UNIVERSITI TEKNOLOGI MARA

LIQUEFACTION OF MUKAH BALINGIAN LOW RANK COAL USING SEMI-CONTINUOUS SOLVENT FLOW REACTOR SYSTEM

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Thesis submitted in fulfilment of the requirements
for the degree of
Master of Science

Faculty of Applied Sciences

Jun 2010

Candidate'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 result of my own work, unless otherwise indicated or acknowledged as reference work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

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ABSTRACT

Direct coal liquefaction on un-irradiated and microwave irradiated Mukah Balingian (MB) coal were successfully carried out in semi-continuous solvent flow reactor system at temperature and pressure of 300 - 450 °C and 4 MPa, respectively, using tetralin as hydrogen-donor solvent. The coal conversion, oil+gas, asphaltene and preasphaltene for un-irradiated coal sample obtained at optimum condition using response surface methodology (RSM) i.e., solvent flow rate of 7 ml min^{-1} and soaking time for 60 min, were 81%, 62%, 9% and 10%, respectively. It was observed that solvent flow rate and soaking time seem to have minimum influence on the coal conversion and oil+gas yield. In this study, microwave irradiation pretreatment was also applied on MB coal at power of 600W for 1 min. In the microwave irradiation pretreatment, as solvent flow rate increased from 7 to 15 ml min^{-1}, slightly higher amount of coal conversion was obtained with comparison to the un-irradiated coal sample. The increased in solvent flow rate also resulted to an increased in percentages of asphaltene and preasphaltene with exception to the solvent flow rate of 10 ml min^{-1}, that was due to conversion of these materials to oil+gas. There are two reasons for this observation i.e., insufficient of solvent at solvent flow rate of 7 ml min^{-1} and insufficient time of free radical reaction occurred during the liquefaction process at solvent flow rate of 15 ml min^{-1}. The increased in coal conversion and oil+gas yield at solvent flow rate of 10 ml min^{-1} might due to the sufficient amount of the solvent to penetrate deeply into the coal macropores to cap the radicals instantaneously, and promote the volatile matter released from coal to produce light molecular weight product i.e., oil+gas. Coal liquefaction process of un-irradiated and microwave irradiated coal was being proposed using this reactor system. There are three stages that were monitored during the liquefaction process i.e., heating up, isothermal and free radical reaction stage. The asphaltene and preasphaltene could be obtained at heating up stage for both samples. Thus, it shows that the extraction process predominant at lower temperature of liquefaction process. Two reactions occurred at isothermal stage i.e., extraction and free radical reaction due to the oil+gas increased with reduction of asphaltene and preasphaltene as solvent flow rate increased. As temperature increased from 400 – 450 °C, insufficient of solvent might increased the formation asphaltene and preasphaltene and promote the retrogressive reaction to occur. Sufficient amount of solvent available to stabilize the free radical species resulted higher amount of oil+gas obtained during this stage. In brief, free radical reaction predominant at this stage to increased coal conversion and oil+gas yield. Thus, the semi-continuous solvent flow reactor system could be a promising approach in understanding coal liquefaction process at lower and higher liquefaction temperatures.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This chapter provides the background and rationale for the study. The overview describes the coal as potential energy sources to be utilized in the future.

1.1 Global Energy Scenario

Fossil fuel energy such as coal, petroleum and natural gas are the main energy resources that provide more than 80% of the energy consume in worldwide mainly in transportation and industrial sector [1]. It has been consumed for other sectors including residential and commercial floor space, manufacturing, services, agriculture and forestry sector. According to International Energy Outlook (IEO) 2007, total world consumption of market energy from all resources such as petroleum, natural gas, coal, nuclear and renewable energy is projected to increase from 447 quadrillion British thermal unit (Btu) in 2004 up to 702 quadrillion Btu in 2030 [2].

Growth in energy consume is linked to growth of population. These energy resources are used to fulfill the energy demands that are needed to achieve a comfortable life and to strengthen the economic growth. In developed countries, energy becomes the most important element in maintaining and providing the stable social economy due to highly potential to supply energy in long duration period for many sectors [3].

According to International Energy Outlook (IEO) 2008, world consumption of marketed energy from all resources over 2005 to 2030 projected period is estimated to increase and fossil fuels are expected to continue supplying much of the energy