DESIGN CRITERIA AND EARLY-STAGE DEVELOPMENT OF THE NEXT GENERATION OF BUTANOL-CPC's

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Introduction

- Particle number concentration and size distribution is an established parameter in understanding emissions and immissions with increasing importance.
- The **Reference method** for counting nanoparticles in aerosols is the Condensation Particle Counter (CPC).
- The CEN/TS 16976 guideline harmonizes the measurement of ultrafine particles in the atmosphere for regulatory purposes.
- UN-ECE Regulation R83 harmonizes the measurement of ultrafine particles in the emissions of light duty vehicles for type approval.
- Specialized CPCs have been developed to cover a wide range of requirements for the various regulated or non-regulated applications.
- The **new Butanol-CPC series** (TSI Inc., Shoreview, USA) is an update to the family of instruments that provide real-time, reference aerosol measurements.

Operational Principle and Technology

- Core measurement technology inside the CPCs is based on the well-proven model 377x series (TSI Inc.; Hermann et al. 2007).
- A laminar flow transports aerosol through a serial configuration of heated saturator, cooled condenser and heated optics.
- Alcohol vapor is introduced to the aerosol in the saturator by diffusion and condensed on the nanoparticles in the condenser by supersaturation. Particles present in the aerosol stream serve as condensation nuclei. Those that are larger than a threshold diameter grow quickly into larger droplets and pass through an optical detector where they are counted individually.
- The threshold diameter, the minimum particle size capable of acting as a condensation nucleus, is called the Kelvin diameter and is depending on the supersaturation ratio, the alcohol properties and temperature.
- Butanol is the most commonly used alcohol in CPCs. Diethylene Glycol (DEG) has been used to more efficiently activate sub-2nm particles (Jiang et al. 2011).
- Internal capillary flow split and sheath flow design are utilized where very sharp counting efficiency curves are beneficial.
- Combining a CPC with nanoparticle sizing by electrical mobility results in fast and traceable (ISO 15900) measurements of nanoparticle size distributions.

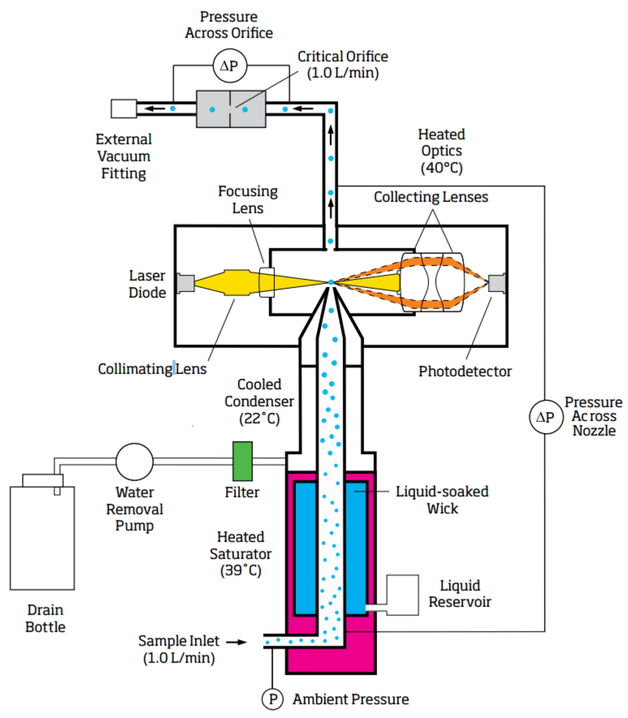
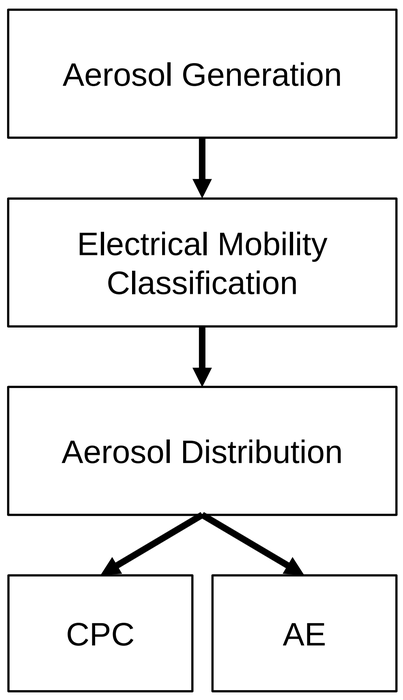


Fig. 1: CPC Operation Schematic.

Performance Testing of CPCs

- The test setup for determining performance of counters consists of
  - Aerosol generation, typically Electrospray, Atomizer or tube furnace combined with a Electrostatic Classifier.
  - Aerosol distribution with equal flow split, dilution air feed and mixer.
  - A reference instrument, typically an Aerosol Electrometer or CPC.
  - The test subject.
- Aerosol material for the test is often salt, sucrose, silver or oil in the nanometer range.
- The performance is at least evaluated for
  - Counting efficiency depending on particle size
  - Concentration linearity across operational range.
  - Response Time



Characterization of Counting Efficiency

- Preliminary test results with sucrose aerosol suggest that the counting efficiency (50%) of the new standard CPC succeeding the 3772 model, shifts from 10 nm to ~7 nm.
- This shift is beneficial for SMPS measurements using a Long-DMA as the D90% moves closer to the lower size limit of the DMA.

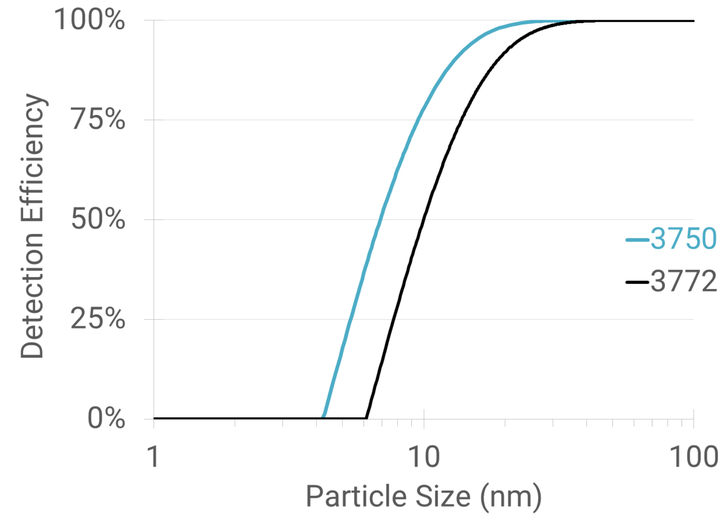


Fig. 2: Preliminary counting efficiency of the 3772-successor compared to the 3772.

Conclusions

- A set of 4 new Butanol-CPC is in development.
- Design criteria for CPCs include counting efficiency, concentration linearity, aerosol chemistry effects, response time, signal quality control features such as pulse height monitoring, and data storage and remote access.
- Characterization of the 1st prototype has started and initial results have been presented.
- As each CPC is also used as part of SMPS particle sizers, the corresponding characterization work is upcoming.

References

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