

Experimental and CFD study of metallic foam and monolith structure as catalyst supports for the selective hydrogenation of acetylene

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Highlights

- Metallic foam and monolith catalyst were successfully fabricated and activated.
- Catalyst support geometry and coating strategy strongly influence conversion and selectivity.
- Structured catalysts show competitive performance versus reference catalysts.
- CFD predictions of pressure drop agree well with experimental measurements.

1. Introduction

This work presents a study on the use of metallic structured supports, namely foams and monoliths, as catalyst supports for the selective hydrogenation of acetylene. Structured catalysts have attracted increasing attention over the past two decades [1, 2, 3] due to their potential advantages in heat and mass transfer, pressure drop reduction, and reactor intensification. Various types of structured supports, including ceramic and metallic materials, have been developed using different fabrication techniques, as reported in the literature. Commercially available metallic foams and monoliths are generally inert and must be catalytically activated, commonly through washcoating and metal deposition techniques.

In this context, the present work investigates different preparation strategies for metallic foam and monolith catalysts and evaluates their catalytic and hydrodynamic performances through combined experimental testing and CFD analysis.

2. Methods

An experimental and CFD-based study was conducted to design, prepare, and evaluate structured catalysts for selective acetylene hydrogenation (Fig. 1). Two main catalyst preparation strategies were investigated:

- Spin-coating [4] of a NiCr metallic foam with a palladium-based catalyst powder supported on α -alumina.
- Washcoating [5] of NiCr metallic foams and FeCrAl monoliths with γ -alumina, followed by calcination to form α -alumina and subsequent impregnation with a colloidal palladium (Pd) solution.

The prepared structured catalysts were evaluated in a pilot-scale unit under selective acetylene hydrogenation conditions. In parallel, pressure drop measurements were carried out on coated and uncoated metallic foams. CFD simulations were performed to study hydrodynamics and pressure drop, and the results were compared with existing predictive models from literature.

3. Results and discussion

The catalytic performances of the structured catalysts were compared with those of reference catalysts in terms of acetylene conversion and selectivity. The results highlight the significant influence of both the support geometry (foam versus monolith) and the catalyst preparation method on catalytic performance. The effectiveness of the washcoating and impregnation strategies was evaluated, showing distinct differences in productivity and selectivity. Pressure drop analysis revealed the impact of catalyst coating on flow resistance, and CFD results showed good agreement with experimental measurements and literature correlations.

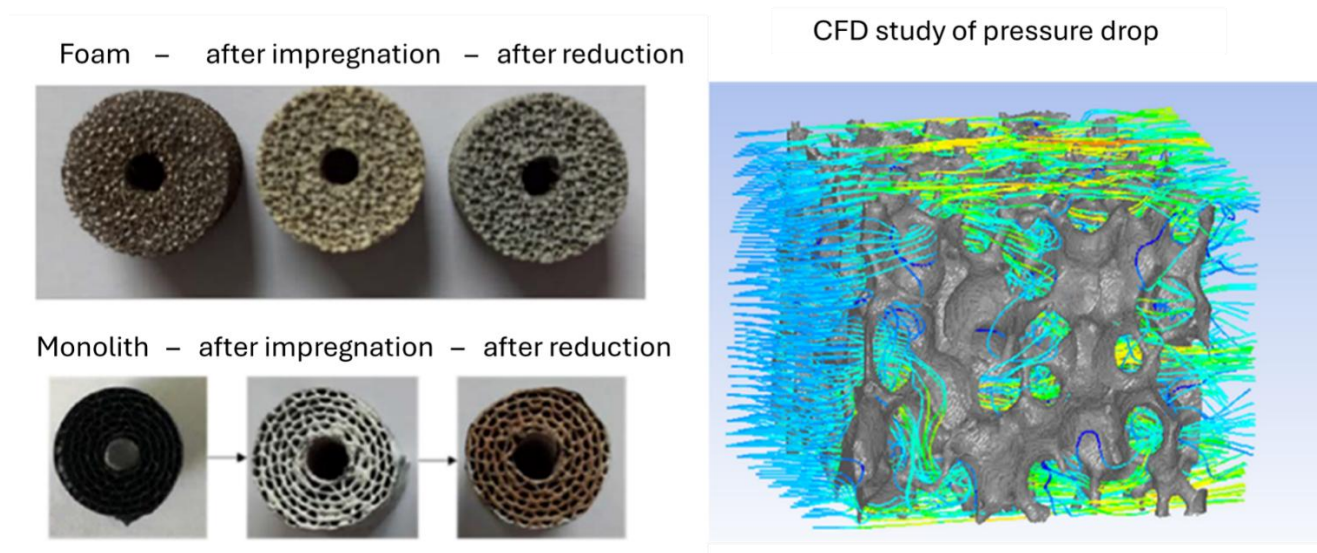


Figure 1. Illustration of the structured catalyst geometries tested.

4. Conclusions

This study demonstrates the importance of support geometry and catalyst preparation strategy in the design of structured catalysts for selective acetylene hydrogenation. The combined experimental and CFD approach provides valuable insights into both catalytic performance and hydrodynamic behavior, supporting the potential of metallic foams and monoliths for future industrial applications in unconventional catalytic reactors.

References

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Keywords

Intensification, structured catalysts, catalyst fabrication, foam support, monolith, CFD