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Electrochemical Sensing with Individual Single-Wall Carbon Nanotubes

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The transport properties of molecular electronic devices can be strongly modulated by immersion in a liquid electrolyte. For example, early investigations with single-wall carbon nanotubes (SWNTs) used the electrolyte as a "liquid gate." That is, the conductance of SWNTs in a field-effect-transistor configuration was tuned via an electrochemical potential applied to the electrolyte. This concept was also extended to sensor applications in which molecules impinging upon the SWNT surface cause a rearrangement of screening ions and a corresponding change of the device conductance. In these approaches, the coupling between the device and the electrolyte is solely electrostatic, and no charge is transferred across the liquid-device interface. Here we demonstrate that individual SWNTs can also be used as electrodes for electron transfer reactions, that is, electrochemical reactions in which electrons are exchanged between a SWNT and redox-active molecules in solution. The rate of electron transfer to SWNTs is observed to be very fast. It can nonetheless be resolved in dc transport measurements due to the high diffusive flux of redox molecules resulting from the nanometer diameter of SWNTs. Interestingly, metallic and semiconducting SWNTs yield similar current-voltage characteristics; we show that this behaviour is consistent with theories of electron transfer in which the electronic structure of the SWNTs is explicitly taken into account. Finally, we demonstrate that noble metals can be controllably and selectively electrodeposited from aqueous solution unto individual single-wall carbon nanotubes, opening new routes for the functionalization of SWNT devices. Work done with K. Besteman, H. A. Heering, I. Heller, J. Kong, J.-O Lee, B. M. Quinn, F.G.M. Wiertz, K. A. Williams and C. Dekker.