Aerosols into Suspension Collectors, a New Approach for and Efficient Collection of Airborne Particles for Toxicological Studies

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BACKGROUND

• Accurate information on the toxicological responses to ambient aerosols is needed for human exposure models and risk assessment studies.

• In vitro exposure studies are widely used as a model to assess the interactions between air pollutants and cells.

• They are more economical than animal studies.

• Responses either in the cells or in the supernatant provide fast information regarding the toxicological properties of ambient aerosols.

• Conventional in vitro assays cannot assess accurately the toxicity of aerosols as exposure studies are limited by the sample collection system:
  1. loss of physical and chemical integrity of the particles during collection
  2. transformations during extraction and resuspension.
To eliminate the need for filter-base collection, are reduce sampling artifacts we have developed two new devices that collect ambient aerosols directly:

1) into liquid as concentrated suspension  
2) into cell culture systems

These systems use the three-stage, moderated laminar flow water condensation technology develop by Hering et al. (2014) to grow and collect particles down to 6 nm in liquid
Advantages of the ASCs:

1. *Direct collection* into liquid reduces sampling artifacts

2. *No need* for extraction and resuspension steps

3. Collects *soluble particle-phase* components, and *insoluble particles* suspended in the collection liquid

4. The *concentrated nature* of the collection allows reducing sampling times

5. Provides concentrated aerosol/particle samples ready to be characterized using *in-vitro and in-vivo* assays
1. AEROSOL INTO SUSPENSION COLLECTOR (ASC)

Specifications:
1.5, 3 or 5 lpm sampling flow rate
200-500 µL collection volume
2. DIRECT IN-VITRO EXPOSURE SYSTEM (DIVE)

Specifications:
- 8 lpm sampling flow rate
- 32 impaction nozzles to minimize disruption of the cell culture medium
- CO₂ introduced to the incoming flow (5%)
- Temperature (37°C) and RH (>90%) maintained in the collection chamber
Collection efficiencies >90% for particles sizes between 5 nm and 10 µm at moderated temperatures.
FIELD DEPLOYMENT: Michigan State University

a) Indoor (Lab testing) - March 2014
   • Biosafety level 2 (BSL-2) lab - HEPA filter
   • Low #/cc (~4x10^3) – lab ambient ai

b) Ambient - May 6-9, 2014
   • Empty office room on the first floor
   • 100-150m back side of the parking lot
   • 3 hr samples, morning and afternoon
FIELD DEPLOYMENT: In-vitro assays

**Cells:**
- Mouse leukaemic monocyte macrophage cell line (RAW 264.7)
- Human Bronchial Epithelial cell line (BEAS-2B)
- Normal Human Bronchial /Tracheal Epithelial cell line (NHBE)

**Cytotoxicity:**
- Trypan Blue
- MTS Assay

**Stimulation:**
- **Plating:** 30,000 cells/well, 24-well plates, 1 mL BEGM, 24 hr
- **Stimulation:** 0.001 m$^3$ air/mL (incense burning), 300 μL/well, 16hr
- 0.05 m$^3$ air/mL (outdoor), 300 μL/well, 16 hr

**Endpoints:**
- **Pro-inflammatory markers:** interleukin 6 (IL-6)
  interleukin 8 (IL-8)
RESULTS: Cell viability

ASC

Exposure to 0.05 m³/mL of outdoor PM did not have a significant impact on BEAS-2B cell viability.

DIVE

No major differences in viability were observed between the control and exposed cells.
RESULTS: Pro-inflammatory effects of PM (ASC)

- Ambient PM induced a:
  - 10- to 34-fold increase in IL-6
  - 5- to 25-fold increase in IL-8
- Important diurnal and daily variability in the pro-inflammatory capacity of PM
- Higher effect observed in morning periods
RESULTS: Pro-inflammatory effects of PM (DIVE)

- Differences between control and exposed cells were observed
- Higher difference for ambient PM

- A significant increase in IL-8 production was only observed in 2 of the days
- Different behavior for different days
SUMMARY

A. We have developed a new collection system for collecting ambient aerosols directly into highly concentrated liquid suspensions (ASC).

B. DIVE prototype provides the means to assess aerosol toxicity using *in-vitro* assays under realistic ambient and physiological conditions.

C. Collection Efficiencies for both systems were higher than 90% for particles sizes ranging from 5 nm to 10 µm.

D. Cell viability after exposure to ambient PM was similar to control.

E. Inflammatory responses measured as IL-6 and IL-8 production were observed for exposures to ambient particles down to 3 hrs.
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