SOUTHERN RESEARCH

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Development of a Low-Flow Liquid Impinger

2011 Air Monitoring Users Group Meeting

Las Vegas, NV May 3-6, 2011

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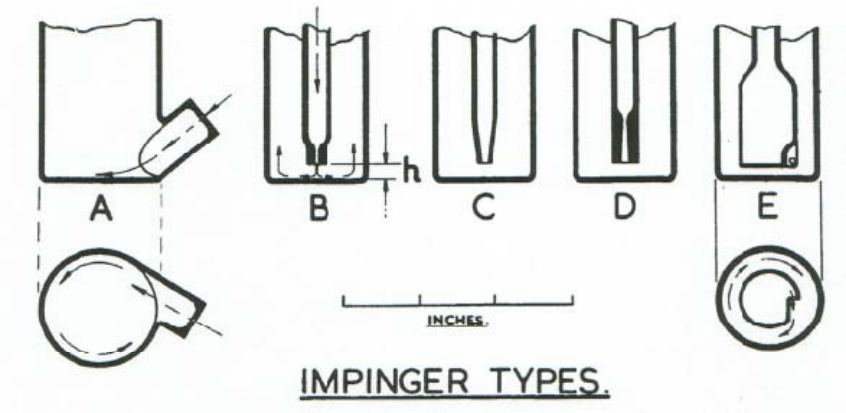
Overview

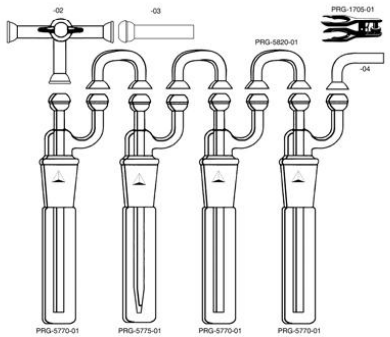
- What is an impinger
- History of impingers
- Objective
- Results
- Questions

What is an Impinger

- Aerosol sampling device that collects particles by inertial forces
- Diffusion within the bubbles enhances particle collection



What is an Impinger



History of Impingers

- Originally developed by J.H. Gaddum
- 1922 Greenburg and Smith – Dust Cloud Sampler
- 1947 Rosebury and Henderson – Porton Development
- 1955 Druett – sonic velocity flow
- 1997 SKC Bioasmpler
- 2010 ITP Stainless Steel Impinger
- 2011 ITP Plastic Impinger

Objective

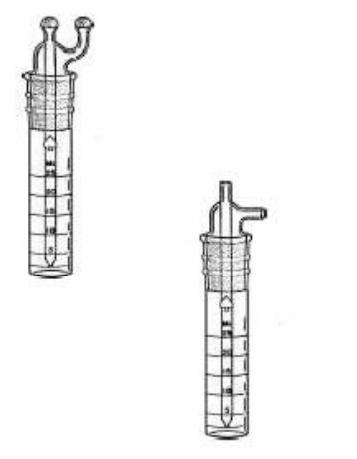
Design an impinger to replace the glass model

- Safe, durable
  - Autoclave decontamination - 121°C, 15 psig, 30 min
- Efficient
  - E (%) = 97.7 to 99.6 d_p = 1.02 μm[1]
- Flexible
  - Variable flow
  - Variable height orifice

1. Lin, X., et al., Effect of Sampling Time on the Collection Efficiency of All-Glass Impingers. *Am. Ind. Hyg. Assoc. J.* 58:480-488 (1997)

