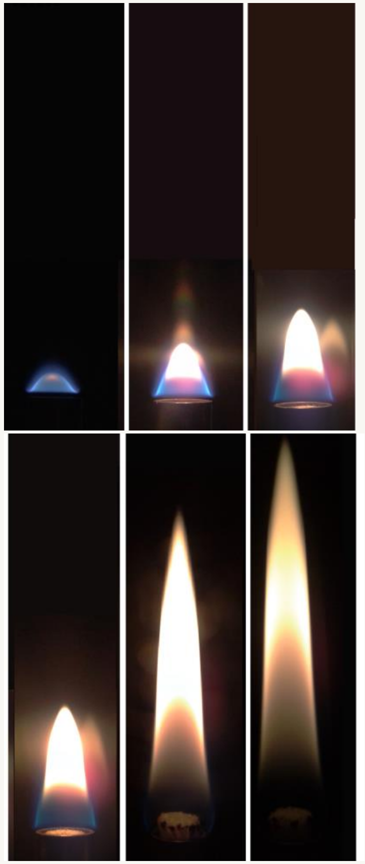
Sooting tendency of paraffin components of diesel and gasoline in diffusion flames



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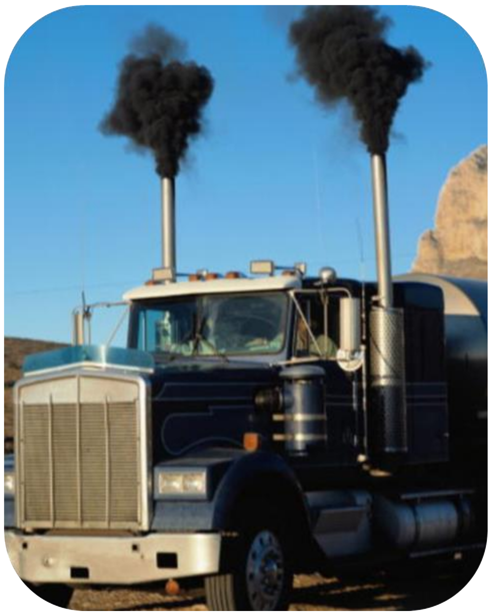
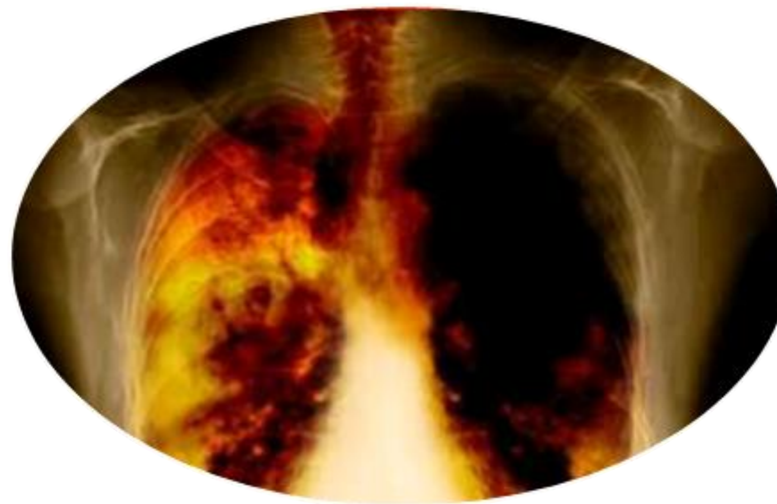
Soot – A harmful pollutant

Negative Environmental Impact



Harmful to Human Health



Soot mass and also ***particle number*** *regulations in Europe*

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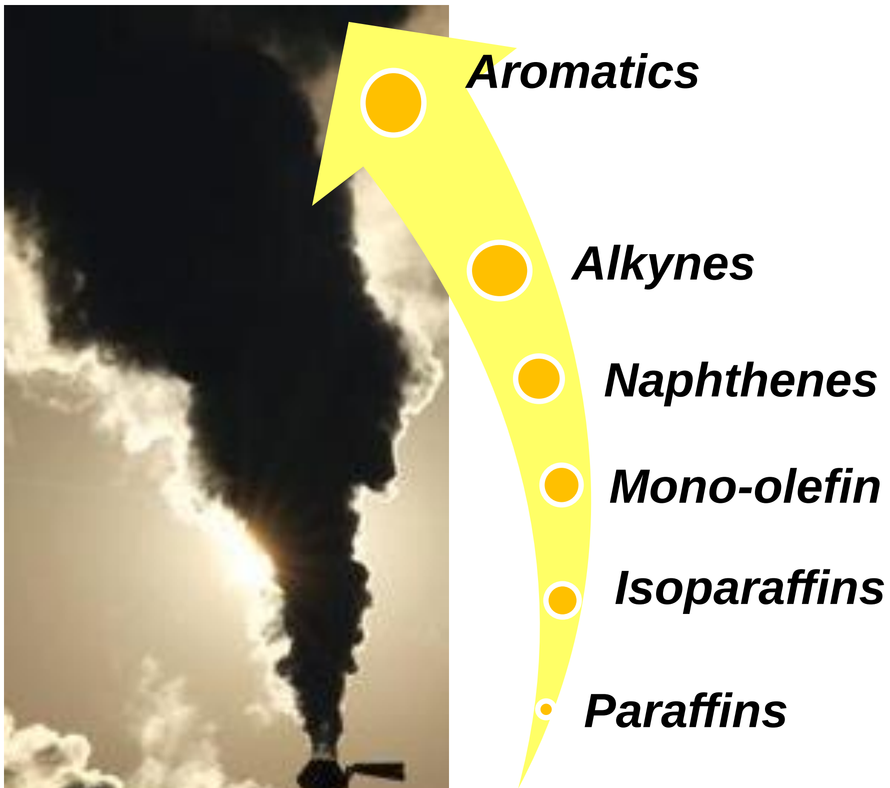
Hydrocarbon sooting propensity

IN DIFFUSION FLAMES SOOT INCREASES AS FOLLOWS:



Hunt 1953

Calcote and Manos 1983

The variations in smoking tendency due to **dehydrogenation process**

Schalla and McDonald 1953

Chances of dehydrogenation increase:

C-C > C-H > C=C > C≡C

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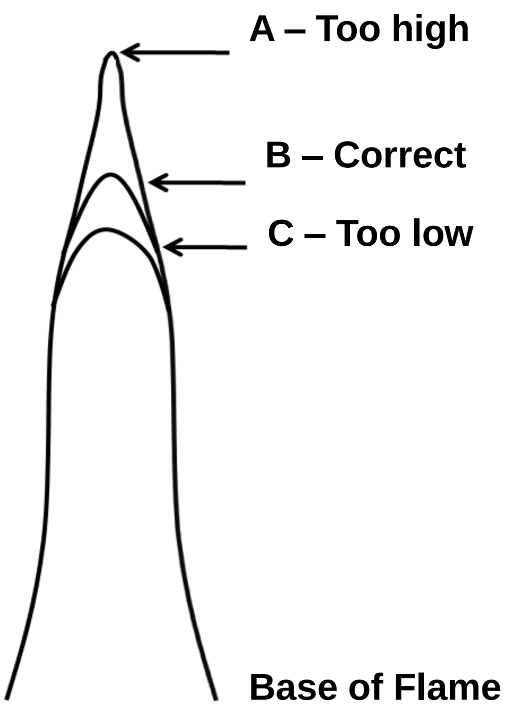
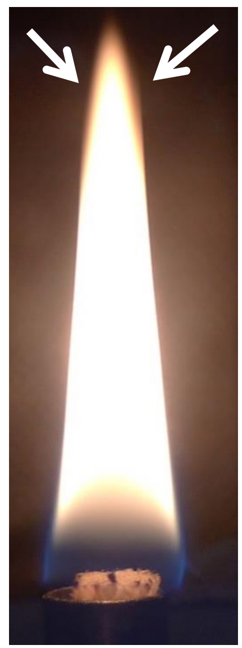
Smoke point and Threshold Sooting Index (TSI)

