AMS Collection Efficiency

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Outline

• CE issues
  – Size
  – Shape
  – Phase

• Ron Brown and Aerodyne laboratory-generated aerosol tests
  – AMS – PILS IC comparison (Ron Brown)
  – Humidified inlet (Ron Brown)
  – Poly-disperse BWP analysis (Ron Brown)
  – Mono-disperse BWP analysis (Aerodyne)
  – Light scattering probe analysis (Aerodyne)
CE Issues

• SIZE:
  – Particle transmission loss at the critical orifice and lens. (Leah Williams, Peter Liu, Ann Middlebrook)
  – Large particles may not fully vaporize or may breakup? (Leah Williams, Peter Liu)
  – Particles can be focused to different positions on the AMS vaporizer as a function of particle size. (Ann Middlebrook, Eben Cross)

• SHAPE:
  – Nonspherical particles are not as well focused as spherical liquid droplets. (CU, Aerodyne)

• PHASE:
  – Liquid particles “splat” on AMS vaporizer.
  – Solid particles and particles with low volatility can bounce off the vaporizer resulting in loss of signal.

FOCUS: Collection Efficiency AFTER passing through the lens.
  - Phase and Size
Beam Width Probe

Regularly-shaped particles (red)
- Not blocking beam
- Tightly-focused particle beam

Irregularly-shaped particles (black)
- Blocking particle beam
- Wide particle beam
- Some irregular particles may miss vaporizer

Front View

Top View
NEAQS-ITCT 2004
AMS Mass Loadings

![Graph showing mass loadings over time for different dates and chemicals including org, so4, no3, and nh4.](image-url)
AMS – PILS SO4 comparison

Collection Efficiency is directly related to Sulfate acidity
Test #1
Polydisperse AS and AN
RH = 60%

Date and Time

Mass Concentration (µg m\(^{-3}\))

Water
Ammonium
Nitrate
Sulphate
Chloride
Organics
PILS Nitrate
PILS Sulfate
PILS Ammonium
Test #1
AMS – PILS comparison

[PILS vs AMS scatter plot with lines at 1:1, 2:1, and 3:1 scales.]

- RH = 60%
- Sulfate
- Nitrate

Legend:
- Red circles: Sulfate
- Blue squares: Nitrate
- Solid line: 1:1 scale
- Dotted line: 2:1 scale
- Dashed line: 3:1 scale
Test #1
Wire Analysis

- 1 mm wire – 5 overlapping positions selected with an apparent 0.5 mm wire.
- wire positions 1 and 5 are still fully on horizontal axis of vaporizer.
Test #1
Conclusions

• AMS : PILS = 1 for AN
• AMS : PILS = 0.3 for AS
• AN and AS particle beam spread are similar
• AN and AS particles appear to all hit vaporizer
Test #2
Polydisperse AS
Variable RH
Test #2
AMS – PILS comparison
Test #2
Wire Analysis

- 1 mm wire – 5 overlapping positions selected with an apparent 0.5 mm wire.
- wire positions 1 and 5 are still fully on horizontal axis of vaporizer.
Test #2
Conclusions

• AMS : PILS dependent upon RH
• AMS : PILS NH4 ranges from $<1/3$ to 1
• AMS : PILS SO4 ranges from $<1/3$ to 0.9

RH controls AMS SO4 CE
Test #3
Polydisperse AS, AS+Org, AN
Variable RH

Organics used for this test are a mixture of:

- Succinic Acid
- Malonic Acid
## Test #3

### Polydisperse AS, AS+Org, AN

### Variable RH

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### Graph

- **Ammonium (NH₄⁺)**
- **Relative Humidity**
- **Organics**

**Date and Time:**

- 12:00 PM, 8/12/2004
- 3:00 PM
- 6:00 PM
- 9:00 PM

**Mass Concentration (µg m⁻³):**

- 100
- 80
- 60
- 40
- 20
- 0

**Relative Humidity (%):**

- 100
- 80
- 60
- 40
- 20
- 0
Test #3: AMS – PILS SO4 comparison

100% AS

50% AS

50% Org

25% AS

75% Org

75% AS

25% Org
Test #3
AMS – PILS
SO4 comparison

AMS/PILS SO4 Ratio

Sulfate Mass Fraction

Relative Humidity

Organic Mass Fraction

AMS

PILS IC

AMS/PILS SO4 Ratio

AMS

PILS IC
Ambient Sampling at High RH

Mass Loading (ug/m3)

