A substance-specific technique for the detection of nanoparticles in workplace air

N. Neubauer[1], F. Weis[1], M. Seipenbusch[1] and G. Kasper[1]

[1] Institute for Mechanical Process Engineering and Mechanics,
Karlsruhe Institute of Technology (KIT), Straße am Forum 8, 76131 Karlsruhe, Germany

Keywords: specific detection, engineered nanoparticles, catalysis, workplace air

1 Introduction

Engineered nanoparticles (ENP) in the workplace air are normally mixed with background particles. However, available measurement devices are not capable of distinguishing between a target ENP and a background aerosol (Kuhlbusch et al., 2009; Murashov et al., 2009). Furthermore, the chemical composition of ENP can only be analyzed by off-line techniques. Therefore, new, substance-specific on-line analytical methods are required to identify target ENP from background particles.

Catalysis offers a good potential for the material-specific detection of catalytically active nanoparticles as well as for the discrimination of trace amounts of airborne ENP against an inactive background aerosol. We therefore investigated the applicability of catalysis for the specific measurement of ENP, both in their airborne state and after deposition from the aerosol onto a substrate. The experiments were conducted with catalytically active nanoparticles generated by spark discharge. These nanoaerosols were exposed for a defined time to gaseous educts. The reaction products were detected by infrared spectroscopy. Based on the experimental results detection limits for several ENP were calculated.

2 Detection techniques

Catalysis on airborne nanoparticles

The method of catalysis on gasborne nanoparticles offers the possibility to determine the catalytic activity of nanoparticles on very short time scales in the order of seconds to minutes. It is therefore a true on-line technique for measurements of the catalytic activity of ENP. In addition, the method requires only small catalyst mass concentrations in the order of ng/cm^3. Another advantage is the avoidance of contaminations like in off-line methods.

Catalysis on deposited nanoparticles

By sampling the particles on a filter prior to the catalytic reaction, it is possible to accumulate small amounts of catalyst material in the order of micrograms. This approach is therefore better suited for ENP aerosols at low concentrations, for slow catalytic reactions and/or less active nanoparticles. The catalytic activity is nevertheless determined on-line, as educt gases are added directly to the filter. Thereby filter handling and potential contaminations of the sample by exposure to ambient air are avoided.

3 Results

Direct measurements on airborne particles showed that this on-line approach is suitable for the detection of very active ENP aerosols in high concentrations, such as platinum or nickel. The detection of platinum is even possible with a room temperature reaction, where as the other catalysts require temperatures between about 200ºC and 450ºC. The filter based technique shows a good potential for the detection of less concentrated or less active ENP aerosols like iron oxide (Fe_2O_3) based on their catalytic activity. In addition, the filter method can be considered a true real-time method for the detection of palladium and a near-real-time technique for catalysts with similar activities as platinum or nickel. Calculated detection limits indicate that concentrations in the range of 1 ng/cm^3 can be detected in a few seconds for palladium, in a few minutes for platinum or nickel, and in about 30 min for iron oxide.

4 Conclusion

A new, substance-specific technique for the detection of airborne nanoparticles via their catalytic activity was presented. In our experiments we could demonstrate that very small amounts of catalytically active nanoparticles like palladium, platinum, nickel or iron oxide (Fe_2O_3) can be very rapidly detected on the basis of their catalytic activity.

Acknowledgement

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 211464-2 (Nanodevice).

Literature

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