ASTM Smoke Point

"The maximum height (mm) of a smokeless flame of fuel burned in a wick-fed lamp"



Sooting Wings



Threshold Sooting Index

('0'= least sooting   '100'= most sooting)

(methylcyclohexane=5 ; methylnaphthalene=100)

$$\mathrm{TSI} = a_h \left(\frac{M_W}{h} \right) + b_h$$

Where a_h and b_h *are apparatus-dependant constants. And* $\boldsymbol{h}$ *is the Smoke Point*

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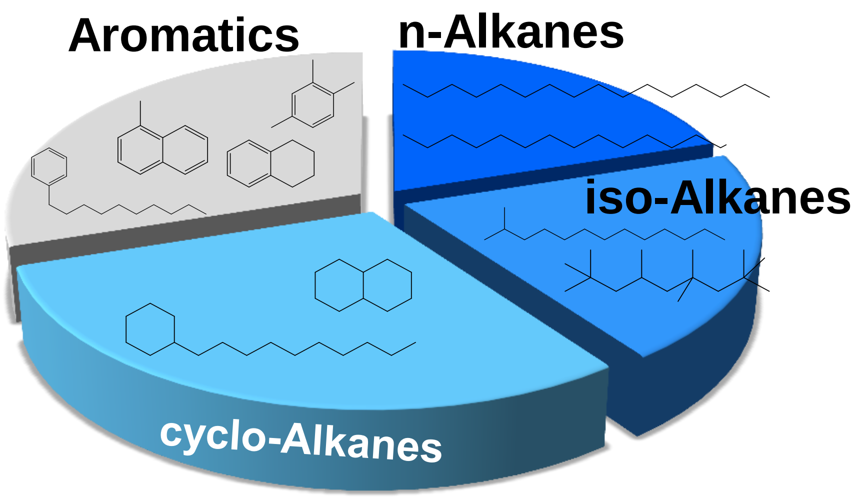
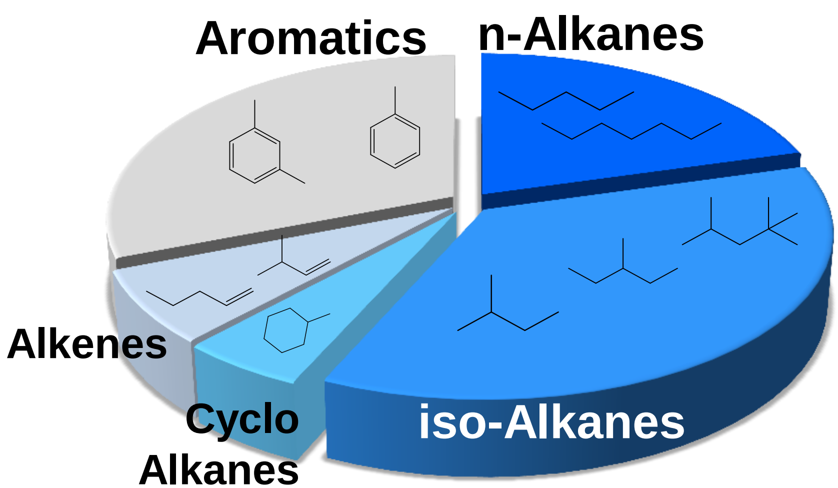
Fossil fuels composition

DIESEL FUELS



C_{10}-C_{20}

GASOLINE FUELS



C_5-C_8

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Motivation

- **No information on the characteristics of the soot** formed is available through TSI or SP.

- The need of **detailed information on the sooting characteristics of paraffins** found in gasoline and diesel fuels

Study the influence of the fuel structure on the formation of soot in diffusion flames

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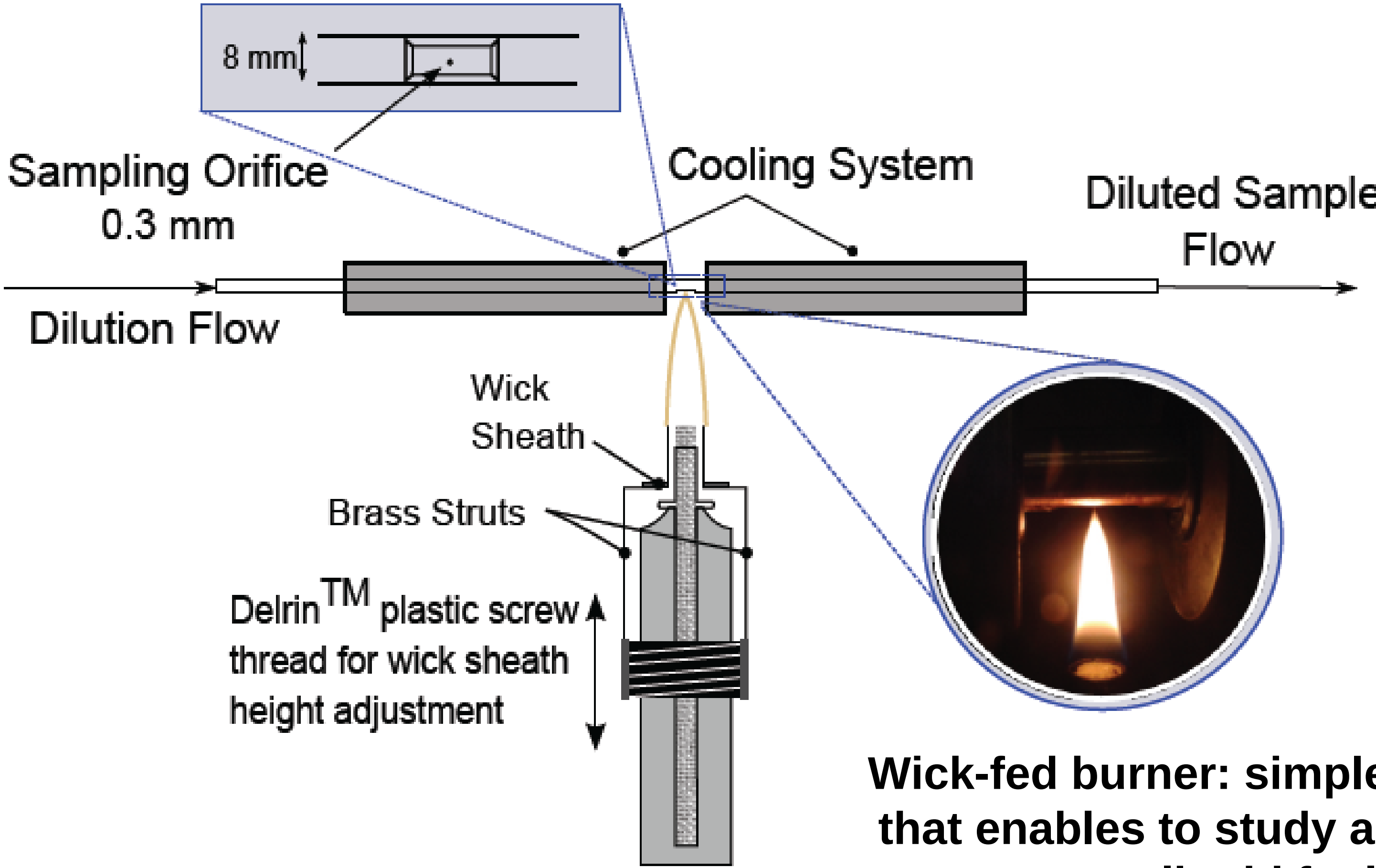
Probe sampling and particle analysis



