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Microreactor Coating using Gold as Catalyst for Oxidation of Ethanol

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Highlights

- Stainless steel microplatelets were coated with gold catalyst used in ethanol oxidation
- Suspension method was used for coating
- Rheological behavior of the slurry played a crucial role in coating
- The coating uniformity, stability and thickness was optimized

1. Introduction

Development of milli and micro-scale production technology is a hot topic in current chemistry and chemical engineering. Microreactors associate with process intensification concept meaning a reduction in equipment size by several orders of magnitude causing a remarkable drop in capital and energy costs along with the environmental impact. The aim of this work is to develop microreactor technology to be applied in selective oxidation of molecules from biomass; focuses on the catalytic oxidation of the hydroxyl and carbonyl groups in molecules from biomass. The technology is based on the use of selective heterogeneous catalysts in continuous microstructured devices (Figure 1). Gold (Au) was used as catalyst. The target molecules are aldehydes, esters and carboxylic acids which are needed as intermediates and end products. Acids and aldehydes from alcohols are important intermediates in chemical, pharmaceutical and alimentary industries. Herein, it is discussed about development of microreactor plates coating via suspension method with heterogeneous Au/Al_2O_3 catalyst with the aim of optimizing stability, homogeneity and thickness of the catalyst layer.

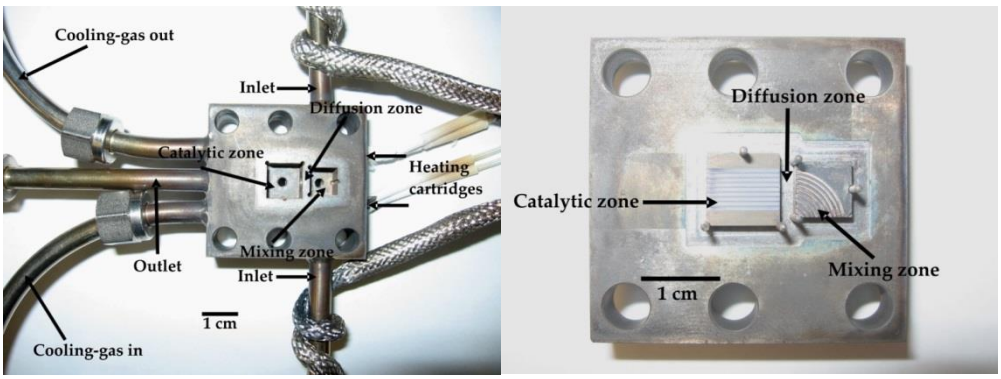

Figure 1. Microreactor; consists of ten plates and nine channels in each plate (IMM GPMR-Mix).

2. Methods

In order to use the microreactor, the chosen catalyst (Au/Al_2O_3) from screening section [1-2] has been used for coating of the stainless steel microreactor platelets. There are several methods reported for coating [3] the microreactor plates, however, the method used in this work is based on suspension because it is straightforward and enables to utilize ready-to-use catalysts in microreactors. There are three important

parameters in coating procedure; homogeneity of the catalyst layer along the plate channels, stability of the catalyst on the plates and catalyst layer thickness. In this section, different characterization techniques are used to study the effect of different processing parameters on stability, homogeneity and thickness of the catalysts; including confocal white light microscopy, scanning electron microscopy/energy dispersive X-ray spectroscopy, nitrogen physisorption and transmission electron microscopy.

3. Results and discussion

Stability of the catalyst on the plates needs a treatment step prior to the coating. Thermal treatment has been chosen in this work. This technique causes formation of an oxide layer on the plate which makes the surface rough and inhibits wetting by making higher contact angles between the liquid and solid surface. Different amount of oxygen was formed on the metal surface determined by EDXA based on the calcination temperature (Energy Dispersive X-ray Analysis). In addition, the viscosity of the suspension played a crucial role in uniformity of the catalyst layer within the microchannels.
There are different ways to test the stability of the catalyst on the plates but the most reliable way is to test at reaction conditions. SEM images after the reaction showed that there was not a noticeable loss of the catalyst which means that the catalyst layer was quite stable.
The homogeneity of the catalyst layer was controlled by varying the viscosity of the solution and the drying temperature after the coating. Low temperature e.g., 5°C, for drying assisted to get a higher degree of homogeneity of the catalysts, otherwise, the catalyst particles would transport to the borders of the channel walls and cause inhomogeneity. The thickness of the catalyst layer was controlled by solid content of the solution and the amount of catalyst deposited on the surface.

4. Conclusions

In summary, Au/Al_2O_3 catalyst was coated successfully on stainless steel microreactor plate via suspension method. The rheology of the slurry played a crucial role in homogeneity of the catalyst layer within the microchannels. The catalyst was used in partial oxidation of ethanol.

Keywords
Microreactor; suspension method; gold catalyst.

References

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