

Experiment #4 - Aerosol Sampling by Cascade Impactor

The purpose of this experiment is to teach you a method for sampling atmospheric aerosols, by particle size, for chemical analysis. Particulate matter will be collected by drawing air through a cascade impactor. Air is accelerated to higher velocities in successive impaction stages, leading to removal of smaller particles on each subsequent stage. Particles are impacted onto aluminum foil substrates, coated with silicone spray to minimize particle bounce. The MOUDI impactor you will use samples air at 30 l min^{-1} , collecting particles on nine stages. 50% size cuts for the stages range from $18 \mu\text{m}$ down to $0.18 \mu\text{m}$ aerodynamic particle diameter. We will also install a Teflon “after-filter” to collect particles $< 0.18 \mu\text{m}$. The impactor will be operated for 48 hours. After operation the impactor will be disassembled and the aluminum substrates and Teflon after-filter extracted in water. The extracts will be analyzed for major cations (NH_4^+ , Na^+ , K^+ , Ca^{2+} , and Mg^{2+}) and anions (NO_3^- , SO_4^{2-} , and Cl^-) to determine the distribution of various chemical species with particle size.

We will run the MOUDI impactor during two separate weeks of class, together with the URG denuder/filter-pack sampler (Lab #3). During each week, two student groups will work together to prepare the MOUDI for sampling.

Materials Needed:

- MOUDI (Micro Orifice Uniform Deposit Impactor)
- Vacuum pump
- Aluminum foil roll
- Work surface with tape indicating MOUDI stage positioning
- Tweezers, tongs and dental pick
- Coated aluminum impaction substrates
- Teflon after-filter
- Colored lab tape
- Permanent marker
- 16 ml test tube
- Adjustable pipettes and tips
- ethanol
- Ultrasonic bath
- 5 ml cryovials
- IC vials

MOUDI Impactor Size Cuts:

Stage #	Size Cut (μm)
0	18
1A	10
2A	5.6
3A	3.2

4A	1.8
5A	1.0
6A	0.56
7A	0.32
8A	0.18
9A	0.10
10A	0.056
After-filter	Collects particles <0.056 μm

Procedure:

1. Loading, unloading, and extraction of the MOUDI impaction and filter substrates will be done by one group each of the two weeks.
2. Tear off a new, big piece of aluminum foil. This will be your work surface, and you should make it as long as the piece of tape on the MOUDI preparation table. Set it out right in front of the piece of tape. This piece of tape is labelled “top”, “0”, “1”, “2”, ..., “10” so that you can easily keep track of the MOUDI stages.
3. Set the assembled MOUDI on the aluminum foil work surface. Pull apart the MOUDI stages. Only touch the outside of the stages. Set each stage on the aluminum foil work surface in front of the corresponding stage number that is on the tape (so you would put the top stage in front of the “0”, the next stage in front of the “1” and so on).
4. Get out and open the plastic dish that contains the clean impaction surface holders.
5. Get 11 new petri dishes with unused impaction surfaces. Each aluminum foil impaction surface has been sprayed with Silicone grease and baked; it is important to make sure that you do not flip the petri dishes over.
6. Put a pair of clean gloves on, rinse with DI water, and air dry.
7. *This is a rather involved step that takes some tweezer and dental pick practice.* With the tongs, pick up the impaction surface holder and set it out on the clean aluminum foil work surface. With a pair of clean tweezers and a clean dental pick, pull off the ring that holds the impaction surface onto the impaction surface holder. Using the tweezers, place a new impaction surface into the impaction surface holder. Be sure the tweezers only touch the edge of the impaction surface. Using the tweezers and dental pick, place the hold down ring over the impaction surface and press down firmly to seal it in place. Set the impaction surface holder onto the corresponding MOUDI stage. Close the petri dish. Repeat this step for each impactor stage. Be sure that students in both groups get a chance to load stages.
8. Following instructions provided by the TA, load a Teflon filter into the after-filter stage of the MOUDI impactor.

9. Put the stages back together in the correct order. This should be easy since they are sitting in front of you in descending order. The TA or Instructor will help you mount the MOUDI impactor into its housing and show how the flow is started, set and measured. The TA will start the sample for you and shut it off after 48 hrs of sampling. The TA will provide you with the sample time and the total sampled flow. After operation, the impactor will be sealed and refrigerated until the next laboratory period.
10. The lab period after you prepare the MOUDI impactor you will disassemble the impactor and retrieve the sampling substrates. Label the 11 petri dishes from last time as follows: sample name = AT560MMDDMS where MM stands for month (e.g., July = 07), DD stands for the day of the month the sample was started (e.g., July 4th = 04), M stands for MOUDI, and S stands for Stage number (which will be 0-10 plus AF (after-filter)).
11. Use clean tweezers and a clean dental pick for removing the sample substrate hold-down ring and clean tweezers for removing the impaction substrates and the after-filter. Place each substrate into the corresponding, appropriately labeled petri dish.
12. Reload and unload 3 additional impaction substrates. These will be used as blanks to determine background concentrations on the handled substrates. Label these samples as above, except replace the stage number by B1, B2 or B3 for the blanks.
13. Stack the petri dishes, tape them together with colored lab tape, and give them to the TA to be stored in the freezer unless you are instructed to extract them immediately.
14. When you are ready to extract the collected material from the substrates, use clean tweezers to place each substrate into a clean 16 ml test tube with the sampling side facing the tube interior. The TA will demonstrate how to do this. For the aluminum substrates, pipette 6.0 ml of DI water into each tube and cap. For the Teflon after-filter, pipette 100 μ l of ethanol onto the filter surface, one drop at a time trying to cover the filter surface as well as possible. Add 5.9 ml DI water and cap the tube. Label each tube with the sample name. Don't forget to also extract the additional blanks you prepared for the experiment.
15. Place filter tubes into a rack in the ultrasonic bath (filled to 3-5 cm with DI water) and sonicate for 30 minutes. Remove and dry tubes.
16. For each substrate: pipette 600 μ l of substrate extract into IC vial and label appropriately. Pipette 5 ml of filter extract into cryovial and label.
17. Provide sample vials to TA for refrigeration. These samples will be analyzed by ion chromatography.

Items for Discussion:

1. Plot bar graphs for each impactor sample of aerosol nitrate, sulfate, ammonium, sodium, and calcium in terms of nanoequivalents/ m^3 vs. particle size. Which particle size range(s) contained the greatest amount of each species? Do the shapes of the distributions meet your expectations? Why or why not? What do you think might be the major sources for these aerosol species?

2. Compute the total aerosol nitrate, sulfate, and ammonium concentrations during each of the two class sampling periods. Compare these to concentrations measured simultaneously using the URG filter-packs. Which MOUDI stage results should be summed for the best comparison with $PM_{2.5}$ filter samples?

3. From the blank substrate results, calculate detection limits for aerosol nitrate, sulfate, ammonium, sodium, and calcium for the impactor sampling method. Based on your findings, what minimum sampling time would you recommend if conditions are similar to those on the days you sampled?