DECOLOURISATION OF DYE SOLUTION CONTAINING AZO ACID ORANGE 7 BY ELECTRICITY

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To my beloved mother and father

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ABSTRAK

Sisa berwarna daripada aktiviti industri memberi kesan kepada persekitaran dan kesihatan manusia. Pelbagai kaedah telah digunakan untuk menyahwarna sisa ini termaksuklah kaedah yang menggunakan aplikasi elektrik. Kajian ini dilaksanakan untuk menyelidik kelakuan larutan yang mengandungi bahan pewarna Azo asid oren 7 oleh elektrik. Fokus kajian ini menjurus kepada kesan penyahwarnaan oleh faktor ketumpatan arus elektirk, kepekatan pewarna dan tempoh aliran arus elektrik. Sel kimia yang mudah disediakan dengan menggunakan dua kepingan diperbuat daripada besi tulen dan besi campuran. Keberkesanan kaedah ini ditentukan melalui pengukuran peratus penyingkiran warna dan penyerapan. Peratus penyingkiran warna adalah lebih tinggi daripada peratus penyingkiran penyerapan. Semasa proses dijalankan apabila jumlah ketumpatan arus elektrik dan tempoh aliran arus elektrik semakin bertambah, penyahwarnaan turut meningkat. Berdasarkan analisis MINITAB™, ketumpatan arus elektrik, kepekatan pewarna dan tempoh aliran arus elektrik memang mempengaruhi peratus penyingkiran warna.. Kecekapan penyahwarnaan bagi kepekatan antara 100 mg/l dan 200 mg/l boleh ditingkatkan kepada 95% penyingkiran warna dan 88% penyingkiran penyerapan pada tempoh aliran arus elektrik 18 minit dan ketumpatan arus elektrik pada nilai 120 A/m^2.

ABSTRACT

Colouring effluent from industrial activities may affect environment and human health. Many methods have been used to decolourise such effluent including using electricity. This study was performed to investigate the behaviour of decolourisation of solution containing Azo Acid Orange 7. This study was focusing on the effect of decolourisation due to current density, dye concentration and duration of current flow. Simple electrochemical cell was prepared by using iron and steel plate electrode. The effectiveness of the method was determined by measuring percentage of colour and absorbance removal. The percentage of colour removal was higher then the percentage of absorbance removal. It is found that decolourisation was directly proportional to current density, duration of electric current flow and concentration of the dye. Based on MINITAB^{TM} analysis current density, duration and concentration does affecting the percentage of colour removal. The efficiency of decolourisation for 100 mg/l to 200 mg/l concentration was able to increase up to more 95% of colour removal and more than 88% of absorbance removal when duration was 18 minutes and current density was 120 A/m^2.

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Ao	-	Initial absorbance
A	-	Final absorbance
Co	-	Initial color (ADMI)
C	-	Final color (ADMI)

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CHAPTER 1

INTRODUCTION

1.1 Background

Colour is a visible pollutant and its presence not only hampers the aesthetic quality of surface waters but also affects and alters the aquatic ecosystem by reducing the penetration of light (Prabhakara et.al, 1990). The development of industry and improvement of human life, cause more and more dyes are used and needed. Dyes are coloured, ionising, aromatic organic compounds (Fessenden et.al, 1990). A wide variety of dyes are used by industry and released into the environment as industrial effluents. Textile are the industry that largely using this product. These dyes have to be highly stable in everyday use and resistant to microbial degradation. Azo dyes are the largest class of dyes used in industry. In general, bacteria are not able to degrade Azo dyes. However, some anaerobic bacteria in intestinal micro flora have been demonstrated to degrade a few Azo dyes. Under these conditions the Azo can be toxic and potentially carcinogenic (Maarit et.al, 2000).

Dyes caused serious environmental pollution and health problem in many ways. Highly colour dye wastewater, contain a large amount of chemical (Qian and Gu. , 1994). That's make the treatment of dye wastewater are important. The treatments of dye wastewater are expensive, so water –reused is attractive practice that able to give and operation and cost effective treatment system (Eroglu et.al, 1991). The treatments of textile wastewater are based on chemical and biological treatment (Nicolaou et.al, 1992).

