On the temperature dependence of heterogeneous nucleation of n-butanol vapor on silver and sodium chloride nanoparticles

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Commercial Condensation Particle Counters (CPCs) are mainly used to measure the number concentration of airborne particles (McMurry 2000). Most ultrafine continuous flow CPCs use n-butanol as working fluid and have typical lower particle detection limits in the range between 2.5 and 10 nm (Stolzenburg, McMurry 1991). Given the fact that butanol CPCs are operated at fixed temperatures, the performance towards the detection of even smaller particles may be optimized by choosing appropriate temperature settings.

Until now the temperature dependence of heterogeneous nucleation of n-butanol vapor on nanoparticles in a size-range down to 2.5 nm was not investigated. A topic, however, that is worth examining since it gives information on the saturation ratio which is needed to activate particles in this size range. Results of earlier experiments with water vapor on silver particles have shown a theoretically unpredicted maximum in the onset saturation ratio as a function of temperature (Kupc et. al. 2013). Further studies on the nucleation of n-propanol on sodium chloride particles in the temperature range from 262K to 287K indicate a reversed trend compared to the Kelvin equation (Schobesberger et. al. 2010). Due to the close chemical similarity of n-propanol and n-butanol, and the common use of butanol as a working fluid in commercial CPCs, the temperature dependence of heterogeneous nucleation of n-butanol on Ag and NaCl particles is investigated in this study.

To this end, measurements with the Size Analyzing Nuclei Counter (SANC) (Wagner et. al. 2003) were performed. A schematic diagram showing the experimental setup is illustrated in figure 1. We performed heterogeneous nucleation experiments of n-butanol vapor on silver and sodium chloride particles at various sizes and nucleation temperatures. By varying the chamber and humidifier temperature and the pressure drop in the expansion chamber, different nucleation conditions were analysed. As a result, heterogeneous nucleation of n-butanol vapor on NaCl and Ag aerosol particles shows different behaviour depending on the nucleation temperature. This finding is of immediate relevance for nanoparticle detection in CPCs and raises questions on the fundamental mechanisms leading to this behaviour.

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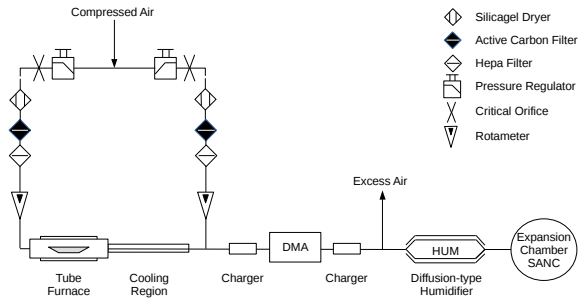

Figure 1. Schematic diagram for the experimental setup.

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