Journal of Engineering and Development, Vol. 16, No.2, June 2012 ISSN 1813- 7822

COD and Direct Blue Dye Removing from Textile Wastewater by Electrochemical Oxidation Method

Nidaa Adil Jasem
Asst. Lecturer/Highways &Transportation Dep.
College of Engineering/Al-Mustansiriyah University.

Abstract

An electrochemical cell is designed using a graphite plate as the anode and a stainless steel plate as the cathode with dimensions (7*4*0.3) cm^3. The tests were performed on a synthetic wastewater. Many experimental runs were done at a different operating conditions (pH, concentration of electrolyte and electrical supply voltage) to study the removal efficiency of electrochemical oxidation for the removal of COD and direct blue dye. The results indicated that the maximum removal were 89% and 98%for COD (chemical oxygen demand)and color respectively at pH 2, 500 mg/L NaCl concentration and 5 V electrical supply voltage.

Key Words *:Electrochemical Oxidation, Textile wastewater, COD, Direct Blue Dye.*

ملخص البحث

*يهدف البحث الى دراسة كفاءة ازالة اللون الازرق direct blue والمتطلب الأوكسجين الكيمياوى COD بالطريقة الكهروكيمياوية.تم تصميم الخلية الكهربائية باستعمال صفيحة من الكرافيت لقطب الأنود وصفيحة الحديد الغير قابل للصدأ لقطب الكاثود بأبعاد cm^3 (7*4*0.3). تم تحضير مياه صناعية مختبريا لأجراء التجارب عليها آخذين بنظر الاعتبار ظروف تشغيلية مختلفة لمعرفة مدى فعالية الأكسدة الكهروكيماوية في معالجة هذه المياه .أجريت عدة تجارب بتغيير pH وتراكيز كلوريد الصوديوم وفولتية التيار الكهربائي .أظهرت النتائج ان اعلى نسبة ازالة كانت 89%، 98% لكل من المتطلب الأوكسجين الكيمياوى واللون على الترتيب في ظروف pH=2 وتركيز كلوريد الصوديوم = 500 mg/L وفولتية =5 فولت.*

1. Introduction

Textile industries consume large volumes of water and chemicals in the wet processing of textiles. The chemical products used are different in composition, from inorganic compounds to polymers and other organic products [1]. Dye molecules often receive the largest attention due to their color , as well as the toxicity of some of the raw materials used to synthesize dyes

, although dyes are often not the largest contributor to the textile wastewater[2]. In recent years, there has been an increasing interest in using electrochemical techniques, such as electro coagulation, electro flotation, electro decantation, electrochemical oxidation and catalytic wet air oxidation for dye removal from effluents[3]. Electrochemical treatment is an emerging technology used for the removal of organic and inorganic impurities from water and wastewater. Hence, many researchers are attempting to use electrochemical methods for the treatment of wastewater. The treatment of the textile wastewater from dyes by combined chemical coagulation, electrochemical oxidation, and activated sludge process has been investigated by Sheng and Guohua[4,5] their experimental results were assessed in terms of chemical oxygen demand(COD)and color reduction to determine the treatment efficiency. Many advanced treatments have been studied and electrochemical oxidation has been applied to many kinds of wastewater [6]. An electrical process was studied by Rajeshwar et.al.1994 for decolorization, COD and SS removal from wastewater under variable conditions pH, current, reaction time and settling time. They reached optimum removals of 87%, 37%, 49% for color, COD, SS respectively at pH 5, using a current of 1.5 Amber and reaction time of 40 minutes[7]. Decolorization and degradation of synthetic and industrial textile wastewater were performed by Parsa et.al.2007 using the electrochemical oxidation process, they used Pt as the anode and stainless steel as the cathode for removing Mordant Red 3 dye. The results indicated that the removal of COD and color were 86% and 100% respectively, by increasing voltage of the current and chloride concentration at low pH[8]. The aim of this study is to investigated the removal of color and COD from synthetic waste water containing direct blue dye(the chemical composition of dye is shown in Fig.1) using an electrochemical oxidation process .

