UNIVERSITY OF BIRMINGHAM

Some Characteristics of Particulate Matter Exhaust Emissions of Bio-fuels

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Acknowledgement

- Work carried out

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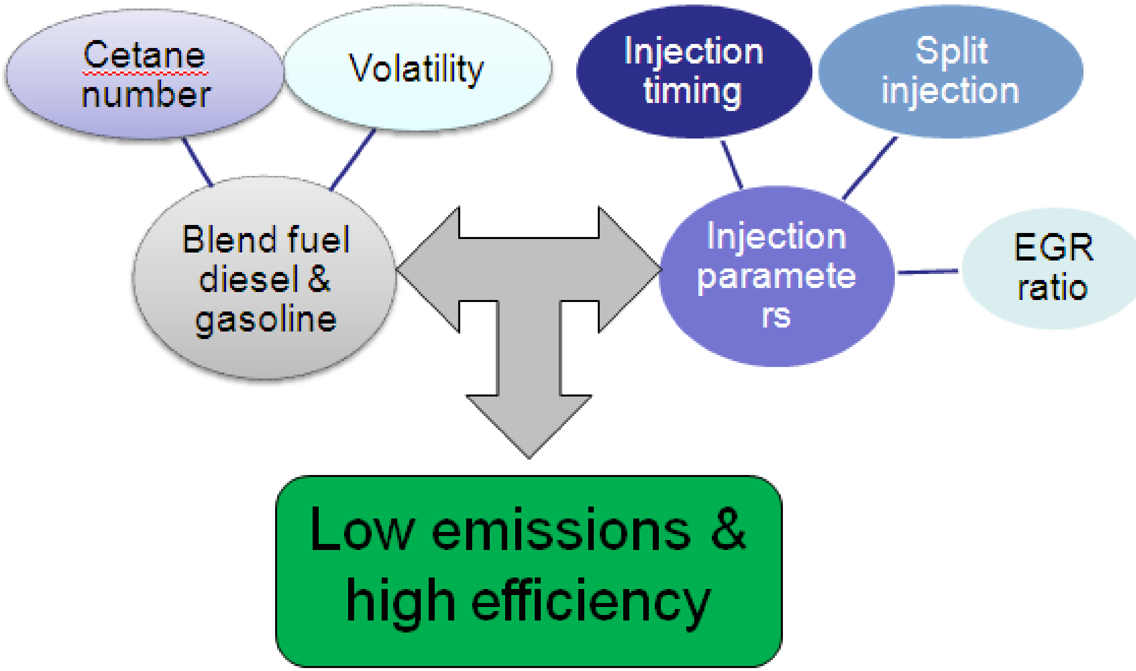
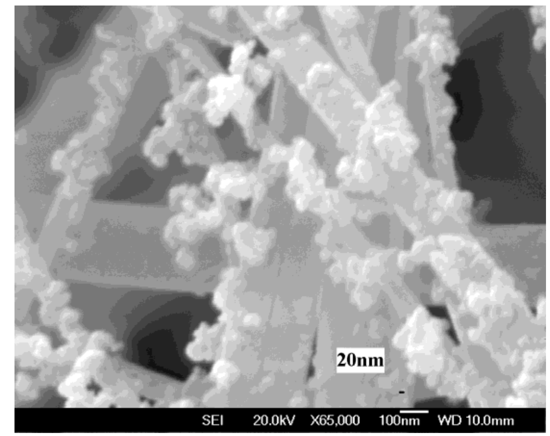
Presentation outline

1. Background
2. Research on bio-fuels
    - DMF, Ethanol
    - RME
3. Some results and discussion
4. Summary

PM studies for automotive engines





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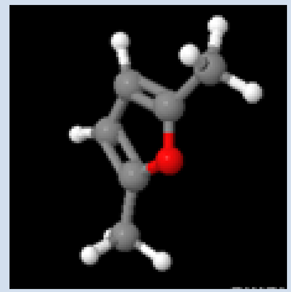
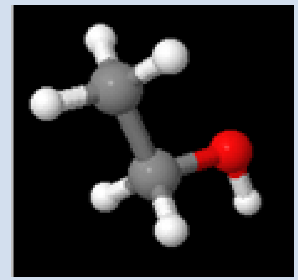
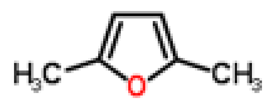
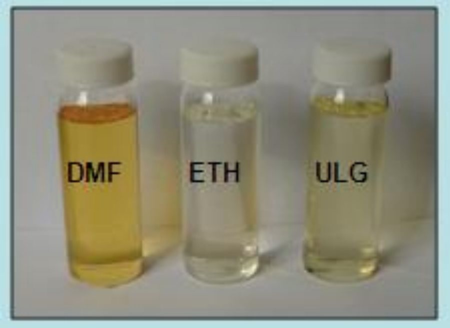
DMF, Ethanol – alternatives to gasoline

Name(s)[i,ii]	2,5 Dimethylfuran	Ethanol	Gasoline
Linear Structure Formula[i]	$(CH_3)_2C_4H_2O$	CH_3OCH_3	Variable
Molecular Formula[i]	C_6H_8O	C_2H_6O	C_2 to C_{14}
Molecule 3D View[iv]			Variable
Molecule Schematic[iv]			Variable
BP, Boiling Point (1atm)[i]	$93.0°C$	$77.3°C$	
Enthalpy of Vaporization[iv] ($20°C$)	$31.91 kJmol^{-1}$	$43.2496 kJmol^{-1}$	
Enthalpy of Combustion[iii]	$42.0 kJmol^{-1}$	$26.9 kJmol^{-1}$	$43.4 kJmol^{-1}$
ρ, Density of Liquid [i]	$0.8954 kgm^{-3}$ @$20°C$	$0.79363 kgm^{-3}$ @$15°C$	
Research Octane Number (RON)[v]	119	110[vii]	95[iv]
Auto Ignition Temperature[vii]	$285.85°C$	$423°C$	$257°C$

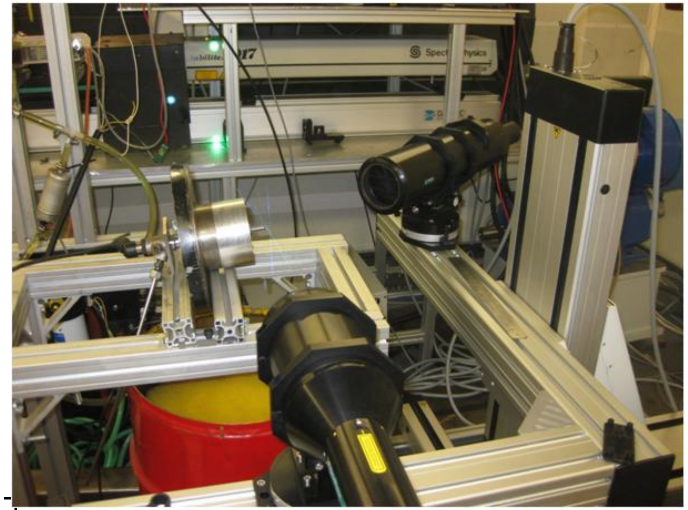
Why researches on DMF

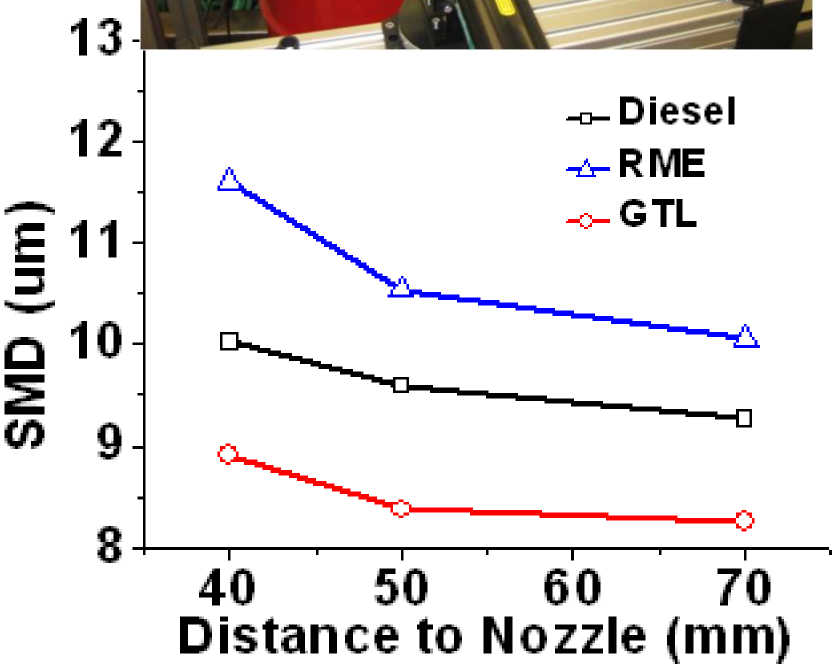
- DMF has physical properties very close to gasoline, but it has a very high octane number (RON=119) and relatively low volatility.
- Compared to ethanol, it has an energy density higher by 60 per cent in volume and by 40% in mass.
- DMF is stable in storage and not soluble in water and therefore it cannot become contaminated by absorbing water from the atmosphere.
- It consumes only one-third of the energy in the evaporation stage of its production, compared with that required to evaporate a solution of ethanol produced by fermentation for biofuel applications.

