

Sorption enhanced catalytic steam reforming of blends of bio-oil model compounds for hydrogen production

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Hydrogen is considered a promising energy carrier with great potential for a clean energy economy. However, nowadays hydrogen is mainly produced by means of steam methane reforming (SMR). This employs non-renewable energy sources like natural gas. It also generates CO₂ as byproduct, a well-known greenhouse gas with the largest contribution to Climate Change.

To improve the weaknesses of SMR, a new technology called sorption enhanced steam reforming (SESR) has been under study in the recent years. The SESR process integrates conventional steam reforming and CO₂ removal in a single reactor. Coupling of both processes generates a synergetic effect, as CO₂ removal shifts the reversible reforming and water gas shift (WGS) reactions to the product side beyond their thermodynamic limits. This increases hydrogen production and captures CO₂ by a CaO-based sorbent at the same time. The process can be carried out at lower temperatures, but requires stable and very active reforming catalysts. Sorbent can also be regenerated by energy-intensive calcination.

In a context of clean energy production, renewable energy sources are mandatory. Biomass appears as the best choice for hydrogen production: coupling of biomass conversion with CO₂ capture and storage offers a great opportunity for effective reduction of CO₂ concentration from the atmosphere. Among other techniques, fast pyrolysis of biomass aims at producing bio-oil, a complex mixture of organic acids, aldehydes, alcohols, ketones, phenols and sugars, which could be later reformed to obtain hydrogen.

The objective of the present study was to investigate the effect of reaction temperature on H₂ production by sorption enhanced steam reforming of bio-oil over a Pd/Ni-Co hydrotalcite-derived catalyst and using dolomite as CO₂ sorbent. Experiments were carried out in a fluidized bed reactor at temperatures between 525 and 725 °C. In order to simulate bio-oil behavior, acetic acid, acetone, phenol and blends of the three model compounds were tested. Analysis of the thermodynamic equilibrium of the process was conducted by means of Aspen Plus software in order to assess the theoretical feasibility of the process.

Experimental results show that SESR process always reaches concentrations near the thermodynamic equilibrium, no matter which model compound is used. H₂ yield reaches a maximum between 575 and 625 °C. The H₂ yield of the mixtures is significantly lower (83.3-88.6%) compared with individual compounds (90.2-95.9%) but it is enhanced when phenol is included in the mixture.

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