

PAHs and EC in nano-size DEP collected by DMA sampler

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[Introduction] Diesel exhausted particles (DEP) are mainly consisted of ultrafine particles around 100 nm in diameter and contain many kinds of organic chemical substances such as polycyclic aromatic hydrocarbons (PAHs) and nitroarenes, some of which are known as carcinogenic or mutagenic. Though health effects of DEP have been concerned, there is insufficient knowledge of chemical components in ultrafine particles. A differential mobility analyzer (DMA) was used as nano sampler for DEP, and OC/EC and PAHs are analysed.

[Method] We used two custom - made DMAs and modified the operational condition by increasing its sampling flow rate. DEP from a diesel - electric generator were collected through a dilution tunnel by this nano sampler. The generator was operated at different loads. The average sizes of the DMA nano-sampler were 80 and 150 nm and the sampling duration was 10 - 60 minutes to collect particles enough for chemical analysis. Flow rate of DMA was set as 4 L/min and nano-size particle is collected on a quartz fibre filter at the outlet of each DMA. Non-classified particles was also collected to compare the fraction of chemical substances. DEP collected on a quartz fibre filter were analysed for 13 PAHs (3- to 6- rings PAHs) by a direct injection - thermal desorption GC/MS method. By this method, PAHs and other semi - volatile organic chemicals are able to be analysed without any pretreatment, such as solvent extraction and concentration. Elemental carbon (EC) was also measured by the thermal - optical method (Method NIOSH 5040).

[Results] The sampled nano-size particles were relatively enriched with EC and 5- to 6- ring PAHs compared with non-classified particulate matter sampled parallel to the DMA nano sampler. Smaller amount of EC was observed for the 80 nm particle than in 150nm particles. For lighter load, OC and high- volatile PAHs are observed.

[Conclusion] Considering the chemical components of the classified particles, different formation mechanisms of nano-size DEP should be suggested.

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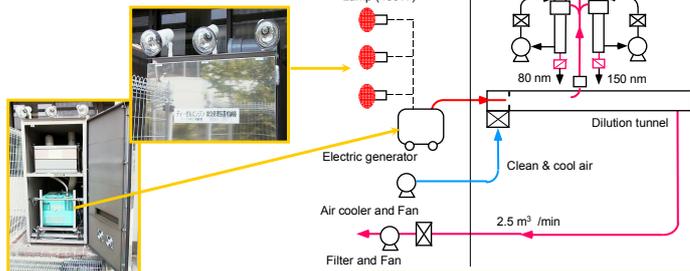
Introduction

Diesel exhausted particles (DEP) contain nano-size particles with PAHs (Polycyclic Aromatic Hydrocarbons), other organic carbons (OC) and EC. Size distribution of them, especially in nano-size particle, is not fully understood, though it is a useful information to understand the formation mechanism of DEP.

Differential mobility analyzer (DMA) extracts aerosol particles ranging from 1 to 1000 nm in diameter. We used twin custom-made DMAs as nano-particle samplers. DMA sampling flow-rate was increased at 4 l/min to increase sample mass.

Size selected DEP (80 nm and 150 nm) and whole DEP are collected on quartz fibre filters. PAHs are analysed by thermal desorption – GC/MS method and OC/EC was measured by a thermal-optical method (NIOSH 5040).

Sampling of DEP



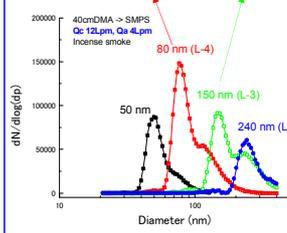
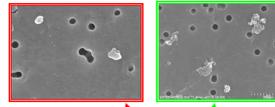
Diesel engine

Engine: Electric generator (Yammer diesel YDG200SS)
Load: Number of lamps lighting (1 lamp, 3 lamps)
Fuel: JIS No.2 (Sulphur 50 ppm)

Sampling condition

After 1 μ m-cut impactor,
ALL: whole PM, not size-selected
(sampling flow rate: 2 l/min)
80 nm and 150 nm PM: by DMA sampler
(sampling flow rate: 4 l/min)
Filter: Quartz fibre filter (PALL QMA)

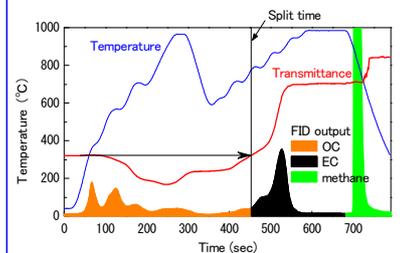
Collected DEP on DMA surface observed by SEM



Size distribution of outlet aerosol from 40cm DMA (measured by SMPS)

Thermogram of SRM 1650

Method: NIOSH 5040 (Sunset OCEC monitor)