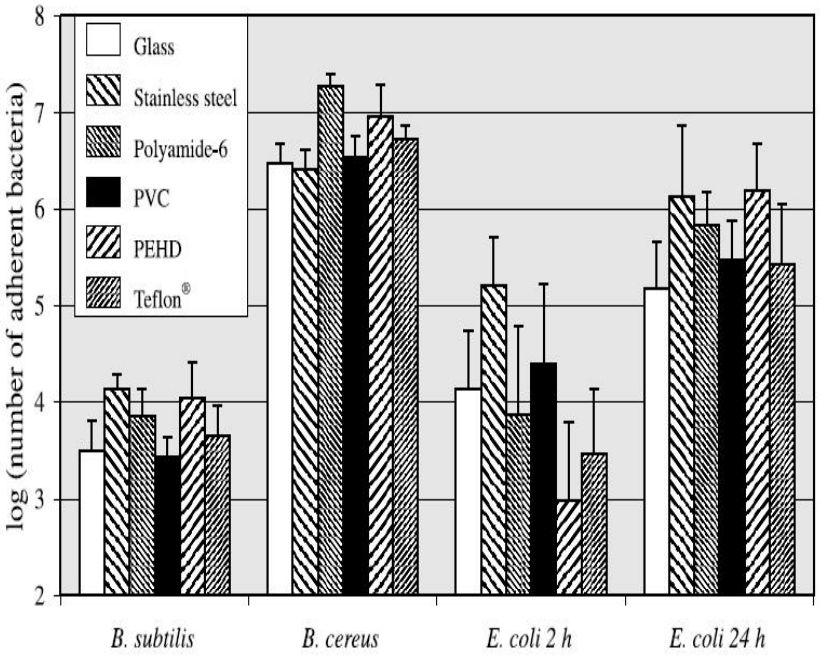
Objective

- All-Glass Impinger (AGI)
  - Critical orifice nozzle
  - 6 or 12 L/min nominal flow rate
  - Fixed 4 mm orifice spacing
- Midget Impinger
  - Subsonic nozzle
  - 2.5 to 3.1 L/min flow rate
  - Very inefficient

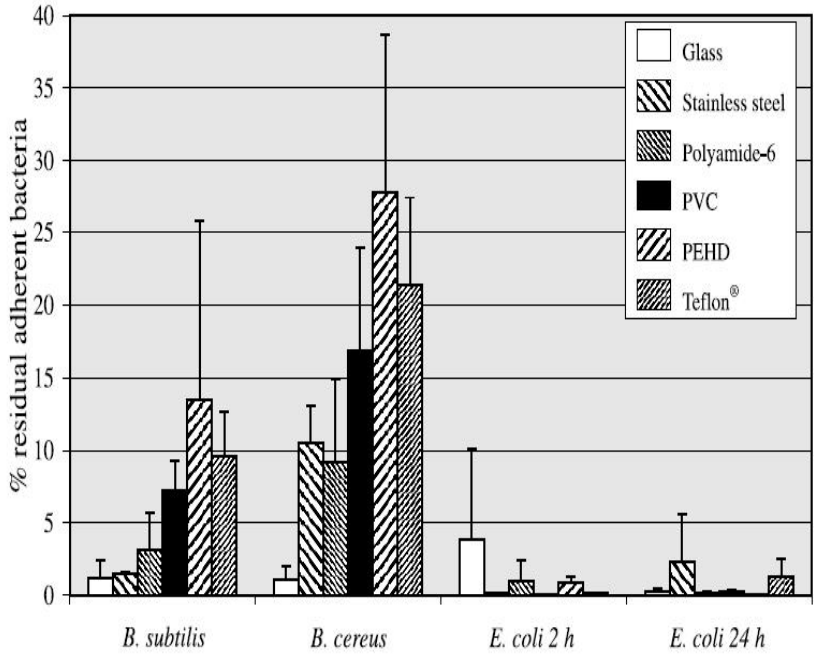


Objective

Spore and Cell Adhesion[2]



Residual Spores and Cells[2]