2-Amino-β benzenedisulofnic acid

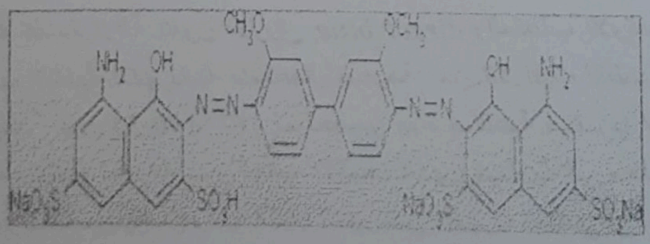
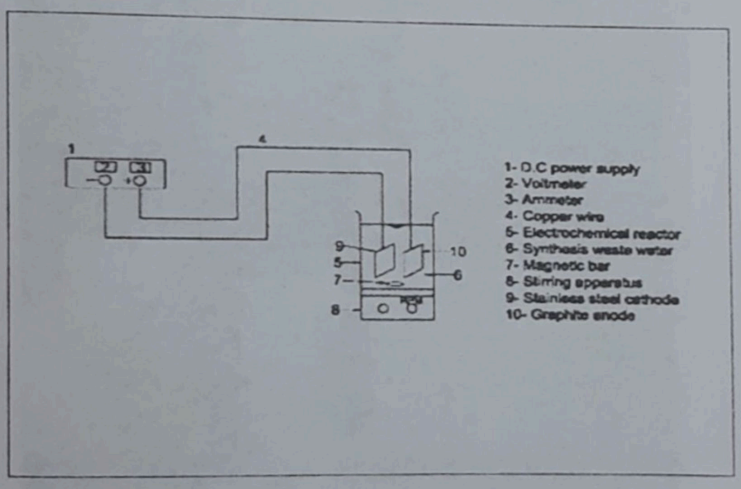


Fig. 1. Chemical composition of the direct blue dye.

2. Experimental work

The experiments were conducted in a beaker 0.5 L in capacity. The anode and cathode were positioned vertically and in parallel to each other with an inter electrode gap of 3.5 cm. The anode was a graphite plate (7*4) cm^2. Where the cathode was stainless steel plate of the same dimensions, the thickness of the plate was 0.3 cm. These electrodes were dipped in the electrolyte solution. Stabilized DC power supply was used as the source of electrical current.

Aschematic illustration of the experimental setup is shown in Fig (.2) and plates1-4. Preliminary experiments showed that stirring the solution between 100–400 rpm does not influence the rate of reaction, hence the solution was constantly stirred at 200 rpm using a magnetic stirrer in order to maintain uniform concentration of the electrolyte solution, a stirrer Model LMS-1003 Korea was used. Many experimental runs were performed under different operating parameters as shown in table (1). A synthetic wastewater was prepared using 1000 mg/L direct blue dye 2-Amino-β benzenedisulofnic acid. The color removal efficiency was calculated from the relative decrease of absorbance at 566 nm peaks. Experiments were carried out at room temperature. The samples collected were analyzed according to the Standard Method for Examination of Water and Wastewater [9]. For the determination of color , a spectrophotometer Therme electro corporation, Model GENSYS 10 UV(made in U.S.A) was used to measure the transmittance at wave length 566 nm. As for COD measurements the dichromate reflux method was selected. The experimental work was performed at the Sanitary lab./ Collegeof Engineering/ University of Al-Mustansiriyah.



