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Light Scattering and Extinction Measurements Combined with Laser-Induced Incandescence for the Real-Time Determination of Soot Mass Absorption Cross Section

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The aerosol albedometer was combined with laser-induced incandescence (LII) to achieve measurements of aerosol scattering, extinction coefficient, and black carbon (BC) mass concentration on dispersed aerosol. A colinear beam of both λ = 532 and 1064 nm was used for measurements. The green beam was used to perform cavity ring-down spectroscopy (CRDS), with simultaneous measurements of scattering coefficient made through use of an integrating sphere nephelometer. The nephelometer was calibrated with Rayleigh scattering gases of known optical density. The 1064 nm beam was selected and directed into a second, smaller integrating sphere. Thermal denuder experiments showed the LII signals were not affected by the particle mixing state when laser peak power was 1.5–2.5 MW. Combined measurements of optical properties and soot mass concentration allowed determination of mass absorption cross section (M.A.C., m2/g) with 1 min time resolution when soot concentrations were in the low microgram per cubic meter range. Fresh soot from a kerosene lamp exhibited a mean M.A.C and standard deviation of 9.3 $\pm$ 2.7 m2/g while limited measurements on dried ambient aerosol yielded an average of 8.2 $\pm$ 5.9 m2/g when soot was >0.25 μg/m3. The method also detected increases in M.A.C. values associated with enhanced light absorption when polydisperse, laboratory-generated BC particles were embedded within or coated with ammonium nitrate, ammonium sulfate, and glycerol. Glycerol coatings produced the largest fractional increase in M.A.C. (1.41-fold increase), while solid coatings of ammonium sulfate and ammonium nitrate produced increases of 1.10 and 1.06, respectively. Fresh, soot did not exhibit increased M.A.C. at high relative humidity (RH) owing to its hydrophobicity; however, lab-generated soot coated with ammonium nitrate and held at 85% RH exhibited M.A.C. values nearly double the low-humidity case. The hybrid instrument for simultaneously tracking soot mass concentration and aerosol optical properties in real time is a valuable tool for probing enhanced absorption by soot at atmospherically relevant concentrations.