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Structured Catalysts for the Realization of a Single Stage Water Gas Shift Process

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Highlights

- Preparation of structured catalysts with high thermal conductivity.
- Development of an adiabatic laboratory system for the water gas shift reaction
- Redistribution of the heat of reaction on the catalytic bed.
- Flattening the thermal profile while increasing the conversion.

1. Introduction

The Water Gas Shift (WGS) can be considered the first step in the synthesis gas purification; it is based on an exothermic reversible reaction and is normally carried out in a two-step adiabatic process. This configuration allows to take advantage of fast kinetics in the high temperature step (HTS) and achieve good conversions in the low-temperature step (LTS) however, it is extremely expensive, making this process susceptible of considerable improvements. In previous works we have shown the benefits obtained from the use of highly conductive structured carriers, in the preparation of catalysts for the WGS reaction [1]. The high conductivity of carrier allows, in adiabatic conditions, to flatten the temperature profile of the catalytic bed, improving the kinetics and the CO conversion, by back diffusion of the heat of the reaction along the bed. In this work we present the preparation of bimetallic structured catalysts, obtained by washcoating of highly conductive aluminum carriers.

2. Methods

The catalysts preparation was performed into two stages, the carriers were firstly loaded with an alumina slurry by dip-coating procedure, subsequently impregnated with the active components, based on platinum/rhenium bimetallic formulation.

The catalysts were characterized by several chemical-physical techniques, such as ultrasonic adhesion tests, specific surface area B.E.T., ED-XRF, XRD, Raman, H2-TPR. The WGS tests were performed at atmospheric pressure in the temperature range of 453-673 K, with a reaction mixture containing the 8% of CO, 30% of water and 62% of Nitrogen, in a fixed bed tubular stainless steel reactor with an internal diameter of 30 mm.

3. Results and discussion

The ultrasonic adhesion tests showed the high resistance of the deposited washcoat, to the mechanical stress, the weight loss was less 10% in 30 minutes of tests for all the samples. The specific surface area measurements showed the remarkable increase of the surface area obtained by deposition of the washcoat over the carriers, with an increase of two orders of magnitude. The TPR experiments showed the high reducibility of the catalysts, due the occurrence of the spillover effect.

Through the realization of an adiabatic system, we highlighted the real benefit in using the structured carrier with respect to powder one. The wide range of activity of the Pt-Re catalytic system, allowed to obtain a considerable improvement, moreover the good activity at very low temperature allows to improve the performance of the LTS processes. The obtained results were compared to the performance reported for the actually used catalysts for the WGS process, showing better activity, especially for medium temperatures, making this catalysts a valuable alternative to the traditional one and a concrete possibility in view of the design of a single-stage process.

4. Conclusions

In this abstract we introduced our results on the preparation, characterization and evaluation of the performance of Pt-Re-based structured catalysts.

The activity tests showed high conversions in the studied temperature range; while the results obtained through the realization of and adiabatic system, showed the concrete possibility to realize a single-stage WGS process.

References

[1] V. Palma, D. Pisano, M. Martino. Structured catalysts with high thermoconductive properties for the intensification of Water Gas Shift process. Chem. Eng. J. 304 (2016) 544–551.

Keywords
Water Gas Shift; structured catalyst; heat transfer.