Novel NI/LA-AL203 for Gasification of Biomass Surrogate in Supercritical Water

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OBJECTIVES/SCOPE:
The aim of this work is to study the promotional effects of La on Ni/LaAl2O3 catalyst for enhanced gasification of a biomass surrogate. The specific objectives are: (1) Synthesis of lanthanum modified alumina supported nickel catalyst, (2) Development of a thermodynamic model based on Gibbs' free energy, which will be minimized according to material balance constraints to give the equilibrium product distributions, (3) Validation of the model by comparing the obtained compressibility factor Z with its counterpart determined for a gas stream having the same composition at selected set of operating conditions in a process simulator (i.e. AspenHYSYS). (4) Evaluation of the catalysts for glucose gasification as a biomass surrogate in batch reactor under supercritical water conditions, and (5) Assessment of the experimental findings based on the theoretical results obtained from the thermodynamic model.

The scope of this work is limited to (1) Synthesis of highly dispersed nickel catalysts, supported on La modified γAl2O3 for biomass gasification in supercritical water, and (2) Thermodynamic model development and application to assess the proximity of the experimental results to the equilibrium model predictions.

METHODS PROCEDURES, PROCESS:
Commercial γAl2O3 was modified with lanthanum promoter and then impregnated with nickel via incipient wetness technique. The synthesis involves the dropwise addition of the lanthanum nitrate or nickel nitrate solutions to the support under vacuum and vigorous mixing; calcination to decompose the nitrate species, and then reduction of the metal oxide in a fluidized bed under a constant flow of a gaseous stream containing 10%H2/90%Ar. Temperature programmed desorption was applied to investigate the acidity using NH3 as the probe molecule, while hydrogen TPR was applied to determine the catalysts' reducibility as well as their appropriate regeneration temperature. The morphological properties were investigated via SEM, while the surface properties were determined from N2 adsorption/desorption isotherms. Glucose was used as a biomass surrogate to evaluate the catalyst performance in a batch reactor at 400500°C and 25 MPa.

RESULTS, OBSERVATIONS, CONCLUSIONS
Following are the key findings of the present study:

- At 500 °C, Ni/LaγAl2O3 catalyst showed higher selectivity for hydrogen, approaching the thermodynamic predictions, unlike the unmodified Ni/γAl2O3 catalyst.

- Ni/LaγAl2O3 catalyst suppressed methanation reactions during gasification of glucose. The La2O3 helped to adsorb CO2, thereby favoring the forward water gas shift reaction to form hydrogen.

- The equilibrium model was validated by comparing the model predicted compressibility factor Z with that of a gas stream having the same composition at the same sets of operating conditions using Aspen HYSYS process simulator.

- The catalyst could be applied for enhanced hydrogen production from biomass materials at SCW conditions in batch, continuous or fluidized bed reactor.

- The new thermodynamic model developed, is a rigorous one, and could be applied to predict the equilibrium product distribution of any real biomass.