

# (Quasi) Real-time detection of catalytically active nanoparticles in presence of a background aerosol

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## Introduction

Workers involved in the production or handling of engineered nanoparticles are likely to be at a high exposure risk. The isolation of this additional contribution to the total background particle concentration at the workplace still remains a challenge. Especially small particles can quickly attach to the background aerosol of the workplace due to coagulation (Seipenbusch, 2008). Because of the resulting disappearance in the size distribution, the on-line measurement devices currently used during exposure studies are not capable to discriminate them from the background particles of the workplace. 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 further details of this method, especially with regard to the discrimination of catalytically active nanoparticles from a non-active background aerosol.

## Experimental

To investigate the specificity of our method, the detection of palladium nanoparticles both directly after their production by spark discharge and after mixing them with SiO<sub>2</sub> background particles was studied. At first the particles were sampled onto a filter 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.

In addition, 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<sub>2</sub> 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<sup>2</sup>.

The catalytic experiments showed a proportional dependence of the catalytic activity of the pure palladium nanoparticles on their BET surface. In addition, the influence of the temperature and the contact time between the reaction gases and the particles were studied in order to find ideal conditions for the substance-specific detection of palladium.

After the addition of the background aerosol, the smaller palladium agglomerates attach to the SiO<sub>2</sub> 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.

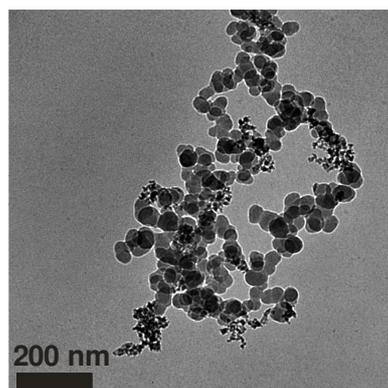


Figure 1: Palladium agglomerates attached to a background agglomerate of SiO<sub>2</sub>

## 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. The used setup is already a compact and portable version which allows measurements directly at workplaces.

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Seipenbusch M, Binder A and Kasper G (2008) *Ann. Occup. Hyg.* 52(8)

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