Development of the partial flow diluter for the measurement of particle size distribution and the investigation of nuclei mode particle during the transient cycles

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Objectives

- Optimize the measuring method of real world PM size distribution from vehicles
- Evaluate vehicles for nuclei mode particles

Real world : Short time after tailpipe emission

Secondary aerosol formation is not included

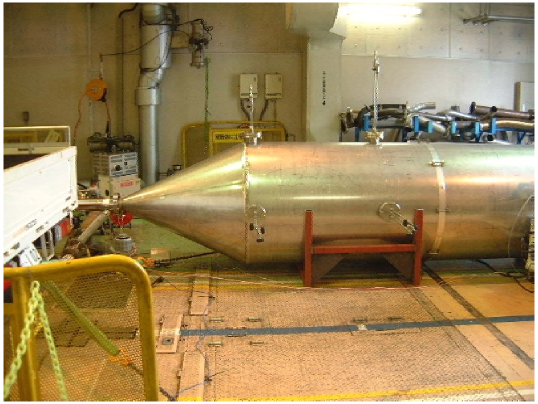
Presentation overview

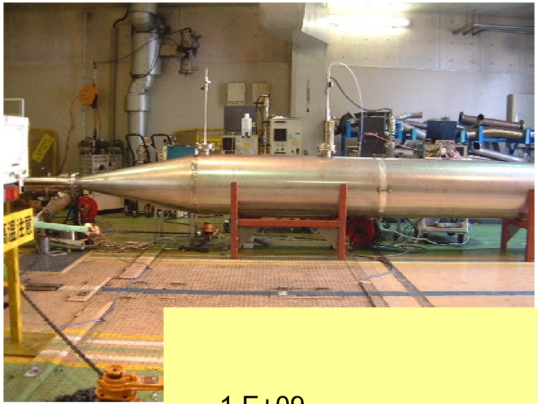
1. Partial flow diluter (PPFD-II)
2. Key factors for nucleation mode measurements
3. Investigation of nuclei mode during the transient cycles
4. Effects of after-treatments on nucleation mode particles
5. Conclusion
6. Further Study

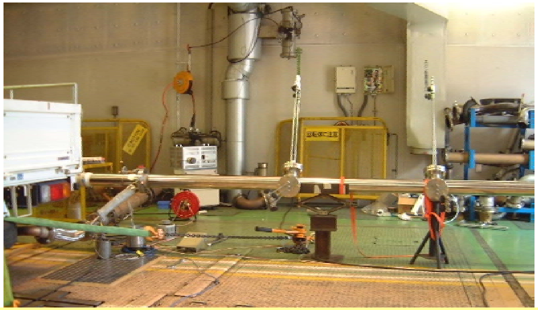
PPFD-I

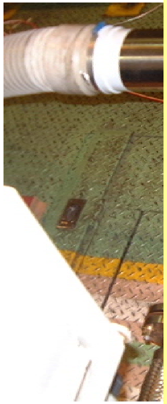
for investigation of dilution processes

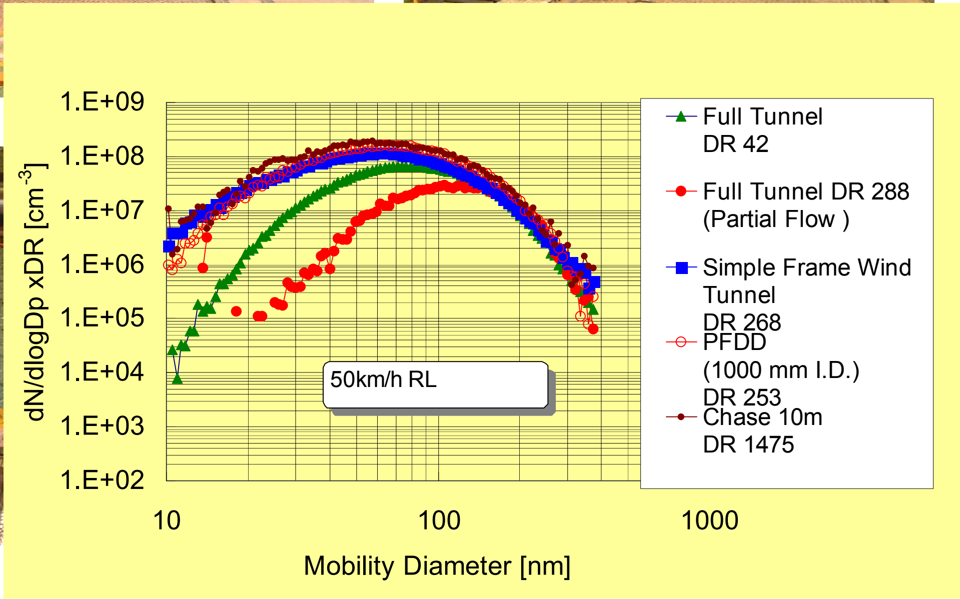
1.Partial flow diluter (PPFD-II)





