An Experimental Study of PM Emission Characteristics of Commercial Diesel Engine with Urea-SCR System

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Abstract

Background

- Diesel engine: excellent fuel economy benefit, "Fun-to-Drive" High Torque
- But, the regulation of emission: PM, NO_x ← various Aftertreatment system
- NO_x: Utilization of SCR system using urea solution as a reductant

Experiment

1. the experiment of a diesel engine equipped with Urea SCR system, and its emission characteristic including particle is analyzed and evaluated against its regulation.
2. Measurement of PM: Diluter + Thermodenuder + ELPI
   under various conditions of engine RPM and load (Particle number distribution of size range from 7nm to 10μm

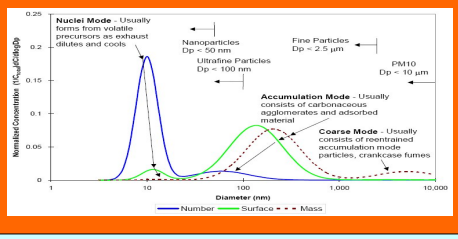
Results:

1. The particle number was increased in the proportion of amount of urea injection
2. The increase of Fine particle range(< 2.5μm) was remarkable
3. The effect of thermodenuder and engine exhaust temperature(250°C~450°C) is almost negligible for the change of particle number distribution tendency
4. But Increase of injection pressure (1bar~4bar) of Urea solution :
   Fine particle (~1μm): Decrease of number of particle While,
   Ultra Fine particle(< 100nm) and Nano particle(< 50nm) range: Increasing tendency
5. This particles: include new complex matter from urea decomposition process on SCR catalysts and most dry-Urea ← FTIR , TGA/DSC, TEM.

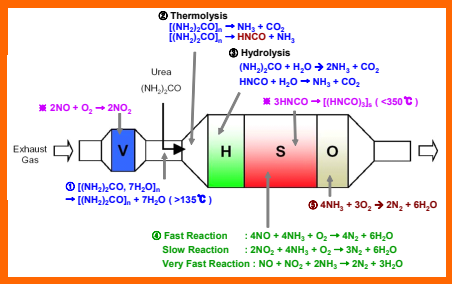
Emission Regulations (EURO-IV)
1. Advanced FIE & Combustion
2. Urea-SCR System

White PM & PM Weight Increase

Nano PM Number Distribution | **Nano PM Increase ▲ Urea Solution Injection** | Characteristics of Particle

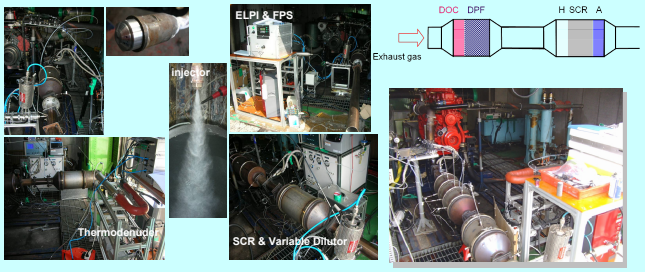


Chemistry

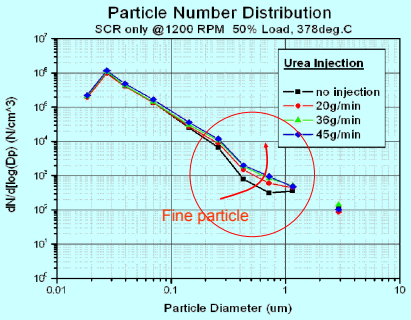


SO_2 Oxidation :		
$2SO_2 + O_2$	→	$2SO_3$
Ammonium Nitrate Formation :		
$2NH_3 + 2NO_2 + 2H_2O$	→	$NH_4NO_3 + HNO_2$
Ammonium Sulfate Formation :		
$NH_3 + SO_3 + H_2O$	→	NH_4HSO_4
$2NH_3 + SO_3 + H_2O$	→	$(NH_4)_2SO_4$

