Boston College- Aerodyne Soot Project 2

Summer 2008

Schedule and Experimental Details

Schedule – July 2008

	JULY						
			1	2	3	4	5
mass-based	6	7	8	9	10	11	12
overlap	13	14	15	16	17	18	19
optical-based	20	21	22	23	24	25	26
	27	28	29	30	31		

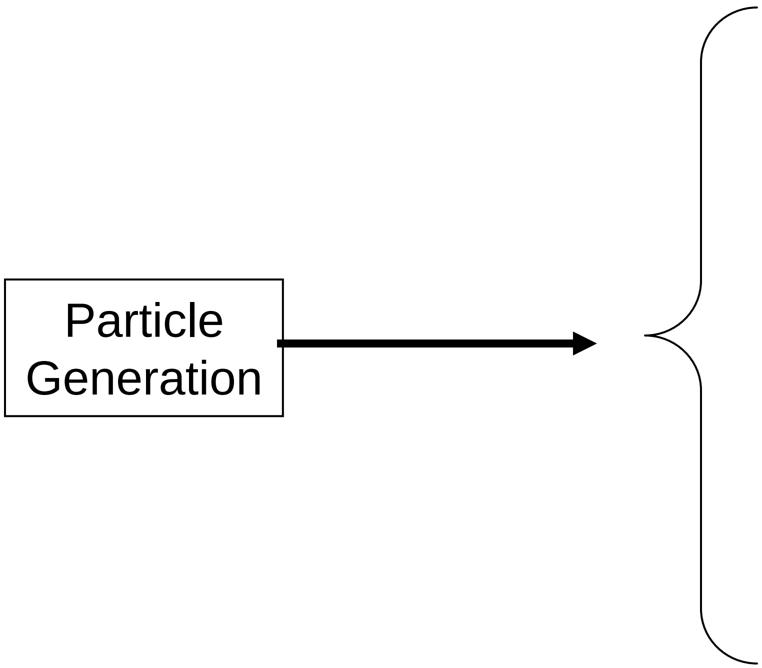
Mass-based Instrument Configuration

Particle Generation →

Instruments:	Flows (lpm):
CPMA/CPC	0.3
SMPS	1.0
AMS	0.1
SP2AMS	0.1
CPC	0.3
{CCN	1.0}
SP2 (DMT)	0.125
SP2 (NOAA)	0.125
PA (UN-Reno)	1.0
PA (NOAA)	3.0
PAS2000 (VT)	2.0
{Filters for OC/EC	2.0}
TOTALS	8.0-9.0

LiCor (CO_2/H_2O; 1 lpm flow) operated in line with another instrument

Optical-based Instrument Configuration



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{CCN	1.0}
SP2 (DMT)	0.125
SP2 (NOAA)	0.125
PA (UN-Reno)	1.0
PA/CRD (NOAA)	3.0-6.0
CAPS (ARI)	1.0
PTI (BNL)	1.0
PA (LANL)	1.0
Filters for SEM	
TOTALS	9.0-13.0

LiCor (CO_2/H_2O; 1 lpm flow) operated in line with another instrument

Project Objectives

Mass-based Objectives:

1. Include an APM/CPMA instrument (in combination with DMA) for accurate particle mass, density, and fractal dimension measurements. These measurements will verify our SMPS-AMS measurements of particle mass, density, and fractal dimension as well as provide a reference for other elemental carbon mass measurements.
2. Quantify SP2AMS carbon ion cluster measurements as a function of black carbon particle mass. Investigate how coatings (liquid/solid, organic/inorganic/water) affect carbon ion cluster measurements. How well can the SP2AMS characterize the chemistry and mass of the soot particle coatings?
3. Verify the quantification of SP2 incandescence measurements as a function of black carbon particle mass. Continue to investigate how coatings (liquid/solid, organic/inorganic/water) affect the SP2 measurements.
4. How do DMA-APM, SP2AMS, and SP2 BC mass measurements compare with OC/EC mass measurements? Investigate how coatings (liquid/solid, organic/inorganic/water) affect the OC/EC measurements. In particular, how well can the OC/EC instrument separate elemental carbon from organic carbon?

Optical-based Objectives:

5. Make measurements of mass specific absorption coefficients as a function of black carbon particle type (e.g. as function of fuel, fuel-to-air ratio, soot particle size and shape) and coatings (liquid/solid, organic/inorganic/water).
6. How does water coatings (e.g. RH) affect optical signals (e.g. photoacoustic, maap)? Particle may rearrange or collapse during denuding of coating material, how might morphology changes affect measure optical signals?
7. What are the effects of absorbing organics on black carbon particles with respect to optical instruments?
8. Conduct an optical closure study (Extinction, Scattering, and Absorption) utilizing the extinction and scattering measurements by the new Aerodyne CAPS-based SSA instrument, the NASA Cadenza instrument, and the NOAA cavity-ring down system

Boston College's Immediate Goals: Flame soot characterization

Overview paper for study focusing on mass-based and optical-based instrument comparisons:

Mass-based Objectives:

1. Include a CPMA instrument (in combination with DMA) for accurate particle mass, density, and fractal dimension measurements. These measurements will verify our SMPS-AMS measurements of particle mass, density, and fractal dimension as well as provide a reference for other elemental carbon mass measurements.

