UNIVERSITI TEKNOLOGI MARA

BIORECOVERY OF SILVER FROM SIMULATED SILVER ELECTROPLATING WASTEWATER USING PHENOLIC COMPOUNDS EXTRACTED FROM OIL PALM (*ELAEIS GUINEENSIS*) LEAVES

AHMAD ARIF BIN AZMI

MSc

April 2020

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Ahmad Arif bin Azmi
Student I.D. No.	:	2013867004
Programme	:	Master of Science (Chemical Engineering) – EH750
Faculty	:	Chemical Engineering
Thesis Title	:	Biorecovery of Silver from Simulated Silver Electroplating Wastewater Using Phenolic Compounds Extracted from Oil Palm (Elaeis guineensis) Leaves
Signature of Student	:	……..
Date	:	April 2020

ABSTRACT

Oil palm (*Elaeis guineensis*) leaves extract contains phenolic compounds which are capable to act as reducing agent to reduce and recover silver from simulated silver electroplating wastewater containing silver and copper ions by bioreduction method. Objectives of this research are to reduce and recover silver from simulated silver electroplating wastewater using oil palm leaves extract and optimize the silver biorecovery process using response surface methodology (RSM), to characterize the size, structure and elemental compositions of the biorecovered solids, and identify the bioactive phenolic compounds involved in the silver biorecovery process, and lastly to compare the efficiency of silver biorecovery process in simulated and industrial silver electroplating wastewater. Six factors namely; amount of palm leaves extract, initial concentration of silver ions in wastewater, pH of reaction solution, reaction temperature, initial concentration of copper ions in wastewater, and reaction time are known to affect the silver biorecovery process. However, only four factors were found to be statistically significant, which are amount of palm leaves extract, initial concentration of silver ions in wastewater, pH of reaction solution, and reaction temperature, which were screened by Plackett-Burman design (PBD). In order to maximize the silver biorecovery process, the significant factors were further optimized using RSM. Optimum conditions of the silver biorecovery process were found to be 50 % (v/v) of palm leaves extract, 1974.75 mg/L of initial concentration of silver ions in wastewater, pH 7.7 of reaction solution and 70 °C of reaction temperature. The maximum yield of silver being reduced at optimum silver biorecovery process was 92.80 ± 0.18 %. Characterization of the biorecovered solid particles revealed that elemental silver was successfully reduced and recovered from the simulated wastewater with sizes ranging from 20 to 60 nm, average crystallite size of 29.91 nm, including 32.09 nm of organic capping layer which accounts 32.33 % than the total weight of the solids. Besides that, copper was also reduced at amount of 16.46 ± 0.35 % and recovered along with silver. On the other hand, characterization of the palm leaves extract and the residue solution revealed that phenolic compounds naturally present in the leaves extract could acts as reducing agents since its amounts reduce from 63.8795 ± 0.0386 mg GAE/g to 7.5167 ± 0.0171 mg GAE/g throughout the process. Such of the bioactive phenolic compounds identified are 1,3-benzenediol, 4-(hydroxyphenylmethyl)- and 2-[(3,4-dihydroxybenzoyl)oxy]-4,6-dihydroxybenzoic acid. Hydroxyl and carboxyl groups of the compounds release protons and simultaneously reduce silver ions into zero valence silver atoms. Additionally, polysaccharides, carboxylic acids and proteins act as stabilizing agents to cap and stabilize the silver solid particles formed. Furthermore, silver was successfully reduced and recovered from silver electroplating industrial wastewater along with copper and other traces of metals. The yield of silver being reduced from the industrial wastewater was 88.57 ± 0.41 %, which is 4.23 ± 0.45 % lower than the simulated ones. To conclude, palm leaves extract was able to reduce and recover silver from both simulated and industrial silver electroplating wastewater, with slightly lower recovery efficiency compared to other commercial reducing agents such as hydrogen peroxide.

ACKNOWLEDGEMENT

Firstly, I wish to thank Allah S.W.T for giving me this opportunity to embark on my Master study and for completing this long and challenging journey successfully. I want to express my deep gratitude and thanks to my supervisor, Associate Professor Dr. Junaidah Jai for the continuous encouragement, motivation, guidance and supervision towards this study. Besides that, I would like to extend my gratitude to my co-supervisors Dr. Azil Bahari Alias and Ms. Norashikin Ahmad Zamanhuri for their endless support, ideas, and comments and guidance in assisting me in this study.

I also would like to express my gratitude and appreciation to all staffs from Faculty of Chemical Engineering, UiTM Shah Alam especially to Dean; Associate Professor Ir Dr. Syed Shatir Asghrar Syed Hassan, Head of Postgraduate Studies; Dr. Putri Nadzrul Faizura Megat Khamaruddin, Executive Officer (Administration); Mr. Mohd Faizul Hassan, Administration Officer; Ms. Adibah Md Zen, and laboratory Science Officer Mr. Mohd Nazmi Mohd Mukelas, Mr. Mohd Yazid Yusof , Mr. Mustaffa Mokhtar, Ms. Azizan Din, Ms. Rohaida Zainordin, and Ms. Nor Suhaila Sabli who provided the facilities and assistance during conducting the experiments and research. Special thanks to my postgraduate colleagues and friends for helping me in this study.

Finally, my gratefulness goes to my lovely family for the endless support and motivation in completing this study. This victory is dedicated to all of you. Alhamdulillah.

TABLE OF CONTENTS