



Physical and chemical characterization of the particles emitted by a DI SI engine with low- and zero-carbon fuels

B. Apicella, F. Catapano, S. Di Iorio, A. Magno, C. Russo, P. Sementa, A. Tregrossi, B. M. Vaglieco

*Institute of Science and Technology for Sustainable Energy and Mobility (STEMS) - CNR,
Naples, Italy*



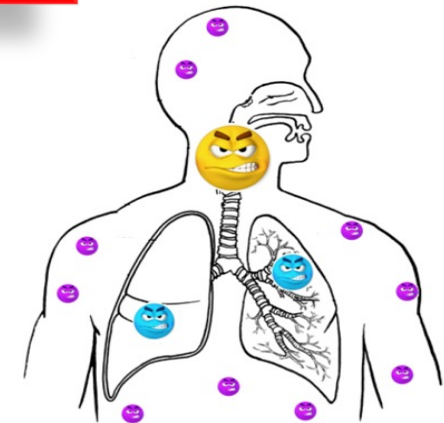
Climate Change



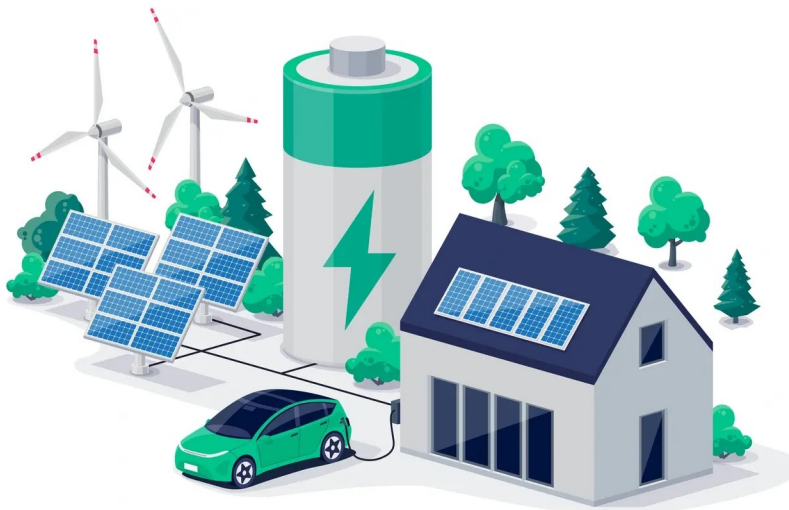
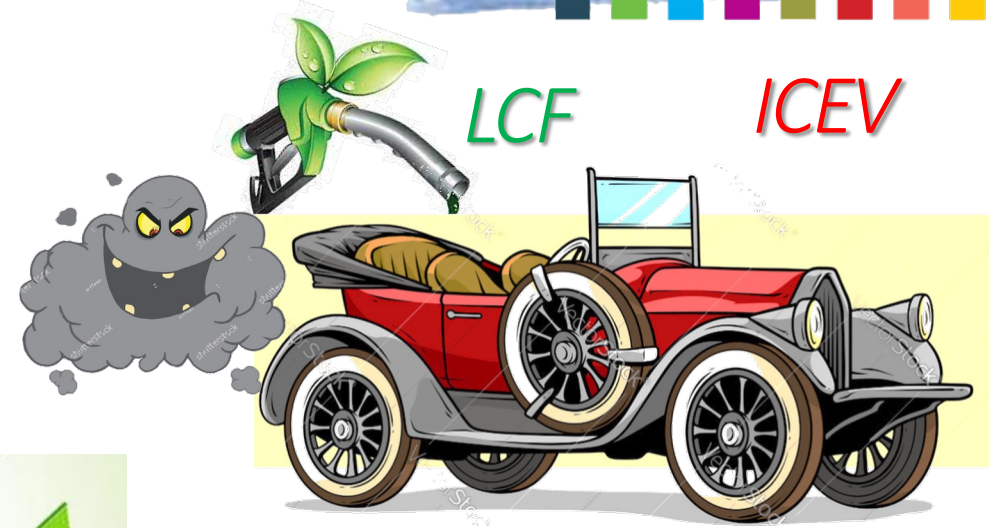
Deterioration of Air Quality



PM

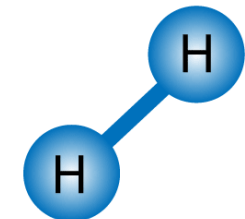
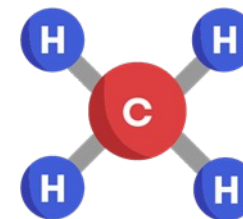


Sustainable Mobility

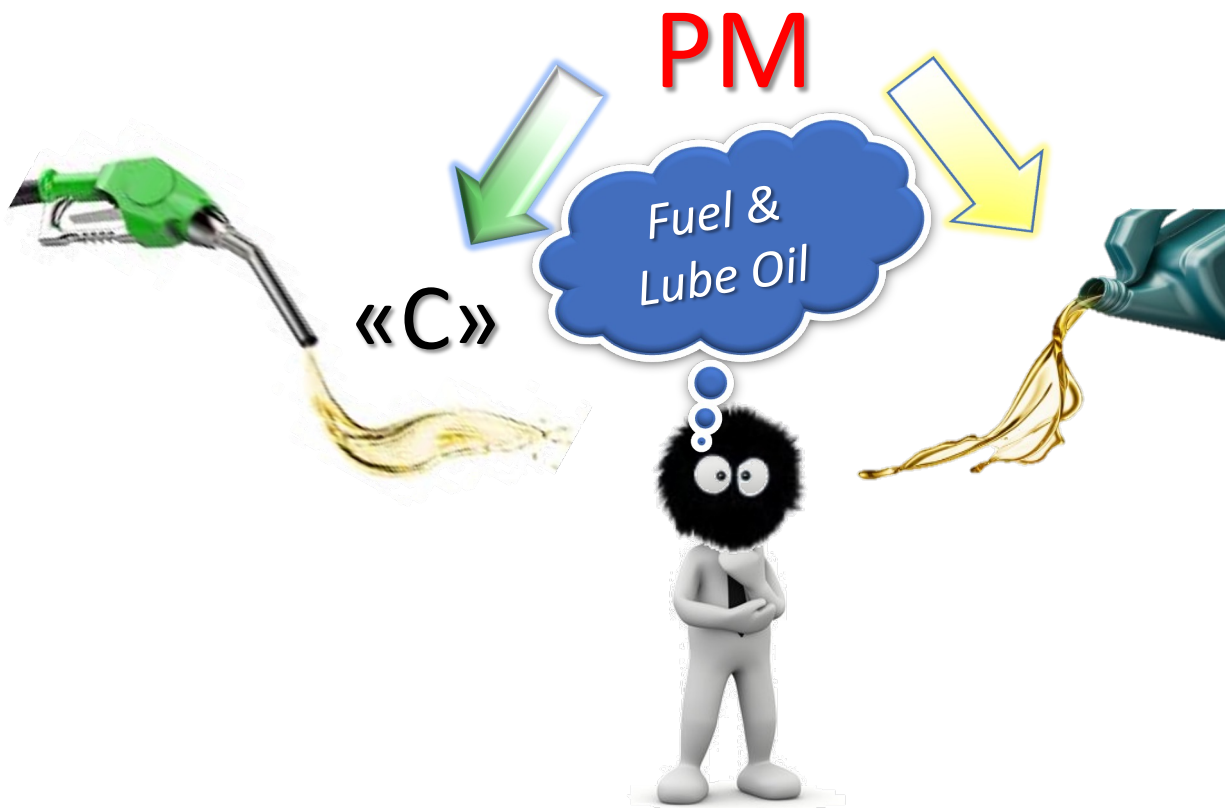
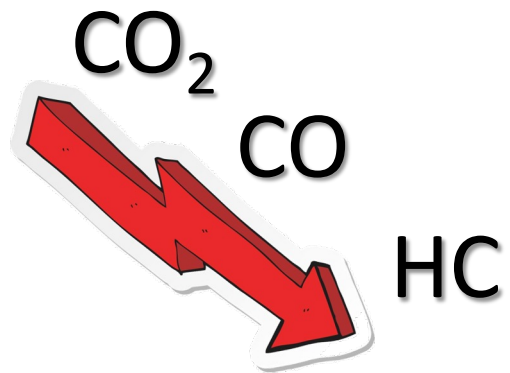
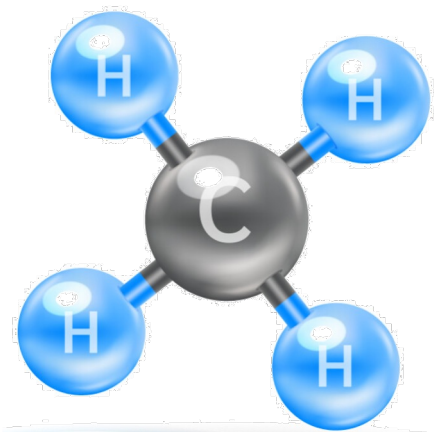


