Effect UV Irradiation and Ozonation(O3) Process for Degradation of Copper from Electroplating Wastewater

by Aji Prasetyaningrum

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Effect UV Irradiation and Ozonation(O₃) Process for Degradation of Copper from Electroplating Wastewater

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Abstract. Copper (Cu) is one of the most common pollutant of the plating industrial wastewater. UV irradiation and ozonation (O3) treatment will enhance reduction of heavy metals pollutans in electroplating wastewater such as copper (Cu). This research intended to study the performance of degradation of Cu using UV irradiation and ozonation (O3) treatment. The research uses variable proses are the intensity of UV irradiation and the ozon flowrate. UV irradiation equipped with UV-lamp tube (8 W, 16 W and 24 W). Ozonation process was carried out at different flowrate (3 L.min-1, 5 L.min-1 and 7 L.min-1). Experiment was done at room temperature and initial pH reaction adjusted at pH 8. Synthetic copper wastewater was prepared at the initial concentration of 150 mg.L-1. The reduction of Cu concentration was analyzed using Atomic Absorption Spectroscopy (AAS). The results of this research showed that treatment of UV and O3 have significant effect for degradation of copper pollutant. The treatment of UV irradiation and ozonation (O3) reduced of Cu contaminant until 48.9% and 66 %, respectively after 60 min of reaction.

Keyword: degradation, Cu, ozonation, UV irradiation

INTRODUCTION

Advanced oxidation processes (AOPs) are promising and effective to remove contaminants in wastewater [1,2]. The basic principle of AOP involves the production of hydroxyl radicals (HO•), which can be generated from hydrogen peroxide (H2O2), ozone, photo-catalysis, or oxidants in combination with using ultraviolet (UV) radiation [3]. Ozone is one of the most powerful commercially available oxidants and is commonly used for municipal water and wastewater treatment. In addition to its ability to oxidize, it is an environmentally friendly treatment method where pollutants, including color, odor and microorganisms are directly destroyed by oxidation, without creating harmful chlorinated by-products or significant residues [4].

UV radiation and ozonation (O3) are excellent treatment methods for different hazardous wastes [5]. Ozonation and irradiation using UV spectra has been a potential option for in wastewater treatment [6,7,8]. The operational condition such as ozone flow rate and pH are very beneficial for quality of effluent [9,10]. However, during the process, there are so many uncertainty condition such as UV irradiation intensity and ozone flow rate. The aim of this study was to compare UV radiation and ozonation processing for the degradation of heavy metals (Cu) in electroplating wastewater. This research is carried out to evaluate the variable process of UV irradiation and ozonation (radiation intensity and ozone flowrate) in reducing Cu content in the wastewater. The parameters of the process are

anorganic substances of electroplating wastewater (% degradation of Cu). Therefore, this research gives an alternative to minimized the problems related to the treatment of electroplating effluents would be the development of more effective.

MATERIAL AND METHOD

Synthetic wastewater with concentration of 150 ppm were synthesized with CuSO4 (E Merck, CAS# 7758-99-8) Initial pH reaction was adjusted using reagen HCl (E Merck, CAS# 7647-01-1) and NaOH (E Merck, CAS# 1310-73-2). UV irradiation equipped with UV-lamp tube mounted in the horizontal position.The solutions are exposed to UV irradiation by the UV-C lamp (Philips TUV 8, 16 and 24 Watt) operating at 254 nm wavelength. The ozonation (O3) were conducted in semi-batch reactor. Ozone was produced from air using a corona discharge ozone generator type dielectric barrier dicharge (Dipo Technology, Diponegoro University), with a production capacity of 20 g.h-1 of ozone. The Cu solutions were ozonated in 200 mL glass reactor. The ozone gas sparger was adjusted at the bottom of reactor during the ozonation process, allowing efficient ozone diffusion in the liquid phase.

During UV and O3 treatment the reaction adjusted for different periods of time (i.e 10, 20, 30, 40, 50, 60 min) at initial pH 8. All UV and O3 processes were performed at room temperature and atmospheric pressure. Initial pH was controlled with addition of HCl or NaOH. The samples were characterized in term of matter in the change of Cu content. The heavy metal of Cu in the samples was characterized by its absorbances with Atomic Absorption Spectroscopy (AAS) (Quantachrome 11.0), and pH of the solution measured with pH meter analyzer (EZDO PH-5011A). The absorbance of synthetic and treated wastewater were measured using UV-Vis spectrometer at wave length of 810 nm. The oxidation experiments were performed in duplicate and the observed standard deviation was always less than 6% of the reported value.