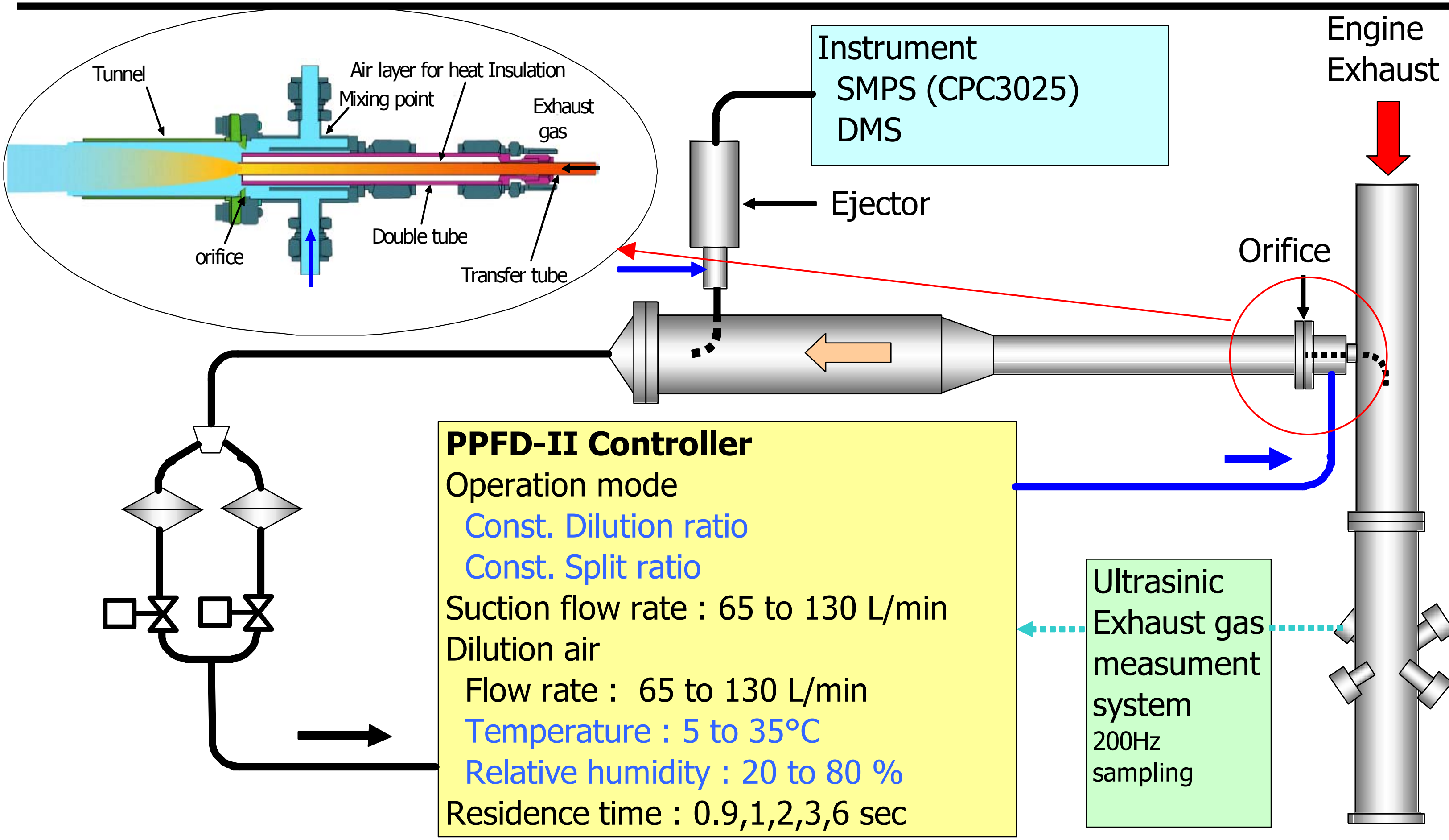






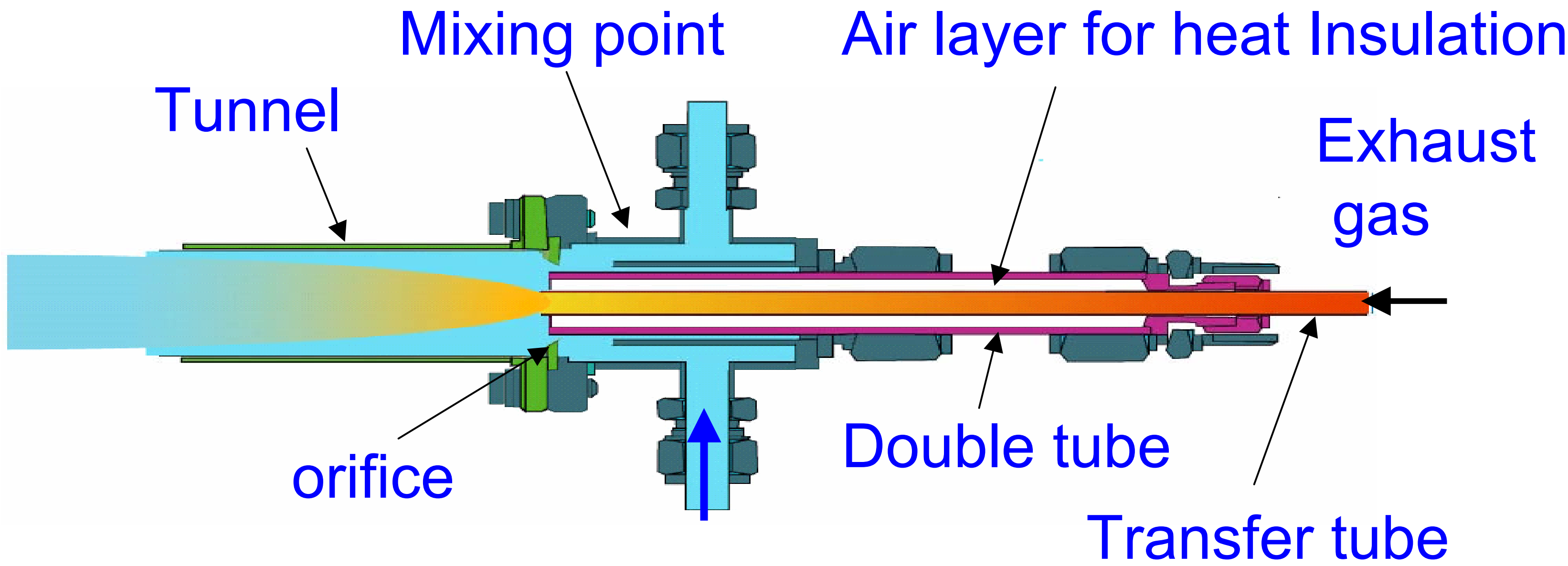
PPFD-II

1.Partial flow diluter (PPFD-II)



Sampling probe of PPFD-II

1.Partial flow diluter (PPFD-II)



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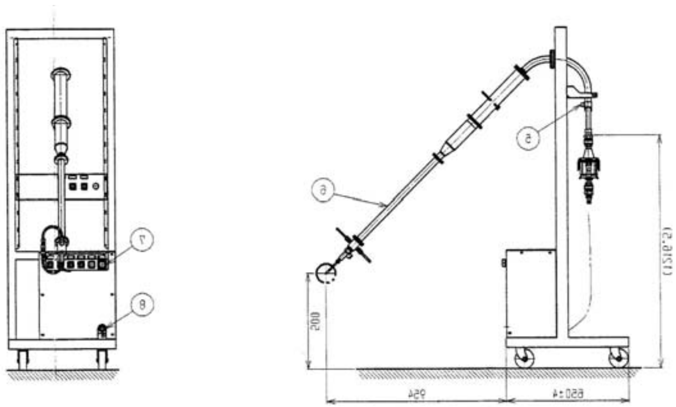
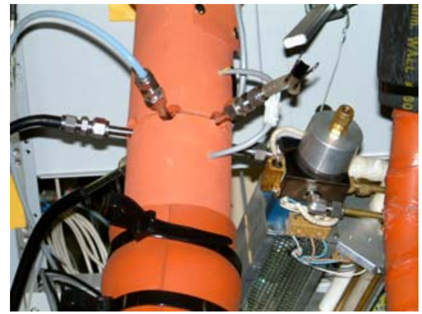
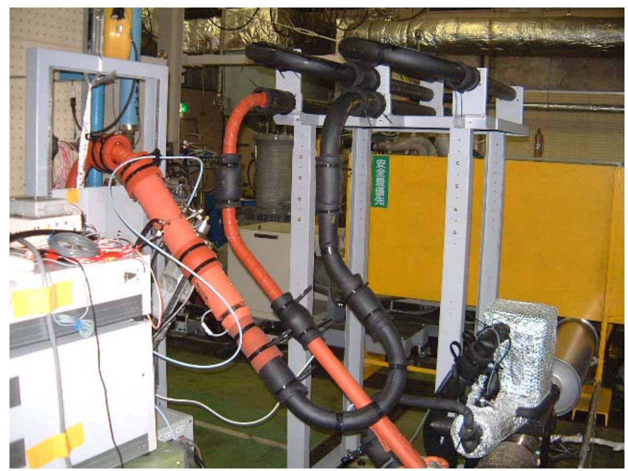




