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In-situ and ex-situ analysis of terminal lengths and growth rates of vertically aligned carbon nanotubes grown by acetylene and alcohol catalytic chemical vapor deposition J. JACKSON, ORNL, K. BELAY, Florida A&M Univ., A. PURETZKY, D. GEOHEGAN, H. CHRISTEN, H. CUI, ORNL — Controlled synthesis of carbon nanotubes (CNTs) at a fast growth rate which produced long, vertically aligned, and containing required number of walls, from MWNT to double- and single-walled nanotubes by varying processing parameters have been achieved in a thermal chemical vapor deposition (CVD) process. Both in-situ optical monitoring and ex-situ characterization methods have been used to determine the terminal lengths and growth rates of CNTs for acetylene, methanol and ethanol feedstocks grown on silicon substrates coated with an aluminum underlayer (∼10 nm), molybdenum (∼ 0.2 nm), and iron (∼ 1nm). Maximum growth rates of CNTs were 3-8 times and 50-125 times slower for ethanol and methanol, respectively, compared when using an acetylene feedstock. The terminal lengths of CNT arrays were estimated as: from 200 mm to a few mm for acetylene, ∼ 20 mm for methanol, and ∼ 8 mm for methanol. The terminal lengths, growth rates, the number of walls, and quality of the carbon nanotubes for all three feedstocks show similar temperature dependences. This indicates the existence of a common mechanism responsible for the activation and deactivation of catalyst nanoparticles at different growth temperatures, probably related to catalytic activity and/or the oxidation state of the catalyst nanoparticles. The restart of growth was also observed while controlling subsequent methanol and hydrogen gas flows.

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