Abstract

In response to the escalating global threat of antibiotic resistance, innovative strategies are imperative. This thesis focuses on surface-engineered magnetic nanoparticles (MNPs) with potent antibacterial properties, aiming to combat antibiotic resistance effectively. Specifically, uniform 16-nm Fe_3O_4 nanoparticles were synthesized via oleic acid-stabilized thermal decomposition of Fe(III) oleate in a high-boiling organic solvent. Optionally, 8-nm γ-Fe_2O_3 particles were obtained by coprecipitation of Fe^{2+} and Fe^{3+} salts in a basic medium. For the application of antibacterial MNPs in biological media, water-dispersible nanoparticles were required. Hence, original magnetic particles containing hydrophobic oleic acid (OA) coating were modified with silica using a water-in-oil reverse microemulsion. Subsequent modification with (3-mercaptopropyl)trimethoxysilane and decoration with silver nanoclusters yielded Fe_3O_4@SiO_2-Ag nanoparticles. Additionally, neat Fe_3O_4 particles were coated with Sipomer PAM-200 containing both phosphate and methacrylic groups, facilitating attachment to the iron oxide and enabling (co)polymerization with 2-(dimethylamino)ethyl methacrylate and/or 2-*tert*-butylaminoethyl methacrylate. Furthermore, γ-Fe_2O_3 nanoparticles were rendered antimicrobial through modification with biocompatible dextran (Dex), to which β-cyclodextrin (β-CD) was covalently linked to form non-covalent complex with silver-sulfamethazine (SMT-Ag). To enhance interaction between β-CD-modified dextran and nanoparticle surface, dextran was functionalized with diphosphonic acid (DPA), ensuring robust binding to Fe atoms.

Comprehensive characterization of the synthesized polymers and nanoparticles was conducted using diverse techniques, including nuclear magnetic resonance (NMR), Fourier-transform infrared (FTIR) and ultraviolet-visible (UV-Vis) spectroscopies, transmission electron microscopy (TEM), thermogravimetric analysis (TGA), atomic absorption spectroscopy (AAS), and dynamic light scattering (DLS). The resulting surface-modified iron oxide nanoparticles were tested *in vitro* demonstrating antimicrobial activity against Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria and fungi (*Candida albicans* and *Aspergillus niger*). The synergistic combination of magnetic properties and bactericidal effects holds promise for applications in medical instrument disinfection, water purification, food packaging, etc.

Keywords: magnetic nanoparticles; polymer; dextran; silver; sulfamethazine; antimicrobial.