Wick-fed burner: simple configuration that enables to study a wide-range of liquid fuels

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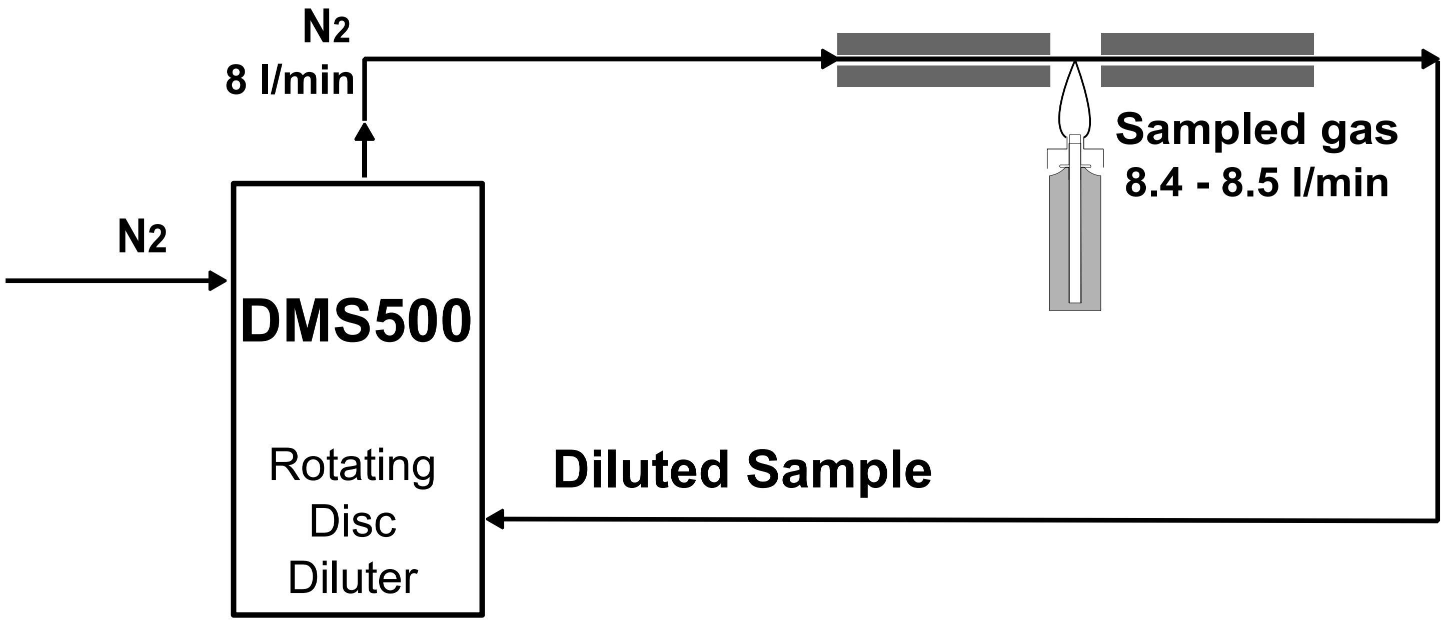
Probe sampling and particle analysis



DMS500 is a fast particle analyzer that enables to measure PSD in real-time. Particles are sized based on their mobility diameter

The total dilution factor ranged from 10000-15000 sufficiently high to ensure PSD independence of dilution ratio

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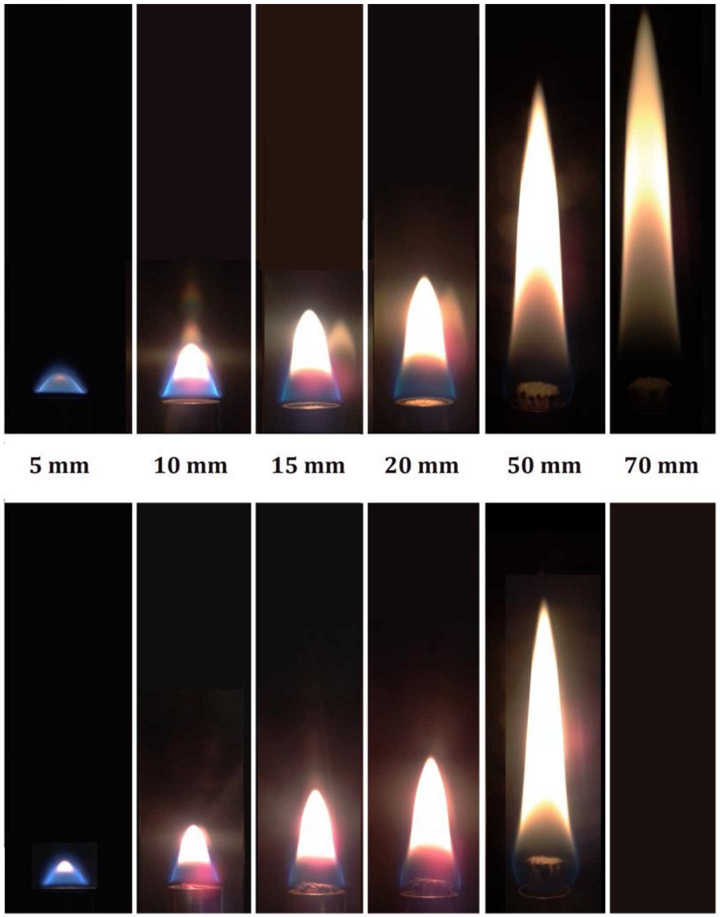
Hydrocarbon flames

Heptane



Hexadecane

This **maximum achievable flame height is different for each fuel**, because od set-up limitations

