Adsorption enhanced chemical looping gasification of biomass with Fe$_2$O$_3$/CaO: Oxygen carrier activity and process optimization study

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Keywords: chemical looping, gasification, carbon conversion, hydrogen production

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Adsorption enhanced chemical looping gasification of biomass is an important technology for the future because it can uniquely allow inherent capture of CO$_2$ during conversion process, thus promoting syngas production and acquiring carbon credit. The advantages for adsorption enhanced chemical looping gasification includes: a) Oxygen provided by oxygen carrier can be used for biomass gasification, which is more economical than pure CO$_2$/H$_2$O gasification; b) In-situ CO$_2$ adsorption by CaO can promote the useful syngas production. c) The oxidation of oxygen carrier is an exothermic reaction, which can provide heat for biomass gasification through oxygen carrier circulation; d) The oxygen carrier can be potentially used for tar cracking. In this study, oxygen carrier was prepared with wet impregnation method by using calcium nitrate tetrahydrate (Sigma-Aldrich, >99%) and iron oxide (Sigma-Aldrich, >99%). After calcination at 800 °C for 4 h in a muffle furnace under air atmosphere, oxygen carriers were obtained with different ratio of Fe$_2$O$_3$ and CaO. Then the oxygen carriers were applied for chemical looping gasification of rice straw in steam/N$_2$ atmosphere to generate H$_2$ with in-situ CO$_2$ adsorption. Different temperatures, steam/biomass ratios, oxygen carrier/biomass ratios, and Fe:Ca ratios were investigated during chemical looping process to optimize the reaction conditions for carbon conversion, syngas/H$_2$ production. The characterization of oxygen carriers before and after reaction were carried out by X-Ray Diffractometer, Scanning Electron Microscope, and Temperature
Programmed Oxidation to explore the reactivity of different oxygen carriers. With the increase of reaction temperature, the gasification conversion was promoted which increased the carbon conversion, while the CO₂ adsorption efficiency was decreased when temperature higher than 800 °C. The CO₂ capture by calcium cycle enhanced both the biomass gasification and oxygen carrier reduction process which benefited the fuel gas production. The content of H₂ was enriched by the iron ore reduction and the following CO₂ adsorption. Chemical looping gasification of rice straw with in-situ CO₂ adsorption by Fe₂O₃/Cao shows oxidation activity for fuel gas/H₂ production.