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Field and Laboratory Evaluation of a Sequential Time Resolved Aerosol Composition Measurement Instrument

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BACKGROUND

Desired characteristics of a field sampling system for time-resolved aerosol composition measurements

- Continuous measurements of aerosol chemical composition
- Accurate and precise measurements
- Simple, compact, robust and low maintenance
- Inexpensive capital and operating costs

Condensation Particle Sampler or Aerosol "SMART SAMPLER"

- Developed by scientists at ADI Inc.
- Time-resolved collection of aerosols
- Easy to maintain
- Minimal sample substrate lab prep required prior to field deployment
- Automated sample extraction/measurement with an auto-sampler and IC

INSTRUMENT DESCRIPTION

The Condensation Particle Sampler (Figure 1) grows aerosol particles by passing them through the interior of a wet-walled tube. Interfering gases are removed through use of upstream denuders. Three temperature zones are defined in the growth tube to control water vapor concentrations. Zone 1 is the Conditioner where the temperature is held at 30°C less than Zone 2 (Initiator). The Initiator's temperature is held at approximately 35°C and Zone 3 (Equilibrator) is held at approximately 13°C. Sampled particles are grown and deposited in a Sample Collection Chamber, which holds a Sampler Plate (Figure 2). Each well of the Sampler Plate (while in the sampling position) is held at 26°C . Deposited samples can be extracted for analysis of aerosol components such as inorganic anions and cations and various organics, including carboxylic acids, PAH, carbohydrates, etc….

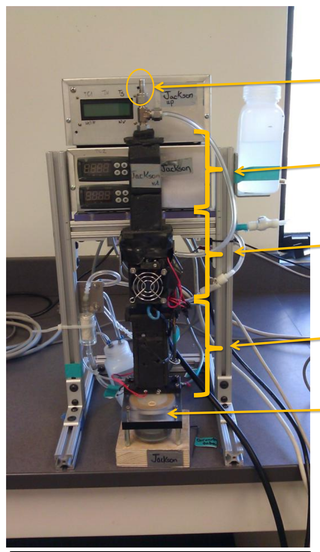


Figure 1. Condensation Particle Sampler or SMART SAMPLER

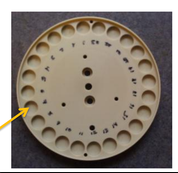


Figure 2. Sampler Plate

LABORATORY EVALUATION

•Plates made of various materials were investigated for sample stability and potential sample artifacts. Plates made of PEEK were chosen for aerosol anion and cation measurements, based on better precision (Tables 1 and 2) and sample stability over time (Figure 3 a and b).

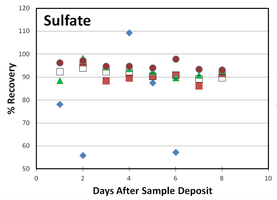
• Tests were conducted by depositing 10µL solution of known standards into each well. The wells were heated at ~26°C to evaporate the water. The samples were then cooled to room temperature and extracted in 100µL of DI water.

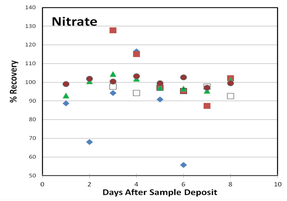
	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
HDPE	7	3	29	3	4	4	2
PEEK	5	3	23	4	4	3	3
UHMW	10	5	34	5	6	6	4
ABS	9	3	49	2	4	4	3

Table 1. Anion sample precisions for various plate materials. The numbers in the table show the %error for each component and plate type. (n=10)

Table 2. Cation sample precisions for various plate materials. The numbers in the table show the %error for each component and plate type. (n=10)

	Lithium	Sodium	Ammonium	Potassium	Magnesium	Calcium
PEEK	1	2	2	1	1	1
ABS	2	4	5	4	4	4





Figures 3a,b. Percent recovery of deposited standards during a period of 8 days using various plate materials.

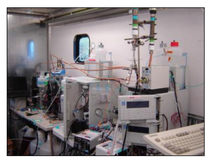
Plates were kept in sealed Petri dishes, in a freezer after each extraction.

