Evaluation of Monodisperse Silver Particle Sintering Using a Tandem DMA Setup

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Apart from silver ultrafine particles being used in a broad variety of applications for years (Ankilov et al., 2002, Giechaskiel, et al., 2009, Wiedensohler, et al., 2017), sintering of silver particles has been of special interest to researchers (Ku, B. K., et al., 2006; Zihlmann, S., 2014; Tuch, T., 2016; Silva, E. Z., 2019). The work shown here is aimed at bringing more repeatability and usability to various fields of aerosol science which use sintered silver nanoparticles.

It has been shown that a very stable and reproducible silver particle generation is possible, achieving +- 1 % in GMD, and +- 1,25 % in total concentration while offering a usable size range of 2 – 200 nm (Berger, V. et al., 2023). This opened the possibility to extend these capabilities to other applications, e. g. calibration of automotive CPCs, PNCS, and PEMS. These applications pose more demanding requirements to the aerosol generation: As these systems use sections heated to 350 °C to remove volatile particles (as part of the so-called Volatile Particle Remover, VPR), it is essential that any particles used for calibration are thermally stable (Giechaskiel, B., 2018). It has been shown that sintering of metallic nanoparticles starts at temperatures well below the melting temperature of the respective material (Ku, B. K., et al., 2006). For silver, first sintering effects can be observed at temperatures around 100 °C. To confirm these effects and determine their magnitude for typical VPR systems, the authors present results for silver particles sintered in a heated tube (mimicking an Evaporation Tube, ET) and silver particles sintered in a catalytic stripper (CS). To minimize unwanted effects (especially agglomeration after sintering) and match conditions typically found during PEMS or VPR calibration, a tandem DMA setup is used. Additionally, this approach facilitates the analysis of results. A schematic of the experimental setup is depicted in Figure 1.

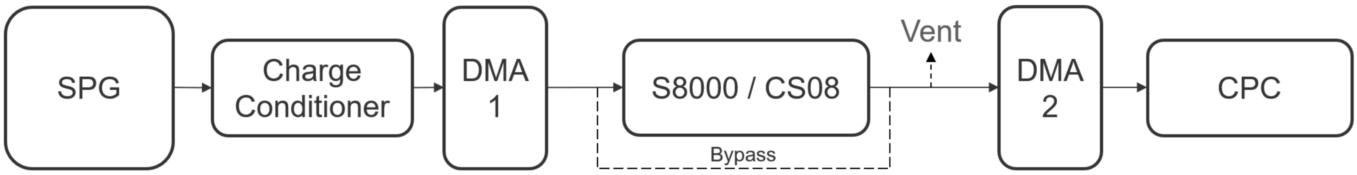

Figure 1 Experimental setup. Silver particles are generated in the Silver Particle Generator (SPG), charge conditioned and size-selected in DMA 1. Subsequent sintering takes place in a S8000 Sintering Stage, a CS08 Catalytic Stripper or is bypassed. DMA 2 and the CPC perform particle size distribution scans.

Sintering reduces the electrical mobility diameter of a particle (Ku, B. K., et al., 2006). This reduces the effective usable size range of the forementioned silver particle generator. To tackle this, the authors investigate methods to increase the particle size before sintering. As it has been shown that higher furnace temperatures lead to larger particles (Berger, V. et al., 2023), we show silver particle size distributions generated at 1150, 1200 and 1250 °C. Because agglomeration of particles yields larger particles, we show the effect of introducing a residence chamber in between the furnace and the sintering stage.

[1] Ankilov, A., et al., Atmospheric Research, **2002**, 62, 177-207.
[2] Berger, V., et al., Congrès Français sur les Aérosols, Paris, **2023**.
[3] Giechaskiel, B., Publications Office of the European Union, **2018**, EUR 29036 EN.
[4] Giechaskiel, B., et al., Aerosol Science and Technology, **2009**, 43:12, 1164-1173.
[5] Ku, B. K., et al., Journal of Aerosol Science, **2006**, 37, 452-470.
[6] Tuch, T., et al., Aerosol Science and Technology, **2016**, 50:4, 331-338.
[7] Wiedensohler, A., et al., Aerosol Science and Technology, **2017**, 52:2, 146-164.
[8] Zihlmann, S., et al., Journal of Aerosol Science, **2014**, 75, 81-93.