Optical-based Objectives:

5. Make measurements of mass specific absorption coefficients as a function of black carbon particle type (e.g. as function of fuel, fuel-to-air ratio, soot particle size and shape) and coatings (liquid/solid, organic/inorganic/water).

Cross et al.

Aerodyne's Immediate Goals: Instrument Development

Studies for instrument development and instrument papers:

Mass-based Objectives:

2. Quantify SP2AMS carbon ion cluster measurements as a function of black carbon particle mass. Investigate how coatings (liquid/solid, organic/inorganic/water) affect carbon ion cluster measurements. How well can the SP2AMS characterize the chemistry and mass of the soot particle coatings?

   Trimborn et al.

Optical-based Objectives:

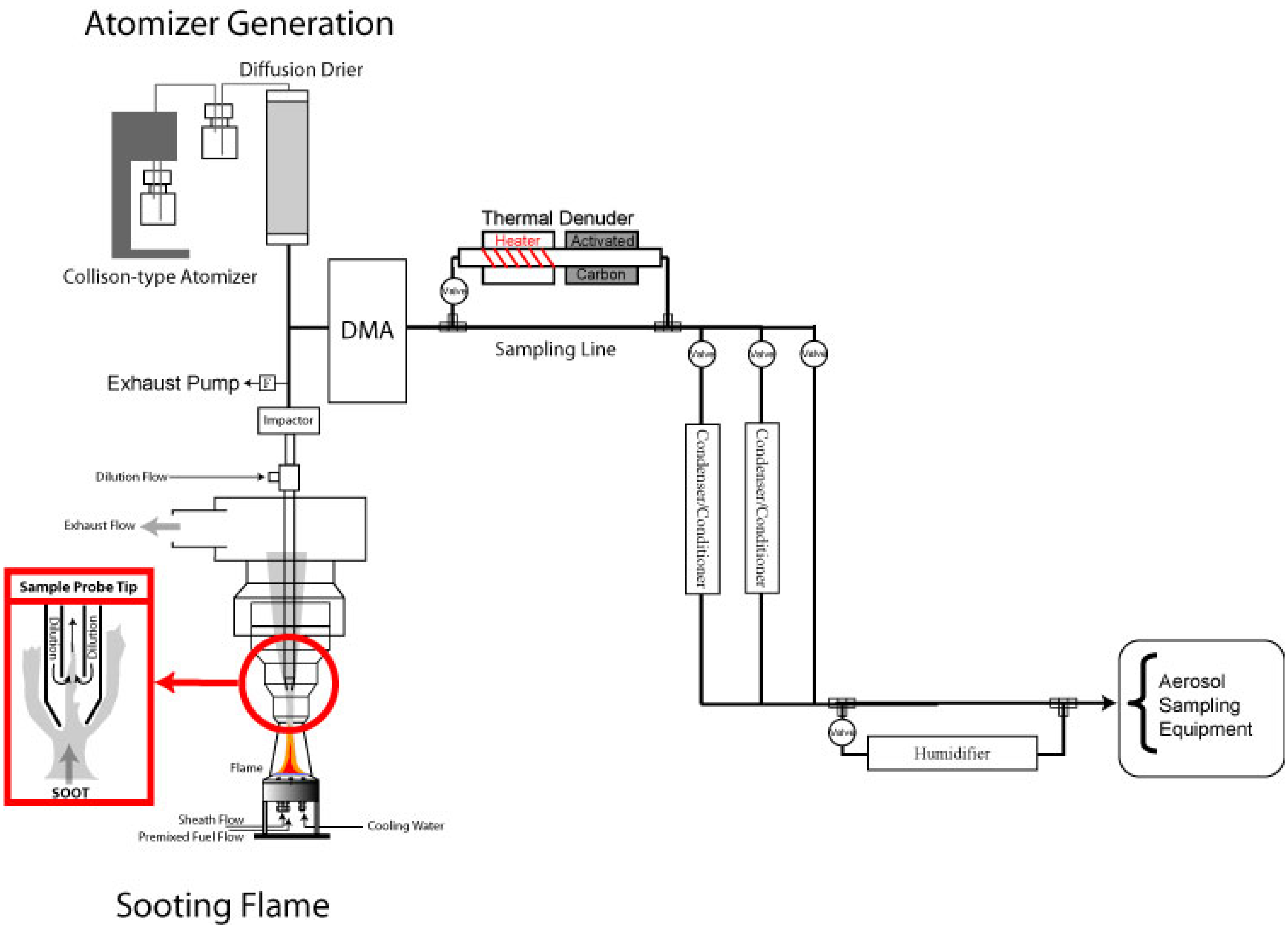
8. Conduct an optical closure study (Extinction, Scattering, and Absorption) utilizing the extinction and scattering measurements by the new Aerodyne CAPS-based SSA instrument and the NOAA cavity-ring down system

   Freedman et al.

