UNIVERSITI TEKNOLOGI MARA

CATALYTIC REFORMING/CRACKING OF BIOMASS DERIVED TAR USING ACTIVATED CARBON SUPPORTED IRON CATALYST FOR CLEAN PRODUCER GAS

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science
(Chemical Engineering)

College of Engineering

December 2022

ABSTRACT

Biomass-derived producer gas has high potential to replace natural gas as gaseous fuel in internal combustion engine (ICE) but the presence of tar hinders its utilization for commercialization and requires effective catalytic gas cleaning. Nevertheless, a serious catalyst deactivation due to agglomeration of active metal particles on support has been overlooked in much research. The objective of this study is to utilize activated carbon supported iron (Fe/AC) catalyst prepared by a new approach of impregnating iron from an aqueous solution onto the activated carbon (AC) in a stepwise manner. Novel catalyst was assessed in catalytic reforming of pyrolyzed tar derived empty fruit bunches (EFB) to compare its superiority with catalyst prepared by the conventional one-step impregnation method. Reforming conditions at different range of reaction temperature, steam/carbon (S/C) ratio and equivalence air ratio (ER) were also assessed. The best Fe/AC catalyst for this study was then evaluated in an integrated pilot-scale gasification system consisting of a downdraft gasifier and a secondary catalytic tar-cracking reactor to produce clean producer gas. To further purify the producer gas, the system was also integrated with a cyclone, a water scrubber and a carbon-bed filter. Based on the catalyst characterization results, stepwise impregnation was able to minimize the agglomeration of iron particles on AC surface, allowing high loading of iron onto the AC without severely affecting iron dispersion and catalyst pore properties. In terms of the catalytic performance in tar reforming, Fe/AC catalyst prepared by stepwise method was highly reducible and efficient which able to reduce tar concentration in producer gas below 100 mg/Nm^3, compared to one-step method. The best composition of burnable product gas was obtained with iron loading of 15 wt% at 800^{o}C, S/C ratio of 1.0 and 0.1 ER, with gas composition of 33.5 vol% H_2, 21.0 vol% CO, 14.0 vol% CH_4, and a cold gas efficiency (CGE) of 78.5%. For pilot scale, the performance of developed 15 wt% Fe/AC catalyst in the hot gas catalytic tar-cracking reactor at 800^{o}C and 0.1 ER indicates that stepwise Fe/AC catalyst was able to produce a clean burnable gas with lower heating value (LHV) of 9.05 MJ/Nm^3, CGE of 89.9%, carbon conversion efficiency (CCE) of 79.4%, and H_2 and CH_4 concentration of 29.5 vol% and 10.3 vol%, respectively. The final outlet gas was found to only contain 32.5 mg/Nm^3 of tar, thus suitable for ICE application (<100 mg/Nm^3).

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent and the Most Merciful.

Alhamdulillah, all praise to Allah S.W. T, for this beautiful journey in completing my thesis. I am very grateful from the depth of my heart for His permission, guidance and blessing that always gave me tremendous courage and spirit to keep going towards the finishing line.

I owe my deepest gratitude to my academic supervisor, Associate Prof. Ir. Dr. Syed Shatir Asghrar Syed Hassan for sharing his expertise, continuous support, and boundless patience to my study. During my period of MSc candidature, he consistently allowed this research to be my own work, but steered me in the right the direction whenever he thought I needed it. I would also appreciate useful suggestions from my co-supervisor, Dr. Rusmi Alias.

A million thanks to Universiti Teknologi Mara (UiTM) for providing the facilities to advance the project. My deepest appreciation also extends to all my colleagues, laboratory technicians, lecturers and others who have provided assistance at various occasions. Their views, tips and corporation were helpful indeed.

I would like to present my sincere thankfulness to my late father (Allahyarham Malek Muhamat Said) and my dear mother ([redacted]), for their great role in my life, numerous sacrifices and persistence prayers. They have always been there for me, lending their ears throughout the hurdles in accomplishing this hard bound. And Alhamdulillah, I have fulfilling my father's last wishes.

Last but not least, I take this opportunity to extend my genuine appreciation and gratefulness to my husband (Mohd Nizar Moh Nasir), my children (Nur Nayla Hannani and Muhammad Nuh Huzair), for their unconditional love, moral support, and reliable sacrifice in terms of time and emotions which are far more valuable than I could express in words. To them I dedicate this thesis.

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