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Miniature Electrostatic Precipitator for Gas Chromatography–Mass Spectrometry Aerosol Analysis

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INTRODUCTION

- The World Health Organization considers air pollution the world's largest environmental heath risk[1]
- Personal exposures to particulate matter (PM) pollution are 2-3 times higher than levels measured by stationary insruments[2]
- Chemical composition and mass concentration of PM exposure are important for assessing health risks[3]
- Polycyclic Aromatic Hydrocarbons (PAH) are carcinogenic compounds from incomplete combustion useful for source identification[4]

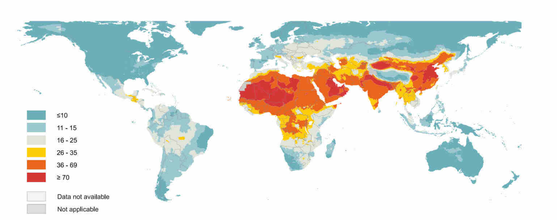

Figure 1. Map showing global $PM_{2.5}$ air pollution as modeled by the World Health Organization.[1]

OBJECTIVES

- Develop a low cost electrostatic collector capable of collecting ultrafine PM for personal sampling applications
- Improve the design of personal samplers for PM with the goal of better understanding health risks of PM exposure
- Characterize PAH content of PM collected by the electrostatic collector

Table 1. EPA priority PAH compounds[5] measured by GC-MS.

PAH	Structure	PAH	Structure
Naphthalene (NA)		Chrysene (CHR)	
Acenaphthene (AC)		Benzo[b] fluoranthene (BbF)	
Acenapthylene (ACN)		Benzo[k] fluoranthene (BkF)	
Fluorene (FL)		Benzo[a]pyrene (BaP)	
Phenanthrene (PHE)		Benzo[ghi]-perylene (BgP)	
Anthracene (AN)		Indeno[1,2,3-cd]-pyrene (IP)	
Fluoranthene (FA)		Dibenz[a,h]-anthracene (DaA)	
Pyrene (PY)			
Benz[a]anthracene (BaA)			

METHODS

SAMPLE COLLECTION

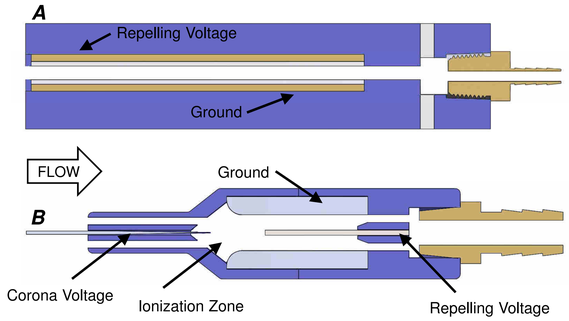

Figure 2. Cross sectional views of parallel plate collector with no ionization source (A) and tube collector with corona ionization source (B)

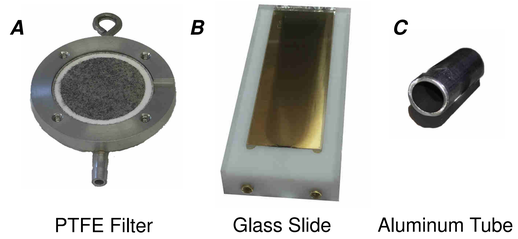

Figure 3. Photographs of sampling media after collection of wood smoke at UW Clean Cookstoves Lab. Filter collected using Harvard PEM with $PM_{2.5}$ impactor (A), slide collected with parallel plate electrostatic collector (B), tube collected with tube collector using corona ionization (C).

SIZE DISTRIBUTION

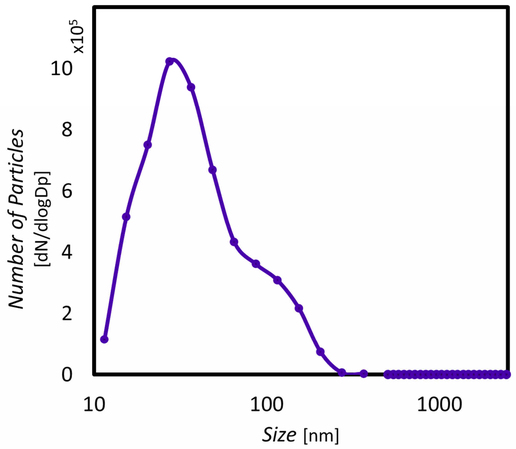

Figure 4. Size distribution of wood smoke particulate matter sampled at UW Clean Cookstoves Lab measured with TSI SMPS NanoScan (10-320 nm) and TSI APS (500-2800 nm)

