UNIVERSITI TEKNOLOGI MARA

DIRECT LIQUEFACTION OF MUKAH BALINGIAN LOW RANK MALAYSIAN COAL USING WATER-TETRALIN MIXTURE AT SUPERCRTICAL STATE

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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 referenced work. This topic 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 liquefaction on untreated Mukah Balingian (MB) coal using water-tetralin mixture was successfully performed in batch-wise reactor system, carried out at temperatures of 375 – 450 °C and under pressure up to 22 MPa. The coal conversion and oil+gas yield obtained at optimum conditions of 450 °C and 70:30 tetralin to water ratio, 22 MPa, 30 min reaction time, 1:10 coal-to-solvent ratio and with 500 rpm stirring rate, were 70.6 % and 66.1 % respectively. It was observed that heat plays an important role in comparison to pressure in contributing to high coal conversion and oil+gas yield, and these results are well correlated with the high content of reactive macerals. The addition of tetralin to water increased the coal conversion and oil+gas yield by the stabilization of radical fragments and inhibition of radical recombination. In this study, the application of response surface methodology (RSM) and central composite rotatable design (CCRD) for modeling the influence of reaction temperature and solvent mixed ratios on the liquefaction of MB coal. Predicted values were found to be in good agreement with the experimental values (R^2 values of 0.9989 and 0.9931 for coal conversion and oil+gas yield respectively).This study has shown that the CCRD and RSM could efficiently be applied for the modeling liquefaction of coal and it is economical way of obtaining the maximum amount of information in a short period of time and with the fewest number of experiments. In this study, microwave irradiation pretreatment was applied on MB coal prior to coal conversion and products yield. The coal conversion and oil+gas yield obtained increased up to 8 – 16 % and 10 – 19 %, respectively. Inherent moisture in coal was found to be the determining factor in increasing coal conversion and oil+gas yield by absorbing the microwave energy in order formation of cracks and fissures in coal microstructure that enhanced the coal-to-solvent interaction, and the weakened C-C bonds, respectively.

TABLE CONTENTS

CHAPTER ONE

INTRODUCTION

This chapter presents an introductory overview of energy scenario that includes a description of global energy scenario along with discussion of Malaysian Energy demand and supply, alternative fuels, research and development of coal to liquid technology and scope and objective of the research study. The purpose of this chapter is to provide basic energy information as a prelude to the subsequent chapters.

1.1 The Global Energy Scenario

In the reference case projections for the International Energy Outlook 2000 (IEO2000) [1], world energy consumption increases by 60 % over a 23-year forecast period, from 1997 to 2020. Although high prices for oil and natural gas, which are expected to continue throughout the period, are likely to slow the growth of energy demand in long term. World energy consumptions are projected to continue increasing strongly as a result of robust economics growth and expanding population in the world's developing countries.

Over the next 25 years, world demand for liquid fuels and other petroleum is expected to increase more rapidly in the transportation sector than any other end use. According to the International Energy Outlook (IEO) 2008 reference case [2], the transportation share of total liquids consumption increases from 52 % in 2005 to 58 % in 2030. Much of the growth in transportation energy is projected in developed country. More rapidly expanding economies are expected to see strong growth in the energy consumption as transportation system are modernized and rising standard of living increase the demand for personal motor vehicle ownership.