Charge Transfer in Carbon Nanotubes-Supported Nanoparticles

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Abstract

Due to their outstanding mechanical and electrical properties, carbon nanotubes (CNTs) are being considered as promising materials in various fields such as electronic, materials engineering, sensor design and catalysis. A potential application of this carbon allotrope consists of using it as support of nanoparticles for heterogeneous catalysis. Aiming this, we chose bimetallic clusters as precursors of metallic catalysts nanoparticles from which a synergic effect between both constituting metals is expected. Moreover, the size and composition of the activated metallic nanoparticles can be easily controlled by selecting the appropriate starting cluster. More specifically, we synthesized a Ru_5Pt cluster compound.[1] In order to coordinate this cluster on the surface of CNTs, we developed a four-steps functionalization pathway: (i) covalent functionalization of carbon nanotubes by diazonium salt; (ii) derivatization of the functionalized nanotubes in order to anchor a ligand for cluster coordination; (iii) cluster coordination; and eventually (iv) thermal activation (Figure 1). At the end of this process, we obtained 'naked' Ru-Pt nanoparticles supported on carbon nanotubes, which are expected to exhibit catalytic activity.[2]

Using individual single-walled carbon nanotubes field-effect transistors (SWNT-FETs, Figure 2a), we measured the electrical response of those carbon nanotubes-supported bimetallic nanoparticles. Measurement of functionalized-carbon nanotubes revealed a high loss of conductance (70 to 80 %) compared with pristine-CNTs. This result is due to the covalent nature of the functionalization step, which alters the aromaticity of the nanotube.[3] Modification of the grafted moieties does not change the electrical characteristics, since the tube is not further altered by these steps. During thermal annealing, activated nanoparticles are deposited on the carbon nanotube surface. After this activation step, carbon nanotubes recover about 60 % of their initial conductance. Moreover, these measurements show evidence of a charge transfer from the nanotube to the nanoparticle, as revealed by the p-doping of the carbon nanotubes (Figure 2b). This charge transfer is of significant relevance for catalytic applications, since the nanoparticle can be viewed as an electron sink.

In summary, we have covalently grafted Ru_5Pt clusters on single-walled carbon nanotubes. After thermal activation, we obtained bimetallic nanoparticles-decorated carbon nanotubes. Electrical characterization of those nanohybrids revealed a charge transfer between nanoparticles and carbon nanotubes as evidenced by p-doping of CNTs. Those materials are expected to exhibited catalytic activity.

References

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Figures

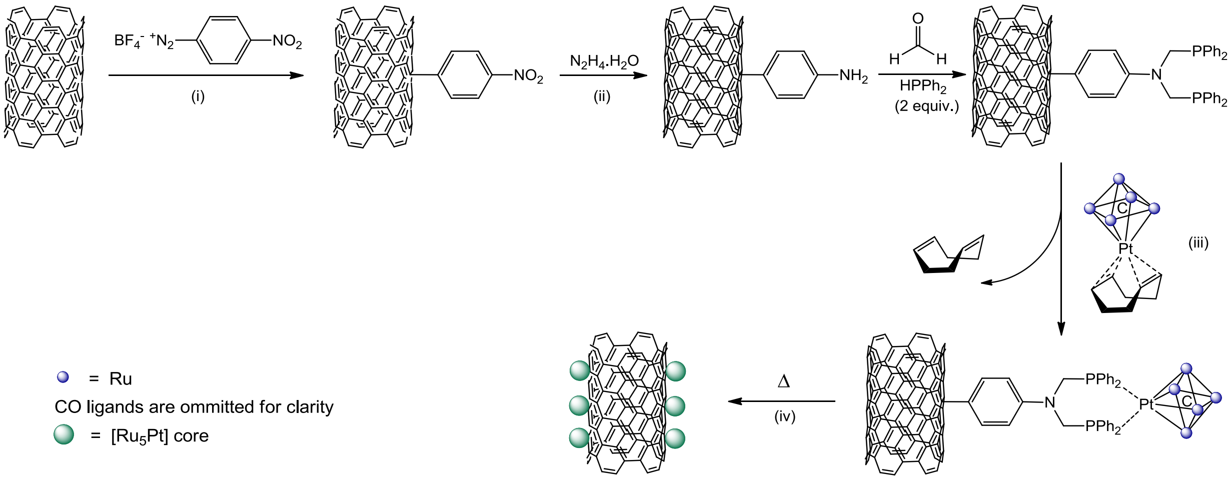

Figure 1. Reaction scheme of the functionalization pathway developed for the formation of $[Ru_5Pt]$ nanoparticles on carbon nanotubes.

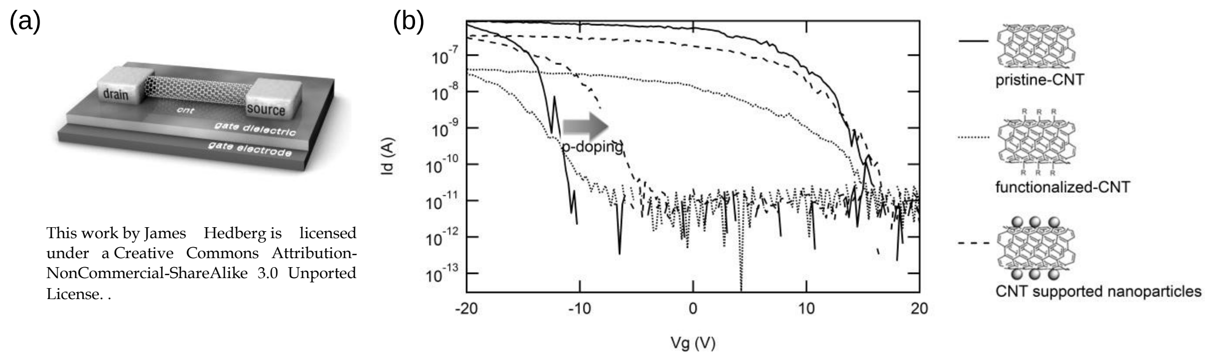

Figure 2. (a) Schematic representation of a CNT-FET; (b) Charge transfer in carbon nanotubes supported nanoparticles.