Methane

Hydrogen



CH₄ & H₂ Engines: Emissions

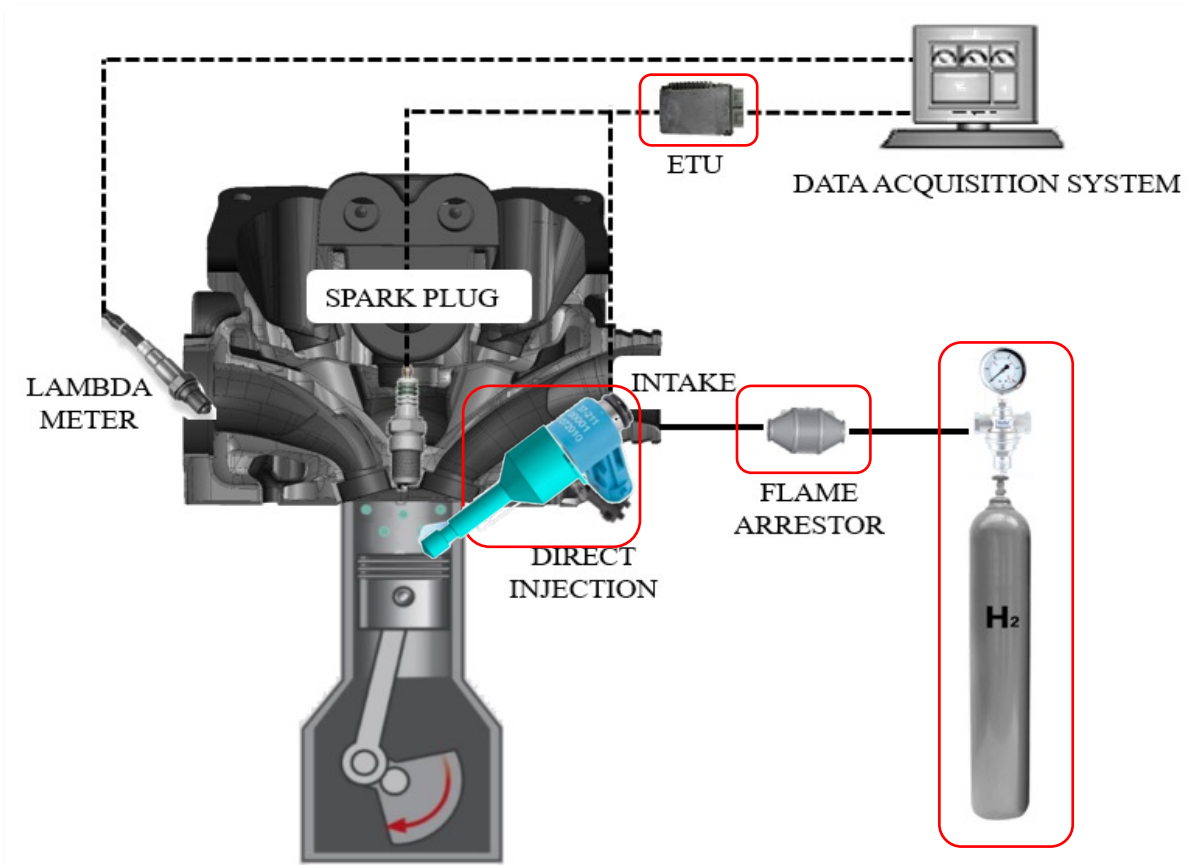




Role of fuel and lubricating oil on particle emissions from a DI gaseous fueled engines:

Methane vs Hydrogen





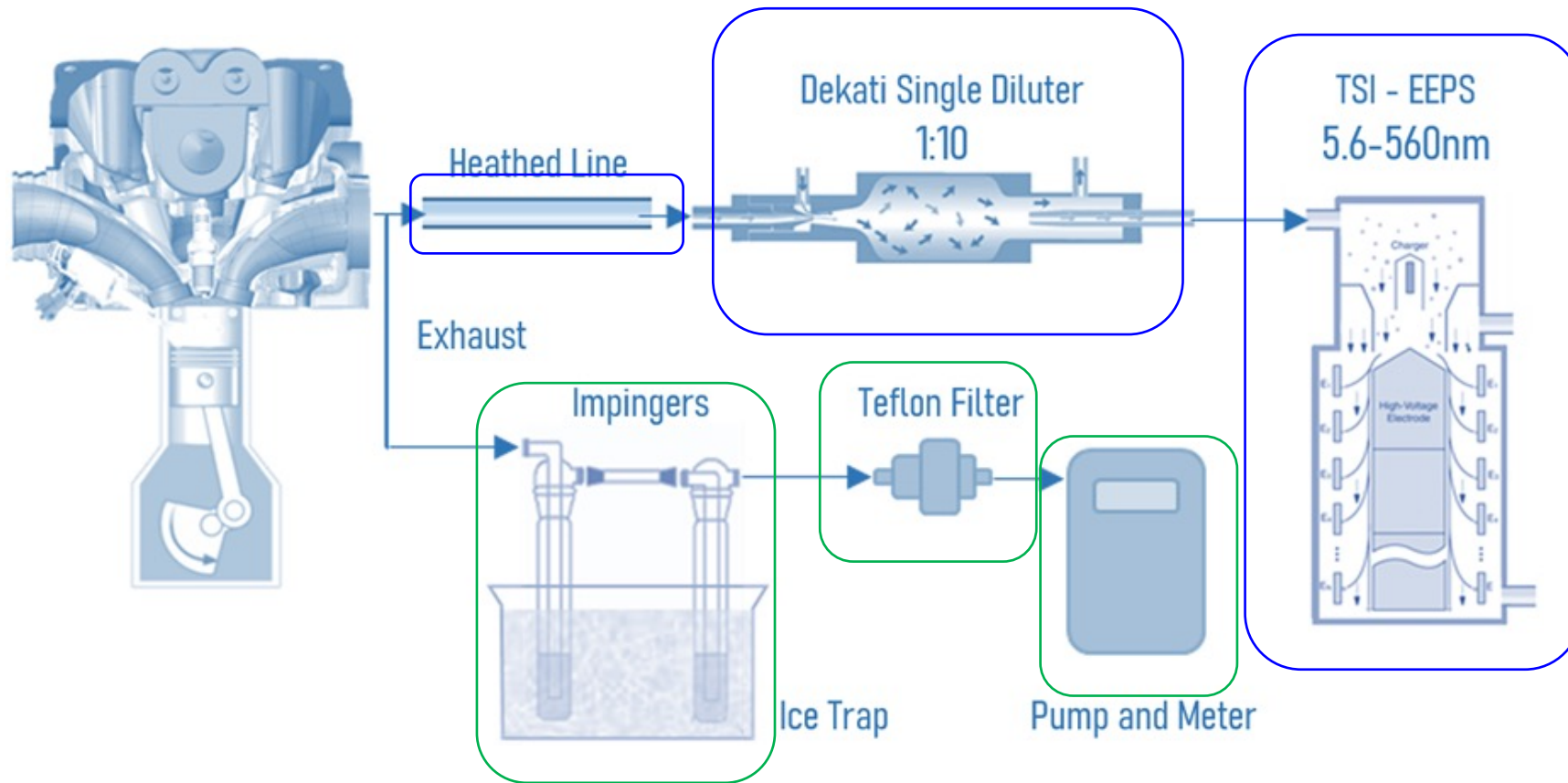
DI SI Engine	
Cylinder volume [cm ³]	250
Bore [mm]	72
Stroke [mm]	60
Compression ratio	9:1
Max power [kW]	7.9 @ 5000 rpm
Max torque [Nm]	14.7 @ 5000 rpm