Fig(2).Schematic diagram of the experiment set

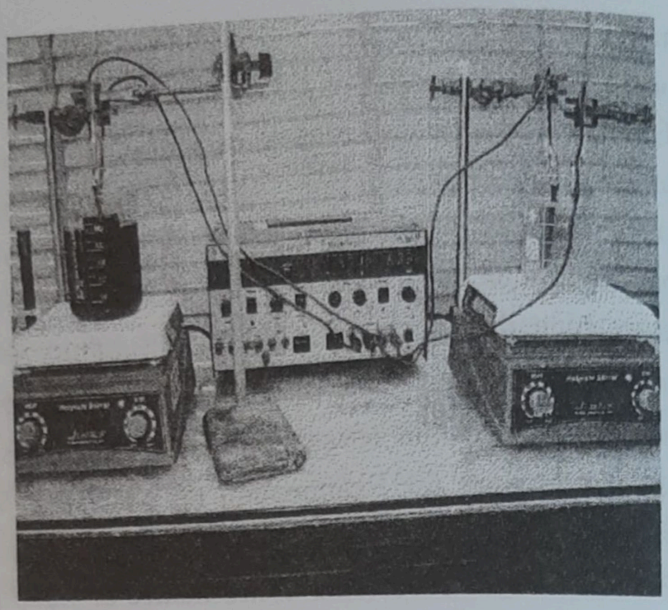


Plate1 .The experiment set Up

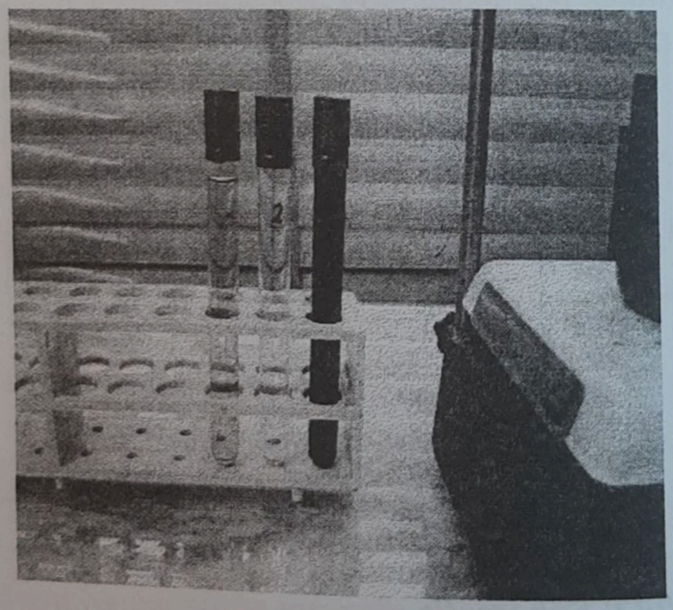


Plate2.The first two runs resultes

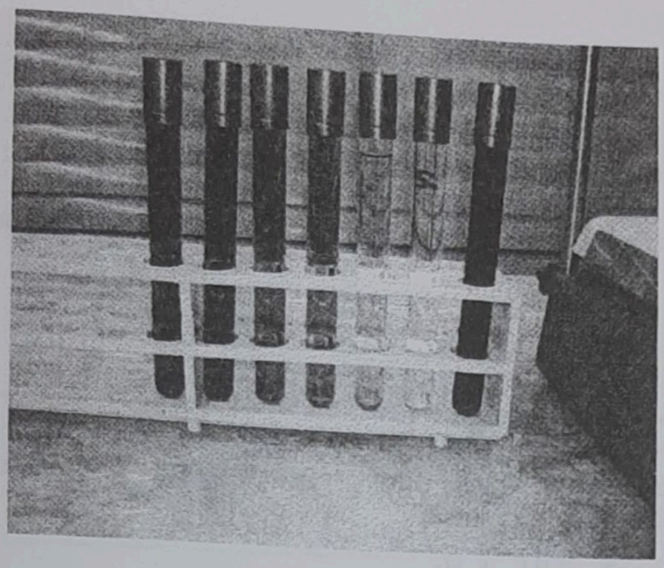


Plate3 .The first seven runs results

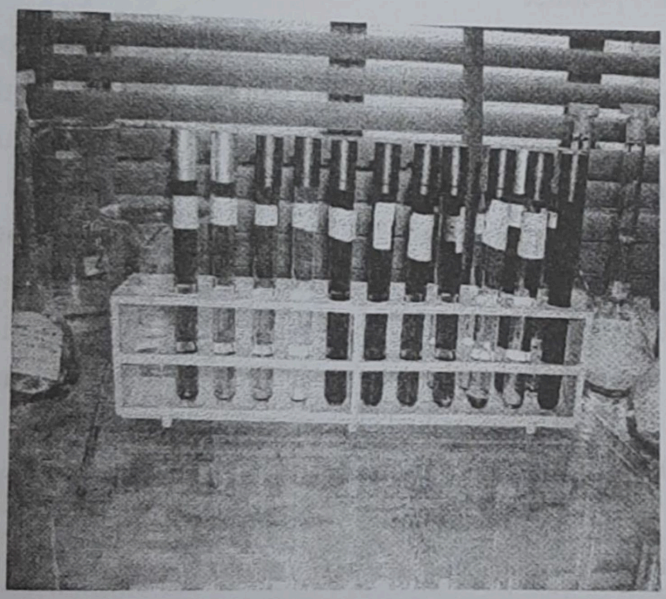


Plate4 .Results of 14 runs

Table1:Experimental operation parameters.

