SP-AMS: $C_{>5}^+$ and soot nanostructure

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See also Malmborg et al 2018:
https://www.sciencedirect.com/science/article/pii/S0008622318309886
Rationale for studying soot nanostructure

- Soot formation and oxidation (destruction)
- Reactivity (particle filter regeneration and biological)
- Source attribution
- Radiative forcing (colour)
- Ice nuclei??

Nanostructure metric:
Fringe (“aromatic island”)
length
Quantifying Soot Nanostructure with HR-TEM

- HR-TEM analysis:
  - Fringe length [nm]
  - Tortuosity $\frac{\text{Fringe length}}{\text{Endpoint distance}}$
Can we measure soot nanostructure?

• Difficult to reproduce large carbon fragments in previous studies
• LU instrument: decent reproducibility over time
• LU instrument has relatively low laser power (low Refl. Mirror) -> low heating rate
• Still RIE 0.2-0.3 (last IE from RB I have is 550 ions/pg @ AB 7.E5 Hz)
• Mid-carbons and small fullerene carbons scales ~ linear with low C in laser power drops
• Large fullerenes increase exponentially with laser power -> secondary ionisation mechanism (Onasch et al. 2015) -> avoid high laser powers and large fullerenes
Comparison with TEM and OCEC
Effects of laser power on carbon ions

- Large fullerenes (>~C50) shows exponential increase with laser power
  - Avoid too high laser powers -> Thermal vaporisation of large fullC
Repeatability over time mini-CAST soot
Set-up

Sandra Török et al. (2018): Investigation of the absorption Ångström exponent and its relation to physicochemical properties for mini-CAST soot,

Aerosol Science and Technology, DOI: 10.1080/02786826.2018.1457767
CAST operating point (OP) simulates soot maturity. (For some reason it starts at 7 and goes backwards)
HR-TEM (Transmission Electron Microscopy)

Nanostructure evolves:
Heating changes the average soot nanostructure
Heating changes the average soot nanostructure

evaporation and oxidation experiment at op 6 (young soot)
Connection to heteroatoms
Engine: effects of "exhaust gas recirculation" (EGR) in biodesel combustion

![Graphs showing effects of EGR on engine performance](image-url)
Towards reproducibility and quantification

• Laser (overlap with particle beam, intensity)
• Ion source tuning
• Dual vs single vaporizers (+cylinder around ionization region)
• Nebulizable reference needed!
Summary

• Fringe length was inversely correlated (r=-0.97, p=0.028) to large carbon ions in SP-AMS mass spectra, which shows that we can use SP-AMS to measure carbon nanostructure.

• (low carbon ions (C≤5+) were correlated to elemental carbon (r=0.98, p<10-8))

• A warning: reproducibility between instruments is poor.

ESSAY
The importance of stupidity in scientific research
Martin A. Schwartz

“Science makes me feel stupid too. It's just that I've gotten used to it. So used to it, in fact, that I actively seek out new opportunities to feel stupid. I wouldn't know what to do without that feeling.”