Extended Abstract of PSA-19

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Shape identification and classification of aerosol particles using SEM image

Ryota Koiwai,[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: ct13087@ns.kogakuin.ac.jp

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For the analysis of aerosol, the bulk analysis method of collected particles on a filter is widely used. In the bulk analysis, the information with high accuracy as the averaged value of collected particles can be obtained, but the information of individual particle is disappeared. Some surface analysis techniques such as SIMS and SEM-EDX have also been employed for individual particle analysis. Since the individual analysis for all the collected particles is not realistic in terms of analytical time, statistically reliable data cannot be obtained. Therefore, it is difficult to compare the data of individual particle analysis with bulk analysis data and discuss the abundance ratio of particles. In this study, aerosol was analyzed with a high resolution by means of FIB-TOF-SIMS developed by our group. From the results of the individual particle analysis, it was found that there is a good correlation between the aerosol type and shape of particles. But, these need much time and labor. Therefore, a method for classification particles from shape data was devised. Based on a shape to be provided from an SEM image, they are classified by means of cluster analysis.

1. Introduction

Many fine particles (aerosol) exist in the atmosphere where we live. In recent years, by the economic development of the Asian region, harmful aerosol emitted from industrial zones becomes a serious problem. Particularly, the interest in human health impact and environment issues such as acid rain cause in relation to aerosol increase. In case of analysis of aerosol, bulk analyzing method of all the collected particles on a filter is widely used. In the bulk analysis, information with high accuracy as the average values of collected particles can be obtained. Therefore, it is difficult to compare the data of individual particle analysis with bulk analysis data and discuss the abundance ratio of particles [1]. In this study, aerosol was analyzed with a high lateral resolution FIB-TOF-SIMS developed by our group [2]. From the results of the individual particle analysis, it was found that there is a good correlation between the aerosol type and its shape. Therefore, a method for classification particles from shape data was devised. Based on a shape to be provided from an SEM image, they are classified by means of cluster analysis.

2. Method

Aerosol particles were collected on a flat silicon substrate (Nilaco, 0.5 mm thickness) by the hand-made aerosol sampler which can collect aerosol on flat substrate with uniformly by movable stage [3]. Next, SEM (3.0 kV, JSM-6700F, JEOL Ltd.) observation was performed. Figure 1 shows photograph and SEM image of the aerosol particles collected on the silicon substrate. The image analysis was performed for SEM image using a software "ImageJ" in order to pick up the shape parameters of each aerosol [4]. Cluster analysis was performed using the obtained shape parameters of particles. The statistical software "R" was employed for cluster analysis based on clustering for similar shape. In this study, cluster analysis was performed using three shape parameters, Circ (circularity), Round (roundness), and Mean (average gray value) extracted

from the SEM image using "ImageJ". There are many yellow sands that are relatively large size. From this, the filter was applied with a size of 2.5 μm from a certain size.

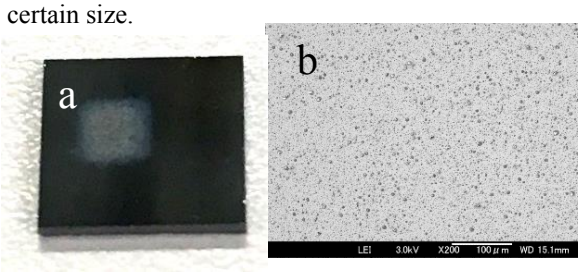

Fig. 1 (a) Photograph of aerosol sample collected on a Si substrate. (b) Low magnification SEM image of collected area.

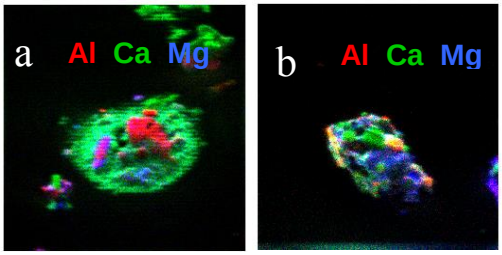

Fig. 2 Positive mode TOF-SIMS maps of main components in (a) dissolved yellow sand (chlorinated yellow sand), (b) dry yellow sand.

3. Results and Discussion

Figure 1 shows the collected aerosols on Si substrate. Aerosols were collected uniformly on the surface. This means that aerosols in an arbitral area are enough to be analyzed to obtain whole information of the collected aerosols. In this paper we focused on yellow-sands. As shown in Fig.2, there were two types of yellow-sand particles. Namely, dissolved particles and dry one. In general, yellow sands contains calcium with high concentration compared with the other mineral types of aerosol, and the main components are alumina, magnesia, silica and calcium carbonate [5]. Dissolved particle is thought to the reaction product of yellow-sand chlorination. The shapes of these two types are quite different. The ratio of chlorination will provide us the information on the trajectory of the particle during the emission and collection.

Using SEM images of the same sample, shape-parameters were extracted, and then classified them using cluster analysis. They were classified into four clusters (groups) as shown in Fig.3. Cluster1 was "dry yellow-sands". Cluster 2 was "dissolved yellow-sands". However, the rest of the clusters (3 and 4) were neither dry nor dissolved yellow-sands. These two clusters were other kinds of aerosols. After the clustering, the TOF-SIMS measurement was proceeded for the typical particles of each cluster, and we confirmed that cluster 1 and 2 were yellow sand. By a number of previous TOF-SIMS analyses, it was found that there is a good correlation between the aerosol type and its shape. Therefore, by performing component analysis once for obtaining the correlation, classification can be performed only by shape.

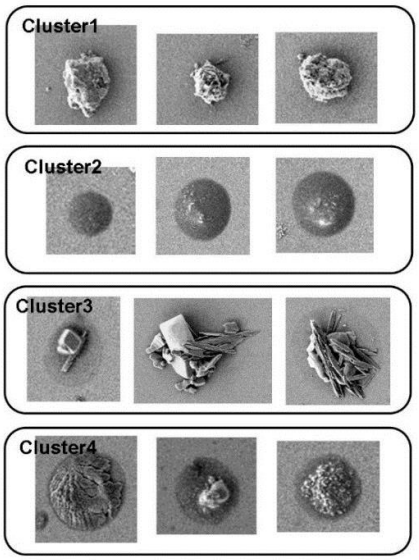

Fig. 3 SEM images of typical aerosol particles of each cluster.

4. Conclusions

Although yellow-sand was used this time to examine our methodology, it can be said that classification can be performed quickly if the particles have a correlation in shape. Not only yellow sand, but also correlation with shape can cope with various particles.

5. References

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