A High Efficiency Instrument for Collecting Airborne Particles Down to 10 Nanometers on Solid Surfaces or Into Liquid

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INTRODUCTION

Airborne microorganisms (viruses, bacteria, and fungi) are part of ambient particulate matter found as either individual particles, aggregates, or bound to other airborne particles. Their size distribution ranges from a few nanometers to several micrometers.

Active sampling methods with liquid collectors (best for maintaining microbe viability), filters, and impactors[1] are widely used. However, they are limited by:
inefficient physical collection, <10% for particles 30-100nm[2] and
low viability of those collected, due to microbe stress, desiccation and breakup.

We present an alternative method of sampling airborne particles that uses water condensational growth and soft impaction on either a dry surface or in liquid media. Our **SPOT SAMPLER™** collector provides

high physical collection efficiencies *for particles 10 nm and larger,* and

higher viability of the collected organisms

INSTRUMENT CAPABILITIES

The Spot Sampler system collects particles via gentle impaction on a solid substrate or as suspensions into liquid for chemical, biological and toxicological characterization[3,4,5] (Figure 1).

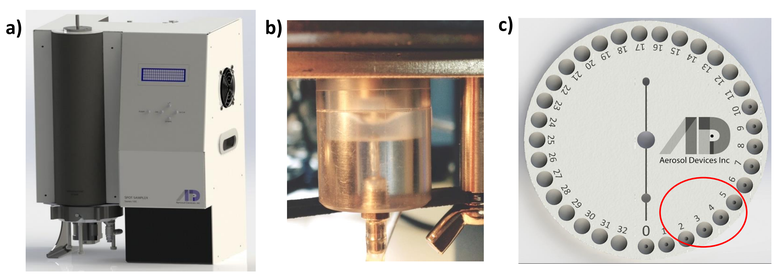

Figure 1. a) Integrated Spot Sampler; b) Liquid collection; c) Dry multi-well collection disk

Advantages of aerosol particle collection into liquids (Figure 1b):

- *Direct collection* into liquid reduces sampling artifacts and maintains microorganism viability
- *No need* for extraction and resuspension steps
- Collects *soluble particle-phase* components, and *insoluble particles* suspended in the collection liquid
- The *concentrated nature* of the collection allows reducing sampling times
- *Versatile collection medium*: water, culture media, virus growth medium, etc.
- Provides concentrated particle samples ready to be characterized using *rapid microbiological analysis* techniques, such as PCR, and *in-vitro* assays[5]

Advantages of dry particle collection (Figure 1a, 1c):

- *Uninterrupted, time-resolved* collection of concentrated "spots" (1-mm) in a 33-well disk: minutes to hours
- *Easy transport* of sample plate from the field to the laboratory for analysis
- *Automated* extraction and injection by autosampler reduces contamination for wet chemical analysis[3,4] (IC, HPLC, etc.)
- *Concentrated deposits* are suitable for spectrographic or molecular analysis

HOW IT WORKS

The sampler uses a three-stage, moderated laminar-flow condensation method to grow tiny airborne particles as small as 5nm into ~3µm droplets and collects them by bounce-free, soft impaction into the collection substrate[3,6] (Figure 2).

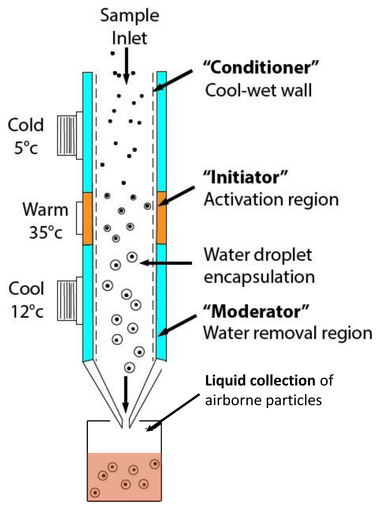

Figure 2. Three-stage water condensational growth approach

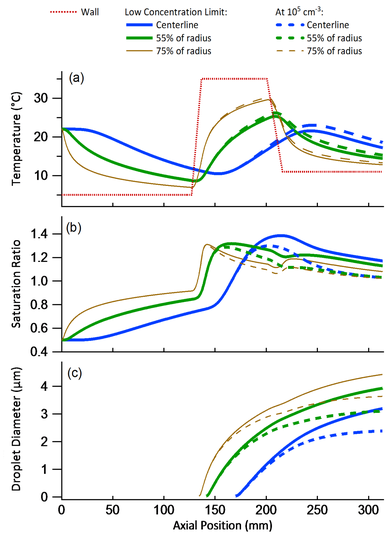

Figure 3. Temperature, saturation ratio, and droplet size under standard operating conditions[6]

