Carbon Nanotube Synthesis in Premixed and Diffusion Flame Configurations: Roles of Gas Composition and Catalyst & Related LII Measurements

Randy L. Vander Wal

Penn State University, John and Willie Leone Family Dept. of Energy and Mineral Engineering and the EMS Energy Institute., 203 Hosler, University Park, PA 16802, USA

Flame synthesis of CNTs provides unique features not realized in current synthetic methods utilizing an arc discharge or high-temperature furnace. Combustion of a portion of the hydrocarbon gas provides the elevated temperatures required with the remaining fuel quite naturally serving as the hydrocarbon reagent. Hence the flame constitutes an efficient source of energy and hydrocarbon reactant. Furthermore, since flame synthesis has a demonstrable history of scalability for high-volume commercial synthesis, the method holds promise in this regard.

Perhaps the most significant aspect of the flame synthesis approach are the very short residence times realized for catalyst inception and nanotube growth. Reported results from the high-temperature furnace approach suggest reaction times on the order of seconds. In contrast, the flame synthesis method realizes residence times on the order of tens of milliseconds, an attribute that underscores the potential of flame synthesis for large-scale production of nanotubes. As with other processes demonstrated to date, the critical steps for optimum nanotube yield and growth are catalyst particle formation and their proper entrainment into a high-temperature hydrocarbon environment where nanotube growth can commence.

Illustrated in this talk is the use of premixed and diffusion flames as reaction environments for carbon nanotube synthesis. We have tested both systems using catalysts as aerosols and supported upon substrates. Highlights will be shown demonstrating success and further challenges. For illustration, this talk will illustrate two key parameter spaces, namely gas composition and catalyst (size and composition) in premixed and diffusion flames, respectively. Results of applying LII to measure, in situ, CNTs will also be shown.