Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

AAS21-08 Room:201B Time:May 22 10:15-10:30

Optical properties of diesel exhaust particles

GUO, Xuesong[1*], NAKAYAMA, Tomoki[1], MATSUMI, Yutaka[1], Hiyroyuki Yamada[2], TONOKURA, Kenichi[3], INOMATA, Satoshi[4]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]National Traffic Safety and Environment Laboratory, [3]The University of Tokyo, [4]National Institute for Environmental Studies

Aerosol particles influence climate directly by scattering and absorbing of an incoming solar radiation and indirectly by acting as cloud condensation nuclei. Diesel exhausts partials (DEP) are known as one of main anthropogenic source of element carbon (EC), and organic carbon (OC). The light absorption of BC is generally considered to be increased by coating with OC, which is called lensing effect. In addition, recently light-absorbing OC, 'brown carbon', involving humic-like substance (HULIS), organonitrate, and nitro-aromatics etc., has been proposed as a source of significant absorption, particularly in the near-UV. However, contributions of lensing effect and brown carbon for DEP have not been well known because of the difficulty in the accurate measurement of light absorption of internally mixed BC particles without collecting on filter. In this study, a photoacoustic soot spectrometer three wavelength (PASS-3) has been applied to research optical properties of DEP.

A diesel engine was operated in a car driven on a chassis dynamometer with an urban driving mode (JE05) and constant speed mode (0 km/h or 70 km/h). The diesel exhaust was diluted and then sent through a heater before the measurement of optical properties. Absorption and scattering coefficients at 405, 532, and 781 nm of the DEP are measured by the PASS-3. Size distributions of DEP before and after heating are also measured by two scanning mobility particles sizers (SMPS) during constant mode experiments.

For the JE05 mode, optical properties were measured with inlet temperatures of 20, 100, and 300 degC. Enhancement of scattering coefficient was observed during acceleration and deceleration patterns before and after high speed driving (˜80 km/h) at 25 and 100 degC. The result that the enhancement was not detected at 300 degC indicates that emission of volatile OC compositions increased during the patterns. From the observed absorption coefficients, absorption Angstrom exponent (AAE) is calculated. The AAE values between 405 and 532 nm are found to increase during the periods when volatile OC compositions increase at 20 and 100 degC, while the AAE values are almost constant at 300 degC. By assuming that OC was removed by heating up to 300 degC and that light absorption by OC is negligible at 781 nm, the contributions of light absorption by OC to total light absorption at 405 and 532 nm are estimated to be ˜15% and $<$5%, respectively.

For the constant mode, optical properties of DEP were measured with variety of inlet temperatures between 20 and 400 degC. No significant temperature dependence of AAE between 405 and 532 nm was found in both case of idling and 70 km/h patterns. The result indicates that the contribution of light absorption by OC is small ($<$6%). By comparing absorption coefficients at 20 and 400 degC, increase in light absorption by coating during idling and 70 km/h patterns are estimated to be 20 and 15%, respectively.

Recently, Dr. Inomata and co-workers detected nitro-aromatics in gas and particle phases of diesel exhausts from the same car. The concentrations of nitro-aromatics in gas phase are significantly high during the same periods, when the light absorption by OC was found in the present study. Therefore, nitro-aromatics in DEP can be considered as plausible sources of light absorbing OC, observed in this study.

Keywords: Aerosol optical properties, Diesel exhaust particle, Photoacoustic spectroscopy, Lensing effect, Black carbon, Brown carbon