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REDUCTION OF HEXAVALENT CHROMIUM TO TRIVALENT CHROMIUM USING GREEN TECHNOLOGY

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ABSTRACT

Hexavalent Chromium (Cr^{6+}) is carcinogenic and harmful substance that can harm human health. These Cr^{6+} are mainly from electroplating industry that produce metal with have high corrosion resistance to environmental conditions. Thus, the residue from this industry generate chromium waste that can pollute the environment if it is not treat properly. Common method in treating Cr^{6+} is by using Sodium Metabisulfite (SMBS) as reducing agent to reduce it to Cr^{3+} and further process in hydroxide precipitation for completely remove the chromium content in the wastewater effluent. This chemical generated harmful gases which are Hydrogen Sulfide (H_2S) and Sulfur dioxide (SO_2) that give health problems for human through inhalation. Production of the huge amount of sludge that generates from the treating process using SMBS, eventually will be disposed at landfill gives effect on the environmental aspects. Other inorganic waste of that can be used as a reducing agent is Leeden Gas sludge (LG sludge) that are from acetylene production gas. LG sludge contains high in Calcium (Ca) element and Ferum (Fe) ions that are essential for the reduction of Cr^{6+} to Trivalent Chromium (Cr^{3+}). The analysis of LG sludge characterization was done by XRF and XRD instrument with the result of high Ca and Fe ions with Calcium Hydroxide ($Ca(OH)_2$) alkaline properties. The initial concentration of Cr^{6+} is 3.25 mg/L using HACH Method 8023 and the initial total Cr concentration is 1124 mg/L was analyzed by using ICP-AES. From the jar test result in the effect of pH variation (from pH 2.5, 3.5, 4.5, 5, 5.5, 6, 6.5, 7.5, 8, 9 to 10), the highest % reduction is at pH 5.51 with 61.5% reduction and the dosage of LG sludge was 1.15 mL. The ORP value was at 320.2 mV with 1.25 mg/L of Cr^{6+} concentration. Next, result from the effect of volume LG sludge variation (from 0.7 mL, 0.8 mL, 0.9 mL, 1.0 mL, 1.1 mL, 1.2 mL, 1.4 mL, 1.6 mL, 1.8 mL, 2.0 mL to 2.1 mL), 100% reduction occurs at pH 6.04 with the dosage of 1.8 mL and the ORP value was at 264.9 mV. The result of SMBS dosage as a reducing agent was 10.5 mL for 100% reduction. Comparison between the dosage of SMBS and LG sludge is that SMBS used 8.7 mL more than LG sludge. Thus, the optimization of cost can be accomplished by replacing the SMBS with LG sludge in treating the Cr waste. Furthermore, LG sludge can also act as precipitate agent due to the formation of brownish precipitate at the bottom of the beaker which suspected to be $Cr(OH)_3$ precipitate. Other than that, LG sludge can also be used as pH adjustment without adding any other chemical due to it's high Ca properties which is alkaline. LG sludge has better performance of reducing the Cr^{6+} to Cr^{3+} compare to SMBS as reducing agents.

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CHAPTER ONE

1.1 Research Background

Chromium substance can exist at different oxidation states range between -2 to 6 such as chromate, dichromate and so on. But, only two oxidation state that is stable in the natural environment which is hexavalent chromium (Cr^{6+}) and trivalent chromium (Cr^{3+}). Chromium is one of the heavy metal that use in several process industry such as tannery, electronic device manufacturing units, electroplating and power generation (Selvaraj, Manonmani, & Pattabhi, 2003). All these companies produce industrial influent streams that have chromium and other heavy metal that need to be treated before releasing it to any inland water in Malaysia. Other heavy metal such as cadmium, lead, mercury, nickel and copper may present in the industrial influent that needs specialized and advances treatment to remove these heavy metal so that it does not pollute the environment (Ramakrishnaiah & Prathima, 2012). According to the Department of Environment (DOE) under Environment Quality (Industrial Effluent) Regulation (IER 2009), state that any industrial effluent that contaminates with any of the heavy metal, need to possess its own Industrial Effluent Treatment System (IETS) for removal of the heavy metal contaminant (Environmental , 2017).

According to the compound annual growth rate, estimation of 2.98% increment of electroplating market from previous annual value. The total of RM 51.33 billion estimations of market demand for the electroplating industry (Wood, 2017). Electroplating industry consists of passivation process where the metal substance is cover by layers of a passive oxide such as inert chromium oxide surface for improvement of its corrosion resistance (García, Steeghs, Bouten, Ortiz, & Urtiaga, 2013). This passive oxide film form when the reactive metal reacts with oxygen and protect the inner element of the metal from corrosion. The waste product from this process is actually containing heavy metal that can harm both the environment and human health. Hexavalent Chromium (Cr^{6+}) is the main component that polluted the environment due to its level content that is high in industrial effluent which has been discharged to the public drain or inland water in Malaysia (Owlad, Aroua, Daud, & Baroutian, 2009).