1002 CD
DOI: 10.1017/S1431927606068085
Microsc Microanal 12(Supp 2), 2006

Polymer/Carbon Nanotube Processing and Sample Preparation for Use in Nanotechnology

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The recent development of nanotechnology has provided a unique opportunity to explore the fundamental interactions between nano-sized materials, such as carbon nanotubes, and a variety of materials including polymers. Polymers offer many advantages for applications in the military and industry such improved electrical, thermal, mechanical, and biological performance including their versatility for fabrication over large areas, flexibility, biocompatibility, and low cost [1]. However, many applications require surface modifications to achieve the desired final product properties. This can be accomplished in aligned/micropatterned carbon nanotube arrays by modifying their surfaces with polymers [2,3].

Plasma processes have become a very attractive approach for introducing either region-specific functional surface groups via plasma treatment or smooth and pinhole-free functional polymer layers via plasma polymerization [4]. However, if masks are used for patterning the polymer patterns, the spatial resolution is limited by the structure and resolution of the physical mask used. Therefore, new and improved methods of fabrication have been developed such as layer-by-layer assembly of catalyst particles for the controlled synthesis of aligned carbon nanotubes as shown in Figure 1 [4]. Additionally, the microscopy and microanalysis techniques that have shown great success in characterizing these materials include scanning probe imaging, x-ray photoelectron spectroscopy, secondary ion mass spectrometry, and x-ray/neutron reflectometry for the microanalysis of surface compositions and depth profiles [2].

A working knowledge of tradition polymer sample preparation for electron microscopy proves very useful for examining polymer/carbon nanotube composites and polymer-functionalized carbon nanotubes arrays. As with all samples for electron microscopy, care should be taken to avoid volatiles and contaminants along with producing a sample able to withstand electron beam irradiation, produce atomic-based contrast, and act as a conductor or be thin enough for electron transmission. Most polymers do not naturally possess these characteristics, which creates obstacles to having the best imaging conditions. These obstacles can be combated and overcome by proper cleaning and drying, etching and staining of low contrast samples, lightly coating to prevent charging and protect from beam damage, making a pathway to ground with conductive paint or tape, and sectioning with an ultramicrotome for ultrathin sections [5]. Additionally, polymers can be imaged under variable pressure conditions in an environmental SEM (ESEM) if necessary.

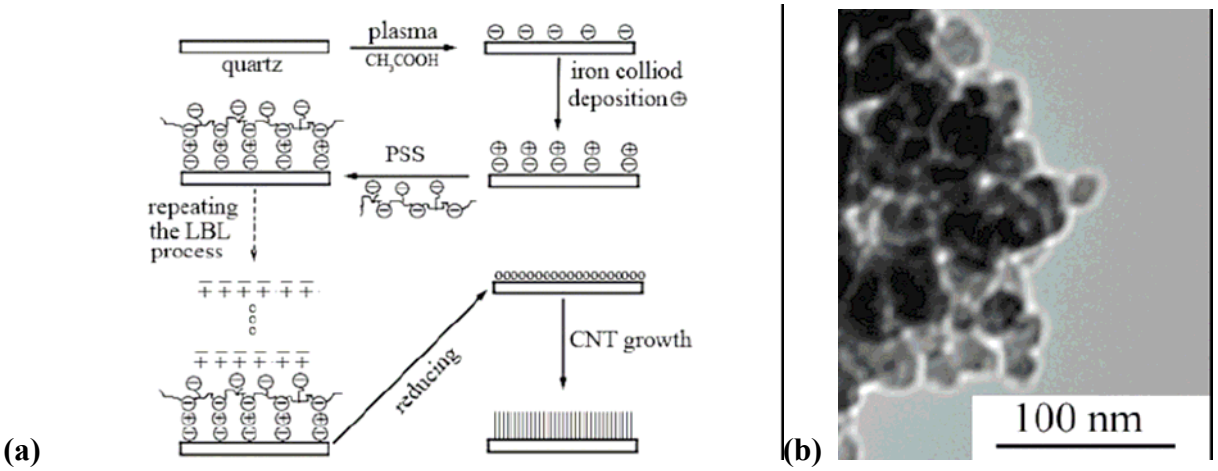

Figure 1. Method of using the layer-by-layer (LBL) assembly process to fabricate catalyst particles of a controlled size distribution and packing density for aligned carbon nanotube (CNT) growth (a) Schematic illustration of the procedures for the layer-by-layer assembling of iron hydroxide colloidal nanoparticles and poly(sodium-4-styrenesulfonate) (PSS), followed by the catalyst nanoparticle reduction and growth of aligned carbon nanotubes (b) Transmission electron microscope (TEM) image of the resulting nanoparticle sample [4].

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https://doi.org/10.1017/S1431927606068085 Published online by Cambridge University Press