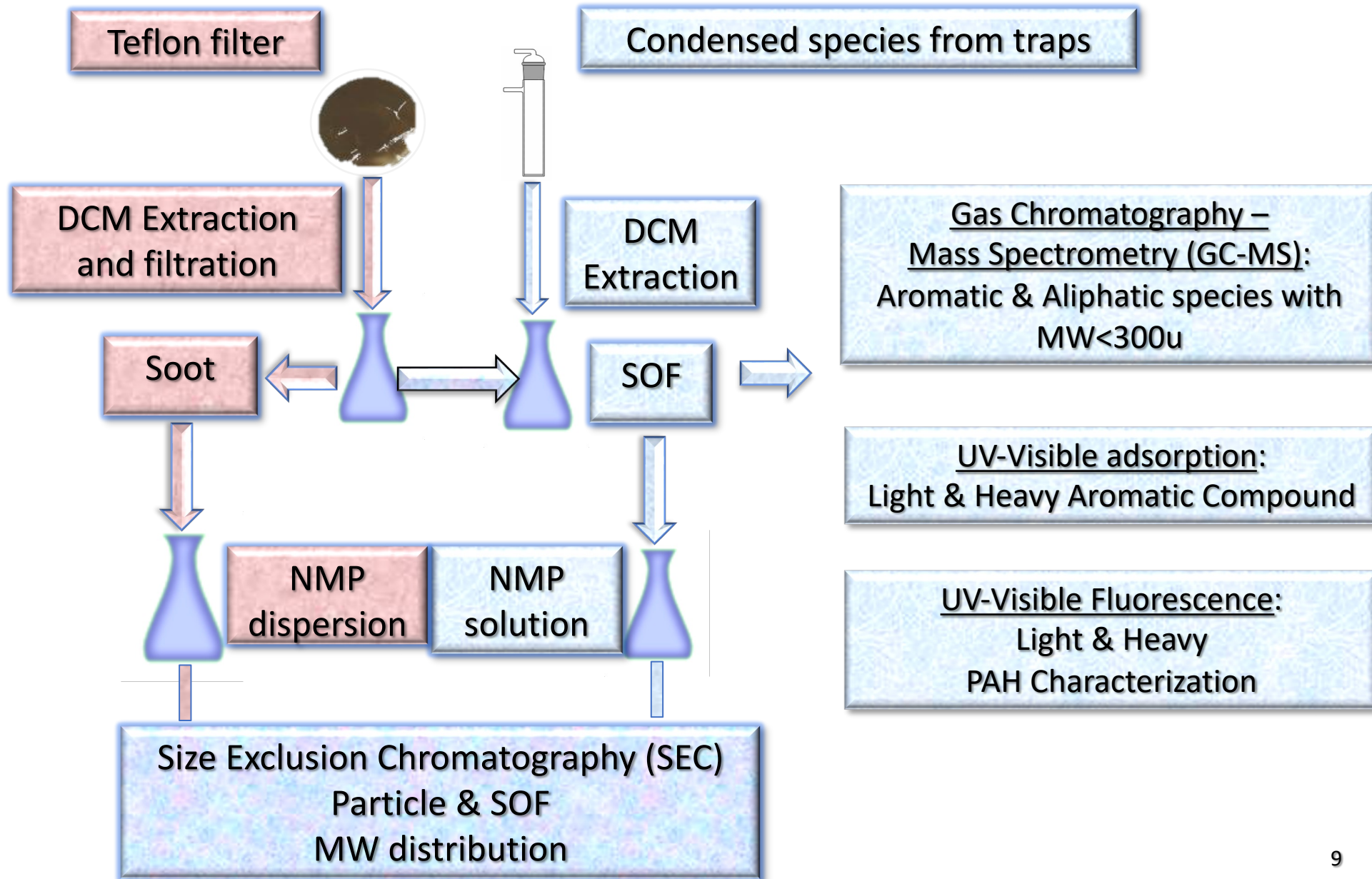
Oil Properties	
Viscosity	10W-40
Density @ 20 °C	0.870 kg/l
Viscosity @ 40 °C	101.7 mm ² /s
Viscosity @ 100 °C	14.5 mm ² /s
Viscosity index	151
