Stabilization of laminar nonpremixed DME/air coflow flames at elevated temperature and pressure

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**Abstract**

The structure and stabilization mechanism of laminar nonpremixed autoignitive DME/air coflow flames were investigated at elevated temperature and pressure. Computations with detailed chemistry were performed for DME and heated coflow air at 30 atm, with uniform inlet velocities imposed for both streams. The heat release rate profiles were first examined for each case to demonstrate the multibrachial thermal structure. Selected species profiles of the structure were then examined to demonstrate the chemical structure. Species concentrations and temperature were sampled along mixture fraction iso-contours, and Chemical Explosive Mode Analysis (CEMA) was performed to differentiate autoignition from flame chemistry and identify the controlling chemistry at representative points. One-dimensional Lagrangian Flamelet Analysis (LFA) was also performed and compared with the two-dimensional computations to elucidate the relative importance of diffusion processes parallel and perpendicular to the mixture fraction gradient. Various coflow temperatures with different inlet velocities were examined to elucidate their influences on the multibrachial structure, as well as the stabilization mechanism. It is found that at high coflow boundary temperature or low inlet velocity, the classical tribrachial flame structure was first achieved, and autoignition contributed less to the stabilization due to reduced lift-off height and therefore limited residence time. The kinematic balance between the flow speed and flame propagation speed is the dominant stabilization mechanism. On the contrary, kinetic stabilization was achieved at lower coflow temperature or higher inlet velocity, as autoignition became dominant. The coupling between autoignition and flame propagation results in the multibrachial structure. Based on these results, a regime diagram is constructed that identifies the possible stabilization regimes: blow-off, purely kinetically stabilized, autoignition-propagation-coupled stabilized, purely kinematically stabilized, and burner stabilized regimes.