Optical and physicochemical properties of brown carbon aerosol: light scattering, FTIR extinction spectroscopy, and hygroscopic growth

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It is suggested that atmospheric brown carbon (BrC) aerosol particles, with a variety of sources, can contribute significantly or even dominate the total aerosol absorption at certain wavelengths (Laskin et al., 2015). Aqueous reaction of ammonium sulfate with methylglyoxal is believed to be an important pathway for the formation of BrC and has been investigated previously (Sareen et al., 2010; Yang et al., 2009); nevertheless, knowledge of the optical and chemical properties of BrC aerosol formed by the reaction of ammonium sulfate with methylglyoxal is still very limited (Moise et al., 2015).

In this work we have investigated the light scattering properties at 532 and 402 nm of BrC particles formed by aqueous reaction of ammonium sulfate with methylglyoxal, and their optical extinction properties in the IR range. We also characterized BrC particles using Raman spectroscopy and explored their hygroscopicity using H-TDMA.

Our light scattering measurements at 532 and 402 nm suggest that there is no significant difference in the real parts of retrieved refractive indices between BrC and ammonium sulfate particles, as shown in Figure 1. However, optical absorption of aqueous BrC solutions is largely enhanced in 200-700 nm spectral range. This is due to the fact that our light scattering measurement is relatively insensitive to the change in optical absorption.

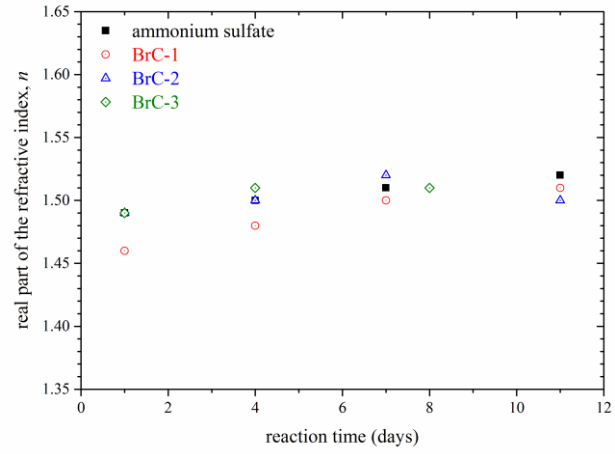

Figure 1. Retrieved real parts of the effective refractive indices (at the wavelength of 402 nm) of brown carbon aerosol particles as a function of reaction time.

In addition, our measurements of FTIR extinction properties find that ammonium sulfate and BrC aerosol particles have very similar refractive indices (both the real and imaginary parts) between 800 and 7000 cm^{-1}. This is supported by our Raman spectroscopy analysis which shows that compared to ammonium sulfate, the amount of organic materials contained by BrC particles is small.

We also measured the hygroscopic growth of ammonium sulfate and BrC particles. As shown in Figure 2, the deliquescence and efflorescence relative humidities and the hygroscopic growth factors at the same relative humidity are reduced for BrC particles, compared to ammonium sulfate.

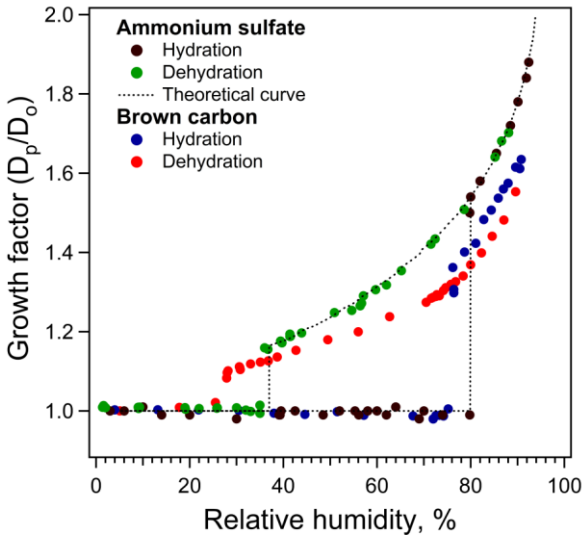

Figure 2. Hygroscopic growth factors of ammonium sulfate and brown carbon aerosol particles as a function of relative humidity during hydration and dehydration processes.

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