Ceramic Hollow Fiber based Catalytic Modules

R. Nandini Devi,[a*] **Ulhas Kharul,**[b] **T. Shibin**[a]**, Shunottara Jogdand**[a]**, Pavan Dongapure**[a]
[a]*Catalysis Division, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune 411008, India*
[b]*Polymer Science and Engineering Division, CSIR-National Chemical Laboratory, Dr. Homi Bhabha Road, Pune 411008, India*
**nr.devi@ncl.res.in*

Abstract: Ceramic hollow fiber based modules for metal catalysts is developed. Catalyst is synthesized by capillary diffusion impregnation of metal precursors. A gradient in concentration of metal is found outside in of the fibers. The fibers are tested for CO_2 hydrogenation which showed an enhancement of ~20% in activity when compared to conventional catalyst. Multifold increase in the surface area for deployment of active metals and addressing diffusion limitations are found to be the advantageous features.
Keywords: ceramic hollow fibers, catalytic membranes, CO_2 hydrogenation.

1. Introduction

Conventional heterogeneous catalysts are based on active metals supported on high surface area supports. Usually they are employed in powder form in small scale reactions, especially in liquid phase reactions or as small pellets in gas phase reactions, where mass transfer limitations are virtually absent. However, in higher scales, this as well as mechanical strength becomes a huge problem and different formulations and shapes of catalysts are adapted to reduce pressure drops and related issues. Even though cylindrical pellets with multiple holes, foil supported structure etc. are mainly used in industrial scale, new structures like monoliths and foams are gaining momentum now. However, these structures also have drawbacks in that they have materials limitation, for eg., monoliths are made of cordierite and direct metal dispersion is not possible. Also simultaneous separations cannot be employed in these systems.

In this scenario, ceramic hollow fibers have great potential to be used in catalysis due to many advantageous features. Fibers can be fabricated using many different materials, including most of the oxides used usually as supports. In addition, these fibers have finger shaped macropores which help in increasing the surface area multifold compared to a conventional monolith. Controllable porosity of the fiber wall will also help in carrying out size selected separations parallel to catalysis.

2. Experimental (or Theoretical)

The catalyst module is fabricated by using alumina hollow fibers as supports for metal impregnation. First the fibers are impregnated by different concentrations of metal precursor by employing a capillary diffusion method. Then further calcination at temperatures ~400-500 °C prepares the catalyst loaded fibers which are subsequently fabricated into stand alone modules. Catalytic testing was carried out for CO_2 hydrogenation in a fixed bed reactor and also with the module.

3. Results and discussion

Structured catalysts are fabricated by capillary diffusion based impregnation of alumina hollow fibers of length 25 cm. For comparison, similar composition of conventional catalyst also is synthesized. SEM EDAX elemental mapping of the fibers show good distribution of the metal on the surface with maximum concentration on the inner wall and at ~ 10-12 cm. Catalytic testing of this material was carried out for CO_2 hydrogenation and the results show ~20% enhancement in activity when compared to conventional pellet based catalyst.

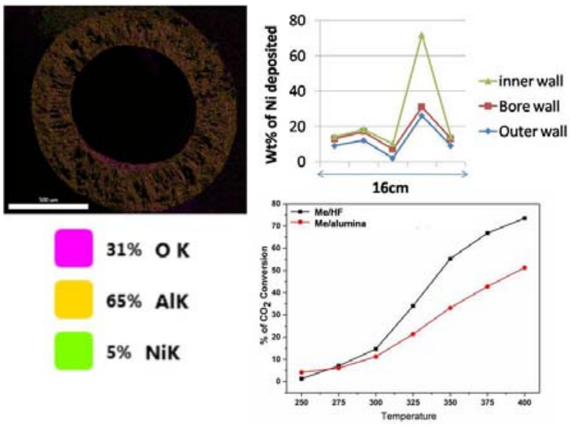

Figure 1. Characterisation and catalytic activity of metal supported on alumina hollow fibers for CO_2 hydrogenation

4. Conclusions

Ceramic hollow fibers can be envisaged to be better options for catalyst deployment compared to currently used monolith structures. Hollow fibers have better surface area for active metal dispersion due to the finger shaped features. We observed a ~20% enhancement in CO_2 hydrogenation activity in such a case.

References

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