REMOVAL OF DIRECT BLUE DYE IN TEXTILE WASTEWATER EFFLUENT BY ELECTROCOAGULATION

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ABSTRACT

Removal of direct blue dye by electrocoagulation method has been investigated using aluminum electrode in a bench-scale electrochemical system. Current density, NaCl concentration, electrocoagulation time, and dye concentration has been studied as effecting parameters in color removal efficiency. Increasing of current density will increase the color removal efficiency and energy consumption as well. While increasing NaCl concentration increase the color removal efficiency but it decrease energy consumption. High dye concentration is needed for extra electrocaogolation time to reach the same efficiency that obtained with low dye concentration .With current applied 0.35 amps. and NaCl concentration of 2 g/l more than 93% efficiency achieved in 14 min. of electrocaogolation time.

KEYWORDS

Dye removal, decolonization, direct blue, electrocoagulation

أزالة صبغة الزرقاء المباشرة من مياه الصناعات النسيجية المطروحه بطريقة التخثيرالكهربائي

الخلاصة

دُرست الازالة اللونية لصبغة الزرقاء المباشرة بطريقة التخثير الكهربائي بأستخدام اقطاب الالمنيوم بنظام كهروكيمياوي مختبري.تم دراسة كثافة التيار, تركيز ملح هدروكسيد الصوديوم, زمن التخثير الكهربائي و تركيز الصبغة كعوامل موثرة في كفائة ازالة اللون.زيادة كثافة التيار تزيد كفاءة ازالة اللون والطاقة المستهلكة,بينما زيادة تركيز الملح يزيد كفاءة ازالة اللون وتقلل الطاقة المستهلكة.تراكيز الصبغة العالية تحتاج الى زمن التخثير الكهربائي أضافي للحصول على نفس الكفاءه التي تم الحصول عليها في تراكيز الصبغة الواطئة. تم الحصول على كفاءه اكثر من 93% بتسليط تيار مقداره 0.35 امبير و2 غم/لتر تركيز ملح هدروكسيد الصوديوم بزمن تخثيركهربائي مقداره 14 دقيقة.

INTRODUCTION

From the early days of textile industries, the wastewaters of those industries were classified as the most polluting effluent, because of the volume of its influent as well as, variability and complexity in pollutant contents involved. In particular, dyeing and finishing processes are responsible for large water pollution.

Dyes are considered to be dangerous organic compounds for the environment. High level of color is not the only reason, but dye may contain chemicals, which are toxic and carcinogenic, they causes variation in pH, high temperature, high biological oxygen demand, high chemical demand and high concentrations of suspended solids. According to articles, nearly 40,000 dyes and pigments are listed which consist of over 7,000 different chemical structures. Most of them are completely resistant to biodegradation processes (Ayhan Demirbas, *2009*).

Dyes used by the textile industry are largely synthetic and are derived from coal tar and petroleum-based intermediates. The primary classification of dyes is based on the fibers to which they can be applied. The chemical nature of each dye determines the fibers for which the dye has affinity and they are mainly divided into acidic dyes, reactive dyes, disperse dyes and, direct dyes (Yang C.-L., McGarrahan, 2005)

Therefore, engineering effort has been focused on handling this problem, in many ways the solution came with several configurations, biological, Physical and chemical methods or combination of two or more of these methods. Biological treatment processes are often ineffective in removing dyes which are highly structured polymers with low biodegradability(O.T. Can, M. Bayramoglu, M. Kobya, 2003) .Therefor, the needing of pre-treatment appear obviously(D. Georgiou, P. Melidis, 2003)

In addition, many other treatment processes adopted to achieve the adequate settlement to eliminate dyes which listed under physico-chemical methods such as : adsorption on activated carbon, polymer and mineral sorbents or biosorbents(T. Robinson.,2002, A. Pala,2002)

Chemical oxidation by ozone and hydrogen peroxide (E.G. Solozhenko,1995) and combining hydrogen peroxide with UV(A. Aleboyeh,2003, E. Kusvuran,2004) photolysis(W. Chu,2002)

Among the above methods, electrochemical treatment appear to achieve strong promotion to dyes removal treatment ether by direct or indirect electrochemical technique, electrocoagulation draw attention in last years ,Aluminum and iron sheets have been used as consumable anodes to generate coagulants that adsorb and remove organic dyes(*M. Kashefialasl*,2006, C. Phalakornkule,2009).

