Design and Collection Efficiency of a New Electrostatic Capillary Collector for Fine and Ultrafine Particulate Matter

Gaurav Mahamuni, Byron Ockerman, Igor V. Novosselov
Mechanical Engineering, University of Washington

ABSTRACT

- Collection of ultrafine particulate matter having aerodynamic diameter less than 2.5µm (PM2.5) is used for sensing potentially harmful chemical and biological aerosols.
- We introduce a novel Electrostatic Capillary Collector (ECC) that collects aerosol particles in size range from ultrafine to PM2.5 directly onto an analysis substrate.
- Electric Potential applied between ring and concentric needle ionizes molecules to create positive ions.
- Particles collide with positive ions and get positively charged as they enter the device.
- Charged particles change their path due to electric field and collect on a capillary substrate.

RESULTS AND ANALYSIS

- Corona voltage generates positive ions to charge particles as they enter the ionization region.
- Electric field due to repelling voltage in collection region repels charged particles onto a fused silica capillary (OD 350µm ID 250µm).
- Device is attached to a pump to generate flow.

TESTING COLLECTION EFFICIENCY

Nebulizer dispersing fluorescent particles

Compressed Air

ECC

To Pump

Aerosol Chamber

Monodispersed fluorescent polystyrene spheres are collected in ECC at optimized conditions and on a filter

$$\text{CE} = \frac{I(\text{Capillary})}{I(\text{Filter})}$$

CE: Collection Efficiency

I(x): Bulk Fluorescence Intensity of particles collected on x

INTRODUCTION

The ECC collects ambient air particles on a capillary substrate which can be used for in-situ analysis.

MOTIVATION

- Long exposure to fine and ultrafine particulate matter (particles < 2.5µm diameter) due to air pollution is associated with respiratory and cardiovascular diseases.
- The composition of fine and ultrafine particles in air changes with pollution sources and environmental conditions in a short time.
- Sampling of these particles to understand their sources and their analysis in-situ is essential for regulatory control strategies.

PROJECT OBJECTIVES

- To design and prototype a sampling device for fine and ultrafine particles to be integrated into an analysis system.
- To optimize device operating parameters to achieve maximum collection of particles on analysis substrate.
- To test the device for collection efficiency.

EXPERIMENTAL SETUP

DEVICE DESIGN

- Air particles are sampled at varying corona and repelling voltages using Aerodynamic Particle Sizer (APS).
- The flow rate is varied from 2lpm to 4lpm and voltages applied are varied to achieve maximum collection.

CONCLUSIONS

- At the optimized operating conditions of the ECC, more than 50% of fine and ultrafine particles are collected on the capillary substrate having total surface area of 100mm².
- Collected particles on the small capillary surface can be used for spectroscopic analysis in situ.

FUTURE WORK

- Integrate in-situ analysis technique with ECC for source identification of sample.

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