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Copper nanoparticles: Retarding air-oxidation without electrical isolation using organic ligands, and the size dependence of nanoparticle work function

Copper nanoparticles (Cu NPs) have potential as a cost-effective alternative to gold and silver nanoparticles for many emerging applications, including hybrid materials for plasmonic hot-electron devices and photovoltaics, although their potential has sparsely been explored due to their higher susceptibility to oxidation in air. This talk will present the remarkable findings of a systematic investigation into the correlation between the air-stability of Cu NPs and the structure of the thiolate capping ligand, which turns conventional wisdom about ligand selection to retard air-oxidation on its head. The experimental methodology used is based on monitoring (in real time) the oxidation of isolated nanoparticles tethered to a solid substrate via the evolution of the localized surface plasmon resonance. Additionally, the work function of a metal nanoparticle is a key determinant of the energetics at the interface it forms with a surrounding semiconductor and so knowledge of how this property scales with size is critically important for electronic applications. Classical theory predicts that the work function should increase with decreasing diameter, although experimental evidence to support this is disputed. We have exploited the exceptional stability of ligand capped copper nanoparticles to unambiguously show that the work function of small metal nanoparticles increases with decreasing nanoparticle diameter, using Kelvin probe force microscopy. Together these finding open the door to the development of hybrid electronic materials based on colloidal metal nanoparticles and organic/perovskite/transition metal oxide semiconductors in which the copper nanoparticles are strongly electrically coupled to the surrounding semiconductor.

Biography

Ross A Hatton is an Associate Professor of Physical Chemistry at University of Warwick in UK and is currently holder of a UK Engineering and Physical Science Early Career fellowship (2016-2020). He was awarded his PhD in 2003 at University of Nottingham (UK) and a prestigious five year Royal Academy of Engineering Research Fellowship in 2007. He has published 50 papers in peer reviewed international journals and has a long standing interest in "The utility of nanomaterials in emerging photovoltaic devices, including carbon nanotubes, metal nanoparticles and ultra-thin nano-structured metal window electrodes".

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