An aluminum coagulant removes colorant by complexation and electrostatic attraction followed by coagulation adsorption. Three main processes occur during electro-coagulation: electrolytic reactions at the surface of electrodes, formation of coagulants in aqueous phase, adsorption of soluble or colloidal pollutants on coagulants, and removal by sedimentation and floatation Electrochemical coagulation for textile effluent decolonization.[Chen-Lu Yang a,2005, A. Wilcock,1992)

Aluminum sheets as consumable electrodes, Al^{3+} ions are produced on the anodes.

$$Al \rightarrow Al^{3+} + 3e^{-} \text{ (at anode)} \qquad (1)$$

$$3H_2O + 3e^{-} \rightarrow \frac{3}{2} H_2 + 3OH^{-} \text{ (at cathode)} \qquad (2)$$

The destabilized particles then aggregate to form flocs. In the meantime, the tiny hydrogen bubbles produced at the cathode induce the floatation of most flocs, helping to effectively separate particles from wastewater. In addition, the cathode may be chemically attacked by OH^{-} ions generated together with H2 at high pH values.(T. Picard,2000)

$$2Al + 6H_2O + 2OH^{-} \rightarrow 2Al(OH)_4^{-} + 3H_2 \qquad (3)$$

$Al(aq)^{3+}$ and OH^{-} ions generated by electrode reactions (1) and (2) react to form various monomeric species which transform finally into $Al(OH)_3$ according to complex precipitation kinetics (A. G¨urses,2002). Several interaction mechanisms are possible between dye molecules and hydrolysis by-products.

EXPERIMENTAL

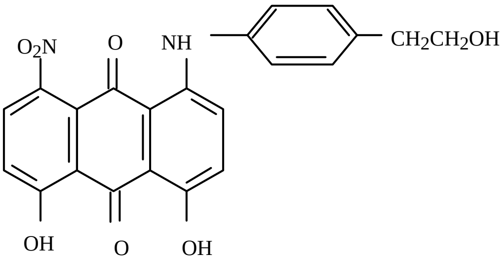
Bench-scale electrochemical system was used in this study. It consists of power supply model (KW/IC-TRIPLE, SCHWEIZ) with digital multimeter DT-832, cylindrical electrochemical reactor (9.5 cm diameter, 10cm high) made of PVC, provided with 7.5*4.5*1 cm graphite cathode, solid aluminum wire of 77 cm^2 total area represent the anode electrode was coiled around the cathode as show in fig.(1). Approximately 0.5 cm separated between the two electrodes. Before and at the end of each run, electrodes were washed thoroughly with water, dipped in HCl solution.

Synthetic dye wastewater prepared by dissolving 50, 25, 10 ppm direct blue dye directly in a distilled water, using a commercially available Direct Blue , which its chemical structure shows below.1,2 and 4 g of NaCl was added to each liter of solution and different currents of 0.1,0.2 and 0.35 amps. were supplied to the system .The samples had been taken every two minute .All samples were allowed to settle for 20 min and after that they were analysed

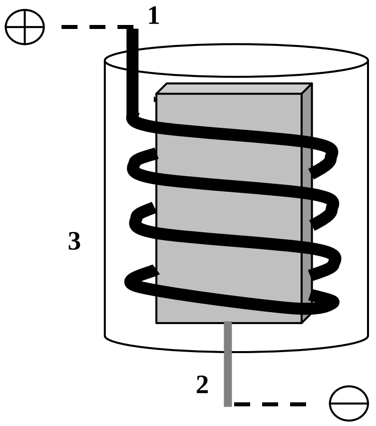
a UV-Vis spectrophotometer (Spectro SC, USA) at the wavelength of 570 nm was used to determine the color removal efficiency . Where the color removal efficiency is written as:

Color removal efficiency (%) = [(Ao-A)/ Ao)]*100

where Ao and A are the light absorbance of dye before and after electrocoagulation, respectively.



