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Impact of hydrogen as a fuel additive on the formation of soot precursors and particles in atmospheric laminar premixed flames of methane

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1. Context
➢ Hydrogen as a fuel additive
   - Non carbonaceous species
   - High LHV (120MJ/kg)
   - High flammability limit
   - High flame speed
➢ GN (Natural Gas)
   - Large reserve
   - Main compound: CH₄
   - Low CO₂ emission

2. Objective
✓ Co-combustion properties of H₂ and CH₄ on emission of:
   • Soot particles
   • Soot precursors
   • CO, CO₂

3. Flame condition

H₂ + CH₄/O₂/N₂

Slight sooting premixed flame

H₂ Substitution

H₂ Addition

4. Experimental section

4.1 Soot measurements

LII & CRDS

Burner

Laser 1064 nm

Vertically moveable

Microprobe

Stabilization disk

SMPS

4.2 Gaseous species measurements

Microprobe

Stabilization disk

Jet Cooled LIF

Burner

Detector

FTIR

 ✓ TCD: CO, N₂, O₂, H₂
 ✓ FID: Aliphatic species (C₁-C₆) and benzene
 ✓ Naphthalene
 ✓ Pyrene
 ✓ CO₂

5. Results
➢ Soot particle sizer distribution function (PSDF)

Small impact on PSDF

Kinetic impact of hydrogen atom on soot formation process

(A) Oxidation process enhanced

(B) PAHs (Terminal reaction)

(C) PAHs + C₃H₆ → H₂PAHs (Surface growth) (HACA)

(D) C(5) + C₃H₆ → H₂C₅ + C₃H₆ (Terminal reaction)

(E) Change of soot volume fractions profiles essentially depending on aromatic species concentrations

Small impact on formation of aliphatic species and CO, CO₂, H₂

Aromatic species and soot

6. Conclusion
➢ The H₂ introduction into slight sooting premixed flames of methane strongly influences the formation of soot and their precursors
➢ This impact depends on the operating conditions (addition or substitution)