Catalytic gasification of wheat straw in hot compressed (subcritical and supercritical) water for hydrogen production

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ABSTRACT

To supplement the increasing energy demands and cope with the greenhouse gas emissions, biofuels generated from lignocellulosic biomass are gaining widespread attention. In this study, wheat straw was used as a candidate lignocellulosic biomass to produce hydrogen fuel through hydrothermal gasification. The fluid phases of water investigated for gasification included subcritical (300 and 370°C) and supercritical (450 and 550°C) phases. Along with the effects of temperature (300-550°C), the influences of feed concentration (20-35 wt%) and reaction time (40-70 minutes) were comprehensively studied for wheat straw gasification in subcritical and supercritical water. To maximize hydrogen and total gas yields, the effects of two metal catalysts (eg, Ru/Al_2O_3 and $Ni/Si\text{-}Al_2O_3$) were examined. Hydrogen and total gas yields, as well as lower heating values of the gas products, were comparatively evaluated during the subcritical and supercritical water gasification of wheat straw. Supercritical water gasification of wheat straw at 550°C with 20 wt% feed concentration for 60 minutes of reaction time resulted in higher yields of hydrogen (2.98 mmol/g) and total gases (10.6 mmol/g). When compared to noncatalytic gasification, catalytic gasification using 5 wt% loading of Ru/Al_2O_3 and $Ni/Si\text{-}Al_2O_3$ enhanced the hydrogen yields up to 4.18 and 5.1 mmol/g, respectively, along with respective total gas yields of 15 and 18.2 mmol/g. Nonetheless, wheat straw-derived biochar produced at high supercritical water temperatures also retained high carbon content and calorific value.

KEYWORDS: catalyst; gasification; hydrogen; subcritical water; supercritical water; wheat straw