Pour point	-35.0 °C
TBN	10.1 mg KOH/g
Flash point	228 °C



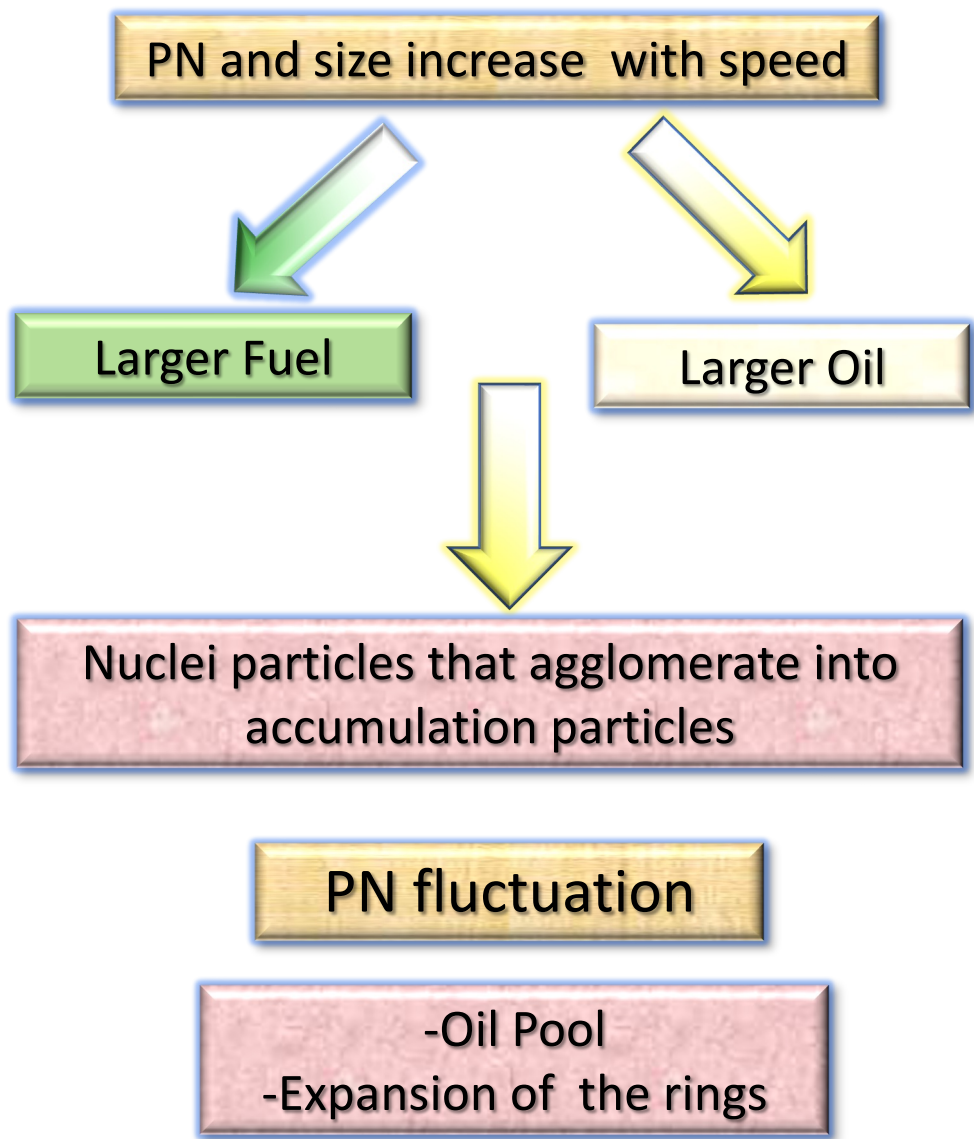
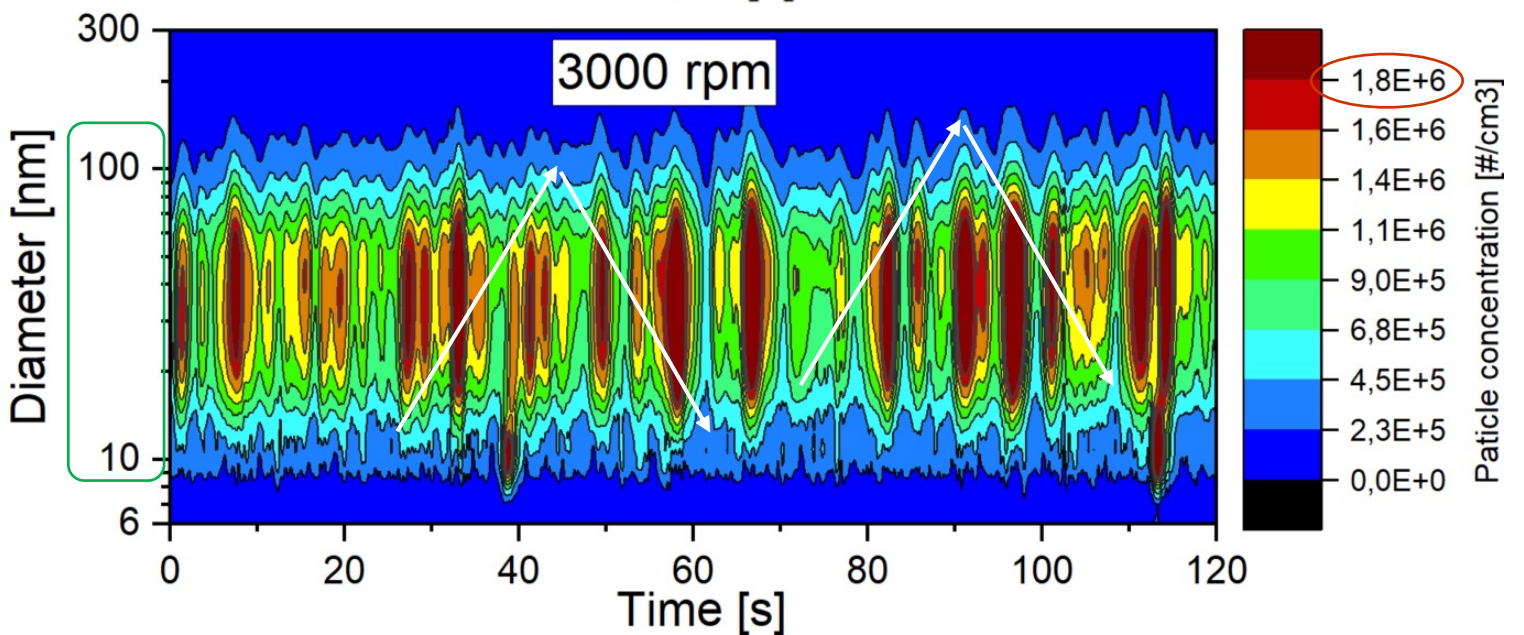
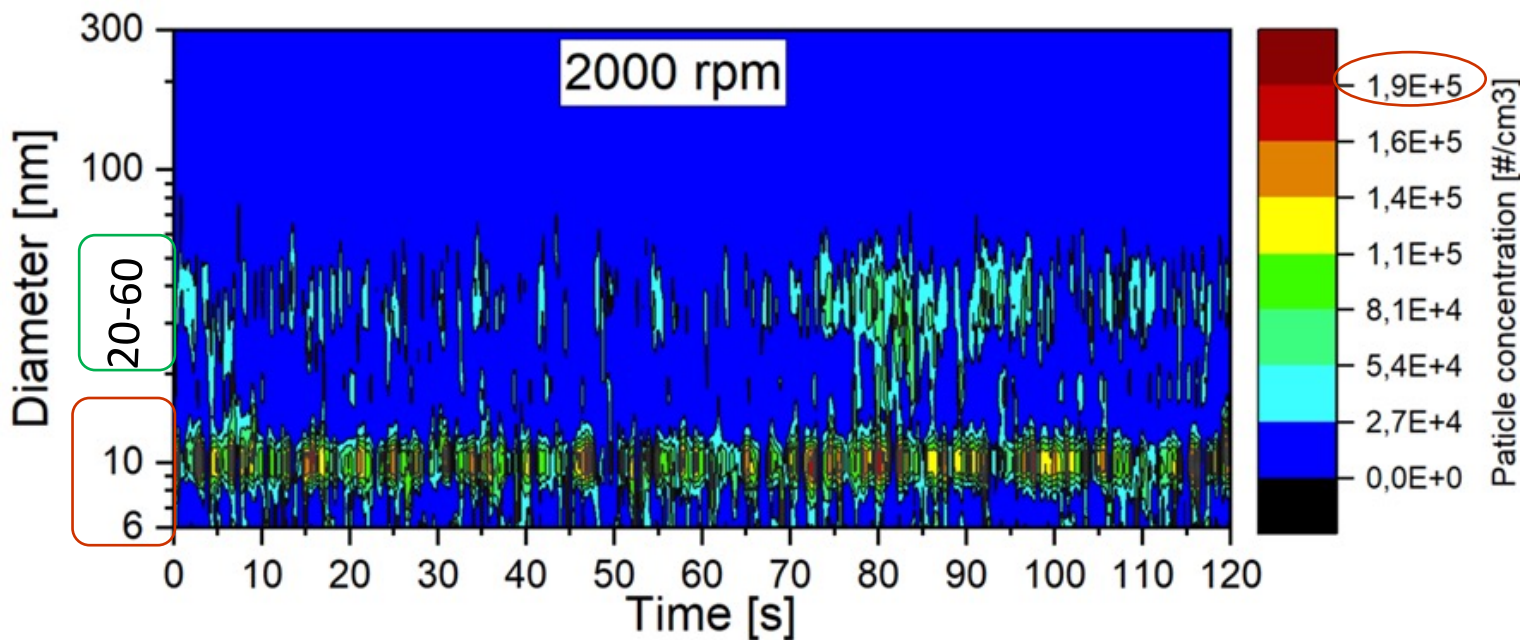


