A NOVEL SAMPLER FOR VIRUS AEROSOLS THROUGH WATER-BASED CONDENSATION PARTICLE GROWTH

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BACKGROUND

- Inhalation of aerosols containing respiratory viruses can lead to upper and lower respiratory tract diseases.
- Virus aerosols can be produced during viral respiratory illnesses through coughing, sneezing, speaking, and expiration.
- The size distribution of virus containing particles varies between 20-300 nm for "naked" viruses to micrometer sizes (< 5 µm) for those aggregated or attached to fomites or encased in secretions.[1]
- The smaller virus containing particles present more of a hazard health hazard because lower respiratory tract infections can result in pneumonia.[2]

CURRENT LIMITATIONS

- Samplers commonly used for bioaerosols are designed for collection of particles >0.5µm and have low efficiencies in the nanometer range.[3]
- Common sampling methods often inactivate the collected viruses through mechanical damage or irreversible desiccation.
- Virus detection is dependent on collection methodology and effective retrieval of the viruses or their components from the collection media.

MAIN NEED AND APPROACH

Accurate assessment of airborne viruses requires new sampling devices capable of efficient collection of aerosols that span nm to µm sizes, and maintaining virus viability (infectiousness). Virus viability is important for accurate assessment of true biothreat, as non-viable viruses are normally in the air we breathe.

Based on our laminar-flow water condensation particle growth technique we have developed a new virus sampling system capable of collecting airborne particles (6nm to 10µm) directly into liquid at moderated temperatures

OBJECTIVES

Evaluate the performance of our novel growth tube collector (GTC) for the collection of MS2 virus compared with that of a standard BioSampler® by measuring:

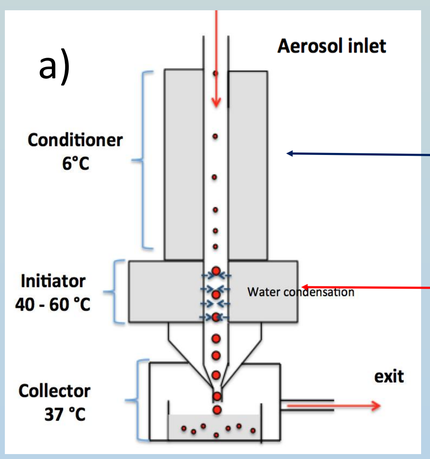
1. Physical collection efficiency
2. Viability of the virus in the collected sample

MATERIALS AND METHOS

Test Virus: MS2 single-stranded RNA genome bacteriophage, Dp ~28 nm

Growth tube collector (GTC)

The GTC system (Figure 1) consists of 8 parallel growth tubes for a flow rate of 7 lpm.



The **cold conditioner** serves to condition the T and RH of the aerosol

The **hot initiator** induces condensation and provides time for particle growth.

ΔT (°C) between conditioner and initiator determines the smallest activation size

Figure 1. Schematic diagram of the Growth Tube Collector (GTC) : a) system, b) delivery nozzles

Quantification of collection efficiency

Physical: Difference in the particle count (#/ cc) at the inlet and exit of the GTC

Viability: A single-layer bioassay method (EPA, 1984) was used to determine the quantity of Plaque Forming Units (PFU) of viable MS2 collected in liquid media

EXPERIMENTAL DESIGN

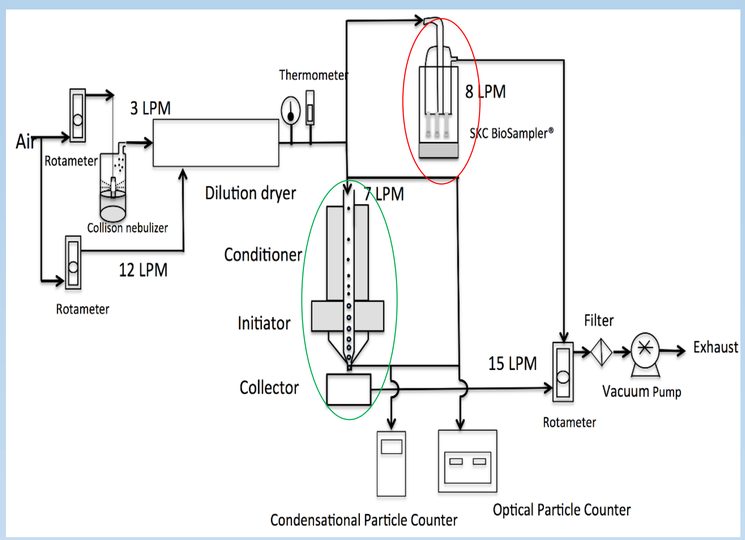


Figure 2. Schematic diagram of the experimental setup

Biosampler @ 8 lpm
Sample collection: 5, 10, 15 min
Collection Media: water
broth

Acknowledgements:
National Science Foundation Grant number: IDBR-1353423, and Aerosol Dynamics Inc.
The authors are grateful to Eduardo Gomez and Julia C. Loeb for their assistance.