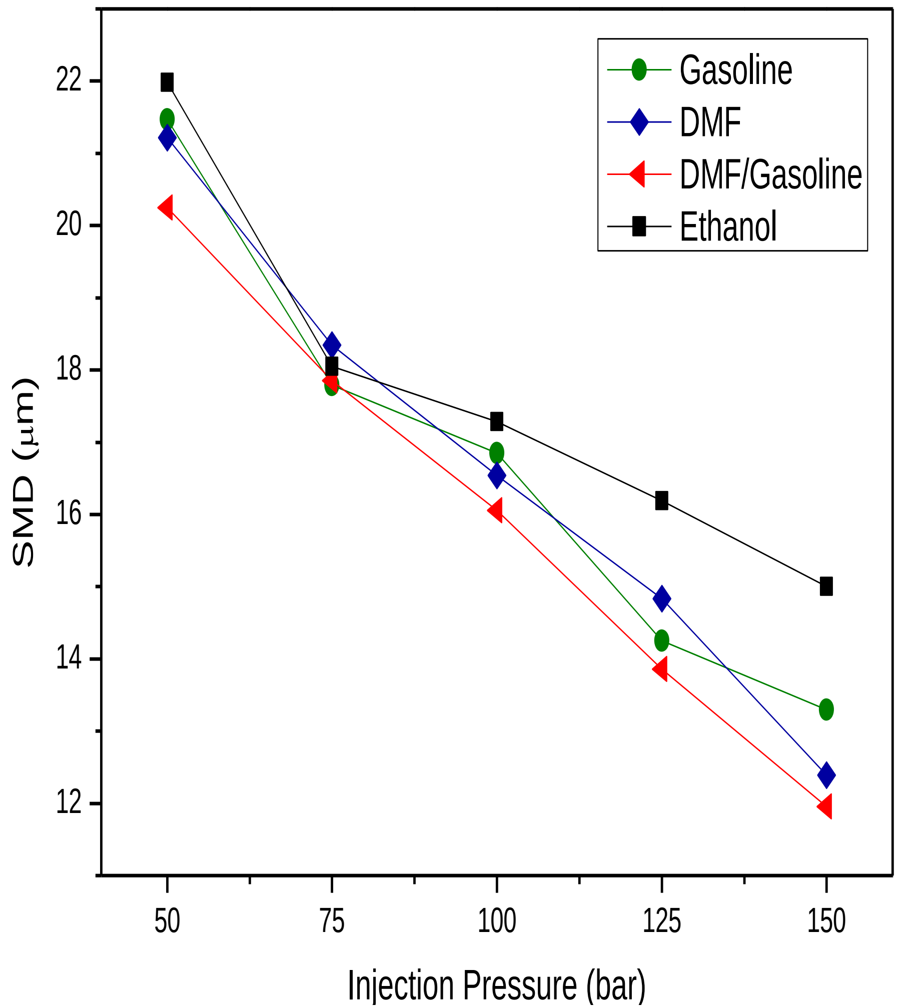
The most attractive advantage is that making DMF will not compete with land and food, and therefore it can be an ideal candidate for a new generation of sustainable bio-fuel!