parameters	Experimental runs
pH	1.7, 2, 4, 6, 8, 10, 12
Electrolyte concentration (mg/L)	250, 500, 1000
Voltage (v)	3, 4, 5, 10

3.Results and discussion

3-1.Effect of NaCl concentration

The general chloride reactions involved in the electrochemical oxidation are as follow [8]:

$$2Cl^- \longrightarrow Cl_2 + 2e^-$$
$$H_2O + Cl_2 \longrightarrow H^+ + HOCl + Cl^-$$
$$HOCl \longrightarrow H^+ + ClO^-$$
$$6HOCl + 3H_2O \longrightarrow 2ClO^-_3 + 14Cl^- + 12H^+ + 3O_2 + 6e^-$$
$$2e^- + 2H_2O + ClO^- \longrightarrow Cl^- + 2OH^-$$
$$6ClO^- + 3H_2O \longrightarrow 2ClO^-_3 + 4Cl^- + 6H^+ + 1.5O_2 + 6e^-$$
$$2e^- + 2H_2O \longrightarrow 2OH^- + H_2$$
$$R + HOCl \longrightarrow P + Cl^-$$

Where R = dye and P= product

The results show that color removal was significant in the presence of NaCl as a supporting electrolyte . The decolonization occurred in the solution because of the reaction between the hypochlorite ion (OCl^-) and blue dye. Hypochlorite ions which are subsequently produced as the result of the hydrolysis of chlorine molecules as shown in the equations the effect of changing the electrolyte concentration (250,500 and 1000 mg/L) on color is illustrated in Fig.(6).It is clear from the figures that the maximum color removal is achieved at NaCl concentrationat of 500 mg/L and pH= 2. Increasing NaCl concentration above 500 mg/L had no major effects on the removal efficiency as it decreased to 82% at 1000 mg/L. The same notice was observed for COD removal as shown in Figs.3 and 4. The optimum COD removal was achieved at 500 mg/L NaCl concentration. The same conclusion was achieved by Abu Ghalwa et.al. 2005, where they found that above 2000 mg/L NaCl had no effect on the removal of acid green dye [10]. Miled et al.2010, used 0.1, 0.5 and 1M NaCl concentrations for the removal of indigo dye in acidic and neutral synthetic wastewater (pH 2 and 7). The results showed that color removal increased with increasing NaCl concentrations, but not higher than 0.5 M [11].

