Development of High Sensitive and Rapid Measurement Method for Chemical Substances in Nano-particles

Background

It is pointed out that nano-particles emitted from diesel engine may interfere enormously with human bodies by breathing. Measurement of chemical substances in nano-particles is an important issue, since the interference of nano-particles to human bodies is different by chemical substances, mainly organic substances, absorbed on the particles. Therefore, CRIEPI has performed the development of new measurement technique for organic chemicals, especially Polycyclic Aromatic Hydrocarbons (PAHs) which have potency to cause mutagen to cells, in nano-particles with high sensitivity and rapidly by support program of Ministry of Education, Culture, Sports, Science and Technology.

Objectives

The objectives of this study are the following; to evaluate potency of measurement for PAHs in nano-particles using differencial mobility analyzer (DMA) and laser ionization time-of-flight mass spectrometry (laser ionization TOFMS), to develop a technique of concentration and separation for chemicals in classified nano-particles, and furthermore, to evaluate potency of measurement for PAHs in nano-particles by the system which is newly planned and developed by CRIEPI.

Principal Results

1. Evaluation of potency of measurement for PAHs in nano-particles using DMA and laser ionization TOFMS

PAHs in nano-particles from diesel exhaust were classified and measured by the system combining DMA and laser ionization TOFMS. As a result, 10-450 nm diameters of diesel particles were collected by DMA, furthermore, mass spectrum of 50-300 m/z was obtained by measurement of classified nano-particles using laser ionization TOFMS (Fig.1). This result indicated that the system combining DMA and laser ionization TOFMS has potency to measure PAHs in nano-particles.

2. Development of concentration and separation technique for chemical substances

An instrument of concentration and desorption for chemical substances in nano-particles was developed and applied for 11 PAHs (fluorene, dibenzothiophene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo (e) pyrene, benzo (a) pyrene, pelyrene, benzo (ghi) pelyrene) to investigate conditions of concentration and separation of each PAH. As a result, target PAH was individually separated about 15min, which is 1/3 to 1/4 of former method, using the developed instrument by suitably controlling varieties of adsorbents, temperature conditions of concentration and separation, and so on. Consequently, the developed instrument was evaluated to apply concentrations and separations of PAHs.

3. Development of the system planned by CRIEPI

The system planned by CRIEPI was developed (Fig.2). Target PAHs were confirmed to be quantified using the developed system, by comparing quantitation data of standard PAHs on chemical analysis (Fig.3). Accordingly, it was evaluated that the system developed in this study has potency to classify nano-particles from various size particles in diesel exhaust, to separate chemical substances in the particles, and to qualify and quantify the separated chemicals with high sensitivity.

Future Developments

CRIEPI will apply the system developed in this study to measurement of chemical substances in nano-particles from diesel exhaust and in the atmosphere.

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References

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Y. Deguchi and N. Tanaka, 2004, “Measurement technology for chemical substances in nano-particles emitted from diesel engine”, Nensyo-gijutsu, 46 (in Japanese).

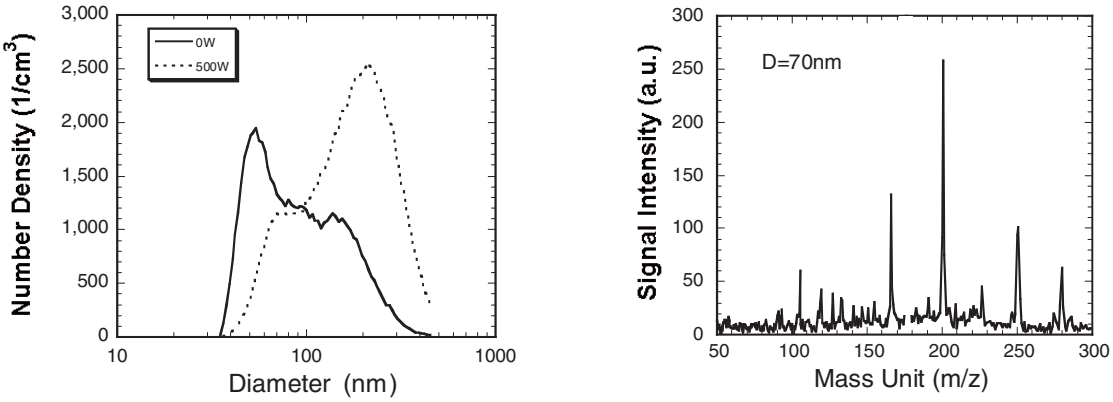

Fig.1 Particle size distribution of diesel exhaust classified by DMA (left), and mass spectrum pattern of chemical substances in nano-particles measured by laser ionization TOFMS (right: 500W engine load, 70nm diameter particles)

The left figure shows that big peak appears near 50nm when engine load is 0W (idling mode), contrary a peak near 200nm appears instead of the peak near 50nm at 500W engine load. In addition, laser ionization TOFMS measurement of chemical substances in 70nm diameter particles collected at 500W engine load resulting in various peaks, including big peaks such as m/z 202 and 252, being detected (the right figure). These results above correspond to the past reported data which indicate that peak of particle diameter increases according to increasing engine load.

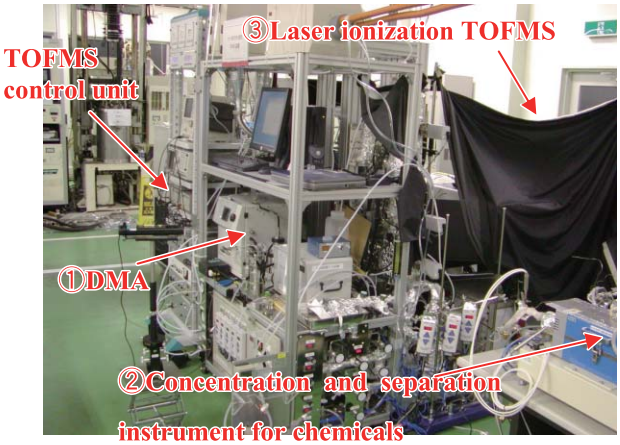

Fig.2 Developing system

Sample gas transfers in the pipe are as follows;①DMA→② concentration and separation instrument for chemicals→③laser ionization TOFMS. ① and ② are controlled individually, contrary pipes and ③ are controlled collectively. Hence the parameters such as temperature and pressure are highly managed. Furthermore, ③, which uses high potential laser, is set in a blackout curtain for accident prevention.

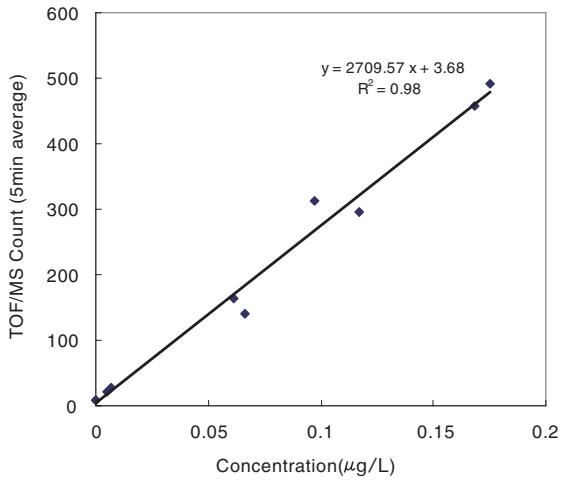

Fig.3 Measurement data comparison of GC/MS and laser ionization TOFMS (Anthracene)

Measurement data of anthracene by GC/MS is mutually related to that by laser ionization TOFMS, meaning that the developing system in this study has potency to classify nano-particles and qualify and quantify chemical substances in the particles.