BLACK CARBON AND ELEMENTAL CARBON CONCENTRATIONS OF SPARK-GENERATED CARBON PARTICLES

BC/EC measurement for CARBON

BLACK CARBON CONCENTRATIONS ARE COMPARED WITH ELEMENTAL CARBON CONCENTRATIONS FOR CARBON NANO-PARTICLES GENERATED USING A SPARK-DISCHARGER. THE SHAPE OF CARBON NANOPARTICLES IS USUALLY NON-SPHERICAL CHAIN-LIKE AGGREGATE, WHICH HINDERS US FROM CHARACTER-IZING THE OPTICAL PROPERTIES AS WELL AS THE PHYSICAL PROPERTIES. IN THIS SITUATION, WE SUGGEST AN ALTERNA-TIVE METHOD FOR BETTER CHARACTER-IZATION OF NON-SPHERICAL PARTICLES. OUR METHOD INCLUDES THE MEASURE-MENTS OF ELECTRIC MOBILITY EQUIVA-LENT SIZE, THE NUMBER CONCENTRA-TION AND THE MASS CONCENTRATION. THE MOBILITY DIAMETER ALLOWS US TO ESTIMATE AN EFFECTIVE VOLUME FOR THE PALAS CARBON. FROM THE EFFECT-IVE VOLUME AND THE MASS, WE CAN EASILY OBTAIN AN EFFECTIVE DENSITY.

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INTRODUCTION

Black carbon (BC) is formed by the incomplete combustion of hydro-carbon fuels and intensively absorbs light of all wavelengths of solar radiation. BC is emitted with other particles and gases such as SO_2, NO_x and organic carbon (OC). These other gases and particles than BC sometimes create uncer-tainty associated with measurement techniques which are affected by the presence of the 'others'. In the pre-sent study, to remove the effect of the other particles and gases than BC, we have initiated the investiga-tion of the nearly 'pure' BC. The optical properties such as the absor-ption cross section as well as the physical properties such as the effective density will be estimated to characterize the pure BC. Then we compare the BC with the elemental carbon (EC) to quantify the relation between the BC and the EC.

METHOD

Particle Generation

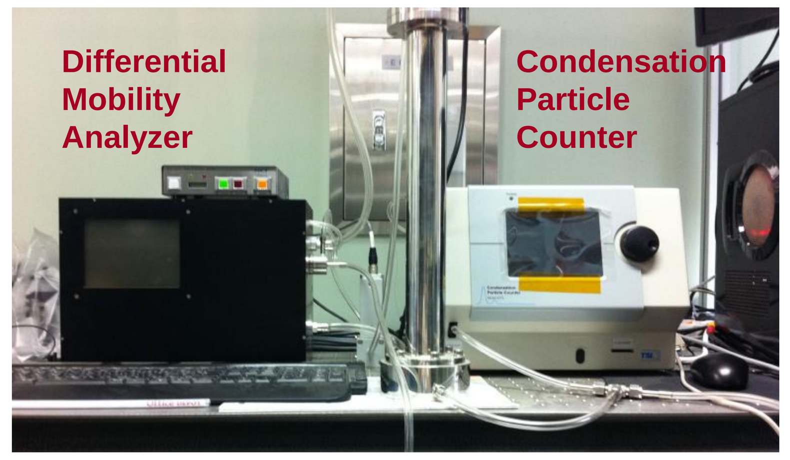
A spark discharger (PALAS GmbH, DNP 2000) generates black carbon (BC) by continuous sparks created by high voltage. The generated particle is called as 'PALAS carbon', which is known to similar to diesel soot.

Mass Concentration Measurement

Multi-angle Absorption Photometer (MAAP, Thermo Scientific 5012) was used to measure the BC mass con-centration, which is converted from light absorption coefficient. When aerosol samples are attached on the fiber filter tape, light from a light source (670 nm) scatters back to hemisphere. The MAAP has three detectors to revise reflection (back hemisphere) and transmission (for-ward hemisphere) for correction of any backward scattering. Sampling time was 1 min. Aerosol was intro-duced into the MAAP through a sam-pling inlet.

