Effect of Droplet Evaporation on the Optical Properties of Wood Smoke Extracts and Nitrite/Phenol Solutions

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Abstract

Atmospheric organic aerosols that exhibit light absorption are referred to as brown carbon (BrC). The integration of BrC into climate models presents a significant challenge due to its complex composition, diverse sources, and aging processes. Cloud droplet evaporation, a process that may contribute to the formation and enhanced absorption of BrC, has been insufficiently explored using fast response optical instruments that monitor droplet and aerosol properties. In a laboratory study using evaporating aqueous droplets, we explore the impact of droplet evaporation on BrC formation and absorption enhancement, using both an aqueous catechol/nitrite reaction system and wood smoke water extracts. We observed absorbance enhancement in the catechol/nitrite reaction system through offline filter collection and UV-Visible spectrometry, noting the emergence of new absorption bands extending deep into the visible region. Variations in spectra across different relative humidity (RH) conditions indicated that 80% RH drying conditions led to maximum enhancement. Use of a 5-wavelength aethalometer that measured absorption in a rapid, online manner also revealed pronounced spectral shape change, especially at 50-60% RH. Aerosol mass spectrometer measurements showed higher N:C elemental ratios of the evaporated droplets at 50-60% RH than at 80% RH. Overall, these results were comparable for the wood smoke extract system, with absorption enhancement also occurring in the visible part of the spectrum after droplet evaporation. Our study illustrates the need for incorporating online instruments in aerosol studies of this type, as traditional filter collection may promote heterogeneous reactions on the filter post-collection. This work demonstrates the potential significance of cloud droplet evaporation in facilitating the formation of BrC.

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