N° 2 – CHARACTERIZATION, DETECTION AND MONITORING

SPECIFIC DETECTION OF ENGINEERED NANOPARTICLES USING CATALYSIS

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The potential health hazard for workers involved in production or handling of engineered nanoparticles (ENP) is not yet sufficiently understood. In addition the methods currently used in monitoring nanoparticles in workplace air are not capable to distinguish a target ENP from background particles. Therefore a great uncertainty arises from the possible adhesion of ENP to these background particles and the resulting disappearance in the size distribution. Catalysis offers great potential with regard to the discrimination of ENP from a background aerosol without any catalytic activity. In this work the applicability of catalysis for the detection of a specific ENP is investigated. Two different approaches, catalysis on airborne nanoparticles and catalysis on deposited nanoparticles, are studied. Both methods are based on specific model reactions selected according to model ENP materials.

Catalyst preparation
As catalysts for the catalytic reactions nanoparticles are produced in a spark discharge generator using electrodes of the desired material (nickel, platinum or iron of high purity). The carrier gas is nitrogen. By using an Ar/O_2-mixture as carrier gas it is possible to oxidize the generated iron particles to iron oxide (Fe_2O_3).

Catalysis on airborne nanoparticles
Catalysis on airborne nanoparticles - also known as aerosol catalysis - offers the possibility to determine the catalytic activity of nanoparticles on short time scales. For this reason this concept enables an online measurement of the catalytic activity of ENP.
After production of the catalytically active nanoparticles the educt gases are added to the aerosol before entering the heated reactor initiating the catalytic reaction. The amount of gas phase products of the reaction is monitored online with a Fourier Transformation Infrared Spectrometer (FTIR).
Experiments show that the approach of aerosol catalysis is suitable for the specific detection of very active ENP aerosols - e. g. platinum or nickel - at high concentrations of approximately 10^7 #/cm^3.

Catalysis on deposited nanoparticles
The method of catalysis on deposited nanoparticles allows the accumulation of material and thus is potentially better suited for low concentrated ENP aerosols or slow catalytic reactions. At this approach the nanoparticles are first sampled on a filter after production. In a second step the filter is heated and the reaction gases are added so that the catalytic reaction can start. The gas phase products are also measured by FTIR. In experiments with the CO-Oxidation over deposited Fe_2O_3 nanoparticles sufficient amounts of the reaction product CO is produced for a detection by FTIR. Thus, using catalysis the ENP Fe_2O_3 can be detected.
Based on the experimental results detection limits and with these the sensitivities for the detection by catalysis were investigated. The calculations indicate that only a few µg or even ng of ENP material are required for the detection of ENP based on their catalytic activity.

Conclusion
The application of catalysis for the specific detection of nanoparticles was investigated. The results show that catalysis enables the detection of ENP, e.g. platinum, nickel, iron oxide. The required minute amounts of ENP material (in the µg- or even ng-range) assures the good potential of catalysis for the detection of a specific ENP with a high sensitivity.

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