	Engine speed [rpm]	Throttle opening [%]	SOI [cad BTDC]	DOI [cad]	SOS [cad]	λ [-]	imep [bar]	COV imep [%]
CH4	2000	8	305	175	22	1.2	6.0	1.03
	3000	4	315	240	15	1.2	6.0	0.96
H2	3000	95	352	245	10	1.6	6.0	1.65





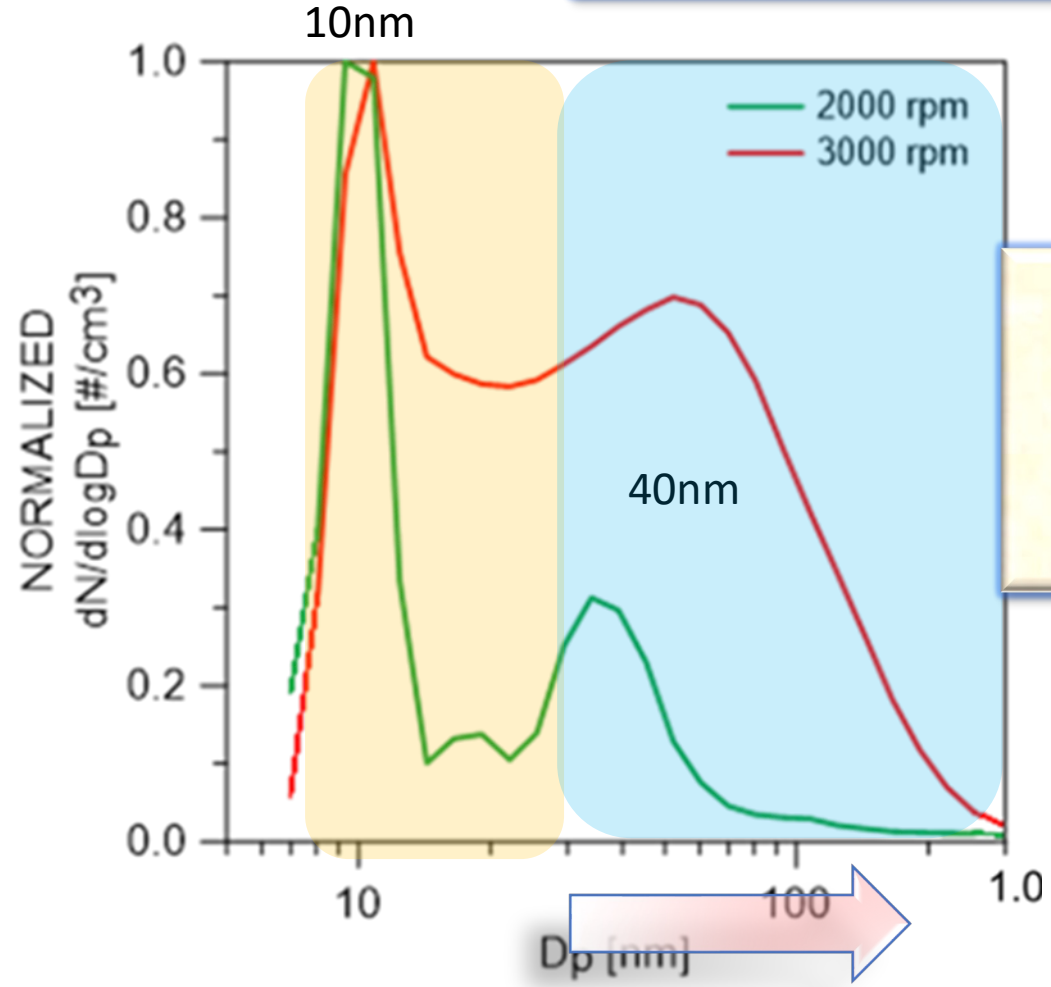
Experimental Results: CH₄ - PSDF



Experimental Results: CH₄ – PSDF vs SOF/SOOT

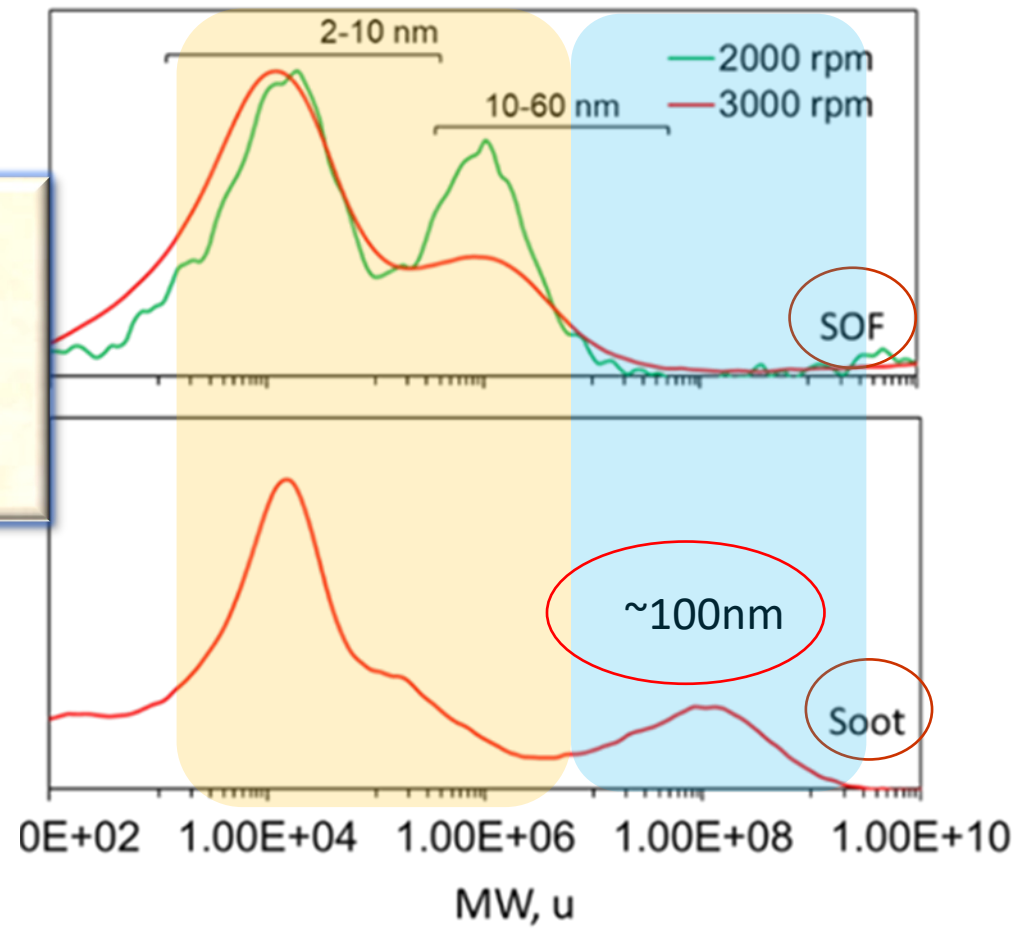


NPSDFs vs MW distribution profiles of the soot and SOF



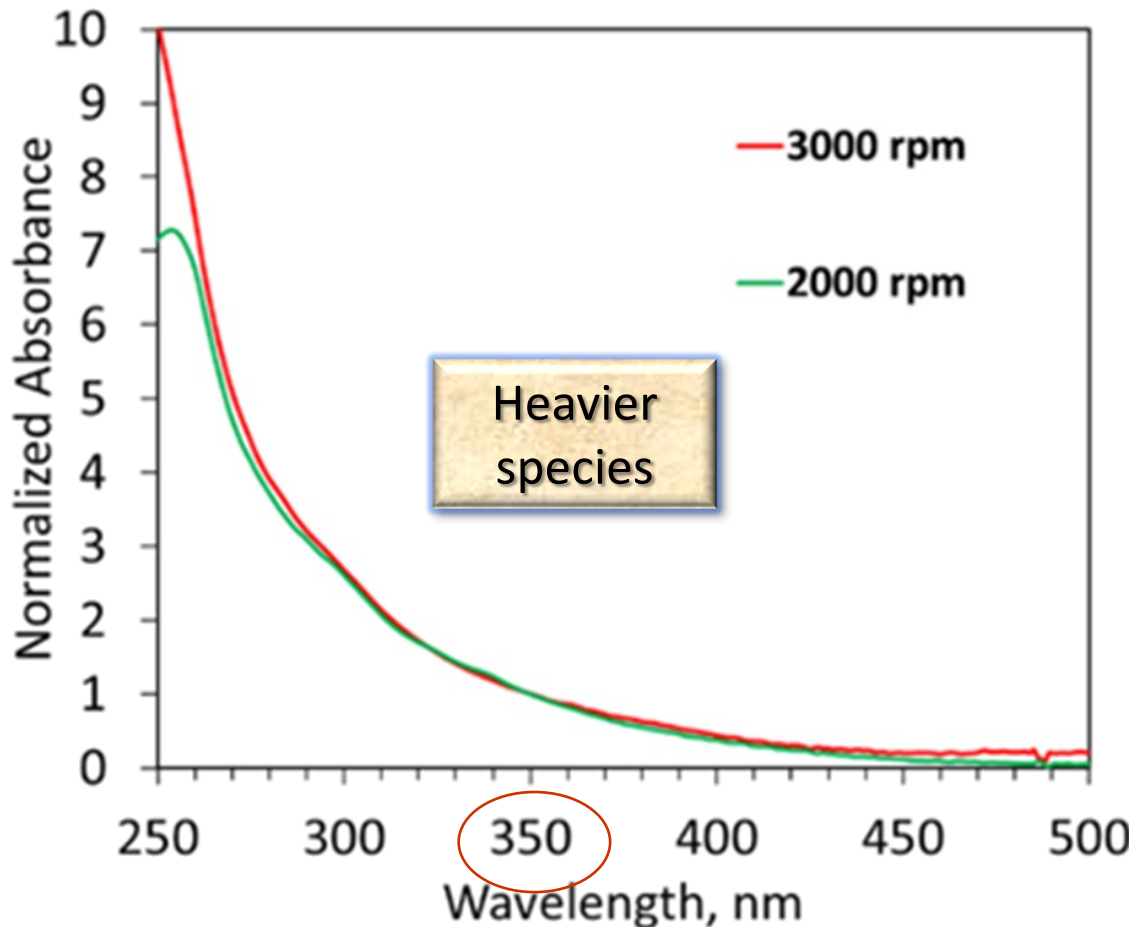
3000 rpm
SOF & Soot

2000 rpm
SOF

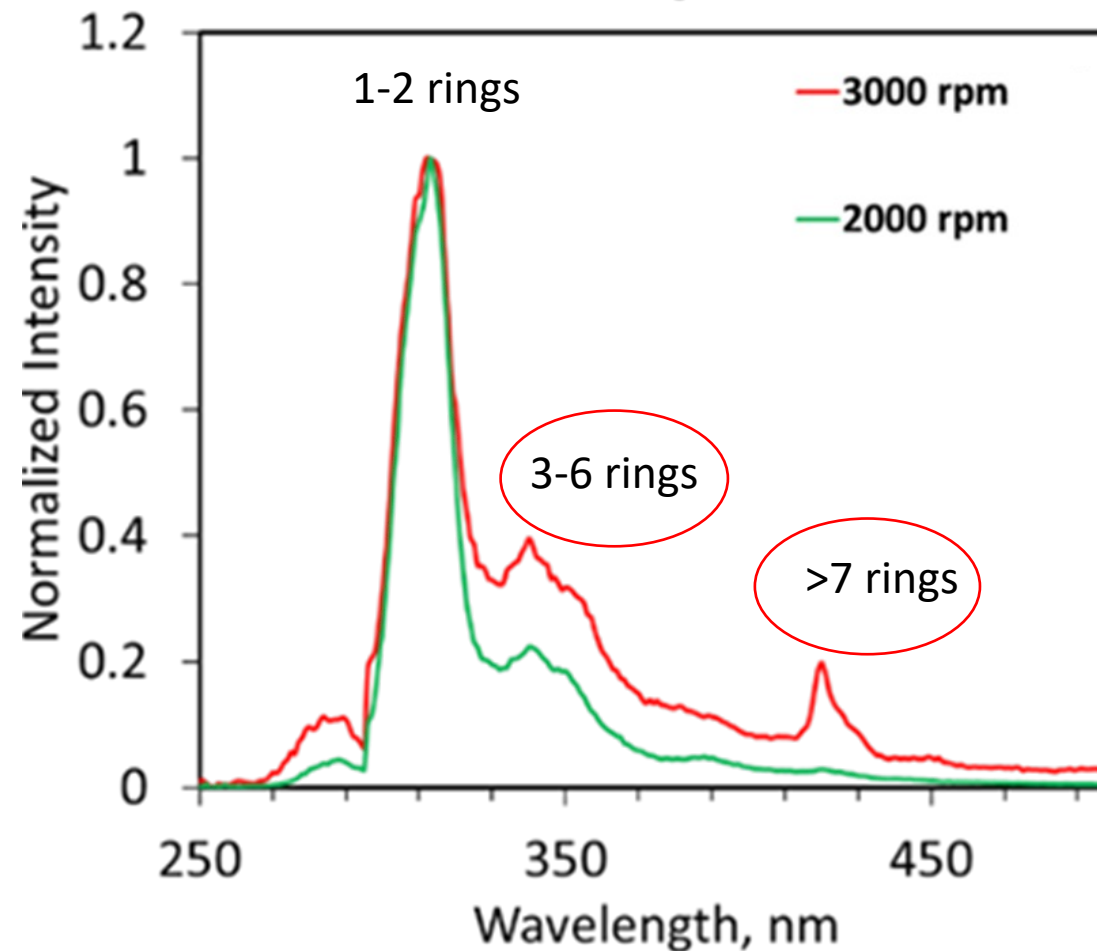




Normalized UV-Visible absorption spectra
Light & Heavy Aromatic Compound

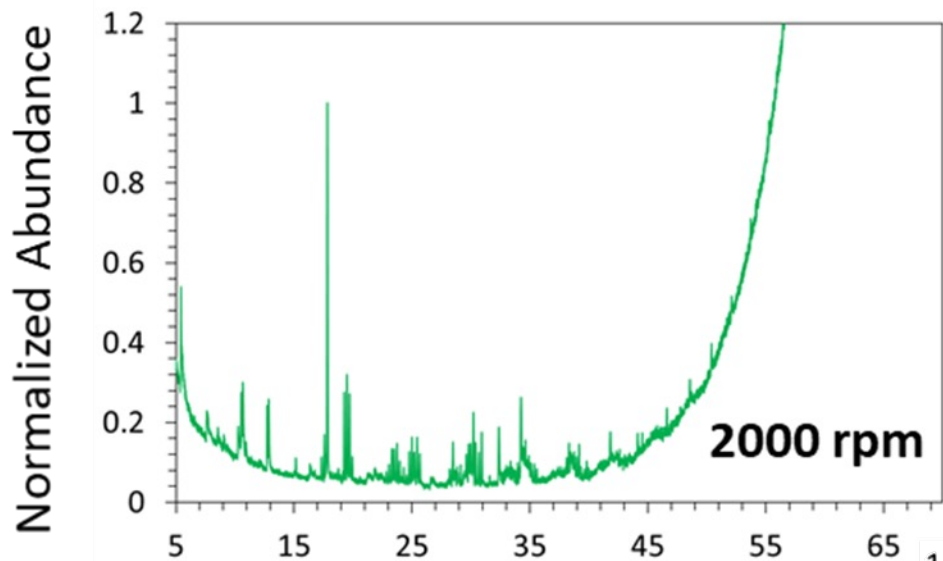


Normalized Fluorescence spectra
Light & Heavy PAH Characterization

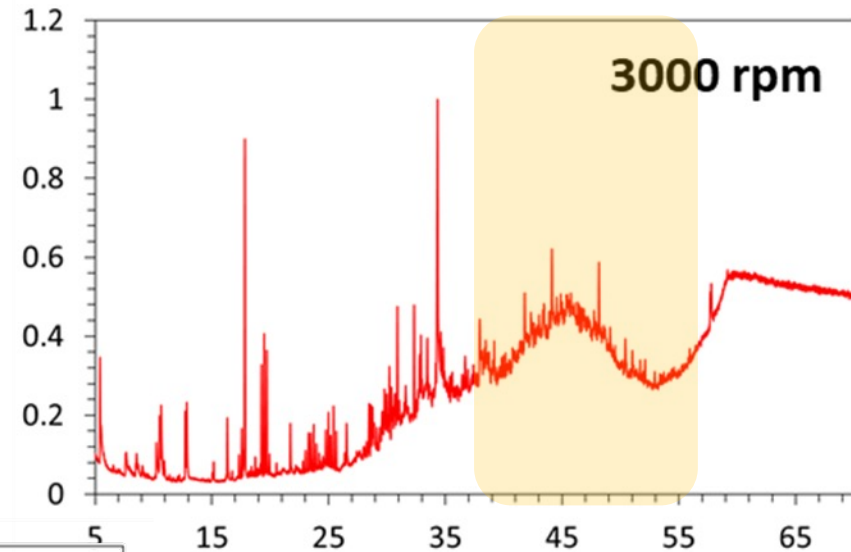




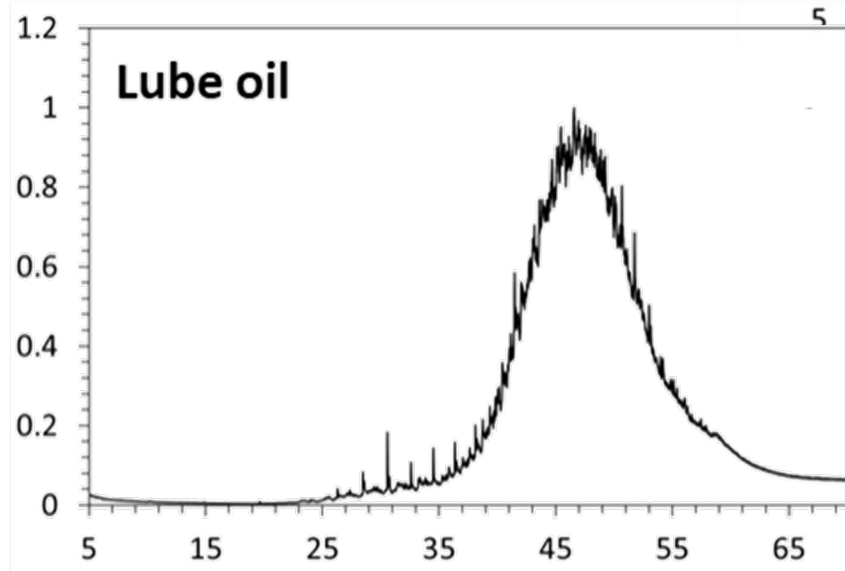