The moderated temperatures under 30˚C (Figure 3), create a hospitable environment advantageous for viable microorganism collection. The time the particle is subjected to high humidity conditions is brief – on the order of milliseconds. If the presence of water is an issue for the particles or assay, a dry deposit eliminates any negative effects due to condensation.

PARTICLE COLLECTION EFFICIENCY

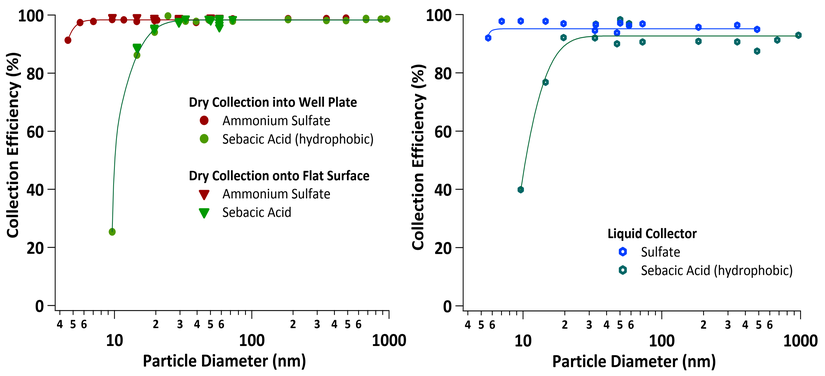

Figure 4 Collection efficiency test with monodisperse hydrophilic and hydrophobic aerosols

The physical collection efficiency is over 90 percent for liquid and dry collection down to 5nm for hydrophilic particles and 10nm for highly hydrophobic particles.

IN-VITRO TOXICOLOGY ANALYSIS

In-vitro toxicity of airborne particles (promising early results):

- Collect ambient particles as a liquid suspension over a period of four days at Michigan State University (East Lansing, MI)
- Expose human bronchial epithelial **cells line BEAS-2B** to the particle suspension for 16 hours
- Measure pro-inflammatory markers interleukin-6 (IL-6) and interleukin-8 (IL-8)
- Ambient aerosols induced a 10- to 34-fold increase in IL-6, and a 5- to 25-fold increase for IL-8, compared to controls (Figure 5)

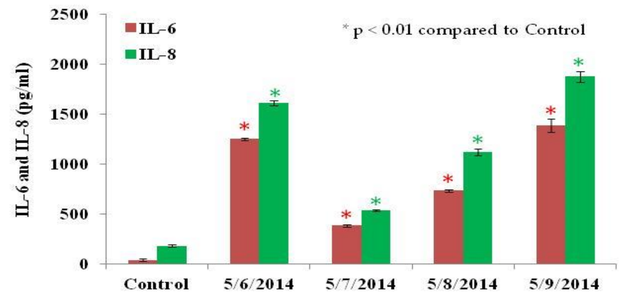

Figure 5. Production of IL-6 and IL-8 in cells after exposure to East Lansing ambient aerosols.

CONCLUSIONS

1. The Spot Sampler instrument provides a new approach to efficiently collect airborne particles as concentrated, ready-to-analyze, liquid suspensions or dry deposits with low contamination.
2. High physical collection efficiencies (>90% from 10nm to 10µm) for both collection configurations, increasing the range of efficient collection from nm (bare viruses) to µm (virus associated with airborne particles, bacteria and fungi).
3. Gentle collection, moderate temperatures, and the ability to control the sampling relative humidity conditions, is advantageous for collecting viable microorganisms.

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