

## Novel Compact Reactor for 3-Phase Hydrogenation

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### Introduction

Catalytic selective hydrogenation of functional groups in organic molecules is one of the most important chemical reactions used to produce fine chemicals and pharmaceutical products. The performance of the hydrogenation process is strongly dependent on the catalyst activity/selectivity and the interaction of chemical kinetics with mass transfer in the eventual reactor. To avoid internal and external mass transfer limitations and to attain high product selectivity, the micrometer range catalyst particles are required leading to the use of suspension reactors. The most common reactors are the batch wise operated slurry reactors like stirred tanks and loop reactors. The minimum size of the catalyst particles is, however, limited by the separation from the reacting mixture after the reaction. Another problem for the reactor design is related to the heat removal since hydrogenations are highly exothermic reactions. Precise temperature control is required to achieve high selectivity and to prevent run-away. The efficient heat removal can be provided using micro-structured heat exchangers. In this way a considerable intensification of the hydrogenation process could be attained at high catalyst and reactant concentration. But due to the plugging of micro-channels by catalyst particles, micro-structured heat exchanger is difficult to incorporate in a traditional suspension reactor. Therefore, the heterogeneous catalyst must be immobilized within the reactor and spatially separated from the micro heat exchanger.

A novel approach in the three phase reactor engineering is based on the use of structured catalytic materials. Recently we suggested a reactor design as a bubble column staged by fiber catalysts in the form of woven cloths [1, 2]. As the diameter of the single fiber is usually in the micrometer range, mass transport limitations can be effectively avoided, while the open macrostructure of the material leads to low pressure drop and acts as a micro-mixer to enhance bubble redistribution. Glass fibers as well as activated carbon fiber cloths have shown promising results in this type of reactor, but their low rigidity requires supplemental supporting stages of metal grids.

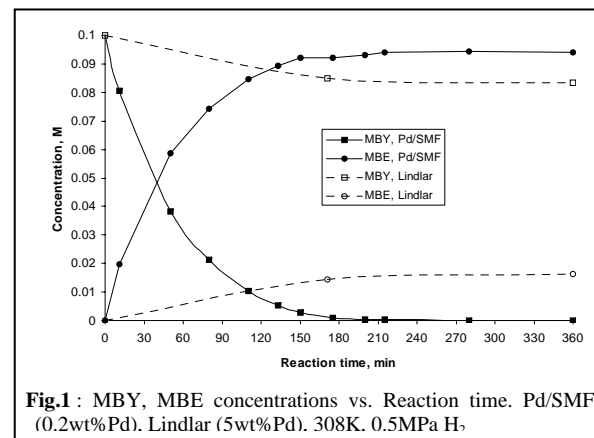
The present work is aimed on the development of a novel compact reactor in the form of staged bubble column with an integrated heat exchange. We report the use of Sintered Metal Fibers (SMF) catalysts in the form of porous sheets of ~0.4 mm thickness. These sheets are self-supporting and can be easily shaped into any macro-structured catalytic bed.

### Materials and Methods

SMF materials are available on the market from different metallic fibers with diameters of 10-20  $\mu\text{m}$ . Their open structure possesses a high porosity >80% allowing easy passage of reactants without high pressure drop. Furthermore, the high thermal conductivity of metallic SMF ensures isothermal conditions on the catalyst surface even for highly exothermic reactions. The catalytic material used is based on SMF structured support with Pd nanoparticles as active phase. The Pd/SMF structured catalyst was tested in the liquid phase

hydrogenation of 2-methyl-3-butene-2-ol (MBY) to 2-methyl-3-butene-2-ol (MBE) taken as model reaction. Prior to Pd deposition the SMF was coated with grained metal oxide layer to increase the specific surface area. In addition, its basicity further increases the performance and selectivity of the active Pd phase. The hydrogenation was carried out batchwise in a stainless steel reactor equipped with a heating jacket and a hydrogen supply system. The Pd/SMF catalyst was integrated into a self-gassing hollow shaft impeller. The Lindlar catalysts were used for a comparison.

### Results and Discussion



Concentration vs. reaction time profiles are presented in Fig.1 for the Pd/SMF and Lindlar catalyst with the same Pd loading and under identical reaction conditions. The initial activity of Pd/SMF catalyst was found to be an order of magnitude higher than the activity of the Lindlar catalyst at the same initial selectivity of 97% for the target MBE.

### Significance

Novel compact reactor in the form of a bubble column staged with structured Pd/SMF catalyst is developed for a liquid-phase hydrogenation.

### References

1. V. Höller, I. Yuranov, L. Kiwi-Minsker, and A. Renken, *Catalysis Today*, 69 (2001) 175.
2. L. Kiwi-Minsker, E. Joannet, and A. Renken, *Chem. Eng. Sci.*, 59 (2004) 4919.