Introduction

One challenge in evaluating the effect of air pollutants on disease is the accurate assessment of personal exposure to a broad panel of air pollutants. The fragile design and cost of this method have limited the application to personal exposure assessment of sensitive population to air pollutant mixtures.

The Fresh Air Wristband

• The Fresh Air wristband was developed to profile personal organic air pollutant exposures. This sampling device consisted of a silicone wristband with a PTFE chamber which contained our fabricated non-polar sorbent bar. While the wristband was worn, pollutants were passively collected onto the sorbent bar (Figure 4).

• Follow the exposure assessment period, the sorbent bar was removed from the wristband and analyzed offline using TD-GC-MS (Figure 5). The sorbent bars were heated to 250 ºC under a flow of He. Extracted compounds were cold trapped in split mode onto a glass wool liner cooled to -90 ºC prior to elution onto the GC. The ToF-MS was operated in full scan electron ionization mode (70 eV). Exposure concentrations were quantified using retention times and identifying ions.

• Nitrogen dioxide, a marker of tailpipe vehicle emissions, is also passively sampled with the Fresh Air wristband using a triethanolamine coated pad (GigaPul). Nitrogen dioxide exposure concentrations were measured offline using colorimetric methods.

Methods

Passive Air Pollutant Sampling

• Solid phase micro-extraction PDMS fibres have been widely demonstrated to be an efficient technique for sampling a wide panel of air pollutants. The fragile design and cost of this method have limited the application to personal exposure assessment. To make the design of the sampling device more robust, we coated a borosilicate glass rod with a thin film of PDMS (Dow Corning) (Figure 2).

• The capacity of the PDMS sorbent to absorb a range of non-polar compounds was tested through controlled laboratory exposures (Figure 3). PDMS sorbent bars were first cleaned by heating to 300 ºC under a flow of a high purity N₂ for 2 hours. Uptake on cleaned PDMS sorbent bars was evaluated using two approaches (direct infusion to a certified semi-volatile mixture and air loading) over multiple exposure periods. Retention of compounds to the sorbent material tested at different storage temperatures.

Results

Loading Duration and Storage

• PDMS sorbent bars were worn by individuals living in western MA. Following a 24 hour exposure period, PAHs were detectable on the PDMS sorbent bar (Figure 7) by comparing bars that were worn for 24 hours compared to 7 days by the same individual, lower molecular weight PAHs were closer to reaching equilibrium in the PDMS compared to heavier compounds (Figure 8).

• Lower molecular PAHs experienced losses during storage at room temperature compared to PDMS sorbent bars stored at 4 ºC (Figure 9).

Application as a Personal Exposure Tool

• A cohort of children (n=36, aged 12–13 years) living in Springfield, MA which wore the Fresh Air wristband for 5 consecutive days.

• Children with asthma (n=12) were found to have elevated exposure to nitrogen dioxide and various combustion derived PAHs compared to children with no diagnosis of asthma (Figure 10).

Conclusions

• A cost-effective wearable monitor was developed to enhance personal exposure assessment of sensitive population to air pollutant mixtures.

• Future work will focus on modifying the PDMS sorbent material to expand the sampling range to increasingly polar compounds.

Figure 1. Understanding the link between air pollutant exposure and health requires new tools that facilitate exposure assessment at critical windows of susceptibility such as pregnancy and childhood.

Figure 2. Approaches for air pollutant sampling using PDMS as a sorbent material.

Figure 3. The sorption properties of PDMS are proportional to the octanol water partitioning coefficient (log Kₗow) of a compound.

Figure 4. Personal exposure to non-polar airborne chemicals and nitrogen dioxide can be assessed using passive sampling techniques with the Fresh Air wristband.

Figure 5. Uptake of various PAHs on the PDMS sorbent bar through direct infusion.

Figure 6. Variation across replicate PDMS sorbent bars (n=5) PAHs through exposure by direct infusion and air loading.

Figure 7. GC-ToF MS total ion chromatograms of a clean PDMS sorbent bar (top) and a PDMS sorbent bar worn for 24 hours in the Fresh Air wristband (bottom). Observed peaks in the clean bar chromatogram were confirmed as airborne. Peaks uncorrelated to PAHs are labeled for the personal exposure chromatogram.

Figure 8. Percent difference in PAH uptake on PDMS sorbent bars air loaded for 24 hours compared to 7 days.

Figure 9. Percent difference in PAH recovery on PDMS sorbent bars stored for 24 hours at 23 ºC compared to 4 ºC in order of increasing molecular weight.

Figure 10. Ambient air pollution is composed of many chemical compounds. Organic air pollutants include VOCs.