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Simultaneous use of a butanol and water CPC that are connected to a size classifier to obtain time resolved submicrometer particle size distributions in the vicinity of a mail distribution center

Two identical Palas® UF-CPCs (universal fluid condensation particle counters) were connected to a differential electrical mobility classifier (DEMC) in order to obtain continuous particle size distributions in the sub-micrometer size range. The time resolution of the system was three minutes and it was continuously operated for several days in a row.

The key feature of the used UF-CPC is that without changing the hardware different working fluids can be used. In the saturator, the working fluid is moved helically around the flow area of the aerosol leading to a homogeneous contact area. In order to account for the different viscosities and saturation vapor pressures of different working fluids, the temperatures of the saturator and the condenser and the speed with which the working fluid is circulated can be adjusted individually. As an additional benefit, the size distribution of the formed droplets is reported to the user thereby providing feedback on the condensation process. In summary, this UF-CPC provides a platform to analyze how different working fluids influence the condensation of airborne particles, e.g. of different material.

For the following measurements one UF-CPC used water, the other UF-CPC used butanol as working fluid and both were operated in parallel.

In the lab, different aerosol particles were generated, for example by a spark generator, by a rotating brush generator with Arizona fine test dust, and by an atomizer with salt and then analyzed with the setup described above. The results will be presented.

The setup was then applied to a mail distribution center where the high volume of cars and trucks causes a considerable amount of emissions during the day. The test period was two weeks including weekends where the SMPS ran continuously for 24 hours per day.

By using water and butanol simultaneously it was possible to conclude on hydrophilic and hydrophobic particles as part of the car exhaust particles and to study how these properties change during aging of the aerosol. The results of this measurement campaign will be presented for discussion.

SIMULTANEOUS USE OF A BUTANOL AND WATER CPC THAT ARE CONNECTED TO A SIZE CLASSIFIER TO OBTAIN TIME RESOLVED SUBMICROMETER PARTICLE SIZE DISTRIBUTIONS IN THE VICINITY OF A MAIL DISTRIBUTION CENTER

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Introduction

Typically airborne nanoparticles and often submicrometer particles are measured and counted by a condensation particle counter (CPC). In a CPC, the particles are enlarged via condensation, a process in which the supersaturated vapor of the working fluid transitions to form droplets around the particles that act as condensation nuclei. These resulting droplets are large enough to be detected optically.

Due to its patented design of providing the working fluid the Palas® universal fluid CPC (UF-CPC) is the first CPC available where the user can change the working fluid himself. To account for the different viscosities and saturation vapor pressures of different working fluids, the temperatures of the saturator and the condenser and the speed with which the working fluid is circulated can be adjusted individually. As an additional benefit, the size distribution of the formed droplets is reported to the user thereby providing feedback on the condensation process.

In summary, this UF-CPC provides a platform to analyze how different working fluids influence the condensation of airborne particles, e.g. of different material.

In this poster results of simultaneous measurements of the same type UF-CPC, one using butanol, the other using water as working fluid are presented. In the laboratory different particle generators were used to disperse different types of material.

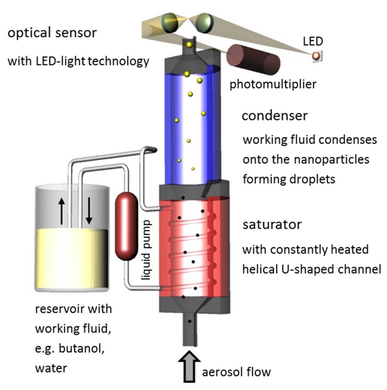
In the rotating brush generator (RBG) the powder (SAE Fine) is transported onto a rotating brush at a precisely controlled feed rate. An adjustable volume flow streams over the tightly woven precision brush and pulls the particles out of the brush, dispersing them in the process.

The AGK is used to generate test aerosols from salt in the range from about 5 nm to 15 µm. A specially developed nozzle from Palas® makes it possible to atomize salt solutions with a high level of dosing constancy while preventing salt crystals from crystallizing at the nozzle exit.