Gasoline type of fuel spray characterisation

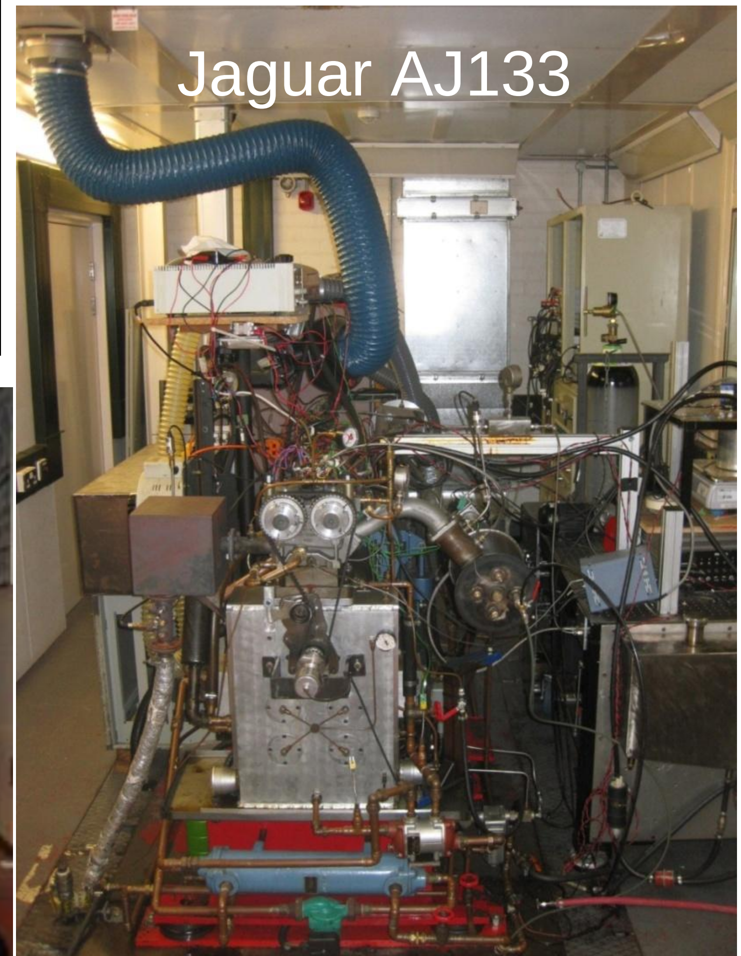




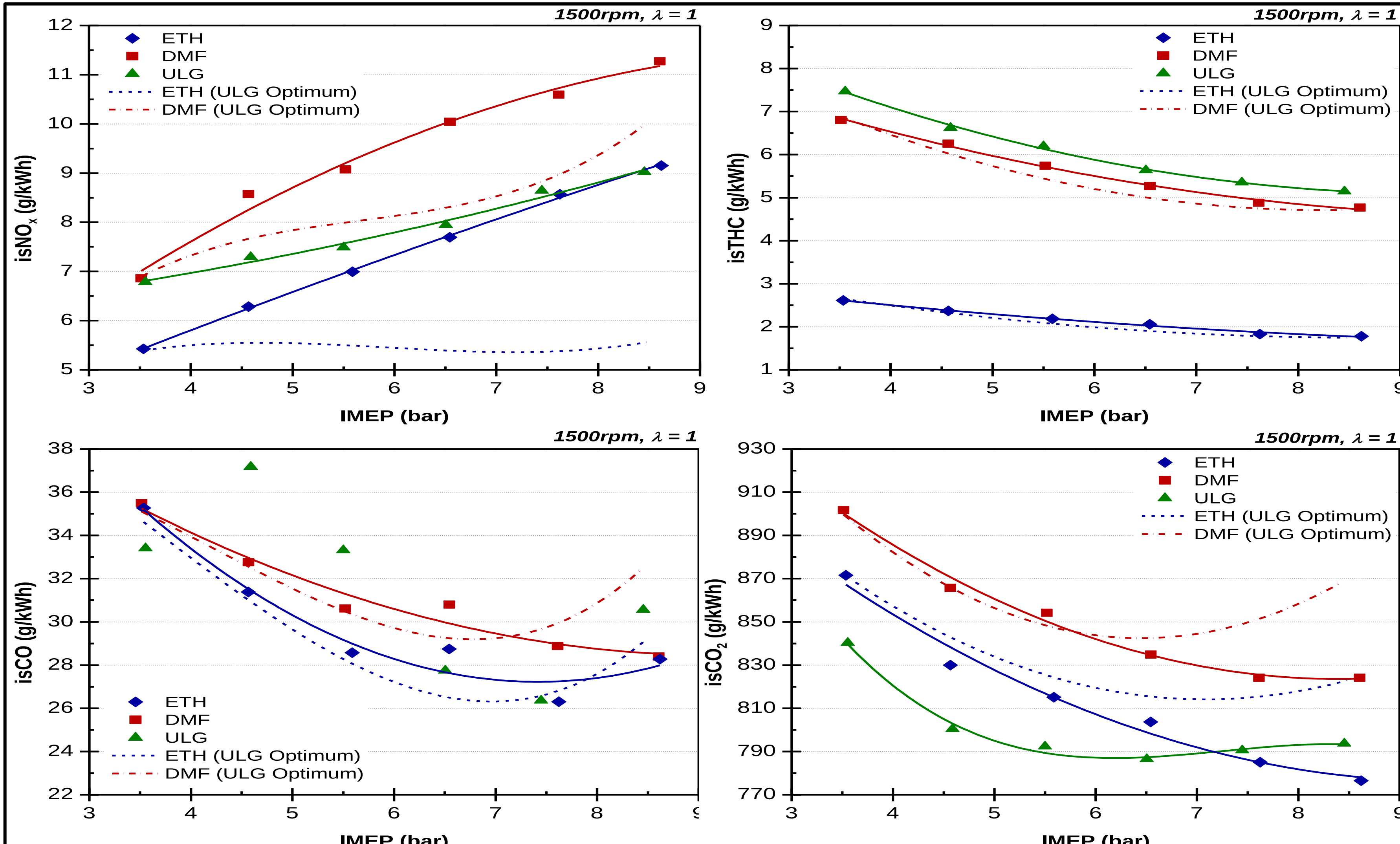


Single cylinder GDI Engine and SMPS

SMPS Settings	
Sample Flow Rate (L/min)	1
Sheath Flow Rate (L/min)	10
Scan Time (s)	120
Minimum Particle Diameter (nm)	7.23
Maximum Particle Diameter (nm)	294.3

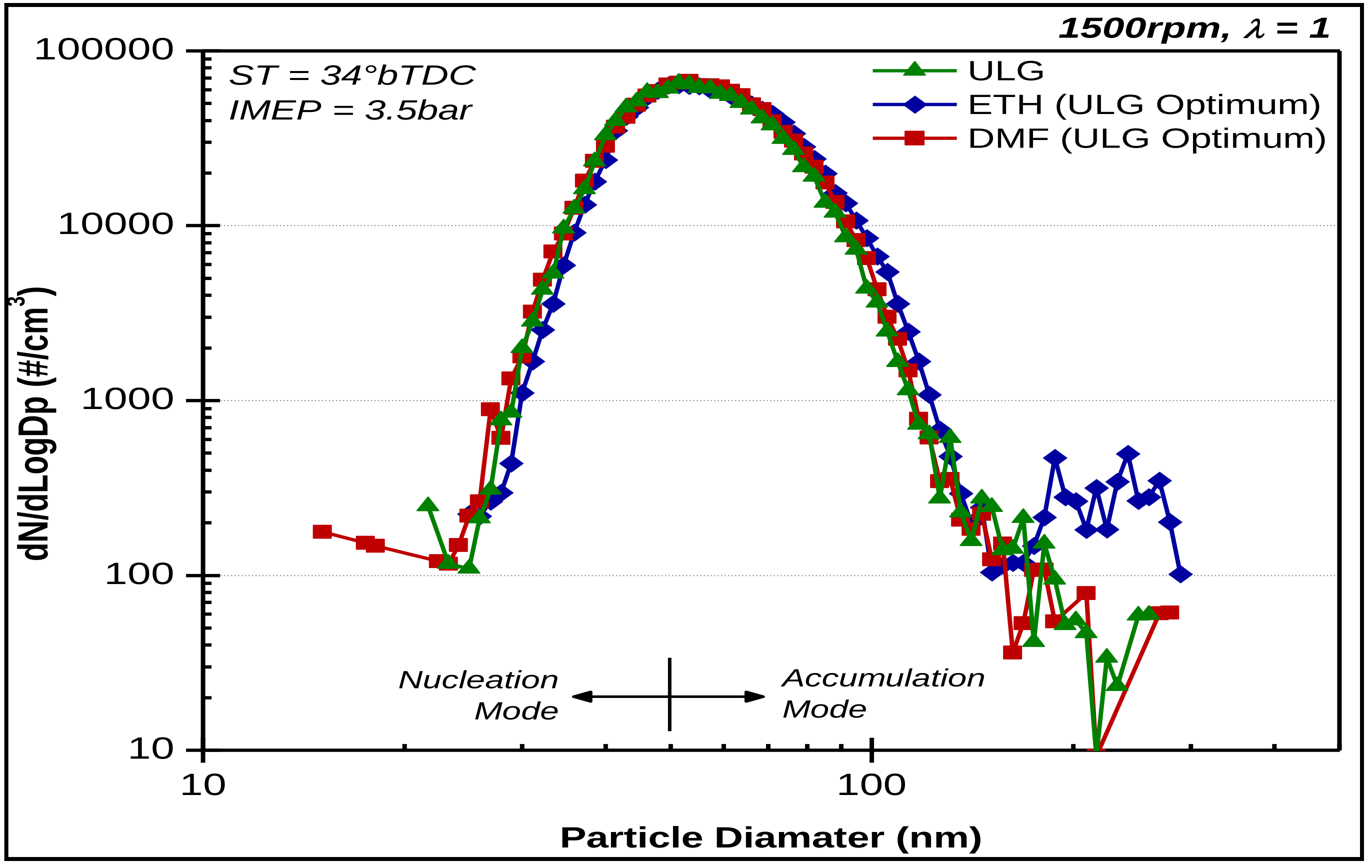


DMF, Ethanol and gasoline – gaseous emissions



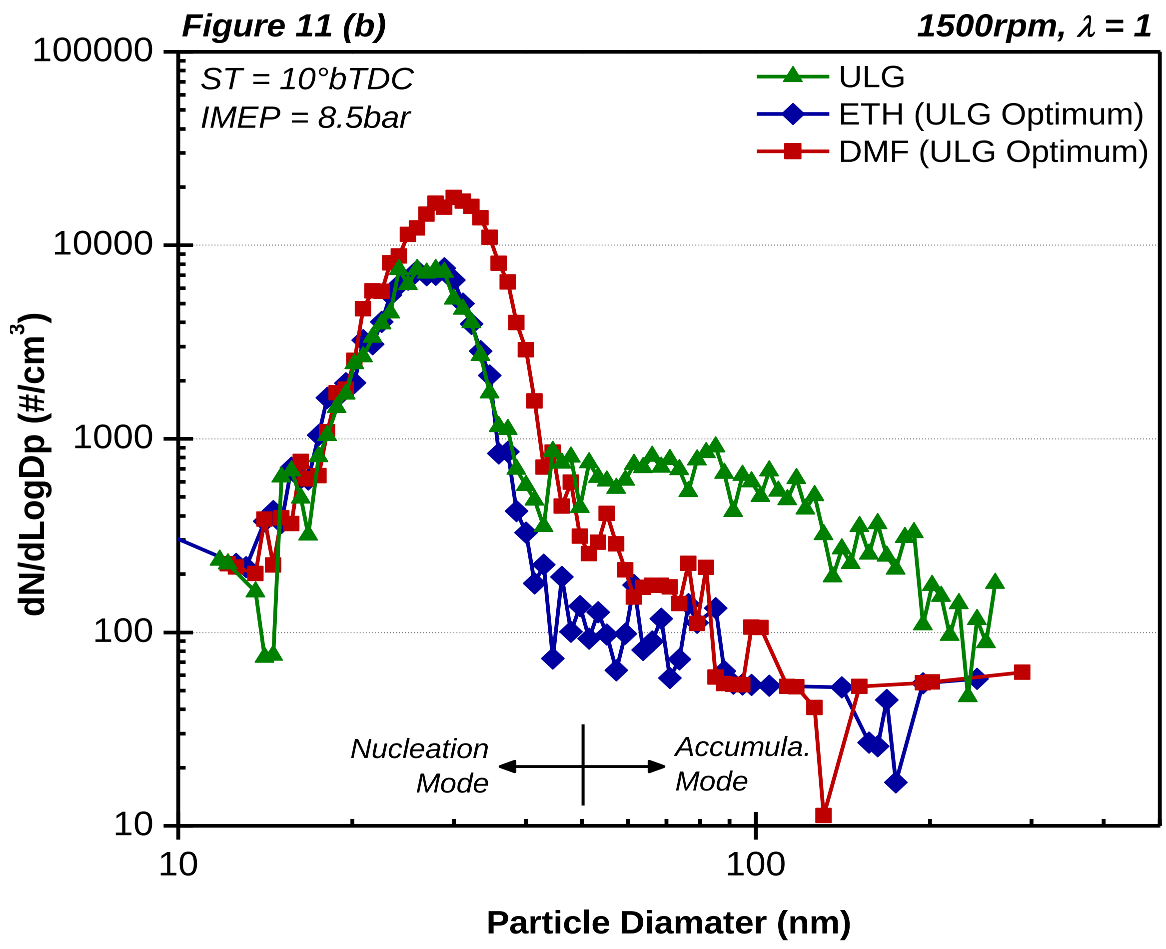
Effect of Load

PM size distribution at lower load



More accumulation mode particles than nucleation ones with the nucleation mode dominating the distribution.

