Comparison of iron complexes, clusters, and colloids as catalyst precursors for single-walled carbon nanotube (SWNT) growth

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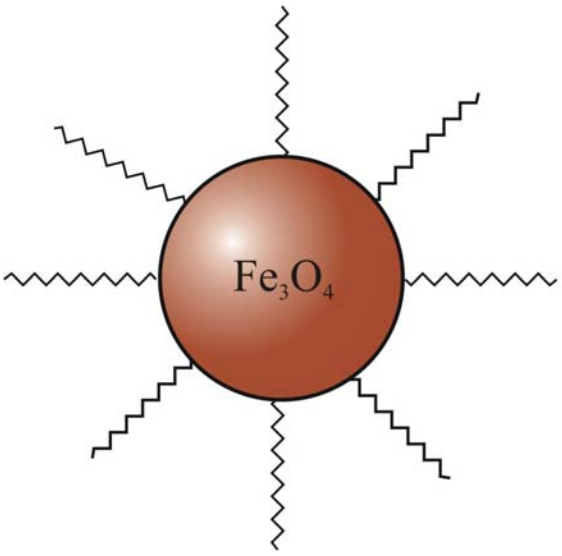
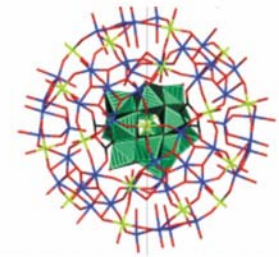
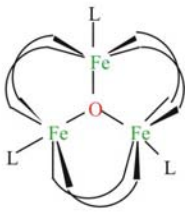
Recent studies of the vapor-solid-liquid (VLS) growth of single-walled carbon nanotubes (SWNTs) from metallic catalysts on solid substrates (e.g. iron nanoparticles on silicon wafers) have suggested that there is a correlation between the size of the catalyst precursor and the diameter of the resultant SWNTs. Understanding how the initial catalyst properties influence the characteristics of the grown nanotubes is a crucial step toward furthering attempts to prepare SWNTs with controlled dimensions and chiralities. To this end, we have studied the VLS growth of SWNTs using the following catalyst precursors that contain increasing amounts of iron atoms and exhibit three distinct dimensions: (1) an oxo-hexacarboxylate–iron trimer complex, which contains 3 iron atoms, $[Fe_3O(O_2CCH_3)_6(EtOH)_3]$ (d < 1 nm), (2) a molecular cluster, FeMoC, which contains 30 iron atoms, $[H_xPMo_{12}O_{40} \subset H_4Mo_{72}Fe_{30}(O_2CCH_3)_{15}O_{254}(H_2O)_{98}]$ (d = 2 nm), and (3) a magnetite (Fe_3O_4) nanoparticle, which contains 1,300 iron atoms (d = 4 nm). We will discuss how factors such as the initial iron content, catalyst size, and catalyst aggregation influence the characteristics and growth rates of the SWNTs on various substrates (Si, SOG, HOPG, Al_2O_3) under different growth conditions (i.e. varying growth temperatures and gases). Characterization of the SWNTs by AFM, SEM, and Raman spectroscopy will be presented.





FeMoC



Fe_3O