Experimental Setup

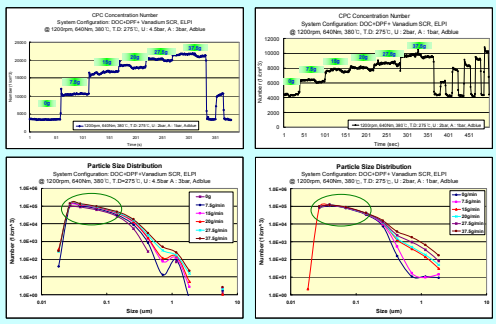


Particle distribution

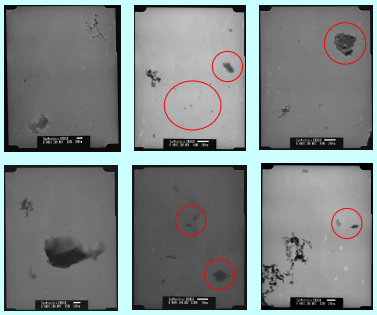


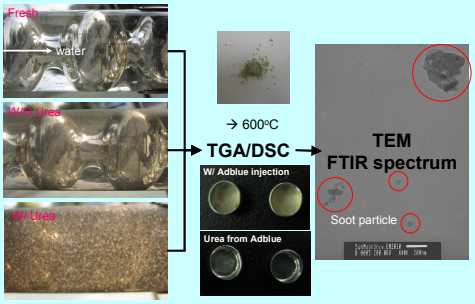
Effect of Injection Pressure

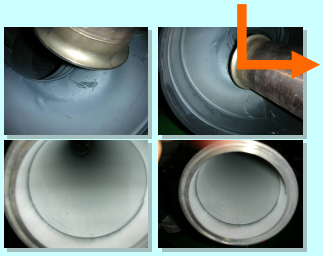
Urea (4.5bar)+Air(3bar) ← Injection Pressure → Urea (2bar)+Air(1bar)

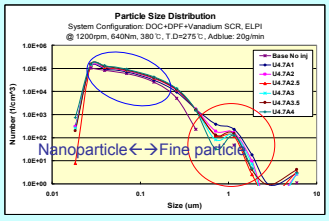


TEM Photograph

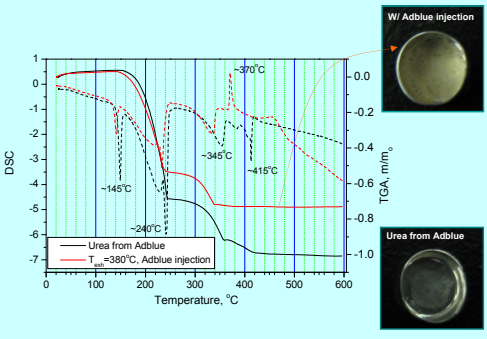




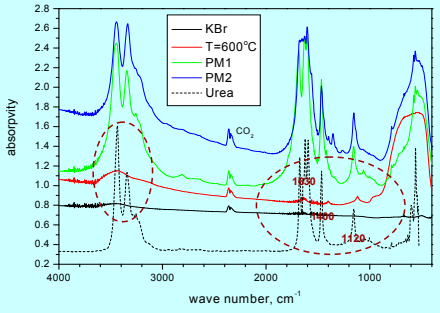




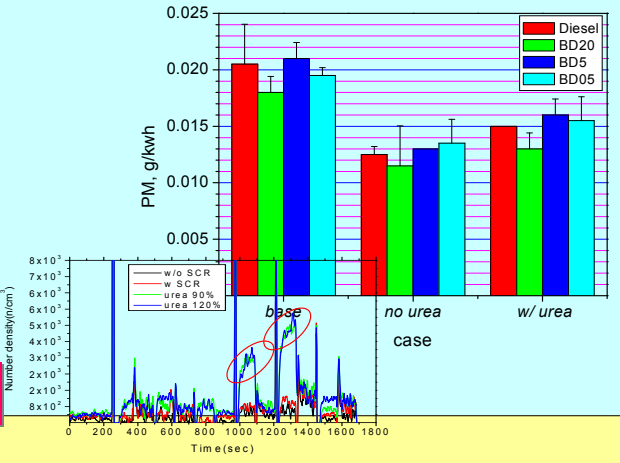
TGA/DSC



FTIR spectrum



PM weight- ESC



Conclusions

Undesirable particles come from Urea-SCR :

- **Ammonium Sulfate, Ammonium Nitrate, New polymer Complex(by HNCO base), etc**

Weight and Number of PM deeply depend on the Urea injection strategy & Urea Injection System Design

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