Determining glass transition temperatures of individual isoprene-derived secondary organic aerosol particles under varying relative humidity

Katherine Rebecca Anne Kolozsvari
Yao Xiao
Alison Fankhauser
JIN YAN
Madeline Cooke
Cara Waters
Rebecca Parham
N. Cazimir Armstrong
Zhenfa Zhang
Avram Gold
Jason Surratt
Andrew P Ault

Abstract

The ability of an atmospheric aerosol to take up water or to participate in heterogeneous reactions is highly influenced by its phase state – solid, semi-solid, or liquid. These changes in phase state can be predicted by glass transition temperature (T_g), as particles at temperatures below their T_g will show solid properties, while increasing the temperature above their T_g will allow for semi-solid and eventually liquid properties. Historically, measurements of the T_g of bulk materials have been studied in order to model the phase states of aerosols in the atmosphere; however, these methods only permit an estimation of aerosol T_g based on their bulk chemical composition. Determining the T_g of individual particles will allow for more accurate model predictions of aerosol phase state. Herein, we apply a recently developed method utilizing a nano-thermal analysis (nanoTA) module coupled to an atomic force microscope (AFM), to determine the T_g of individual secondary organic aerosol (SOA) particles generated from the reactive uptake of isoprene epoxydiol (IEPOX) onto acidic ammonium sulfate aerosol particles. NanoTA works by using a specialized AFM probe which can be heated while in contact with a particle of interest. As the temperature increases, the probe deflection will first increase due to thermal expansion of the particle followed by a

decrease at its melting temperature (T_m). The T_g of the particle can then be determined from T_m using the Boyer–Beaman rule. We compared the T_g of IEPOX-derived SOA particles generated at relative humidity (RH) of 30, 65, and 80%, and found that increasing RH from 30 to 80% led to a decrease in average T_g of 22 K, indicating less viscous particles at higher RH conditions. Our measurements with this technique will allow for more accurate representations of the phase state of aerosols in the atmosphere.