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ORIGINAL PAPER

Hydrogen from renewable palm kernel shell via enhanced gasification with low carbon dioxide emission

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Abstract Hydrogen economy has become more attractive with the energy crises and environmental issues associated with fossil fuel utilization more so with the discovery that hydrogen can be produced from renewable biomass. This provides good prospects to Malaysia that generates abundant palm wastes. Nevertheless, there is still limited knowledge on kinetics parameters for hydrogen production from palm kernel shell (PKS) gasification. Hence, this work aims to develop a mathematical model that is able to describe the kinetics of steam gasification of PKS with in situ CO_2 capture while considering tar formation. A mean-squared error minimization approach has been used to estimate the kinetics parameters of the gasification process. Using the calculated kinetics parameters the process efficiencies are profiled with respect to the effect of gasification temperature, steam/biomass ratio and sorbent/biomass ratio. The parametric study indicates that the three variables promote hydrogen production at different degree of influence. This developed model can be further extended to incorporate optimization study on the potential clean production of hydrogen from PKS.

Keywords Gasification · In situ CO_2 capture · Kinetics modelling · Kinetics parameters · Mean-squared error · Palm kernel shell · Tar modelling

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Introduction

Hydrogen fuel has gained increasing attention in the energy sector attributable to its advantageous properties including environmentally friendly combustion characteristics and high energy content. Biomass steam gasification is an efficient and economically viable technology to convert the energy in biomass into chemical energy in the form of hydrogen gas (Gil et al. 1999). Steam gasification results in high hydrogen production attributed to the utilization of the hydrogen content of the steam (Abuadala and Dincer 2010). The concept of in situ CO_2 capture during gasification could potentially result in the net removal of CO_2 from the atmosphere and the removal of CO_2 from the reaction system alters the composition of the product gas hence promoting hydrogen production (Florin and Harris 2008). The presence of tar, undesirable mixture of condensable hydrocarbons with molecular weight higher than benzene (Gerber 2007), in the product gas limits the application of biomass-derived hydrogen. Therefore, unless the tar content in the product gas is reduced it imposes various operational problems including fouling and plugging in colder parts of the plant and downstream devices such as exit pipes, heat exchangers, particulate filters, fuel cell electrodes and gas turbines (Paasen and Kiel 2004). Steam gasification produces the highest amount of tar as compared with gasification with steam–oxygen mixture