High-throughput generation of aircraft-like soot

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Motivation

Ultrafine (< 100 nm) particle air pollution [1]

Specific surface area, SSA, is one of the most important metrics for quantifying toxicity [2]


Atmospheric aging

SSA measurement requires 10s of mg of soot!

Cannot produce high-thrust aircraft soot (OC/TC too high or $d_m$ too large)
Experimental set-up

- Thermocouple
- Sampling tube
- Rotating disk
- Air dilution
- N₂ dilution
- Pump
- Glass fiber filter
- X-ray Neutralizer
- N₂ Adsorption
- TEM
- TGA
- SMPS
- APM
- DMA
- CPC
- Sheath air
- O₂ dispersion
- Jet A1 fuel
- Premixed flame
- Burner
- Air
- O₂
- CH₄
- N₂

Mobility size distributions

Mobility diameter, $d_m$ (Mobility diameter)

Richer flame

EQR = 1.25

Aircraft soot: 3% thrust [1]

85% [1]

100% [2]

$85\%$ [1]

$100\%$ [2]

$\frac{dN}{d\log(d_m)/N_{tot}}$

Mobility diameter, $d_m$ (nm)

Dynamics of soot $d_m$ and $d_p$

Median mobility, $\bar{d}_m$, or primary particle $\bar{d}_p$, diameter (nm)

Equivalence ratio, EQR

Aircraft soot $\bar{d}_p$ from 10 – 20 nm [1,2]

Organic carbon to total carbon ratio

Equivalence ratio, EQR

High thrust aircraft soot: TOA [1-4]

OC/TC from:
Thermal Optical Analysis, TOA

Mass concentration

Median mobility diameter, $\bar{d}_m$ (nm)

Mass concentration, $M$ (mg/m$^3$)

Enclosed spray combustion [2]

3 orders of magnitude

MiniCAST 5201 [1]

0.3 mg/min

18 mg/min

Pore size distributions

Pore area, dA/dlog (w) (m$^2$/g)

Pore width, w (nm)

1.59
258 m$^2$/g

1.46
282 m$^2$/g

100% thrust [1]

EQR = 1.29
SSA = 160 m$^2$/g

85% thrust [2]

1.34
239 m$^2$/g

Conclusions

- Aircraft-like soot is generated here by enclosed spray combustion by varying EQR

- The present reactor can produce up to 3 orders of magnitude larger mass concentrations than existing generators

- Aircraft soot is primarily non-porous but at take-off (100% thrust) there may be an increase in porosity.
Thank you for listening