ELECTROCHEMICAL METHOD TO REDUCE WATER TURBIDITY

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I hereby declare that this dissertation is based on my original work, except for quotations and summaries each of which have been fully acknowledged.

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ABSTRAK

Kajian penggumplan pepejal-pepejal terampai dengan mengggunakan kaedah elektrolis telah dijalankan. Dalam kajian ini aluminium (Al) telah digunakan sebagai elektrod anod and katod. Larutan piawai (800 NTU) telah disediakan dengan mencampurkan 10 g kaolin ke dalam 1 L air suling. Sebelum elektrokogulasi dilakukan, pH sampel teleah dilaraskan di antara pH 3.5 hingga 8.5. Dalam kajian ini arus terus yang digunakan adalah di antara 1 A hingga 5 A dan masa elektrokogulasi adalah 0 hingga 60 minit. Kajian menunjukkan bahawa penggunaan kaedah elektrolis dapat mengurangkan kekeruhan air. Penurunan optima sehingga 92.68 % pada pH 8.5, selama 50 mint dan arus 3 A.

ABSTRACT

The electrocoagulation technology for reducing suspended solids in water treatment has been studied. All the experiments carried out in this work were static method. Batch experiments with two mono polar aluminum (Al) plate anodes and cathodes were employed as electrodes. The turbid sample (800 NTU) was prepared by dissolving 10g of kaolin into 1 L of distill water. Prior to the experiment, pH of the sample was adjusted at range of 3.5 to 8.5. DC current was varied 1 A to 5 A, and operating time between 0 to 60 minutes. The results showed that, electrocoagulation can reduce turbidity efficiency as high as 92.68 % with the optimize pH at 8.5, at 50 minutes, 3A of current.

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CONTENTS

LIST OF SYMBOL AND ABBREVIATIONS

NTU	Nephelometric Turbidity Unit
FTU	Jackson Turbidity Unit
JTU	Formazin Turbidity Unit
rpm	Round per minute
g	Gram
mg	Milligram
L	Litre
mL	milliliter
DC	Direct Current
ζ	Zeta potential
mg/l	Concentration in milligram per litre
mV	milivolt
min	minute
W	Watt
A	Ampere
ms	Millisecond
P	Power
V	Voltage
I	Current
Al	Aluminium
e^-	Electron
H_2O	Water
H	Hydrogen
T	Temperature
Q	Heat
C_p	Calorific capacity
NaOH	Sodium Hydroxide
HCl	Hydrochloric
M	molar

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CHAPTER 1

INTRODUCTION

1.1 Overview

Water quality standard were becoming more and more stringent for all purposes including drinking water, swimming pools or wastewater reclamation in agriculture (Drogüi *et al.*, 2000). Turbidity in natural waters reduces light transmittance and affects the species that may survive in the water (Droste, 1997). According to WHO guidelines and standard, treated water for human consumption should have a turbidity value that is less than 5NTU. (Bryant *et al.*, 1992)

An application of electrolytic treatment to reduce the turbidity water was carry out. There were many industries using this treatment because it has been showing as an efficient technique of treatment effluents. These factors will influence the effectiveness of reducing turbidity which include power supply (Ferreira *et al.*, 2007), pH (Droste, 1997) and initial turbidity.

1.2 Electrochemical method

Electrochemical method means using electrolysis process for an experiment. In this study, the method electroflocculation was use. There are many synonymous for electroflocculation, and the most usual are electroflotation, electocoagulation, eletrodecantation (Ferreria *et al.*, 2007).

Technically, electrolysis consists of plates (electrodes) parallel ordered and interspersed in arrangement. When electrical current applied in the electrodes, positive ions will move to cathode and negative ions to anode.

1.3 Objectives of study

The objective of this study was:

- To determine the effect of electrochemical method towards reduce turbidity in water and factors influence the optimization of the reducing turbidity.

1.4 Scope of study

The main focus of the research was to apply the electrochemical method and verify its technical viability, to ensure the efficient option of the effluent treatment. In this study, a jar test experiment was carried out to investigate the ability of reducing turbidity in water under varying current voltage supply, initial turbidity and pH conditions. The sample water used was kaolin suspension.

CHAPTER 2

LITERATURE REVIEW

2.1 Turbidity

Turbidity was a measure of the cloudiness of water, the cloudier the water, the higher the turbidity value. Turbidity in water was caused by suspended matter such as clay, silt, organic matter, plankton and other microscopic organisms that interfere with the passage of light through the water.

A natural water and wastewater will contain many different sized particles at different concentration. Impurities in water often cause the water to appear turbid or be coloured. Impurities include suspended and colloidal materials and soluble substances (Culp *et al.*, 1986). A rough correlation exists between suspended solids concentration and turbidity (Droste, 1997).

Turbidity normally measured in the laboratory using turbidity, which is a meter that measures the intensity of light scattered at 90 degrees as a beam of light passes through a water sample. Light dispersing units are used for low turbidity water such as potable water and light scattering units are used for water containing more turbidity (Alley , 2000).According to the Rayleigh's law, it is observed that size and concentration of particles are able to influence the measurement of the turbidity (Droste, 1997). The most commonly used turbidity unit is NTU, or nephelometric turbidity units. The higher the intensity of scattered light, the higher the turbidity will be.

