New ISF3 – Premixed Flame 6

Premixed Flame 6*

References:

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Chiara Saggese, Alberto Cuoci, Alessio Frassodalti, Sara Ferrario, Joaquin Camacho, Hai Wang, Tiziano Faravelli, "Probe effects of soot sampling from a burner stabilized stagnation flame," *Combustion and Flame*, 167, 184-197 (2016).

Aamir D. Abid, Joaquin Camacho, David A. Sheen, Hai Wang, "Quantitative measurement of soot particle size distribution in premixed flames – The burner-stabilized stagnation flame approach," *Combustion and Flame* 156, 1862–1870 (2009).

Datasheet Table of Contents:

Approach:

Reproduce measurements of mobility PSDF for ISF3-Premixed Flame 6 (burner-stabilized stagnation flames) across 3 Universities (Stanford, Shanghai Jiao Tong and Tsinghua) and using a 5cm custom burner, 7.6 cm custom burner and McKenna burner.

Measure the particle mass / mobility size relationship via tandem mobility and mass measurements for nascent soot in ISF3-Premixed Flame 6.

Quantify probe perturbation effects to the assumed pseudo 1D flow field due to the finite flow velocity (deviation from non-slip boundary condition) at the probe orifice. Provide recommended spatial shift to the pseudo 1D numerical solution to account for 2D probe effects.

Recommendation to adopt new ISF3 Premixed Flame 6 data:

As discussed in Camacho 2015, there is excellent agreement in mobility PSDF measured between the 3 universities across 4 different burners. There is a slight discrepancy between the new PSDF the PSDF originally reported for ISF3-Premixed flame 6 in Abid 2009. The onset of nucleation was observed approximately 1 mm later in Abid 2009 than the current measurements. It is likely, as discussed in Camacho 2015, that the porous material plug in the burner used in Abid 2009 was excessively aged such that the local temperature was lower than expected which would cause soot nucleation to be artificially delayed. The new mobility measurements should be weighted more heavily than those reported in Abid 2009.

The particle mass was measured in tandem to the new mobility measurements, thus the new mobility measurements should be adopted when the mass measurements are considered.

A systematic modeling study was carried out comparing 2D and pseudo 1D models of the burner-stabilized stagnation sampling configuration in terms suction induced 2D perturbations of the flow field. A factorial analysis to quantify the extent of probe perturbation was carried out by considering the parameters which the perturbation is most sensitive to. These parameters are the height above the burner, the pressure drop across the sampling orifice and the flow velocity at the burner boundary. The analysis resulted in suggested spatial shifts to be applied to the numerical solution of the pseudo 1D flame simulation to account for 2D probe effects during sampling from the flame.

Apparatus:
3 separate experimental facilities for flame temperature measurements and mobility sizing.

Stanford Facilities: custom burner-stabilized flame 5 cm burner and custom 7.6 cm burner both with porous bronze (10 micron pores). Water cooled. Flame aerosol sampling was carried out with a stagnation surface/ sampling probe having an orifice size of 125 microns and wall thickness of 125 microns. For further details, see Camacho 2015. Temperature; 130 (after coating) micron wire Pt/Pt-Rh wire coated with Y/BeO. Fast-insertion method with radiation correction. The uncertainty is 10-90 K depending on the measured temperature. For further details, see Camacho 2015. Mobility sizing carried out with TSI SMPS (3085 Classifer 3025 Condensation particle counter)

Shanghai Jiao Tong Facilities: custom burner-stabilized flame 5 cm burner with porous bronze (10 micron pores). Water cooled. Flame aerosol sampling was carried out with a stagnation surface/ sampling probe having an orifice size of 130 microns and wall thickness of 125 microns. For further details, see Camacho 2015. 150 (after coating) micron wire Pt/Pt-Rh wire coated with Y/BeO. Fast-insertion method with radiation correction. The uncertainty is 10-90 K depending on the measured temperature. For further details, see Camacho 2015. Mobility sizing carried out with TSI SMPS (3085 Classifer 3776 Condensation particle counter)

Tsinghua Facilities: commercial McKenna burner 6cm with porous bronze (70-130 micron pores). Water cooled. Flame aerosol sampling was carried out with a stagnation surface/ sampling probe having an orifice size of 160 microns and wall thickness of 125 microns. For further details, see Camacho 2015. 130 (uncoated) micron wire Pt/Pt-Rh wire coated with Y/BeO. Fast-insertion method with radiation correction. The uncertainty is 10-90 K depending on the measured temperature. For further details, see Camacho 2015. Mobility sizing carried out with TSI SMPS (3085 Classifer 3776 Condensation particle counter)

Mass Measurements: The mass of nascent soot particle greater than 14nm mobility diameter were measured with a Cambustion centrifugal particle mass analyzer (CPMA). Mobility diameter distributions were measured for classified masses ranging from 2 to 113 attograms.

Measurements:

1. Temperature measurements

Fast-insertion method with radiation correction. The uncertainty is 10-90 K depending on the measured temperature. For further details, see Camacho 2015.

2. Evolution of mobility PSDF, number density and volume fraction

Mobility sizing was carried out on an TSI SMPS (models listed above for each facility). Sampling procedures have been standardized as to minimize artifacts due to probe sampling. For further details, see Camacho 2015.

2. Particle mass vs. particle mobility size

Mass measurement by CPMA was carried out in tandem with measurement of the mobility PSDF such that the mobility size distribution was measured for a given monodisperse (by mass) aerosol flow.

Summary of Conditions

laminar, atmospheric pressure premixed BSS flames

16.3% (mol) ethylene and 23.7% (mol) oxygen in argon. The unburned gas has an equivalence ratio, φ, of 2.07 and a cold velocity of 8 cm/s (298 K and 1 atm).