Using Vacuum Ultraviolet and X-Ray Tools to Solve the Mystery of Soot Formation

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Soot is formed at high temperatures during the incomplete combustion or pyrolysis of hydrocarbons. Atmospheric emissions of soot from natural and anthropogenic sources are responsible for millions of deaths annually through cardiovascular and pulmonary diseases, substantial contributions to regional and global climate change, adverse effects on air quality, enhanced damage from uncontrolled wildfires, and significant loss of agricultural productivity [1,2]. On the other hand, soot has important commercial uses and industrial applications, such as providing a means of radiative heat control in large-scale boilers and furnaces and acting as a reinforcing filler in rubber products and as a stable black ink or pigment for many applications [1,3].

There are large gaps in our understanding of the fundamental physical and chemical processes involved in soot inception and evolution during combustion. These gaps limit our ability to reduce emissions and control the particle characteristics for commercial uses. The current physical description of soot formation and chemical evolution is largely based on experimental results derived from *ex situ* or online diagnostic techniques that rely on extractive sampling. Such sampling techniques perturb the flame substantially and potentially lead to large artifacts that can be difficult to interpret and often impossible to circumvent. Bridging gaps in the understanding of soot chemistry will require advances in *in situ* diagnostics and studies that combine advanced diagnostics. We have combined *in situ* techniques (laser-induced incandescence, laser extinction, small-angle X-ray scattering, and X-ray Raman spectroscopy) with *ex situ* methods (X-ray photoelectron spectroscopy, VUV aerosol mass spectrometry, and transmission electron microscopy) to probe the formation and chemical evolution of soot in premixed and diffusion flames. We have coupled some of these results with theoretical analysis. This talk will focus on the advantages of, and difficulties with, employing VUV and X-ray diagnostics to study soot chemistry.

References

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