

*The Department of Mechanical Engineering presents:*

***The Master's Dissertation Defense of:***

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**10:00AM, Bourns Hall A171**

**Oxidation and Atmospheric Transformation  
of Vehicle Exhaust Particle**

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Dr. Heejung Jung, Chairperson

Soot particles pose significant adverse health effects and influence on earth's temperature and climate. Hence, the elimination of soot emissions from diesel engines has attracted a lot of attention. Prior to this work, the investigation of soot oxidation is done mostly under air environment. However, since it is typical for NO<sub>2</sub> to be used in promoting regeneration under low-temperature soot oxidation for modern DPF, this study focuses on deriving the kinetics of soot oxidation under the influence of NO<sub>2</sub> being a major oxidant. An online aerosol technique of high-temperature oxidation tandem differential mobility analysis is used with soot being oxidized in a laminar flow reactor at temperature ranging from 500 to 900 K with NO<sub>2</sub> concentration from 0 to 600 ppm. The exposure of soot particles to the non-uniform temperature and NO<sub>2</sub> mixing ratio inside the furnace causing NO<sub>2</sub> thermal decomposition is thoroughly accounted for the first time. The soot oxidation rates being calculated as a function of frequency factor  $A_{\text{soot}}$  and activation energy  $E_{\text{soot}}$  are found to be:  $A_{\text{soot}} = 2.4 \times 10^{-14} \text{ nm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$  and  $E_{\text{soot}} = 47.1 \text{ kJ mol}^{-1}$ . Result from the current study shows significantly lower activation energy with NO<sub>2</sub> oxidation as compared to O<sub>2</sub> at temperatures below 500 K. At higher temperature (800 to 900 K), the soot oxidation rates with NO<sub>2</sub> is still comparable to that with air. However, this indicates that NO<sub>2</sub> is a stronger oxidant than O<sub>2</sub> since only parts per million levels of NO<sub>2</sub> are sufficient to cause such significant soot oxidation.

After the emissions from diesel exhausts are released into the atmosphere, secondary organic aerosol (SOA) are formed from the photo-chemical oxidation of organic vapors and followed by gas-to-particle partitioning. This study aims to advance the understanding of diesel emission influences on SOA formation with a major focus on the photo-oxidation of aromatic hydrocarbons inside an environmental chamber that simulates atmospheric chemistry. The investigation through combining the real-time density measurement and other physical/chemical analysis (APM-SMPS, HR-ToF-AMS) demonstrates that mass-based measurement techniques are necessary for interpreting the physical processes (evaporation of SVOCs and condensation of secondary organic compounds) during SOA formation due to the external void space in the agglomerate particles. Analysis of O/C ratio has shown to increase rapidly from 0.05 to 0.25 within 12 hours inside the chamber, emphasizing that the multigenerational oxidation of volatile organic vapors from the exhaust to be an important source of SOA formation. The impact of different dilution methods on the diesel particles evolution inside the chamber is investigated for the first time. Higher effective densities and stronger evaporation of semi-volatile species is observed from the dilution with ejector dilutor as opposed to the raw exhaust injection into a full bag inside the environmental chamber.

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