Sampling probes

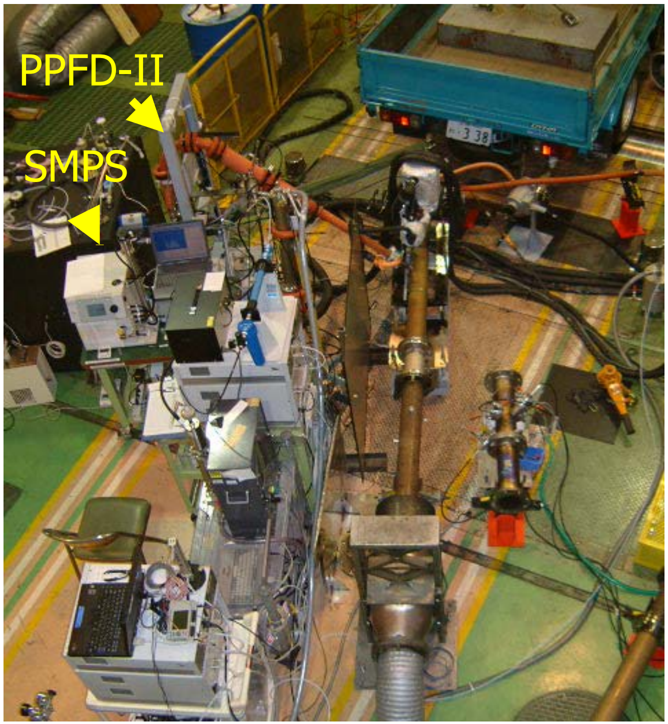


Additional residence tube ;6sec

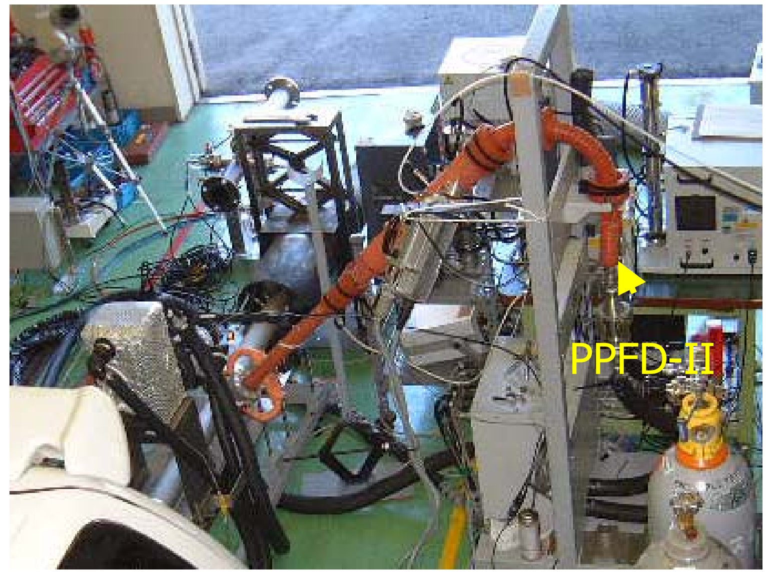
Set up of the PPFD-II for CD test

1.Partial flow diluter (PPFD-II)

Light duty diesel truck



Passenger car



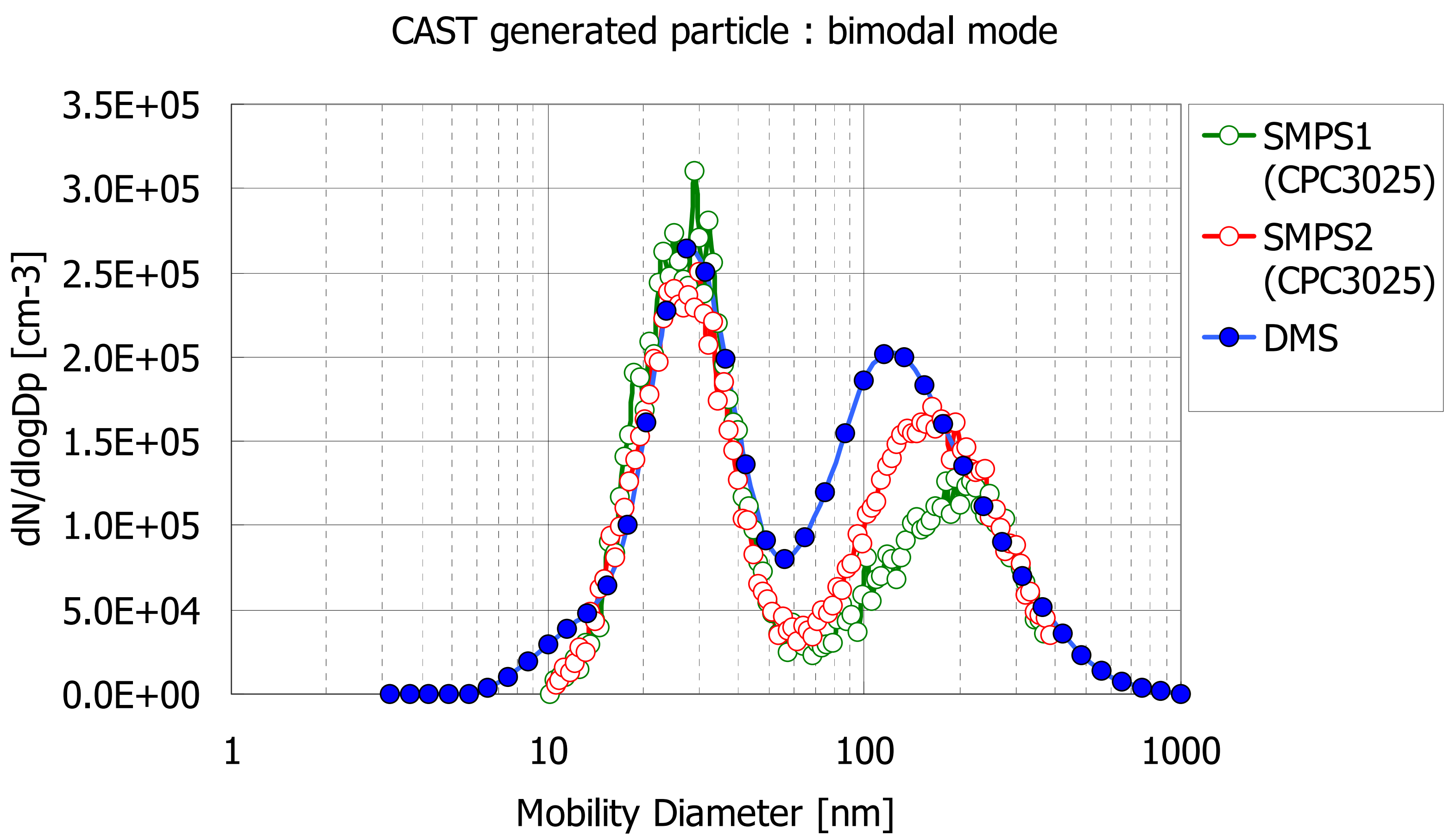
Main Measuring Instrument

2 Key factors for nuclei mode measurements

- Scanning Mobility Particle Sizer
  - DMA(differential Mobility Analyzer + CPC(Condensation Particle Counter)
    - 90sec/1data scan) 10nm to 400nm
    - TSI Model 3081 + 3025
- DMS for transient mode analysis

Comparison of SMPS vs. DMS

2 Key factors for nuclei mode measurements



Vehicle and Engine Specifications

2 Key factors for nuclei mode measurements

Symbol	G1	G2	D1	D2	D3	D4	E1	E2
Vehicle or Engine	Gasoline Passenger car	Gasoline Passenger car	Diesel Passenger car	Diesel Truck	Diesel Truck	Diesel Truck	Diesel Engine	Diesel Engine
Exhaust gas regulation	1998 idling regulation	2000 regulation 25% reduction	1998	1998	1998	1998	1999	1999
Fuel S (ppm)	11	10	28	28	28	28	28	28
Gross vehicle weight (kg)	1765	1655	2125	4535	4555	5675	-	-
Total displacement (L)	2.5	2.0	3.0	4.6	4.3	5.2	9.2	8.6
Fuel system	DI	MPI	DI-Common Rail	DI	DI	DI	DI-Common Rail	DI-Common Rail
After treatment	TWC	TWC	OxiCat	none	none	none	none	none

