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Functional Single-walled Carbon Nanotube Electrodes for Solar Energy Conversion

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In this presentation, we discuss our progress in producing high surface area electrodes from single-walled carbon nanotubes (SWNTs) and the utilization of these electrodes in solar energy conversion devices. SWNTs have several fundamental properties that make them attractive for functional electrodes, including high electron and hole mobilities, a tunable work function with an energy range relevant to many photovoltaic devices, and optical transitions in the visible and near infrared that may be useful for solar driven photochemical reactions. Additionally, they possess numerous properties amenable to practical, scalable, and economic electrode deposition including abundant source material, a natural disposition for solution processing, and high surface area and flexibility. All of these features make them extremely attractive for replacing conventional electrodes, such as tin-doped indium oxide (ITO), which suffer from questionable world supply, high temperature/low pressure deposition requirements, and brittleness. We will present our development of a versatile and scalable ultrasonic spray process for producing SWNT electrodes with high transparency, high conductivity, and very low surface roughness. This method can be adapted for aqueous and organic solvents, allowing SWNT electrodes to be sprayed on a variety of different substrates, including directly on photovoltaic devices. The performance of PV devices incorporating our electrodes is nearly equivalent to devices incorporating traditional transparent conducting oxides. Finally, we demonstrate that this method can be extended to the production of a variety of different functional SWNT electrodes, including bio-hybrid electrodes for the production of hydrogen fuel. These electrodes achieve electrolytic current densities close to that of platinum at a fraction of the cost. We will discuss devices incorporating bulk SWNTs as well as SWNTs enriched in specific electronic structures.