Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

AAS22-12 Room:511 Time:May 1 10:00-10:15

Light absorption and morphological properties of soot-containing particle mixed with sulfate observed at Noto Peninsula

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Black carbon (BC) in atmospheric soot particle is known as strongly absorber of visible spectrum solar radiation in the atmosphere. The coating materials on soot particle can enhance the magnitude of light absorption by the soot-containing particles, according to the coating conditions including composition, amount and morphology. Several studies have indicated that the estimation by assuming core-shell shaped particle and simple composition tends to estimate larger than that for the real soot-containing particles (Adachi et al., 2010; Lack and Cappa, 2010; Cappa et al., 2012). To elucidate the enhancement of light absorption of aged soot-containing particles and their relation with the individual particle condition, we made an observation for continental outflow at Noto Peninsula, Kanazawa, Japan, in spring 2013.

Atmospheric observations were conducted at NOTO Ground-base Research Observatory (NOTOGRO) in Suzu City, Kanazawa, Japan from April 17 to May 14 in 2014. Absorption and scattering coefficients at 405, 532, and 781 nm, and soot mass concentrations of PM1 particles were measured using the photoacoustic soot photometer (DMT, PASS-3) and a single-particle soot photometer (DMT, SP2), after passing through diffusion dryers and one of the heaters controlled at 25, 300, and 400 deg C every 10 min. Aerosol samples were collected using two-stage cascade impactors (50% cutoff diameters of the two stages were 1.5 um and 0.3 um) on carbon-coated nitrocellulose (collodion) films for individual analysis using a transmission electron microscope (TEM). Elemental compositions of individual particles were analysed for particles on second stage using an energy-dispersive X-ray spectrometer (EDS) used along with the TEM. Mixing states between non-volatile chain-like soot and volatile materials to high-density electron beam were identified by comparing photograph before and after EDS analysis.

Increase in BC light absorption due to coating was estimated by comparing absorption coefficients at 781 nm with and without heating (300 deg C). The increase in BC light absorption on average was 23$\pm$25%. The maximum values of the increase in BC light absorption ($>$40%) were observed in air mass condition that derived from around Shanghai across the East China Sea, based on backward air mass trajectory analysis. In the TEM sample obtained at the air mass, most of soot were found as internally-mixed particles, which were well-embeded into round-shaped sulphate. On the other hand, increase in light absorption estimated at 405 nm was usually less than that at 781 nm over the entire observation period. Particularly the increase in light absorption at 405 nm tended to be negative under air mass derived from around Japan or the Korean Peninsula. Because absorption at 405 nm is more affected from OC, the negative values might to be attributed to formation of brown carbon in thermo denuder. In TEM sample obtained when the increase in light absorption were negative at 405 nm and $<$25% at 781 nm, most of soot were also internally-mixed particles with sulphate. The differences with sample of air mass from Shanghai were that many soot-containing particles were irregular shape, and that carbonaceous residues other than soot were found in particles after irradiation of high electron beam. Our results suggest that the variation of increase in BC light absorption were attributed to morphology and mixing state with OC of internally mixed soot-containing particles.

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Lack, D. A. and Cappa, C. D., Atmos. Chem. Phys., 10, 4207-4220 (2010)
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Keywords: Aerosol optical properties, Ambient measurement, Black carbon, electron microscope, Lensing effect