UNIVERSITI TEKNOLOGI MARA

LIQUEFACTION OF MUKAH BALINGIAN COAL VIA TWO-STAGE SOLVENT FLOW REACTOR SYSTEM

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ABSTRACT

Liquefaction of Mukah Balingian (MB) coal was successfully performed in ordinary one-stage semi-continuous solvent flow reactor system at various temperatures (300 – 450 °C), various solvent flow-rates (1 – 5 ml/min), and various reaction times (30 – 60 min) with fixed pressure at 4 MPa and tetralin as the solvent. The coal sample was ground into small particles before it being liquefied. The best condition for the solvent flow reactor was found at temperature of 420 °C, solvent flow rate of 1 ml/min, and reaction time of 60 min. The coal conversion and oil+gas yield obtained at those conditions were 79.1 % and 60.1 %, respectively. Despite the ability of adding fresh solvent into the extraction process, the conversion of oil+gas still considered to be low compare with percentage of coal extract using batch-wise reactor. This may due to the reactor enabled the re-polymerization to occur during liquefaction process which led to more formation of heavier coal extracts. One possible option to increase the oil+gas yield is by applying catalyst that will break up the heavier coal extracts into small molecular weight compounds. By using normal impregnated into the coal sample, the coal liquefaction residue (CLR) might be contaminate with the catalyst which may influence the ability of the CLR to be further used as combustion material. Thus, the second reactor was introduced consisted of $NiSiO_2$ as the catalyst that will separate the coal sample and the catalyst. The Ni catalyst was prepared using simple impregnation method. The application of response surface methodology (RSM) was chosen because of its ability to decrease the number of experiments, time and material resources due to its capacity to evaluate important test that requires achieving the optimum result. The system shown that the optimum conditions were 1.12 ml/min of solvent flow-rate, 30 min of reaction time and 5 wt.% of Ni loading that gave out response value for oil+gas yield of 70.25 %. Durability tests were done in order to figure out the ability of the catalyst to maintain its performance. Such tests were done by repeatedly used the same catalyst over and over again while observing the conversion of product distribution yields. The result showed that the $NiSiO_2$ can hold up to 5^{th} run before the percentages started to depleted. It may be because of carbon deposited on the surface to cover the active sites.

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CHAPTER ONE
INTRODUCTION

This chapter presents an introduction of energy scenario that begins with world energy demand followed by discussion of Malaysian Energy demand, alternative fuels, scope and objective of the research study. The purpose of this chapter is to provide basic knowledge of energy scenario around the world as a prelude to the following chapters.

1.1 WORLD ENERGY DEMAND

Coal is an abundant natural resource that can be used as a source of energy, as a chemical feedstock from which numerous synthetic compounds (e.g., dyes, oils, waxes, pharmaceuticals, and pesticides) can be derived, and in the production of coke for metallurgical processes. Coal is a major source of energy in the production of electrical power using steam generation. In addition, gasification and liquefaction produce gaseous and liquid fuels that can be easily transported (e.g., by pipeline) and conveniently stored in tanks. Higher prices for crude oil and refined petroleum products and also the coming shortage of this resource are one of the opportunities for alternative energy to displace petroleum in the traditional fuel supply mix.

In the transportation and industrial sector, more than 80 % of the energy consumed is provided by fossil fuel energy such as coal, petroleum and natural gas which are the main energy resources worldwide [1]. According to International Energy Outlook 2012 (IEO2012) [2], global energy demand will be about 30 % higher in 2040 compared to 2010. Economic output more than doubles and prosperity expands across a world whose population will grow to nearly 9 billion people. Total world consumption of market energy from all resources such as petroleum, natural gas, coal, nuclear and renewable energy was assumed to increase from 447 quadrillion British thermal unit (Btu) in recent year, up to 702 quadrillion Btu in 2030.

Fossil fuel energy has been used for other sectors including residential and commercial floor space, manufacturing, services, agriculture and forestry sector. 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. High prices for oil and