Palas® developed for the PLG a nozzle based on the Laskin principle to provide droplet aerosols of fluids that differ in viscosity, e.g. H_2O, DEHS, motor oils, white oil etc. Due to its reliable and reproducible performance it is used worldwide in acceptance procedure measurements such as the testing of HEPA/ULPA filters.

Also presented are the first results from a field measurement campaign near a mail distribution center.

Equipment, principle of operation & characteristics

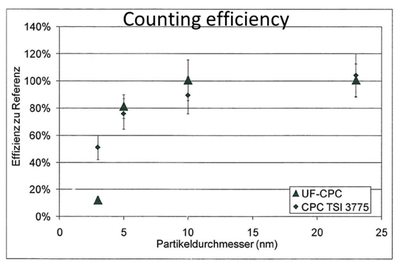


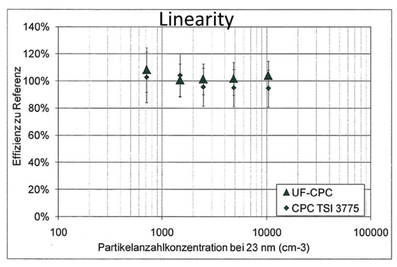
Principle of operation of the UF-CPC

UF-CPC

U-SMPS

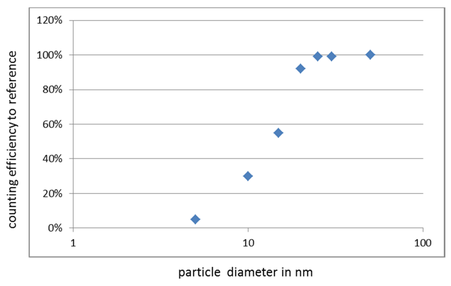
Counting efficiency and linearity (at 23 nm) with butanol as working fluid





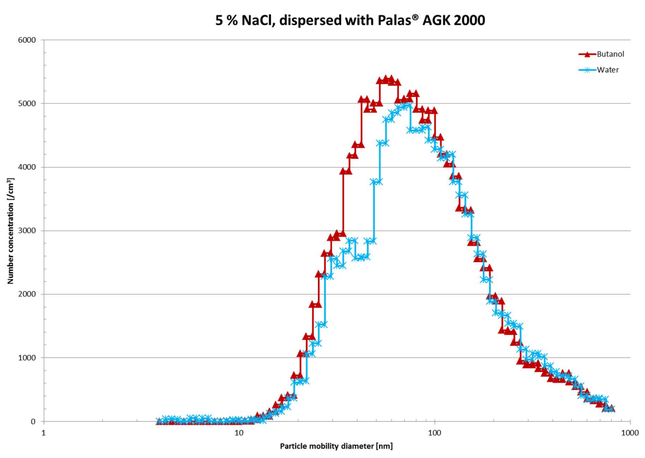
Settings: saturator temperature 44°C, condenser temperature 10°C, flow rate 0.5 l/min; [Source: METAS Report 235-10285]

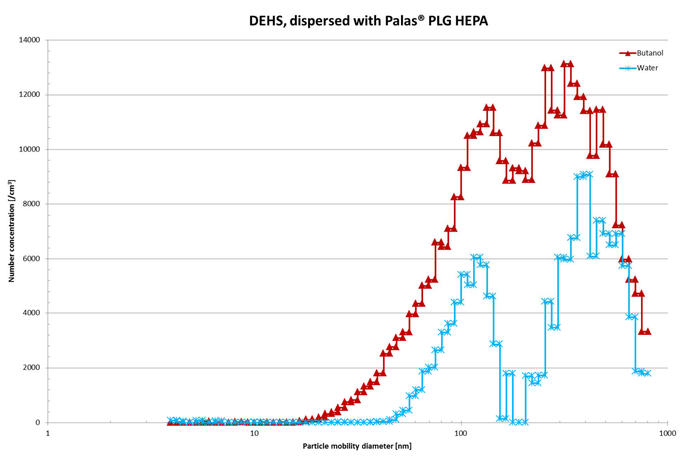
Counting efficiency measurement performed at Palas® with NaCl