One of alternative way that has been used to treat dye wastewater is by using system that used electric energy (Daneshvar et.al, 2004). Example of method that used electric energy is electrocoagulation, electrolysis and many more. This study was using the application of electrolchemical to treat coloured wastewater. This system has been in existence for many years. The process is based on principles involving responses of water contaminants to strong electric fields. According to Daneshvar et.al (2004), the chemistry, pH, particle size and chemical constituent of wastewater are influencing this process. The range of current density, duration of current flow and dye concentration was used for this study was based on study done by Daneshvar .et.al. But the study done by Daneshvar was using Acid Red 14, while for this study Azo Acid Orange 7 was used. Azo Acid orange 7 was used to determined the applicability of the process to others type of colours. Azo dye was chosen because almost half of the dyes used in textile industry are Azo type and it caused environmental problem when 15% of it discharge into the environment without proper treatment (Mat Daud, 2003)

The test was conducted by using plate steel cathodes and plate iron anode with size 50 mm x 50 mm x 1 mm and distance between electrode is 3 cm. Artificial wastewater was prepared by mixing Azo acid orange 7 dye with discharged water. The concentration of the artificial wastewater was between 25 mg/l to 200 mg/l. Volumes of artificial wastewater that was used for each test was 500 ml. Current density that was used between 40 A/m^2 to 240 A/m^2. The duration of current flow for each test were with in 5 to 25 minutes, each stage required different sample. The initial and final absorbance and colour for each sample were determined in order to determine the behaviour of decolourisation of the sample. The initial and final absorbance was determined by using UV/VIS spectrophotometer Jasco model 7800 to calculate the percentage of absorbance removal. Colour was measured to determined the physical condition of the sample in term of it colour. Absorbance was measured to determine the concentration of sample. Value of colour must equal to value of absorbance. By measuring the absorbance at the same time it able to conform value of colour that has been obtained. The percentage of removal was determined by using formula below:

$$\text{Absorbance removal (\%)} = \frac{Ao - A}{Ao} \times 100 \qquad \text{.............................(1)}$$

Ao = initial absorbance

A = final absorbance

The initial and final colour was determined by using DR/4000 (Hach) spectrophotometer. The percentage of colour removal was determined by using formula below:

$$\text{Colour removal (\%)} = \frac{Co - C}{Co} \times 100 \qquad \text{.............................(2)}$$

Co = initial colour (ADMI)

C = final colour (ADMI)

Laboratory works were divided into two stages, which was preliminary laboratory test and final laboratory test. Results obtain in preliminary laboratory test and final laboratory test was used in the MINITAB™ analysis. Based on the result of the

MINITAB^{TM} analysis, the most significance factor that influencing decolourisation of Azo acid orange 7 was able to obtain.

1.2 Problem statement

Fabrics are important to all humankind. People used fabric to make clothes and others household equipment. Due to high demand of fabric a lot of fabrics are made to fulfil this demand. In the process of making fabric a lot of colours were used in dyeing process. In the dyeing process highly coloured wastewater were produced as the process involved a lot of water. According to Jabatan Alam Sekitar, Malaysia is experiencing rapid economic growth of textile industries and this caused a lot of highly coloured textile effluent produced.

The wastewater effluents from the dyeing process are colourful and their decolourisations are very important before discharge. Dyes need to be treat before discharge because it affects the environment and human health (Zee et.al 2002). In order to have sustainable development this effluent must be treated, as the effluent is aesthetically unpleasant when discharge to receiving water and can be polluted.

Various physical and biological technique such as membrane filtration, electrolysis, flocculation, ion exchange, oxidation, aerobic, anaerobic, anoxic and biodegradation were used to removes the dye from the effluent. According to Daneshvar et.al, (2004), the effective methods are by using activated carbon or oxidation process but the cost are really high. As an alternative method which using electric energy in the process was used. This process has a fast rate of pollutant removal, simplicity in operation, low operating and equipment cost (Daneshvar et.al, 2004). This process has been tested successfully to treat many kind of wastewater such as restaurant wastewater, urban wastewater, defluoridation of water and many more. It is expected that this method would be an ideal choice for decolourisation of dye solution. But the performances of this method are not well defined as it is considered to be new method in treating textile wastewater. By doing this study, hopefully it able to give more information about it.

