UNIVERSITI TEKNOLOGI MARA

THE COMBUSTION CHARACTERISTICS OF COAL BIO-OIL SLURRY

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ABSTRACT

Global concerns on suppression of coal consumption for carbon emissions reduction have led to a wide interest on the implementation of coal-biomass co-combustion. Since a complete replacement of fossil fuel-based power generation technologies are capital intensive and unachievable in a short term period, Coal Bio-oil Slurry (CBS) fuel is being proposed in this research as it has strong potential to overcome the drawbacks of direct use of biomass in co-combustion, as bio-oil has much higher energy density and results in less transportation cost. The aim of this research is to investigate the fuel properties of the CBS to be potentially applied in the vast existing coal-fired power plants. Coal at different ranks were blended with bio-oil into several ratios from 90:10 to 50:50 and tested under inert and air atmosphere separately using thermogravimetric analyzer (TGA). The results revealed that the addition of bio-oil has improved the reactivity of the coal blends that lead to an early decomposition at maximum rate of decomposition under pyrolysis condition and improved the combustibility of the slurry blends under combustion condition. The values of pre-exponential factor, A and activation energy, E_a were evidently increased with the increasing of bio-oil ratios in the coal blends. Under pyrolysis condition, 90:10 blends appear to be the optimum fuel with highest decomposition rate, while 90:10 blends appear as optimum fuel under the combustion regardless of their high E_a value. In overall, Clermont coal has shown greater potential due to its higher heating value and combustibility compared to Adaro coal.

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INTRODUCTION

1.1 RESEARCH BACKGROUND

World necessity lies on water and energy supplies. With continuous surge on populations and economies, the global energy demand is foreseen to climb up by more than a third by 2035 [1]. Since continuous supply of energy is vital in sustaining all aspects of development, the limitations and impacts of fossil fuel utilisation such as the price hikes and fluctuations of crude oil can never guarantee a long-term effectiveness on its total reliance. Beyond this addiction to fossil fuel, major concern lies within the global environmental threat of climate change issues. Fossil fuel, by far has been the ultimate source of world energy production, and coal is one of them. However, coal-burning activity in power generation industry has become the major source of greenhouse gas (GHG) emission that is responsible to the horrific climate change. GHGs which are associated with CO_2, CH_4, NO_X, and SO_X emissions are contributed approximately 70% by the energy sector [2]. To overcome this never-ending issue, the world is now driven to rapidly shifting towards renewable energy sources. One of the most appealing alternative sources nowadays is biomass.

Biomass, a carbon-neutral resource that abundantly exists can become an initiative to carbon-free emission. However, a complete replacement of coal with biomass in a short-term period seems infeasible due to the economic and technical constraints. Therefore, researchers have proposed co-combustion of coal-biomass in the existing coal-fired power plants to quell the coal consumption. This mixed technology has become one of the fastest and low-cost alternative solutions in recent years with proven study in reducing NO_X and CO_2 emissions [3]. Unfortunately, the undesired characteristics of the biomass such as bulky, fibrous, high moisture content and low energy density can lead to logistic and cost problems and may result in a bigger carbon footprint [4]. Therefore, biomass conversion into bio-oil is being proposed to develop an energy mix technology known as coal bio-oil slurry (CBS) fuel.

Bio-oil is a high-density oxygenated liquid that can be easily obtained by means of simple and low-cost pyrolysis of biomass [5, 6]. The conversion is beneficial to