UNIVERSITI TEKNOLOGI MARA

A NEW APPROACH OF PROGRESSIVE FREEZE CONCENTRATION IN REMOVING OF 2, 4, 6 TRICHLOROPHENOL FROM WASTEWATER: EFFECT OF COOLANT TEMPERATURE & OPTIMIZATION STUDIES BY USING RESPONSE SURFACE METHODOLOGY (RSM)

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ABSTRACT

2,4,6-Trichlorophenol (TCP) is a poisonous, carcinogenic and mutagenic pollutant that is characterize as a clear and colourless liquid, have strong odour like trichloroethylene or chloroform. 2,4,6-TCP has been classified as one of the primary pollutants as enacted by the Department of Environment (DOE). According to Malaysia in Environmental Quality Act 1979 (Sewage and Industrial Effluent), it should be treated to be less than 1 ppm for inland water discharge. PFC is a separation process by using freezing to progressively produces ice crystal layer by layer on a cooled surface until it forms a large and single crystal block. The aim of this paper is to study the effect of coolant temperature on the performance of progressive freeze concentration (PFC) in removing 2,4,6 TCP from wastewater. The performance determinant used to measure the efficiency of the process were effective partition constant, K and TCP reduction, T_R. To achieve the objective of the experiment, 100 ppm of TCP simulated wastewater samples were used throughout the experiments to ensure the data obtained can be applied to the industries in the future. The experiments were operated at different coolant temperature started at -3^{o}C, -4^{o}C, -5^{o}C, -6^{o}C, and -7^{o}C. Operation time was kept constant at 30 minutes and circulation flowrate rate 700 rpm. By conducting experiment to study the effect of coolant temperature towards PFC performance, it was found that low K value and high T_R was obtained at -6^{o}C. Moreover, this paper also aims to obtain the optimum coolant temperature and circulation flowrate for better performance of PFC using Response Surface Methodology provided by STATISTICA 12.5 software. The values of R^2 of the model obtained for K and T_R were 0.957 and 0.927 respectively indicates that the ANOVA model were fit as it was more than 0.9. According to the ANOVA analysis, PFC system was predicted to be able to produce low K value of 0.15 at -4.55^{o}C of coolant temperature and 1255rpm of circulation flowrate. The analysis also predicted that the PFC able to produce T_R as high as 84.81% at -5.04^{o}C of coolant temperature and 862.08 rpm of circulation flowrate. Validation experiments also was done to verify the prediction of ANOVA analysis, and the K and T_R value were obtained at 0.415 and 73% with percentage error of 176.67% and 13.93% respectively.

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CHAPTER ONE
INTRODUCTION

1.1 Background Study

2,4,6-Trichlorophenol (TCP) is a toxic, carcinogenic and mutagenic pollutant that is characterize as a clear and colorless liquid, have strong odor like trichloroethylene or chloroform. This high-density chemical (1.39 g/ml) is also known as allyl trichloride, trichlorohydrin or glycerol trichlorohydrin. Similar to other chlorinated hydrocarbons, it has ability to react with some metals, strong basic agents and oxidizing agents. This tremendously flammable hazardous chemical is subtle to prolonged exposure to light and heat, and will yield toxic fume of hydrogen chloride gas when heated to decomposited (Samin & Janssen, 2012; I. A. W. Tan et al., 2009).

The synthesis of various chemicals resulting in formation of TCP as by product, where one of the known process is classical synthetic route to epichlorohydrin, and commercial preparations of the soil fumigant 1,3-dichloropropane. In addition, TCP is useful to be applied as an intermediate in the manufacturing various chemicals. The first one is to produce cross-linking agent hexafluoropropylene which will be applied for producing elastomers. Apart from that, TCP is also a good solvent for oils and fats, waxes, and resins in chemical industry. Previously, this compound is also used in paint thinner, varnish remover and degreasing agent (Samin & Janssen, 2012).

Apart from that, in the course of industrial activities that generates millions of revenues to the country, improper disposal of wastes, unintentional spillage and as diffuse contamination of TCP as it is present in 1,3-dichloropropene has been a source for soil and groundwater contamination (Samin & Janssen, 2012). TCP can also be found in the emissions from fossil fuel combustion, municipal waste incineration and chlorination of water containing phenol or certain aromatic acids with hypochlorite or during disinfection of water (I. A. W. Tan et al., 2009). It can be found from industrial wastewater that are based from paint, pharmaceutical, pesticide, wood, pulp and paper industries as well as water disinfecting process (Krishnaiah et al., 2013).