

# A unique technology for the deposition of nanoparticles on catalyst supports

Jan Meißner<sup>1</sup>, Quoc Khanh Tran<sup>1</sup>, Truc Ha Bui<sup>1</sup> and Joachim Pasel<sup>1\*</sup>

<sup>1\*</sup> Institute of Energy and Climate Research, IEK-14: Electrochemical Process Engineering, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

## INTRODUCTION

Wet-chemical methods (impregnation, precipitation) for the synthesis of heterogeneous catalysts in powder form suffer from several disadvantages. Often the complexity of wet-chemical syntheses is high with various subsequent steps, such as impregnation, precipitation, filtration, washing, drying, calcination, reduction etc., and the combination of materials to be deposited is limited. In some cases, enrichment and/or depletion of the catalytically active metallic nanoparticles on the support occur with nanoparticle dimensions ranging from a few nm to over 100 nm<sup>1</sup>. It was also found that oxidic precursor phases were not fully reduced<sup>1</sup>. All these points often lead to limited catalytic activities. The unique technology for the deposition of metallic nanoparticles on powder catalyst supports described in this study offers high potential to overcome these drawbacks<sup>2</sup>. The nanoparticles are deposited in just one step. All conductive and semi-conductive materials from the periodic table of elements can be used and. As the nanoparticles are produced via a commercial nanoparticle generator, their size is uniformly smaller than 10 nm. Ligands and solvent-free pure metallic phases are applied to the supports.

## EXPERIMENTAL

The operating principle is shown in Fig. 1 on the left. It works in such a way that a gas flow enriched with nanoparticles is fed into the deposition apparatus through the glass inlet at the bottom left, after the powder catalyst support was filled into the lower area of the apparatus through the same nozzle. The screw conveyor has the function of transporting the catalyst support upwards in the axial direction. Through the windows in the transport sleeve, the upwardly shifted support is then ejected from above into the annular gap between the inner wall of the glass vessel and the outer wall of the transport sleeve, through which the gas stream enriched with nanoparticles flows in the opposite direction. This contact causes the nanoparticles to physisorb on the surface of the catalyst support by means of van der Waals forces. The glass prototype of the deposition apparatus with its screw conveyor and transport sleeve is depicted in Fig. 1 in the middle.

## RESULTS AND DISCUSSION



Fig.1 Operating principle of the deposition apparatus with screw conveyor (left), picture of the patented prototype of the deposition apparatus (middle) and result of an SEM/EDX measurement with an Al<sub>2</sub>O<sub>3</sub> powder catalyst support (right)

Fig. 1 on the right-hand side shows the EDX spectrum of an Al<sub>2</sub>O<sub>3</sub> sample, whose surface was coated with Ni and Pt nanoparticles in the deposition apparatus from Fig.1. Thereby, the Ni and Pt nanoparticles were produced in a commercial nanoparticle generator with a molar ratio of 95:5. The deposition time was 6 hours. The EDX spectrum makes clear that it was possible to deposit Ni nanoparticles on the Al<sub>2</sub>O<sub>3</sub> support using the operating principle of the deposition apparatus. Pt nanoparticles could not be detected in this way. ICP-OES measurements of the mass fractions of Ni and Pt on an Al<sub>2</sub>O<sub>3</sub> support showed a comparable picture. This study will present more experimental data with respect to deposited quantities of nanoparticles, homogeneity of the coating and catalytic activity of the catalysts for the synthesis of iso-butanol from mixtures of sustainable ethanol and methanol.

## CONCLUSION

This study presents a unique technology for the deposition of catalytically active metallic nanoparticles on powder catalyst supports. This technology will help overcome various drawbacks of conventional wet-chemical syntheses of these catalysts.

## REFERENCES

1. J. Häusler et al., Catalysts 14, (2024)
2. J. Häusler et al., Apparatus and method for loading catalyst carriers with nanoparticulate catalyst precursors from the gas phase, German patent application 102024105425.5 (2024)