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Development of novel silica-coated superparamagnetic iron oxide nanoparticles for highly efficient magnetofection and molecular imaging.

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Magnetofection, a site-specific delivery of nucleic acids to cells guided by a magnetic field, has received increasing attention for its great potential on gene therapy. To promote its clinical therapeutic applications, development of safe and effective magnetic nanocarriers is in high demand. Superparamagnetic iron oxide (SPIO) nanoparticles have been clinically proven safe and used as a magnetic resonance imaging contrast agent approved by Food and Drug Administration. In this work we present an initial study of the development of novel silica-coated SPIO nanoparticles for efficient magnetofection. Our patented silica-coated SPIO nanoparticles have many features including 1) facile synthesis with a 2-hour reaction time (compared to a 24-hour standard Stöber process; 2) stability in biological fluids for a year with low degree of aggregation; 3) lack of degradation and oxidation due to polyvinyl alcohol coating layer; and 4) versatility for surface functionalization and drug loading of the silica shell. In this study, the silica-coated SPIO could efficiently condense plasmid DNA (pDNA) into nanoparticles (PSPIO), which exhibited several favourable properties for gene delivery. In vitro transfection efficiency of PSPIO was significantly enhanced under an external magnetic field in a variety of cancer cell lines and PSPIO were found advantageous over existing nonviral transfection methods with the additional benefit of maintaining high cell viability. The superiority of magnetofection could not be inhibited by serum, and fast accumulation of PSPIO on cancer cells was observed. In conclusion, our results demonstrate that the silica-coated SPIO is a technically simple and effective alternative to current methods for gene transfer as well as molecular imaging under the guidance of a magnetic field. Ongoing and future work includes pharmacokinetic study of PSPIO and tumor-directed gene therapy in vivo.

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