The Nature of Carbon Breakdown and Catalyst Nanoparticle Interaction in a Continuous Gas Phase Process for CNT Synthesis

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Carbon nanotubes (CNTs) have been shown to possess significantly improved mechanical and electrical properties compared to existing materials. However, the quality of industrially produced bulk CNTs is limited in comparison. In our lab, we focus on the bulk production of high quality CNTs from a continuous gas phase process.

In this paper, the nature and influence of catalyst nanoparticles on carbon breakdown followed by the CNT formation in a continuous gas phase process for CNT synthesis is studied. To date, few studies have examined the phenomena associated with the carbon precursor breakdown and carbon (precursor) interaction with the catalyst nanoparticles and actual CNT formation within this reactor.

CNT formation follows the thermal decomposition of sulphur and iron precursors, nucleation of iron catalyst nanoparticles, and decomposition of a carbon source in a horizontal tube furnace (see Figure 1). Conditions within the furnace are a temperature range of 300–1300°C and a (reducing) hydrogen atmosphere at atmospheric pressure. The nucleated iron nanoparticles act as a catalyst to form CNTs. The resulting CNTs agglomerate to form an aerogel, which propagates down the reactor and is continuously wound out of the furnace as a fibre or film.

We will present a deconvolution study of the process to gain insight into the nature of carbon and sulphur breakdown particle conditioning. We examine results from mass, number, chemical in-situe and ex-situ analyses to separate the multiple phenomena occuring in the reactor and to understand their main drivers.

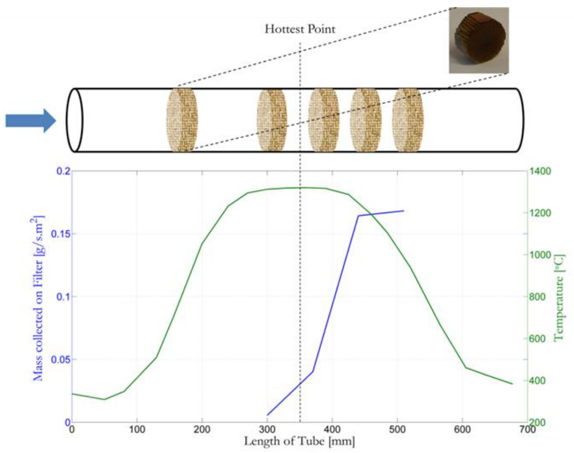

Figure 2: Total Mass of CNTs collected on Filter with respect to location in the tube and temperature.

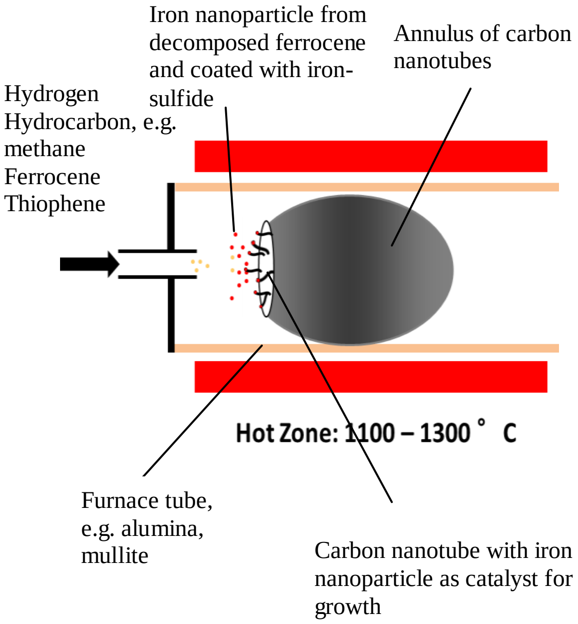

Figure 1: Small quantities of ferrocene and thiophene are dissolved, mixed with hydrogen and then injected into a tube furnace, in which an aerogel of nanotubes forms. This aerogel or annulus that forms can then be captured and wound out of the hot zone continuously as a fiber or film.

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