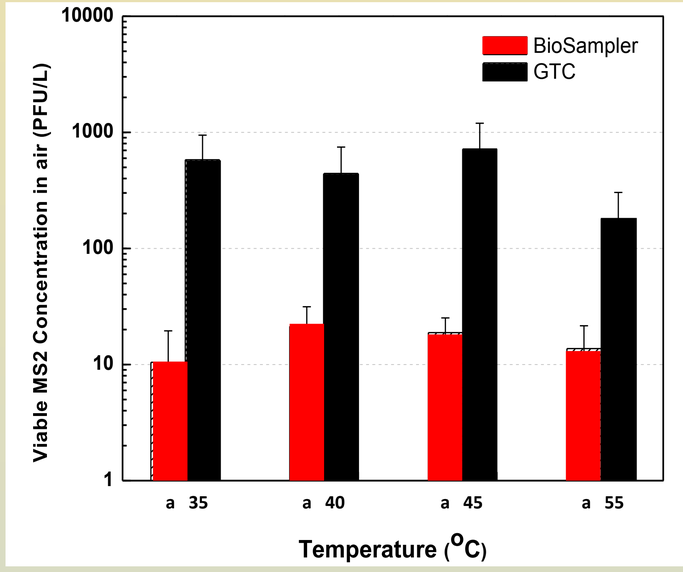
RESULTS

1. Physical Collection Efficiencies

Collection efficiencies **>95%** were observed for the GTC. These collection efficiencies are **9 times higher** than reported efficiencies for the Biosampler[3]

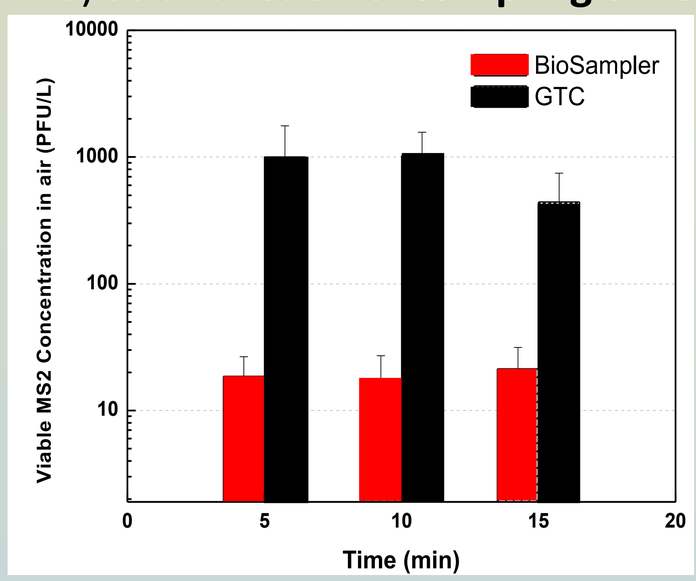
2. Viable Virus Collection Efficiencies

a) as a function of **ΔT (°C)**



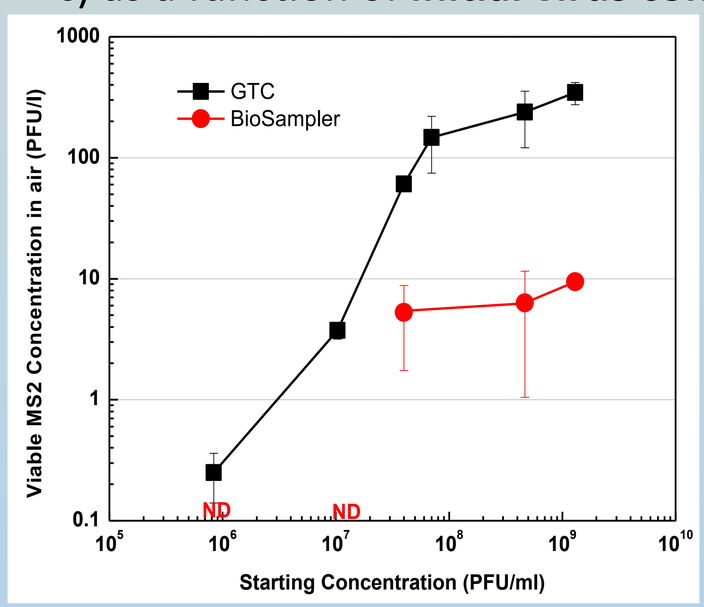
- The GTC is, on average, **45 times more efficient** than the BioSampler
- The activation temperature does not change efficiency up to 45 °C difference
- ΔT = 40 °C was selected as optimum for further studies as will maintain optimum virus infectivity and activate nm size particles

b) as a function of **sampling time**



- No significant differences were observer for sampling periods between 5 and 15 minutes

c) as a function of **initial virus concentration in solution**



- The GTC showed **lower detection limit** (2×10^4 PFU/L) than the BioSampler
- The PFU detected by the GTC systematically increased with the virus concentration

d) as a function of **the collection medium**

	GTC (PFU/L)	Biosampler (PFU/L)
Water	**442 ± 304**	**21.4 ± 10.4**
Tryptone Yeast Extract Broth	**1721 ± 335**	**12.4 ± 15.4**

The viable collection efficiency of the GTC was **over 100 times more effective** than the BioSampler when using TYB as the collection medium

SUMMARY

1. The GTC is **45 and 100 times more efficient** than the BioSampler for the collection of viable MS2 viruses in water and tryptone yeast extract broth, respectively
2. The GTC is capable of collecting viable MS2 virus at much lower airborne concentrations than the BioSampler (lower LOD)

References:

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