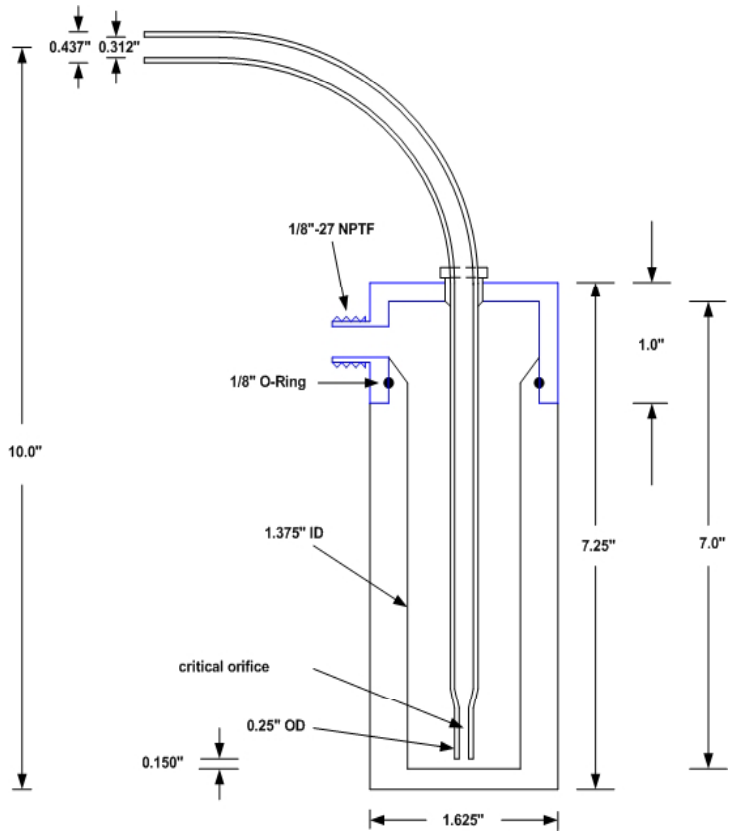
2. Faille, C., et.al., Adhesion of Bacillus spores and Escherichia coli cells to inert surfaces: role of surface hydrophobicity. *Can. J. Microbiol.* 48: 728-738 (2002)

Objective

- Critical orifice diameter calculation[3]:

$$D = 1.66 \times 10^{-2} \sqrt{\frac{Q\ \rho_a\ \sqrt{T}}{C\ P\ \pi}}$$

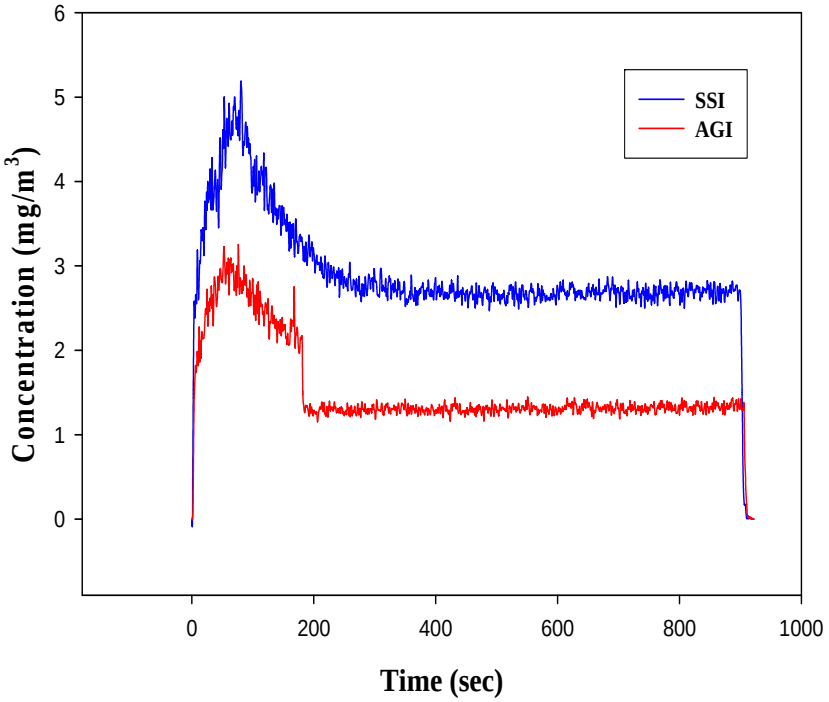
where ρ_a = density of air, g/L
T = upstream temperature, degrees Rankine
P = upstream pressure, psi
C = coefficient of discharge (0.6 to 1.0)
Q = flow rate, L/min
D = orifice diameter, inches