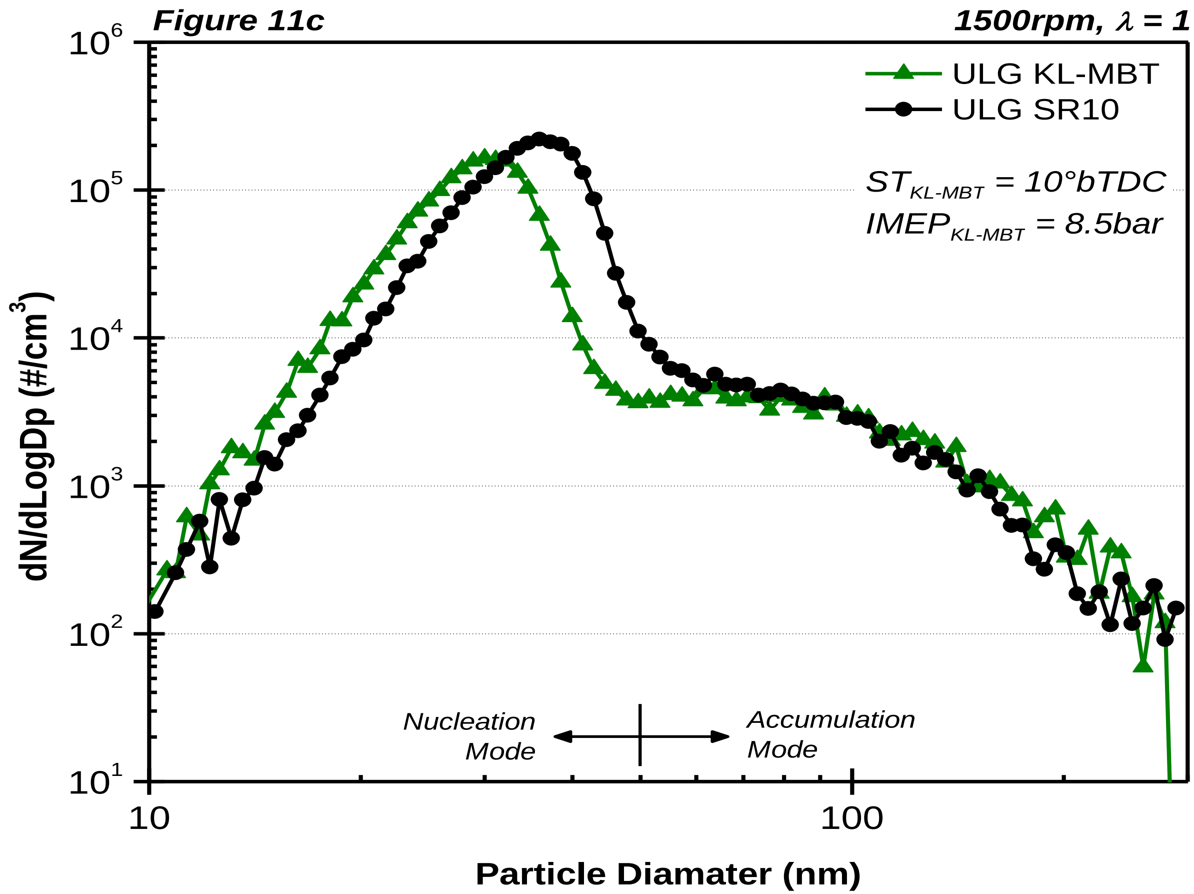
PM size distributions at higher load



The separation between the nucleation and accumulation modes becomes clear at higher load.

