A Personal Sampler to Estimate Particle Deposition in the Human Respiratory Tract

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Introduction

- Measurement of aerosol deposition is a better surrogate for dose, risk assessment.

Advantages of Estimating Deposition vs. Exposure
- Not all inhaled particles deposit in the respiratory tract.
- Filter based samplers measure all particles (inhaled and exhaled).
- This results in error
  - Deposition vs. Inhalability
  - Deposition vs. PM2.5
- A sampler that mimics lung deposition may minimize this error.

Measurement Error: Exposure vs. Deposition

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Aerosol Deposition Model

Lung deposition sampler engineered from porous foam.

\[
D = 1 - \exp\left(-\frac{t}{\tau}\left(a(St)^b + c(Ng)^e + e(Pe)^f\right)\right)
\]

Clark et al. (2009)

Designing the Foam Sampler

- Inexpensive
- Lightweight
- Reliable

Using off-the-shelf parts the deposition sampler was built for <$100 and weighs about 0.3 kg (0.5 lb).

Battery Operated Pump Performance

- Tested variation in flow over a typical 8-hr exposure period.
- Linear decrease in flow rate with running time, due to the battery.
- The ~10% decrease in flow has a negligible effect on the deposition efficiency of the foam.

Real-Time Exposure Monitoring

- Can apply on a real-time basis using a condensation particle counter or nephelometer (here, Personal DataRam, pDR, Thermo Scientific, Inc.).
- Unmodified pDR gives the total aerosol concentration in mg/m³.
- pDR with the foam insert measures the exhaled portion.
- *Deposited Aerosol = Total Aerosol – Exhaled Aerosol.

Battery flow rate and battery voltage (after poloniometer) as a function of running time of the battery.

Known Limitations

- Gravimetric analysis influenced by humidity, electrostatics.

Conclusions

- A foam sampling system was developed that mimics the aerosol deposition in the human respiratory tract and is expected to provide a more physiologically relevant estimation of risk.
- This sampler presents a significant reduction in cost because inexpensive pumps can be used to control flow.
- Some difference in total and deposited aerosol concentration are noted for common exposures.

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References:


ICRP deposition fraction compared to ICRP (1994) total deposition and inhalable fraction. The red line represents modeled data; the symbols represent experimental data. Error bars represent one standard deviation.


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