3. Newton, G.J., *Critical Orifice Memo*, LRRI, 1996

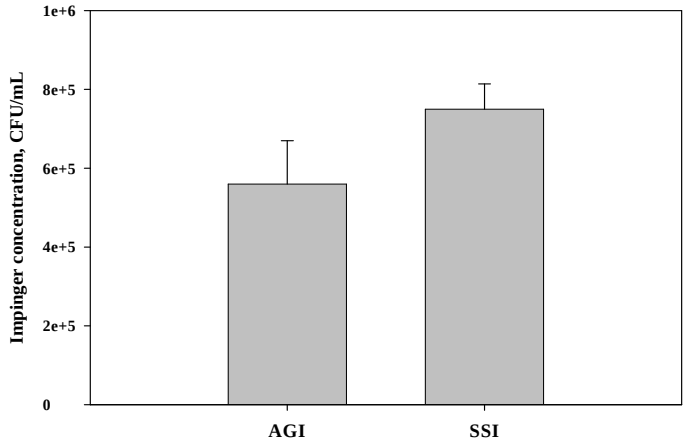
Results

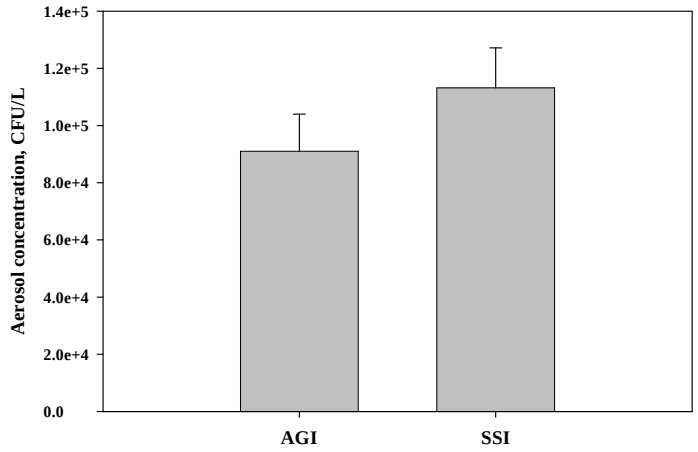
- Particle Conservation
  - Prepare two identical nebulizer suspensions
  - Collect nephelometer sample and AGI sample
  - Collect nephelometer sample and SSI sample



Results

- Head-to Head Comparison
  - Prep nebulizer
  - Collect AGI and SSI samples simultaneously
  - Determine impinger concentration
    - Expected higher AGI concentration
  - Calculate aerosol concentration
    - Expected equivalent aerosol concentrations



