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Multi-Wavelength Measurement of Soot Optical Properties: Influence of Non-Absorbing Coatings

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Soot, a product of incomplete combustion, plays an important role in the earth's climate system through the absorption and scattering of solar radiation. Important in quantifying the direct radiative impacts of soot in climate models, and specifically of black carbon (BC), is the assumed BC refractive index and shape-dependent interaction of light with BC particles. The latter assumption carries significant uncertainty because BC particles are fractal-like, being agglomerates of smaller (20-40 nm) spherules, yet many optical models such as Mie theory in particular, typically assume a spherical particle morphology. It remains unclear under what conditions this is an acceptable assumption. To investigate the ability of various optical models to reproduce observed BC optical properties, we obtained measurements of light absorption, scattering and extinction coefficients and thus single scattering albedo (SSA) of size-resolved soot particles.

Measurements were made on denuded soot particles produced using both methane and ethylene as fuels. In addition, these soot particles were coated with dioctyl sebacate or sulfuric acid and the enhancement in the apparent mass absorption coefficient determined. Extinction and absorption were measured using a dual cavity ringdown photoacoustic spectrometer (CRD-PAS) at 405 nm and 532 nm. Scattering and extinction were measured using a CAPS PMssa single scattering albedo monitor (Aerodyne) at 630 nm. Soot particle mass was quantified using a centrifugal particle mass analyzer (CPMA, Cambustion), mobility size with a scanning mobility particle sizer (SMPS, TSI) and soot concentration with a CPC (Brechtel). The results will be interpreted in light of both Mie theory which assumes spherical and uniform particles and Rayleigh-Debye-Gans (RDG) theory, which assumes that the absorption properties of soot are dictated by the individual spherules. For denuded soot, effective refractive indices will be determined.