EFFECT OF OPERATIONAL PARAMETERS ON TREATMENT OF TEXTILE WASTEWATER BY ELECTROCOAGULATION PROCESS USING DIFFERENT ELECTRODE MATERIALS

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by

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LIST OF ABBREVIATIONS

Abs	Absorbance of wastewater after treatment at time t (min)
Abs_0	Initial absorbance of wastewater
Al	Aluminum
Al^{3+}	Aluminum ions
ANOVA	Analysis of variance
BOD	Biochemical oxygen demand
CCD	Central composite design
CD	Current density
CO_2	Carbon dioxide
COD	Chemical oxygen demand
DC	Direct current
EC	Electrocoagulation
Fe	Iron
$Fe(OH)_2$	Ferrous hydroxide
$Fe(OH)_3$	Ferric hydroxide
Fe^{2+}	Ferrous ions
Fe^{3+}	Ferric ions
H_2O	Water
H_2O_2	Hydrogen peroxide
H_2SO_4	Sulfuric acid
HCl	Hydrochloric acid
MYR	Malaysian Ringgit
NaCl	Sodium chloride

NaOH	Sodium hydroxide
NTU	Nephelometric turbidity unit
O_2	Oxygen
OFAT	One- factor- at-a time
OH^-	Hydroxide ions
RPM	Revolutions per minute
SEM	Scanning Electronic Microscopy
SS	Suspended solids
SS	Stainless steel
TDS	Total dissolved solids
USEPA	United State Environmental Protection Agency
UV-Vis	Visible and Ultraviolet Spectrophotometer
Zn	Zinc
$Zn(OH)_2$	Zinc hydroxide
Zn^{2+}	Zinc ions

LIST OF SYMBOLS

Symbol	Description	Unit
λ	Wavelength	nm
E	Amount of energy consumed during EC process	KWh
M	Anode material	
I	Applied current	mA
C	Final concentration of dye	mg/L
cm	Centimeter	
C_o	Initial concentration of dye	mg/L
^{o}C	Degree celeius	
Q	Electric charge passed through the electrode material	coulomb
e^-	Electron	
F	Faraday constant	C mole-1
kwh	Kilowatt	
L	Liter	
Δm	Mass of the substance liberated at an electrode surface	gram
m	Meter	
mA	Milliampere	
mg	Milligram	
mm	Millimeter	
ms^{-1}	Millisiemens	
M	Molar mass of the substance	
nm	Nanometer	

n	Number	
Z	Number of electrons transferred during the anodic reaction	
U	Operating voltage	Volt
ppm	Part per million	
T	Temperature	ºC
A	The submerged effective surface area of anodes	cm^2
t	Time	min
Y_o	Turbidity value of the sample before treatment	NTU
Y	Turbidity value of treated sample	NTU
%ΔW	%Weight loss of electrode material	
W2	Weight of the electrode after EC treatment	gram
W1	Weight of the electrode before EC treatment	gram

KESAN PARAMETER OPERASI KE ATAS RAWATAN AIR SISA TEKSTIL MENERUSI PROSES ELEKTRO PENGGUMPALAN MENGGUNAKAN BAHAN ELEKTROD YANG BERBEZA

ABSTRAK

Proses elektro penggumpalan telah digunakan untuk mengatasi masalah yang dihadapi oleh proses fiziko kimia konvensional dalam rawatan air sisa tekstil. Air sisa tekstil sebenar mengandungi pencelup reaktif selalunya bersifat alkali. Bahan-bahan elektrod yang berbeza seperti zink dan keluli tahan karat boleh digunakan bagi mengatasi prestasi lemah elektrod aluminium dalam medium beralkali untuk rawatan air sisa tekstil sebenar. Prestasi proses elektro penggumpalan untuk rawatan air sisa tekstil sintetik (disediakan menggunakan pencelup biru reaktif 261) dan air buangan tekstil sebenar telah disiasat. Tiga jenis bahan elektrod iaitu aluminium, zink dan keluli tahan karat telah digunakan dalam kajian ini. Parameter operasi terlibat dalam kajian ini ialah ketumpatan arus (2-8 mA/cm^2), kepekatan pewarna awal (20-100 mg/L) dan nilai pH awal (5-9). Kajian permulaan telah dijalankan menggunakan air buangan tekstil sintetik untuk menentukan keadaan operasi optimum yang memberikan penyingkiran pencelup yang tinggi untuk setiap bahan elektrod. Keadaan-keadaan optimum yang diperolehi ialah ketumpatan arus (4 mA/cm^2 untuk semua elektrod-elektrod), kepekatan awal pencelup (50 mg/L untuk elektrod aluminium dan 100 mg/L untuk elektrod zink dan keluli tahan karat) dan nilai awal pH (7 untuk elektrod aluminium dan 9 untuk elektrod zink dan keluli tahan karat). Satu penyiasatan yang menyeluruh dari segi penyingkiran pencelup, COD, kekeruhan, kehilangan berat elektrod, dan penggunaan tenaga dijalankan di bawah keadaan optimum (ketumpatan arus dan kepekatan pewarna yang awal) manakala nilai pH awal telah ditetapkan pada

