UNIVERSITI TEKNOLOGI MARA

REDUCTION OF CHROMIUM HEXAVALENT IN ELECTROPLATING INDUSTRY PASSIVATION TANK EFFLUENT USING LINZ-DONAWITS SLAG

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ABSTRACT

Hexavalent chromium, Cr(VI), while widely utilised in electroplating industry for its wear and corrosion resistance, is a known carcinogen and mutagen, requiring a strict wastewater treatment. Current Cr(VI) treatment method in the electroplating industry is using Sodium metabisulfite (SMBS) as a reducing agent, capable of completely reduce Cr(VI) at pH 2. However, SMBS application as reducing agent generates large volume of sludge destined for landfill and possess health risks to the facility workers due to the release of hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) gases. This study explores the utilisation of a steel making industry by-product, Linz- Donawits (LD) slag as a sustainable, low-cost alternative to SMBS. Electroplating passivation tank effluent was first characterised using ICP-MS, revealing Chromium as the highest component at 1614.6 mg/L. On the other hand, LD slag sample composition was characterised using XRF, showed Ferrous (II) oxide (FeO) as the major component (37.2% by mass). Cr(VI) concentration during the experiment was measured using HACH DR900 multiparameter portable calorimeter, aided by ChromaVer® 3 Chromium Reagent. This study investigates the effect of solution pH, treatment duration, LD slag particle size and LD slag particle dosage on Cr(VI) reduction. Complete Cr(VI) reduction (100%) without chemical conditioning of the effluent of pH2 was achieved in 5 minutes in two conditions which is at particle size 1.18mm of LD slag with dosage of 1.8g and with a particle size of 0.425mm with LD slag dosage of 1.6g. Therefore, showing a pattern of the smaller particle size of the LD slag, the smaller amount of LD slag is required to completely reduce Cr(VI) concentration in the solution. By comparison, SMBS at 8 ml of 4% v/v concentration SMBS reduced 40% of Cr(VI) in the sample solution. Regression model for predicting Cr(VI) reduction was achieved and it was found that the Adjusted R-squared is 0.7165 that indicates that the data were acceptably fit.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Chromium (Cr) is a versatile element utilised across multiple industries such as textile dying, tanneries, metal electroplating and wood preservation due to its exceptional resistance to corrosion, hardness and ability to form a durable compound, (Sharm, et al. 2022). Among these applications, the electroplating industry is one of the biggest consumers of Cr, particularly in the form of Chromium hexavalent, Cr(VI). Electroplating process relies on the electro chemical process to deposit a thin, protective metallic layer on prepared metal surface such as automotive parts, aerospace components, and decorative items. However, not all Cr ions are deposited on the metal surface and excess Cr will be discharged with the effluent. Therefore, electroplating industries are one of the major contributors to Cr(VI) in wastewater (Sharma, Chaudhari and Prajapati 2022).This is why wastewater from electroplating industries was selected as the sample water in this study.

Two prevalent oxidation states of Cr in the world are trivalent, Cr(III) and hexavalent Cr(VI). Cr(III) is essential trace element for the human body and plays an important part in the metabolism of glucose, protein, and lipid, with a recommended daily dosage of 25-35 µg/day for adults, (National Institutes of Health 2021). In contrast, Cr(VI) has been recognized as hazardous and a known carcinogen and mutagen to the human body (Sharm, et al. 2022). Structurally, chromate resembles phosphate and sulfate thus it readily enters all cells by means of the general anion channel protein, (Hiller and Leggett 2020), (Vaiopoulou and Gikas 2020). Once Cr(VI) enters a cell, it will be reduced to Cr(III) by body mechanism. As the result of the reduction process, unstable and reactive intermediates such as Cr pentavalent, Cr(V), hydroxide, thiyl and organic tradicals and active oxygen radicals are produced (Hiller and Leggett 2020). It is believed that these moieties are at fault of Cr carcinogenicity. In Malaysia, the limits on the discharge of industrial effluent were set by the Environmental Quality Regulation, 1979. According to the Environmental Quality Act 1974 (Act 127), the maximum allowable concentration limit of Cr(VI) is 0.05 mg/L and for Cr(III) is 1.0 mg/L.