RESULTS AND DISCUSSION

Effect of UV irradiation

This study was conducted to determine the effect reaction time and lamp intensity on reducing Cu content. The UV irradiation experiments were carried out at different irradiation intensity of UV lamp (8 W, 16 W and 24 W) for 60 min of reaction. The effect of decreasing Cu content on reaction time and irradiation intensity of UV shows in Fig.1.
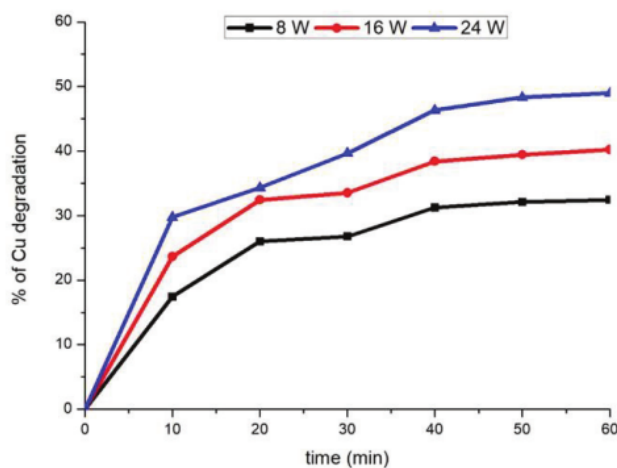

FIGURE 1. The effect of % Cu degradation at UV irradiation different irradiation intensity of UV lamp.

Fig 1. shows that % Cu degradation increases with increasing reaction time. Significant reduction in Cu concentration occurred after 40 minutes of reaction. After 40 minutes of reaction, the decrease in Cu concentration tends to be stable. During 60 minutes of UV lamp treatment at lamp intensity of 8 W, 16 W and 24 W, the Cu content are reduced to 47.2 %, 48 %, and 48.9 %, respectively. The highest reduction in Cu content was obtained by 24 W intensity irradiation of UV lamp. The results of this study have the same tendency as the previous research. Lin and Frankel [11] reported that high intensity of ultraviolet illumination had a significant accelerating effect on Cu degradation. On the other Burleigh et al [12] reported that long-term exposure of UV potensial for degradation of metal Cu.

Hydroxyl radicals (HO•) are formed by the photolytic dissociation of water by UV irradiation. The hydroxyl ions (HO•) are the likely traps for holes, leading to the formation of hydroxyl radicals which are strong oxidant agents [13]. Vaferi et al. [14] reported that the formation hydroxil radical during UV treatment shows in Equation 1.

$$H2O + h\upsilon \longrightarrow 2\ HO\bullet \qquad at\ (h\upsilon : \lambda < 300\ nm) \qquad (1)$$

Hydroxyl radicals will react with organics and inorganic wastewater. Decolouration process in dyehouse wastewater which treated with UV radiation, ranged from 67 % to 75 % [15]. Degradation of organic and anorganis pollutans with UV irradiation depends on the wavelength of the UV light source and the quantity of energy transmitted [16,17]. Applying UV irradiation for disinfection can be both less costly and less complex than using ozone. In addition, UV irradiation does not generate toxic residuals as does ozone [8]. Fleisch and Mains [18] find that with UV irradiation in vacuum Cu2O have a slightly faster rate of oxidation compared to CuO. The combination of the UV irradiation and ozone processes was expected to increase the rate of Cu waste degradation.

Effect of Ozonation (O3)

This study was conducted to determine the effect reaction time and ozon flowrate on reducing Cu content. The ozonation experiments were carried out at different the ozon flowrate (3 L.min-1, 5 L.min-1 and 7 L.min-1) for 60 min of reaction. The effect of decreasing Cu content on reaction time and ozone flowrate shows in Fig.2.
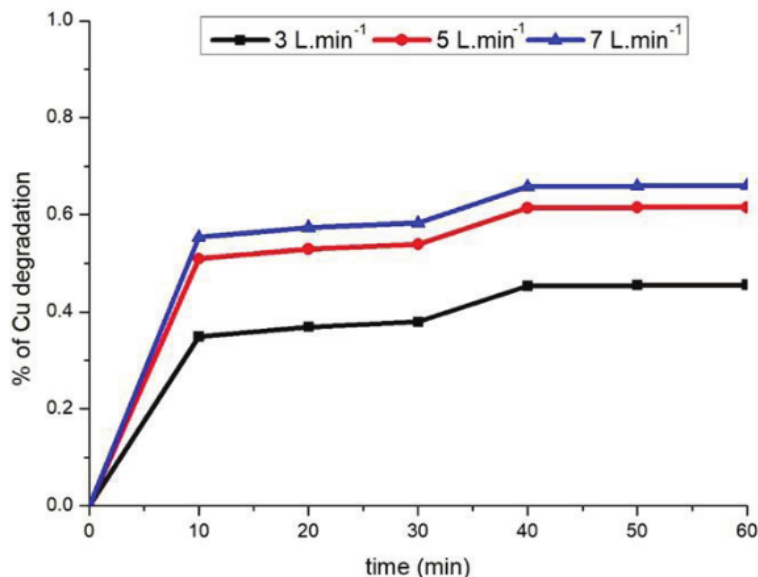

