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Controlling the interfacial properties of one-dimensional nanostructures

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CONTROLLING THE INTERFACIAL PROPERTIES OF ONE-DIMENSIONAL NANOSTRUCTURES

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The high surface area of nanomaterials dictates that the interface with their surroundings is important in determining their properties or functionality. For example, all atoms in single-walled carbon nanotubes (SWCNTs) exist on the surface and, therefore, have excellent sensing capabilities. The interface of SWCNTs with their surroundings is also important to their application in polymer composites, devices, drug delivery, bioimaging and biosensing. Understanding and ultimately controlling these surface layers is important because of its influence on dispersion, reactivity, adsorption of pollutants, and interaction with biological materials. SWCNT interfaces are often altered with surfactants to improve their dispersion in aqueous suspensions. While the surfactant surrounding the nanotube provides many benefits, the inability to alter or control this interface often limits the performance or functionality of the nanotube.

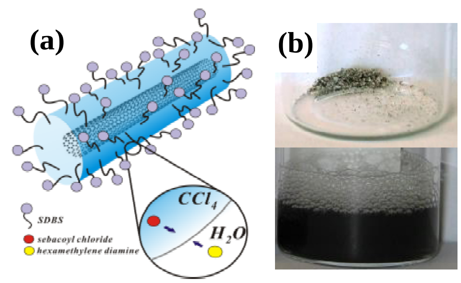

Figure 1 – (a) Coating SWCNTs through interfacial polymerization. (b) Encapsulated SWCNT product freeze-dried and re-dispersed.

Our group has focused on characterizing and controlling the interfaces of nanomaterials, especially SWCNTs. We have exploited the natural sensing capabilities of the nanotubes to help us characterize the localized environment surrounding them. The ability to characterize the surface of SWCNTs has enabled new methods to alter or create new surface properties, enhance their fluorescence, control their adsorption onto materials, separate them by their electronic properties, and limit their toxicity. For example, we have demonstrated that organic solvents can swell the hydrophobic core of surfactant micelles surrounding SWCNTs, especially SDBS, to yield an emulsion-like microenvironment surrounding the SWCNTs. These swelled micelle states can be used for the *in situ* interfacial polymerization of Nylon 6,10, as shown in Fig. 1a. These polymerized nanotubes remain dispersed in the aqueous phase and the polymer is not covalently bound to the sidewalls. Therefore, the intrinsic properties of the SWCNTs, including fluorescence, are maintained. The SWCNTs can even be freeze-dried and re-dispersed (Fig. 1b). Finally, we have shown that the ability to control these interfaces is an important parameter during the selective adsorption of semiconducting SWCNTs onto agarose gels (Fig. 2a). Using our understanding of the surfactant structure surrounding SWCNTs, we developed high-fidelity separations of nanotubes by both selective adsorption and two-phase extraction.

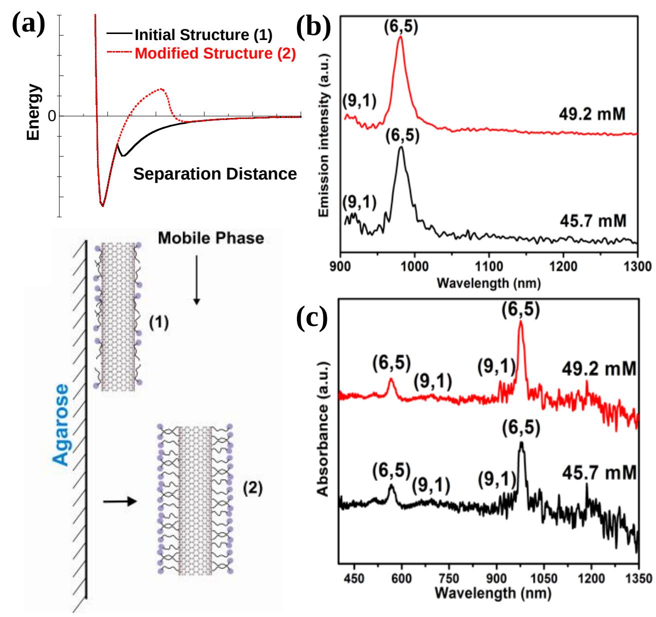

Figure 2 – Selective adsorption to hydrogels. (a) Entropic differences to the surfactant structure effects the potential energy between the SWCNT and substrate. High-fidelity separations of the (6,5) nanotube as characterized by (b) fluorescence and (c) absorbance spectroscopy. Note that the absorbance spectra show the first and second energy transitions.