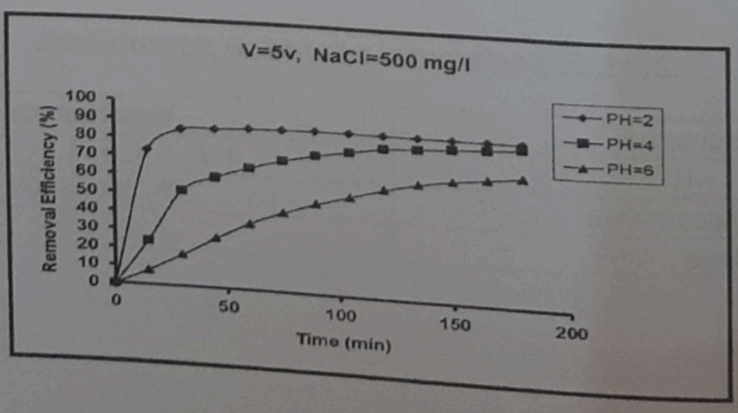


Fig.(3)%COD removal with time .V=5v,NaCl=500mg/L and variable pH

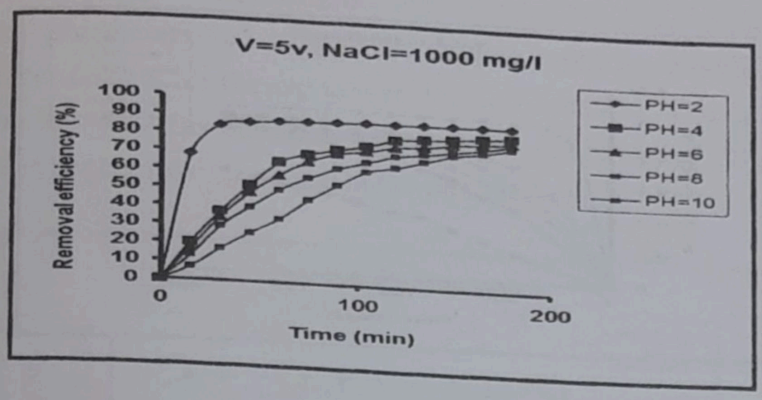


Fig.(4)%COD removal with time .V=5v,NaCl=1000mg/L and variable pH

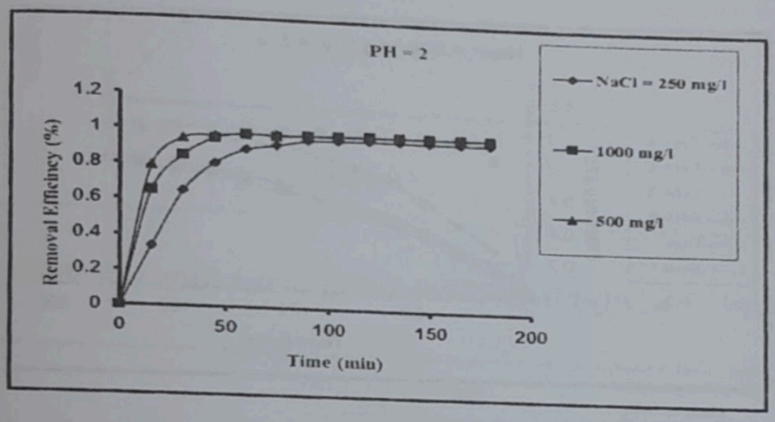


Fig.(6)%Color removal with time,pH=2,V=5v and variable NaCl concentrations

3-2.Effect of pH

Experiments were conducted under acid, alkaline and neutral conditions as mentioned in Table(1) by adjusting the electrolyte with sodium hydroxide or sulfuric acid 0.1 M NaOH and 0.1 M H_2So_4. The observations are given in Figs 3, 4, 7, 8 and 9, where the removal of color and COD increased with decreasing the pH of the solution. The reason may be due to the increasing of the hypochlorite ion in acidic medium and in low pH solutions the presences of hypochlorous acid (HOCl), which possesses higher oxidation potential than that of hypochlorite ion. It can be ascertained from Fig.8 that the percentage of color reduction had increased from 42 % at pH 4 to 98% at pH 2 for NaCl concentration 500 mg/L and voltage of 5 V after about 30 minutes reaction time. The maximum removal percentages reached 94.8% and 85% for color and COD respectively as shown in Fig.8 and 3. Abu Ghalwa et,al 2005, reached in their work that the maximum removal of color and COD were achieved in the pH range of 1.5 – 4 [10].

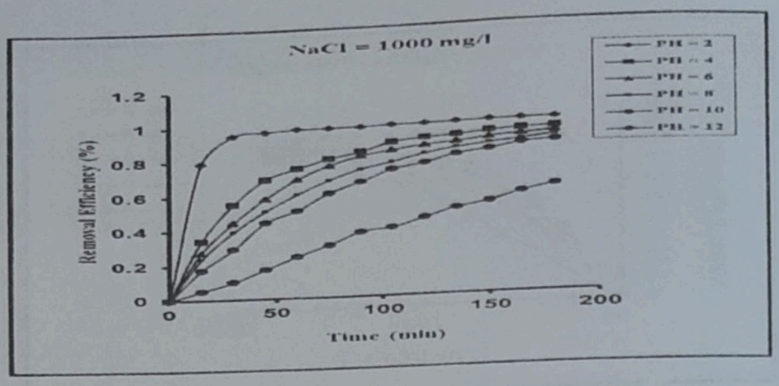


Fig. (7)%Color removal with time.V=5v,NaCl=1000 mg/L and variable pH.

