UNIVERSITI TEKNOLOGI MARA

CHAR-SUPPORTED NICKEL AND COBALT CATALYSTS FOR THE STEAM REFORMING OF TAR

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

Faculty of Chemical Engineering

May 2016

ABSTRACT

The formation of tar is a major problem in the biomass gasification process since it can disrupt downstream process operations. One of the approaches used to address this problem is by nickel-based catalysts for tar removal. However, these catalysts are negated by the fact that they are pose waste disposal problems. Hence, an alternative approach for tar removal is to use the char as catalyst support. To date, little is known on the catalytic steam reforming performance of char-supported nickel and cobalt catalysts for tar removal. Therefore, the main objective of this research is to investigate the catalytic performance of char-supported nickel and cobalt catalysts on steam reforming of toluene, whereby the chars used as catalyst supports are derived from different types of biomass available in Malaysia. In order to achieve the objective above, the adsorption capacity of nickel and cobalt ions in four types of biomass is first investigated, comprising oil palm mesocarp fibres (OPMF), empty fruit bunches (EFB), palm kernel shells (PKS) and sawdust. The metal-loaded biomass are characterised using FTIR and ICP-OES. The biomass having the lowest and the highest metal adsorption capacity are chosen to prepare the char-supported catalysts in order to determine the effect of char precursor on the catalytic steam reforming performance of toluene. The char-supported catalysts are characterised by ICP-OES, N_2 adsorption surface analysis, FESEM, and ultimate and proximate analysis. The effect of temperature on the catalytic steam reforming performance of toluene is studied within a temperature range of 700–950 °C. It is found that the possible mechanism for metal adsorption on biomass is ion exchange, which can be observed from the changes of the -OH group in the FTIR metal-loaded char spectra. The order of metal adsorption capacity as followed: OPMF>sawdust>EFB>PKS. Carbonisation and steam activation of the biomass results in a large surface area, which then contribute to the higher contact between the catalysts and the tar compound. . Carbonisation and steam activation produced high surface area 206 to 277 m^2/g. The cobalt catalyst exhibits higher catalytic activity compared to the nickel-supported catalyst. The concentration of syngas increases up to 45% with an increase in temperature from 700 to 850 °C. After 850 °C, the catalytic activity of the catalysts begins to decrease, which may be due to carbon deposition and thermal sintering.

ACKNOWLEDGEMENT

In the name of Allah, the most Gracious and the Most Merciful

Alhamdulillah, all praises to Allah SWT for the strengths and His blessings that gave me the opportunity to complete this thesis, entitled char-supported nickel and cobalt catalysts for the steam reforming of toluene as a biomass derived tar model compound. Special appreciation goes to my supervisor, Dr Syed Shatir Asghrar Syed Hassan, for his supervision and continuous support. His invaluable assistances of constructive comments and suggestions throughout the experimental stage and thesis works have contributed to the success of this research. Not forgotten, my appreciation to my co-supervisor, Prof Mohammad Asadullah for his guidance, support and share of knowledge throughout this program.

I would like to express my appreciation to Dr Shawalliah Idris, the Head of Postgraduate Studies at the Faculty of Chemical Engineering, for her support and assistance towards my postgraduate candidature. My acknowledgement also goes to all the lab technicians, especially Mr. Mustaffa Mokhtar, Mr. Idris Md Desah, Mrs. Rohaida Zainordin and Mr. Faez Sarulan for helping me in completing my research as well as officers in the Faculty of Chemical Engineering for their cooperations. My sincere thanks to all my postgraduate friends for their ideas, suggestions, hardship, kindness and support during my study. Thanks for the memories and friendship.

I would like to thank the Ministry of Higher Education Malaysia for awarding me with the Mymaster Financing Program throughout my Master's program. I would also like to acknowledge the financial support of this study from Malaysian Ministry of Science, Technology and Innovation (MOSTI) via the Science Fund grant (Project No.: 06-01-01-SF0463).

My deepest thanks and appreciation to my beloved parents and husband; Mr. Fuadi Sumrah, Mrs. Norshimah Abd Karim, Mr. Nazmi Zulkifli and also my siblings for their endless love, prayers, cooperation, encouragement, constructive feedback and full support throughout my postgraduate study, from the beginning till the end. To those who indirectly contributed to this research, your kindness means a lot to me. Thank you very much.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF THE RESEARCH

Malaysia is highly dependent on fossil fuels as an energy source. The consumption of energy in Malaysia has escalated since 1994 [1]. To improve energy security, Malaysia is working towards fuel diversification in order to decrease its reliance on fossil fuels [2].

Biomass has great potential for exploitation as a renewable and sustainable source of power, heat, fuels and chemicals [3-4]. Biomass feedstock includes agricultural residues, herbaceous crops, forestry residues and municipal green wastes. More than 70 million tonnes of biomass are produced in Malaysia [5]. Palm biomass appears to be one of the prospective energy sources due to its large quantity. The other resources of biomass include municipal solid wastes, wastes from the wood industry, rice industry and sugar cane industry. The amount of biomass produced in Malaysia according to industry is shown in Figure 1.1.

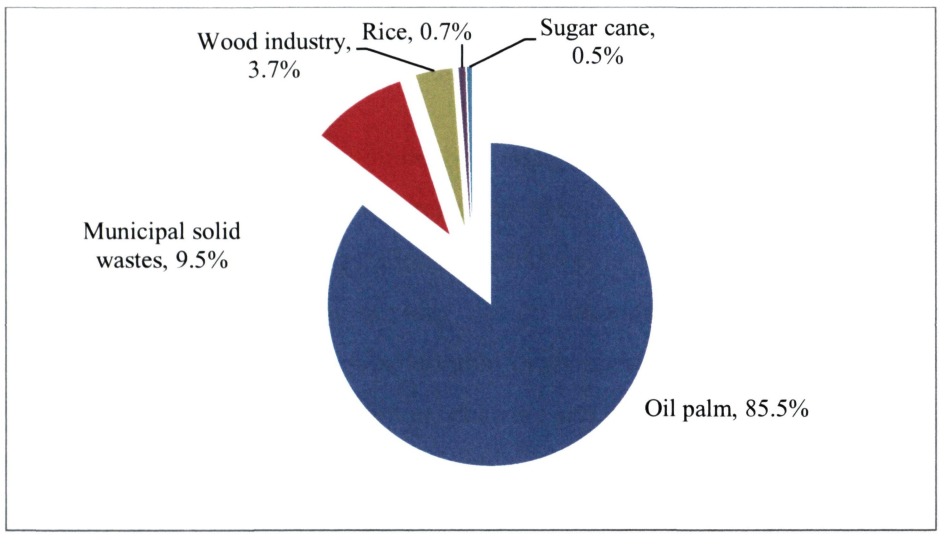

Figure 1.1: Percentage of Biomass Produced in Malaysia. Adapted from Shuit *et al.* [5].