GC-MS chromatograms



No satisfying match

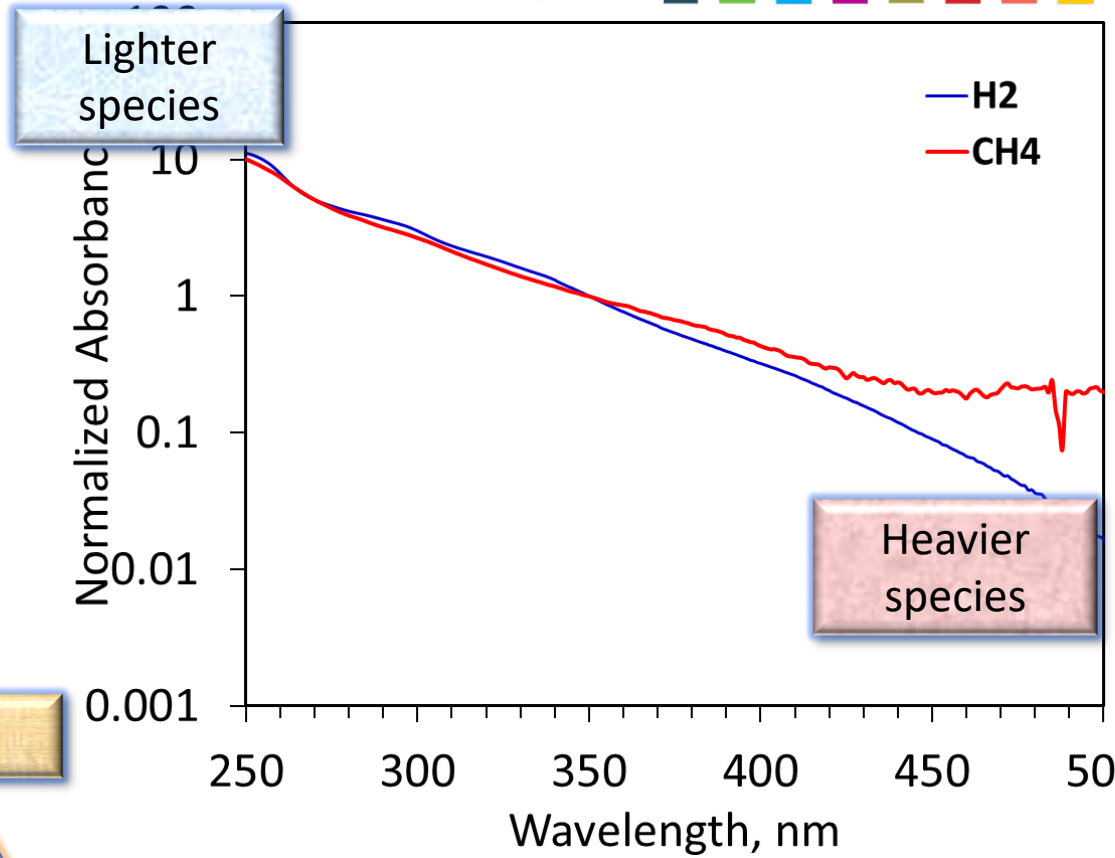
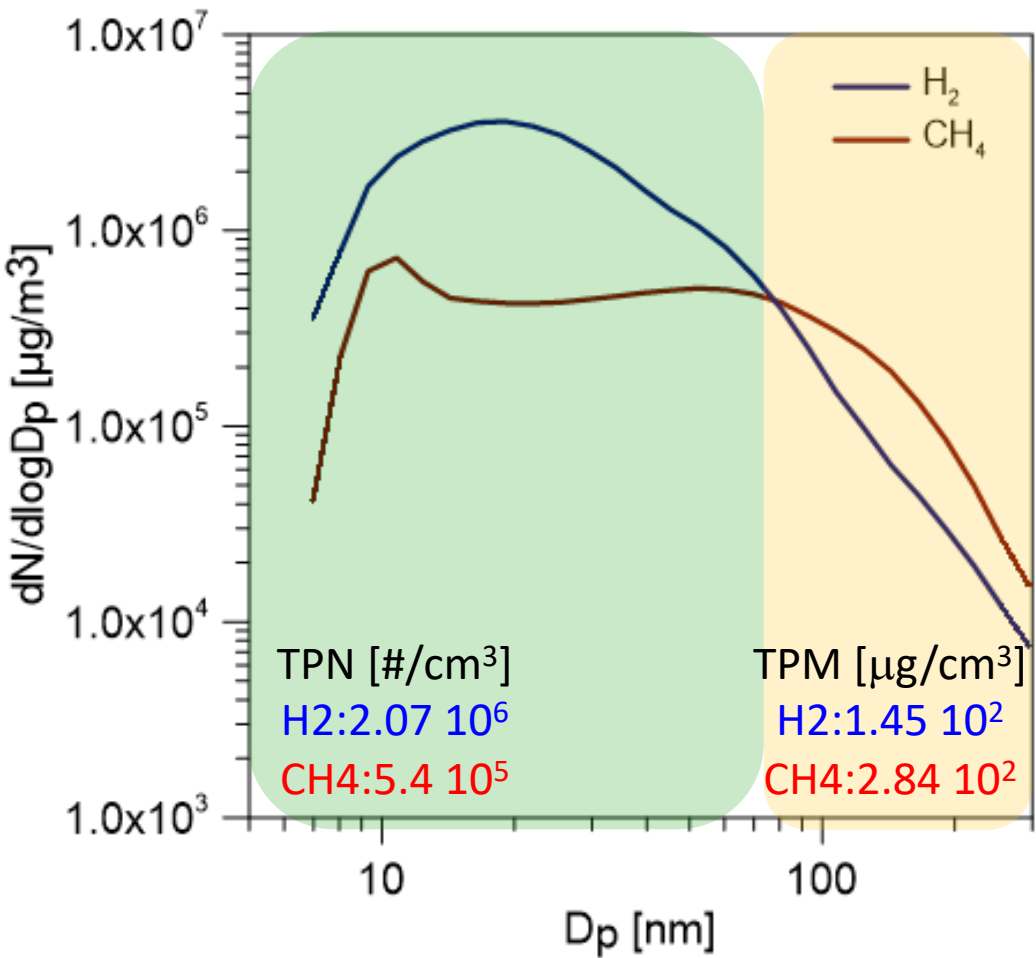


Aromatic Species



Retention time, min

Experimental Results: CH₄ vs H₂



Temperature

High Temperature for H₂
 Enhanced evaporation of oil that partially burns leading to soot precursor formation

Low Temperature for CH₄
 Worsen evaporation and enhanced particles growth and coagulation



- Role of fuel and lube oil on PM emitted from a Gaseous DISI engines: Methane and Hydrogen.
- Physical (PN/Size) and chemical analysis (SOF/Soot) was performed.

➤ **CH4:**

- Particle number and size increases with speed: larger fuel and oil consumption.
- PN fluctuation ascribable at the presence of oil pool that burns periodically.
- Oil presence was more evident at high speed.
- PAH were found at all engine conditions: heavier species were more abundant at 3000 rpm.
- Soot was collected on the filter only at 3000 rpm.



➤ **CH₄ vs H₂:**

- Methane emits lower number concentration than Hydrogen.
- Methane emits higher mass concentration than Hydrogen.
 - Hydrogen emits smaller particles (20nm).
 - Methane emits particles with a larger size (70nm).

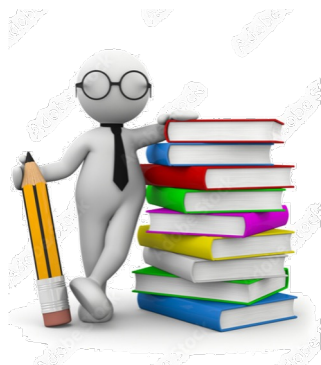
H₂

Higher Temperature:
Enhanced evaporation of oil that partially burns leading to soot precursor formation

Lower quenching distance
Burn the oil on the cylinder surface

CH₄

Lower Temperature
Worsen evaporation and enhanced particles growth and coagulation



Understand the mechanisms of oil transformation, as oxidation and dissociation, leading to the particle formation