Nephelometric Turbidity Unit (NTU), Jackson Turbidity Unit (JTU) and Formazin Turbidity Unit (FTU) were those units used in measuring the turbidity. Turbidity was measured using the Jackson candle turbidimeter in the pass. (Sadar, 1996) The standard method for determination of turbidity is based on the Jackson candle turbidimeter, an application of Whipple and Jackson's ppm-silica scale (Sadar, 1996). The Jackson candle turbidimeter consist a special candle and a flat-bottomed glass tube (Figure 2.1), and were calibrated by Jackson in graduations equivalent to ppm of suspended silica turbidity.

A water sample was poured into the tube until the visual image of the candle flame, as viewed from the top of the tube, is diffused to a uniform glow. When the intensity of the scattered light equals that of the transmitted light, the image disappears; the depth of the sample in the tube is read against the ppm-silica scale, and turbidity was measured in Jackson turbidity units (JTU) (Sadar, 1996).

This method is no longer in standard use as turbidities lower than 25 units can not be measured directly using this instrument. It was removed from Standard Methods for the Examination of Water and Wastewater, published by the American Public Health Association, in their 17th edition (1989).

Nowadays people are using turbidity meter to measure the turbidity. Turbidity level which is above 1.0 NTU is associated with significant increases in total coliform densities (Droste, 1997). According to the Surface Water Treatment Rule (SWTR), the maximum allowable treated drinking water turbidity is established at 5.0 NTU (Bryant *et al.*, 1992).

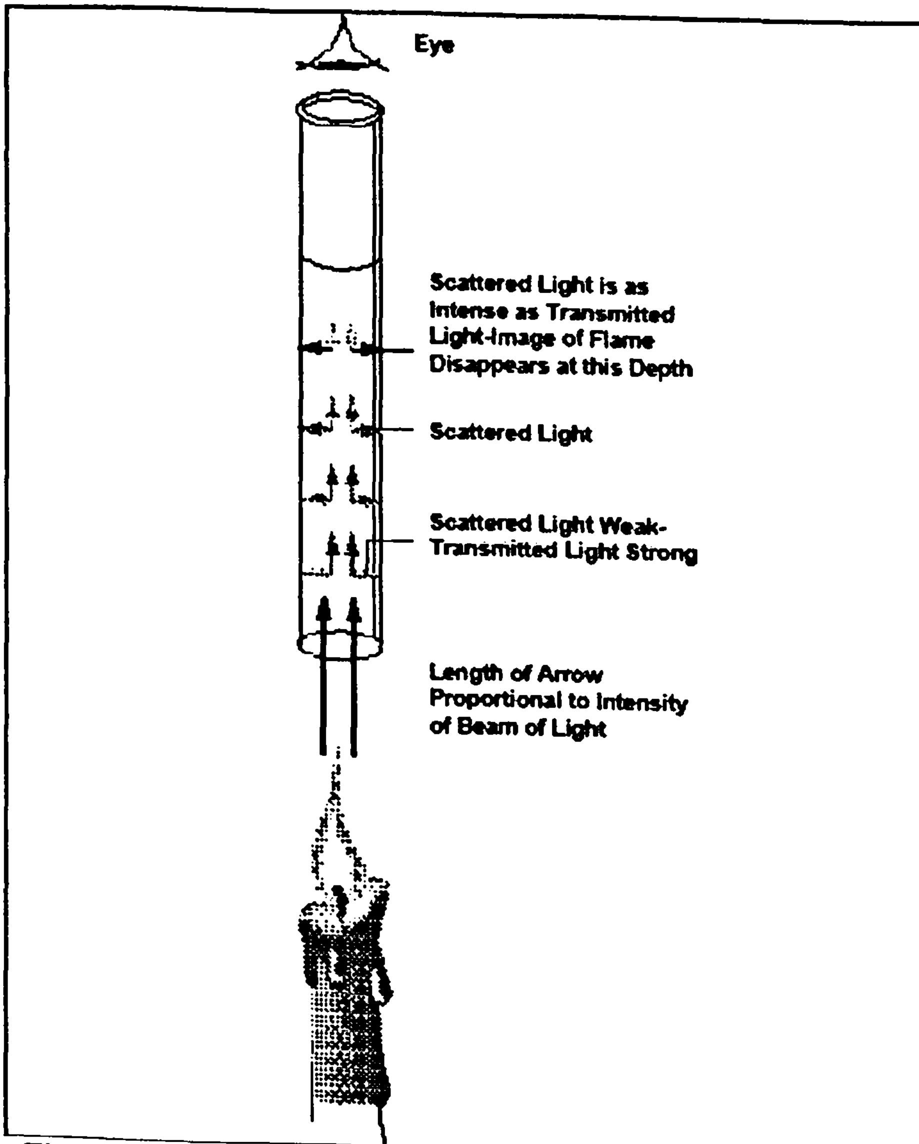

Figure 2.1 Jackson Candle Turbidimeter (Source from Sadar, 1996)

2.2 Jar Test

This is a laboratory method that is normally used to determine the optimum operating conditions for water or wastewater treatment. In another words, the effectiveness and required for water can be evaluated by this apparatus (Droste, 1997).

