Working-fluid dependent response of ultrafine Condensation Particle Counters to biogenic nanoparticles

A. Ojdanic, D. Stolzenburg, P. S. Bauer, P. M. Winkler

Faculty of Physics, University of Vienna, Vienna, 1090, Austria
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Presenting author email: andrea.ojdanic@univie.ac.at

For many decades airborne particle number concentrations have been measured using condensation particle counters (CPCs). These instruments are able to detect aerosols with diameters in the nanometer size range. CPCs are usually characterized by their counting efficiency, using inorganic particles for the determination of the cut-off. Improving the ability of the CPCs to detect particles in the sub-3nm diameter range is of crucial importance for numerous research projects investigating mechanisms of new particle formation, which are currently still poorly understood. As the cut-off diameter of the CPC depends on the seed material, the characterization of CPC response to biogenic nanoparticles is urgently needed.

In this study calibration measurements of two TSI CPCs using butanol (TSI3776) or water (TSI3788) as working fluid as well as an Airmodus Particle Size Magnifier (PSM) based on diethylene glycol (DEG) were performed. The experiments were carried out using biogenic particles from the oxidation of Beta-Caryophyllene (BCP) and commonly used silver particles for comparison. For the butanol operated CPCs two temperature settings regarding the saturator, condenser and laser optics were tested. The temperature settings for the PSM regarding the saturator and the growth tube were varied over a wide range.

The set-up for the CPC calibration is shown in Figure 1. In this experiment BCP vapour was generated from a flask of essential oil containing BCP, which was kept at constant temperature of 35°C. Ozone was generated from an electric discharge ozone generator or a UV lamp, aiming at concentrations of approximately 100ppb. The BCP was oxidized by the ozone in a glas flow-tube with a volume of 1.4l. The flow reactor is equipped with a flexible teflon flange that allows variation of the inlet length and hence the oxidation state in the flow-tube. The resulting oxidation products generated high particle concentrations in the range from 1nm to 30nm. After being charged by an Am^{241} charger the biogenic aerosol particles were led into a differential mobility analyzer (DMA) in order to select a monodisperse particle fraction.

Beside the CPC to record the aerosol concentration behind the DMA a Faraday Cup Electrometer (FCE) was also used simultaneuosly. The set-up for the calibration is similar to the one of Liu and Kim (2012). The CPC counting efficiency was finally calculated as the ratio of the CPC and electrometer particle number concentrations at each individual particle diameter.

A dependence of the cut-off diameter on the seed material is found for all tested particle counters but shows a different behaviour for the different working fluids of the counters. Furthermore we could demonstrate that their performance can be significantly improved by suitable temperature settings. These findings may be of significant importance for the detection of biogenic nanoparticles during new particle formation.

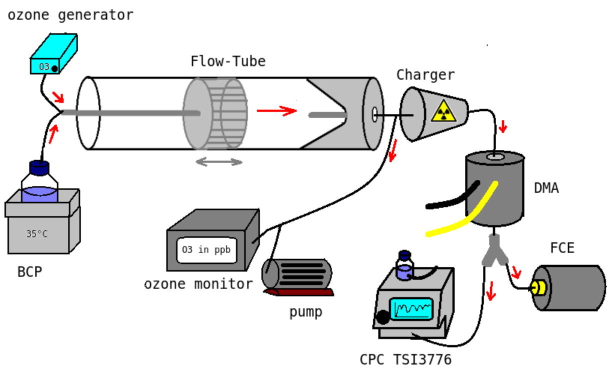

Figure 1. The experimental setup for the calibration of the CPC TSI3776 using BCP. The grey arrow shows the movement directions of the teflon flange of the flow-tube to vary the reaction time. The red arrows show the flow direction of gases and particles.

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