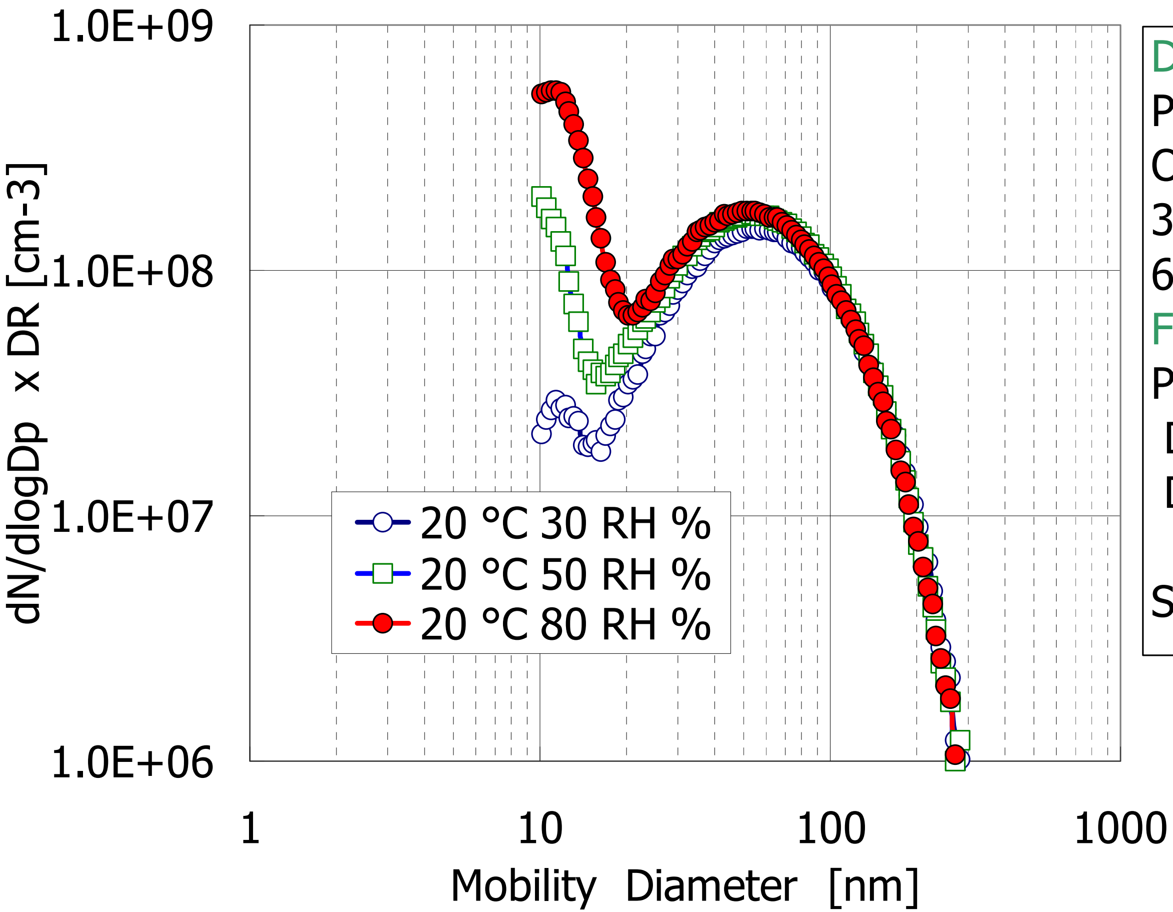
Key Factors for Nuclei Mode Measurements

- Formation of Nuclei mode particle
  - Idling Heavy Duty Diesel Engine
    Light duty truck
  - Deceleration period without fuel injection
    Heavy Duty Diesel Engine
    Light duty truck
  - High temperature on Oxidation Catalyst
    Diesel passenger car with Oxi.Cat.

Humidity effects on nuclei mode

Oxi.Cat Passenger diesel at high load condition

2 Key factors for nuclei mode measurements

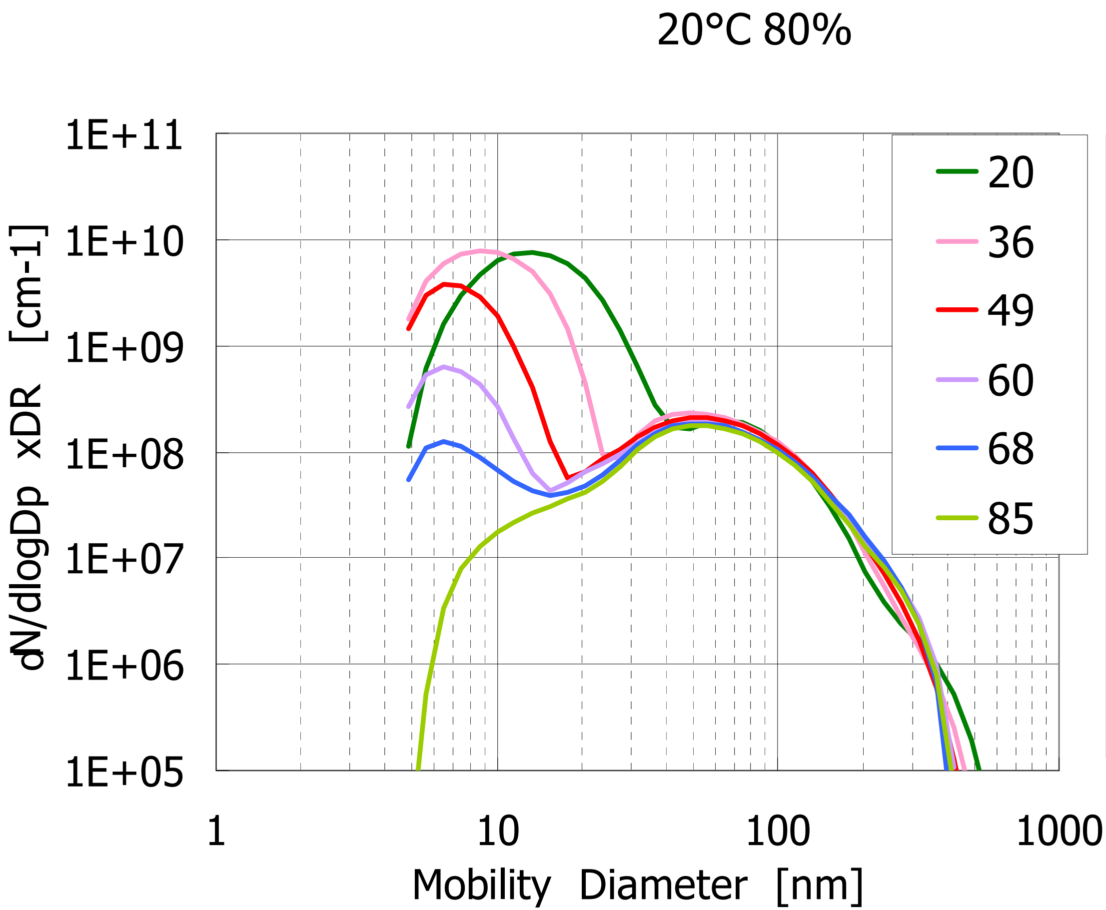


D1: Diesel Passenger Car with Oxi.Cat.
3400 rpm,
6% gradient
Fuel S : 28ppm
PPFD-II
DR:40
Dilution air:
20°C,30-80%RH
SMPS

