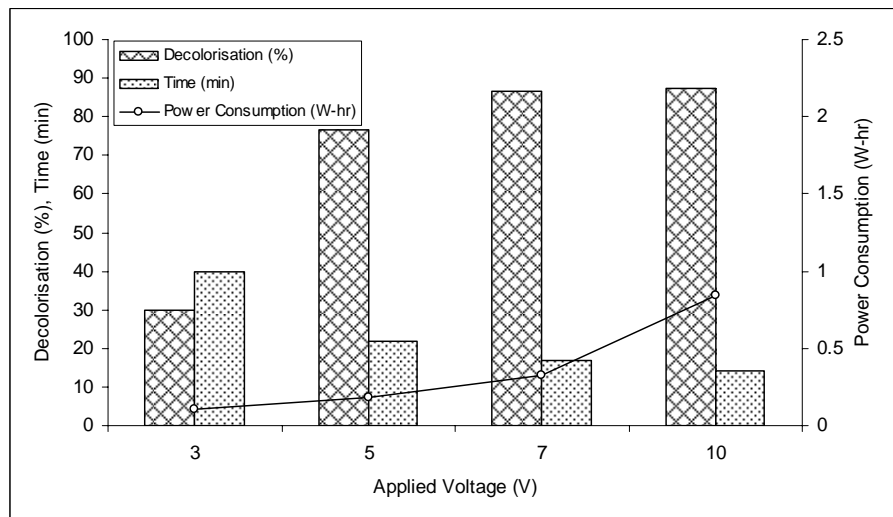


Fig.2 Effect of the applied voltage on removal percentage, treatment time, and power consumed with NaCl concentration of 5 g/l

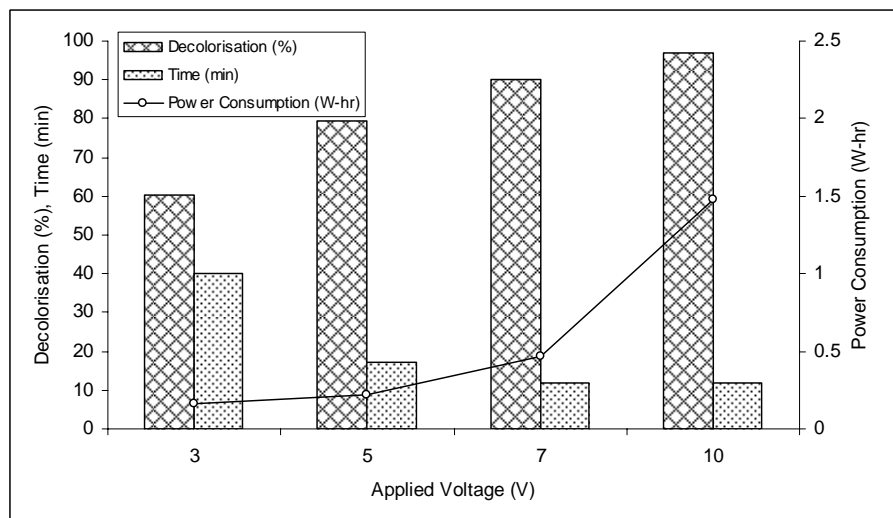


Fig.3 Effect of the applied voltage on removal percentage, treatment time, and power consumed with NaCl concentration of 10 g/l

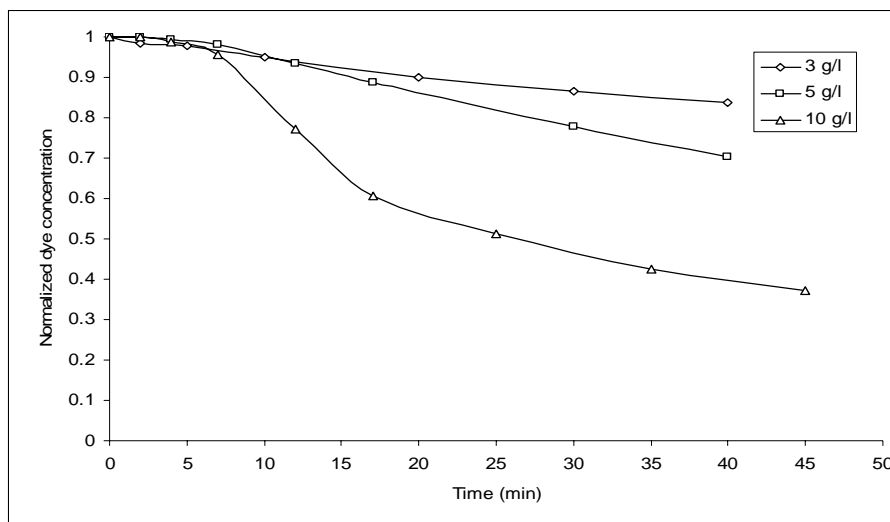


Fig. 4 Normalized concentration of Direct Black dye versus the treatment time at cell voltage of 3 V with different salt concentration

