UNIVERSITI TEKNOLOGI MARA

GRINDABILITY AND KINETIC STUDY DURING PYROLYSIS OF RAW AND TORREFIED LEUCAENA LEUCOCEPHALA

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ABSTRACT

Malaysia is a country that is highly dependent on fossil fuel energy as the main energy source. This has been a problem for the country because for a fact, fossil fuel is an energy source that is not renewable and will be depleted over the years. Biomass is one of the potential alternatives for fossil fuel replacement due to its traits being renewable. The reason Malaysia does not fully utilize its renewable energy resource because Malaysia is lacking in biomass conversion technology and its application. Malaysia is still comfortable with the usage of fossil fuel resource because of the lack of awareness. Direct combustion of biomass is the most promising method to exploit biomass to produce energy. However, one of the method's drawbacks is the difficulty to grind the product to obtain fine particles. To improve the properties of raw biomass, torrefaction or mild pyrolysis is considered. Therefore, for this research, the grindability and kinetics study during pyrolysis need to be carried out to obtain the best way to produce high quality bioenergy feedstock. Biomass chosen for this research project, *Leucaena Leucocephala* (LL) as a type of potential energy crop, was chosen as the raw material. The torrefaction was done under the temperature range from 200°C to 300°C. Torrefied biomass pellet was compared to its raw pellet in terms of its grindability and its kinetics parameter through Coats-Redfern method, a non-isothermal kinetic method. From the results obtained, pyrolysis of biomass does increase the grindability properties of the biomass pellets and its activation energy (E_a) significantly. As the temperature of torrefaction increases, comparing the raw pellets and pellets that is torrefied at 300°C, the weight percentage of particle size below 100 μm of grinded pellets increases from 26.94% to 62.31%. As for the activation energy (E_a), the value decreases as the torrefaction temperature was increased. It means that the higher temperature of torrefied pellets requires less activation energy thus improving the kinetics properties of the torrefied pellets. The value of activation energy of raw pellets was 119.8 kJ/mol meanwhile for pellets that is torrefied at 300°C is 82.9 kJ/mol. It is found that during pyrolysis, raw *Leucaena Leucocephala* (LL) followed Third Order (F3) reaction mechanism.

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TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Research Background

Leucaena Leucocephala (LL) is one of the woody plants that can be used as an energy crop. It is also known as the "Miracle Tree" in some parts of the world where it is heavily utilized due to its long lifespan, and highly nutritious forage tree used to produce firewood, timber, human food, green manure, shade and also to control erosion [1]. *Leucaena Leucocephala* (LL) has a good growth rate and it is very likely to live in Malaysia's weather and geographic conditions.

In Malaysia, at least 168 million tons of biomass produced yearly that include waste from timber, oil palm, rice husks, coconuts, sugarcanes and municipal waste. According to World Energy Market Observatory (WEMO) 2017 report [2], Malaysia's renewable energy usage is predicted to have increment by 4.8% by the year 2030. Renewable Energy Act was introduced in year 2011 to provide establishment and implementation of a special tariff system to catalyze the generation of renewable energy [2]. This act will help to increase the renewable energy contribution in Malaysia, and this shows that the Malaysian government fully supports the idea of utilization of biomass energy. While comparing with other developed countries such as Germany, according to Fachverband Biogas 2016 journal [3], the country's development in biomass energy industry increased 10 times larger since 2000. In 2015, Germany's biomass energy contributed the largest share that is a solid 88% to their country energy usage [3].

The reason energy crop was chosen as a solid biomass fuel is to prevent rapid growth of carbon dioxide and greenhouse gas emissions due to global use of fossil fuels (coal, oil and gas) and Malaysia should use the energy crop as solid biomass fuel due to emissions of carbon dioxide and greenhouse gas is growing rapidly [4]. The focus of this research is to convert the plant into a solid biomass energy product.