Chemical structure of Direct Blue



1-aluminum anode 2-graphite cathode 3-PVC cell body

Fig.(1) Schomatric of electrochemical cell reactor

RESULT AND DISCUSSIONS

The efficiency of color removal of direct blue dye was investigated as a function of current density and electrocoagulation time at constant NaCl concentration of 2 g/l and dye concentration of 20 ppm.

Fig.2 shows the color removal efficiency increases with increasing current applied to the reactor cell, when the current is 0.1 amp. The color removal reached 0.76 in 10 min. and over 0.9 in same time on 0.2 amp. As well as the color removal remarkably increased to reach over 0.93 on 0.35 amp. The amount of Al-coagulant in the solution is the factor determent the efficiency of color removal, this amount present sufficiently when the current is rising. Also the coagulation time offset the regression in the color removal efficiency resulted from falling behind of current applied to the solution.

Picking the proper working current density limited by economic motive, knowing the fact that choosing high current rising energy consumption. As shown in fig. 3

Fig.4 shows the effect of NaCl concentration on efficiency of color removal at constant current of 0.35 amp. and 20 ppm dye concentration.

Increasing the concentration of NaCl in solution increases the efficiency of color removal.

However, in solution contain 0.5 g/l of NaCl the color removal is 0.76 in 10 min. of electrocoagulation time and in 1 g/l of NaCl the efficiency is 0.83 at the same time, while its reach 0.87 in 4 g/l of NaCl .

The above resulted from that during the operation chloride (Cl^-) was present in solution and oxidation to produce chlorine gas (Cl_2) on the surface of the anode. Some Cl_2 evolved from the surface as tiny bubbles while the majority of Cl_2 dissolved and equilibrated with hypochlorous acid (HClO), trichloride ions (Cl_3^-), and hypochlorite (ClO^-) in the solution These are strong oxidizing agents and can be used to further oxidize the dye, that is not quite distinct in this study because of 20 ppm of dye isn't adequacy amount to late the oxidizing agents play a significant role in the removal process.

In the other hand, the increasing of NaCl concentration will reduce the voltage of the cell that causes reducing in energy consumption as shown in fig.(5) above obviously appear because of increasing the salt concentration mean increase in solution conductivity that result low cell voltage and low energy consumption.

