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Droplet Measurement Technologies
Instrument:
Combining two instruments to get benefits of each

SP2

- Quantitative detection of black carbon
- Real-time measurements

AMS

- Quantitative chemical information of non-refractory particles
- Chemical analysis in real time

Little information on absorbed species
Limited chemical information
Lack of sensitivity to refractory particles
- Quantitative detection of black carbon
- Real-time measurements
- Little information on absorbed species
- Limited chemical information

- Quantitative chemical information of non-refractory particles
- Chemical analysis in real time
- Lack of sensitivity to refractory particles
• Quantitative detection of black carbon
• Differentiation of different carbon types
• Real-time measurements
• Quantitative chemical information of coatings on black carbon cores
• Chemical analysis in real time
Absorbing particles (coating and core) vaporize in laser
Vapor is ionized by electron impact ionization
Detection of the ions by Time-of-Flight mass spectrometry
Readily installed in any exiting AMS instrument
Transit of Soot Particles Across Laser Beam

- 5-20 microsecond evaporation time
- Coatings evaporate first at relatively low temperatures (<600°C) potentially dependent upon vapor pressures
- Core evaporates last at high temperature (>1000°C) under SP2-like incandescence conditions
- Coating and core material ionized and detected with mass spectrometry

Gao et al. 2007

\[ R \cdot BC \xrightarrow{\text{laser absorption}} R' + C_m + e^- \]

\[ R'' + C_n \]
Carbon signals including fullerene series

- Ion rate (Hz s⁻¹)
- m/z
- C32, C50, C60, C70
- Fullerenes
- Small carbon clusters
- Medium carbon clusters
- Fullerenes
‘Black Carbon’ Chemical Composition

- Fullerene Soot
- Premixed Ethylene Flame Soot
- Cabot Regal Black Pigment

Bar chart showing the chemical composition of black carbon, with fractions represented as bars: Fullerene soot, Flame soot, Regal black.
Example spectra FLAME 3

Burn 38 Lodgepole Pine

Nitrate equivalent mass (µg m⁻³)

m/z
SP2AMS - 3rd Generation
Laser Profile Camera

Camera is inverted
Walk TEM00 laser beam

forward and backward

Up and down

Normalized loadings (ug/m3/cpc)
Particle vs Laser Walks

- TEM00 Particle Walk
- TEM00 Laser Walk
- Gaussian Fit

Vertical distance at Beam (mm)

Normalized loadings (μg/m³/cpc)

Coefficient values ± one standard deviation

$y_0 = 0.0 ± 0.0$
$A = 0.034524 ± 0.000112$
$x_0 = -0.043444 ± 0.026$
$width = 0.94098 ± 0.037$
Saturation with Laser Power

Low Carbon Signal

Mid Carbon Signal

Fullerene Signal
Linearity
SP-AMS calibrations

- Use of metal particles for ionization efficiency (IE)
- Possible metals are zinc, silver, gold
- IE calibration is similar to AN calibration
SP-AMS calibrations

Zn+ spectrum
SP-AMS calibrations

- Introduce metal particles of known sizes into SP-AMS
  - size calibration
  - ionization efficiency for these metal particles

- Introduce coated particles into SP-AMS
  - ionization efficiencies relative to metal
  - ionization efficiency for AN
  - ionization efficiencies for all species used in standard AMS

- Introduce carbon particles into SP-AMS and into reference instrument (eg. PASS, SP2, MAAP,...)
  - ionization efficiency for low and mid range carbon clusters and fullerenes
SP-AMS calibrations

Done!!

+ metal particles can be easily produced
+ metal particles (Zn+) provide sufficient signal for calibrations

- Zn is affected by oxidation
- Zn particles were always contaminated be organic molecules

Todo

• routinely produce metal aerosol and look for the best suited metal
• Measure coated metal particles with SP-AMS and standard AMS measurements to get relative ionization efficiencies
• Determine relative ionization efficiency for black carbon
  • separated by amount of small carbon clusters, midrange carbon clusters and fullerenes
The End