Novel Renewable Filter for Heavy Metal Removal: A Practical Application of Functionalized Multi-Walled Carbon Nanotubes

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Heavy metals pose a huge threat to society by diffusing through water supplies. Many technologies have been developed for removing heavy metals from industrial wastewater and drinking water, but few are efficient, and almost none are renewable. This project's objective is to create an innovative, low-cost renewable multi-walled carbon nanotube (MWNT) filter that can efficiently adsorb heavy metals from contaminated water. MWNTs were deposited on 3.45g of Quartz Wool through Chemical Vapor Deposition, purified through Wet-Air Oxidation and HCl-Sonification, and functionalized with m-CPBA to produce the filter medium. 0.052M, 0.01M, 0.01M, 0.001M, and 100ppm solutions of Cadmium(II) Acetate, Mercuric Chloride, Nickel(II) Nitrate, Cobalt(II) Chloride, and Lead(II) Acetate respectively were poured into 0.5g filter medium samples packed in a burette, for three filtration trials per metal. Then, a 50:50 solution of de-ionized water and acetic acid was poured through the metal-contaminated filter medium, to renew it. Characterization techniques employed were: UV-Vis Spectroscopy for filtration capacities, Scanning Electron Microscopy for MWNT growth-patterns, Raman spectroscopy for changes in nanotube purity, and X-Ray Photoelectron Spectroscopy (XPS) for filter composition after filtration and renewal. UV-Vis revealed filtration capacities of 99.39%, 99.61%, 99.70%, 99.72%, and 99.97% for Cadmium, Mercury, Nickel, Cobalt and Lead respectively. Thus, heavy metal-contaminated sources even as high as 750µg/L can be filtered to meet current EPA MCLGs as low as 1µg/L. Progression of Raman G/D ratios (0.82-1.92-1.59-1.69-2.29), XPS atomic % (19% to 0%), and filtration/renewal times (120s/180s per 50 ml) clearly indicated that the filter is not only efficient, but also renewable.

Awards Won:

Intel ISEF Best of Category Award of $5,000

First Award of $5,000

Philip V. Streich Memorial Award to the London International Youth Science Forum