Synthesis of single-wall carbon nanotubes@Metal nanocomposites based on photoirradiation with plasmid DNA
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Meeting the ever-growing need of available clean energy requires the development of inexpensive and environmentally friendly synthesis routes to produce efficient energy conversion devices[1]. Single-Wall Carbon Nanotubes (SWNTs) have received considerable attention in photovoltaic field due to their intriguing properties. Metal nanoparticles hybridization to manipulate SWNTs can control electron transports between metal nanoparticles and SWNTs. While the chemical modifications and surfactants have been used to prevent SWNTs bundling, these methods may lead to changes in the electronic structure of SWNTs, affecting its properties[2].

Using biological molecular such as DNA as bioscaffold can assemble SWNTs and metal nanoparticles organically and achieve SWNTs@ metal nanoparticles nanocomposites. SWNTs are bound and stabilized by DNA through non-covalent binding, this method disperses SWNTs well without significantly affecting electron transfer between metal nanoparticles and SWNTs or changing the high electron mobility of the SWNTs. Moreover, the recent research shows that DNA can reduce metallic cations to become nanoparticles using the ultraviolet (UV) irradiation[3]. Synthesis SWNTs@metal nanoparticles in this method has been found more effective than those previously reported methods on releases the resistance for electrons transfer between metal nanoparticles and the SWNTs.

Some first step achievements have been gotten in applying these nanocomposites in Dye-Sensitized Solar Cells (DSSCs). From 2011, Belcher has synthesis such kinds of nanocomposites to improve the incident photo-to-current conversation efficiency (IPCE) by using M13 virus as bioscaffold. In our work, we mixed the SWNTs@Ag nanoparticles with TiO$_2$ to get SWNTs@(TiO$_2$/Ag) nanocomposites, and integrated them into photoanode films to achieve high efficiency DSSCs, as shown in Fig.1. [3] In particular, when the amounts of SWNTs and Ag NPs in the photoanode are 0.15 wt% and 0.8 wt%, the DSSCs got ~37.07% improvement compared with conventional TiO$_2$-only DSSCs. The improvement is ascribed to the SWNTs@(TiO$_2$/Ag) nanocomposites not only increasing the electron collection and transportation due to the SWNTs, but also enhancing the light-harvesting efficiency of the photoanode films based on the Ag Localized surface plasmons (LSPs).

By changing the base pairs of the plasmid DNA, composites of SWNTs and metal nanoparticles with different sizes can be prepared, and other metal nanoparticle composites with SWNTs can be achieved based on this photoirradiation method with DNA. We believe that this strategy, enhancing the performances of DSSCs, could be also applied for other thin film photovoltaic technologies that require efficient light-harvesting and electron collection and transportation.

Reference: