CVD Growth of Less-Common, Small-Diameter Single Wall Carbon Nanotubes using 2D-Zeolites as Catalyst Supports

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ABSTRACT

In spite of much progress over the past few decades, large-scale controlled growth of single-walled carbon nanotubes (SWCNTs) remains hindered by a general lack of understanding of catalyst behavior dynamics. In particular, catalyst coarsening can lead to the formation of large catalyst particles, hindering the growth of small diameter SWCNTs. Here we show that, by using periodic 2D MFI zeolite films, catalyst particles can be pinned such that they exhibit very narrow size distributions. Through in situ environmental transmission electron microscopy (ETEM), we demonstrate that the catalyst particles are preferentially docked to one, three, or four pores, and that the growth of small diameter SWCNTs (between 0.65 and 1.1nm in diameter) takes place from particles docked onto a single pore. The SWCNTs grown include exotic small-diameter near zigzag tubes, which are predicted to be thermodynamically unfavorable. We attribute this to the particle/zeolite interaction, which stabilizes the particles and lowers the barrier for the formation of these SWCNTs.