

## MASTER'S THESIS

### Steam reforming of model compounds of bio-oil with and without CO<sub>2</sub> sorbent

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## ABSTRACT

Hydrogen as a clean energy carrier has drawn great attention. Production of H<sub>2</sub> from sustainable bio-oil is considered an alternative for conventional fossil fuel based energy system, since the overall process of bio-oil converting to H<sub>2</sub> ideally is carbon-neutral and hence environmental friendly.

This study focuses on developing an adequate catalyst for bio-oil steam reforming to produce H<sub>2</sub>. Ruthenium and/ or nickel based catalysts supported on alumina, ceria-alumina or ceria-silica were synthesized by sol-gel method or incipient wetness impregnation and characterized using BET Surface area analysis, Powder X-Ray diffraction (XRD), Temperature Programmed Reduction (TPR) and Scanning Electron Microscopy (SEM). Steam reforming of selected model compounds, *n*-propanol, glycerol and acetic acid, was investigated in a fixed bed tubular flow reactor over the prepared catalysts at 450 or 500 °C. The effects of support nature, preparation method, catalyst composition and reaction temperature on the steam reforming activity and stability of catalysts were studied. Catalysts showing better performance in terms of reactant conversion and H<sub>2</sub> yield were selected for investigating the steam reforming of an acetic acid/glycerol aqueous mixture, consisting of acetic acid and glycerol with a weight ratio of 3/7 similar to a bio-oil generated from fast pyrolysis of cellulose. The steam-to-carbon ratio (S/C) and the flow rate of feed were constant at 4 and 0.1 ml/min, respectively. The effluent gas was monitored by GC/TCD and the evolution of carbon conversion and product gas distribution as a function of time was studied.

Among all catalysts investigated, the one with nominal composition A10C10N1Rnc showed the best performance in steam reforming at 500 °C as indicated by higher and more stable H<sub>2</sub> yields achieved regardless the reactant used.

In order to investigate the sorption-enhanced steam reforming, three CaO-based CO<sub>2</sub> absorbents were synthesized: two derived from calcium acetate with or without MgO support, noted as CAM and CA, respectively, and the other MgO-supported one derived from calcium d-gluconate, denoted as CGM. Results from the 15-carbonation/regeneration-cycle test suggested that the MgO-containing absorbent CAM has the highest CaO molar conversion and stable CO<sub>2</sub> absorption capacity. Though significantly higher CO<sub>2</sub> absorption capacity was shown from absorbent CA in the first one cycle, CA absorbent soon lost most of the CO<sub>2</sub> absorption capacity due to severe sintering. In addition, the CO<sub>2</sub> absorption capacity of absorbent CGM might be underestimated due to insufficient carbonation time.

The A10C10N1Rnc catalyst and the CAM absorbent were applied in the steam reforming of acetic acid/glycerol mixture at 500°C. However, no significant improvement can be observed in the presence of absorbent CAM.

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