GC condition

Instruments: TraceGC + PolarisQ (Thermo)
Thermal desorption: OPTIC3/FOCUS (ATAS GL)
Desorption Temp: 350°C
Column: SGE HT8, 30 m x 0.25 mm i.d.,
Film thickness: 0.25mm
Carrier Gas: He 1mL/min
Ramp Condition: 80°C (1 min),
20°C/min to 350°C (3 min)

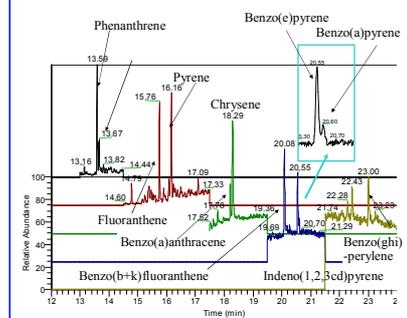
MS condition

Ion Source Temp: 225°C; Transfer Line Temp: 300°C
MS Mode: Selected Ion Monitoring (SIM Mode)
Standard Sample: NIST 1650

Determination

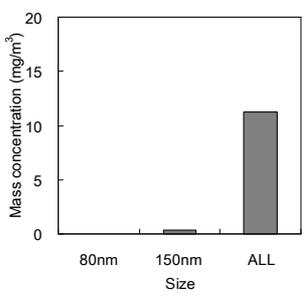
Calibration curves: PAH concentration was determined by comparison of peak height of the standard sample

Chromatogram of SRM 1650 by TD-GC/MS(SIM)



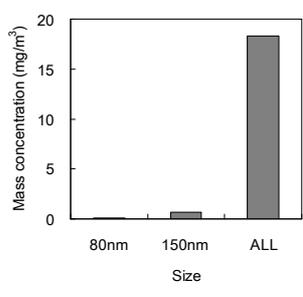
Load: 3 lamps

Mass concentration

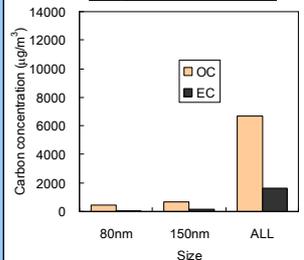


Load: 1 lamp

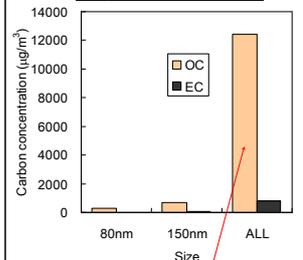
Mass concentration



OC, EC concentration

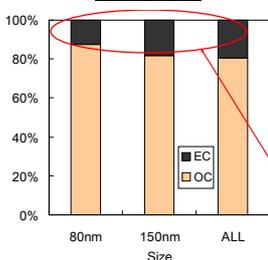


OC, EC concentration

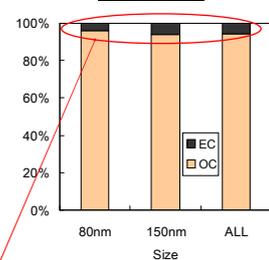


◆ Higher OC for lighter load

OC:EC ratio



OC:EC ratio



◆ Higher EC ratio for heavier load

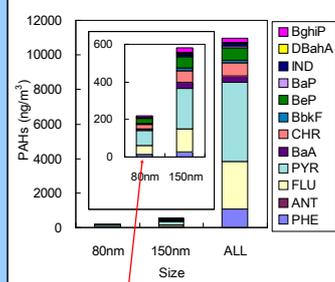
◆ Less EC for 80 nm particle

Conclusion

- ◆ Nano-size DEP were collected by DMA sampler.
- ◆ By 10 - 15 min sampling, PAHs and OC/EC in the DEP were determined.
- ◆ In nano-size DEP, content of lower vapour pressure PAHs is higher than in whole DEP.
- ◆ EC is dominant in 150 nm and larger DEP for heavier load.
- ◆ These results indicate different generation mechanisms for DEP of different size.

Load: 3 lamps

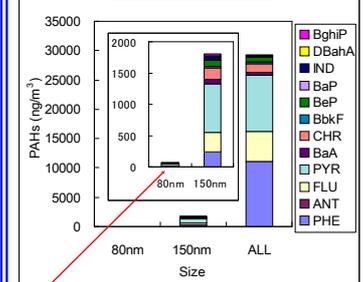
PAH concentration



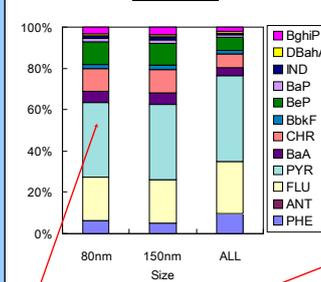
◆ Higher PAHs in 80 nm particles for heavier load

Load: 1 lamp

PAH concentration



PAH ratio



◆ Higher 3-ring PAHs for lighter load

◆ Higher 5,6-ring PAHs in nano-size particles for heavier load