Particle-into-Liquid Sampler

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Overview

Water-soluble sub-micron (PM_1) aerosols will be collected using a particle-into-liquid sampler (PILS) for offline analysis by ion chromatography (IC). These measurements will provide quantification of key inorganic and organic ions in submicron aerosol, allowing us to probe aerosol sources and sinks as part of the FRAPPÈ campaign.

Instrument description

A particle-into-liquid sampler (PILS, Brechtel Manufacturing, Inc) collects ambient aerosol particles < 1 µm (PM_1) into a stream of high purity water. The aerosol particles from the sample inlet (flow rate of 15 LPM) are rapidly mixed with steam from the steam generator (flow rate of 1.7 LPM) within the condensation chamber. As the two streams mix, the steam (~100°C) is cooled by the ambient aerosol sample, thus leading to a water vapor supersaturated environment within the condensation chamber. Under these conditions, the aerosol particles are able to grow into droplets with sizes between 1 and 5 µm. These droplets are large enough to be collected and are accelerated onto an impaction plate. A wash flow of high purity water is then directed across the impaction plate, where it combines with the collected droplets and allows them to be transported through the debubbler and finally to the collection vials.

Dynamic blank measurements are taken for 10 minutes at the beginning and end of each flight by passing sample air through a high-efficiency particulate air (HEPA) filter. A manual 2-way valve determines the airflow to the filter or sample. The instrument is operated using LabView software to control the auto-collector and sampling time, as well as to monitor and record temperature fluctuations.

Measurements

PILS samples will be analyzed at the Atmospheric Chemistry labs at Colorado State University in Fort Collins for inorganic and organic ions. Offline analyses include chloride, nitrite, bromide, nitrate, phosphate, sulphate, lithium, sodium, ammonium, potassium, magnesium, calcium, acetate, formate, and oxalate. Limits of detection are listed for the inorganic ions in Table 1.

An ion chromatograph (IC) is used to separate and quantify various ions. The analyte is first injected and subsequently mixed with the eluent. This mixture then passes through a column containing the ion-exchange resin, where the analyte partitions between the stationary and mobile phases. The ions are separated based on their affinities for the stationary phase; those that have strong affinities will move more slowly through the column and therefore elute later than those with weaker affinities. A suppressor is used to reduce the background conductance of the eluent while enhancing the conductance of the sample ions.

In order to analyze the ions present in the ambient aerosol samples, a Dionex ICS-3000 ion chromatograph with conductivity detection and an AS50 autosampler will be employed. The instrument utilizes a 200 µL injection loop and the temperature is maintained at 30°C. Elution is carried out isocratically with 17 minute run times. The column for cation analysis is a Dionex IonPac CS12A-5µm cation-exchange RFIC 3 × 150 mm analytical column. A Dionex IonPac CG12A-5µm RFIC 3 × 30 mm guard column is placed before the analytical column to ensure the removal of large particles. The suppressor is a Thermo Scientific Dionex 2 mm CERS 500 electrolytically regenerated suppressor, operated at 40 mA. An eluent generator cartridge (EGC) produces 20 mM methanesulfonic acid (MSA) as the eluent for cation analysis. The flow rate through the system is 0.50 mL/min.

The column for anion analysis is a Dionex IonPac AS14A carbonate eluent anion-exchange RFIC 4 × 250 mm analytical column. A Dionex IonPac AG14A RFIC 4 × 50 mm guard column is also employed. The suppressor is a Thermo Scientific Dionex 4mm AERS 500 electrolytically regenerated suppressor, operated at 50 mA. 8 mM sodium carbonate and 1 mM sodium bicarbonate is used as the eluent for anion analysis. The flow rate through the system is 1.0 mL/min. Calibrations for the inorganic ions are made using 8 standards with varying concentrations of each ion of interest, while calibrations of the organic ions are performed using 5 standards.

Ion	**Limit of Detection (µg/L)**
Chloride	0.00034
Nitrite	0.00074
Nitrate	0.00065
Phosphate	0.00049
Sulphate	0.0017
Lithium	0.00083
Sodium	0.00075
Ammonium	0.0016
Potassium	0.0013
Magnesium	0.0016
Calcium	0.0020

Table 1: Limits of detection for inorganic ions