ABSTRACT

Superparamagnetic γ-Fe_2O_3 nanoparticles were synthesized by coprecipitation of ferric and ferrous salts with a base. Resulting nanoparticles were coated with shells, such as poly(*N*,*N*-dimethylacrylamide) (PDMAAm), neat and functionalized silica (SiO_2 and SiO_2-NH_2), and polyaniline (PANI). PDMAAm shell was introduced by modification of iron oxide nanoparticle surface with an initiator and *N*,*N*-dimethylacrylamide was polymerized producing γ-Fe_2O_3&PDMAAm core-shell particles. In case of SiO_2-NH_2 shell, tetramethyl orthosilicate was used to yield γ-Fe_2O_3&SiO_2 nanoparticles, which were subsequently modified by (3-aminopropyl)triethoxysilane to prepare γ-Fe_2O_3&SiO_2-NH_2 particles. Oxidation of aniline hydrochloride with ammonium persulfate in an aqueous solution of poly(*N*-vinylpyrrolidone) in the presence of iron oxides produced γ-Fe_2O_3&PANI nanoparticles. Finally, the last type of the particles was based on thionin-modified poly(carboxymethyl methacrylate) (PCMMA&Th).

The particles were characterized by techniques, such as scanning and transmission electron microscopy (SEM and TEM) and dynamic light scattering (DLS) to determine the particle morphology and hydrodynamic diameter. The presence of the functional groups, chemical composition, and the iron content were investigated by Fourier-transform infrared (FTIR) spectroscopy, elemental analysis (AAS), atomic absorption, energy dispersive X-ray (EDAX), and X-ray photoelectron spectroscopy (XPS). Vibrating sample magnetometry (VSM) determined the magnetic properties of the iron oxide particles.

Last, but not least, γ-Fe_2O_3&PDMAAm, γ-Fe_2O_3&SiO_2, and γ-Fe_2O_3&SiO_2-NH_2 particles were applied in biological experiments, namely they were incubated with murine macrophages of J774.2 line and engulfment of the particles by the cells was quantified. Cytotoxicity of γ-Fe_2O_3&PANI particles was evaluated on human neuroblastoma cells, while cytotoxicity and immune response of porous silica-coated magnetic nanoparticles was determined on proliferating human peripheral blood cells. The particles were localized within the cytoplasm of treated cells and proved to be non-toxic even at high doses and after long incubation periods. The particles might be suitable in cell applications as the cells labeled with the developed nanoparticles can be non-invasively monitored by magnetic resonance imaging (MRI); optionally they can be easily magnetically separated and redispersed in water solutions on removing of the external magnetic field. Especially, γ-Fe_2O_3&PDMAAm nanoparticles seem to be promising for diagnosis of phagocytic activity, as well as delivery of various biomolecules, such as specific proteins. Finally, PCMMA&Th particles represent a highly sensitive and universal tool for labeling of antibodies in enzyme-based sandwich-type immunosensors.

Keywords: polymer; nanoparticles; superparamegnetism; iron oxide; cell.