RESULTS AND ANALYSIS

COLLECTION EFFICENCY

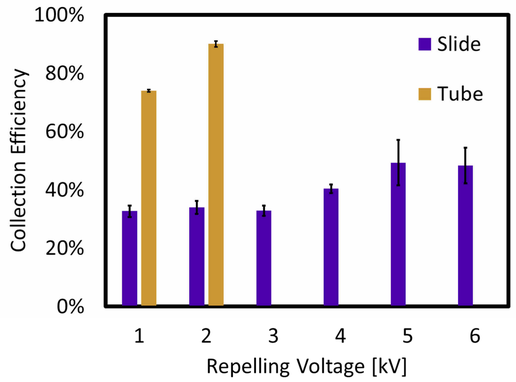

Figure 5. Collection efficiency of parallel plate and tube collectors as a function of applied voltage. Each data point corresponds to three or more measurements of particle count by a TSI SMPS NanoScan particle counter (10-320 nm) with error bars representing one standard deviation.

SLIDE COLLECTOR

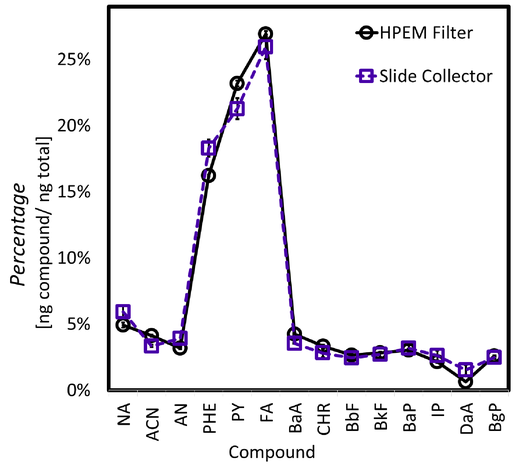

Figure 6. PAH content of filter sample and glass slide samples normalized to total PAH detected by GC-MS. Each experimental value represents the mean from a set of three experiments with error bars that correspond to one standard deviation.

- Glass slide collector 40% efficient in collecting PAH compared to filter
- Profiles normalized by total PAH detected match showing the slide collector as an equivalent sampling method to filters

TUBE COLLECTOR

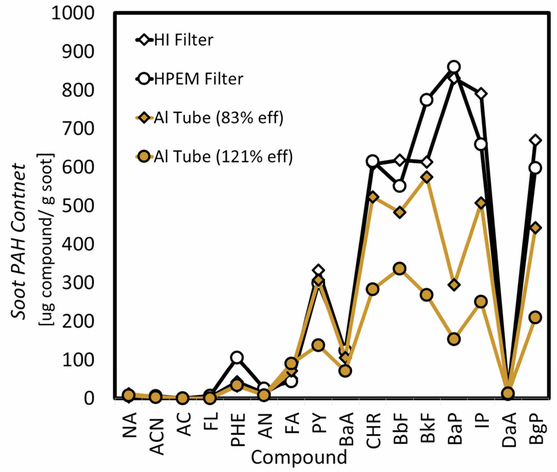

Figure 7. PAH content of filter samples and aluminum tube collector samples normalized to mass of soot collected.

- PAH content on per mass of soot basis lower for tube collectors than filters (negative sampling artifact)
- Ozone and ions generated by corona are the likely cause of observed decrease

CONCLUSIONS/FUTURE WORK

- Tube collector with corona ionization showed higher collection efficiency than slide collector
- Slide collectors gave PAH content results equivalent to filters when adjusted for collection efficiency
- Tube collector showed reduced PAH content per mass of soot collected compared to filters
- Collect and analyze PM from other sources such as diesel exhaust and cigarette smoke
- Explore low cost analysis techniques such as direct fluorescent measurement to screen samples for PAH content before analysis by GC-MS

ACKNOWLEDGMENTS

This research was funded in part by a grant from the NIH National Institute of Biomedical Imaging and Bioengineering (U01 EB021923). We thank Garrett Allawatt at the UW Clean Cookstoves Lab for helping with sample collection and Jacqui Ahmad and Russel Dills at the UW Environmental Health Lab for their assistance with GC-MS analysis.

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[1] World Health Organization. Ambient air pollution: A global assessment of exposure and burden of disease. ISBN: 9789241511353 [2] Deffner, V., et. al. *Journal of Exposure Science and Environmental Epidemiology* (2014), [3] Dai, L., et. al. *Environmental Health Perspectives* (2014) [4] International Agency on Cancer Research (IARC) [5] US EPA Method 610: Polynuclear Aromatic Hydrocarbons