Optimizing the particle counting efficiency of the Grimm 5.412 CPC for airborne sub 4 nm particles and clusters

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In recent years, comprehensive efforts have been made to improve the detection efficiency of airborne aerosol particles down to sizes below 3nm. Differential Mobility Analysers (DMAs) combined with suitable condensation particle counters (CPCs) are the most common setups (DMPS, SMPS) for the detection and sizing of ultrafine airborne aerosol particles. Charging state and the chemical composition of the aerosol particles are especially important for the detection of the aerosols by CPCs. Accordingly, the precise characterization of the counting efficiency of the CPCs is required. (Iida et al. 2009, Kangasluoma et al. 2013)

The main goal for this work was to test the counting efficiency of the new butanol based Grimm 5.412 CPC. In a first step for the "standard" operating conditions and in a second step for "tuned" conditions to enhance the counting efficiency of the instrument in the size range below 4nm. For the experiments seed aerosols of three different compounds were used**:** silver (Ag), sodium chloride (NaCl) and tungsten oxide (WO_x).

A schematic of the experimental setup is shown in Figure 1. Ag and NaCl is generated in a tube furnace. WO_x particles are generated by the Grimm 7.860 tungsten oxide generator. A volume flow of 4.8 L/min transports the particles to an ^{241}Am aerosol charger. Subsequently, a DMA, optimized for the particle size range between 1 and 40 nm (NDMA, Steiner et al. 2010), selects a narrow mobility fraction of the aerosol (well defined mobility equivalent diameter). The classified particles are split in two equally long branches: one to the CPC and one to a custom-built Aerosol Faraday Cup Electrometer (FCE) used as reference instrument. Due to technical reasons, the flowrates to CPC and FCE had to be maintained at different levels (0.6 L/min for the CPC and 3.56 L/min for the FCE).

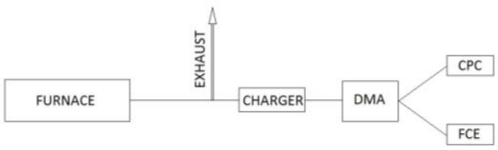

Figure 1.Schematic of the experimental setup

The counting efficiency of the CPC was calculated as the ratio of the measured particle number concentrations of the CPC and FCE. In the data analysis, a laminar diffusion deposition model (Gormley and Kennedy, 1949) accounts for the different losses along the lines, especially for small particles.

Figure 2 shows the particle counting efficiency of the Grimm 5.412 CPC at standard operating conditions (saturator temperature T_S = 36 °C, condenser temperature T_C = 10.1 °C) for NaCl, Ag and WO_x aerosols. The first experiments show that the particle cut-off diameters (D_{50}) match with the predicted D_{50} of > 4nm, showing a clear composition dependency: $D_{50(NaCl)}$ = 6.3nm, $D_{50(Ag)}$ = 4.4nm, $D_{50(WOx)}$ = 4.3 nm

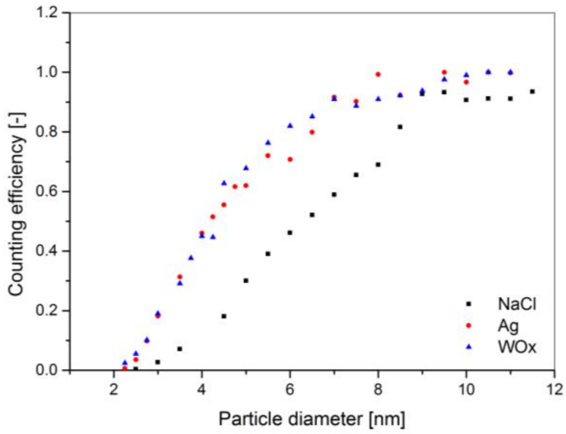

Figure 2. Particle counting efficiency of NaCl, Ag and WO_x of the GRIMM 5412 CPC at standard operating conditions

In the following we will present strategies, following the approach presented by Kangasluoma (2015) to enhance the counting efficiency of the Grimm 5.412 CPC to be used as detector for charged and neutral nanoparticles and molecular clusters.

Iida, K., Stolzenburg, M.R. and McMurry P.H. (2009) *Aerosol Sci. Technol., 43:81–96* .

Kangasluoma, J. et al (2013*) Aerosol Sci. Technol, 47:556–563*

Steiner, G. et al. (2010) *Aerosol Sci Technol 2010, 44, 308-315*

Gormley, P.G., and Kennedy, M. K. (1949) *Proc. R. Ir. Acad.* A52:163–169.

Kangasluoma, J. et al. (2015*) Aerosol Sci. Technol, 49:8, 674–681,*