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Effects of Driving Conditions on Diesel Exhaust Particulates

Jae-Hyun Lim · Cheol-Soo Lim · Jong-Choon Kim · Choong-Youl Seo
Yun-Sung Lim · Joung-Ho Ryu · Sung-Woon Jung · Liya E. Yu[1)]
Yu. Yu. Kostetski[2)]
Transportation Pollution Research Center, National Institute of Environmental Research, [1)]Division of Environmental Science & Engineering, National University of Singapore, [2)]Division of Bioengineering, National University of Singapore

1. Introduction

Diesel exhaust particles(DEPs) are one of the important airborne pollutants responsible for degrading atmospheric environment(Ying et al., 2004) and causing adverse health effects(Hirano et al., 2003; Kagawa, 2002), and systematic and characterization of DEPs are needed to comprehensively evaluate efficiency of mitigation devices and to explore cost-effective control stratagies.

2. Experimental Method

Four steady-state driving modes which could represent real on-road conditions were examined to characterize how operating speeds and loads of a medium-duty diesel engine affect resultant diesel exhaust particulates(DEPs) in terms of number concentrations($\leq$400nm), size distribution, persistent free radicals, elemental carbon(EC) and organic carbon(OC).

3. Results and Discussion

At the medium engine load(60%), DEPs surged in number concentrations at around 40-70nm, while DEPs from the full engine load(100%) showed a distinctive bimodal distribution with a large population in 30-50nm and 100-400nm. Under the full engine load, engine speeds insignificantly affected resultant DEP number concentrations. When the engine load decreased from 100% to the medium level(60%), DEPs in ultrafine size and 100-400nm decreased for at least 1.4 times(5.6-4.0 $\times 10^8$#/cm^3) and more than 3 times(2.7-0.8$\times 10^8$#/cm^3), respectively(Table 1).

Table 1. Summary of DEP characteristics of four driving conditions.

DEP concentration (#$\times 10^8$/cm^3)	Driving conditions(engine speed, rpm/ engine load. %)			
DEP size	1800/60	3000/60	1800/100	3000/100
< 100nm(Ultrafine)	1.9	4.0	5.2	5.6
100-400nm	0.4	0.8	2.6	2.7
≤ 400nm	2.3	4.8	7.8	8.3

The same reduction in the engine load significantly decreased persistent free radicals in DEPs for up to ~30 times(123-4$\times 10^{16}$#spin/g) (Fig. 1). Decreasing the engine load from 100% to 60% also concurrently reduced both EC and OC in total DEPs for around 2 times, from 27.3-13.9mg/m^3 and 17.6-9.2mg/m^3, respectively.

For DEPs smaller than 1㎛, under the full engine load, EC and OC consistently peaked at 170-330 nm under an engine speed of 1800rpm or 94-170nm under an engine speed of 3000 rpm, reflecting processes of nucleation, cluster-cluster agglomeration, and condensation. Decreasing the engine load from 100% to 60% reduced EC and OC in DEPs(smaller than 1㎛) for at least 3 times(0.6 down to 0.2mg/m^3) and 2 times(0.4 down to 0.2mg/m^3), respectively.

Taken together, decreasing the full engine load to a medium(60%) level effectively reduced the number concentrations($\leq$400nm), persistent free radicals, EC, and OC of total DEPs, as well as the concentration of EC and OC in ultrafine and accumulation-mode DEPs.

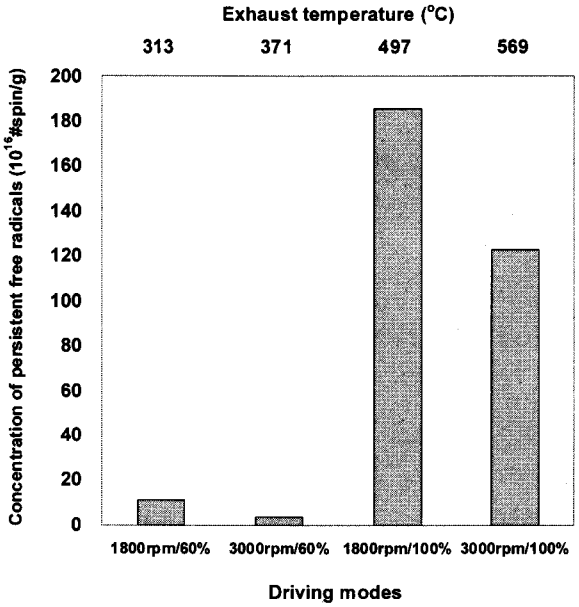

Fig. 1. Concentrations of persistent free radicals in DEPs of individual driving conditions.

References

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