Measurement of evaporation rates of atmospheric nanoparticles

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Atmosphereic organic aerosol (OA) is a complex mixture of thousands of individual organic compounds (Hildemann et al., 1991; Fraser et al., 1997, 1998; Goldstein et al., 2008). Large fractions of OA consist of organic compounds that are difficult to separate by gas chromatography (Schauer et al., 1996), and the majority of the OA consists of highly oxidized organic molecules. A critical determinant of whether an organic compound is found in OA (as opposed to the gas phase) is its saturation vapor pressure (often referred to as volatility). An accurate understanding of OA volatility is therefore important to properly predict the chemistry and phase partitioning of both natural and anthropogenic OA species, and to properly interpret OA measurements.

The current study was undertaken to extend the existing database of vapor pressures of semivolatile organic compounds in the atmosphere. The Tandem Differential Mobility Analyzer (TDMA) technique using a long temperature-controlled laminar reactor between the two DMAs was evaluated. The vapor pressure and surface free energy of glutaric acid have been previously measured by Bilde and Pandis (2001). This system was therefore studied to evaluate our experimental system. The saturation mixing ratio of glutaric acid was found to be 9.5 ppb at 303 K using a surface free energy of 0.1 Jm^{-2} and an accomodation coefficient equal to 1. This is in close agreement to the results obtained by Bilde and Pandis (2001) of a saturation mixing ratio of 11.5 ppb.

The other pure component organic aerosols studied were squalane and docosane.The vapor pressure of squalane was measured after flash-vaporizing it in a smog chamber. The saturation mixing ratio of squalane was found to be 0.03 ppb at 323 K. Docosane 100 nm particles evaporated in less than 2 seconds (before reaching the first sampling port of the TDMA) at 306 K. This behavior is consistent with a saturation mixing ratio of more than 6 ppb at 306 K. However, the results obtained at 298 K are inconsistent with this behavior as the measured saturation mixing ratio was 0.2 ppb. A possible explanation is that docosane particles existed as liquid at higher temperatures and solid at lower temperatures in our experiments. When the docosane particles are injected into the chamber by flash vaporization they exist in the liquid state and do not form solid particles until they reach temperatures below their melting point. Therefore they could be present as supercooled drops at 306 K and solid particles at 298 K.
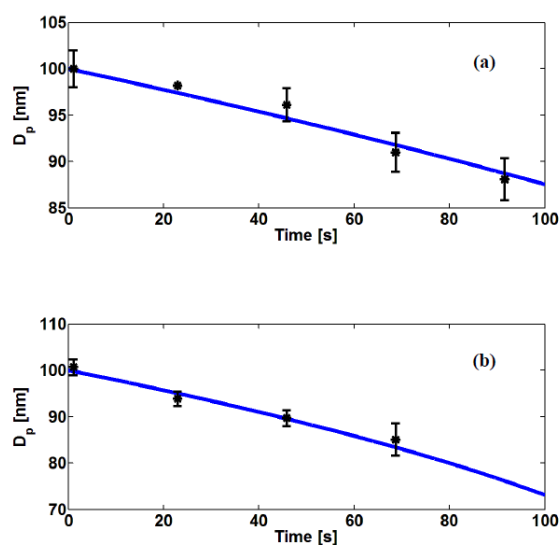

Figure 1. Measured (symbols) and predicted (line) diameters of squalane particles as a function of their evaporation time at (a) 313 K and (b) 323 K.

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