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In-situ Soft X-Ray Absorption Spectroscopy of Flames

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The feasibility of in-situ soft x-ray absorption spectroscopy for imaging carbonaceous species in hydrocarbon flames is demonstrated using synchrotron radiation. Soft x-rays are absorbed by core level electrons in all carbon atoms regardless of their molecular structure. Core electron spectroscopy affords distinct advantages over valence spectroscopy, which forms the basis of traditional laser diagnostic techniques for combustion. In core level spectroscopy, the transition linewidths are predominantly determined by the instrument response function and the decay time of the core-hole, which is on the order of a femtosecond. As a result, soft x-ray absorption measurements can be performed in flames with negligible Doppler and collisional broadening. Core level spectroscopy has the further advantage of measuring all carbonaceous species regardless of molecular structure in the far edge region, whereas near-edge features are molecule specific. Interferences from non-carbon flame species are unstructured and can be subtracted. In the present study, absorption measurements in the carbon K-edge region are demonstrated in low-pressure methane jet flames. Two-dimensional imaging of the major carbonaceous species, CH4, CO2, and CO, is accomplished by tuning the synchrotron radiation to the respective carbon K-edge near-edge x-ray absorption fine structure (NEXAFS) transitions and scanning the burner. We also investigate the feasibility of soft x-ray absorption measurements in flames with larger hydrocarbon fuels.

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