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Enhanced Hydrogen Generation from Empty Fruit Bunches by Charcoal Addition into a Downdraft Gasifier

Hydrogen production by co-gasification of empty fruit bunches of palm oil could be enhanced by adding charcoal. Physiochemical characterization of raw feedstocks was performed to determine their exergy potentiality. The raw feedstocks, gasified charcoal, and the end product of produced gas were analyzed by different techniques. Gasification experiments were performed using a pilot-scale downdraft gasifier. The heating value, composition of product gas, yield of hydrogen, and exergy efficiency were used to verify the improvement of hydrogen production during the co-gasification process. Charcoal with empty fruit bunches of palm oil leads to a much higher yield of hydrogen than lower charcoal ratios or solely empty fruit bunches. This enhanced hydrogen fuel can contribute to future energy demand.

Keywords: Charcoal, Downdraft gasifier, Empty fruit bunch, Exergy efficiency, Hydrogen production

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1 Introduction

Ever-diminishing fossil-based fuels (such as oil, gas, and coal) and their gradually increasing demand require energy security that has become a significantly public concern in recent time [1, 2]. These anxieties on energy crisis necessitate alternative, clean, and sustainable energy resources. Moreover, the continuous and excessive usage of fossil fuels at the present rate reportedly induces global warming and climate changes. Usually, energy is produced from renewable and non-renewable resources [3] which are directly related to the economic development of a nation. In this emergency situation, it is crucial to globally produce more energy from the most available energy resources [4].

Hydrogen is a carbon-neutral fuel [5]. The global demand for hydrogen energy was about 255.3 bcm (billion cubic meter) in 2013, and now it grew to 324.8 bcm by 2020 [6]. It has maximum energy content per unit mass, and water is the only by-product generated during its combustion [7]. It has a high yield of energy ($\sim 122\,kJ\,g^{-1}$), which is 2.75 times higher than that of hydrocarbon fuels [8]. This energy is recognized as one of the most promising fuels for fulfilling future energy demands for various applications, i.e., electricity, household, fuel for automobiles, jet planes, hydrogen-based power industries, and domestic purposes [9].

Currently, hydrogen is produced through gasification/co-gasification processes using biomass, coal, or other carbonaceous materials [10]. In addition, hydrogen-containing syngas is employed for bioethanol production [11, 12]. Yang et al. [13] studied on the gasification increasing rate using coal, char, and carbonaceous materials considering different types of catalysts, namely, sodium chloride, potassium carbonate, alkali, and alkali earth metallic species (AAEMS). Lignocellulosic biomass-based charcoal contained some nanoparticles which are identified by X-ray diffraction (XRD) and field emission scanning electron microscopy (FESEM) with energy-dispersive X-ray spectroscopy (EDX) [14].

Nanoparticles have some advantageous physical, chemical, and electrical properties and are used for enhancing bioenergy production [15]. In the previous study, a co-gasification process was performed using coconut shells with charcoal and it was found that by increasing the char ratio with coconut shells, the energy-containing composition increased significantly [16]. Recently, Gradel et al. [17] examined tar-containing product gas produced from biomass pyrolysis in the gasifier. They reported that activated char coal has an absorption capacity of at least $0.3\,g\,g^{-1}$.

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