Starting at very **small bluish flame** heights up to **large sooting flames**

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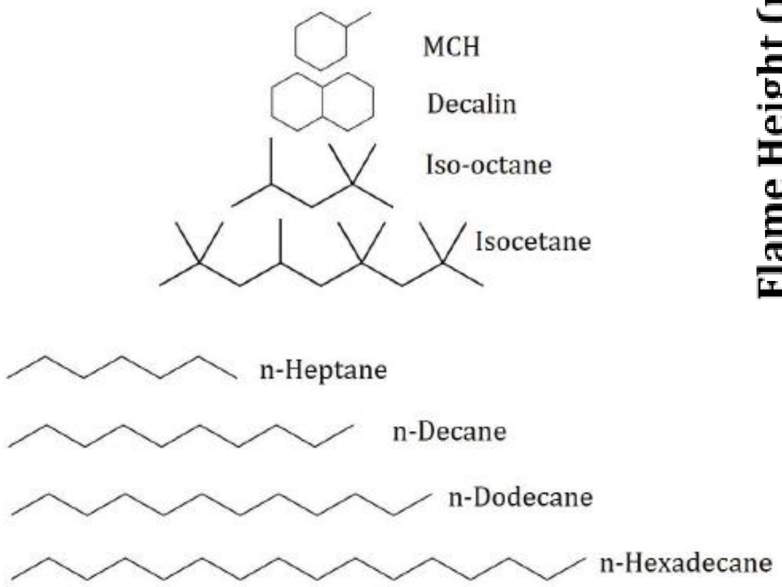
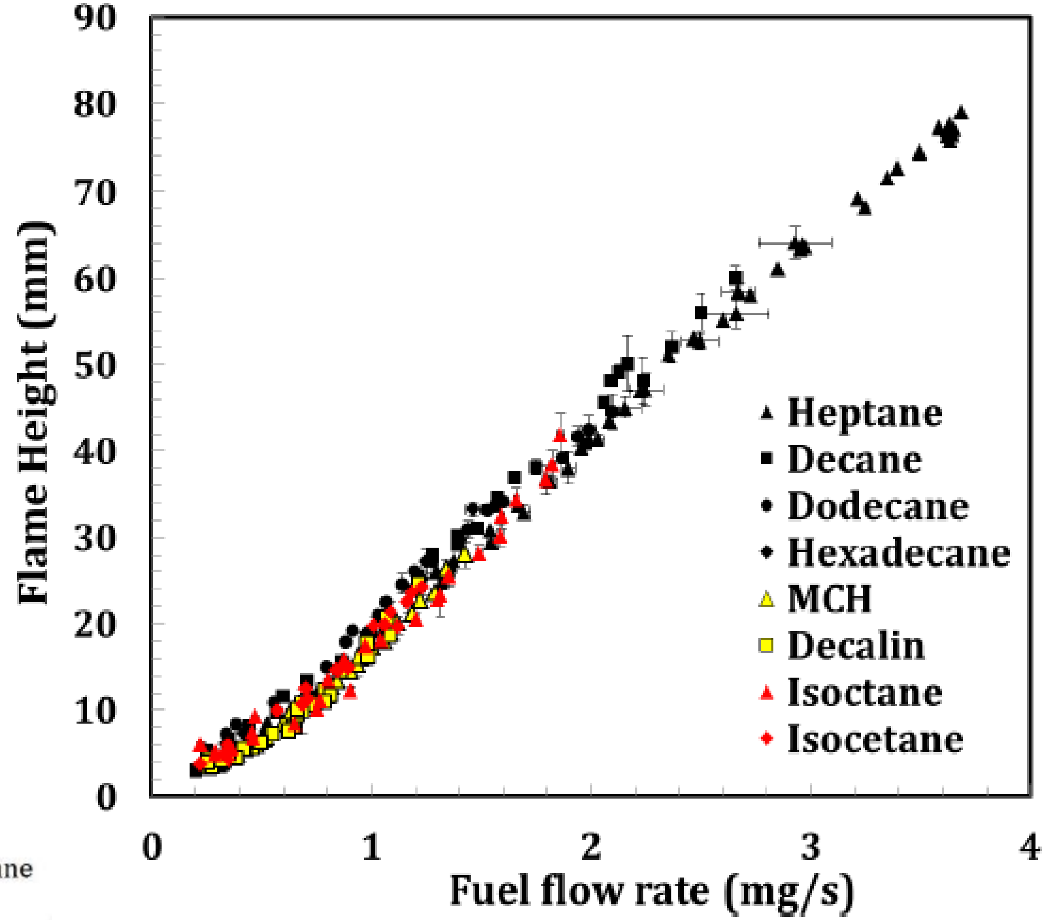
Fuel mass rate and Flame Height

It is then possible to compare flames burning different fuels at the same height





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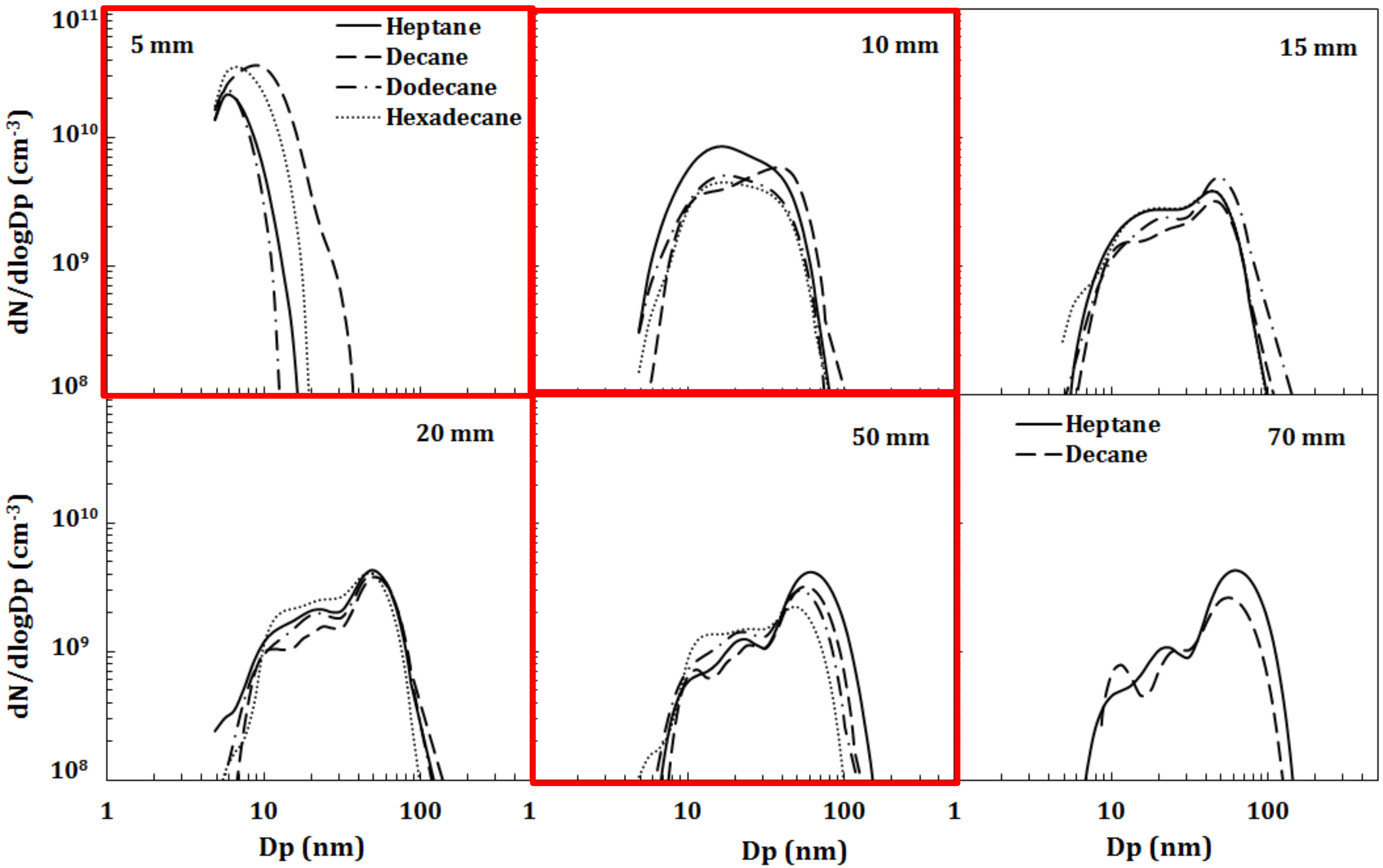
Evolution of PSD: n-Alkanes