Dilution effects on nuclei mode

Oxi.Cat Passenger diesel at high load condition

2 Key factors for nuclei mode measurements

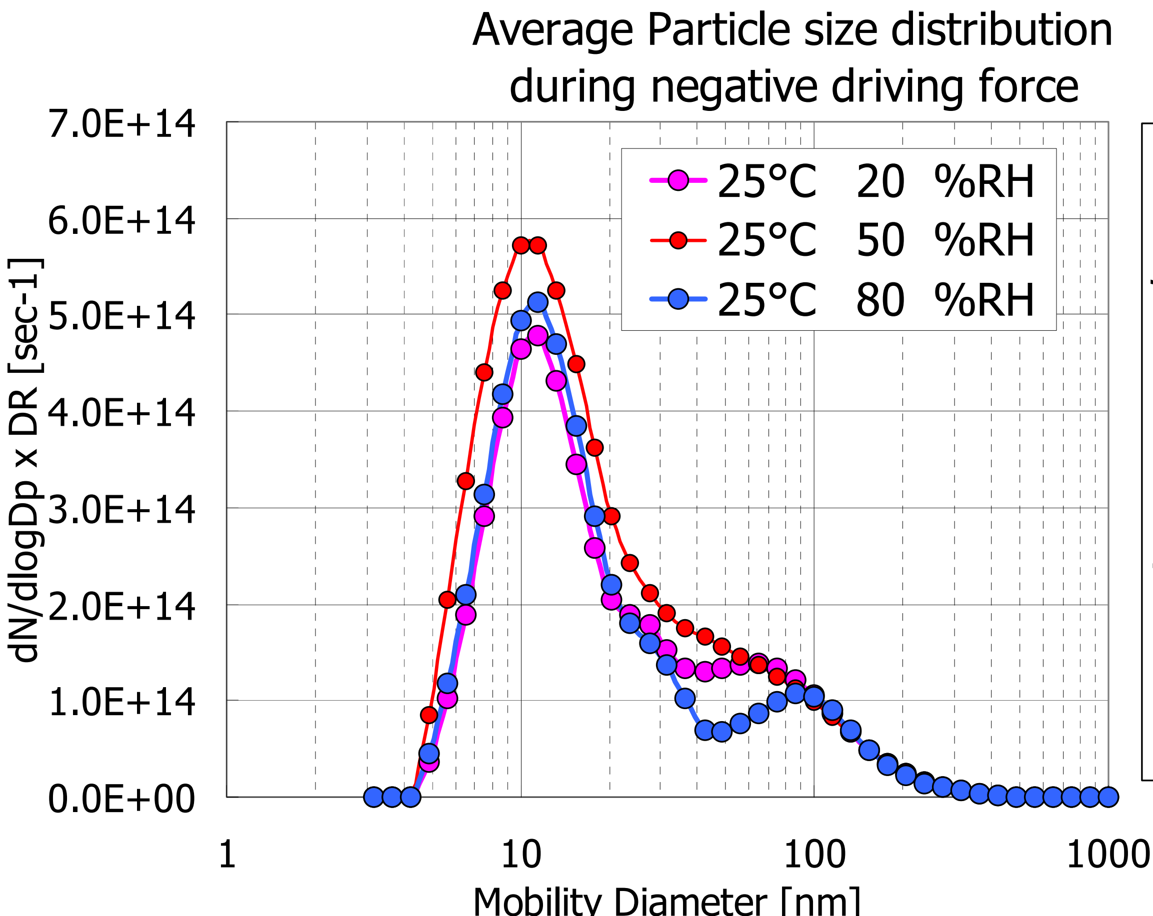


D1: Diesel Passenger Car with Oxi.Cat.
3400 rpm,
6% gradient
Fuel S : 28ppm
PPFD-II:
DR:18 to 85
Dilution air:
20°C,80%RH
DMS

Deceleration period without fuel injection

no effects of humidity

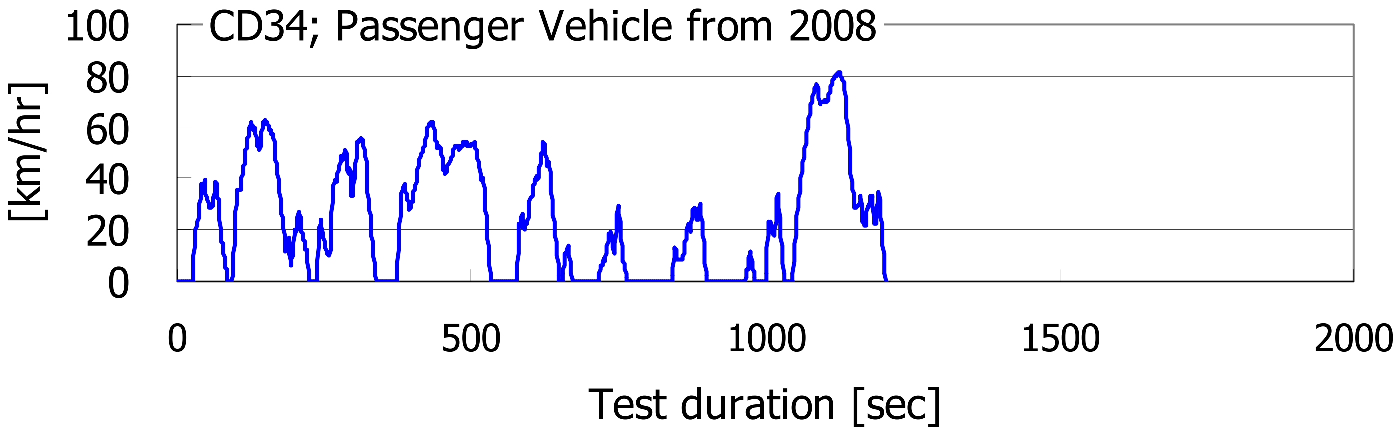
2 Key factors for nuclei mode measurements

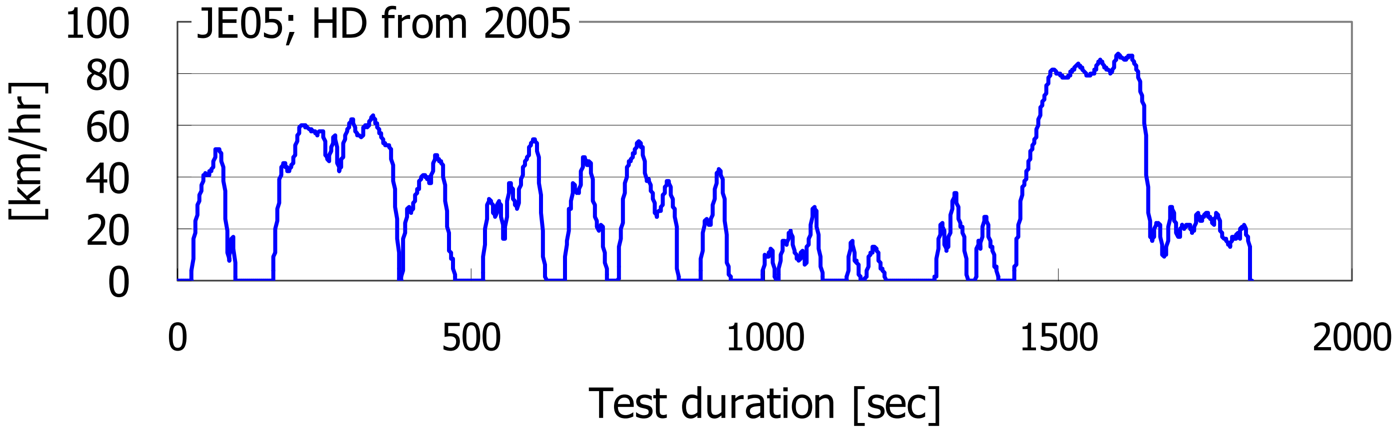


D2: Diesel
Light duty truck
JE05 mode
Fuel S : 28ppm
PPFD-II:
DR:200
Dilution air:
25°C,20-80%RH
DMS

Test Cycles

3 Investigation of nuclei mode during the transient cycle





Definition

3 Investigation of nuclei mode during the transient cycle

Total PM = Σ dN/dlog Dp / 16

- DMS 5nm to 1000nm

PM emission rate [N/sec]