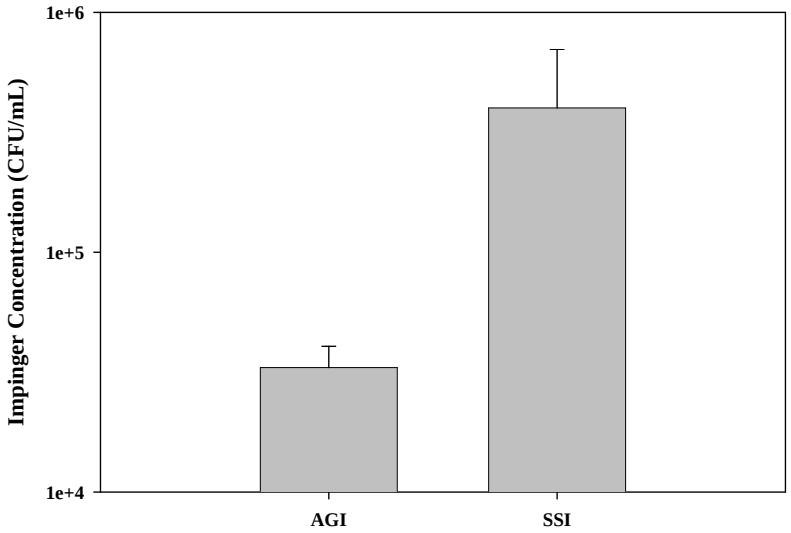


Results

Results

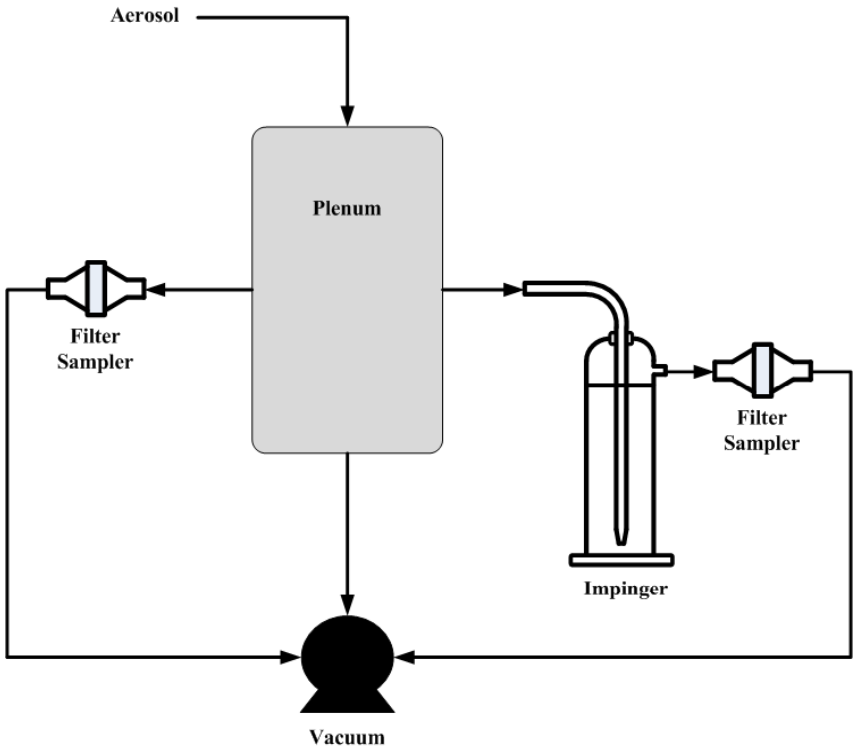
Results

- Impinger Spore Adhesion
  - Prep identical spore suspensions in AGI and SSI
    - 5.0E+06 CFU/mL
  - Percolate filtered air through impingers
    - Equal volumes of air
      - AGI = 15 min
      - SSI = 26 min
  - Plate aliquot from each impinger
  - Determine concentration



Results

- Impinger Efficiency
  - Prepare identical nebulizer suspensions
  - Connect filter sampler to plenum
  - Connect filter sampler to upstream side of impinger
  - Connect impinger and filter sampler to plenum
  - Collect samples simultaneously



Results

- Impinger Efficiency
  - Calculate efficiency

$$E(\%) = 1 - \frac{C_{upstream}}{C_{downstream}} \times 100$$

SSI

Filter Location	Concentration (µg/L)	Efficiency (%)
Upstream	0.150	97.6
Downstream	6.127	

AGI

Filter Location	Concentration (µg/L)	Efficiency (%)
Upstream	0.148	96.1
Downstream	3.753	

