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Hydrogen-rich Syngas Production via Steam Reforming of Palm Oil Mill Effluent (POME) – A Thermodynamics Analysis

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EXTENDED ABSTRACT

According to the oil world's statistical data [1], the world production of edible vegetable oils was approximately 190 million tons in 2014/2015, which constituent of 32.71% of palm oil. The oil palm industry in Southeast Asia enjoyed prospering development, notably in the top three palm oil producing countries (Indonesia, Malaysia, and Thailand). In spite of this, the palm oil processing always associated with the concomitant production of several biomass wastes, namely palm oil fuel ash (POFA), palm oil mill effluent (POME), palm kernel shells (PKS), empty fruit bunches (EFB), and oil palm frond (OPF) [2, 3]. Among the biomass wastes, the POME wastewater itself is the most haunting pollutant because of its enormous quantity (2.5 – 3.75 tons of POME produced/ton crude palm oil processed) and highly polluted characteristics (COD: 15,000 – 100,000 ppm and BOD: 10,250 – 43,750 ppm) [4, 5]. In Malaysia alone, the crude palm oil production in 2017 was 19,919,331 tons [6], therefore *circa* 49.80 – 74.70 million tons of POME was generated. It is envisaged that this vast quantity of POME could be ameliorated into a significant amount of syngas (H_2 and CO) via its steam reforming, whereby this continuous supply of biomass-derived hydrogen energy able to support future local electricity generation.

In this paper, the feasibility of syngas production from POME steam reforming was investigated. For preliminary characterization, the POME liquor was subjected to freeze drying before its solid contents were further analysed via CHNOS organic elemental analysis and GC-MS analysis. The thermodynamics data were either retrieved from reported works or estimated using available methods. Subsequently, the equilibrium constants of possible reactions were computed to estimate their likelihood of occurrence. The thermodynamic analysis of POME steam reforming was presented for the effect of reaction temperature (573 – 1173 K) on product yield (Y_i) and syngas ratio (H_2:CO). In the thermodynamics simulation, the equilibrium compositions were discovered by the minimization of total Gibbs free energy method as the prior knowledge of possible reactions is not required. However, the product distribution was meticulously linked to possible reactions that viable during POME steam reforming. Lastly, the energy requirement analysis of isothermal POME steam reforming system was executed to determine its optimum temperature for syngas production.

To conclude, the POME steam reforming is a viable synthesis route for syngas production despite of its lower product yields as compared to conventional hydrocarbon reforming. It is believed that the successful scale-up of this process able to eliminate the over dependency of palm oil mills on obsolete open ponding system, which permits more effective use of land bank and generation of electricity for workers who resided in isolated oil palm plantation area.

Keywords: Thermodynamics; Steam reforming; Palm oil mill effluent; Hydrogen.

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