UNIVERSITI TEKNOLOGI MARA

THE EFFECT OF SOLVENT SWELLING PRE-TREATMENT ON MUKAH BALINGIAN MALAYSIAN LOW RANK COAL ON PYROLYSIS AND LIQUEFACTION PROCESSES

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

Faculty of Aplied Sciences

May 2007

ABSTRACT

Swelling properties of Mukah Balingian (MB) coal with various H-bonding (i.e. pyridine, tetrahydrofuran (THF), acetone, ethanol and methanol), non-hydrogen bonding (i.e. tetralin, n-hexane, cyclohexane and toluene) was investigated using volumetric swelling ratio method. A higher rank Silantek (SL) coal was used as a comparison study. In general, H-bonding solvents exhibit higher swelling ratio in the coal than the non-H-bonding solvents with pyridine being the best swelling solvent. Swelling ratio of MB coal in all solvents gave higher values than SL coal due to low cross-link density and smaller size of aromatic ring cluster that exhibit in low rank coal. The coal macrostructure of the swelled MB coal samples showed some changes when swelled with H-bonding solvents as showed through SEM micrographs. In addition, the swelling ratios of the MB coal with mixed of tetralin with the other H-bonding solvents at volume ratio of 20:80, 40:60, 60:40 and 80:20 were decreased with increased in the volume ratios of tetralin. This is probably attributed to the less interaction of the coal reactive sites with the solvent due to its non-hydrogen bonding characteristics. Furthermore, the thermal behaviours and kinetic properties of untreated and pre-treated swelled samples during pyrolysis were determined using thermogravimetric analyzer (TGA). The thermal behaviour of pure and mixed swelled samples that were represented by DTG curve showed some changes on coal macrostructure had occurred during swelling process. In general, the overall activation energy and pre-exponential factor of solvent-swelled samples at second stage pyrolysis (i.e. 200 to 700°C) that were determined using the first-order kinetic reaction model showed lower values in comparison to the untreated coal due to the bond weakening of the coal macromolecular interaction network of the former. Interestingly, in all cases, the mixed solvent swelled samples exhibit much lower activation energy and higher organic volatile matter in comparison to untreated and pure solvent-swelled coal samples indicating an increased in reactivity of the coal during swelling. The liquefaction on acetone-swelled sample that was carried out at 4 MPa and 420°C showed higher coal conversion and oil+gas yield in comparison to the untreated coal. This finding was due to the enhancement of coal macropores and solvent-coal interactions during the swelling process that promote the releasing of volatile matter at lower temperature. The highest oil+gas yield was obtained with 20%tetralin:80%acetone mixed solvent-swelled sample when liquefaction was carried out at less severe condition (i.e. 4 MPa and 420°C). These findings seem to agree with the thermal behaviour and kinetic properties of the 20%tetralin:80%acetone mixed solvent-swelled sample during pyrolysis that showed the lowest activation energy with high organic volatile matter yields indicating an increased in coal reactivity. Thus, these phenomena proved the beneficial effect of swelling pre-treatment on coal in enhancing oil yield prior to liquefaction at less severe condition. Thus far, the characteristics coal liquefaction residue (CLR) study showed that it had potential to be a good feedstock for gasification and combustion processes.

ACKNOWLEDGEMENTS

Alhamdulillah, praise to Allah S.W.T, for giving me the opportunity to complete this thesis successfully.

I wish to convey my sincere appreciation to the following person:

Associate Professor Dr. Hj. Khudzir bin Hj. Ismail, for his patient supervision and encouragement.

Mr. Mohd Azlan bin Mohd Ishak, for his encouragement, valuable suggestions, impeccable direction and help throughout liquefaction studies.

Members of Fuel Combustion Research Laboratory, Mr. Ridzuan Mat, Mr. W. Izhan Nawawi, Mr. Zubri Zakaria and **Ms. Nasulhah Kasim**, for their help and support throughout the research.

Mr. Vladimir from University Malaya (UM) and **Mrs. Jamilah from University Science Malaysia (USM),** for their collaboration in the form of experimental work and interpretation of petrographic and SEM analyses, respectively.

Thanks go also to my lovely mother;
father; **Abdullah Abu Bakar** and all family members whom I admire most, for the opportunities, continuous support and encouragement they have always given to me. A special acknowledge is express to my fiancée, **Yusniza Abdullah**; your patience, encouragement and motivation always energise and force me to accomplish this study.

I would like to express my acknowledgement to Universiti Teknologi MARA (UiTM) and Ministry of Science, Technology and Innovation for awarding me scholarship (PASCA Siswazah) to pursue this research study and Institute of Research, Development and Commercialisation, UiTM and UiTM Perlis Campus Director for supporting the research work.

Finally, perhaps this work will be benefited and contributes to knowledge, InsyaALLAH.

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CHAPTER 1

INTRODUCTION

1.0 Coal as Alternative Fuel Resources

We live in a world that was built and is sustained by inexpensive, readily available fossil fuels. Fossil energy powers our delivery vehicles and all our farm machinery, it pumps water to our homes, and it produces nearly all of the products that we call chemicals. In short, without fossil fuels our civilisation cannot exist, as we currently know it. Some might argue that there could be other sources of energy and that would be right but we are simply not ready for them.

Nuclear energy can be used to generate electricity and can even make motor fuels, but safety concerns; waste disposal issues, and needs for further technological development mean that it will not be a major source of energy for several decades. Hydroelectric power could be the choice but is now near its maximum potential because the unavailability of rivers remaining to be dammed and the water shortages problem has affected the reliability of hydroelectric power. Wind power has a moderately promising future of energy resources but the unreliability of wind has limited its use throughout the world. There are also other energy sources such as solar power but they are very minor contributors and yet need further technological development in order to accept it as a potential energy resource.

In short, the only major energy sources for the next few decades will be oil, natural gas and coal. However, as many people with even a casual interest in energy now know, natural gas and oil reserves and supplies throughout the world were in a big crisis. Most of the gas production countries such as North America and Canada have "plateaued" and will no longer be self reliant in meeting its gas needs. The oil situation may turn out to be just bad, if not worse. Studies conducted by petroleum geologist such as Campbell [1] and Ivanhoe [2] suggest that conventional oil production will peak sometime before 2010. The unsuspected increase in crude oil