Prototype Compact Denuders for Ambient Air Sampling

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Overview

CASTNet currently uses a multiple-filter approach for sampling all target species. Unfortunately, particulate nitrate volatilizes from the initial filter and is collected on a secondary nylon “gas phase collection” filter; thus, nitric acid is overestimated and particulate nitrate is underestimated. Since the gaseous and particulate phases have much different deposition velocities, this bias interferes with the accurate determination of nitrogen deposition. Ammonia, which is an important yet poorly quantified contributor to nitrogen deposition and fine particle formation, is measured only in the particulate phase and is also subject to loss via volatilization. To address these shortcomings, a compact, extractable denuder has been designed to fit into the Met One, Inc.-Special Air Sampling System (SASS), to provide a more complete and accurate inventory of nitrogen species concentrations and partitioning.

Lab and Ambient Testing Approach

- The SASS compact denuder performance was compared in both lab and field environments.
- Tests included denuder-behind-denuder measurements to evaluate ammonia collection efficiency and side-by-side comparisons against URG ammonia denuder sampling system.
- Lab tests utilized a stream of ammonia generated using a permeation tube. Ambient tests sampled outdoor air, including particles and gases, in Fort Collins, Colorado.

Findings

Prototype 1: Ammonia Testing Results

- SASS Prototype 1 denuder efficiency measured 98.8% ± 14.5% below target (>95%) efficiency levels.
- Prototype 1 efficiency decreased in the presence of high loads, indicating insufficient load capacity.
- Extensive handling of denuder inserts required in Prototype 1 made extraction and coating inconvenient and prone to contamination.
- Delrin materials in Prototype 1 proved incompatible with the phosphoric acid coating solution.

Prototype 2: Ammonia Testing Results

- Schematic of lab testing setup
- Figure 1: Lab testing of Prototype 2 revealed improved collection efficiency and no relationship between collection efficiency and total applied ammonia load.
- Figure 2: Similar total ammonia loads were collected by URG denuders and Prototype 2 SASS denuders operated in parallel during lab tests.
- Figure 3: During ambient air testing, the Prototype 2 ammonia collection efficiency averaged 95% ± 6.4%. Again, no correlation (r² = 0.0778) was observed between collection efficiency and total ammonia load.
- Figure 4: An intercomparison of PM10, ammonium and gaseous ammonia collected by the modified SASS and the URG samples showed good agreement for gaseous ammonia. SASS Prototype 2 denuders collected somewhat higher ammonia amounts than were observed with URG denuders.

Conclusions

- A compact denuder has been designed and successfully tested for use with the SASS sampler. This denuder has high efficiency for ammonia collection and sufficient capacity for daily or weekly sampling in most ambient environments. The denuders can be prepared with low background (Blank) concentrations (< 3 µg).
- The compact nature of the denuder makes it easier to ship and to deploy on sampling towers. Drop “tests” demonstrate that the denuder is robust against breakage.
- Additional testing is planned in the coming year as part of a measurement methods intercomparison.
- Deployment of a denuder/filter-pack system can provide a more accurate determination of the split between gas (e.g., ammonia and nitric acid) and particle (e.g., ammonium and nitrate) species than is possible with a filter-pack sampling approach. Accurate knowledge of the phase partitioning split is crucial to improving estimates of reactive nitrogen deposition.

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