Tailored Nanoparticles Prepared in Superfluid Helium Droplets

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By doping superfluid droplets of 10^6 to 10^{10} helium atoms (He_N) with foreign atoms or molecules, cold complexes of atomic or molecular species are formed. In this way, metal or metal oxide nanoparticles and core-shell clusters of different morphology have been generated and deposited on solid carbon, h-BN, ITO, or SiN substrates. The created nanoparticles are characterized by temperature dependent electron microscopy, up to 1000 degrees C, energy-dispersive x-ray spectroscopy, electron energy loss spectroscopy, photoemission electron micros-copy and optical absorption[1]. Recent investigations include the stability of a passivation of Ni [2], Fe [3], and Co cores of 2 to 3 nm diameter by a few layers of gold and the alloy formation at high temperature[4].

Ag@ZnO core@shell particles are studied by two-photon photoelectron spectroscopy. Upon excitation of the localized surface plasmon resonance in Ag at around 3 eV, plasmonic enhancement leads to a strong increase in electron emission when compared to pure ZnO clusters[5]. Vanadium oxides represent a prominent materials class for catalytic applications. On the way towards cluster catalytic experiments, we have shown that V_2O_5 nanoparticles can be generated by sublimation from the bulk[6] and deposited while keeping the original stoichiometry[7].

Nanoparticles in a core@shell@shell configuration are synthesized by sequential doping[8]. Rhodamine B molecules form complexes in helium droplets that give rise to strong fluorescence upon laser excitation. In the presence of an Au core, the rhodamine B fluorescence is quenched due to excitation transfer from excited shell molecules to the Au particle. The addition of an intermediate hexane layer inhibits the contact between Au core and RhB shell, which results in the recovery of the fluorescence.

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