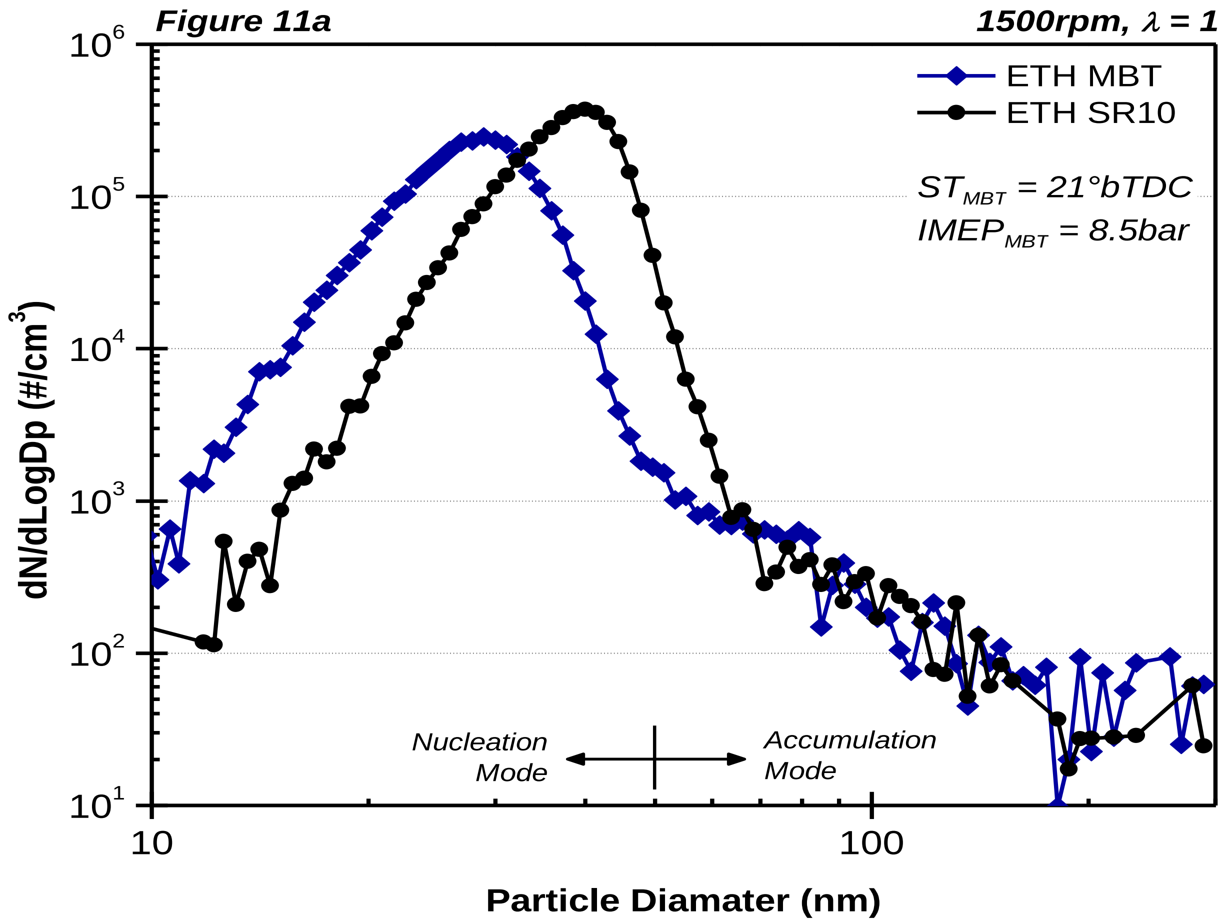
Effect of Spark Sensitivity

Gasoline at SR10



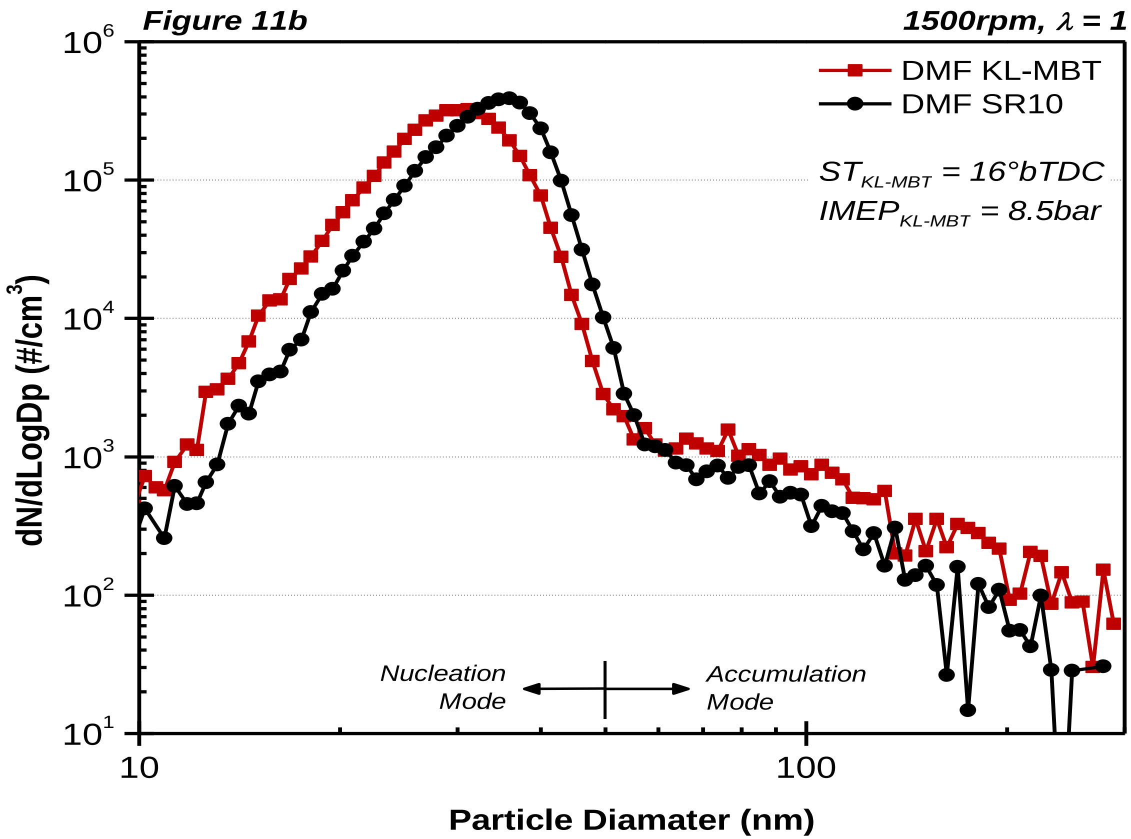
Spark retard largely affects the nucleation mode and not the accumulation mode distribution

Ethanol at SR10



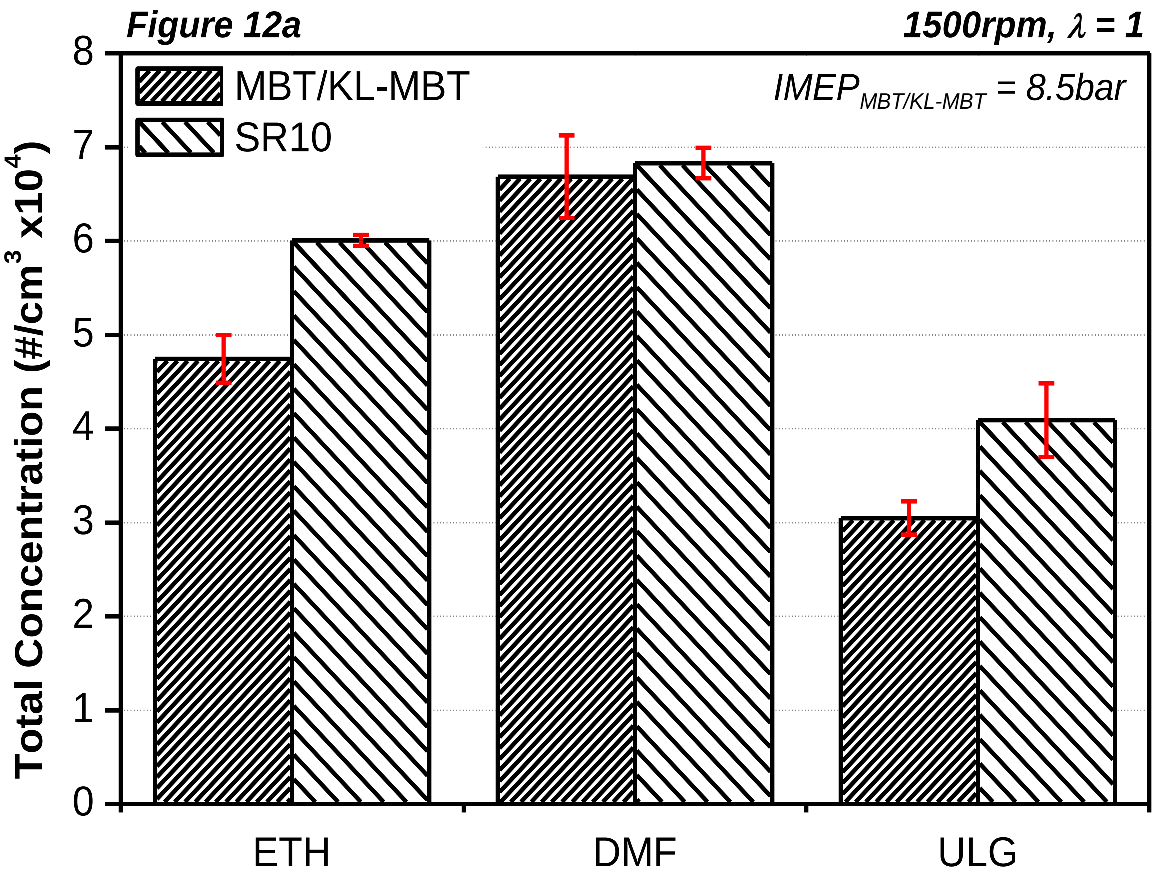
PM @SR10 is 359,614 #/cm^3 @ 38.5nm, 46% higher than at MBT

DMF at SR10



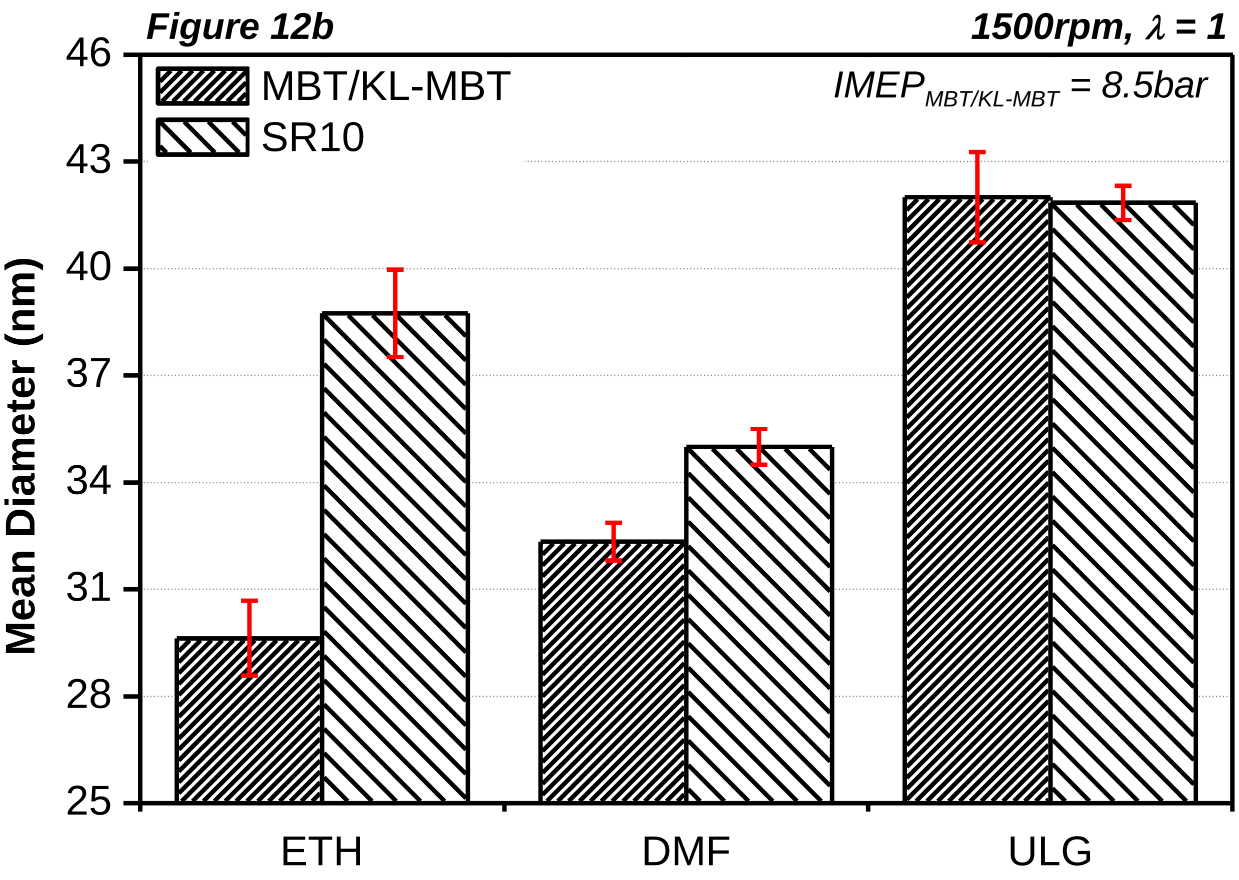
Increase in particle concentration and diameter is less than half compared with gasoline

