Development of Electrostatics-based Collectors to Capture Biological Aerosols

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***Abstract*—Biological aerosol includes airborne particles of biological origin: mold spores, viruses, bacteria, fungi, and fragments or products of such particles. Studies into environmental and health effects of bioaerosols require representative, non-destructive bioaerosol sampling methods that provide adequate biomass for downstream analysis. Commonly used samplers to collect bioaerosols, such as impactors or impingers, are inertiabased techniques known to inactivate certain fraction of collected bioaerosols due to high collection velocities. On the other hand, electrostatics-based methods have low collection velocities and, therefore, have potential to be "gentle" (non-destructive) bioaerosol collection methods. Our previous work has shown that indeed electrostatics-based collectors could be used to effectively capture airborne biological particles. We recently developed an electrostatic precipitator with superhydrophobic surface (EPSS) for bioaerosol collection. In this sampler, biological particles are electrostatically deposited onto a 3.2 mm wide electrode covered by a superhydrophobic substance and then removed by rolling water droplets (20 or 40 micro-liter), which can be analyzed by various microbiological methods. The EPSS has a shape of a closed half cylinder and is made of a static dissipative material (e.g., Delrin). The round top part of the sampling chamber contains multiple ionizers (i.e., carbon fiber brushes) arranged in two lines with each line having four brushes. The flat bottom part of the cylinder contains the collection electrode. In the latest iteration of the sampler, it is comprised of two such half-cylinders thus allowing side-byside collection of duplicate samples (droplets containing removed particles). These duplicate samples can then be analyzed by different techniques, e.g., molecular methods and traditional agar techniques providing another advantage of this sampler. The sampler's performance at different sampling flow rates (20 to 60 L/min) and high voltages (-9 kV) was tested with two common bacteria and a fungus: Pseudomonas fluorescens, Bacillus atropheus, and Penicillium chrysogenum. The collection efficiency was determined using the optical-counter and microscopic counting. The tests indicated that the sampler achieves collection efficiency as high as 69%. The combination of satisfactory collection efficiency and the small collecting water droplet volumes (20 micro-liters) allowed achieving sample concentration rates that reached up to 4.9×105/min. In the upcoming experiments, this electrostatic collector with high concentration rate will be tested in a field environment against several commercial bioaerosol samplers. Using similar principles, we are currently developing a personal electrostatics-based collector for bioaerosols. The airborne particles are drawn into an open channel sampler, electrically charged using carbon fiber ionizer and deposited onto a plate covered by a superhydrophobic substance. After sampling, the plate is removed and the collected particles**

washed-off with a desired amount and type of liquid to be analyzed by one or more techniques. Due to low pressure drop of the open channel design and low electrical current requirement, power for both the air mover and the electrostatic collector can be provided by a built-in battery. Low power consumption and small size make this sampler easy to wear and highly applicable for occupational and environment studies and field deployments.