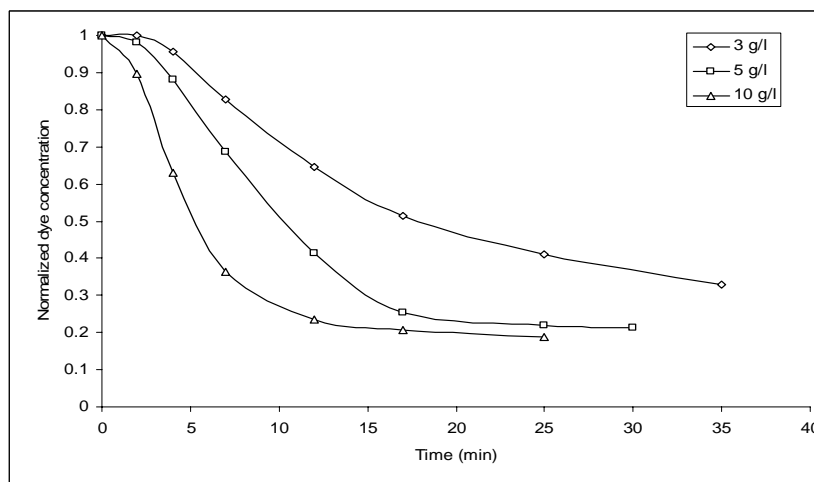


Fig. 5 Normalized concentration of Direct Black dye versus the treatment time at cell voltage of 5 V with different salt concentration

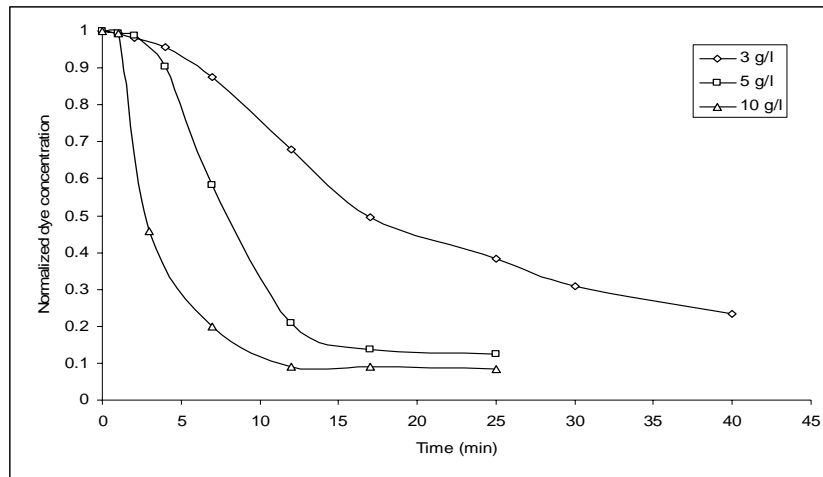


Fig. 6 Normalized concentration of Direct Black dye versus the treatment time at cell voltage of 7 V with different salt concentration

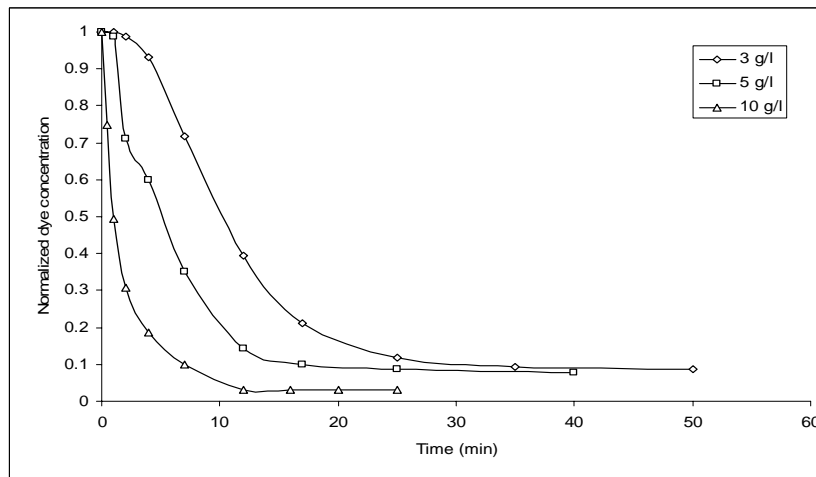


Fig. 7 Normalized concentration of Direct Black dye versus the treatment time at cell voltage of 10 V with different salt concentration