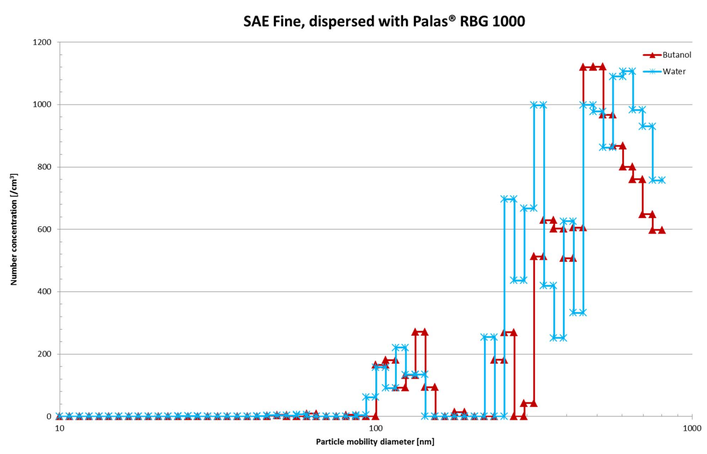


Settings: saturator temperature 70°C, condenser temperature 10°C, flow rate 0.5 l/min
reference: UF-CPC with butanol as working fluid

Laboratory measurements with different materials

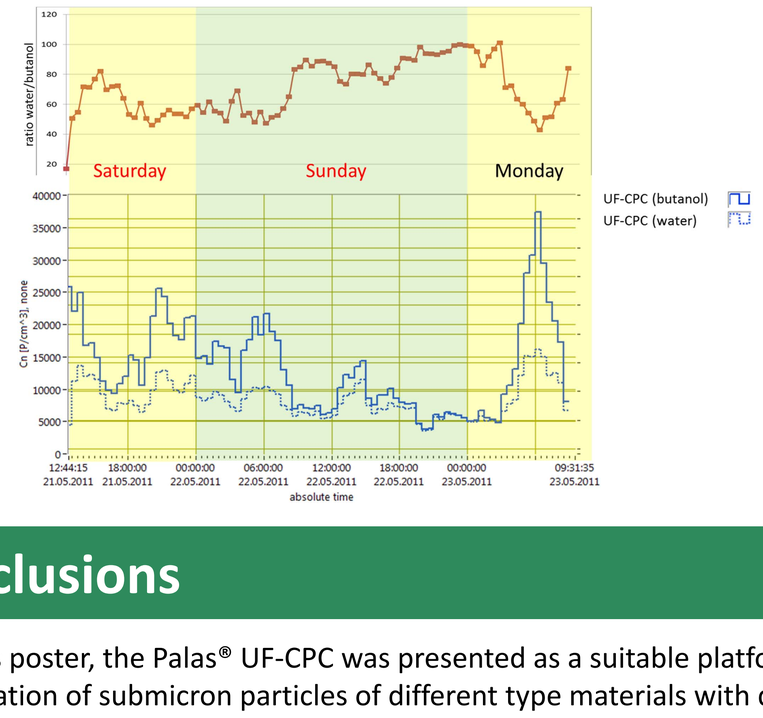






Field measurement near a mail distribution center

Location: Mail distribution center in an industrial area, also in the vicinity (500 m) of a major highway



Future work & conclusions

Future work:

- Continued laboratory measurements with other materials, e.g. metal oxides, soot, printer emissions…
- Testing of more working fluid alternatives
- Field measurements with continuous size resolved data and different working fluids
- Research: Material dependent condensation behavior (as started by KIT, Karlsruhe)

With this poster, the Palas® UF-CPC was presented as a suitable platform to analyze the condensation of submicron particles of different type materials with different working fluids.

It features:

- a unique, patented way of providing the working fluid (US 7, 543, 803 B2, DE 10 2005 001 992 A1)
- additional information by reporting the size distribution of the formed condensation droplets (not shown)
- single particle counting up to 1,000,000 particles/cm^3 due to an exchangeable optical sensor module

Also presented were first data from a field measurement campaign near a mail distribution center.