Large Scale Separation of Single Chirality SWCNTs and Their Application to Near Infrared Vascular Imaging

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Recently, single-wall carbon nanotubes (SWCNTs) have attracted much attention as a fluorescence probe for biological imaging due to their bright emission in near infrared (NIR) biological transparency window (700-1400 nm) where the light penetrates a living body deeply because of the low absorption of water and various biological tissues [1]. However, currently-used HiPco SWCNTs contain various chiral species, each of which has chirality dependent excitation (E_{22}) wavelength. If we use a monochromatic light source for the E_{22} excitation as in the previous work, the excitation efficiency should be very low. Therefore a single-chirality SWCNT was desired for high efficiency imaging. For this purpose, we have developed a novel gel chromatography method for chirality separation of SWCNTs and successfully separated high-purity single-chirality (9,4) SWCNTs in large scale. Since both the E_{11} emission and E_{22} excitation of (9,4) SWCNTs are in the biological transparency window, they could be an ideal fluorescence probe for the biological imaging. In this work, we demonstrate highly efficient biological imaging of mouse vasculature using biocompatible single-chirality (9,4) SWCNTs.

To make the (9,4) SWCNTs biocompatible, surfactants used in the separation were replaced with a biocompatible surfactant (DSPE-PEG). After the SWCNT solution was injected intravenously through a tail of mouse, NIR images of the mouse were recorded using an InGaAs 2D array camera under an illumination of a LED (~730 nm) light. The (9,4) SWCNT exhibited much brighter vascular images than unseparated HiPco. The high brightness of (9,4) enables the imaging using even two orders of magnitude lower dose per mouse than reported values. The use of biocompatible (9,4) SWCNTs as fluorescence probe will reduce any possible risk to the subject.

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[1] G. Hong et al, Nature Medicine 18 (2012) 1841.