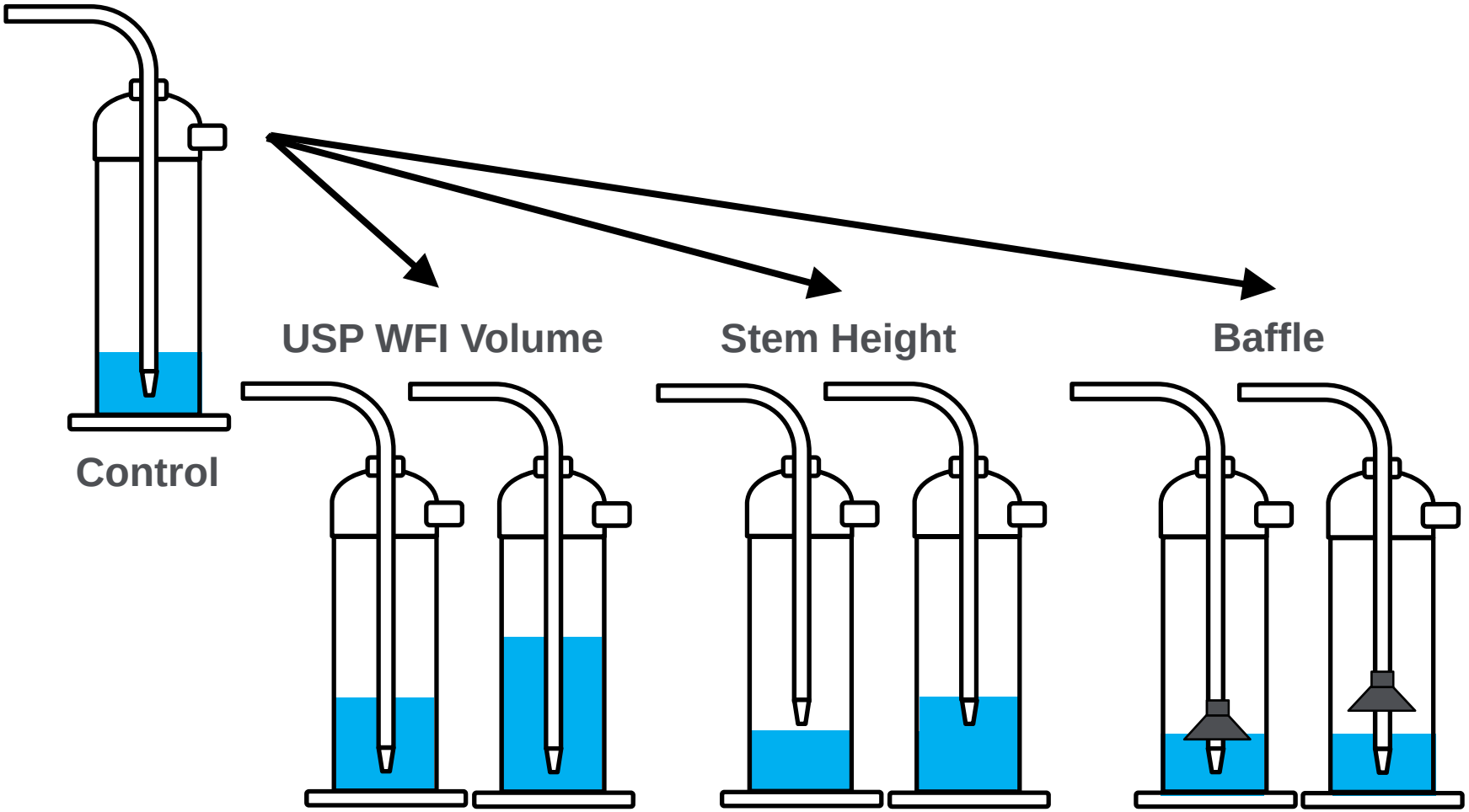
Results

- Impinger Configuration Optimization
  - Spray Factor
    - An indication of bacterial particulate transfer in the inhalation challenge system
    - Assumes unit density and 1 mL = 1 cm^3 = 0.001 L
    - Defined as:

$$SF = \frac{Aerosol\ \ Concentrat\ ion}{Nebulizer\ \ Concentrat\ ion} \times 1000\ mL / L$$