- **Low heights**: **bluish flame**, PSD **single mode** of primary particles
- **After 10 mm**: second mode starts to raise
- **After 15 mm**: **multi-modal behaviour**, with accumulation mode

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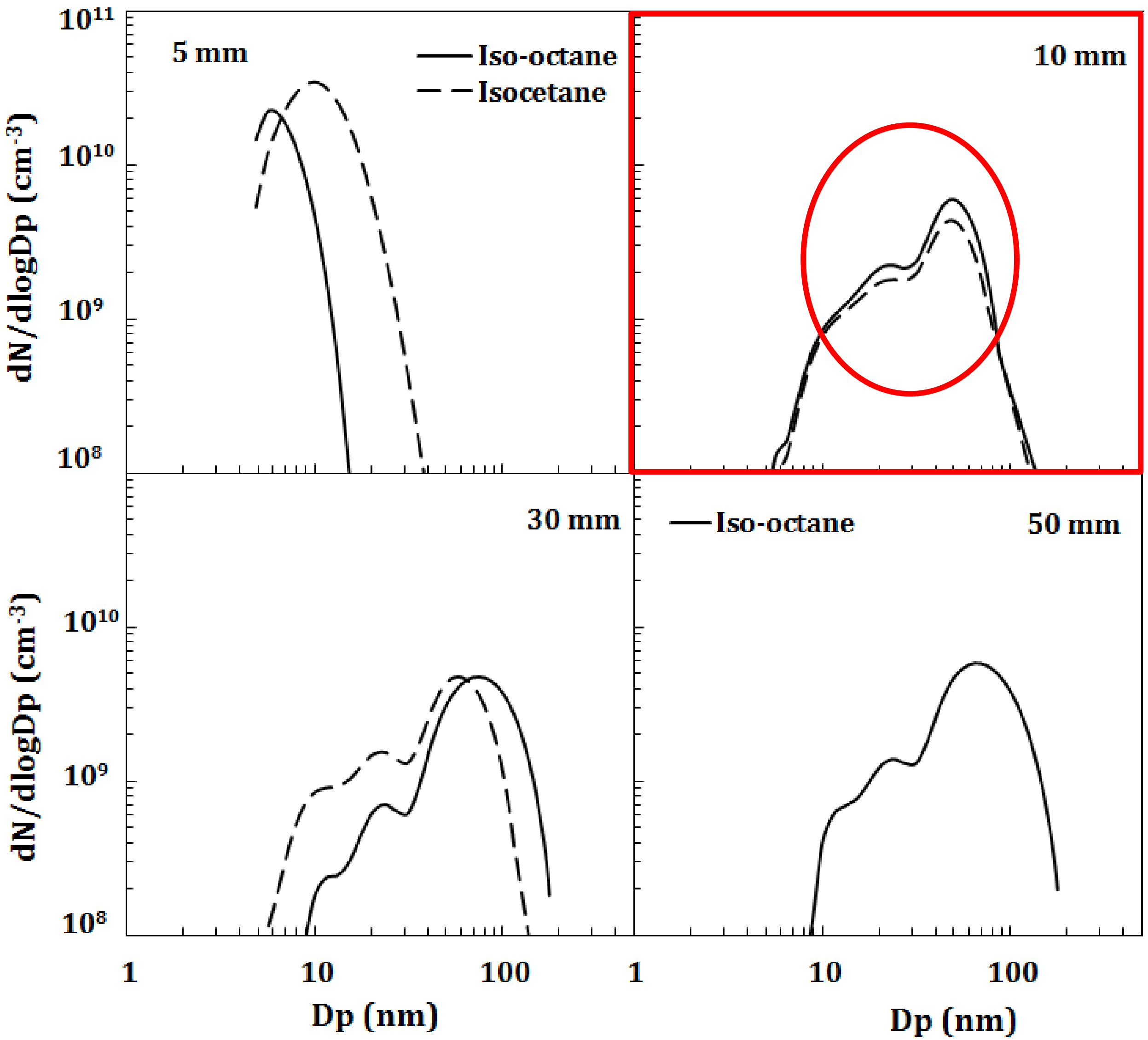
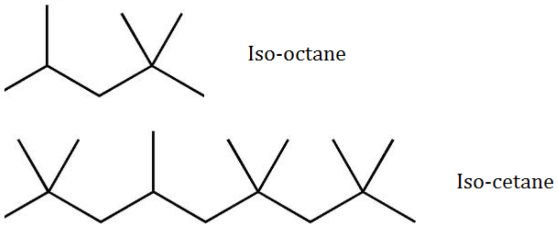
Evolution of PSD: iso-Alkanes





