In situ diode laser cavity ring-down measurements of acetylene in laminar flames

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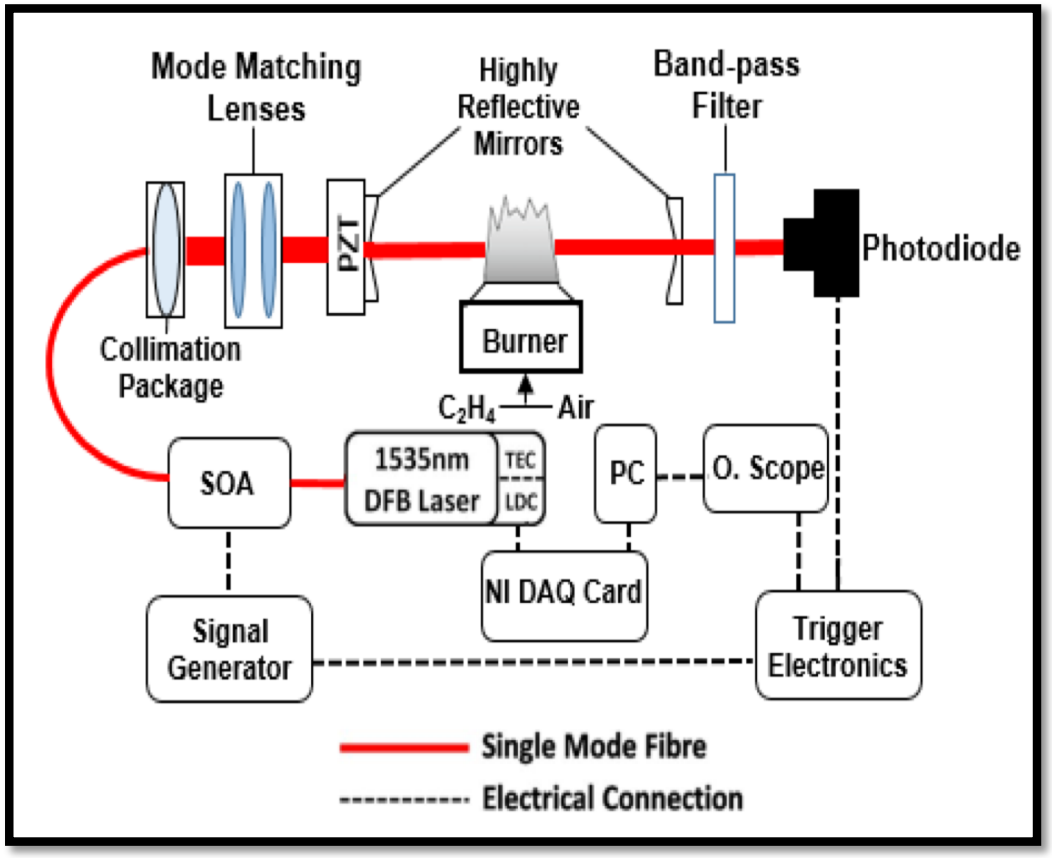
Continuous-wave cavity ring-down spectroscopy