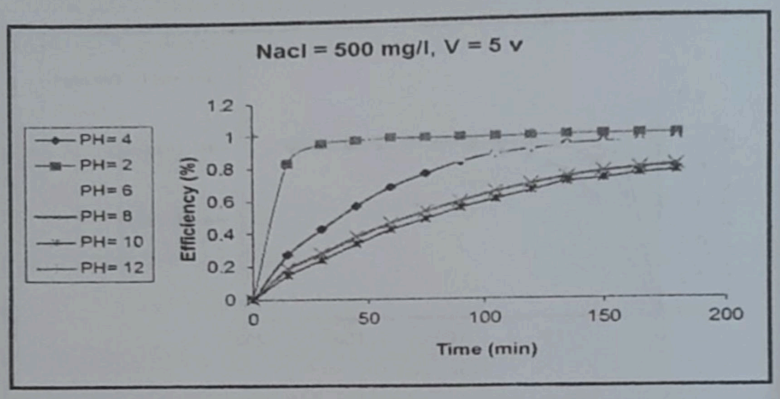


Fig.(8)%Color removal with time .V=5v ,NaCl=500 mg/L and variable pH

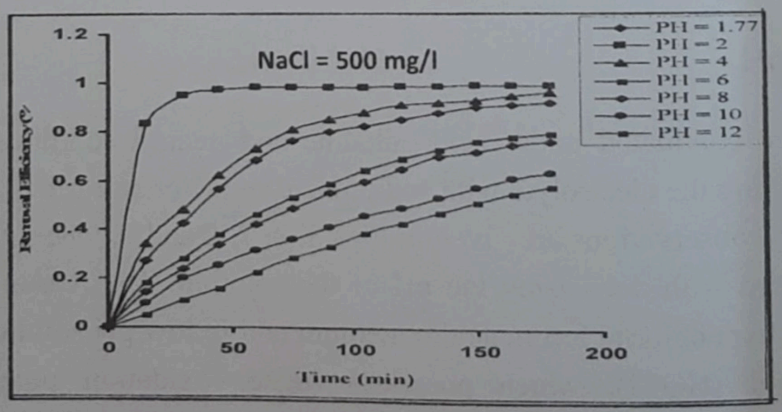


Fig.(9)%Color removal with time.V=5v,NaCl=500mg/L and variable pH.

3-3.Effect of voltage variatio

The effect of varying the voltage in the ranges 3, 4, 5 and 10 V at different operation conditions was investigated. It is clear from Fig. (5) That the removal of COD was greatly increase with increasing in voltage, reaching 5 V, but decreased at 10 V. There was no significant difference in the results at 4 and 10 V. Color removal efficiency also was in the

maximum removal of 98% (Fig, 10) for color and 89%for COD was achieved. This could be explained by increasing the applied voltage the oxygen evolution reaction (OER) may occur on the anode surface along with the oxygen molecule formation. The produce O_2 molecules diffuse into the solution and this has been the cause for oxidation of Cl^- ions and increase in OCl^- production, this process will increase in the dye removal [8].