    - As aerosol concentration increases, spray factor increases

Results



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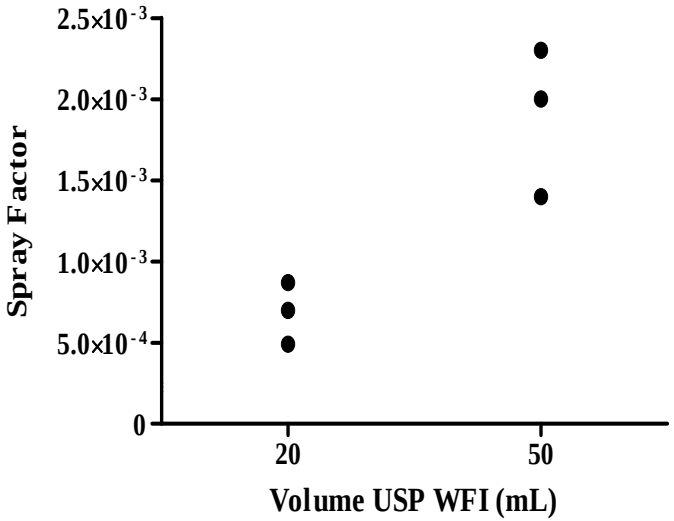

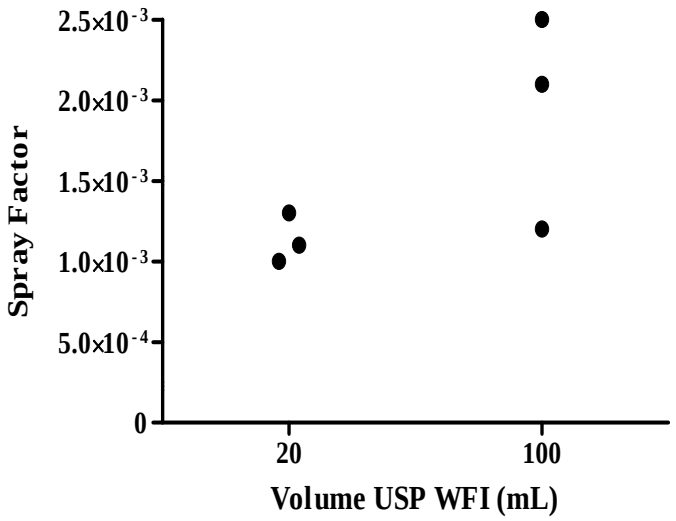

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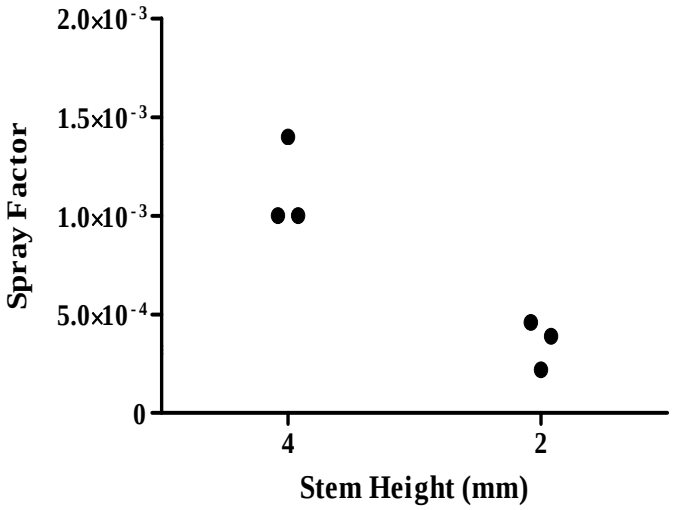