At 10 mm FH the PSD has already a bi-modal shape

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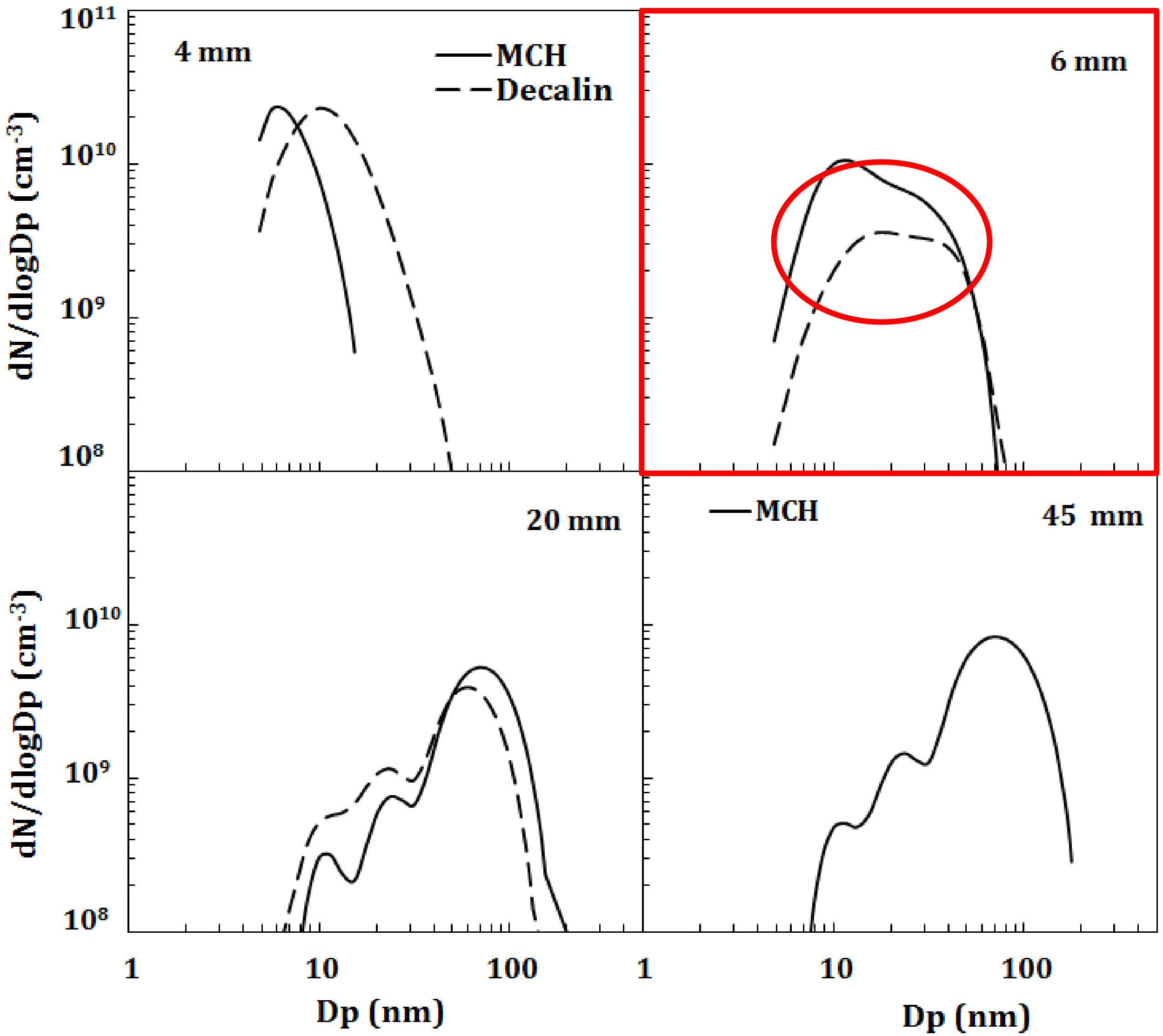
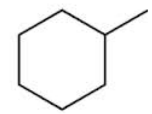
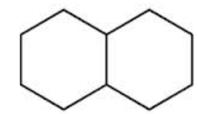
Evolution of PSD: cyclo-Alkanes





Methylcyclohexane



Decalin
(Decahydronaphtalene)

At 6 mm flame height, a lower mode of larger particles begins to grow

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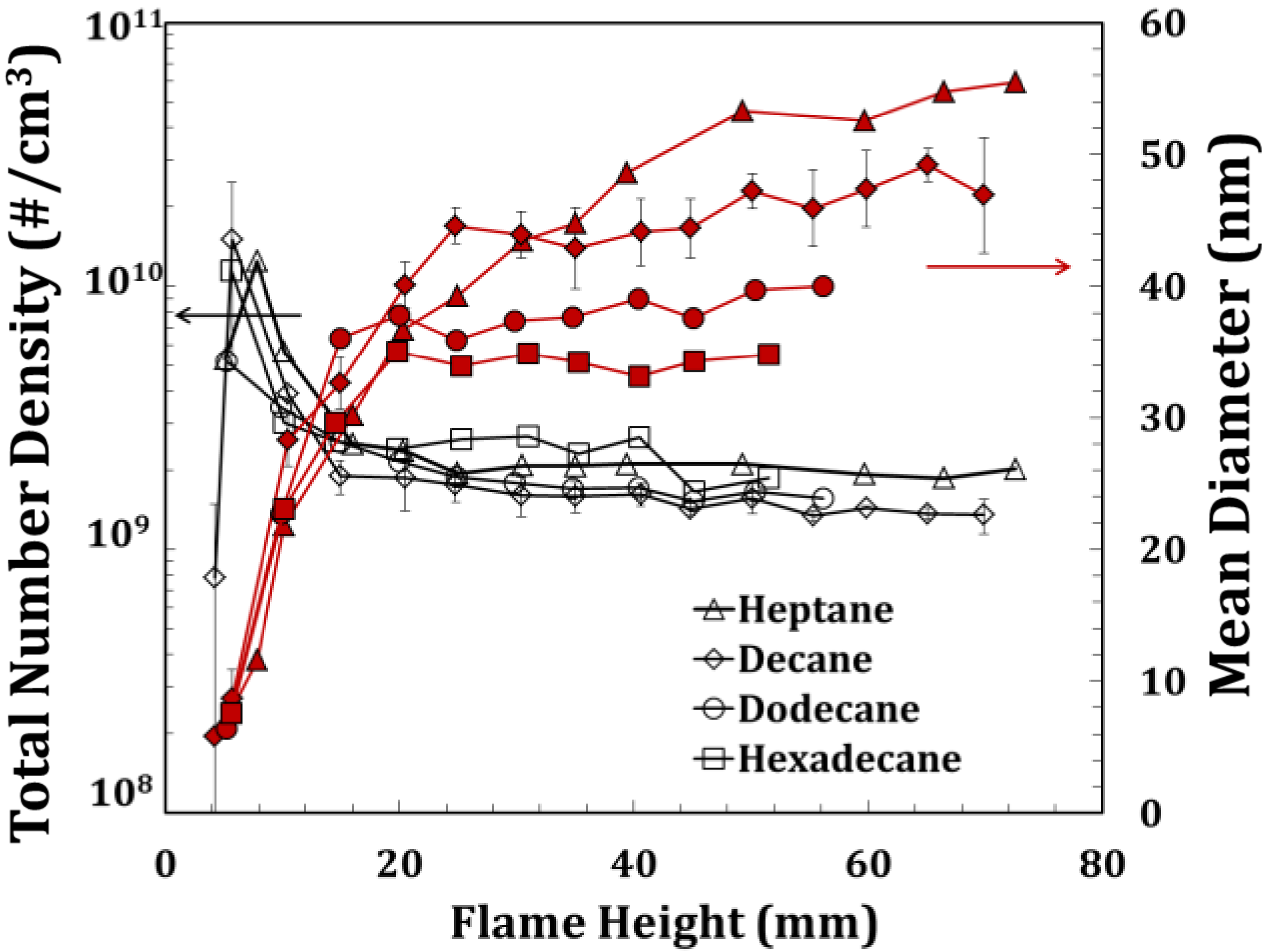
Number of Particles (**N**) and Mean Diameter (**‹dp›**)



N is large at *low flame heights*; and remains fairly constant for *larger flame heights*

‹dp› increases fast *until a flame height* where it *achieves a maximum point and remains fairly constant*.