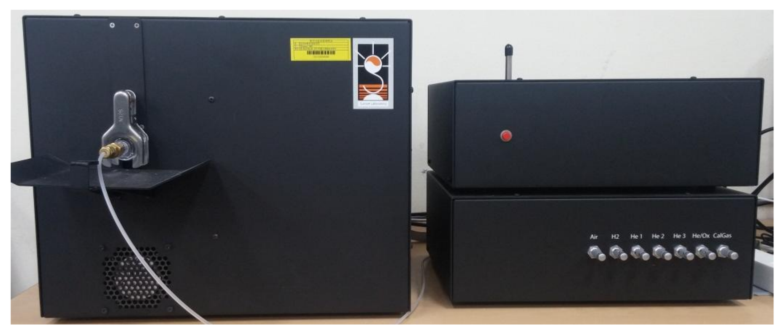
Size Distribution Measurement

The size distributions of the spark-generated soot were measured by the differential mobility analyzer (DMA, home-designed) equipped with a condensation particle count-er (CPC, TSI 3775). The aerosol was dried using a diffusion drier before the aerosol is introduced into DMA & CPC.



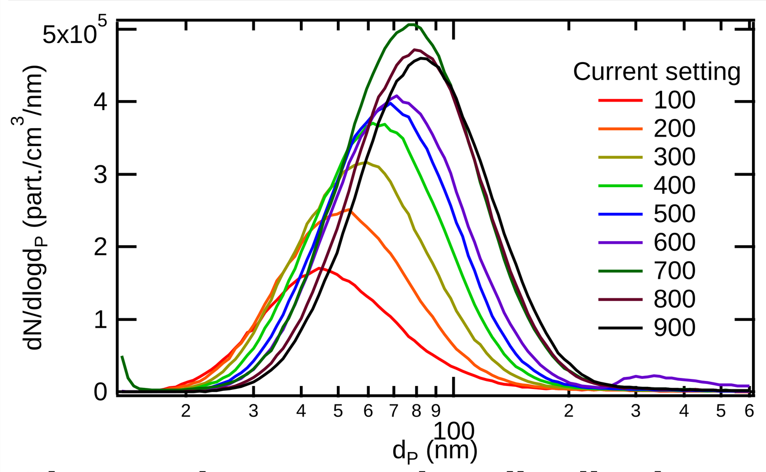
Elemental Carbon Measurement

Elemental carbon concentra-tions are measured by an EC/OC Analyzer (Sunset, USA), which uses a thermal-optical method. In an oxy-gen-free helium atmosphere, PALAS carbon collected onto quartz filter is heated to remove all OC from the sample. As the organ-ic compounds are vaporized, they are immediately oxidized to CO_2. After the PALAS carbon on the filter is cooled to a relevant temperature, a 2% O_2/He mixture is injected into the sample oven. The sample oven temperature is then increased up to a given temperature, during which the EC is oxidized to CO_2 due to the presence of oxygen. This CO_2 is then convert-ed to CH_4 and detected by the Flame Ionization Detection (FID) for the quantification of the EC.