Date and Time

7/11/2004
7/21/2004
7/31/2004
8/10/2004

Relative Humidity

AMS Sulfate

PILS NSS Sulfate

7/11/2004
7/21/2004
7/31/2004
8/10/2004

Relative Humidity

AMS Sulfate
Ambient Data
AMS to PILS comparison

AMS Organic Mass Fraction

AMS NH4:SO4 Ratio
Test #3
Conclusions

- AMS:PILS sulfate dependent upon RH, when aerosol are pure ammonium sulfate.
- AMS:PILS sulfate is not very dependent upon RH when aerosols are internal mixture of sulfate and solid organic acids.
- AMS:PILS sulfate IS dependent upon organic (or sulfate) mass fraction in the internally mixed sulfate and organic particles.

RH does NOT control ambient AMS SO4 CE, when organics are present.
Laboratory Experiments with Light Scattering Module

Eben Cross, Tim Onasch
AMS Users Meeting 10-07-04
Particle Beam Generation

Aerodynamic Sizing

Particle Composition

Quadrupole Mass Spectrometer

Aerodynamic Lens (2 Torr)

Particle Inlet (1 atm)

Pump

Chopper

Laser

TOF Region

Thermal Vaporization & Electron Impact Ionization

Pump

Pump
Percent Coverage of the Laser Beam on the Oven

Oven Diameter = 3.8 mm

Laser beam 1/e height Coverage
2.0 mm at the oven 63.8%*

Laser beam height for 100% particle detection = Coverage
1.7 mm 55%*

*NOTE that these calculations are based on the long chamber (5 Port) version of the AMS
• 350 nm Ammonium Nitrate – well defined vaporizer (dark red) and laser beam (dark blue) signal.
• 350 nm Ammonium Sulfate – less well defined vaporizer (light red) and laser beam (light blue) signal.
Particle Walk in Vertical Direction
To Scale

- 350 nm Ammonium Nitrate – well defined vaporizer (dark red) and laser beam (dark blue) signal.
- 350 nm Ammonium Sulfate – less well defined vaporizer (light red) and laser beam (light blue) signal.

Counting Statistics showing Particle Bounce
Fractal Soot Collection Efficiency

• Even fractal particles strike the AMS vaporizer with a high efficiency!!
• Jay Slowik’s work
Beam Probe Results w/ HTP Lens Rotated

Lens in initial position.

4/2/04
160 micron orifice
w/o p-control inlet
AN solution

Smaller particles focused to the **LEFT** of larger particles.

4/5/04
160 micron orifice
w/o p-control inlet
HTP Lens rotated

Smaller particles focused to the **RIGHT** of larger particles.
Beam Probe Results
Standard Lens 4/6/04

[Graph showing mass concentration and mass concentration over time plots]
• 350 nm Ammonium Nitrate – well defined vaporizer (dark red) and laser beam (dark blue) signal.
• 350 nm Ammonium Sulfate – less well defined vaporizer (light red) and laser beam (light blue) signal.
This is the attenuation for the 350nm systems used in the previous particle walk experiments. The beam width probe info says that the sulfate beam is slightly off center. The beam positions are supposed to run from left to right according to the model program, but I have the module flipped upside down, so it is really right to left 0-4. Therefore, the position where the true center of the sulfate beam is located is slightly LEFT. Left on the apparatus corresponds to the non-laser side of the chamber, so this is the same as the ellipsoid hole excess side (furthest from the laser beam).

0.25 mm movement at the BWP position = 0.325 mm at the oven. So that is why I shifted the LS/CPC sulfate line in the previous walk plots for the x direction.