

Synthesis of well-structured Pt catalysts on spherical SiO₂ support by a CVS/CVD process using novel metal-organic precursors

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Introduction

Platinum on metal oxide support is a widely used catalyst in chemical synthesis and environmental technology. The dependency of activity and selectivity on surface structure and modification of catalysts is a research topic of growing interest. Continuous chemical vapour synthesis (CVS) of gas-borne support particles combined with chemical vapour deposition (CVD) of noble metal dots gives ordered, defined nanocatalysts with high surface area. Previous investigations show narrowly distributed, highly dispersed palladium nanoparticles with median sizes between 3 and 9 nm on SiO₂ (figure 1) produced by the CVS/CVD process at atmospheric pressure (Binder *et al.*, 2010). In this study Pt nanoparticles are deposited on spherical SiO₂ substrates by metal organic chemical vapour deposition (MOCVD) using commercial and newly synthesized precursors. The surface chemistry of the support particles has a great influence on the Pt deposition. It is proposed that the Pt precursor interacts with the surface hydroxyl group (OH) of SiO₂ and decomposes to form Pt on the surface (Xue *et al.*, 1992). Afterwards autocatalysis takes place on local Pt clusters and catalyses nucleation and deposition. Thereby platinum acts as a hydrogenation catalyst on the surface during the deposition mechanism (Kumar *et al.*, 1989). We propose that the precursor formulation is the decisive factor for controlled and highly dispersed Pt dot concentration on the support.

Experimental

For support particle production alkoxide tetraethylorthosilicate (Si(OC₂H₅)₄, TEOS) is evaporated at 60 °C and mixed with oxygen and nitrogen. Subsequently spherical SiO₂ nanoparticles with mean particle size of about 80 nm are generated by homogeneous nucleation, followed by sintering at 1500 °C. Commercially available Methylcyclopentadienyl-(trimethyl)Platinum(IV) (MeCpPtMe₃) or three synthesized organometallic precursors are sublimated at 100 °C. Directly in the aerosol, Pt is deposited on SiO₂ support particle surface in CVD reactor at 380 °C and atmospheric pressure. Afterwards nanoparticles are characterized by SMPS measurement and TEM images.

Results and discussion

According to TEM images (figure 2) the difference between Pt particles deposited on SiO₂ using the

commercial precursor MeCpPtMe₃ and using newly synthesized precursors are significant. In contrast to the particles produced by the commercial precursor, the Pt dots are homogeneously dispersed with narrow size distributions between 2 and 4 nm. Our observations show that the suitable stability of the new precursors under vaporization and the adequate decomposition under CVD conditions play an important role in the synthesis of these well-structured Pt catalysts.

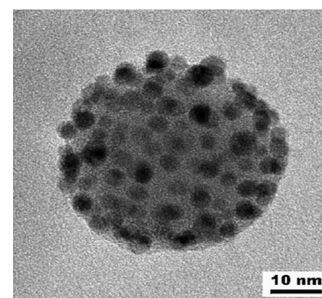


Figure 1: TEM image of Pd deposited on SiO₂.

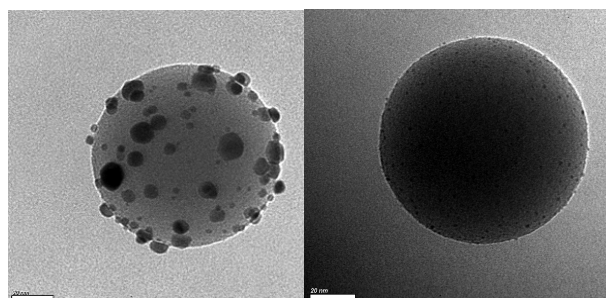


Figure 2: TEM image of Pt deposited on SiO₂ using commercial MeCpPtMe₃ (left) and using newly synthesized precursor (right).

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References

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