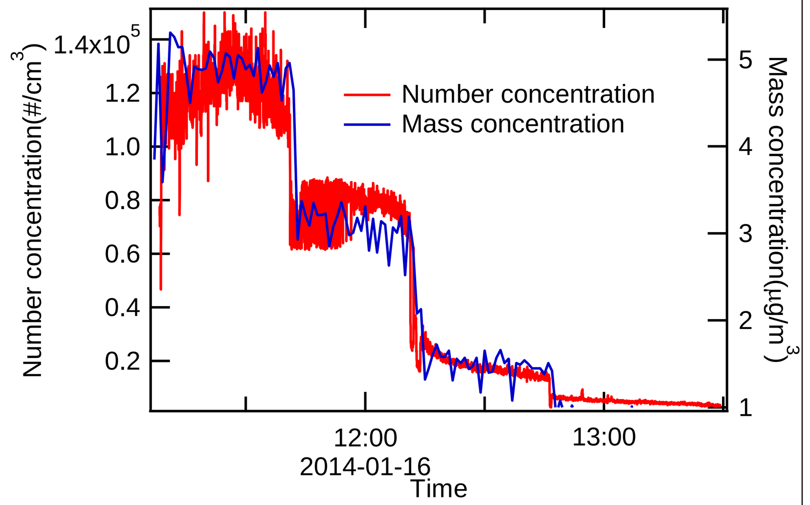
RESULTS & DISCUSSION

Size Distribution of PALAS soot



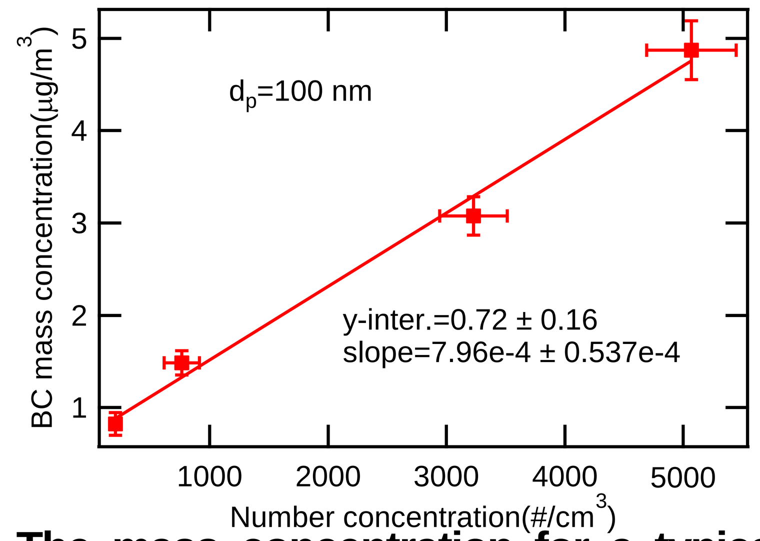
Shown above are size distributions of PALAS carbon measured for various current settings. As the current increa-ses the mode diameter increases. From the mobility diameter, the equivalent volumes were obtained.

Mass Concentration & Number Concentration



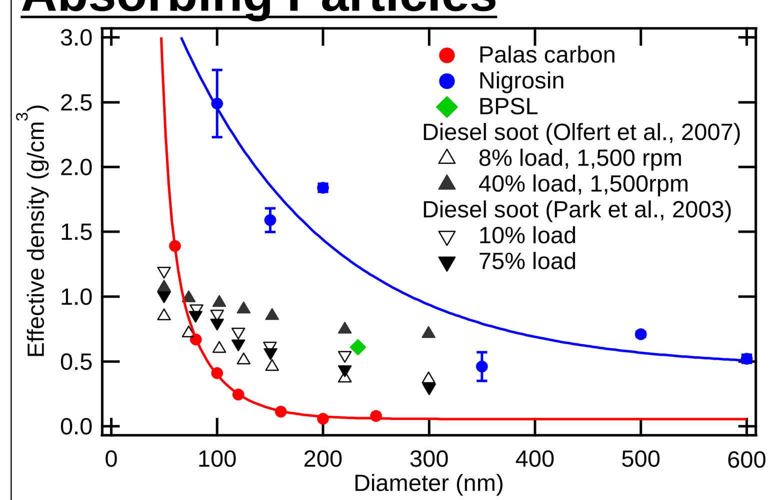
Shown above is a typical measure-ment data of BC mass concent-ration. Number concentration was also overlaid on the same graph. The BC mass concentration follows the number concentration within discernable detection resolution. This data will be used to obtain the effective mass of unit BC.