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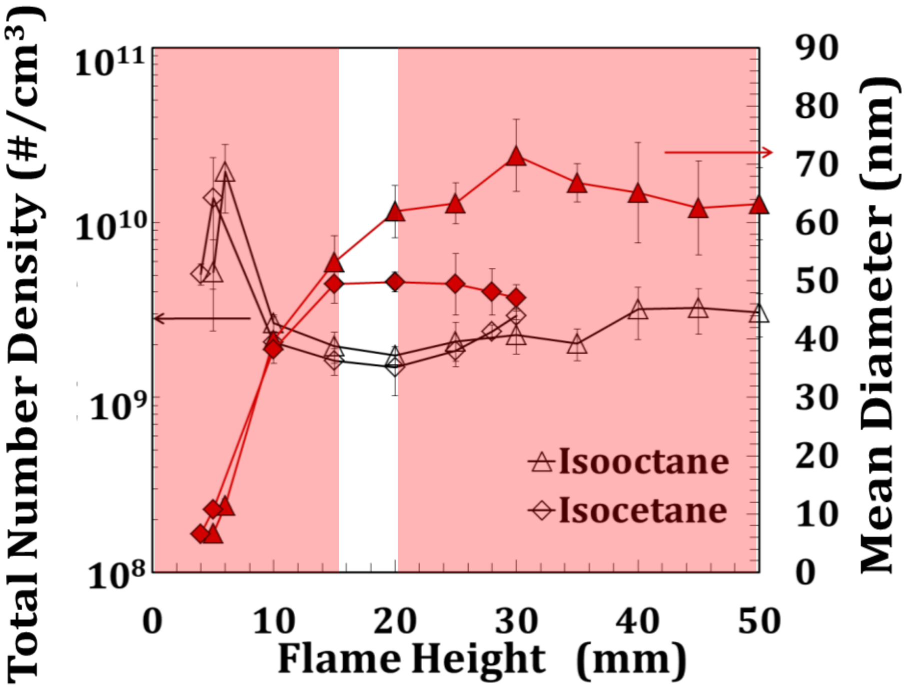
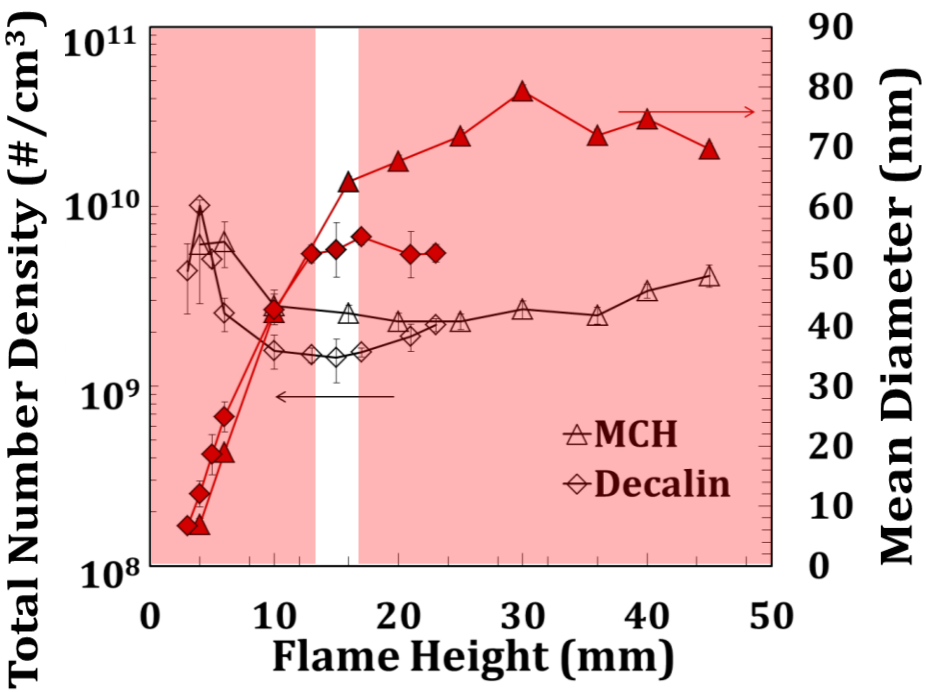
Number of Particles and Mean Diameter

iso-alkanes



cyclo-alkanes



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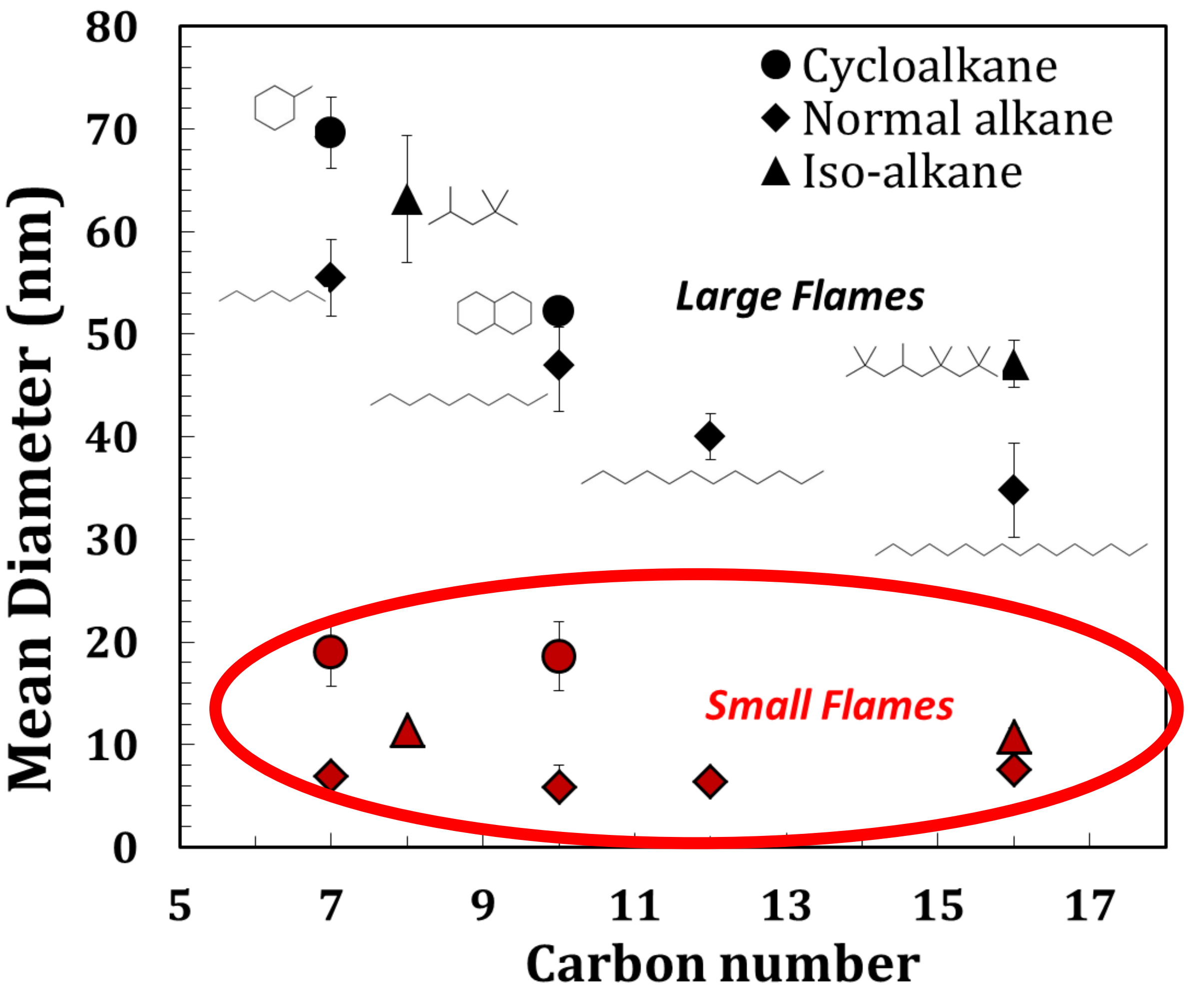
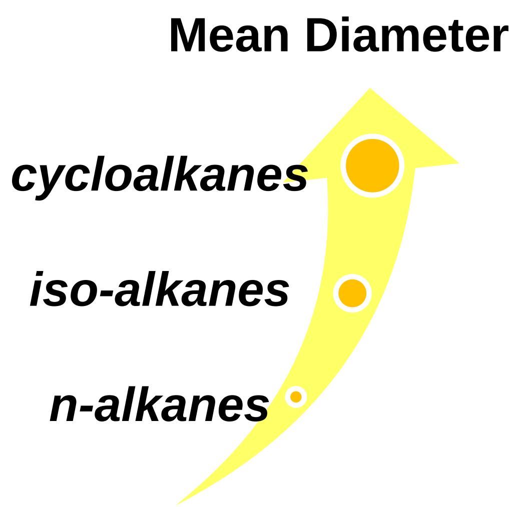
Fuel structure influence on mean diameter