9 bagi mewakili keadaan air sisa tekstil sebenar yang digunakan dalam kajian ini. Penyingkiran pencelup, kehilangan berat elektrod, dan penggunaan kuasa telah direkodkan sebagai 99.8%, 0.66 kWh/m^3 dan 0.039% untuk elektrod zink, 99.1%, 0.70 kWh/m^3 dan 0.066% untuk elektrod keluli tahan karat dan 75.8%, 0.50 kWh/m^3 dan 0.41% untuk elektrod aluminium masing-masing. Rawatan air sisa tekstil yang sebenar di bawah keadaan operasi optimum (ketumpatan arus dan kepekatan pewarna yang awal) dan pada nilai pH semula jadi air sisa tekstil menunjukkan bahawa elektrod zink memberikan penyingkiran pencelup yang tertinggi (83.7%), kehilangan berat elektrod yang terendah (0.043%) dan penggunaan tenaga yang munasabah (0.69 kWh/m^3). Kos operasi duga dianggarkan lebih rendah untuk elektrod zink (MYR 3.93 setiap 1 m^3 air sisa terawat tekstil selama 10 minit) berbanding dengan elektrod aluminium dan keluli tahan karat. Oleh itu, elektrod zink dianggap sebagai bahan elektrod plaing berkesan untuk rawatan air sisa tekstil yang mengandungi pencelup reaktif.

EFFECT OF OPERATIONAL PARAMETERS ON TREATMENT OF TEXTILE WASTEWATER BY ELECTROCOAGULATION PROCESS USING DIFFERENT ELECTRODE MATERIALS

ABSTRACT

Electrocoagulation process (EC) has been used to overcome the problems related to the use of conventional physico-chemical process in treatment of textile wastewater. Real textile wastewaters containing reactive dyes are often characterized by their alkalinity. Different electrode materials such as zinc and stainless steel could be used to tackle the low performance of aluminum electrode in alkaline medium for treatment of a real textile wastewater. The performance of electrocoagulation process for treatment of a synthetic textile wastewater (prepared using reactive blue 261 dye) and a real textile wastewater was investigated. Three types of electrode material namely aluminum, zinc and stainless steel were used in this study. The operating parameters involved in this study were current density (2-8 mA/cm^2), initial dye concentration (20-100 mg/L) and initial pH (5-9). The preliminary study was conducted using synthetic textile wastewater to determine the best operating conditions that would lead to high dye removal for each electrode material. The best conditions were current density (4 mA/cm^2 for all electrodes), initial dye concentration (50 mg/L for aluminum electrode and 100 mg/L for zinc and stainless steel electrode) and initial pH (7 for aluminum electrode and 9 for zinc and stainless steel electrode). A thorough investigation in terms of dye removal, COD, turbidity, energy consumption and electrode weight loss was conducted under the best conditions (current density and initial dye concentration) while the initial pH value was kept at 9 to represent the real textile wastewater condition as used in this study. Dye removal, power consumption and electrode weight loss were found at 99.8%, 0.66 kWh/m^3 and 0.039% for zinc electrode, 99.1%, 0.70 kWh/m^3 and 0.066% for stainless steel electrode and 75.8%, 0.50 kWh/m^3 and 0.41% for aluminum electrode, respectively. The treated real textile wastewater under the best operating conditions (current density and initial dye concentration) and at original pH of textile wastewater demonstrated that zinc electrode showed the highest dye removal (83.7%), lowest electrode weight loss (0.043%) and reasonable energy consumption (0.69 kWh/m^3). The estimated operating cost of the EC process was lower for zinc electrode (MYR 3.9 per 1 m^3 of treated textile wastewater for 10 minutes) compared with aluminum and stainless steel electrodes. Thus, zinc electrode could be an effective electrode material for treatment of textile wastewater containing reactive dye.

CHAPTER ONE

INTRODUCTION

Water pollution is a major environmental problem due to its effects on human life, plants, organisms and other life forms. The problem occurs when wastes are directly or indirectly discharged into waterways (lakes, river, sea, ocean and groundwater) without necessary treatment. The Malaysia Environment Quality Report (2006-2010) indicated that 203 of rivers were slight polluted while 74 rivers were completely polluted in the year 2010. This was due to the increasing number of manufacturing factories as well as high waste dumping from housing and farming areas (Pang and Abdullah, 2013). Industrial sector remains the main source of water pollution due to its high discharge quantity and diversities. Several industries (textile, paper, leather, food and pharmaceutical industries) generate wastewaters containing dyes, which are considered serious environmental pollutants. This study is focused on the treatment of wastewaters produced by textile industry.

