MICROWAVE ASSISTED STEAM REFORMING OF ALCOHOLS FOR HYDROGEN PRODUCTION

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Summary

We perform microwave-assisted and conventional steam reforming of oxygenated fuels (methanol/ethanol) in order to compare the effect of the two heating modes (microwave vs. electric) on fuel conversion and product selectivity at various operating conditions (temperature, feed composition and type of catalyst).

Keywords

Hydrogen production, steam reforming, microwaves.

Introduction

The global requirement for gradually decreasing societal dependence on fossil fuels for environmental, economical and security reasons has given rise to research on alternative fuel synthesis such as hydrogen, which can be converted to electricity in fuel cells. A well-working hydrogen fuel cell needs continuous delivery of pure hydrogen. Instead of storing hydrogen on board, an alternative is to produce it in situ from renewable sources of energy (e.g. biomass derived ethanol) via steam reforming. The ability of microwaves to provide rapid and uniform heat to the entire catalytic bed entails that microwave heating can be considered as a potential alternative[1]. Moreover, the microwave energy provides benefits unachievable in classical routes of heating. It has been reported that due to the interaction of microwaves with the catalytic bed, the catalytically-active phase can reach much higher temperatures than the surrounding support, the so called local hot spots[2]. This phenomenon is considered by some researchers to be responsible for the higher reaction rate observed and the improved selectivity in the desired products under microwave heating[3-8].

Methods

An experimental approach has been conducted in order to investigate potential benefits coming from the application of microwave energy to the methanol/ethanol steam reforming reaction. The study is focused on comparison of alcohols conversion, products distribution and the hydrogen selectivity for different reaction conditions and applied heat source (electric heating vs. microwave). Focus is given to the 3-D temperature mapping of the catalytic bed and hot spot formation during the reaction. Finally, several catalytic systems are investigated, Rh/CeO_2-ZrO_2, Rh/Al_2O_3, Ni/Al_2O_3 and Ni/CeO_2-ZrO_2.

Results and discussion

In a first stage of the investigation, the catalysts were evaluated in terms of bed temperature (during the microwave treatment) as a function of metal content under the conditions of applied irradiation power of 10 W for 40 min. Figures 1-3 show the temperature evolution in time under microwave treatment of the Rh/Al_2O_3, Ni/Al_2O_3 and Rh/CeO_2-ZrO_2 catalytic systems, respectively. It was observed that the higher metal load on the catalytic support the higher the system's temperature. However, in case of the Ni/Al_2O_3 system, the observed temperature differences among the catalysts are smaller albeit the metal content is much higher than that in the Rh/Al_2O_3 and Rh/CeO_2-ZrO_2 systems It was also observed that not only the amount of metal on the catalytic support plays a role but also the type of the catalytic support. More specifically, despite the Rh content in Rh/Al_2O_3 and Rh/CeO_2-ZrO_2 catalysts being comparable, the latter absorbs microwave energy much better and is able to reach

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a much higher temperature. Therefore, it turns out to be the first candidate for further investigation on hot spot formation during microwave-assisted steam reforming.

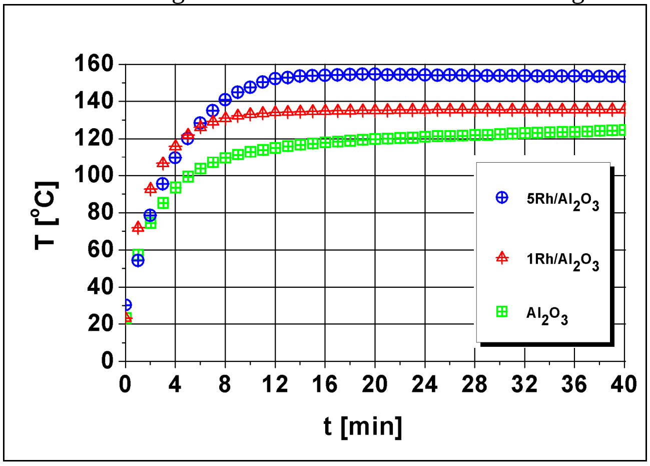

Fig.1 Temperature in the Rh/Al_2O_3 catalytic bed vs. time for different Rh loadings (values in the legend are % values).

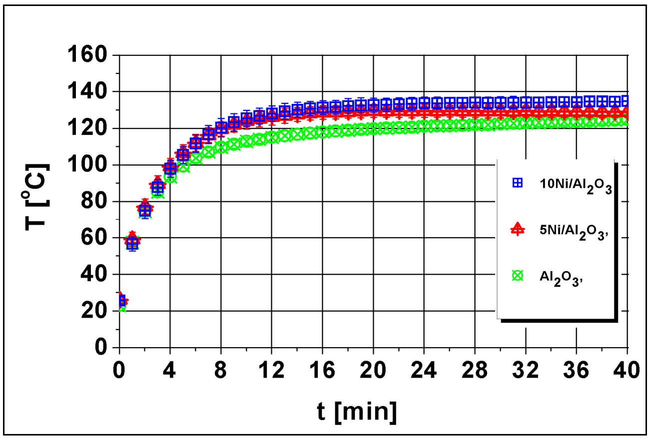

Fig.2 Temperature in the Ni/Al_2O_3 catalytic bed vs. time for different Ni loadings (values in the legend are % values).

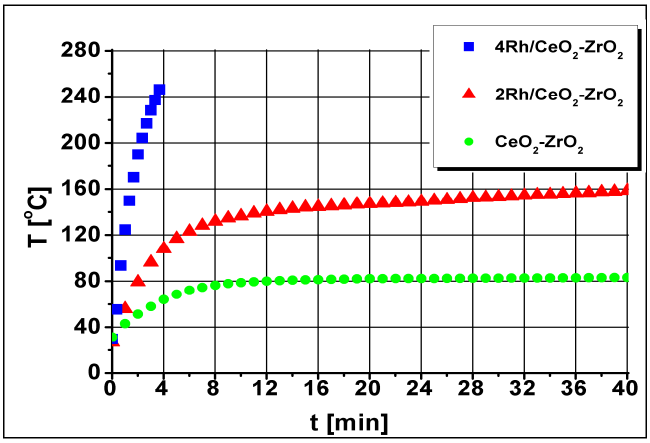

Fig.3 Temperature in the Rh/CeO_2-ZrO_2 catalytic bed vs. time for different Rh loadings (values in the legend are % values).

Conclusions

The microwave-assisted steam reforming of alcohols is seen as a potential alternative to the conventional process. An experimental approach is adopted to explore and quantify the benefits coming from microwave heating such as the lower operating temperature, the higher conversion and selectivity to the desired product and the improved thermal efficiency.

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