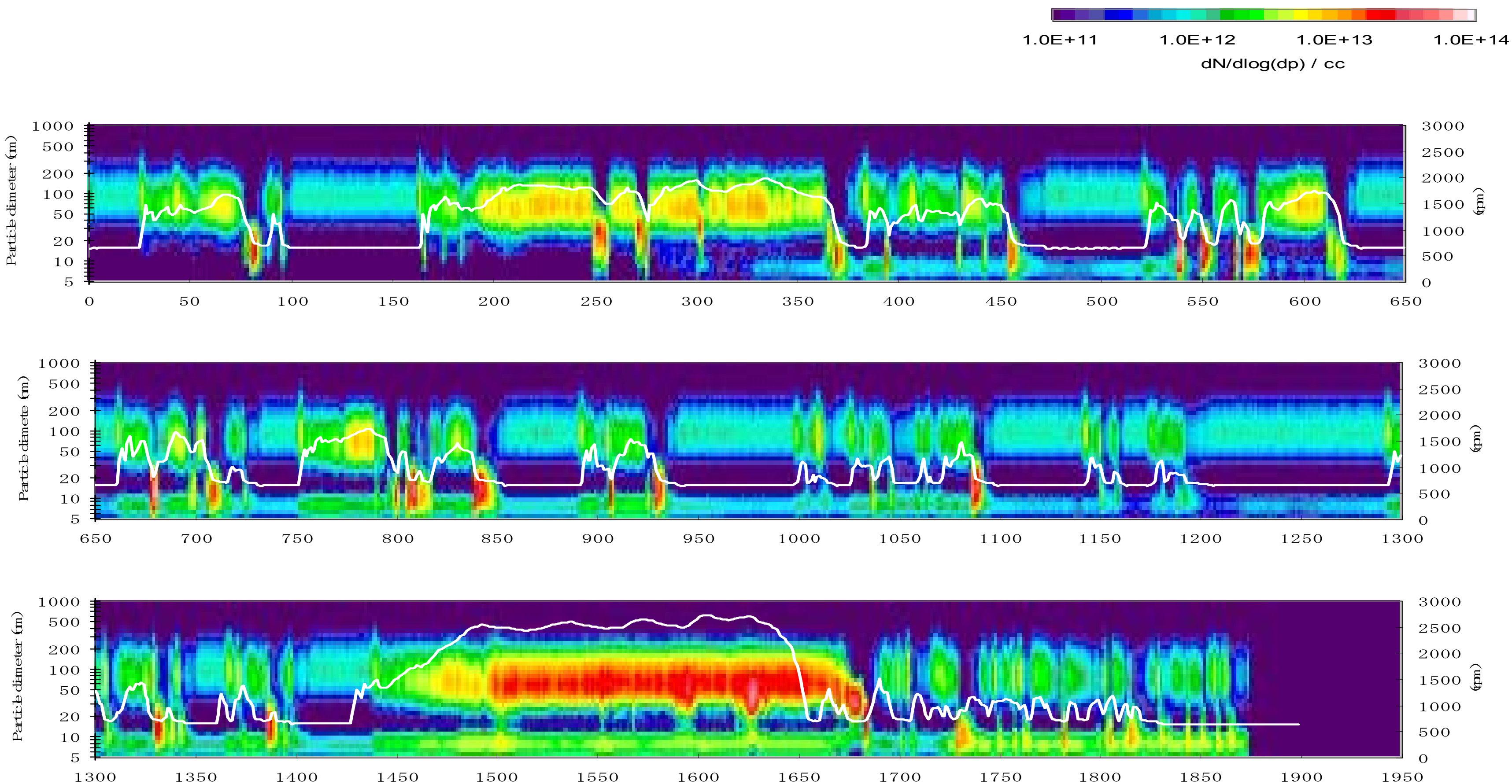
= PM number concentration [N/cc] x 10^6

x exhaust flow rate [m^3/sec]

Example of DMS result

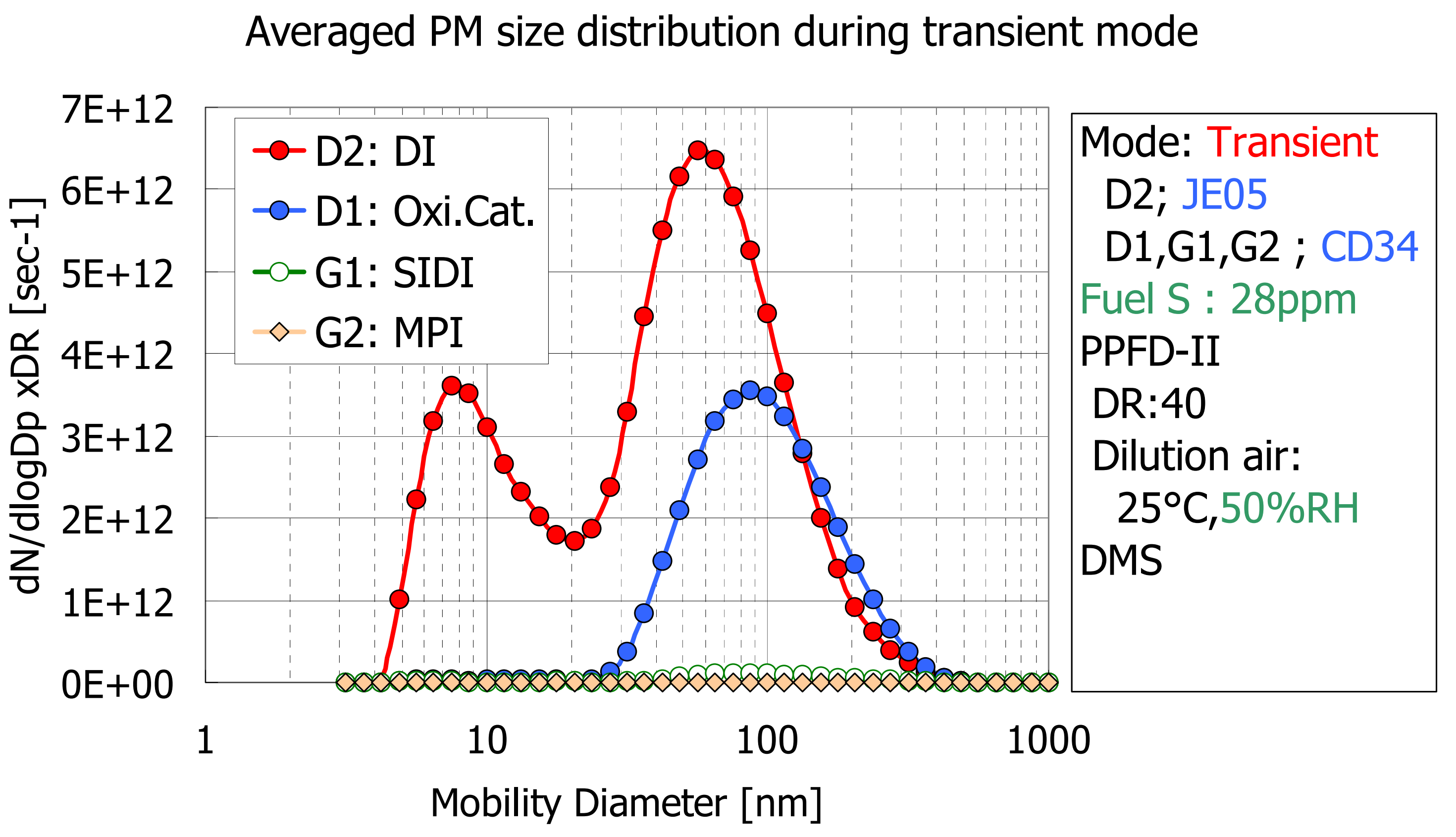
D2:Light Duty Diesel Truck, DR=200,Temp 25°C,50%RH