Proper optimization of the oil formulation

Development of specific After-Treatment Devices

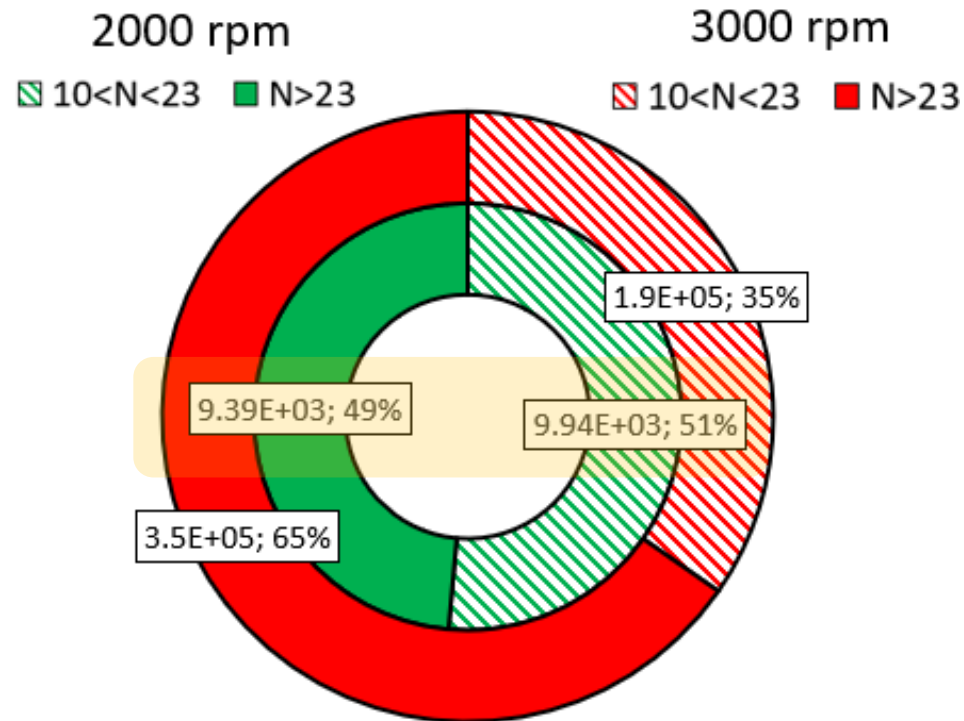




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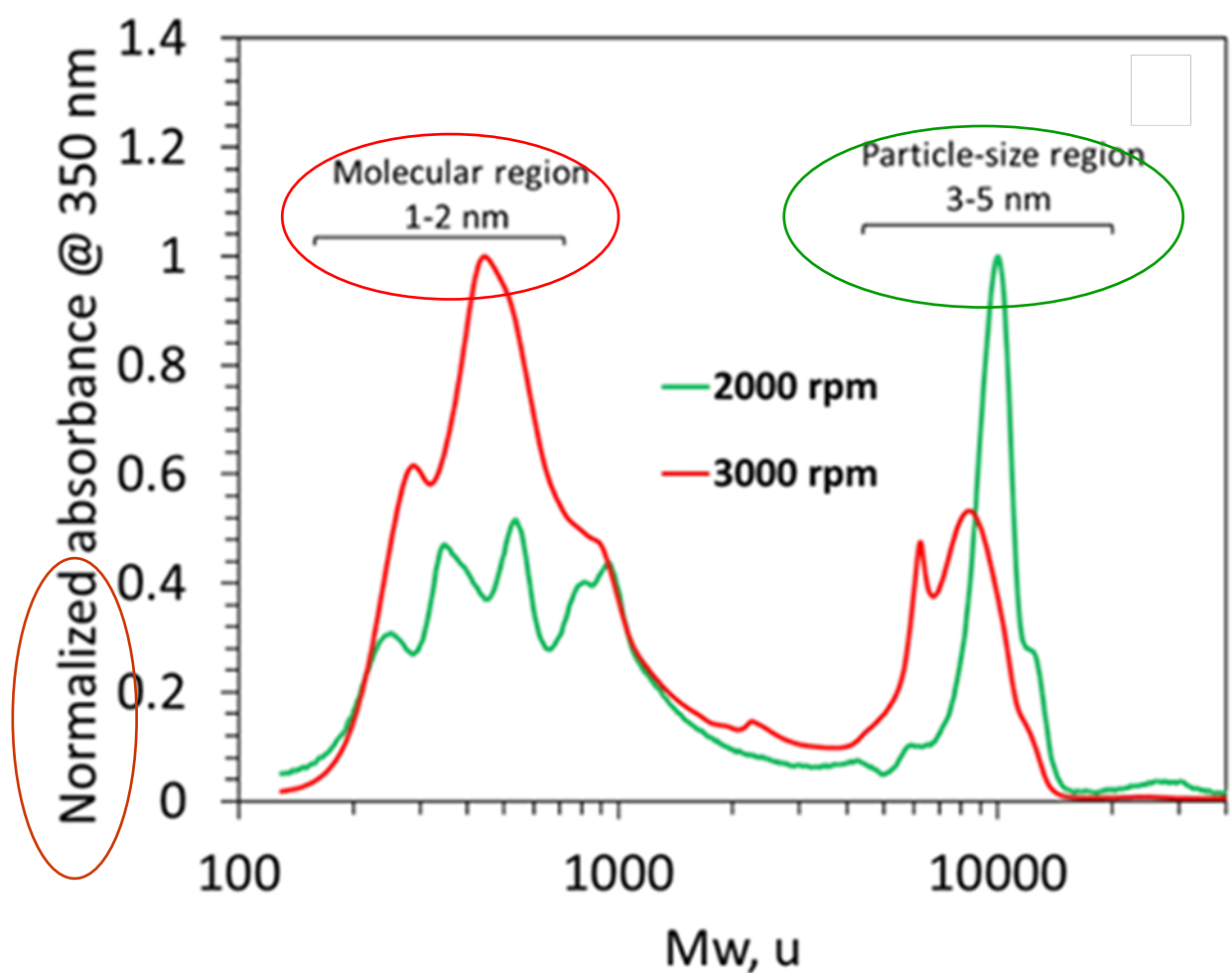
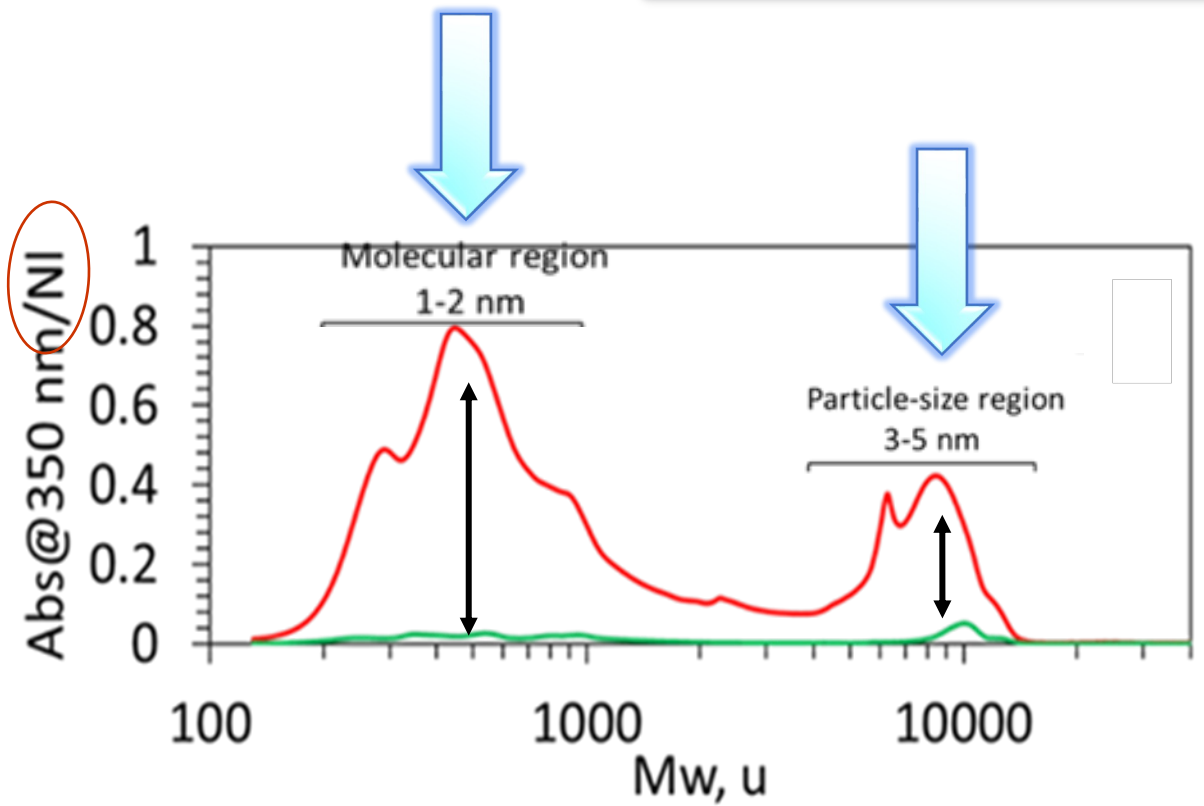
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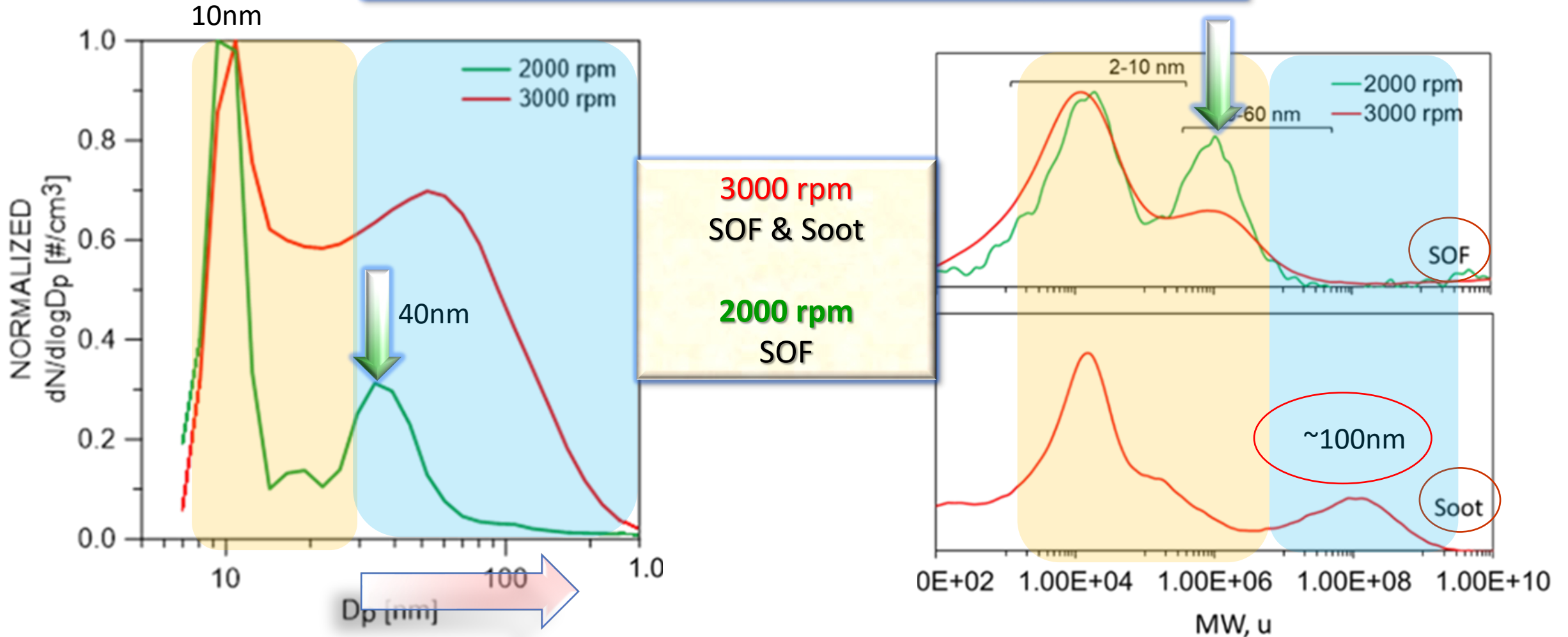


MW distribution profiles: Molecular and Particle Species





NPSDFs vs MW distribution profiles of the soot and SOF



Organic particles can be highly sticky and in the aerosol they could present a larger size compared to when dissolved in a power solvent as NMP