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Catalytic Steam Gasification of Glucose for Hydrogen Production Using Stable Based Ni on a γ–Alumina Fluidizable Catalyst

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Abstract:
Six different Ni-based fluidizable catalysts were synthesized using both incipient impregnation and co-impregnation. Ni-based catalysts were also promoted with 2.0 wt% La or alternatively with 2 wt% Ce. The preparation procedure included catalysts treated at high temperatures and under free of oxygen conditions. Catalysts were characterized using BET, XRD, AA, PSD, TPR, TPD, H_2-chemisorption. TPR and H_2 chemisorption showed good metal dispersion with 10 nm- 40 nm metal crystallites.
Glucose catalytic gasification runs were performed in a CREC Riser Simulator to evaluate the following catalysts: (a) 5 %Ni/γ-Al_2O_3, (b) 5 %Ni-2 %La/γ-Al_2O_3 and (c) 5 %Ni-2 %Ce/γ-Al_2O_3. In all cases, the preparation steps involved acid solutions with pHs of 1 and 4. In between consecutive runs, different approaches were considered: (a) A catalyst was regenerated by air, (b) A catalyst was regenerated by air followed by hydrogen pretreatment, (c) A catalyst was reused directly without any regeneration or hydrogen pretreatment. It was observed that Ni-based catalysts, which were subjected after every run, to both, air regeneration and hydrogen pretreatment, displayed the best yields in close agreement with thermodynamic equilibrium. On the other hand, Ni-based catalysts regenerated with air only, showed the worst hydrogen yields. In between these two-hydrogen yield limits, where catalysts not contacted with air nor hydrogen, with these yields being moderately below chemical equilibrium.
This shows that Ni-based fluidizable catalysts can perform on stream for extended periods, requiring limited reactivation with air and H_2. This makes of gasification using the catalysts of the present study, a viable process alternative that could be implemented at industrial scale.

Keywords: hydrogen, glucose, nickel, cerium, lanthanum, gasification

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1 Introduction

Presently, the world production of biomass is approximately 1880 billion tonnes/year. This represents 14 % of the world energy production (Liu et al. 2014). Biomass is an important renewable energy source. Biomass can be converted into liquid and gaseous fuels as well as be used as a raw material for the production of chemicals like methanol, ethanol and higher alcohols (Demirbas 2008; Devi, Ptasinski, and Janssen 2003). The utilization of biomass-based fuels has as an advantage given that they consume renewable carbon, lessening the carbon footprints when using these fuels (Vandamme, Foubert, and Muylaert 2013).

Gasification is a technology that allows the conversion of solid biomass into synthesis gas (CO, H_2, CO_2, CH_4) assisted by air/oxygen, steam and flue gases (Moilanen, Nasrullah, and Kurkela 2009; Nemtsov and Zabaniotou 2008). Gasification has the inherent flexibility of being able to process different feedstocks (Furusawa and Tsutsumi 2005; Yassin et al. 2009) from industry and agriculture, contributing to a cleaner environment.

Natural catalysts for biomass gasification have been widely used for the steam reforming of tars (Guan et al. 2016). These catalysts may be used for hydrogen production due to their low cost and abundance. However,

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