Effective Mass of BC



The mass concentration for a typical size of spark-generated PALAS carbon was plotted as a function of the num-ber concentration. The slope of the linear fit curve corresponds to the eff-ective mass per unit particle. Effective densities for various PALAS carbon particles were estimated as shown below

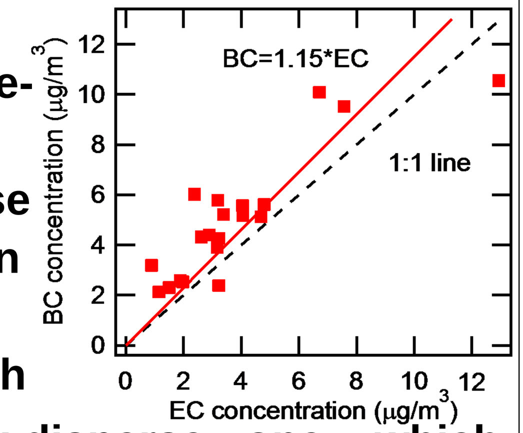
Effective Density for Various Absorbing Particles



The effective density of PALAS carbon decreases as the particle size increa-ses. This implies that the morphology of the PALAS carbon changes from a compact aggregate to a loose agglo-merate. The effective density of nigro-sin and black dyed polystyrene latex (BPSL) is higher than the PALAS car-bon aggregate because nigrosin and BPSL are spherical, that is, of no void. The result of diesel soot lies between those of PALAS carbon and nigrosin.

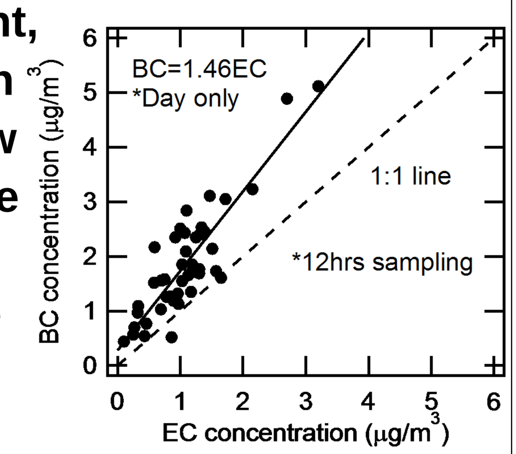
BC/EC Comparison (PALAS carbon)

As shown below, the correlation co-efficient between the BC and the EC for PALAS carbons ranged from 60 nm to 250 nm is 1.15, which is higher than the values of 0.15 and 0.26 ob-tained by Saathoff et al. (2003). We measured BC/EC for size-selected mono-disperse PALAS carbon while the pre-vious research did for poly-disperse one, which might cause overlap onto filter in BC measurement, resulting in underesti-mation of BC concentration com-pared to EC.



BC/EC Comparison (Ambient)

As shown right, the correlation coefficient btw the BC and the EC is 1.46, which is more similar to the present result than the previous study. This result implies that PALAS carbon can be a proxy for ambient absorbing aerosol. The caveat, however, is that this holds good for the size-selected one at low level of concentration.



CONCLUSIONS

- BC and EC concentrations were compared for the PALAS carbon particles generated in a spark-discharger.
- Effective density for PALAS carbon was determined using BC mass concentration, number concentra-tion and mobility equivalent dia-meter.
- BC/EC correlation coefficient for the size-selected PALAS carbon was 1.15, which showed similar trend to the value for ambient aerosol but higher than the values measured in a previous study.

ACKNOWLEDGMENT

This work was supported by the Korea Ministry of Environment as Converging Technology Project (2013001650004). The author gives special thanks to Mr. S. Han for collecting data.

REFERENCES

Olfert et al., 2007, J. Aerosol Sci.; **Park et al., 2003**, Env. Sci. Technol.; **Saathoff et al.**, 2003, J. Aerosol Sci.