3 Investigation of nuclei mode during the transient cycle



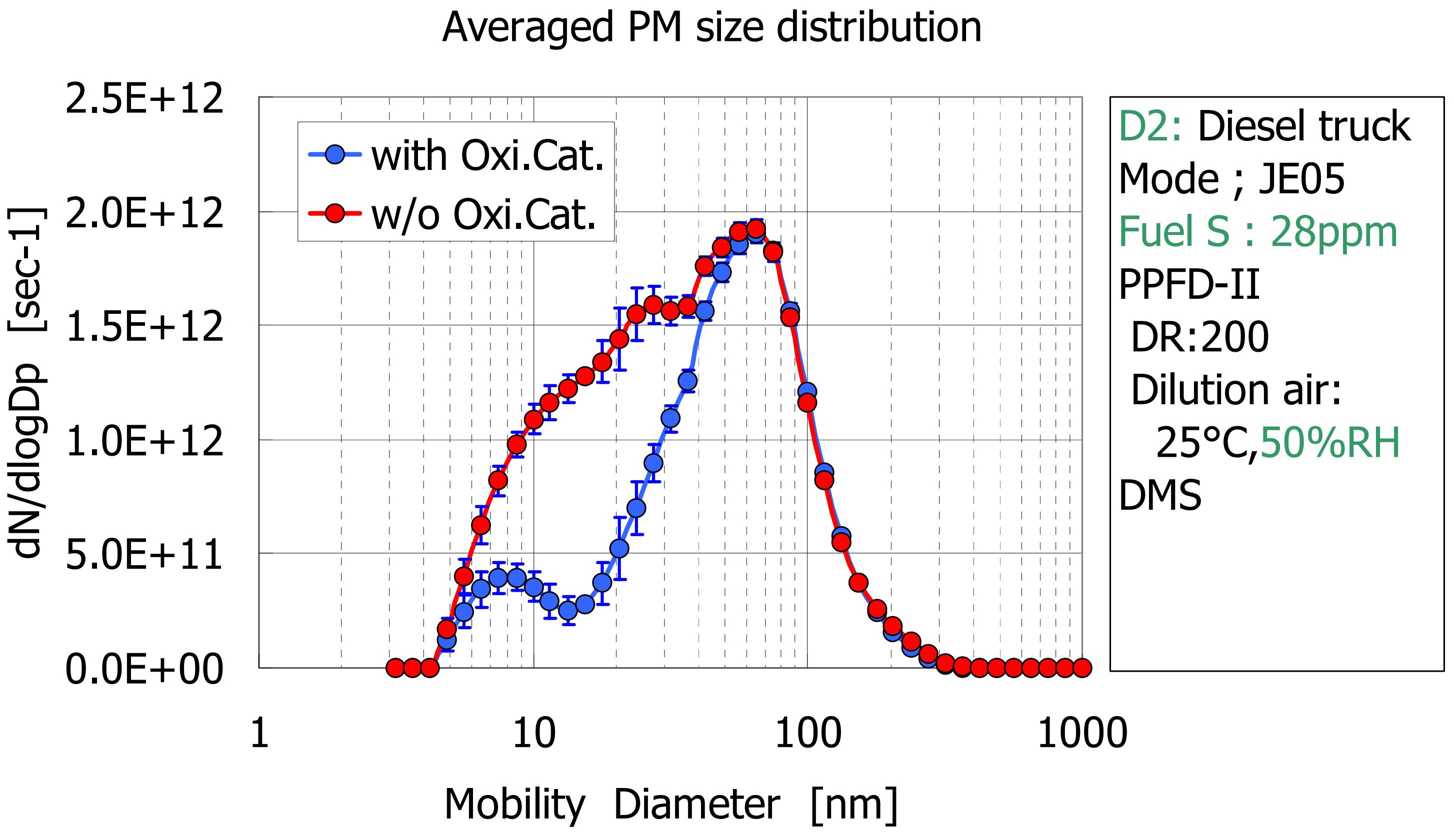
Averaged PM size distribution

3 Investigation of nuclei mode during the transient cycle



Effect of Oxidation Catalyst

4 Effects of after-treatments on nucleation mode particles



Effect of Oxidation Catalyst

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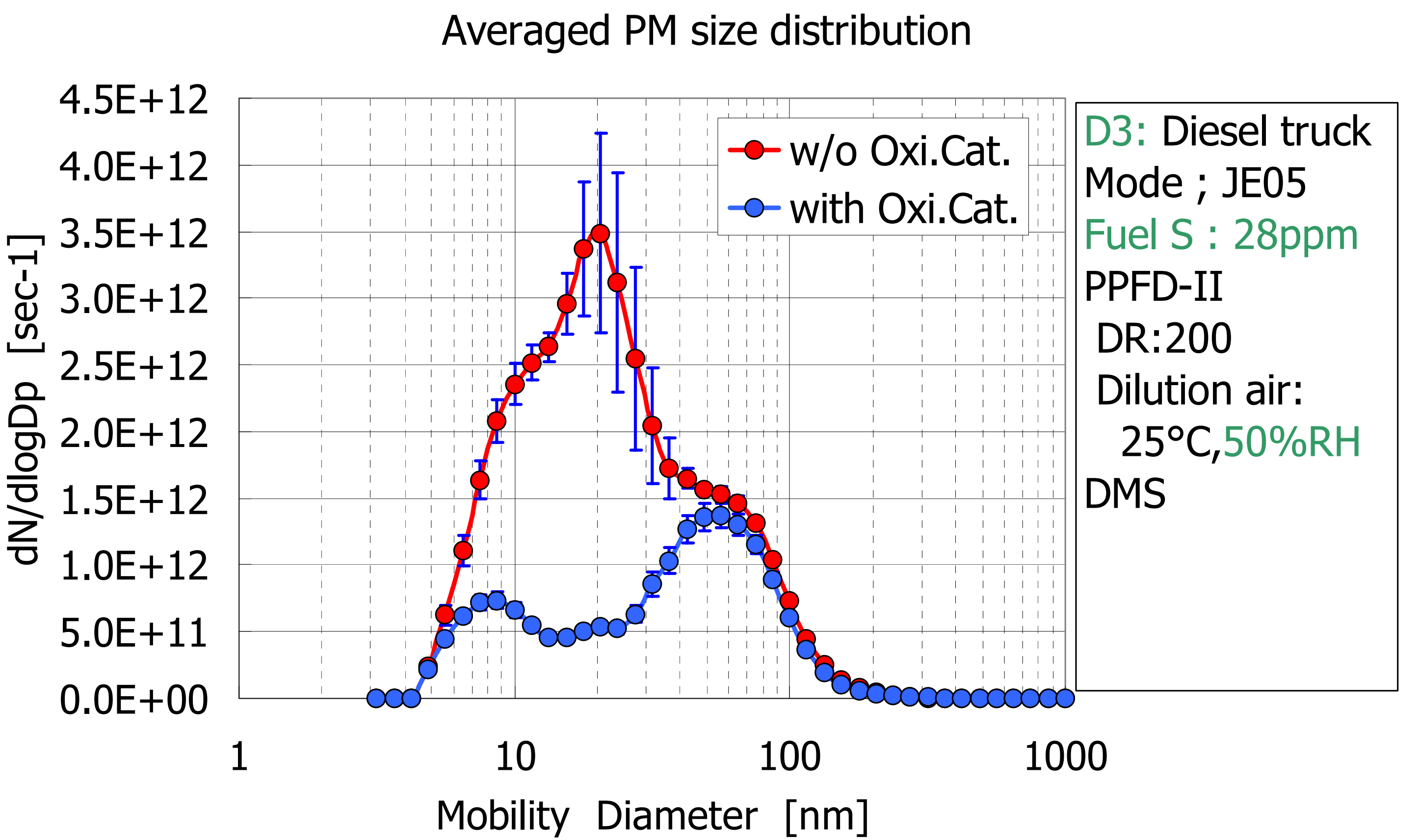