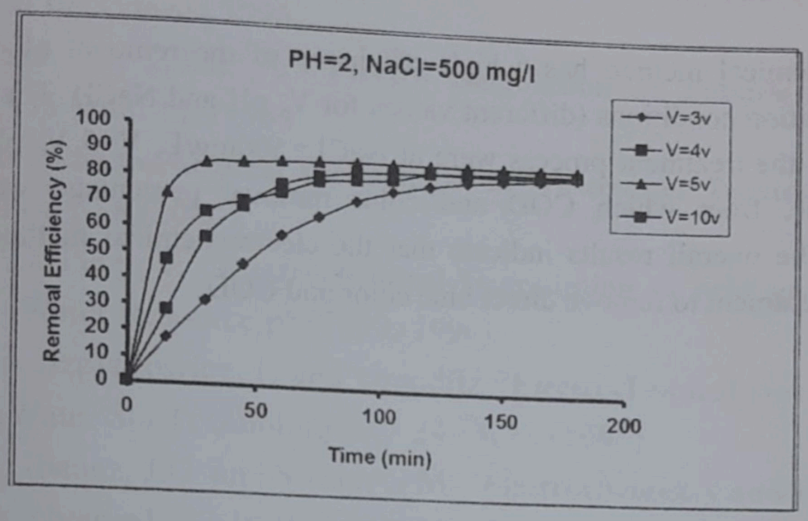


Fig.(5)%COD removal with time. pH=2,NaCl=500mg/L,and variable voltage

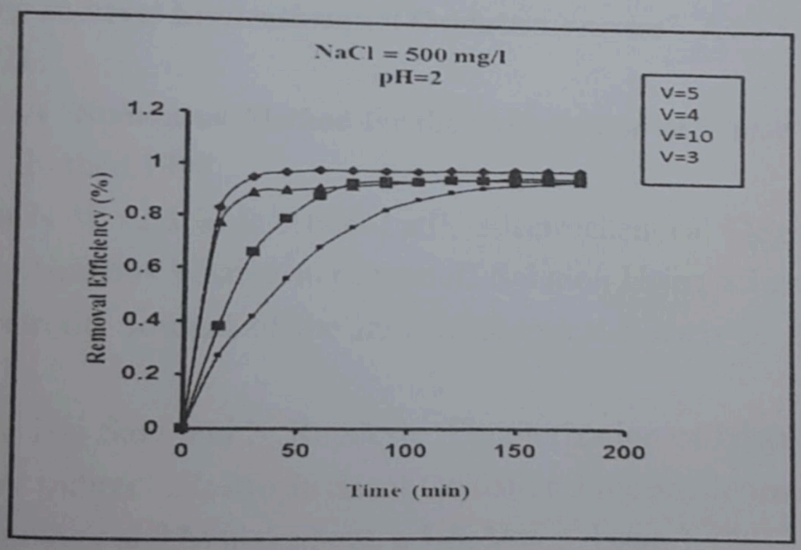


Fig.(10)%Color removal with time.pH=2,NaCl=500mg/L and variable voltages

3-4.Effect of run duration

To study the effect of time on the electrochemical process each run continued for three hours, at NaCl=500mg/L, pH=2 and 5 V, after 90 minutes of electrochemical treatment 88% and 98% COD and color removal was achieved respectively. In general at the first 30 minutes of the experimental run a high removal of color and COD obtained with a small reduction after that, and this is clear in all the previous figures, so it is enough to treat the wastewater for 30

minutes at pH 2 ,500 mg/l NaCl and using 5 volt electrical supply In the tests conducted by Abu Ghalwa and Abdel – Latif , 10 to 15 minutes were enough to achieve maximum removal of acid green dye and COD from synthetic wastewater [10].

4-Conclusions

The electrochemical method has a high efficiency of the removal of color and COD for different operation conditions (different values for V, pH and NaCl). The optimum operation condition for the treatment process were at NaCl =500mg/L, V=5 V, pH=2 for 30 minutes operation time, from which COD and color removal percentage were 89% and 98% respectively.The overall results indicate that the electrochemical method can be used as a preliminary treatment to remove direct blue color and COD.

References

[1]T. Robinson, G. Mc Mullan, Bioresource Technology p247-255, 77, 2001.

[2]Reife. H. S. Freeman, "**Environmental Chemistry of Dyes and Pigments**", John Wiley and Son Inc.Canada,1996.

[3]Jiek, E, Carlson, D, Eikum,A. "**Electro coagulation of Potable Water**". Water Research, p1355-1600,11, (1984).

[4]Guohua Chen, "**Electrochemical Technologies in Wastewater Treatment**" .sep., Putif . Technol, p 11-41,38,(2004).

[5]A.L. Sheng, C. Peng, J. "**Electrochemical Degradation of acid green in Aqueous Wastewater**" .Water Resource,p587 ,30,(1996).

[6]Naumcz. K. J. Szpyrkowicz. L and Grandifz "**Electrochemical treatment of textile wastewater**" ,Water Sci.Technology,p17-24.33(7), (1996).

[7]Rajeshwar, K. Ibanez, J.G. and Swain, G.M. "**Electrochemistry and Environment**" .J.Appl.Electrochem:p1077-1091 .24,(1994).

[8]Parsa J. Basiri and Mahmood Abbasi, . "**Decolorization of Synthetic and Real Wastewater by Indirect Electrochemical Oxidation Process**". Acta Chim. Slov,p792-796,54 ,(2007) .

[9]APHA, AWWA "**Standared Method for the Examination of Water and Wastewater ,Washington**" 20 thed,1998.

[10]Abu Ghalwa N.M. and M.S. Abdel-Latif,. Electrochemical Degradation of Acid Green Dye in Aqueous Wastewater Dyestuff Solution Using a Lead Oxide Coated Titanium Electrode. Journal of the Iranian Chemical Society ,p 238-243, Vol. 2, No. 3,(2005).

[11]Miled W., A. Haj Said and S. Roudesli, .Decolorization of High Polluted Textile Wastewater by Indirect Electrochemical Oxidation Process. Journal of Textile and Apparel Technology and Management, p 1-6, Vol. 6, Issue 3, (2010).

Notations:

COD: Chemical Oxygen Demands.
SS: Suspended Solids.
V: Volt.