1.1 Problems of Textile Effluent

Textile industry is one of the industries that generate large amount of wastewater that presents a significant environmental pollution problem. It usually has high level of pollutants as characterized by high chemical oxygen demand (COD), high suspended solid, strong color, and high biotoxicity. In general, Figure 1.1 summarizes the main characterization of textile effluent at various stages of textile manufacturing process (cotton based textile production processes). Each textile factory has its own manufacturing and treatment processes which are different from another.

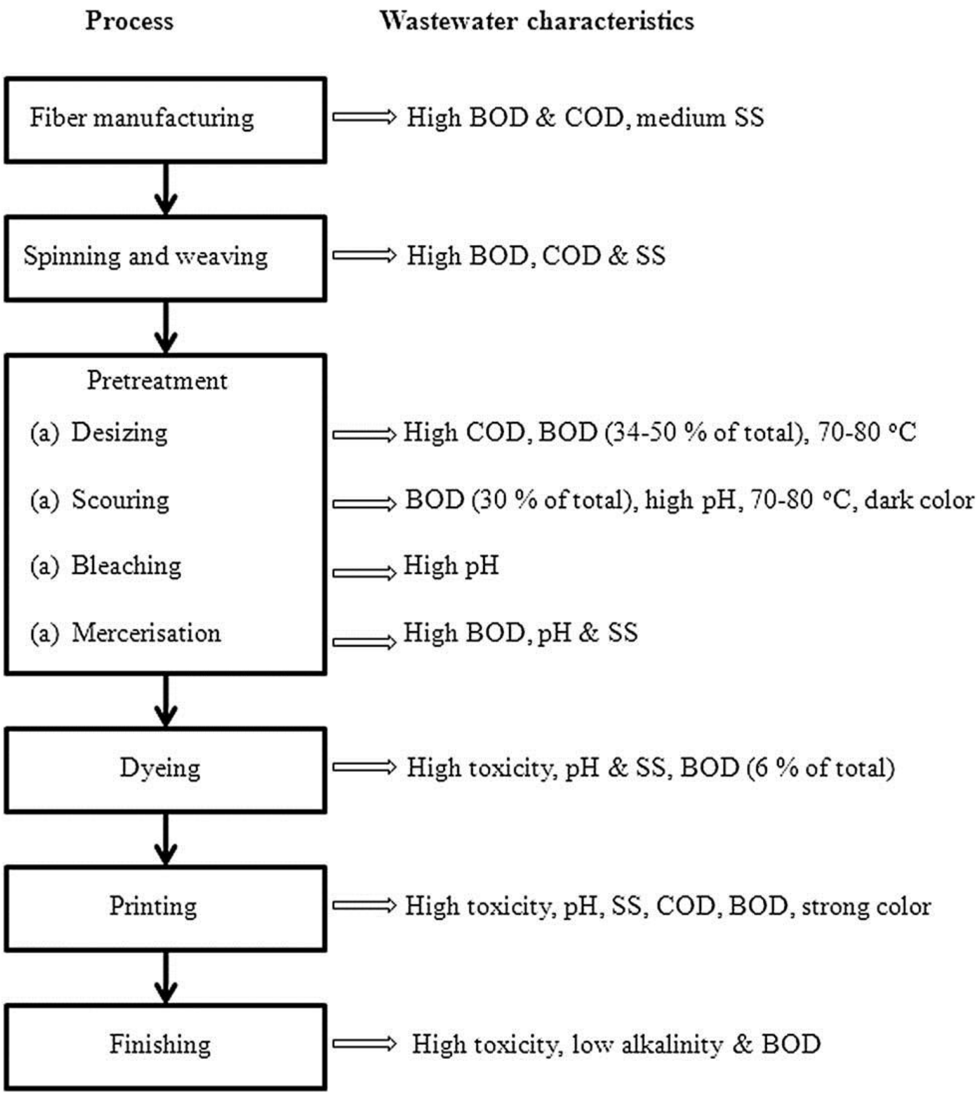

Figure 1.1: Characterization of textile effluent at various stages of textile manufacturing process (Pang and Abdullah, 2013).

Textile industry utilizes 10,000 types of pigments and dyes and many of them are toxic to human and the environment (Essadki et al., 2008). Textile effluents do not only impart color to water ways but also cause environmental damage to living organisms by stopping the reoxyenation capacity of water as well as blocking sunlight, thereby, disturbing the natural growth activity of aquatic life (Rahtinam et al., 2015).

Textile industry uses chemicals and dyes in various fabrication processes (dyeing and finishing process) where large portion of these dyes (up to 50%) is lost in wastewater. Most of pollution problems caused by textile industry have been reported