

Functionalized Carbon Nanotubes and Their Electrochemical Properties

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The recently discovered carbon nanotubes have extraordinary electrical, thermal, mechanical, and chemical properties [1]. These properties make them a promising electrode material in many electrochemical processes. When functionalized with active nanoparticles, carbon nanotubes provide an excellent opportunity for highly enhanced electrocatalytic processes and electrochemical sensing.

Current prototype polymer electrolyte membrane (PEM) fuel cells use carbon black as the catalyst support [2]. The drawback of carbon black is its tortuous structures that make it difficult to maximize the three phase boundary, and therefore leads to low utilization of the expensive platinum catalysts. Due their excellent properties, carbon nanotubes could be a potential substitute for the carbon black. Our work is aimed at functionalizing carbon nanotubes with electrocatalytic nanoparticles for their use as the electrocatalysts in PEM fuel cells.

A simple sonochemical process is developed to modify the surfaces of carbon nanotubes, which is based on the acidic etching technique. However, it was found that with ultrasonic treatment, the carbon nanotubes can be uniformly modified, which is necessary to deposit uniform Pt nanoparticles on them. With this technique, we have synthesized Pt nanoparticles with an average particle size of around 4 nm and a Pt loading up to 30% on multi-walled carbon nanotubes (from NanoLab, Inc., Brighton, MA) A typical TEM image is shown in Figure 1.

Physical properties of the functionalized carbon nanotubes are characterized with electron microscopy, x-ray diffraction, and x-ray photoelectron spectroscopy. The electrochemical characterization is accomplished by using the cyclic voltammetry technique in the oxidation of hydrogen and reduction of oxygen.

References:

- [1] Dresselhaus, M.S., Dresselhaus, G., and Avouris, P., (ed), *Carbon Nanotubes: Synthesis, Structure, Properties and Applications* (Springer-Verlag, New York, 2001).
- [2] Larminie, J. and Dicks, A., *Fuel Cell Systems Explained* (John Wiley, New York, 2000).

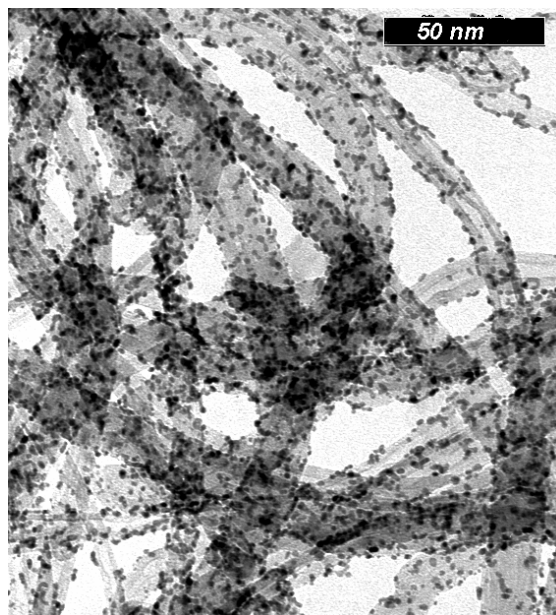


Fig. 1. Carbon nanotubes functionalized with platinum nanoparticles. The nanoparticles are synthesized by reducing the metal salt K_2PtCl_4 in a dispersion of surface modified carbon nanotubes in an ethylene glycol and water solution.