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Studying the Evolution of Soot and Precursors in Turbulent Flames Using Laser Diagnostics

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Abstract : This study focuses on the evolution of soot and soot precursors in three different piloted diffusion turbulent flames. The fuel composition is as follow flame A (ethylene/nitrogen, 2:3 by volume), flame B (ethylene/air, 2:3 by volume), and flame C (pure methane). These flames are stabilized using a 4mm diameter jet surrounded by a pilot annulus with an outer diameter of 15 mm. The pilot issues combustion products from stoichiometric premixed flames of hydrogen, acetylene, and air. In all cases, the jet Reynolds number is 10,000, and air flows in the coflow stream at a velocity of 5 m/s. Time-resolved laser-induced fluorescence (LIF) is collected at two wavelength bands in the visible (445 nm) and UV regions (266 nm) along with laser-induced incandescence (LII). The combined results are employed to study concentration, size, and growth of soot and precursors. A set of four fast photo-multiplier tubes are used to record emission data in temporal domain. A 266nm laser pulse preferentially excites smaller nanoparticles which emit a fluorescence spectrum which is analysed to track the presence, evolution, and destruction of nanoparticles. A 1064nm laser pulse excites sufficiently large soot particles, and the resulting incandescence is collected at 1064nm. At downstream and outer radial locations, intermittency becomes a relevant factor. Therefore, data collected in turbulent flames is conditioned to account for intermittency so that the resulting mean profiles for scattering, fluorescence, and incandescence are shown for the events that contain traces of soot. It is found that in the upstream regions of the ethylene-air and ethylene-nitrogen flames, the presence of soot precursors is rather similar. However, further downstream, soot concentration grows larger in the ethylene-air flames.

Keywords : laser induced incandescence, laser induced fluorescence, soot, nanoparticles
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