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Evaporation of aerosol particles upon heating in a transmission electron microscope

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Thermal property (e.g., evaporation temperature) of atmospheric aerosol particles is important to measure and classify their species using, for example, an aerosol mass spectrometer, a thermos denuder, and thermal method for elemental carbon/organic carbon (EC/OC). However, it is largely unknown about the thermal behavior of ambient aerosol particles especially organic aerosol particles and their mixture with inorganic materials. Therefore, evaporation temperatures of ambient aerosol particles with their compositions need to be determined.

This study uses a transmission electron microscope (TEM) and a heating holder, which can heat samples on TEM grids >1000 ℃ while observing their shapes. Thus, it is possible to observe particle evaporation process upon heating. The TEM chamber is in vacuum (~0.00001Pa) and lacks of oxygen. Thus, particle volumes on TEM grids changes through evaporation/sublimation at specific temperature. In general, an aerosol mass spectrometer uses 600 ℃ to vaporize aerosol particles, a thermos denuder uses 200-300 ℃ to remove volatile materials, and an EC/OC measurement use ~500 ℃ to distinguish OC and EC. Thus aerosol thermal properties were analyzed by heating from room temperature to 600 ℃.

This study mainly used ambient samples collected from biomass burning during Biomass Burn Observation Project (BBOP) in 2013. These samples were collected at North America using an aircraft. The results indicated that organic materials in biomass burning lost their volume while heating up to 600 ℃ but did not completely evaporate but remained residue, which is probably due to charring of organic matters. Especially, spherical brown carbon organic particles occurring in biomass burning (tar balls) left their volume by 30% at 600 ℃. The results imply that tar balls are difficult to measure their properties when assuming they are volatile materials even at 600 ℃.

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Keywords: aerosol, heating, organic matter, transmission electron microscopy, biomass burning