Aerosol nanoparticles captured into colloids by using an electrospray cloud as a filter

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Engineered nanoparticles (ENPs) have remarkable size-dependent properties which make them great candidates for applications in novel materials for catalysis, electronics, optical devices, as well as in the pharmaceutical industry (e.g. drug delivery carriers).

An elegant way for producing well-defined ENPs is by using various aerosol-based techniques (e.g., spark discharge, flame synthesis, etc.). However, many applications require the nanoparticles to be embedded in specific liquids. An intermediate step is therefore required for getting the ENPs from a gaseous to a liquid medium.

Single size colloids, synthesized mainly by chemical reductions, have been extensively studied. However, these reduction methodologies often leave appreciable amounts of residual ions in solution. For applications where these residual ions are counterproductive, a different methodology must be used to ensure a predetermined purity in the single size colloid.

This work introduces a way of capturing well-defined aerosol particles in liquid solvents using the electrospray (ES) technique. Although we demonstrate the performance of the system for metal particles generated from the spark discharge, and use an ethanol/water mixture as a solvent, the technique can be used for ENPs produced from any aerosol-based technique and with a wide range of solvents.

Methodology

Metal nanoparticles having diameters from 1 to 100 nm are produced in N_2 with a spark-discharge aerosol generator (Schwyn et al., 1988, Tabrizi et al., 2008). The particles are then passed through a Differential Mobility Analyzer (DMA) to select particles of a very narrow mobility range. The mono-dispersed aerosol coming out of the DMA, are then neutralized and passed through the ES filter. The highly charged liquid micro-droplets in the ES filter, that capture the ENPs, are collected in a reservoir.

Preliminary results

In order to prove that indeed particles in this size range (1-100 nm) can be captured with an ES cloud, we sent a neutralized poly-dispersed gold aerosol (1-100 nm) directly to the ES filter (ethanol droplets) and measured its capture efficiency (Figure 1.) by counting the nanoparticles that survive the ES cloud with an scanning mobility particle sizer (SMPS; see Figure 2.). Positive filter efficiencies were measured throughout the full nanoparticle size range.

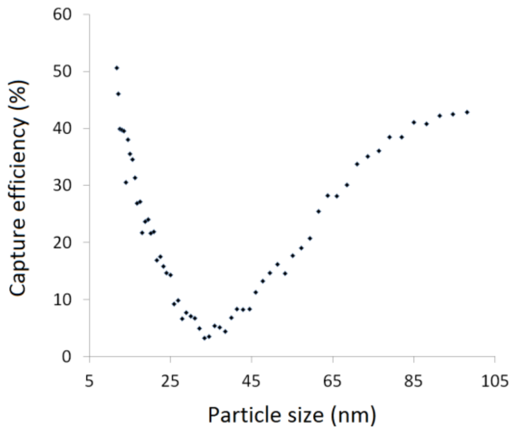

Figure 1. Capturing efficiency of aerosol nanoparticles by an ES filter.

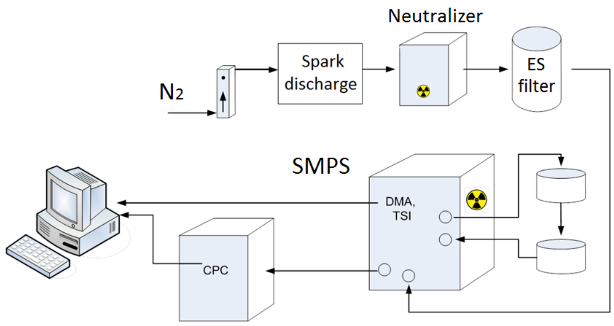

Figure 2. Experimental set-up used to measure the capturing efficiency shown in figure 1.

Conclusions

Gas phase metal nanoparticles within the size range of 1-100 nm can be captured into a colloidal suspension by using an ES filter. The methodology described above could be used to produce well-defined single size colloids with virtually no ion impurities.

Further work has to be made to maximize the capture efficiency of the filter via the ES parameters (e.g. droplet charge, number of droplets, etc).

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