Hybrids of soft and hard matter: Designer functional polymer-metal and polymer-semiconductor nanostructures

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Metal and semiconductor nanoparticles (NPs) exhibit unparalleled photonic, electronic, catalytic, and other functional properties, which make them unique ingredients in functional nanostructures. They are also fascinating objects to study confinement effects in nanoscience. The use of various functional polymers provides materials platforms, which enable the controlled synthesis of metallic NPs and the preparation of hybrid functional nanomaterials. In addition, polymers in combination with semiconductor NPs (hereinafter Quantum Dots, QDs) can be employed to tailor chemical, photonic, physical and responsive properties of the corresponding nanoassemblies. First we show the use of hydroxyethyl methacrylate brush gels, obtained in surface-initiated atom transfer radical polymerization, to prepare gold nanoparticles with controlled, well-defined dimensions. Optical and catalytic properties of these gel-brush-metal nanoparticle hybrids will be elucidated. Synthesis, characterization and cell-biomarker applications of a novel series of comb-copolymers, used in combination with CdSe/ZnS QDs in water will then be presented. These multifunctional polymers feature hydrophobic amide side groups, carboxylates and other functionalities such as polymerizable side chains. Preparation and properties of stimulus responsive polymer structures in combination with the functionalized QDs will then be discussed. In the last example we show the applications of "click" chemistry for QDs and metallic nanoparticles in water. This approach lead to the formation of spherical, covalent NP assemblies with diameter values in the range of 20-200 nm. The QD assemblies exhibited no loss of the luminescent properties. The presented method may also be applied to many other hydrophobically functionalized nanoparticles and nanomaterials.