Inlet gas temperature of 323 K, atmospheric pressure, cold gas velocity of 8 cm/s

Ethylene/oxygen/argon flame (C/O = 0.7) and stepwise addition of ethanol: 5% Ethanol in ethylene/ethanol flames with different equivalence ratio \( \phi = 2.3 \)

Flame temperatures are similar independent of ethanol content

With increasing ethanol content shift of PSDs to smaller diameters for HAB = 12 mm; bimodal (C/O = 0.7, unimodal)

Effect mainly due to fuel structure?

Results for ethylene/ethanol flames with constant \( \phi = 2.3 \)

Reduction of soot volume with increasing ethanol content in the fuel

Already 5% of ethanol in the fuel have a significant influence on the soot formation

Tendency of soot reduction induced by ethanol addition increases at lower equivalence ratios

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References:

[1] The McKenna Flat Flame Burner, Holthus & Associates, P.O. Box 1531, Sebastopol, CA 95473.


Results for ethylene/ethanol flames with constant C/O ratio = 0.7

Addition of ethanol to the fuel leads to a reduction of the soot formation

For constant equivalence ratio the PSDFs are bimodal in pure ethylene flames and in flames with an ethanol content of < 50%, for HAB = 12 mm; for 50% ethanol content the PSDFs become unimodal

The tendency of the reduction of soot formation due to the addition of ethanol is more distinct at low equivalence ratios

For constant C/O ratio soot formation is increasing with higher amounts of ethanol in the fuel due to the fact that the equivalence ratio increases

However, the PSDFs in the flame with 20% ethanol and the pure ethylene flame are quite similar; what leads to the assumption that mainly the fuel structure influences the soot formation

Experimental setup

Oil-cooled flat flame model burner (McKenna burner [1]) with bronze plug (Ø 60 mm) and N2 - shroud

Stabilization plate at HAB = 30 mm

Fluid supply via Bronkhorst MFCs (\( \Delta \phi = 0.03 \))

Direct evaporator for liquid fuel (type aSTEAM from aDROP GmbH)

Mixing of fuel and oxidizer via special mixing chamber

Conditioning of reactants at 323 K after evaporating the liquid fuel at higher temperature

Sample probe (\( \lambda_2O_2 > 99.5\% \), 9 mm ID, 10 mm OD) with \( \phi = 0.3 \) mm orifice

Dilution ratio \( \sim 2 \times 10^4 \) (uncertainty \( \sim 24\% \))

Type 5 thermocouple (Ø 0.5 mm, \( \Delta T = 80 \) K) for temperature measurement

Results for ethylene/ethanol flames with constant \( \phi = 2.2/2.3/2.4 \)

Addition of soot volume with increasing ethanol content in the fuel

Already 5% of ethanol in the fuel have a significant influence on the soot formation

Tendency of soot reduction induced by ethanol addition increases at lower equivalence ratios

Figure 10. Soot volume fractions of ethylene/ethanol flames as function of ethanol percentage at constant C/O ratio (C/O = 0.7) at four different HABs.

Figure 9. Variation of PSD in ethylene/ethanol flames at constant C/O ratio (C/O = 0.7) at HAB = 6 mm and HAB = 12 mm

Figure 8. Radiation-corrected axial flame temperature profiles in ethylene/ethanol flames at constant C/O ratio (C/O = 0.7)

Figure 7. Pictures of ethylene/ethanol flames with different ethanol percentage at constant C/O ratio (C/O = 0.7)

Figure 6. Soot volume fractions of ethylene/ethanol flames normalized with soot volume fractions of pure ethylene flames as function of ethanol percentage at constant C/O ratio (C/O = 0.7) at HAB = 10 mm

Figure 5. Comparison between similar PSDs in ethylene/ethanol flames with 5% and 10% ethanol percentage at constant equivalence ratio (\( \phi = 3.3 \)) at four different HABs

Figure 4. Variation of PSD's in ethylene/ethanol flames at constant equivalence ratio (\( \phi = 2.3 \)) at HAB=6 mm and HAB = 12 mm

Figure 3. Radiation-corrected axial flame temperature profiles in ethylene/ethanol flames at constant equivalence ratio (\( \phi = 2.3 \))

Figure 2. Pictures of ethylene/ethanol flames with different ethanol percentage at constant equivalence ratio (\( \phi = 2.3 \))

Figure 1. Schematic of experimental setup (similar to [2])

Investigated ethylene/ethanol flames

Two series of tests:

- Ethylene/oxygen/argon flame (C2H4/O2/Ar = 0.139:0.181:0.880) at \( \phi = 2.3 \) = const. (C/O = 0.77) and stepwise addition of ethanol: 5% - 50% of total carbon feed
- Ethylene/oxygen/argon flame (C2H4/O2/Ar = 0.128:0.183:0.689) at C/O = 0.7 = const. (\( \phi = 2.3 \)) and stepwise addition of ethanol: 5% - 30% of total carbon feed
- Inlet gas temperature of 323 K, atmospheric pressure, cold gas velocity of 8 cm/s (at 273 K and 1 atm)

Internal probe sampling with suitable gas conditioning and online analysis using a Scanning Mobility Particle Sizer (SMPS)

Aim

- Study on influence of ethanol on soot formation in selected fuel-rich atmospheric pressure laminar premixed ethylene oxygen/argon flames
- Study on influence of residence time (height above the burner HAB) on equivalence ratio \( \phi \) and C/O ratios on Particle Size Distribution Functions (PSDFs)
- Internal probe sampling with suitable gas conditioning and online analysis using a Scanning Mobility Particle Sizer (SMPS)

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