Total PM concentration



Total PM concentration with DMF increases by 1,429 particles/cm^3 (2.1%), whereas with ethanol this is 12,620 particles/cm^3 (26.6%).

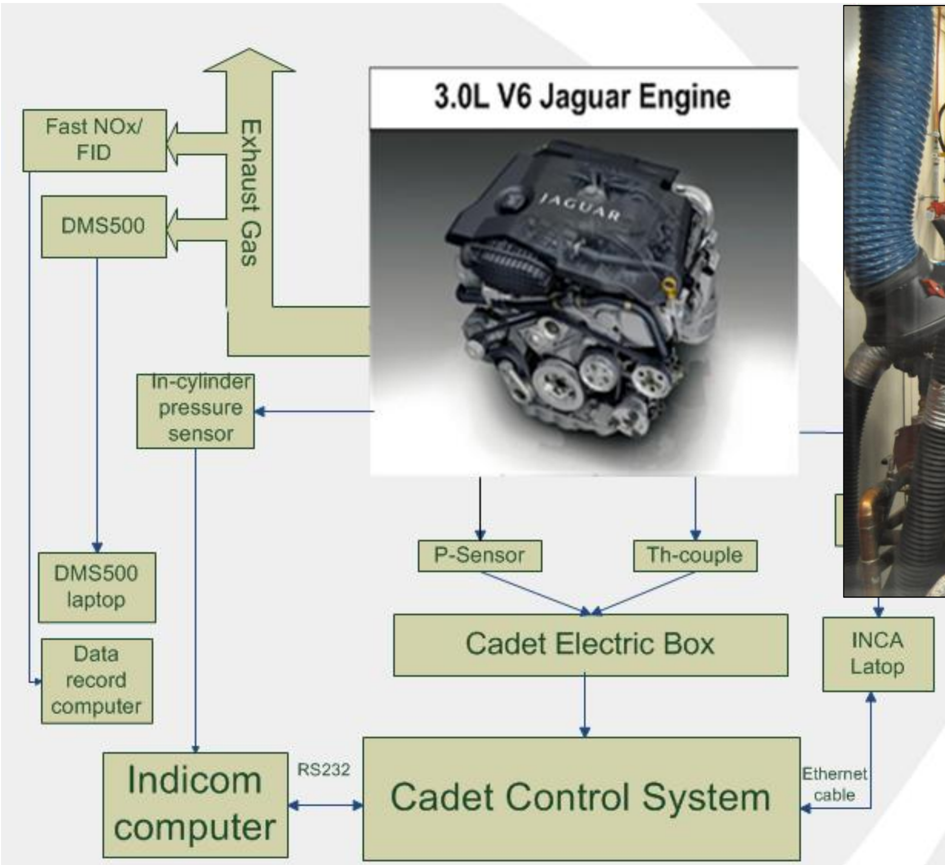
Mean diameter

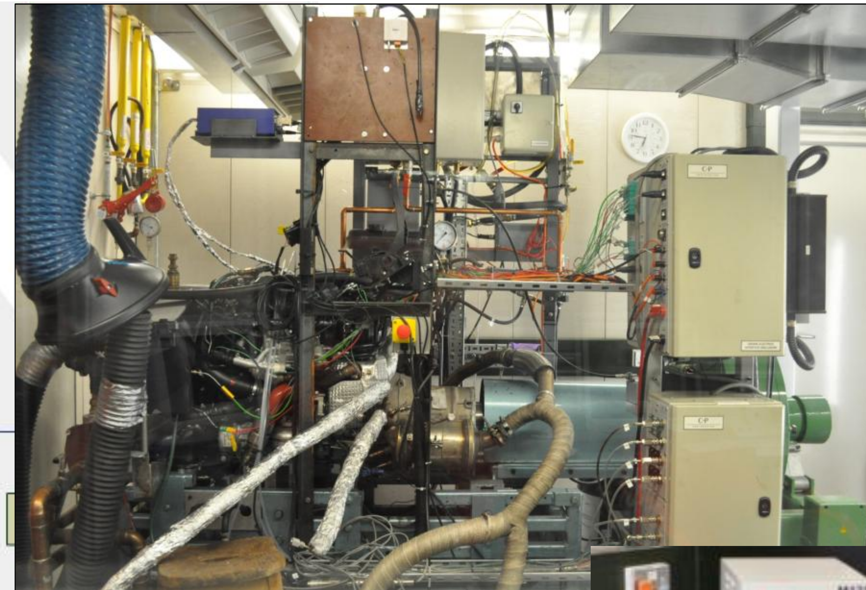


Both of the biofuels have larger total number concentrations compared to gasoline due to the dominant nucleation mode.

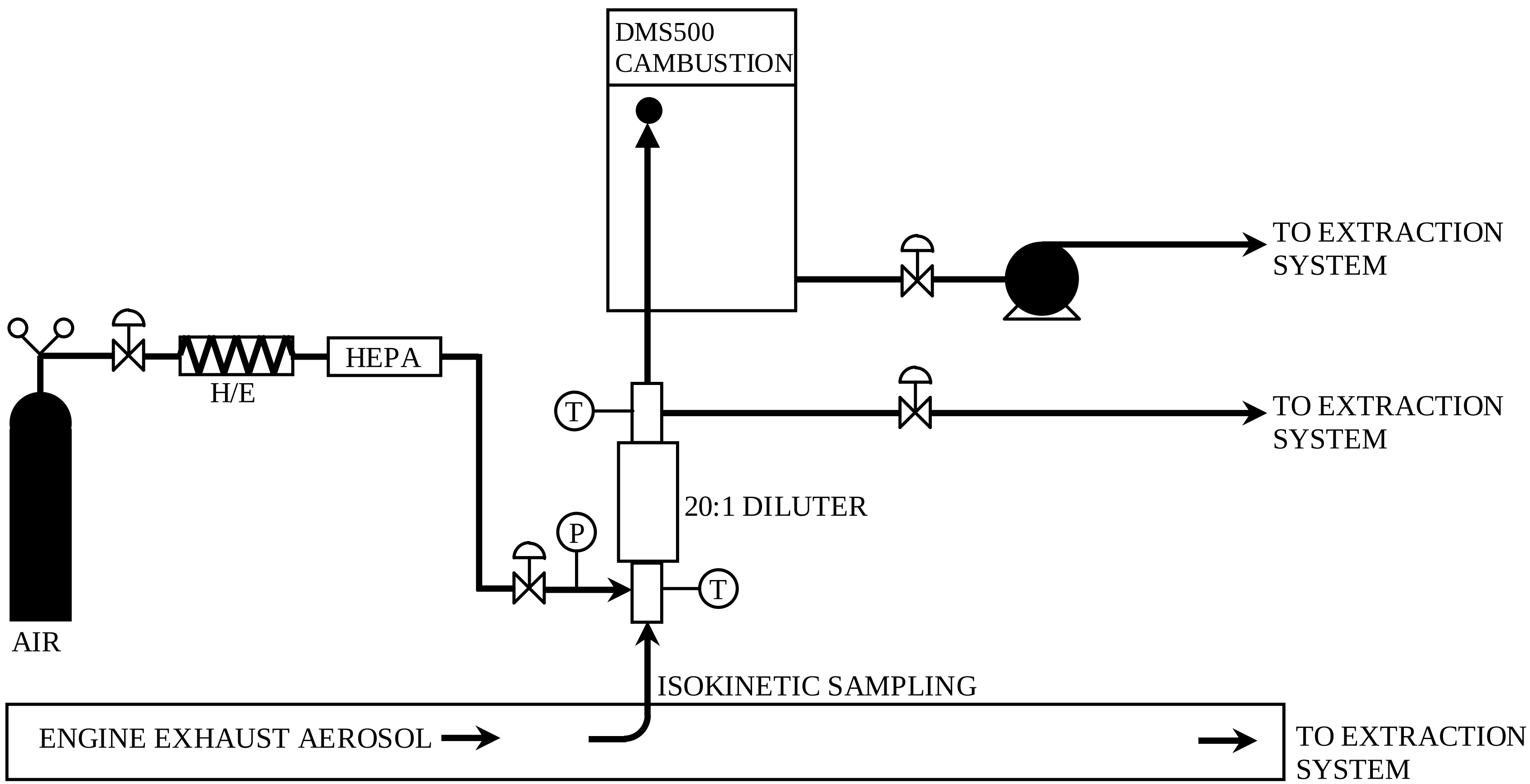
Comparison of PM emissions between RME blends and diesel fuels

