Photoelectrochemical Response of Single-Walled Carbon Nanotubes with Distinct Diameter and Chirality

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Currently progressed research for the construction of ultra-sensitive and low-energy consumption nano-devices requires the ultra-small unit that has well-defined electronic structure. Importance of single-walled carbon nanotubes (SWNT) in this field has been well recognized, because their electronic characters can be tuned precisely if one can control their diameter and chirality of the tubes. Diameter selective preparation of SWNT, however, is rather difficult, because most of popular synthetic methods are based on the high energy processes, such as laser vaporization, arc discharge, and vapor growth etc., which are impossible to control the diameter-difference in an atomic scale. Thus, we have to develop the techniques to prepare ultra-pure SWNT materials via a critical separation from SWNT samples having wide variety of diameter, chirality, and length. Although several techniques for the separation of SWNTs with different lengths, metallic/semiconducting properties, and diameter have been developed, there is no technique to separate tubes of distinct diameters and chirality.

Recently, we have studied the structural dependence of the work function of isolated single-walled carbon nanotubes (SWNTs) by observing the electrochemical potential dependence of Raman intensity measured on a gold electrode in an aqueous solution. The work function of a SWNT becomes larger as in a manner inversely proportional to the diameter of the tube. This structural dependence is greater in metallic tubes than in semiconducting tubes. Results show that metallic tubes thinner than a (15, 6) metallic tube with tube diameter d_t = 1.49 nm are more chemically stable than noble metals with high work functions, such as Au and Pt, and that semiconducting tubes thicker than a (9, 7) semiconducting tube with d_t = 1.10 nm under band-gap photo-excitation show more effective electron emission ability than low work function metals, such as Mg and In. These structure sensitive characteristics of the electronic structure result in a selective photocatalytic reaction of SWNT with distinct diameter and chirality. The reaction can be used to achieve the structure-sensitive separation of SWNT.