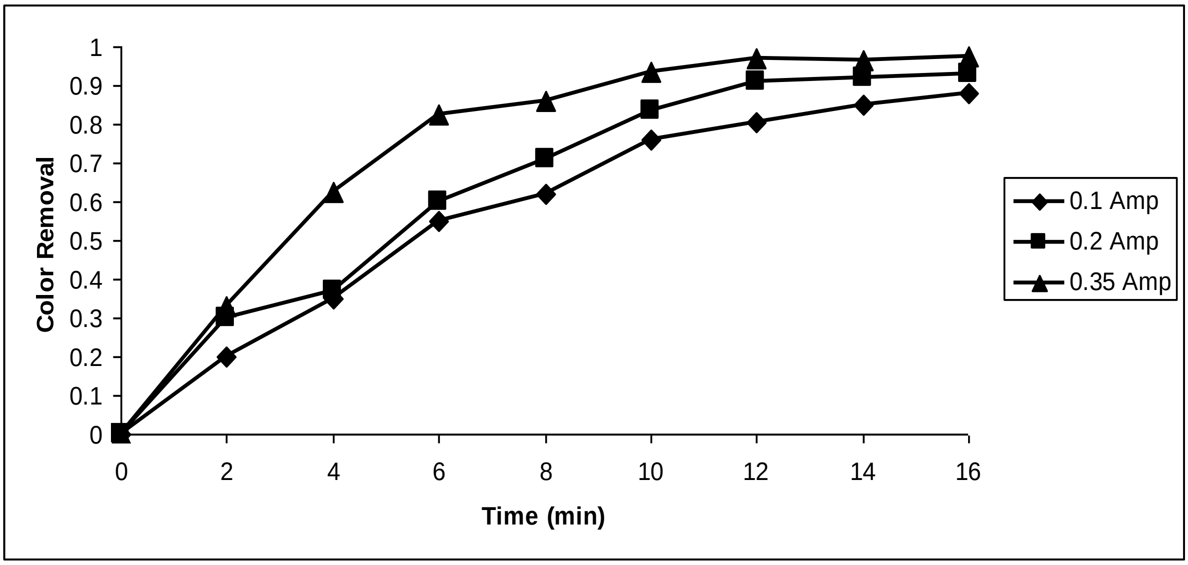


Fig.(2) effect of current density on the color removal efficiency 20 ppm,2g NaCl

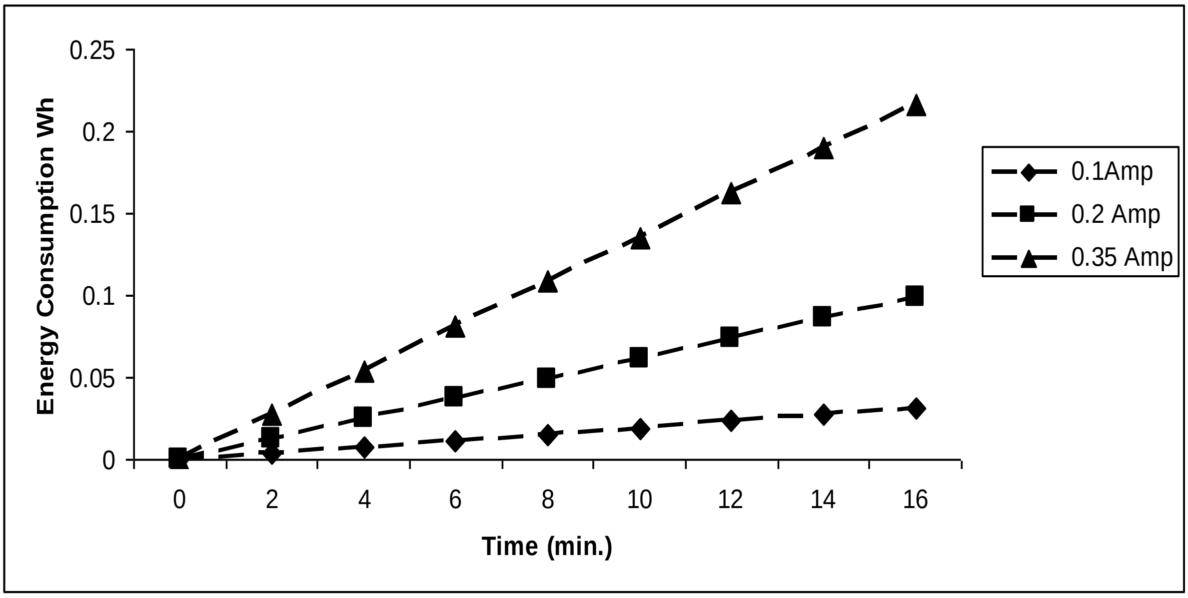


Fig.(3) effect of cuurent density. on the energy consumption in 2g/l NaCl, 20 ppm,