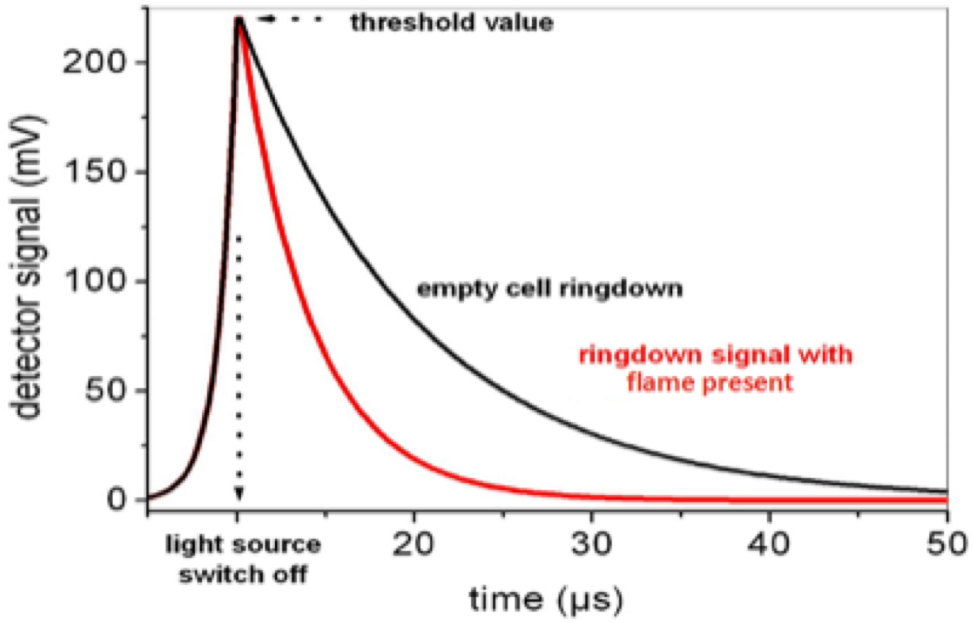
- Acetylene is involved in the hydrogen abstraction-acetylene addition (HACA) mechanism for soot growth.
- It is also involved in other important intermediate reactions during combustion.
- It is useful to obtain more data to validate soot models.
- Several other techniques have been used to measure acetylene.

Continuous-wave cavity ring-down spectroscopy



- Ring-down traces were averaged and recorded for each wavelength increment.
- Between each increment, we tuned to a reference wavelength at which absorption by acetylene is insignificant. This gives a baseline.

Continuous-wave cavity ring-down spectroscopy



The ring-down time of the cavity is given by:

$$\tau = \frac{L_c}{c[(1-R) + \alpha(\lambda)d + X]}$$

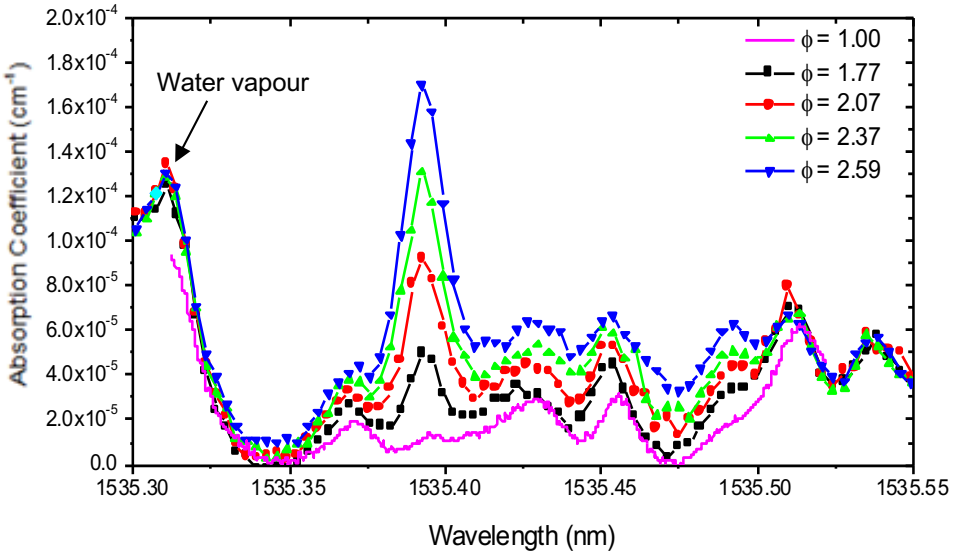
τ is extracted from the decay signal by fitting it to an exponential function of the form:

