Isolating the role of trace carbon on the activity of catalyst populations for carbon nanotube growth

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ABSRACT
Limited understanding of the factors influencing the yield of carbon nanotubes (CNTs) relative to the number of catalyst particles remains an important barrier to their large-scale production with high quality and to tailoring on CNT properties for applications. Here, we show that a trace amount of carbon deposited on to a catalyst film enhances carbon nanotube yield dramatically. By using ambient pressure-X-ray photoelectron spectroscopy (AP-XPS), Raman spectroscopy and in situ environmental transmission electron microscopy (ETEM), we show that trace carbon aids in the reduction of iron oxide catalyst particles, thus improving nucleation success rates and enables the growth of CNTs with high yields. The increased catalyst reduction also corresponds to lower incubation times, thus enabling more particles to be available sooner as the catalyst film dewets upon heating. Analysis of various thicknesses of the trace carbon film (from 0 to 1 nm) shows that the lowered incubation time (and corresponding CNT yield) is highest for a carbon thickness of 0.2 nm.