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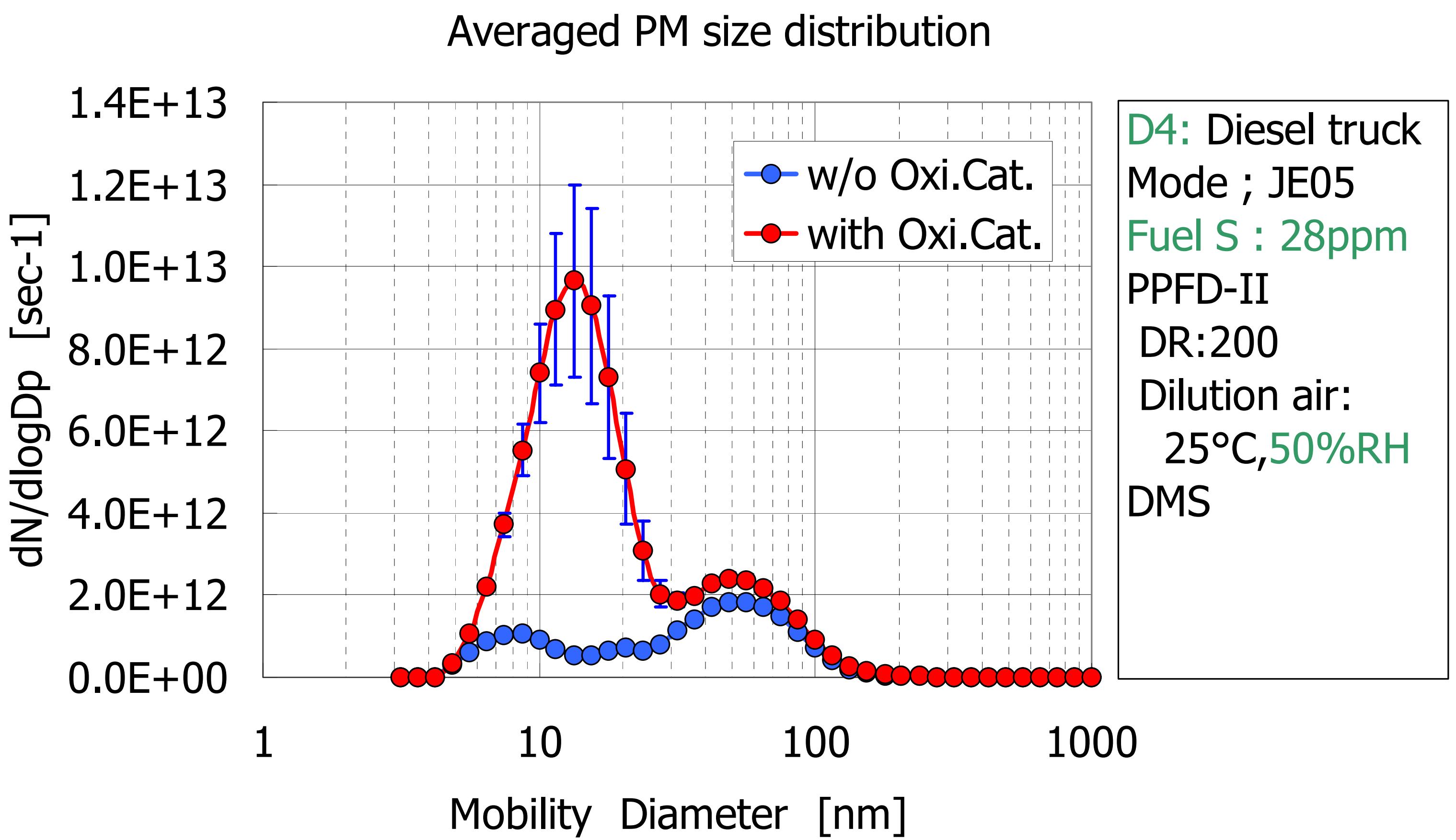
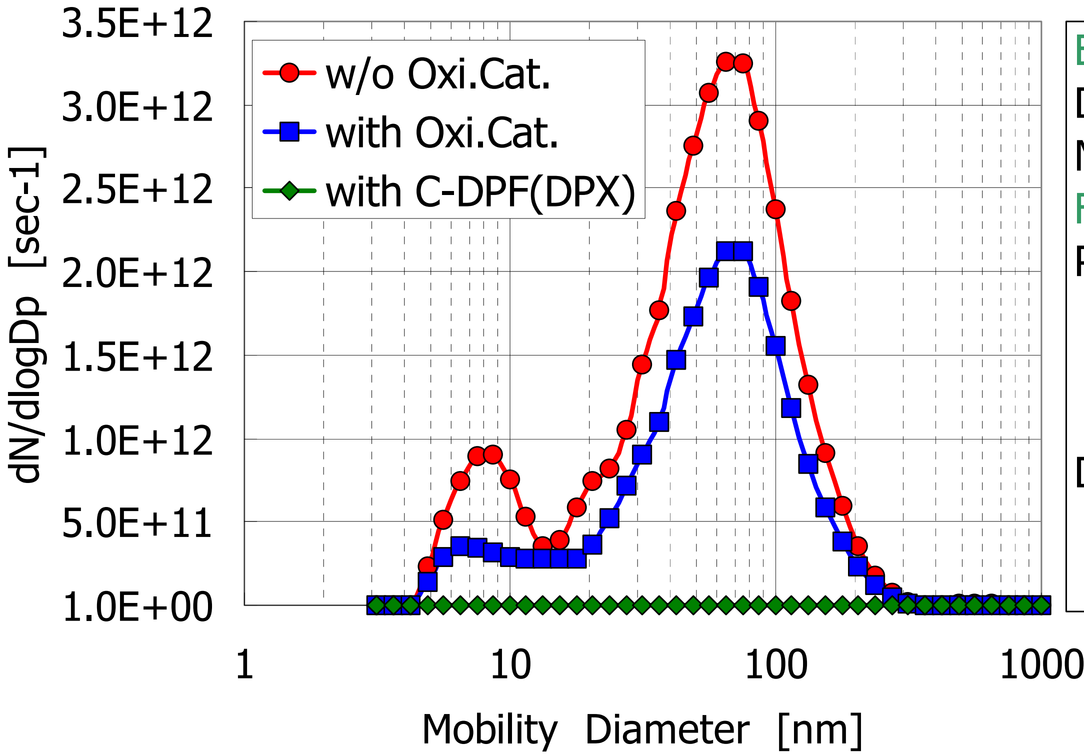


Effects of After-Treatments on Nuclei Mode Particle OxiCat and DPF

4 Effects of after-treatments on nucleation mode particles



E2: Heavy Duty
Diesel Engine
Mode ;JE05
Fuel S : 28ppm
PPFD-II
DR:200
Dilution air:
25°C,50%RH
DMS

Conclusion

- PPFD-II is developed.
- Higher dilution ratio and certain humidity is required to have stable result especially for nuclei mode.
- Nuclei mode particle can be reduced by the after-treatment such as oxidation catalyst.
- DPF is effective for reduction of both nuclei mode and accumulation mode particle.

Further Study

- Data base of other vehicles and engines
- Traceability for particle number measurements
- Background effects on nuclei mode
- Chemical analysis of nuclei mode particle

Acknowledgement

Thank you to Mr. Higuchi of HORIBA Ltd. for modifying the micro tunnel and JAMA working group on fine particle measurements for the collaboration.

Thank you for your kind attention