Novel Iron Oxide Hybrid Nanoparticles and their interaction with Normal and Cancer Human Breast Epithelial Cells

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Abstract

A substantial understanding in the interaction of nanoparticles with normal and cancer cells in vitro will enable the capabilities of improving diagnostic and treatment methods in cancer research, such as imaging and targeted drug delivery. We first demonstrate the integration of a novel nanoparticle hybrid attained by the covalent attachment of IO (iron oxide, γ-Fe_2O_3) nanoclusters onto the surface of a mutagenized cowpea mosaic virus (CPMV-T184C) nanotemplates. Combining these two systems (CPMV and IO) was devised as a desirable method to enhance the local magnetic field strength of the IO nanoclusters for their future use in biomedical applications such as magnetic resonance imaging (MRI). Using a stepwise substrate-based integration, monodisperse CPMV-IO hybrids were anchored on a gold substrate. Covalent attachment of the CPMV-IO hybrids was confirmed by TEM and FTIR spectroscopy. The physical and magnetic properties of individual CPMV-IO hybrids were qualitatively investigated by atomic/magnetic force microscopy (AFM/MFM). During MFM characterization a 'boundary-effect' was observed at the CPMV/IO interface. A strong magnetic field gradient was measured by the magnetic probe and the cantilever experienced a strong attractive force during MFM measurements. This strong interaction at a lift-off distance of 65 nm was indicative of a strong local magnetic field due to a cumulative dipole effect of several IO nanoparticles clustered together. Next, we will demonstrate the utilization of surface Zeta potential measurements as a new tool to investigate the interactions of iron oxide nanoparticles and cowpea mosaic virus (CPMV) nanoparticles with human normal breast epithelial cells (MCF10A) and cancer breast epithelial cells (MCF7) respectively. A theoretical Zeta potential model is established to show the effects of binding process and internalization process during the nanoparticle uptake by cells and the possible trends of Zeta potential change is predicted for different cell endocytosis capacities. The corresponding changes of total surface charge of cells in the form of Zeta potential measurements were reported after incubated respectively with iron oxide nanoparticles and CPMV nanoparticles. After MCF7 and MCF10A cells were incubated respectively with two types of nanoparticles, the significant differences in their surface charge change indicate the potential role of Zeta potential as a valuable biological signature in studying cellular interaction and specific cell functionality.