An Aerosol Sampler for Regional Lung Deposition

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1. Overview
A Lung Deposition Sampler was designed to mimic the regional deposition of aerosol in the human respiratory system.
- Estimating deposition is expected to provide a more physiologically-relevant estimation of risk.
- Substrates are foam and nylon screens that are amenable to chemical analysis.

2. Regional Lung Deposition
- Preliminary work used one collection substrate to represent the entire respiratory system (Koehler et al. 2009).
- Respiratory system is divided into three sections:
  - Head Airways
  - Tracheobronchial Region
  - Alveolar Region

3. Exposure ≠ Dose
- Filter-based sampling is state-of-the-art for aerosol exposure assessment.
- Typically collect all particles smaller than a given size (i.e., PM<sub>10</sub>).
- A large fraction of inhaled PM is exhaled, leading to biased estimation of dose.
- Bias depends on aerosol size distribution.
- Lung dose is difficult to measure but lung deposition is possible.

4. Lung Deposition Sampler
- Previously, we developed a dimensionless model to determine substrate parameters that mimic the regional deposition fractions given by the International Commission on Radiological Protection (ICRP model, 1994).
- Head Airways region represented with two pieces of foam
- Tracheobronchial region represented with two pieces of foam
- Commercially available nylon net screens (Millipore Corp.) were used to mimic Alveolar Deposition.
- The sampler has been configured to operate at 1 m<sup>3</sup> hr<sup>-1</sup> (16.7 L min<sup>-1</sup>).

Foam 1: L= 4.6 cm, D= 0.8 cm, 60 PPI

2 Foams (Head Airways)
PM10 Inlet

30 cm

Foam 2: L= 0.6 cm, D= 4.0 cm, 60 PPI

2 Foams (Tracheobronchial)

Foam 3: L= 4.4 cm, D= 1.1 cm, 45 PPI

4 screens, D= 9 cm, 6 µm fibers

Foam 4: L= 5.0 cm, D= 1.8 cm, 45 PPI

Regional Deposition

Pressure drop through the engineered foam (total deposition sampler) and filter media as a function of aerosol mass loading.

Amenable to a variety of analyses.
- Substrates analyzed by:
  - Elemental analysis by inductively coupled plasma mass spectrometry (Dillner et al. 2007).
  - Polyfluorinated compound analysis by gas chromatography mass spectrometry (Langer et al. 2010).
  - PAH analysis by gas chromatography mass spectrometry (Sun et al. 2009).

More physiological representation of risk.

5. Advantages of a Deposition-based Sampler
- Low pressure drop.
  - Filters show an increase in pressure drop with particle loading, requiring advanced pumps to maintain the correct flow.
  - The engineered foam showed a constant pressure drop, even for very large loadings.
  - Even at 16.7 L min<sup>-1</sup>, the pressure drop through the sampler is only 5.5 inches of water.

6. Limitations
- Gravimetric analysis is challenging.
  - 1. Large humidity artifact
  - 2. Static problems even after careful neutralization

- A 0.1% change in mass with changing relative humidity corresponds to 60-350 µg.
- Carefully controlled weighing environment may improve LOD.

7. Conclusions and Future Work
- A Lung Deposition Sampler has been designed to provide a more physiologically-relevant estimate of risk.
- Next we will test the sampler with 24 hour samples for ambient aerosol to compare collected fractions against a measured size distribution using a MOUDI.
- Ultimately, we will deploy the Lung Deposition Sampler in occupational setting to determine the difference in estimated heavy metal dose from the Lung Deposition Sampler and traditional filter-based sampling. We expect the Lung Deposition Sampler will better correlate with measured heavy metal body burden than filter-based methods.

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References