FIGURE 2. Effect of degradation metal Cu during the ozonation process.

Fig 2. shows that Cu content decreases with increasing reaction time. After 60 minutes of ozon flow rate at 3 L.min-1, 5 L.min-1 and 7 L.min-1 the Cu content are reduced to 45.5 %, 61.5 % and 66 %, respectively. The highest reduction in Cu content was obtained by ozon flow rate at 7 L.min-1.

Perwoski and Kos [15] reported that the effect of oxygen flow rate was investigated within the range of 1 L.h-1 to 30 L.h-1. It was found that with an increase in the oxygen flow rate, the decomposition of impurities also increased, while the irradiation parameters remained constant. The ozone flow rates above 5 Lmin-1 do not have a significant effect on increasing the rate of Cu degradation because in this study air as feed gas. The short life time of oxygen gas which causes the ozone formation process to become imperfect [19]. Oxygen molecules do not have enough time to react to produce ozone [20]. The formation of radicals such as the hydroxyl radical (HO•) and superoxide radical (O2-•) occurs when ozone is added to water, through a complex series of reactions [5]:

$$3 O_3 + OH^- + H^+ \quad \rightarrow 2 HO\bullet + 4 O_2 \tag{2}$$
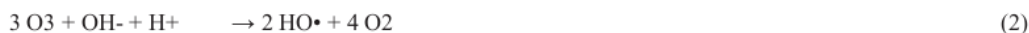
The faster the ozone stays in the system, the less effective the reaction of hydroxyl radicals that available to decrease Cu content. The ozone concentration in the gas depends on the operating parameters of the ozone generator: current intensity, gas flow rate and type of gas used for ozone production [21]. Ozonation process was effective for removal and reduce Cu content from 0.6 mg.L-1 to 0.4 mg.L-1 [22].

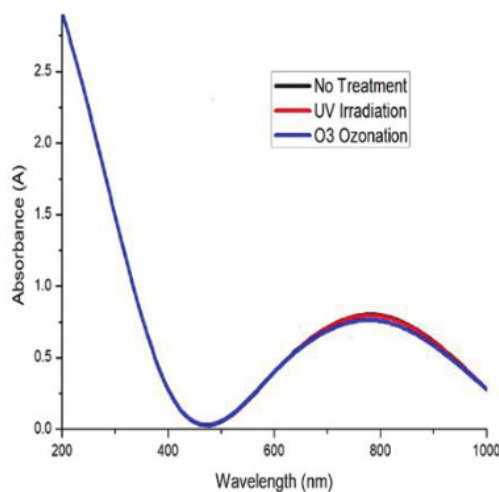## Ultraviolet-visible (UV-vis) Spectra of Copper

FIGURE 3. UV-Vis Spektrum of Cu with UV irradiation and Ozone Treatment

Fig.3 shows the absorption spectra of metal Cu. The UV-Vis spectra reveal a characteristic absorption peak of the Cu metal located at 810 nm. The results of the analysis with a UV-Vis spectrometer showed that the absorbance results of samples with ozone treatment were found to be lower than UV irradiation, which showed that the ozonation process degraded Cu greater than the UV process for the degradation of Cu wastewater.

CONCLUSION

The overall results of this study are the UV and O3 processes as a feasible method for the treatment of electroplating air passages. Cu degradation increases with increasing reaction time. The highest reduction in Cu content was obtained with UV light intensity of 24 W and at ozone flow rate of 7 L.min-1. Ozone flow rate below 5

L.min-1 do not have a significant increase in the rate of Cu degradation. UV radiation and ozonation can be used as alternative methods for waste treatment.

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