Extended Abstract of PSA-19

P-06

Analysis of dissolved components from diesel soot particles

Toru Murata,[1] Kodai Takano,[2] Masato Morita,[2,*] and Tetsuo Sakamoto [1,2]
[1] *Graduate School of Electric Engineering and Electronics, Kogakuin University,*
2665-1 Nakano-machi, Hachioji, Tokyo 192-0015, Japan
[2] *Department of Applied Physics, Kogakuin University,*
2665-1 Nakano-machi, Hachioji, Tokyo 192-0015, Japan
* corresponding author's e-mail: kt13544@ns.kogakuin.ac.jp

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Since diesel soot particles (black carbon, BC) is a very fine particle of about 10 to 50 nm, there is a possibility that it invades deep into human lungs. In order to evaluate the impact of BC on human health, it is necessary to observe the detailed structure of BC along with toxicology. Focused ion beam time-of-flight secondary ion mass spectrometer (FIB-TOF-SIMS) developed by the authors, has a high spatial resolution and low detection limit, and the components imaging of individual particle can be analyzed with many kinds of aerosol. However, since BC is very small, the detailed structure of particles cannot be observed directly with the FIB-TOF-SIMS. In this study, in order to evaluate the structure of BC, we combined a new aerosol dialysis method and the FIB-TOF-SIMS. In this method, even if the lateral resolution is insufficient, the structure of BC can be visualized with separating the particles and surface adhering components, respectively.

1. Introduction

Recently, the problems of air pollution become worse due to the economic development in East Asia. Aerosol particles are transboundary-transported to Japan, and the influences upon human health and climate change are feared [1)]. The fine particle typified to $PM_{2.5}$ has a fear that it invades into the human lungs deeply. Among them, black carbon (BC) is very fine particle less than sub-micrometer in diameter. One of the forms of BC in atmosphere is diesel soot particles which are emitted from factories and automobile exhaust gases. Diesel soot particles are formed with gathering primary particles of BC about 10-50 nm by both organic and inorganic matters [2)]. The impact to health of BC has been evaluated by experimental exposure to animal lungs, but its mechanism has not been fully elucidated [3)]. In order to evaluate the health impact of BC, it is necessary to observe the detailed structure of particle along with toxicology. However, there is no analytical method that can clarify the structure of individual BC particle, because the BC is very small. The individual particle analysis of other kinds of aerosol have been carried out using time-of-flight secondary ion mass spectrometry (TOF-SIMS) and energy dispersive X-ray spectrometry (EDS) with scanning electron microscopy (SEM) [4, 5)]. Individual analysis of BC requires chemical state analysis with high lateral resolution and high detection sensitivity. On the other hand, only the shape information of BC can be observed with vary high resolution by SEM and transmission electron microscopy (TEM). Therefore, it is possible to evaluate the structure approximately by shape observation before and after separating the target component with an appropriate solvent. This is called aerosol dialysis method [6)]. In this study, in order to evaluate the structure of BC, we combined the aerosol dialysis method and FIB-TOF-SIMS observation. In the conventional dialysis method, a target component is removed into a solvent by permeation using a collodion membrane. It was only possible to observe the shape of the undissolved material that remained. So we improved the dialysis method so that we can analyze dissolved matter. By dialyzing particles on a flat and smooth substrate by electrospray, the dissolved components remain as stains around the particles. Figure 1 shows the schematic of Conventional dialysis method and electrospray dialysis (ESD) method.

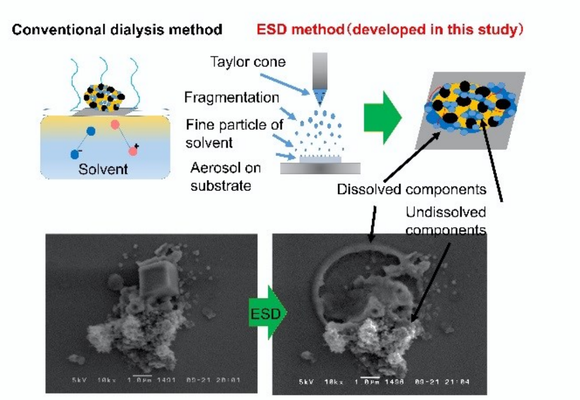

Figure 1 The schematic of conventional dialysis method and electrospray dialysis method. Bottoms show the SEM images of aerosol particle before and after ESD with same field of view.

2. Experimental

Aerosol for dialysis analysis was collected on a crystalline Si substrate (Nilaco, 0.5 mm thickness) by the lab-made aerosol sampler [7]. This sampler collects particles with an impactor method while raster the substrate. So, the particles can be collected uniformly without overlapping. Particles were collected for 30 min at a flow rate of 1.5 l/min in Hachioji-city. Then dialysis of aerosol was performed with acetone for organic matter and the water for inorganic one, respectively. The ESD was proceeded under following conditions. The distance between the tip of electrospray needle to the silicon substrate was 2 cm, the voltage applied to the electrospray needle was 4 kV and the flow rate was 2 ml/min. The collected BC was searched from the substrate and the shape of collected particles was observed by SEM (APCO, Japan) with 3 keV acceleration. Then, an elemental imaging was obtained by FIB-TOF-SIMS. The FIB-TOF-SIMS apparatus developed in our laboratory was equipped liquid metal ion source with 30 keV acceleration as primary ion beam. In the FIB-TOF-SIMS analysis, the three samples, acetone ESD, water ESD and untreated sample, were compared.

3. Result and Discussion

Figure 2 shows the SEM images of diesel soot particle at the same field of view before and after ESD with the acetone and water, respectively. In the SEM image before water ESD, there are bright soil type oxide particles and low brightness particles around the diesel soot particles. Particles with low brightness are sulfate or nitrate aerosol with highly water-solvable. In the SEM image after water ESD, there are no particles with low brightness, and only hydrophobic particles with high brightness remain. Since the relative positions of the undissolved particles have not changed, it can be seen that only the target components can be dialyzed without applying physical impact to the particles. It was found that dialysis is also possible with ESD method. The appearance of diesel soot particles was not changed dramatically by water ESD. On the other hand, in the case of acetone ESD, the particle shape changed dramatically. Also, sulfate aerosol around diesel soot particle did not change. When this method is combined with a surface analysis method such as TOF-SIMS, it is possible to perform component imaging including a chemical state information.

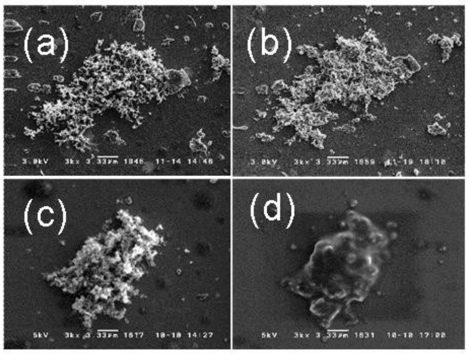

Figure 2 SEM images of diesel soot particle. (a) and (b): before and after water ESD, (c) and (d): those acetone ESD.

4. References

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