This study investigates the effectiveness of using electricity in treating textile effluent. But this study was focusing in Azo dye, since Azo are the largest class of dye used in textile industry (Zee, 2002) and it's constitute a major class of environmental pollutant (Tan and Gu, 2001). Furthermore, Azo dye can be toxic and potentially carcinogenic (Maarit et.al, 2000). This study were focusing in determined the behaviour of decolourisation of Azo Acid Orange 7 by using electricity under the influence of current density, duration of current flow and concentration of dye.

The entire test was done by using plate steel cathodes and plate iron anode. Anode, withdraw electrons from the electrode material, which result in release of Fe(II)-ions produced iron hydroxide. Then cathode produces H_2 gas from water. Iron hydroxide that remains in aqueous stream as a gelatinous suspensions removed the pollutant by complexation or electrostatic attraction. H_2 gas produced in cathode form bubble and caused the floc produced to be floating on the surface of water. Organic compound from dyes react through a combination of electrochemical reduction, electro-coagulation and electrofloatation reactions (Ching et.al, 2005).

1.3 Objective of study

To determine the behaviour of decolourisation of Azo acid orange 7 by using electricity under the influence of current density, duration of current flow and dye concentration.

1.4 Scope of study

There were some matters to be considered, under the laboratory work which were:

1. The test conducted by using plate steel cathodes and plate iron anode with size 50 mm x 50 mm x 1mm and distance between electrodes is 3 cm.
2. Artificial wastewater was made from Azo acid orange 7 dyes, the concentration was in the range of between 25 mg/l to 200 mg/l.
3. Volumes of artificial wastewater used, 500 ml.
4. The current density used between 40 A/m^2 and 240 A/m^2
5. The duration of current flow for each test were with in 5 to 25 minutes, each duration stage required different sample
6. The laboratory works were focusing in obtaining initial and final colour and absorbance change for each test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Surface water becomes coloured by pollution caused by highly coloured wastewater (Sawyer et.al, 1994). Coloured wastewater was waste from dyeing operation in paper, leather, and textile industry. In Malaysia textile industry is the largest industry that discharged highly coloured wastewater (Japan Consulting Institute, 1993). Coloured wastewater affecting environment and human health if directly discharge without treatment. That's make the treatment of dye wastewater are important. There are many treatment used to treat dyes effluent including using electricity. However, the performances of this process are not well defined

2.2 Water pollution by textile industry

Water is so common that we take it for granted. Moreover, its covers nearly three-fourth of the surface of the earth. Water pollution problems in any part of world are far worse from day to day. In 1998, it has been estimated that in year 2000, 2.2 billion people in the developing countries will lack access to safe drinking water (Gilbert, 1998). What are the causes of this problem? The answer is due to human activity and unbalanced development. Water that has been withdrawn, used for some purposed and returned will be polluted in one-way or another. Agricultural return water containing pesticides, fertilizer, and salt, municipal return water containing human sewage, industry returned water-containing chemical. All of this is due to human activity. When water was polluted, the water become unsuitable for drinking water and habitat for aquatic live.

Wastewater discharged from textile industry characterized by high chemical demand (COD), low biodegradability, high salt content and is the source aesthetic pollution related to colour (Alinsafi et.al, 2004). Dyes formula contain numerous auxiliary ingredients for desizing, scouring and mercerising (Wu et.al,1998). The salt and heavy metal from highly coloured wastewater are toxic to aquatic live (Wu et.al, 1998). While some of dye such as Azo dye is carcinogenic, this can cause serious health problem such as cancer (Maarit et.al, 2000). This caused the treatment of dye before discharged are important in order to ensure sustainable development able to achieve.

Based on report wrote by Japan Consulting Institute (1994), textile industry is the fifth major industry that become source of environmental problem (*table 2.1*). However, in term of colouring effluent textile industry is the largest industry discharging colouring effluent. So it is important to studies treatment process that is efficient to reduce the colour in the effluent. In order to ensure our water are safe for future generation.

Japan Consulting Institute (1994) report wrote that, in Malaysia, textile industry is the second largest industry following the electric appliance industry in term of export. Since the domestic market for the product is small, so most of products are exported.