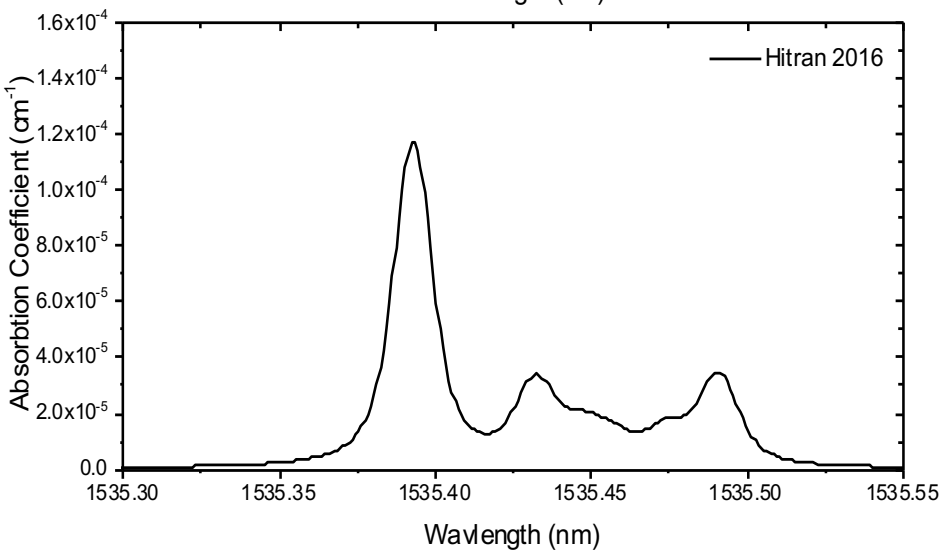
$$I(t) = I_0 exp\left(-\frac{t}{\tau}\right)$$

The absorption coefficient $\alpha(\lambda)$ is calculated from the ring-down time of the cavity and is given by:

$$\alpha(\lambda) = \frac{L_c}{cd}\left(\frac{1}{\tau(\lambda)} - \frac{1}{\tau_0}\right)$$

