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REDUCTION OF HEXAVALENT CHROMIUM TO TRIVALENT CHROMIUM IN ELECTROPLATING INDUSTRY EFFLUENT

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ABSTRACT

Hexavalent chromium Cr(IV) is widely used as electroplating agent to produce a hard, durable coating to a metal with excellent wear and corrosion resistance properties. Yet the effluent of this process needs to be carefully treated as Cr(IV) has been recognized as hazardous, a known carcinogen and mutagen to the human body. Current treatment of Cr(IV) in electroplating industry is by using sodium metabisulfite (SMBS) with a maximum reduction of 100% in a solution of pH 2. Nevertheless, despite the remarkable performance, the application of SMBS as reducing agent generates a massive amount of sludge which eventually will be disposed to the landfill. It also poses detrimental health effects due to the release of hydrogen sulfide (H_2S) and sulfur dioxide (SO^2) gas. Thus, a less harmful reducing agent was studied to replace SMBS in Cr(IV) reduction process. Linz-Donawitz (LD) slag has been discovered to be a good reducing agent due to the presence of Iron in the form of Fe^{2+}. The characterization of electroplating industrial effluent using ICP-MS shows a highest composition of Chromium which is 1614.6 mg/L. Meanwhile, characterization of LD slag shows that the major component is FeO which constitutes 37.184% of the total mass. By using SMBS as reducing agent, 8 ml of 4% v/v SMBS concentration is required to reduce 40% of Cr(IV) in the sample solution. The optimum treatment duration of Cr(IV) using LD slag is found to be 5 minutes and the best pH of the sample solution for optimal reduction rate is 2. In addition, smaller particle size of the LD slag is more advantageous as smaller amount of LD slag is required to completely reduce Cr(IV) concentration in the solution. However, the best particle size is 0.425mm because the reduction reaction is more controllable. Particle size that is smaller than this tends to be more sensitive. ORP value at zero Cr(IV) concentration is found to be ±488 mV.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Chromium, (Cr) has an extensive use in textile dying, tanneries, metal electroplating and wood preservation and these industrial activities have been identified as the highest source of Cr contamination in the environment, (Prevot, et al., 2018). Two prevalent oxidation states of Cr in the world are trivalent, Cr(III) and hexavalent Cr(IV). While Cr(III) is essential to the human body and plays an important part in the metabolism of carbohydrate, protein, and lipid, (Dubey, Sillanpaa, et al., 2017) Cr(IV) has been recognized as hazardous and a known carcinogen and mutagen to the human body. Structurally, chromate is similar to phosphate and sulfate thus it readily enters all cells by means of the general anion channel protein, (Hayes, 2004). Once Cr(IV) 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 radicals and active oxygen radicals are produced (Hayes, 2004). It is believed that these moieties are at fault Cr carcinogenicity.

Due to these reasons, treatment of Cr(IV) in wastewater has been a major concern to scientist all over the world. Among all other remediation strategies, reduction of Cr(IV) is the most broadly used in which reducing agent is introduced to the solution to convert highly toxic Cr(IV) to less harmful Cr(III). Sodium metabisulfite (SMBS), also known as anhydrous sodium bisulfite, is a strong reductive chemical commonly used to reduce Cr(IV) at a pH less than 4. Unfortunately, this reduction method will procedure a massive amount of sludge. This sludge will consequently dried and dispose to the landfills. Furthermore, this method poses a health and environmental effect to industrial workers mainly due to the Hydrogen Sulfide (H_2S) and Sulfur Dioxide (SO_2) gas released. Thus, the main objective of this research to study other reduction methods that are safe and do not generates a waste by-product.

To provide a hard, durable coating to a metal with excellent wear and corrosion resistance properties, the metals are electroplated with Cr(IV). Electroplating industries