The export amount reached 6433 million in 1992. Due to growth of the industry, textile companies has formed Malaysia Textile Manufacturer Association (MTMA). In 1994 number of member registered in MTMA was 290. All of this factories scattered around Selangor, Johor, Pulau Pinang, Terengganu, Kedah and Kelantan

Table 2.1 Industrial sources of water pollution

Type of industry	Percentage, %
Palm oil	11.6
Raw natural rubber	8.6
Rubber and product	14.1
Food and beverage	40.5
Textile and leather	9.0
Paper	4.4
Chemical	11.8
Total	100

(source : Environmental Quality report 1991)

In accordance with the development of textile industry, the pollution of environment by the industry has become apparent. Especially coloured wastewater discharge from dyeing factory. Coloured wastewater caused serious environmental problems in various locations. As example in Penang, visitor enjoying diving but at the same time wastewater from dyeing factories was flows into the diving area (DOE, 1997). Previously DOE has conducted investigation in the bigger textile company. Based on their report, bigger textile industry does equipped with treatment facilities. However, for coloured problem the factories not able to solve the problem of decolourisation. Many of factories discharge coloured wastewater without any treatment because colour is outside the scope of regulation. For small to middle size factory they don't event have treatment facilities to reduced pH, TSS, COD,BOD, temperature and all the hazardous chemical. This caused the pollution caused by textile industry become worst. To reduce water pollution caused by textile industry, study must be done to treat the textile effluent efficiently.

2.3 Dyes

According to Allen (1971) dye is a coloured substance that can be applied in solution or dispersion to a substrate, thus giving it a coloured appearance. Usually a substrate is a textile fibre, but it may be paper, leather, hair, fur, plastic material, wax, a cosmetic base or a foodstuff. Dyes may be classified in several ways, according to it's chemical constitutions, application class, or end-use (DOE,1997). The primary classification of dyes is based on the fibres to which they can be applied and the chemical nature of dye. Each different dye is given colour index (C.I) generic name determined by its application characteristic and colour (Zee, 2002). Society of Dyers and Colourist and the American Association of Textile Chemist and Colourist edited C.I every three month. Previously, 28000 commercial dyes name was list by C.I. *Table 2.2* list the major class of dyes used by the textile industry.

However, this study only focusing in one type of dyes which was Azo dye. Azo dye is the largest class of dye used by textile industry (Zee, 2002). Moreover, according to Allen (1971), Azo dyes account for over 60% of total number of dye manufactured. That is why Azo acid orange 7 was used to represent Azo class of dye for this study.

2.4 Azo dye

Azo dyes are the most widely used dyes in industry with a world market share 60-70% (Sen and Demirer, 2003). Approximately 10000 Azo dye are currently manufactured and it is estimated that at least 15% of these are released into the environment (Donlon et.al, 1997). They occur in industrial effluent, groundwater, contaminated soils and sediments. These organic solution will degrade under anaerobic condition naturally (Sen and Demirer, 2003). This process generated aromatic amines. Aromatic amines are suspected to be mutagenic and carcinogenic. Moreover, it can cause serious danger to aquatic life and human life.

The chemistry of this dyes ranges from simple monoazo compounds to complex polyazo structure and their property varied (Allen, 1971). This dyes are characterized by nitrogen to nitrogen double bond (N=N) (Donlon, B. et.al, 1997). There are various class of dye that contain Azo compound including direct dye, acid dye, reactive dye, dispersed dye, pigment dye, basic dye and mordant dye (Zee, 2002). The colour in Azo dyes is due to the azo bond and associated chromophres (Sen and Demirer, 2003). Azo acid orange 7 was the type of dye that used in this study. It is also kwon as naphthalene orange G and equivalent to Raussin's orange II. Maximum wavelength of Azo acid orange 7 is 480 nm. It is in monoazo groups. *Figure 2.1* shows molecule structure of Azo acid orange 7.

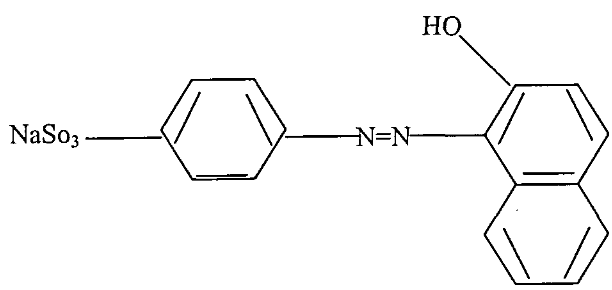

Figure 2.1 Structure of Azo Acid Orange 7 (CI No. 15510)

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