UNIVERSITI TEKNOLOGI MARA

PREPARATION OF IRON ELECTRODE DERIVED FROM IRON STEEL WASTE FOR DECOLORIZATION OF VARIOUS TYPE OF DYES VIA ELECTROCOAGULATION METHOD

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ABSTRACT

This present study examines the preparation of iron electrode (Fe.S) derived from iron steel waste for decolorization of Reactive Black 5 (RB5), Acid Blue 29 (AB29), and Methylene Blue (MB) via electrocoagulation method. The Fe.S was synthesized by varying the loading of iron steel waste and Polytetrafluoroethylene (PTFE) as binder. The Fe.S electrode was characterized using Scanning Electron Microscopy-Energy Dispersive X-ray (SEM-EDX), nitrogen adsorption analysis, X-ray Fluorescence Spectrometer (XRF), and Fourier Transformed Infra-red (FTIR). Additionally, electrochemical characterisation was executed using cyclic voltammetry (CV) and potential electrochemical impedance spectroscopy (PEIS). The electrodes performance was assessed at different operating parameters which includes initial pH, current density, and initial dye concentration. Subsequently, the stability of the Fe.S electrode was tested for the best operating conditions. The best preparation iron electrode was found at 3 g of iron sludge powder loading and 30 wt% of PTFE as binder at ratio 4:1:3, denoted as 30Fe.S which exhibited almost complete decolorization within 60 minutes of treatment time. Interestingly, the best preparation iron electrode also has minimum chemical oxygen demand (COD) of 67% compared to others composition loading ratio. The results have proved that 30Fe.S has a better distribution of binders as compared to other electrodes and a mesoporous material which has a higher surface area (S_{BET} = 11.12 m^2/g). There are 30.72 wt% of iron contained in a 30Fe.S and after formulation, it reveals that some of the atoms were integrated within the surface of the iron mesoporous particle through XRF and FTIR analysis respectively. The electrode also exhibits a broader leave-like shape curve in CV analysis and has 24.4 $\Omega.cm^2$ of electron transfer resistance. The 30Fe.S shows good electrochemical performances, where the best electrode achieved highest decolorization of three dyes (RB5, AB29, and MB) more than 90% at optimal pH 6 with 4 mA/cm^2 of current density. The performance of RB5, AB29, and MB decolorization were reduced after third cycles for RB5 and AB29 from 100% to 55.7% and 26% respectively whereas MB the performance dropped to 10% and 5% for third and fourth cycles with minimal leached metal ions' concentration (0.006 – 0.001 mgL^{-1}) within the allowable regulatory limits. The research concludes that the 30Fe.S electrode with prepared appropriate and economically method could effectively promote the ferrous ions to degrade various type of dyes at moderate operating condition.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Among the major causes of water quality deterioration is the discharge of industrial effluents by the textile industry [1]–[3]. According to the United States Environmental Protection Agency (USEPA), textile industries has consumed 36,000 litres of water to generate 20,000 Ib/day of fabric [4], with textile effluents accounting for almost 20% of global water pollution [4], [5]. The World Water Development Report of the United Nations (UN) disclosed that in 2022, almost 80-90% of textile effluents were neither collected nor treated, directly released the harmful substances into the environment [4]. Additionally, 90% of the total dyes generated was utilized to produce fabrics while the remaining portion was used in the production of paper, leather, plastic, and chemical industry [6].

Based on the Environmental Quality (Industrial Effluent) Regulations 2009 in Malaysia has stated that the allowable dye concentration into the water streams is 80 mg/L and 250 mg/L for Standard A and Standard B categories respectively [7]. There are various types of synthetic dyes, for instance, basic, anionic, cationic, non-ionic, and reactive dyes that are contained in textile effluents [8]. The utilization of synthetic dyes is widely used in textile industries which consequently cause environmental pollution when they are often discharged into the receiving environment [8]–[10]. Even at low concentration of residual dyes contained in wastewater is extremely visible and this capable of inducing cancer and tumours in humans [6], [11]–[13]. The effluents from these industries have been contaminated with a wide range of pollutants with the complex organic and inorganic chemicals that adversely affected the aquatic biodiversity due to toxicity and non- biodegradability are able to minimize aquatic diversity by blocking the passage of sunlightthrough the water [2], [12]. Therefore, the textile wastewater needs to be properly treatedprior to its discharged to minimize the environmental impact [8], [12]–[14].