Specific detection of palladium nanoparticles in presence of a SiO_2 background aerosol

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Introduction

The on-line discrimination of engineered nanoparticles from the background aerosol of the workplace still remains a challenge. In a recent publication (Neubauer, 2011) we introduced a new measurement technique based on catalysis for the material-specific detection of nanoparticles with a high sensitivity. We now present first results with regard to a real-time discrimination of catalytically active nanoparticles from a non-active background aerosol.

Experimental

Palladium nanoparticles both directly after their production by spark discharge and after mixing them with SiO_2 background particles were sampled onto glass fibre filters for a fixed time interval. Afterwards they were exposed to gaseous reaction educts which initiate the catalytic reaction. The hydrogenation of ethene was chosen as a specific catalytic test reaction for the detection of palladium. The conversion of ethene to ethane due to the catalytic activity of the palladium nanoparticles is measured online by infrared spectroscopy. Both the palladium and the background particles as well as their mixture were characterized by an electrical mobility spectrometer and by electron microscopy. The specific surface area of the catalytically active palladium nanoparticles was determined by nitrogen BET.

Results

Electron microscopy analysis resulted in a median primary particle size of 3.2 nm for the palladium nanoparticles. They are arranged in agglomerates with a mode of the mobility equivalent diameter of 74 nm. The SiO_2 background particles also form agglomerates ($x_{mob,mod}$ 163 nm) of primary particles with a median size of 48 nm. The nitrogen BET analysis of the palladium nanoparticles gave a specific surface area of 87 g/m^2.

The catalytic experiments showed a proportional dependence of the catalytic activity of the pure palladium nanoparticles on their mass. After the addition of the background aerosol the smaller palladium agglomerates are attached to the SiO_2 particles due to coagulation (cf. Figure 1) and disappear from the particle size distribution. Nevertheless, it was possible to detect them via their catalytic behaviour – even in the attached state.

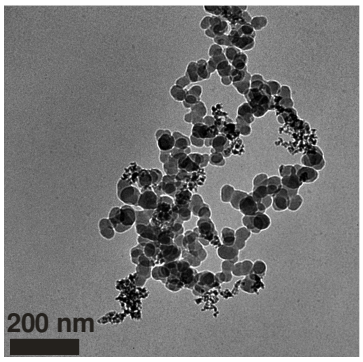

Figure 1: Palladium agglomerates attached to a background agglomerate of SiO_2

Conclusion

The presented measurement technique enables the detection and quantification of palladium nanoparticles based on their catalytic activity. Besides, the method is suitable for a discrimination of catalytically active particles from a non-active background aerosol in (quasi) real-time.

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