# Activated Metal Foams – Attractiveness and Challenges in Industrial Hydrogenations

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## Abstract

Hydrogenation reactions are core technology for upgrading of chemicals in the bulk and specialty chemical industry as well as in pharmaceutical production. Usually, hydrogen is used in gaseous form and reacts in the presence of solid metal catalysts with the substrate to form the required products in high selectivity. Hydrogenation reactions often exhibit complex reaction kinetics and are usually accompanied by mass and heat transport limitations. Therefore, hydrogenations offer a large playground for reactor and catalyst improvements towards higher raw material and energy effectiveness.

As a mature technology development or optimisation of hydrogenation processes does not start nowadays from scratch but runs within existing parameter space with already defined limitations: usually existing single plants or Verbund structures in which significant changes within one step results in reasonable consequences in the total plant which might result in undesired additional development and CAPEX effort.

The metal foam catalyst technology discussed in the presented paper with its conceptionally high flexibility in material design allows the structuring of the internals of our existing plants, without necessarily having to touch the outer geometry, downstreaming or infrastructure with simultaneous efficiency improvements.

Metal foams gained significant industrial interest starting with the beginning of the 21$^{st}$ century and are well known for application in batteries (electrodes), heat exchangers, filters, energy absorbers, flame arrestors or biomedical implants. However, the high cost of the material sometimes limits its use to advanced technologies. Their application as catalysts in chemical industry is not strongly limited by this fact, but so far only few applications exist, as steam methane reforming (SMR), partial oxidation of methanol to formaldehyde or Biogas desulfurization [1].

Open cellular metal foams have been proven to be advantageous compared to classical fixed bed catalysts or even oxidic foam materials [2,3]. The main benefit is mechanical strength combined with low weight, significant improved mass and heat transfer properties and higher selectivities in catalytic reactions.

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**Preference:** Oral presentation [X] Poster [ ]

In our presentation, we will report on the material development of activated Nickel foam based catalysts for industrial hydrogenation reactions, the performance of the materials compared to classical catalysts in batch and continuous operation in a miniplant set-up as well as challenges, that have to be tackled before large scale application. The activated Nickel foam catalysts of Evonik´s Metalyst® MC 9 series*) have been applied for hydrogenation of isononanal (INAL) to isononanol (INA), an important intermediate in the production of plasticizers, and exhibited superior performance in activity, selectivity and good long term stability.

Experimental investigations were, amongst others, performed in a two-stage-reactor setup comprising an upstream recycle reactor containing a Metalyst® MC 981 foam catalyst fixed bed and a downstream finishing reactor filled with a state-of-the-art continuous process catalyst.
Stress test under varying operation conditions (variations in temperature & feed load) were run over more than 3000 hours of operation without significant degradation of the system performance.

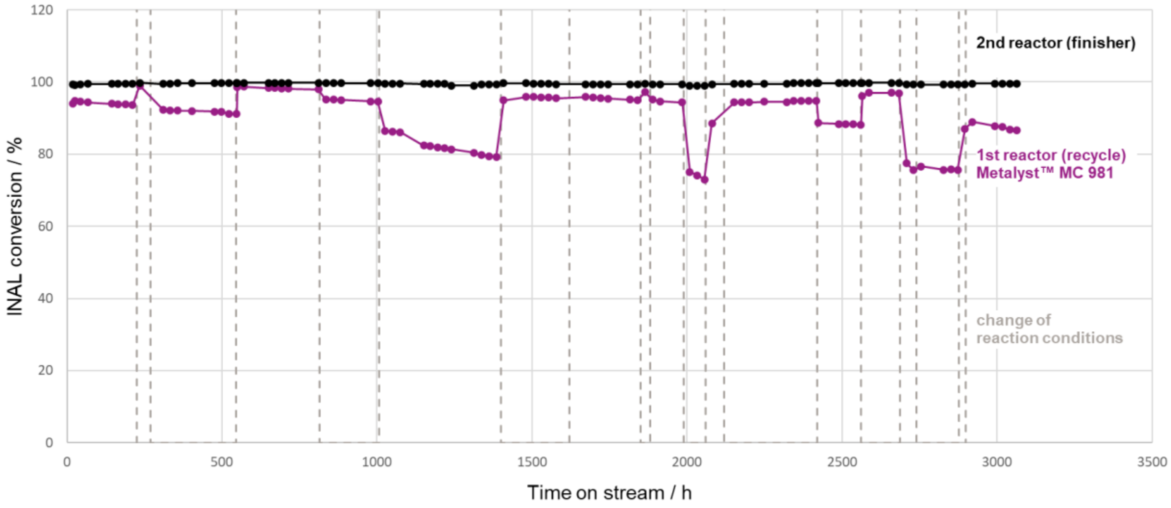


Figure 1 Performance of an activated Nickel foam based catalyst in INAL hydrogenation to INA under different operating conditions during a time-on-stream of 3000 h.

*) The catalyst technology Metalyst® MC 9 presented here is manufactured under a license from Alantum Europe GmbH [4].

Literature:

[1] G. Walther, U. Gaitzsch, T. Büttner, B.Kieback, T. Weißgärber, R. Kolvenbach, M. Lincke, International Powder Metallurgy Congress and Exhibition Euro PM2017, Milan, Italy, 1.-5.10.2017
[2] F. Lali, G. Böttcher, P.-M. Schöneich, S. Haase, S. Hempel, R. Lange, Chem. Eng. Res. Des. 94 (2015) 365–374
[3] S. Cimino, E.M. Cepollaro, L. Lisi, S. Fasolin, M. Musiani, L. Vázquez-Gómez, Catalysts 11 (2021), 13
[4] Radivojevic, D., Naumann, D., Saberi, S., Bae, J., Poss, R., European Patent 2,764,916 (2014).