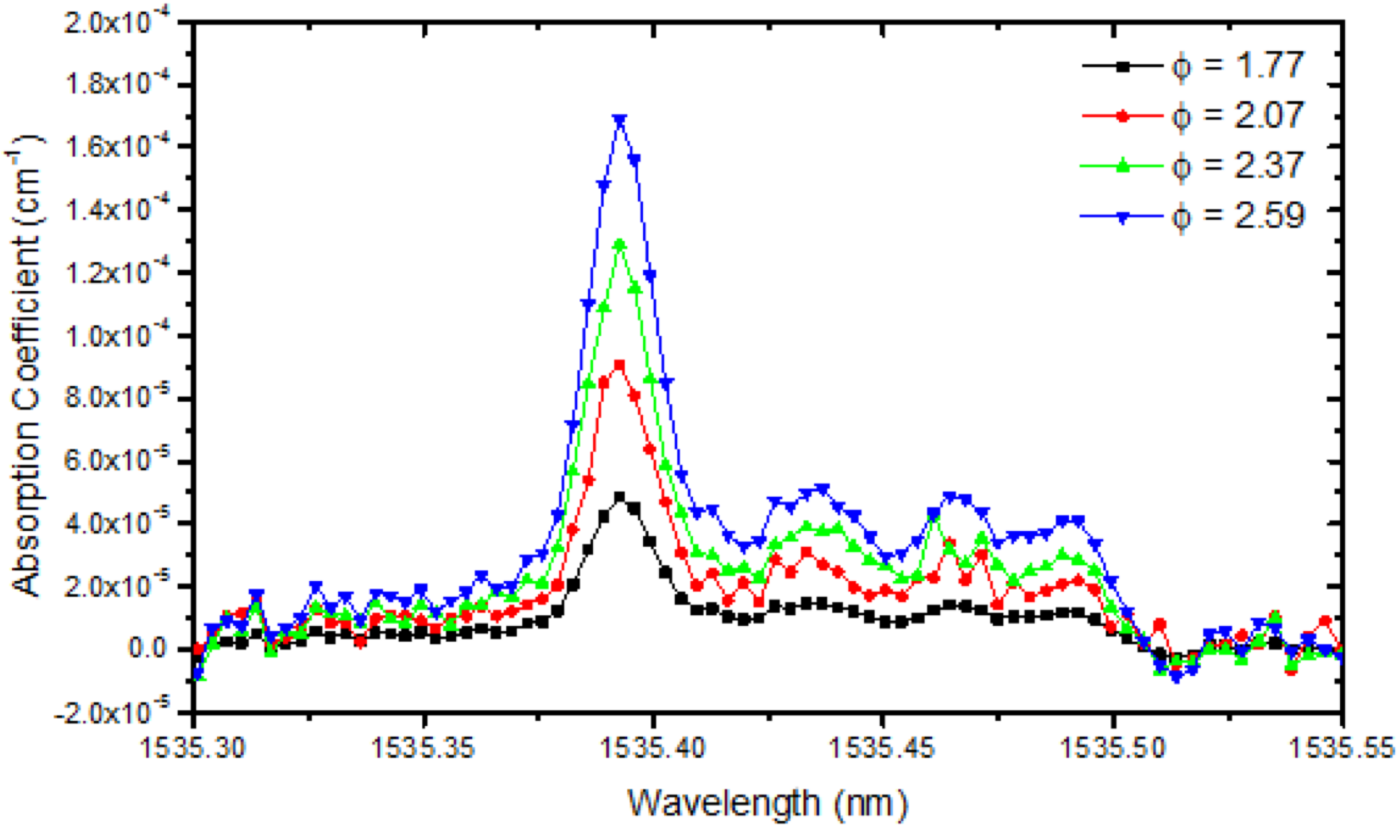
Acetylene cw-CRDS spectra





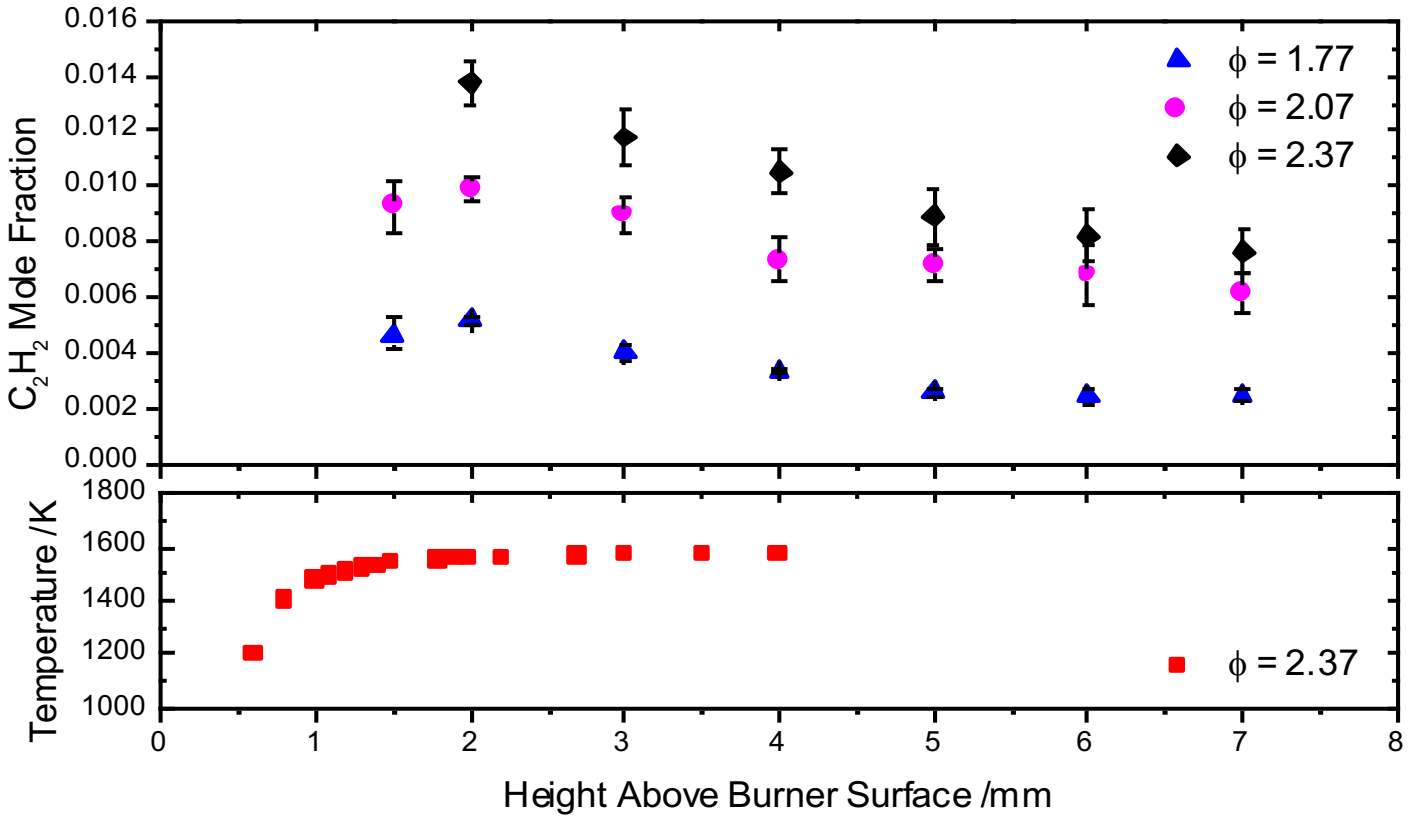
- Spectra for a range of different equivalence ratio flames recorded 2mm above the burner surface.
- Acetylene spectrum simulated from Hitran at a concentration of 1.22%, at 1600K, under atmospheric pressure.

