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Development of biogas reforming Ni-La-Al catalysts for fuel cells☆

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Abstract

In this work, the results obtained for Ni-La-Al catalysts developed in our laboratory for biogas reforming are presented. The catalyst 5% Ni/5% La_2O_3-γ-Al_2O_3 has operated under kinetic control conditions for more than 40 h at 700 °C and feeding CH_4/CO_2 ratio 1/1, similar to the composition presented in biogas streams, being observed a stable behaviour.

Reaction parameters studied to evaluate the catalyst activity were H_2/CO and CH_4/CO_2 conversion ratio obtained. On the basis of a CH_4 conversion of 6.5%, CH_4/CO_2 conversion ratio achieved 0.48 and H_2/CO ratio obtained was 0.43. By comparison of experimental results to equilibrium prediction for such conditions, is detectable a lower progress of reverse water gas shift reaction. This fact increases the H_2/CO ratio obtained and therefore the hydrogen production. The higher H_2/CO and a CH_4/CO_2 conversion ratio in comparison to CH_4 one close to equilibrium is due to the carbon deposits gasification which avoids catalyst deactivation. A thermodynamic analysis about the application of dry and combined methane reforming to hydrogen production for fuel cells application is presented. Data obtained by process simulation considering a Peng–Robinson thermodynamic model, allows optimizing process conditions depending on biogas composition.

Keywords: Biogas; Reforming; Hydrogen; Fuel cell; Processor; Methane

1. Introduction

The problems associated to the extraction capacity and refine of petroleum together to the excessive increment of the fossil fuels consumption, it has increased the possibility of using renewable energy sources as well as the revalorizarion of remainders able to generate fuels such as methane for the energy production.

This solution could reduce the external energy dependence and it would favor the development of the local economy through the concept of decentralized generation, reducing the emissions of greenhouse gases to the atmosphere.

In Europe, the use and production of biogas as a source of primary energy is experiencing to get the objective of production of 15 millions of TOE in the 2010.

The biogas produced in anaerobic digestors could contain methane concentrations of until 80% in volume, and its quality would depend on its origin (drain, anaerobic digestion of residual waters or treatment of residuals).

Traditionally biogas has been burned in internal combustion engines for the electricity production and heat, but its potential use in fuel cells could increase its electric efficiency, especially in applications at low scale, diminishing the NO_x emissions to the atmosphere [1–5].

For biogas reforming in mixtures with considerable contents of CO_2, a process that get special attention is the dry gas reforming or carbon dioxide reforming. This process is of particular interest, since it allows to take advantage of the CO_2 presented in biogas composition as oxidizer in the gas reforming [6–8]. For biogas streams with CO_2/CH_4 ratios less than unit, it is required the addition of an alternative oxidizer for the production of synthesis gas [9,10].

One of the main limitations of dry gas reforming technology application is the development of catalysts able to avoid the deposition of carbon on the active phase to increase their period of useful life [11–14].

In this work, the results obtained for a catalyst developed in our laboratory for the methane reforming with CO_2 are presented. The comparison of the experimental results versus

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