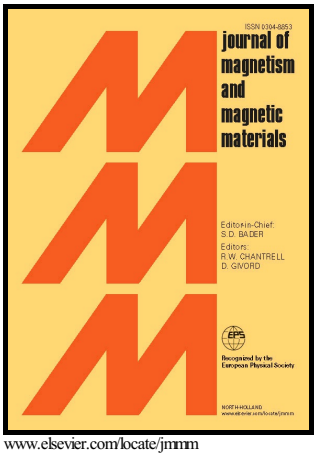

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The Force Analysis for Superparamagnetic Nanoparticles-based Gene Delivery in an Oscillating Magnetic Field

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Abstract

Due to the peculiar magnetic properties and the ability to function in cell-level biological interaction, superparamagnetic nanoparticles (SMNP) have been being the attractive carrier for gene delivery. The superparamagnetic nanoparticles with surface-bound gene vector can be attracted to the surface of cells by the Kelvin force provided by external magnetic field. In this article, the influence of the oscillating magnetic field on the characteristics of magnetofection is studied in terms of the magnetophoretic velocity. The magnetic field of a cylindrical permanent magnet is calculated by equivalent current source (ECS) method, and the Kelvin force is derived by using the effective moment method. The results show that the static magnetic field accelerates the sedimentation of the particles, and drives the particles inward towards the axis of the magnet. Based on the investigation of the magnetophoretic velocity of the particle under horizontally oscillating magnetic field, an oscillating velocity within the amplitude of the magnet oscillation is observed. Furthermore, simulation results indicate that the oscillating amplitude plays an important role in regulating the active region, where the particles may present oscillating motion. The analysis of the magnetophoretic velocity gives us an insight into the physical mechanism of the magnetofection. It's also helpful to the optimal design of the magnetofection system.

Keywords: Superparamagnetic nanoparticles, oscillating magnetic field, Kelvin force, cell, magnetofection, gene delivery;

1. Introduction

Magnetofection, which is known as magnetic particles-based gene delivery under the influence of magnetic field [1], is a physical and non-viral delivery method, enhancing the transfection efficiency [2]. In the past decades, abundant investigations have been carried out to study the method for improving the magnetofection efficiency and the mechanism of particles uptake.