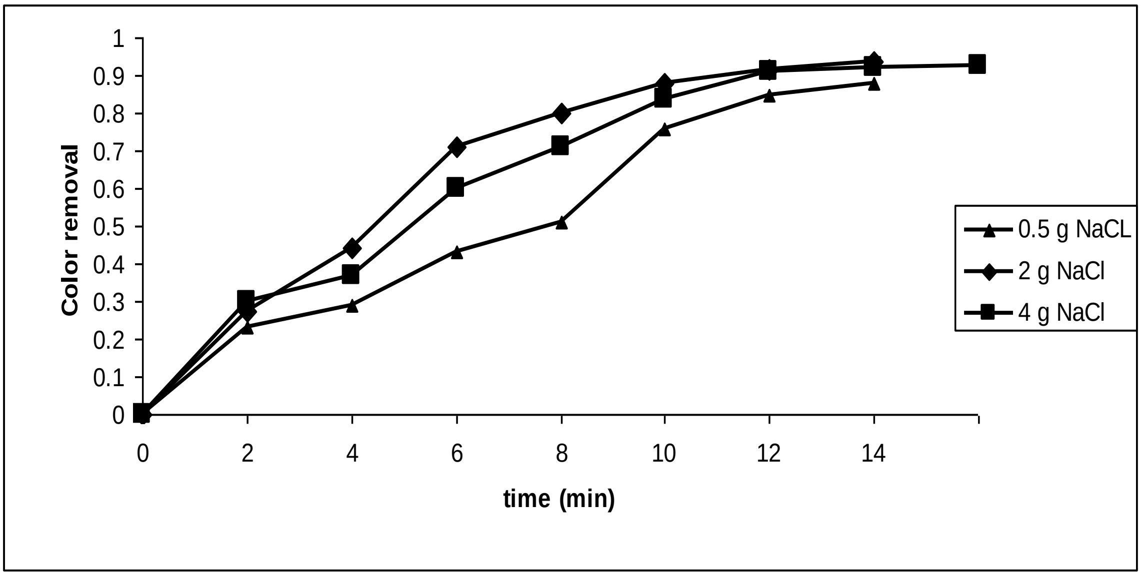


Fig.(4) effect of current density on the color removal efficiency 20 ppm,0.35A

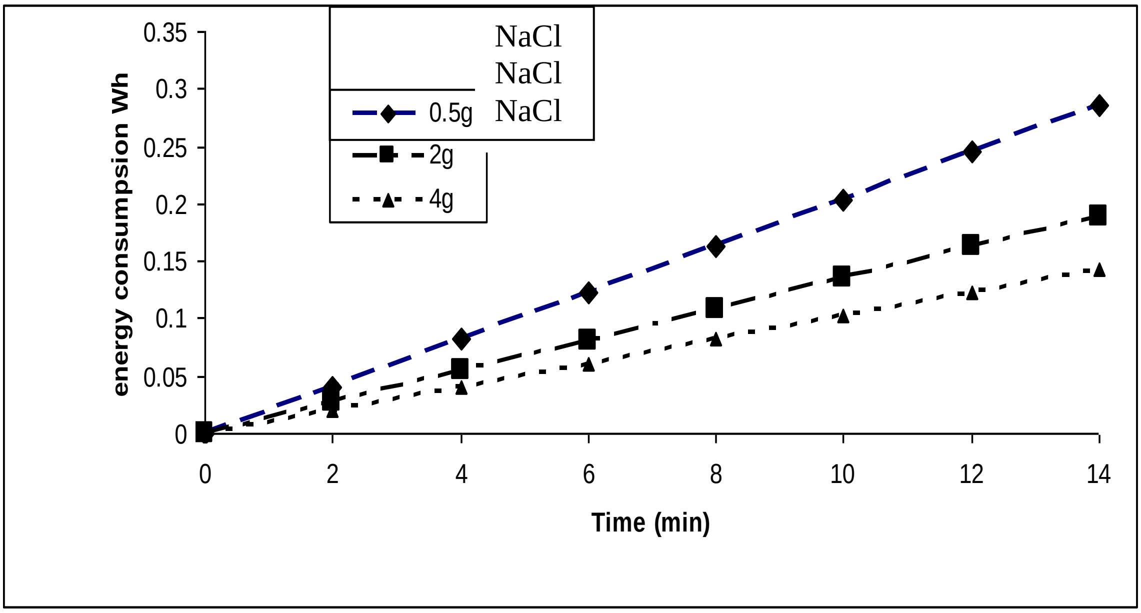


Fig.(5) effect of NaCl conc. on the energy consumption 0.35 A, 20 ppm,

Fig.(6) shows that the effect of dye concentration on color removal efficiency, it observed clearly that the high concentration of dye in solution needs more time to reach the desired removal efficiency that occurred to that of low concentration , however, in 10 ppm dye concentration at 8 min. the color removal efficiency is 0.78 ,in 20 ppm the color removal is 0.71 at 8 min. and its almost 0.55 with 50 ppm at the same time , again the electrocoagulation time offset the regression in color removal efficiency ,it can be reach a maximum value of 94 at 18 min. in 50 ppm dye concentration and 0.93 at 14 min in 20 ppm., also in 10 ppm. More than 90 can be reachs before this time. The reason behind that is high dye concentration needs for Extra time to react with Al-coagulant that generated sequentially in solution.