Jaguar V6 diesel engine (Ford Lion)

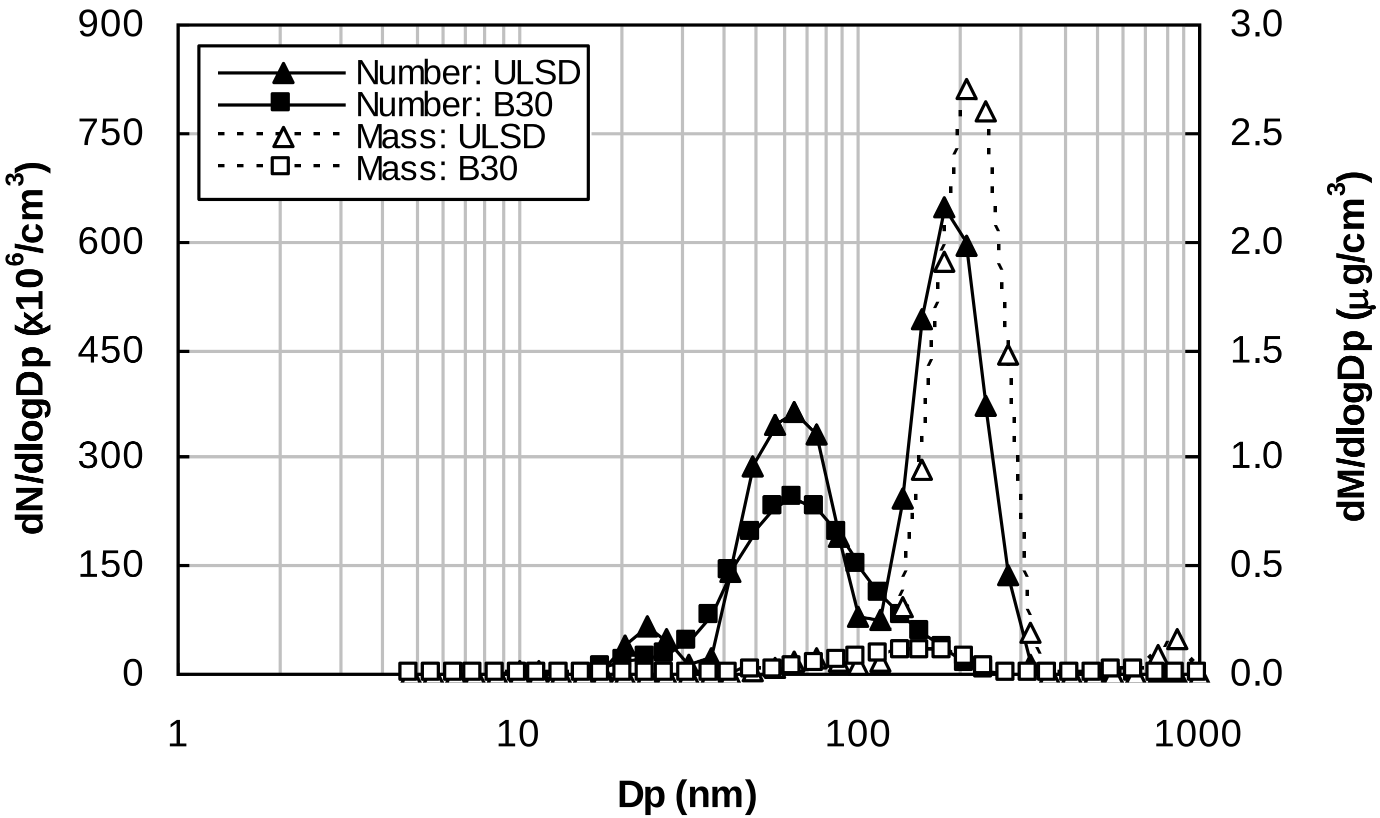




DMS 500 sampling system layout

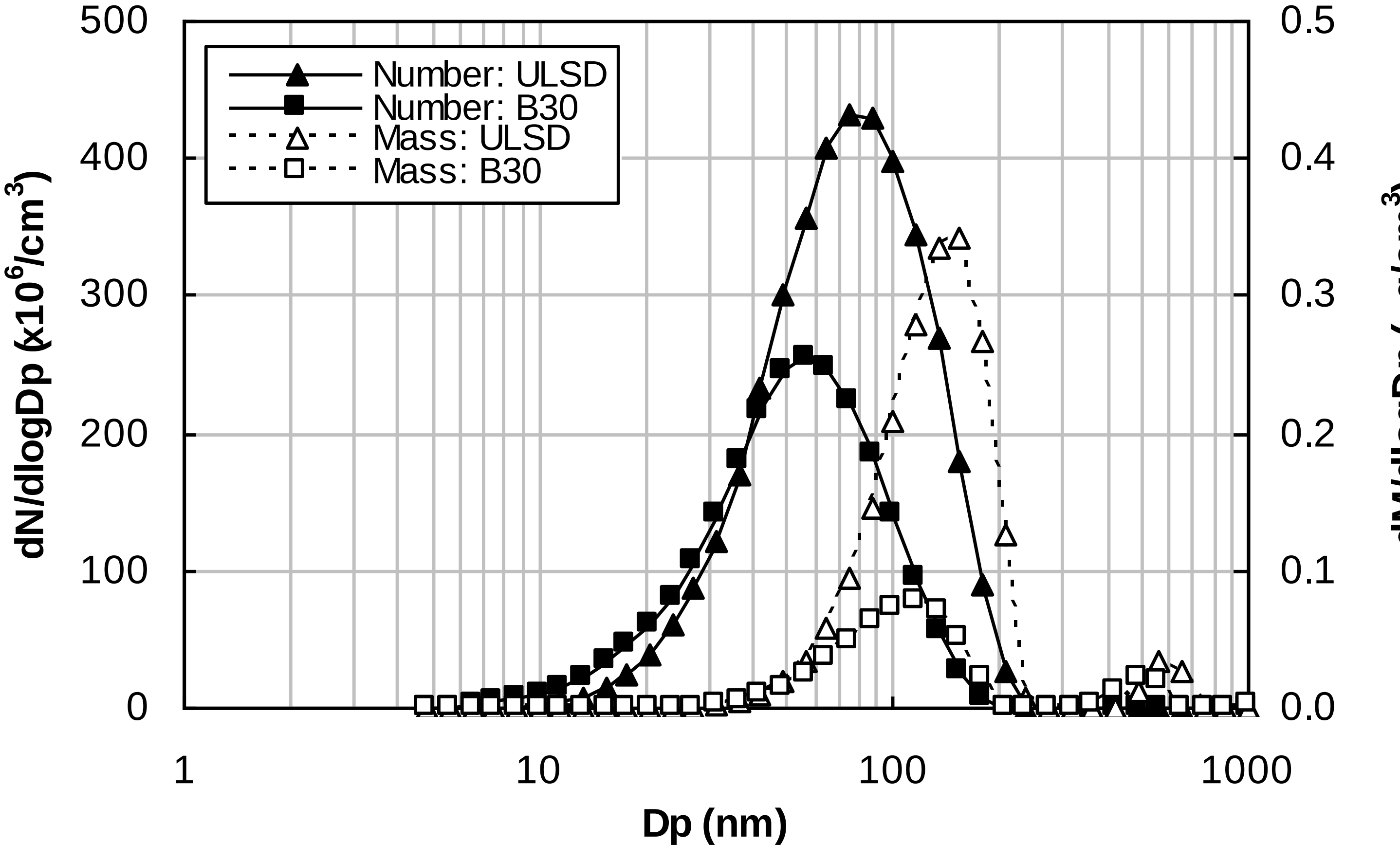


Particle numbers in light load



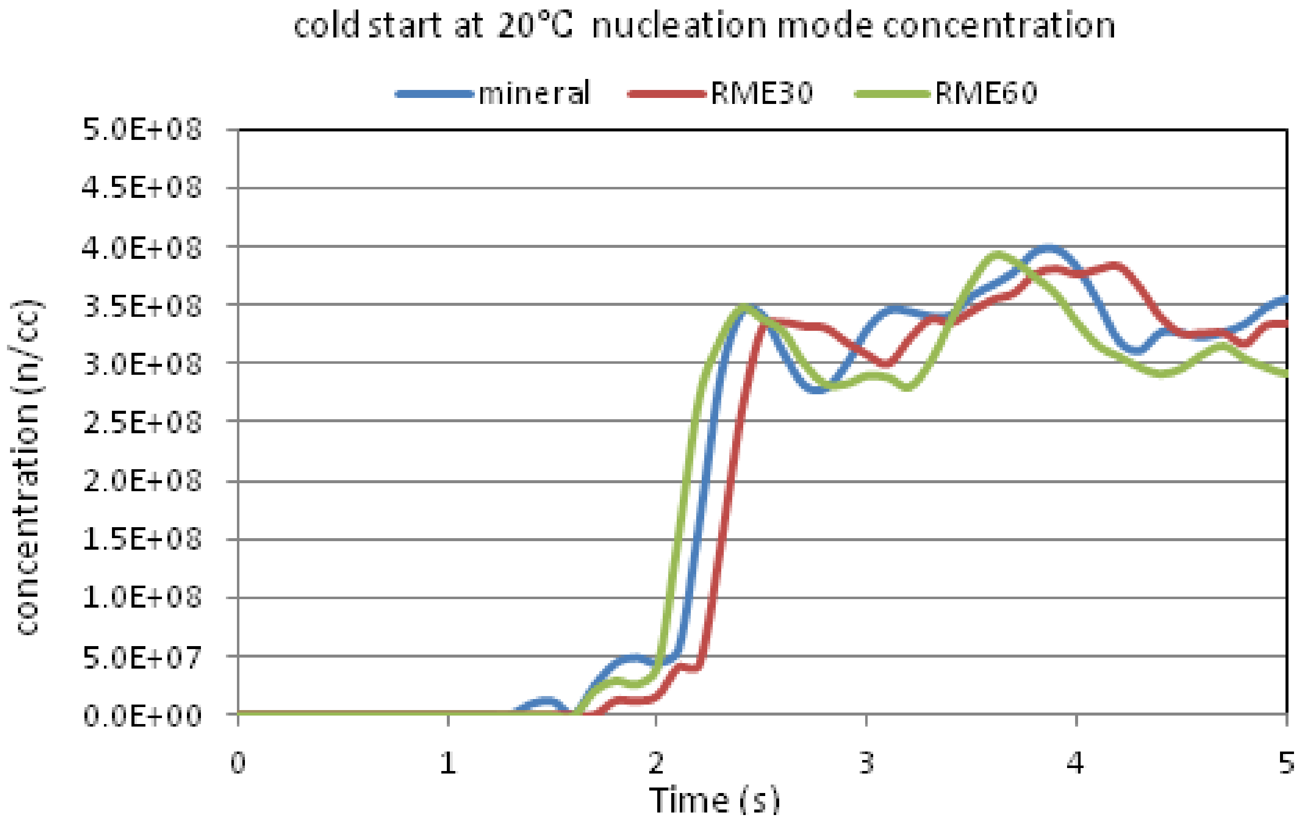
B30 are much higher relatively in PM mainly for smaller diameters (nuclei mode) compared to ULSD

Particle numbers in higher load



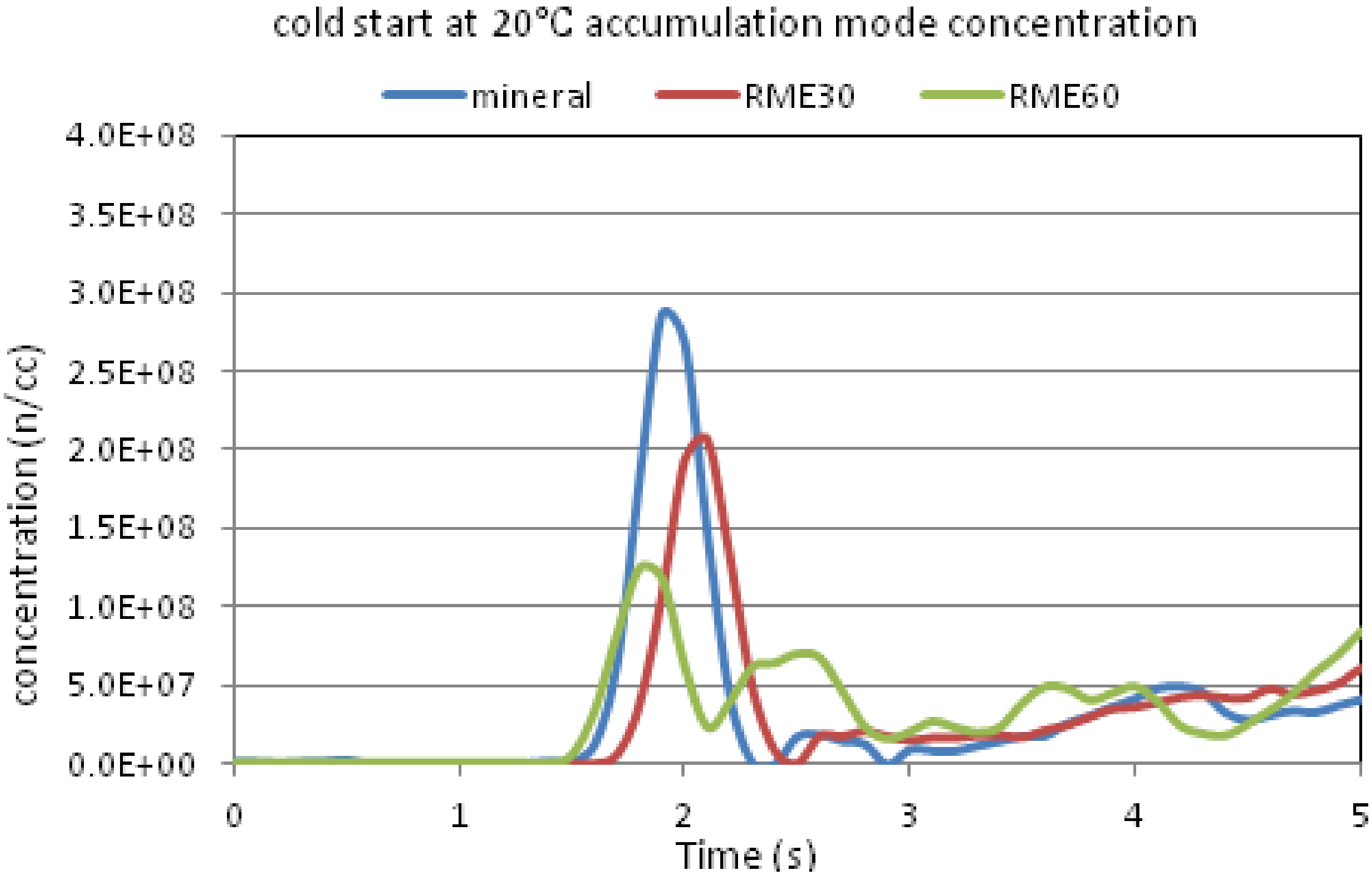
Size distributions re often mono-module with the nucleation mode dominating the distribution

Particle numbers in cold start



Variation in nucleation mode is small with RME blends
With little difference for higher RME blends

Particle numbers in cold start



Variation in PM with RME blends is mainly with accumulation mode, which drop clearly with increasing RME blend ratio

Summary of main conclusions

With Ethanol an DMF

- The separation between the nucleation and accumulation modes becomes clear at higher load with the nucleation mode dominate the distribution.
- More accumulation mode particles than nucleation ones
- Spark retard largely affects the nucleation mode and not the accumulation mode distribution
- Ethanol has higher spark-sensitivity whereas DMF is the minimum

With RME

- Much relatively higher portion of PM in smaller diameters (nuclei mode) compared to ULSD
- Variation in PM with RME blends is mainly with accumulation mode, which drop clearly with increasing RME blend ratio

Thanks very much for your attention