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PA9) 경유자동차 입자상물질의 휘발성에 대한 실험적 연구
Experimental Study of Volatility of Diesel Exhaust Particles

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1. Introduction

Diesel exhaust particles are mostly sub-micrometer agglomerates composed of carbonaceous primary particles ranging from 10 to 80 nm, but contain also adsorbed or condensed hydrocarbons, hydrocarbon derivatives, sulfur compounds, and other materials. If particles are primarily composed of volatile materials, they have different health impacts from solid particles. Thus, the analysis of the volatility of diesel particles is one of an important diesel research area. It is known that the tandem differential mobility analyzer (TDMA) is useful for studying phenomena that lead to size changes in submicron aerosol particles. In this study, the volatility of diesel nanoparticles from the diesel truck set on chassis-dynamometer was analyzed by using the TDMA method. The reduction of particle size and volume with the increased temperature of the electric furnace was estimated. Moreover, by changing the engine load condition, the effect of engine load condition on the volatility of nanoparticles was discussed.on the volatility of diesel particles.

2. Experimental

Figure 1 shows the schematic diagram of experimental apparatus. The system consists of chassis-dynamometer, the diesel test vehicle (3.4L DI), a flow separator, a dilution tunnel, two DMAs (TSI 3081), a condensation particle counter (CPC; TSI 3022A), a 1200K electric furnace and gas analyzers. In order to measure the size distribution of nanoparticles by the TDMA system, the exhaust gas from the test vehicle was introduced into the dilution tunnel (dilution ratio; 12). After the dilution, the particles in the exhaust gas are charged by 241Am neutralizer and introduced into the 1st DMA for size separation. Classified particles were heated up to the temperature of 30~800℃ through the annealing tube in the furnace and the particle size distribution was measured by the 2nd DMA with the CPC.

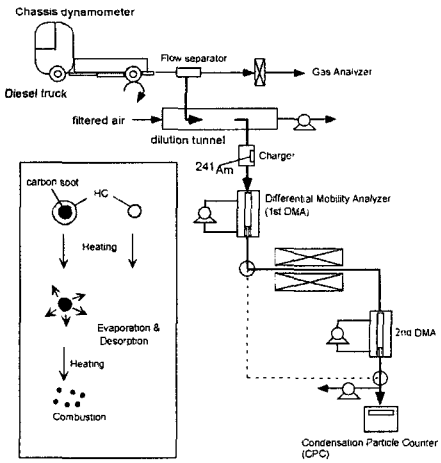

Fig. 1. Schematic diagram of the experimental system and the typical process of diesel particle heating.

3. Results and Discussion

Figure 2 show the size distribution change of the classified particles at initial diameters of 35 nm with respect to the furnace temperature during the idling engine condition. Peak diameters were reduced and the size distributions were broadened as increasing of the furnace temperature. In the temperature range of 30~150℃, water and water-dissolved species are expected to be evaporated from the particles. Bimodal distributions were observed above the temperature of 100℃. Those secondary peaks were maintained until the temperature of 500℃. It is believed that diesel particles are composed of two different volatility species. We

found that 1~2% of peak particles of 35 and 51.2 nm were non-volatile species which formed the secondary peaks, however, 10% of peak particles of 76.7 nm were non-volatile species. In general, light hydrocarbon, sulfuric acid and water species are volatile, but heavy hydrocarbon or carbon soot is a non-volatile species.

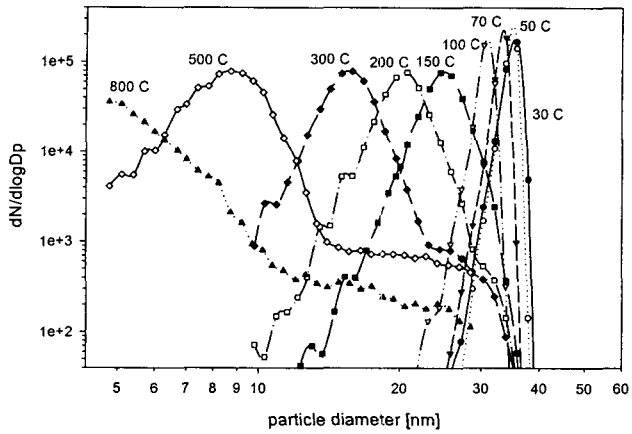

Fig. 2. Change in the size distribution measured by 2nd DMA with respect to the furnace temperature during the idling engine condition. The particles were initially classified at 35 nm.

Figure 3 shows the total volume fraction according to the furnace temperature. Most particles were shrunken as increasing the furnace temperature, however, the significant difference was found between idling and 1/2-load engine conditions. Approximately, 78~96% of particles by the total volume were found to be volatile species during the idling engine condition, but 15~26% were volatile during the 1/2-load engine condition before the ignition temperature of soot particles (~500℃). It was found that the particles exhausted from the idling were more volatile than that of high loading engine condition.

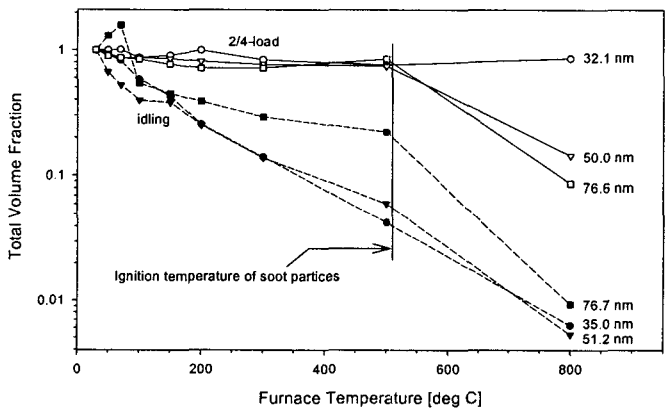

Fig. 3. Total volume fraction at given particle size with respect to the furnace temperature.

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