Evaluation of Composition-Dependent CE using Field Data

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AMS Collection Efficiency
Huffman et al.

• Particles must be transmitted (quantifiably) into the instrument, through the aerodynamic focusing lens, impact the vaporizer, and volatilize. The net overall transmission is called the collection efficiency (CE).

\[ CE(d_{va}) = E_L(d_{va}) \cdot E_s(d_{va}) \cdot E_b(d_{va}) \]

\( E_L \) = transmission efficiency through the lens, function of size

\( E_s \) = focusing efficiency by the lens, function of size and shape

\( E_b \) = probability for vaporization, function of phase (which can vary by size)
Lens Transmission is Important

Vacuum Aerodynamic Diameter (nm)

Lens Transmission Efficiency

Boulder Average Mass Distribution

- $\text{NO}_3$ w/ CE = f(composition, size)
- correction for lens transmission losses
- $\text{SO}_4$ w/ CE = f(composition, size)
- correction for lens transmission losses
Measured CE and H⁺/NH₄⁺/SO₄²⁻/NO₃⁻ Phase Diagram

ICARTT 2004
T. B. Onasch
Four Main Factors Influence Phase

• **Relative Humidity**
  – For AMS, above 90% remains liquid.

• **Acidity/Neutralization**
  – Sulfuric acid particles are liquid.
  – Ammonium sulfate particles are not.

• **Nitrate Content**
  – Ammonium nitrate particles are metastable liquids.

• **Organic Content**
  – Can either be liquid or solid.
AMS Water Content of Ammonium Sulfate Particles ($\text{RIE}_{\text{H}_2\text{O}} = 1$)

Matthew and Middlebrook, unpublished data.
The Process

• Make sure lens transmission losses are accounted for and that the two instruments are comparing the same particle size and/or species.

• Calculate AMS mass with CE = 0.5 for all species.

• Plot histograms of measured mass with AMS data to other measurement.
Histograms of ratios using CE=0.5

Most of the time, the ratio is within the measurement uncertainties.

Most of the points outside the uncertainties are on the high side, implying CE=0.5 is too low.
The Process, contd.

• Now, recalculate AMS mass using CE = 1.0 for all species.

• Ratio of AMS mass to other measurement is the “apparent” CE.

• Plot this ratio as function of acidity, nitrate content, and organic content.
Acidity Effect

Increasing acidity

![Graph showing the effect of acidity on AMS/($M_{true}$-BC) with a note that ANMF < 0.4 at higher NH$_4$/NH$_4$Predict values.](image-url)
Nitrate Effect

Increasing nitrate content
Organic Effect?

Increasing organic content
Combining Field Results with Phase Diagram

Particle phase is important for AMS collection efficiency, where liquid or metastable liquid particles are collected more efficiently than solid particles.
Before and After Correction
What’s Next

- All users: Evaluate with many more datasets
- POA, especially urban, maybe affected by lens transmission and optical properties
- Effect of high RH
- Potential loss of semi-volatile species like ammonium nitrate or HOA.
TexAQS
AMS mass too high w/ CE=0.5
Composition (and CE) varying with particle size
TexAQS 5 Oct. 2006, CE = 0.5
fit = 1.15*Mfine
n = 1543
χ² = 10289

TexAQS 5 Oct. 2006, CE algorithm
fit = 0.98*Mfine
n = 1543
χ² = 3699
ARCPAC, CE = 0.5
fit = 0.86 * Mfine
n = 2622
χ² = 12827

ARCPAC, CE algorithm
fit = 0.89 * Mfine
n = 2622
χ² = 8716