FIELD EVALUATION

SAN GORGONIO (SAGO) FIELD STUDY

During June-July 2012, several instruments were setup inside the CSU Mobile Laboratory at the San Gorgonio Wilderness Area IMPROVE monitoring site (34.19, -116.91). Aerosol chemical composition data were collected using a URG denuder/filter-pack (12 or 24 hourly samples), a Particle Into Liquid Sampler coupled to an Ion Chromatograph (17 minute samples), and four SMART SAMPLERs. Three of the SMART SAMPLERs were coupled with sample collection chambers, two collecting hourly deposits and one collecting 12 hour deposits. One SMART SAMPLER was coupled with a microchip capillary electrophoresis system.

The plates were kept in a freezer and transported to CSU for further analysis, using an automated sampler fitted for the plates and an IC system. The results from two initial days of analysis are presented below, compared with PILS-IC measurements of sulfate and nitrate.



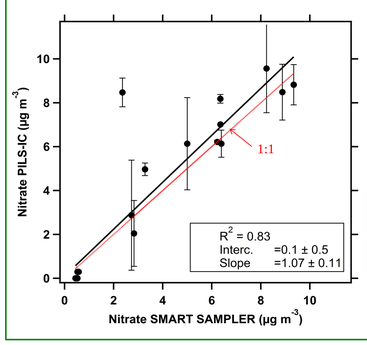


Figure 5. Comparison of $PM_{2.5}$ nitrate measurements for 6/21/2012-6/23/2012 in SAGO.

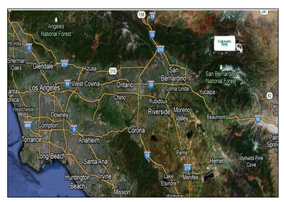
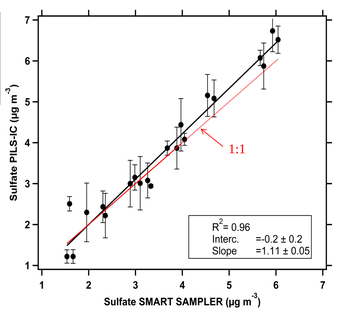


Figure 4. Comparison of $PM_{2.5}$ sulfate measurements for 6/21/2012-6/23/2012 in SAGO.



OTHER APPLICATIONS

CARBOHYDRATES

The SMART SAMPLER can be used for measurement of components such as levoglucosan (biomass burning tracer) and other carbohydrates. Figure 6 shows hourly observations from August 14 to August 16, 2012 in Fort Collins, Colorado. High levoglucosan concentrations were observed in smoke plumes transported from fires in Idaho (Figure 7). Other carbohydrates such as mannosan, galactosan, glucose and xylose were also observed when levoglucosan concentrations were high.

Figure 6. Hourly levoglucosan concentrations from SMART SAMPLER collected at Fort Collins, CO. High concentrations are during a biomass burning plume transport event.

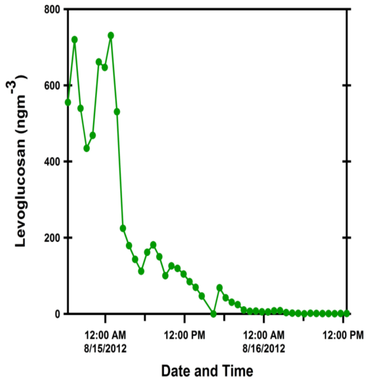


Figure 7. Idaho fires on August 14, 2012
Source: http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=78872

CONCLUSIONS

- The Condensation Particle Sampler/SMART SAMPLER is a compact and low maintenance instrument that can be used for time-resolved measurements of the chemical composition of aerosols. Field tests indicate sufficient sensitivity for hourly measurements under a range of conditions. The system provides an attractive option for time-resolved field collection of aerosols coupled with automated, laboratory sample extraction and analysis for a wide range of compounds.

- Initial comparisons between the SMART SAMPLERs and other traditional methods of aerosol chemical composition measurements yielded good results.

FUTURE WORK

• Further evaluation and validation of the system is planned for more time periods and for different chemical species.

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