

# Aerosol based tandem mass-mobility analysis of colloidal suspensions

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The use of nanoparticles in industrial and medical applications has increased the need for instrumentation and methods to study their physical properties (size, shape, concentration, density). Specifically, researchers are interested in the particle size and density distributions of nanoparticles prepared in liquid suspensions (colloids). To utilize high precision aerosol based measurement methods, these colloidal samples must first be aerosolized. Several established techniques have been employed to aerosolize colloidal particles; however, these methods are sensitive to sample purity, require extensive method development, are unstable over long periods, or lack effective data inversion routines to calculate the true mass and size distributions. This work presents a method for analysing nanoparticle size and mass distributions which couples a newly developed colloidal nanoparticle aerosolization device (Jeon *et al* 2016) to an existing aerosol mass analyser and a low-cost, portable aerosol electrical mobility analyser. Additionally, we present the application of a recently developed data inversion algorithm (Rawat *et al* 2016) to this system.

Colloidal suspensions of nanoparticles will often contain dissolved non-volatile residue (DNVR) composed of surfactants and or salts which are required for stabilization and or are by-products of the manufacturing process. Upon aerosolization of the colloid, the DNVR may substantially alter the size and or properties of the aerosolized colloid particles (by precipitation onto the particle surface) as well as form aerosol particles composed entirely of precipitated NVR (which are indistinguishable from the colloidal particles). Previous studies have utilized electrospray nebulization (Kaufman 1998) to generate relatively small droplets which reduces the effect of precipitated residue on the analysis; however, electrospray nebulization often requires unique operation parameters for different materials and is often not stable for extended periods of time. For this work, a recently developed nanoparticle aerosolizer utilizing pneumatic nebulization was used to aerosolize colloidal mixtures for gas phase analysis.

Previous work using a similar pneumatic nebulization device coupled to a scanning mobility particle system has shown that pneumatic type engineered nebulization (which produces a peak droplet diameter near 100 nm, similar to commercially available electrospray devices) coupled with online sample dilution using ultrapure water is capable of aerosolizing samples with relatively high levels of dissolved NVR (~ 1 ppt) without altering the aerosolized colloid particle properties. For samples containing low levels of DNVR (< ~10 ppm), we are able to accurately aerosolize samples

without using online UPW as a dilutant. In addition to eliminating online UPW dilution, a low cost particle size spectrometer replaced the high resolution system used in the previous studies.

In addition to the size distribution measurements, we show that this lower cost, simplified system can be coupled to an Aerosol Particle Mass (APM) analyser to obtain additional separation based on particle density. Figure 1 shows the results tandem Aerosolizer-APM-SMPS without online dilution and using the low cost, portable particle mobility size spectrometer. The figure shows that this system has the ability to separate particles of similar size and different densities.

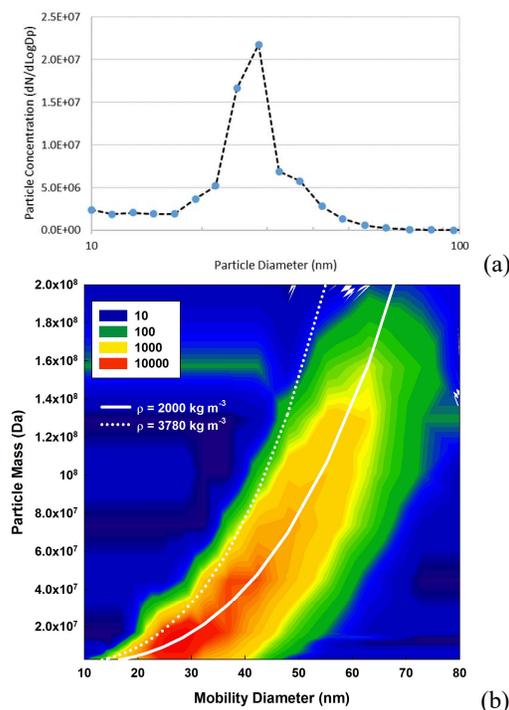


Figure 1. Diameter and Mass-Diameter distribution of a mixture of  $\text{TiO}_2$  and  $\text{SiO}_2$  colloid solutions. (a) with APM off and (b) with APM separation

The results show that for colloids with low levels of dissolved non-volatile residue, a simplified low cost system is able to effectively measure size and density values for the colloidal particles.

Jeon *et al* (2016) *Analyst* **141**(4), 1363-1375.

Rawat *et al* (2016) *Journal of Aerosol Science* **92**, 70-82.

Kaufman (1998) *Journal of Aerosol Science* **29**(5-6), 537-552.