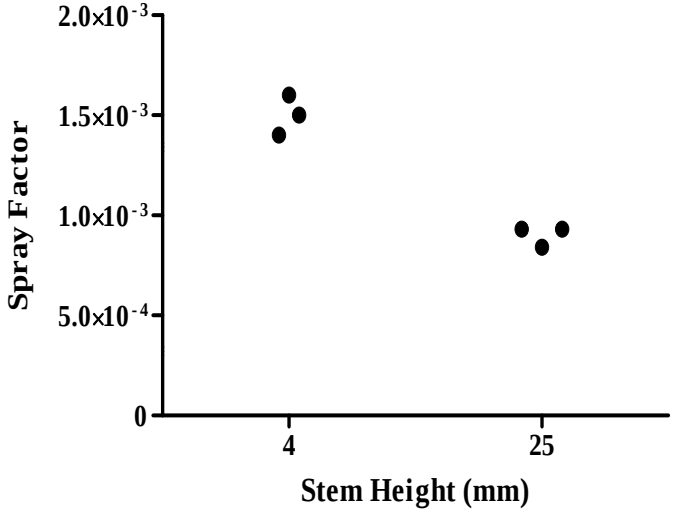

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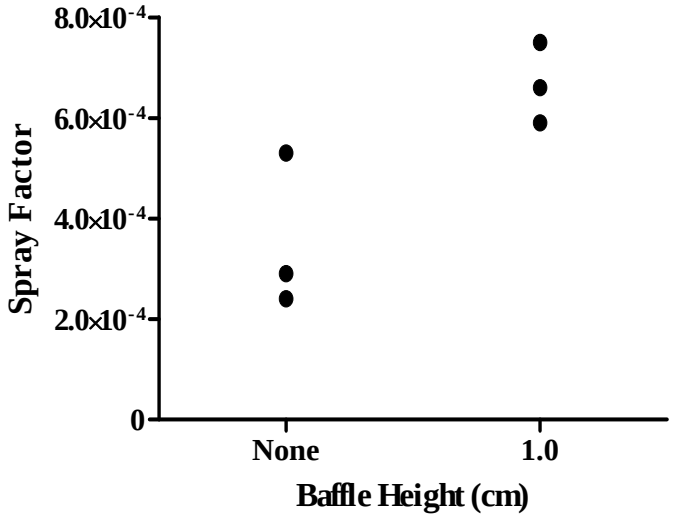

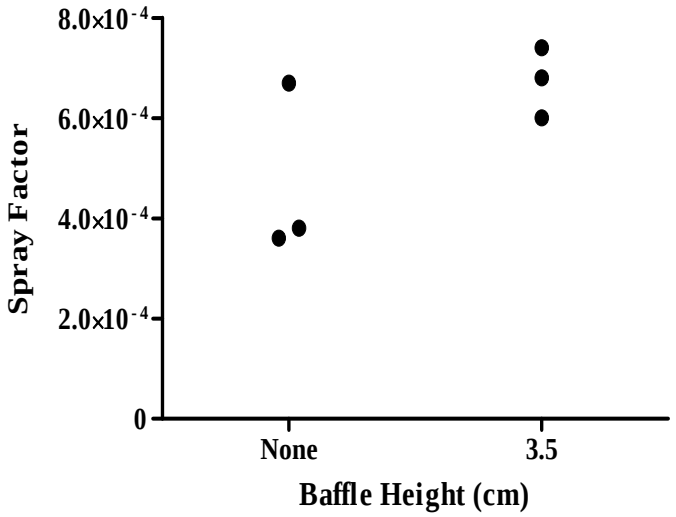

Conclusion

- Developed an acceptable alternative to the glass impinger
  - Safe construction
  - Efficient
  - Flexible
- Optimized the impinger design
  - Impinger jet stem height 4 mm
  - Impinger liquid volume 50 mL
  - Baffle added

Questions?