‹dp› is constant with carbon number



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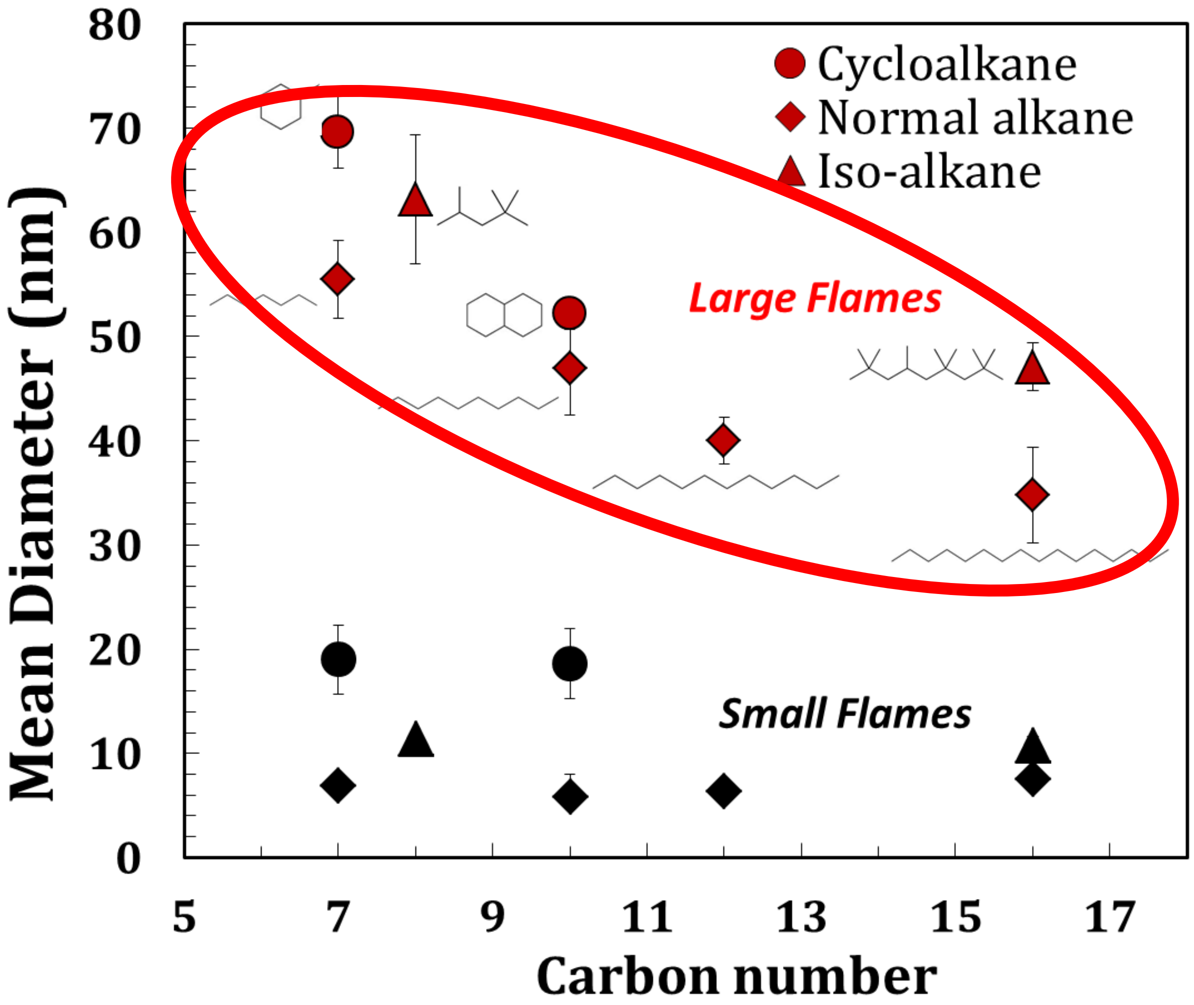
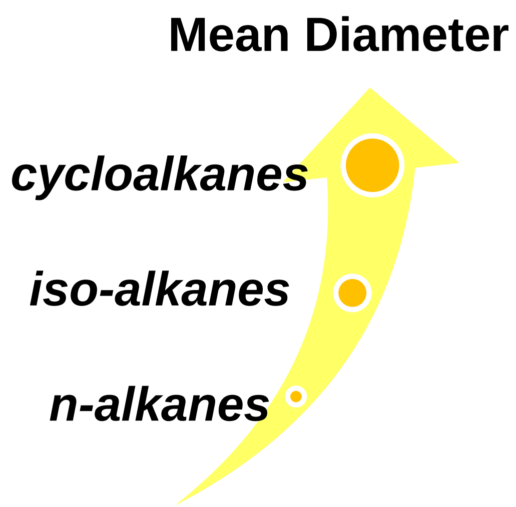
Fuel structure influence on mean diameter



Increases in carbon number result in a decrease of the mean particle diameter



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Conclusions

- At **low flame heights** large amount of particles are observed. **Among each paraffin group**, at each flame height the values of **‹dp› were almost the same.**

- **Cyclic and branched** structures produce **larger ‹dp›** compared to straight alkanes.

- At **large flame heights**, for all fuels tested, **‹dp›** and **N** take constant values. A consistent **decrease in ‹dp› with larger molecule size**.

- Further studies of temperature and morphology in these flames are necessary to elucidate the tendencies observed

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