Measurement of atmospheric metal particles using an ICP-MS and TEM.

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Particles containing transition metal components (hereafter, metal particle) are one of the major aerosols. Some of these metal particles have strong oxidation potential and have health effects by deposition into the human body through generating reactive oxygen and free-radical in and on cells. These reactive oxygen and free radicals cause various effects such as oxidative stress, inflammatory cell, DNA oxidative damages and cell death. However, oxidation potential for each metal particle and the magnitude of hazard to human health are not well known. In addition, colored metal particles, such as iron oxide, absorb solar radiation and contribute to the global warming. However, these effects of metal particles are not clarified because their observations and detailed features are not well known.

In this study, we measured atmospheric metal particle concentrations using an inductively coupled plasma-mass spectrometry (ICP-MS) and collected aerosol samples on the Cu grids using impactors to observe each aerosol particle using a transmission electron microscope (TEM) and an energy-dispersive X-ray spectrometry detector (EDS) with the scanning transmission electron microscopy (STEM). The ICP-MS instrument was coupled with a gas changer for air replacement in argon gas atmosphere, so that aerosol particles were directly measured using the ICP-MS in real-time. As a result, we could measure time trends of atmospheric metal particle concentrations quantitatively with high time resolutions together with their shape and mixing states by the TEM and STEM-EDS analysis.

We measured atmospheric metal particles in winter (2018/1/17–2/8) and in spring (2018/5/8–5/30) at Fukuoka University. We measured increasing events of metal particles by ICP-MS. Fe and Al were the highest concentration followed by Zn, Mn, Cr and Pb. Two different slopes were observed in relation between Fe and other metal elements such as Mn, V, and Al. On the other hand, Ag, Au, Mo and Tc did not correlate with Fe. From TEM observation of samples with high concentrations of metal particles, we found aggregated metal particles as ultrafine metal spheres (for smaller particles were several nm). These particles contained Fe, Mn and Cr as major metal elements, and most particles were internally mixed with a sulphate. Furthermore, some metal particles contained many ultrafine metal particles that distributed separately in a sulphate. Zn and Pb containing particles were also internally mixed with sulphate, however, they were observed as dissolved substances (not particle state) or crystallized state, which were decomposed by electron beam.
We found other metal particles which contained such as Ag, Sb, and Cu during their increasing periods. Our results are useful for understanding of atmospheric metal particles behaviors.

Keywords: Oxidation potential, Metal particle, ICP-MS, TEM, Feature observation