This particular device is capable of testing different reducing turbidity on a small scale in order to predict the functioning of a large scale treatment operation. Besides, it allows adjustments in pH and alternating mixing speeds. A jar test simulates the coagulation and flocculation processes that encourage the removal of suspended colloids and organic matter which can lead to turbidity, odor and taste problems (Faust *et al.*, 1983).

2.3 Electrolysis method

Electrochemical techniques have been widely experimented on the treatment of industrial wastewaters for purification and recycling (Ciardelli & Ranieri, 2001). The electroflocculation has been revival as a very promising alternative in effluent's treatment originating from different branches of the productive chain, such as sewer, groundwater, heavy metal, radioactive, food petrochemical, textile, restaurant, laundry, tannery and paper industry (Ferreira *et al.*, 2007).

Electroflocculation is the combination of an oxidation, a flocculation and a flotation (Ciardelli & Ranieri, 2001).There are many synonymous of electroflocculation, and the most usual are electroflotation, electrocoagulation, and electrodecantation(Ferreira *et al.*, 2007).

Electrocoagulation has been used widely for treatment of waster water. Electrocoagulation is an efficient treatment process for different wastes, e.g. soluble oils, liquid from the food, textile industries, or sellulose and effluents from the paper industry (Ni'am *et al.*, 2007). Electrocoagulation was an effective process for the destabilization of finely dispersed particles by removing hydrocarbons, greases, suspended solid and heavy metals from different types of wastewater (Ni'am *et al.*, 2007). According to Can *et al.* (2006), electrocoagulation has been proposed in recent years as an effective method to treat various wastewaters such as : landfill leachate, restaurant wastewater, salina wastewater, tar sand and oil shale wastewater, laundry wastewater, nitrate and arsenic bearing wastewater, and chemical mechanical polishing wastewater.

The mechanism of the electrochemical process in aqueous system is quite complex (Ni'am *et al.*, 2007). There are three main possible mechanisms involved in the process: electro-coagulation, electro-flotation and electro-oxidation. According to Can *et al.* (2006), three main processes occur during electrocoagulation ; (i) electrolytic reaction at electrode surface, (ii) formation of coagulations in the aqueous phase, (iii) adsorption of soluble or colloidal pollutants on coagulants, and removal by sedimentation or flotation.

2.3.1 Electrode plate

Aluminium or iron usually used as electrodes and their cations are generated by dissolution of sacrificial anodes upon the application of a direct current (Ni'am *et al.*, 2007). Kobya *et al.* (2003) has been investigated electrocoagulation technologies to treatment of textile wastewaters using iron and aluminum electrode materials. The results show that iron was superior to aluminum as sacrificial electrode material, from COD removal efficiency and energy consumption points.

Electroflocculation consists in a set of plates (electrodes) parallel ordered. With an electrical current applied to the electrodes, positive ions will move to cathode and negative ions will move to anode. The plates material normally aluminium or iron , which has low cost and good availability.

When electrolysis occurred, at anode the aluminum plate will produced the ions aluminum and dissolved in water as showed in equation 2.1. Some water molecule will undergo electrolysis to produce molecule oxygen (equation 2.2). At cathode the water will received electron to produce the hydrogen gas (equation 2.4) and OH ions. The ions aluminum which dissolved will react with the water molecule. Reaction will depend on the pH solution. Equation 2.5, 2.6, 2.7 and 2.8 shows the reaction of ions aluminum and aluminum hydroxide react with water to produce H^+. H^+ ions will made the pH solution more acidity.

With the aluminium electrode, the reactions are:

Anode :

$Al(s) \leftrightarrow Al(aq)^{3+} + 3e^-$ 2.1

$2H_2O(l) \leftrightarrow O_2(g) + 4H^+ + 4e^-$ 2.2

Cathode:

$2\,H(aq)^+ + 2\,e^- \leftrightarrow H_2\,(g)$ 2.3

$2\,H_2O(l) + 2\,e^- \leftrightarrow H_2\,(g) + 2\,OH^-(aq)$ 2.4

Since the ions aluminium are dissolved, some species can be formed, depending on the solution pH.

The reactions comprehended are show below:

$Al^{3+} + H_2O \rightarrow AlOH^{2+} + H^+$ 2.5

$AlOH^{2+} + H_2O \rightarrow Al(OH)_2^+ + H^+$ 2.6

$Al(OH)_2^+ + H_2O \rightarrow Al(OH)_3 + H^+$ 2.7

$Al(OH)_3 + H_2O \rightarrow Al(OH)_4^- + H^+$ 2.8

$H_2O \rightarrow O_2(g) + 4\,H^+\,(aq) + 4\,e^-$ 2.9

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