Collection of submicron aerosols by a passive sampler system using corona-charged resin surfaces

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Keywords: design, electric field, outdoor, PM1.0
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Collection of outdoor aerosols using passive samplers has been mostly restricted to particles larger than 1 μm (Brown *et al.*, 1992; Wagner and Leith, 2001). The main objective of our study was to design a system for collecting submicron aerosols on a substrate. A relatively flat substrate with particles can become a target for elemental analysis (e.g. X-ray Fluorescence Spectroscopy (XRF)) or electron microscope methods. Comparing with larger particles, transport of submicron particles can be more influenced by electrostatic force (Katata *et al.*, 2010). Considering that an electret can be used as a collector surface of passive sampling (Brown *et al.*, 1992), and corona-charge can create an electrified polymer surface (Giacometti *et al.*, 1999), we have newly designed and fabricated passive samplers based on corona-charged resin substrates.

Two sampler systems were designed. Numerical flow simulation using COMSOL Multiphysics and electrostatic-model were performed to investigate the wind flow around and inside the sampler and the electric field around the sampling substrates, respectively. Fine metallic mesh with 1.0 mm hole size was placed to "block" the high-speed wind flow. Low-speed wind flow will allow the electrical field to be the main driving force of particle deposition. In the first type sampler (Type-1), a charged surface was faced down to maximize the role of gravity to “filter” large particles. In the second type sampler (Type-2), two charged surfaces are facing each other. As a preliminary sampling experiment using 2 m^3 chamber, aerosols from combustions of Mg ribbons were sampled. Outdoor aerosols were collected from Tokyo (university experimental forest station, 14 days, December-January), and northern Borneo (Kota-Kinabalu (KK) city, 3 days, November). In Tokyo, 30 m height tower was used to investigate the influence of tree/forest canopy. Substrates with collected particles were analyzed using an Energy-Dispersive XRF and Scanning Electron Microscopy routes (SEM or FE-SEM). Trajectory of air masses and meteorological data (METEX, NIES) were monitored to clarify the source of collected particles.

Based on SEM images (Fig.1), in general, Type-1 collects particles with higher number concentration than Type-2. Type-1 collects wider size range (from 0.05-3.0 μm), and Type-2 collects “only” submicron (0.1-0.7 μm) particles. Micron particles will be detected as “stronger” elements in XRF measurement. Therefore, particle collection in “only” submicron size (using Type-2) is a crucial condition.

From the results of Type-2, it is clear that size of particles (with peaks are around 0.15 μm) in KK were smaller than those of Tokyo (around 0.5 μm or above). From the local governmental websites, one can monitor that PM_{10} values in KK are higher than that of Tokyo. XRF data also showed that elements (Zn and others) of aerosols in Tokyo are more diverse than those of KK. In the winter period, Tokyo area is affected by the Asian winter monsoon that developed from northern China and brought long-range air masses (Wakamatsu *et al.*, 1996). After comparing the number concentration of particles collected on charged- and uncharged substrates, there are more “charged” submicron particles than “uncharged” ones at Tokyo site. However, at KK site, uncharged substrates have more particles than charged ones. In KK, our sampling days were rainy. Relative humidity values of KK and Tokyo were around 90 % and 50 %, respectively. Humidity might decrease the collection efficiency of charged aerosols.

In conclusion, the main finding can be summarized as follows: (i) the newly developed passive sampler system can collect “only” submicron outdoor aerosols, (ii) submicron particles can be detected by XRF method for multi-elemental analysis, and (iii) relative humidity influences the collection efficiency.

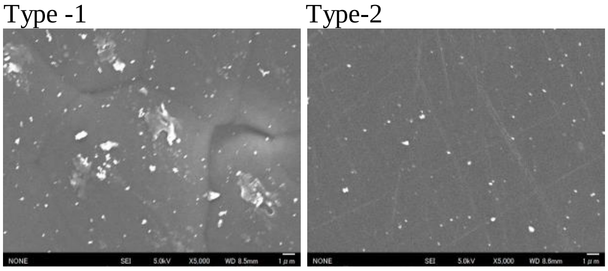

Figure 1. SEM images of substrate with particles collected in Kota Kinabalu (3 days). Bar is 1μm

This work was supported by MEXT/JSPS Kakenhi (26420761). The authors wish thank to Drs. K. Matsuda, H. Hara, and M. Tsukada for scientific advice.

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