Acetylene cw-CRDS spectra



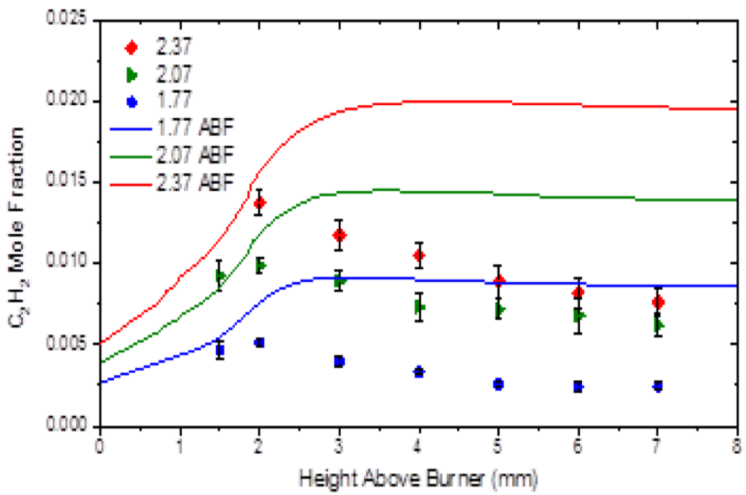
Spectra for a range of different equivalence ratio flames recorded 2mm above the burner surface after background subtraction.

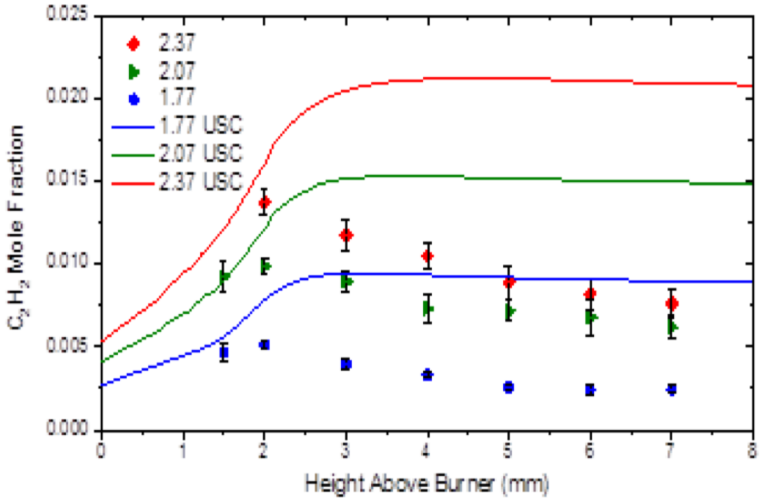
Concentration profiles



- Measured concentration of acetylene as a function of height above the burner surface.
- Previous temperature measurements by OH LIF

Concentration profiles





- Measured and calculated (ABF & USC mechanisms) concentrations of acetylene as a function of height above the burner surface.

Conclusion

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- *In situ* measurements of acetylene have been obtained in an ethylene/air flame.
- Measurements show acetylene concentration increasing with increasing equivalence ratio.
- Acetylene concentration decreases with increasing height above the burner. This would be consistent with the consumption of acetylene including in reactions forming polycyclic aromatic hydrocarbons (PAHs) and ultimately soot.
- ABF and USC mechanisms predict a trend for acetylene concentration that rapidly increases and plateaus with increasing height above the burner surface.