

UNIVERSITI TEKNOLOGI MARA

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

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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°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°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 ($<100 \text{ mg/Nm}^3$).

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