Design and Performance of Personal Electrostatic Bioaerosol Sampler (PEBS)

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Keywords: Bioaerosols; Personal sampler; Electrostatic collection;
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The goal of this project is to develop a self-contained battery-operated personal electrostatic bioaerosol sampler (PEBS) featuring high collection efficiency. In addition, to be suitable for bioaerosol collection, the sampler had to produce low ozone concentrations so as not to affect the properties of collected microorganisms needed for their identification and quantification. Such a sampler is easy to wear and can be applied for occupational and environmental studies and field deployments.

In this sampler, bioaerosols are drawn into an open channel collector, electrically charged and deposited onto a removable metal plate covered with a superhydrophobic substance. To achieve high collection efficiency with low ozone production, the sampler features a novel wire-to-wire charger, where a 1-inch long tungsten wire (0.003 inches in diameter) is positioned in the center of the charging chamber (i.e., 1-inch cylinder) and connected to high voltage; a ring of stainless steel wire (0.015 inches in diameter) is the affixed to the cylinder wall perpendicular to the tungsten wire and grounded. The mixing of incoming particles and produced ions is enhanced by using a novel static air blender positioned at its inlet.

The PEBS itself has a shape of a cylinder of 1 inch (2.54 cm) in diameter, is 5 inches (13 cm) long, and is made of a static dissipative material (Delrin). The air mover and batteries are incorporated in one sampler body. At this stage of development, the sampler was tested in the laboratory at different charging and sampling voltages when challenged with polystyrene (PSL) particles ranging from 0.025 nm to 3 μm in diameter and at flow rates of 10 L/min and 30 L/min. Investigated sampling times ranged from 10 min to 4 hours. The sampler's collection efficiency was determined by measuring the amount of particles deposited on the collection plate relative to the particle concentration upstream of the sampler.

Due to the unique charger configuration, satisfactory sampler performance was achieved at relative low charging voltages of approximately +5.5 kV, while collection voltage was set to -7 kV. For the investigated particles, including the nano-sized ones, the collection efficiency was 70-90%. The observed collection efficiency did not vary significantly as a function of sampling time. Even at the longest investigated sampling time of 4 hours, the collection efficiency of ~70% was achieved. More importantly, the unique wire-to-wire charger resulted in ozone production below 10 ppb. This concentration is much lower than observed in other electrostatic collectors featuring ionizers.

Some experiments have also been performed with airborne biological particles (bacteria) and the sampler showed collection efficiencies in the 70-80% range. Overall, the new sampler concept is showing good potential as a personal bioaerosol sampler. Due to its high concentration rate, it will allow a more accurate monitoring of personal exposures to even low microorganism concentrations and thus improve the ability to identify the exposure risks and protect affected populations.

Acknowledgement
This work was supported by the Centers for Disease Control / National Institute for Occupational Safety and Health grant R21-10560.