UNIVERSITI TEKNOLOGI MARA

EFFECT OF TEMPERATURE AND RESIDENCE TIME ON TORREFACTION OF MUNICIPAL SEWAGE SLUDGE

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ABSTRACT

Malaysia, a developing country with a constant rise in population, recorded an increase in municipal and industrial wastes with approximately 23,000 tonnes of wastes were produced each day in Malaysia (Behzad *et al.*, 2011a). This resulted in an increase of total waste generated. With the common practice of waste disposal through landfill, and incineration, these contributes to another environmental issue; the pollution. To achieve a sustainable environment, new alternatives was found by researchers to treat wastes. Torrefaction is one of thermal process that is applied on biomass, to convert it into three useful products, char, bio-oil and condensable gases. In current research, char from lignocellulosic biomass was proven as the good alternative in the fuel industry. However, the characteristics of non-lignocellulosic biomass makes it possible for researchers to conduct a studies on it. Hence, the objective of this study is to produce char from municipal sewage sludge by using torrefaction method. In this study, municipal sewage sludge obtained from Indah Water Konsortium, located in Johor, Malaysia, has been used as the raw material. A characterization study was performed on the raw and dried sewage sludge. The study was conducted to record the moisture content, ash content and high heating value (HHV) of the raw sewage sludge. Next step is where biomass is being placed in a covered crucible and heated in a muffle furnace. The heating process operates under pressure of 1 atm and temperature of 200^{o}C, 250^{o}C and 300^{o}C with residence time of 20, 30 and 60 mins for every temperature. The effects of torrefaction temperature and residence time on mass and energy yields, and HHV of torrefied sludge were investigated. Mass and energy yield of torrefied sludge were investigated to study the weight and energy loss of raw sewage sludge after torrefaction. HHV of the char was determined to study the energy value stored in torrefied sludge. From the results, the HHV, mass and energy yields were decreased as the torrefaction temperature and residence time increased. Highest peak was at temperature of 250^{o}C and residence time of 60 mins. Thermogravimetric analysis was performed on high HHV of char. It was found that hemicellulose will degrade first at temperature of approximately above 200^{o}C. An average reaction order of 0.59, 6.9852 kJ/mol of activation energy, E_a, and pre-exponential factor of 0.3772, were found to be the kinetics parameters of torrefaction on municipal sewage sludge.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

At the beginning of this chapter, it explained on the research background and problem statement that triggered the proposed title. Next, objectives of research have been clearly stated. In the later section, scope of research is clearly identified and explained.

1.2 Research Background

Pyrolysis is a thermal treatment process where high temperature is applied on the biomass with the absence of oxygen (Chen *et al.*, 2018a). Three methods of pyrolysis are torrefaction, carbonization and hydrothermal carbonization. The pyrolysis of biomass will result to three products, char (solid products), bio-oil (liquid products) and biogas (gaseous products) (Manyà, Azuara and Manso, 2018a). However, various applications on char have been studied. In the article of Weber and Quicker (2018a), the applications of char are presented in various industry, including their use in medical, energy, and agricultural industry and as replacement in fossil fuel. Human overpopulation caused the reducing of fossil fuels and limitations on the energy sources. The implementation of char through torrefaction method can be seen as one of the counter measures in order to balance natural energy sources with the current overpopulation.

Knowing that the application is beneficial to the fuel production, and being used as one of the energy sources, char is a good alternative to substitute with wastes disposal methods (Agrafioti *et al.*, 2013a). The lignocellulosic components such as lignin, hemicellulose and cellulose, in biomass have contributed to the yield of torrefied products to make it useful. These composition varies depending on types of biomass. In the production of char using torrefaction method, the types of biomass that are commonly used are lignocellulosic biomass and non-lignocellulosic biomass. Lignocellulosic biomass contains lignocellulosic components and are mainly woody