Projects suggested by others:

- SP2 detection limits for small particle sizes (Schwarz, NOAA)
- SP2 response to changing RH (Schwarz, NOAA)
- PA detection limits for low absorptions (e.g. <5 Mm-1) (Cappa, UCDavis)
- PA response to changing RH (Dubey, LANL)
- Mass specific absorption measurements (Art Sedlacek, BNL)
- SEM filter collection for particle morphologies (Mazzoleni/Dubey, LANL)
- OC/EC measurements compared with real-time instruments (Bond, UCI)
- Surface-bound PAH measurements (Marr, VT)

Particle Generation



Flame Soot Experiment Objectives

- Measure particle mass (black carbon and organic carbon), diameter (mobility, vacuum aerodynamic and optical), shape factor, fractal dimension, primary spherule size
- Test instruments for single particle and ensemble aerosol detection limits
- Test instruments’ responses to liquid organic coatings
- Test instruments’ responses to sulfuric acid coatings at different humidities

Flame Soot Experiments

- Monodisperse soot as function of mobility diameter and equivalence ratio
  - Denuded and undenuded type II
- Polydisperse soot as a function of equivalence ratio and number/mass loadings
- Liquid organic coated monodisperse soot as function of core size (small range), coating thickness (large range)
- Sulfuric acid coatings to convert hydrophobic soot particles to hygroscopic particles
  - RH control

Monodisperse Flame Soot Experiments

Eq. Ratio*	dm (nm)**	Soot Type***
2.0	~30 - 300	I
2.5	~30 - 300	I
3.0	~50 - 300	I
4.0	~80 - 300	I and II****
5.0	~150 – 500	II ****
5.5	~150 – 500	II ****
6.0	~150 – 500	II ****

* Eq. Ratio = Fuel to Air ratio

** with < 20% Q2 by mass

*** Type I is > 90% black carbon with a fractal dimension ~ 1.8, while type II has significant coatings of PAH and aliphatic hydrocarbons with nearly spherical shape (fractal dimension ~ 3).

**** denuded and undenuded

Polydisperse Flame Soot Experiments

Eq. Ratio	dm (nm)	Soot Type	#/cm^{3*}
2.0	poly	I	~1e2 – 1e5
4.0	poly	I and II**	~1e2 – 1e5
6.0	poly	II **	~1e2 – 1e5

* Change through simple diluter
** denuded and undenuded

Flame Soot Coating Experiments

Eq. Ratio	dm (nm)	Soot Type	Coating (nm)*
2.0	~30 - 100	I	0-500

- Liquid organic (DOS, oleic acid, etc.) to test instruments' detection limits for small core sizes and large coatings
- Sulfuric acid coating to test instruments' response to changing RH and particulate water content

Atomized Experiment Objectives

- Generate particles with known compositions
  - Ammonium sulfate
  - Nigrosin dye
  - PSL with and without absorbing dye

- Generate black carbon (soot) particles with coatings that cannot readily be condensed
  - Ammonium sulfate
  - Nigrosin dye
  - Fulvic acid (absorbing organics – or brown carbon)

Atomized Experiments

- Ammonium sulfate and nigrosin dye particles atomized, size selected, and humidity varied

- Black carbon particles atomized with inorganic ammonium sulfate coatings in solution, size selected and humidity varied

- Black carbon particles atomized with fulvic acid and/or nigrosin dye coatings
  - Mass-based
    - Check for potential charring in laser-based SP2 and SP2AMS systems
  - Optical-based
    - Interference of absorbing organic compounds

Note on Humidity Experiments

- Relative Humidity experiments are notoriously difficult experiments to conduct. While some systems have their own temperature/relative humidity control, most likely do not.
- Our intent is to provide particles in a sample stream with varying humidity. The actual relative humidity for each measurement will depend critically on instrument temperatures and sampling procedures.
- We will control and measure the absolute humidity in the sample lines and leave it to each researcher to measure instrument temperatures and determine the relative humidity upon sampling.
- We anticipate some good fun working together to obtain the important, higher RH levels!