Optical Properties of Mixed Organic / Inorganic Aerosols at High Relative Humidities

Benjamin T. Brem (bbrem@illinois.edu), Francisco C. Mena, Mark J. Rood and Tami C. Bond
Department of Civil and Environmental Engineering, University of Illinois

Background
- Aerosol water content and size are a function of ambient relative humidity (RH) and aerosol chemical composition
- Water content alters the optical properties of an aerosol in terms of light scattering and light absorption
- Light absorption of organic and mixed organic / inorganic aerosols have rarely been examined at variable and high RH values (>85%)

Objectives
- Determine light scattering and absorption of organic and mixed inorganic aerosols as a function of RH in a laboratory setting and evaluate closure with models
- This work: Determine light absorption as a function of RH for organic wood pyrolysis aerosols and verify methodology with benchmarks (ammonium sulfate, water soluble nigrosin)
- Future work: Measure light absorption of organic wood pyrolysis aerosols mixed with ammonium sulfate and ammonium nitrate; provide parameterization of results

Methodology

Instrumentation
- Light absorption ($\sigma_{ap}$) → difference method: light extinction ($\sigma_{ep}$) minus light scattering ($\sigma_{sp}$)
- Light extinction ($\sigma_{ep}$) → measured with a custom-made extinction cell at 467, 530 and 660 nm wavelength
- Light scattering ($\sigma_{sp}$) → nephelometer (TSI 3563)
  Instrument modifications: optical band-pass filters changed to 470, 530 and 660 nm, electronics separated (heating reduced from 4.5 to 0.6 °C)
- RH control and characterization → membrane humidifier, 2 RH sensors (Vaisala, HMP-233) and 2 dew point meters (General Eastern, Hygro M1)

System Benchmarking Results

Humidified Ammonium Sulfate
- Good sampling system performance under non-absorbing conditions for RHs between 32 and 95%
- Absorption enhanced by factor of 2 +/- 0.2 between 32 and 95% RH at the 467 and 530nm wavelength
- Red oak wood pyrolyzed under anoxic conditions at 425°C to produce absorbing OC aerosols
- Absorption wavelength dependence similar to field data of smoldering biomass OC aerosols
- Enhancement could be caused by strongly absorbing water insoluble OC
- No significant absorption detected at the 660nm wavelength

Humidified Nigrosin
- Absorption enhanced by a factor of 1.3 +/- 0.07 between 38 and 95% RH
- Absorption wavelength dependence consistent with spectrophotometric bulk liquid measurements
- Optical model agrees for RH < 90%. At RH > 90% mismatch likely caused by growth factor and particle losses

Implications
- OC from biomass or biofuel burning can be up to 90% of primary organic aerosols
- Increase in OC absorption with increasing RH needs to be implemented in radiative transfer models

Conclusions and Outlook
- Instrumentation is capable of measuring aerosol optical properties including absorption as a function of RH between 32 and 95%
- Absorption of both the benchmark nigrosin and the pyrolyzed OC aerosols was enhanced with higher RH
- Current work focuses on closure evaluation of results with modeling and additional measurements, as well as on mixing the generated OC with inorganic salts

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