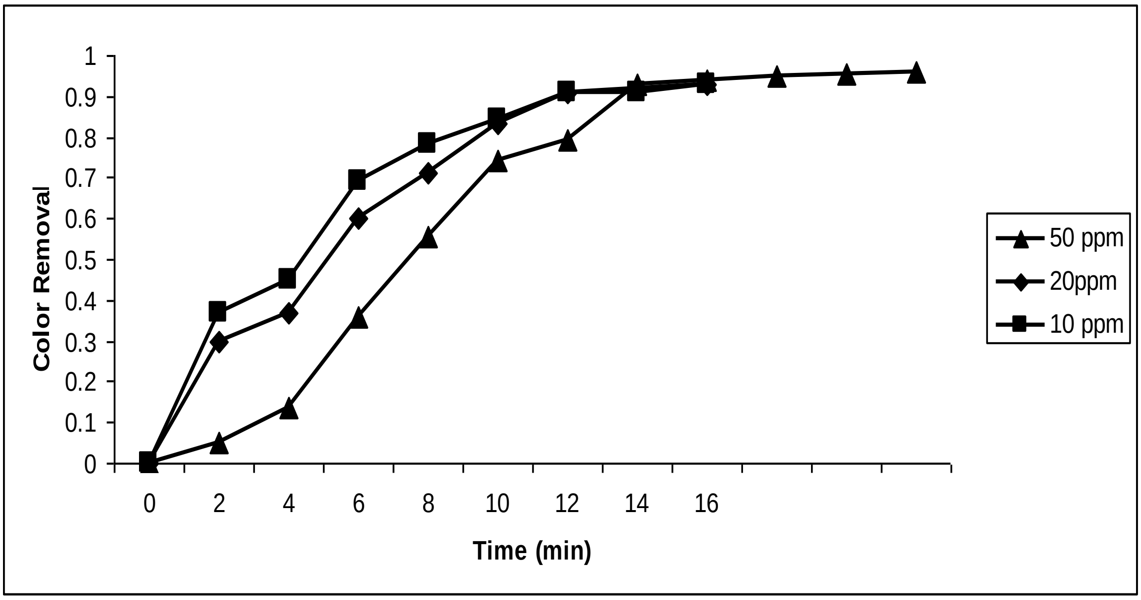


Fig.(6) effect of dye conc. on the efficiency of color removal 0.35 Amp, 2 g/l NaCl

CONCLUSION

Electrocoagulation of direct dye is a sufficient method to treatment textile west. The current density is effective factor in electrocoagulation process also the time of which the dye is in treatment ,NaCl concentration provide additional factor to eliminate dye from solution .picking the working current density and NaCl concentration limited by economic motives. More than 93% color removal efficiency achieve in this research by applying current of 0.35 amps. and NaCl concentration of 2 g/l in 14 min. of electrocaogolation time using aluminum electrode.

NOMENCLATURE

Amp	Ampere
ppm	part per million

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