Real-time aerosol monitoring of LFS produced silver nanoparticles with DENSMO

Paxton Juuti, Janne Haapanen, Juha Harra and Jyrki M. Mäkelä

Department of Physics, Aerosol Physics Laboratory, Tampere University of Technology, Tampere, 33720, Finland
Keywords: effective density, LFS, silver nanoparticles
Presenting author email: paxton.juuti@tut.fi

Large scale production of nanoparticles is increasing. However, the processes are seldom monitored real-time during the actual production. Batch sampling is more tedious, and it can lead to huge losses in time and bulk material. One widely used approach for nanoparticle production via aerosol routes is to utilize flame based methods. For this study, the Liquid Flame Spray (LFS; Tikkanen et al., 1997) was used to produce spherical ∼15 nm silver nanoparticles. The production of these particles was monitored with DENSMO (Juuti et al., 2015), recently developed monitoring device, which measures aerodynamic and mobility median diameters, and thus the effective density. All of these quantities are measured at one second time resolution. For real-time comparison, Engine Exhaust Particle Sizer (EEPS, TSI Inc.) and Electrical Low Pressure Impactor (ELPI+, Dekati Ltd.) were used to measure mobility and aerodynamic number size distributions, respectively.

Here we present results from a single production run from LFS, which consists of two production periods, separated by a refill period. The aim was to identify how stable the production is, and what transitions take place at the start and the end of the liquid feed of LFS.

Figure 1 shows the measurement setup, where silver nanoparticles are produced by LFS, diluted and then characterized. The liquid precursor is silver nitrate dissolved in mixture of ethyl alcohol and water. Figure 2 shows aerodynamic (d_a) and mobility (d_b) median diameter measurement results. Aerodynamic median diameters are from DENSMO and ELPI+ and mobility median diameters are from DENSMO and EEPS. The correlation between these measurements is excellent, which is to be expected because all of the requirements of operation DENSMO are fullfilled. From this data, the starts and the ends of production phases can easily be determined.

The measured values for aerodynamic and mobility diameters were then used to calculate the effective density values. These values are presented in Figure 3. Similarly to the previous figures, the separate periods are clearly distinguishable and the correlation is well within the ±25 % uncertainty of DENSMO. Conversely to the median diameters, the effective density results show clearly a settling trend, most likely due to the introduction of high temperature flame to the ambient conditions. After the temperature has settled, the second period reaches stable conditions faster.

Based on the presented results, DENSMO was shown to be capable of replacing two standalone instruments, ELPI and EEPS, in monitoring a flame synthesis process in real-time. Time dependent behaviour of LFS synthesis was also characterized, with both DENSMO and reference instruments.

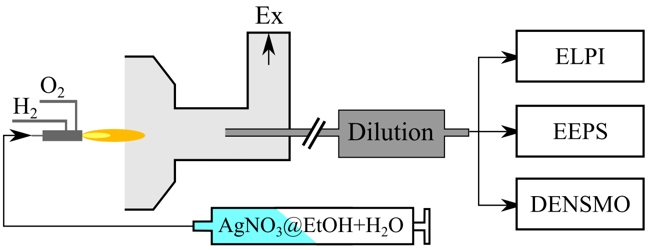

Figure 1. Measurement setup of silver particle generation and characterization.

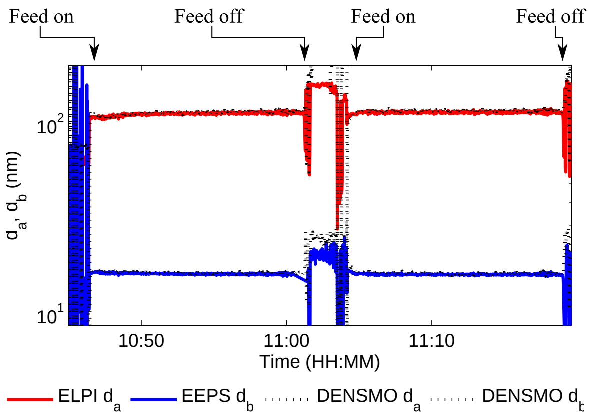

Figure 2. Median diameter measurement results from ELPI, EEPS and DENSMO.

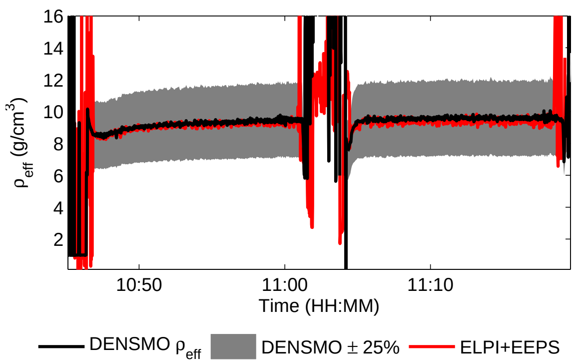

Figure 3. Effective density from DENSMO (with ±25% uncertainty) compared against the value calculated from the medians measured by ELPI and EEPS .

Tikkanen, J., Gross, K. A., Berndit, C. C., Pitkänen, V., Keskinen, J., Raghu, S., Rajala, M., Karthikeyan, J. (1997) Characteristics of the liquid flame spray process. *Surf. Coat. Technol.* **90**, 210-216.

Juuti, P., Arffman, A., Rostedt, A., Harra, J., Mäkelä, J.M., Keskinen, J. (2015). Real-time effective density monitor (DENSMO) for aerosol nanoparticle production. *Aerosol Sci. Technol.*, Accepted.