Screening of modified CaO-based catalysts with a series of dopants for the supercritical water gasification of empty palm fruit bunches to produce hydrogen

ABSTRACT

Catalytic supercritical water gasification (SCWG) of empty palm fruit bunches (EFB) was carried out using bulk and modified CaO-based catalysts with several selected dopants. The catalysts were prepared via a wet impregnation method and characterized using X-ray diffraction (XRD), N2 adsorption (BET), temperature programmed reduction (TPR-H2) and temperature programmed desorption (TPD-CO2). The catalytic reactions were performed using 0.3 g of EFB with 5 wt% of the catalysts in 8 mL of deionized water at 380 °C. The results show that addition of the catalysts into the EFB SCWG reaction improves the overall gas yield and hydrogen selectivity. Furthermore, the catalysts after reduction were found to be more active than the unreduced catalysts in which the presence of metallic Ni enhances the gasification reaction. The addition of bulk CaO into the reaction improves the hydrogen yield (50.6 mmol mL−1) when compared to the reactions conducted in the absence of a catalyst (41.3 mmol mL−1) while the addition of 5 wt% of Ni-doped CaO shows a further improvement (57 mmol mL−1). However, the addition of secondary dopants into Ni–CaO shows significant elevation in the hydrogen concentration. Among the catalysts studied, Zn-doped Ni–CaO gave the highest hydrogen yield (105.7 mmol mL−1) due to its increased promotional effects on the water gas shift reaction. The effect of the dopants on the CaO catalyst in the EFB SCWG reaction is discussed in detail.

Keyword: CaO-based catalysts; Supercritical water gasification; Empty palm fruit bunches (EFB); Catalytic supercritical water gasification (SCWG)