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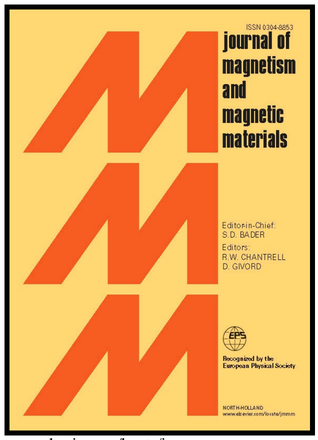

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E.G. Abramov, L.K. Panina, V.A. Kolikov, E.V. Bogomolova, V.N. Snetov, I.A. Cherepkova, A.A. Kiselev

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MAGNETICALLY MODIFIED BIOCELLS IN CONSTANT MAGNETIC FIELD

E.G.Abramov[2], L.K.Panina[2], V.A.Kolikov[1], E.V.Bogomolova[3], V.N.Snetov[1], I.A.Cherepkova[4], A.A.Kiselev[1]

[1] Institute for Electrophysics and Electric Power of the RAS, St. Petersburg, Russia, e-mail: kolikov1@yandex.ru
[2] Saint Petersburg State University, St. Petersburg, Russia
[3] Botanical Institute of the RAS after V.L.Komarov, St. Petersburg, Russia
[4] Saint Petersburg State Institute of Technology, St. Petersburg, Russia

Abstract

Paper addresses the inverse problem in determining the area, where the external constant magnetic field captures the biological cells modified by the magnetic nanoparticles. Zero velocity isolines, in area where the modified cells are captured by the magnetic field were determined by numerical method for two locations of the magnet. The problem was solved taking into account the gravitational field, magnetic induction, density of medium, concentration and size of cells, and size and magnetization of nanoparticles attached to the cell. Increase in the number of the nanoparticles attached to the cell and decrease in the cell' size, enlarges the area, where the modified cells are captured and concentrated by the magnet. Solution is confirmed by the visible pattern formation of the modified cells Saccharomyces cerevisiae.
Keywords: pulsed electrical discharges (PED), magnetic nanoparticles, magnetic field, modified cells, zero velocity isolines, inverse problem.

Introduction

Recently there has been an increase in interest for development of new methods of nanoparticles preparation including the pulsed electrical discharges (PED) [1-3]. PED method allows for production of almost any nanoparticles: iron, silver, copper, zinc, titanium, cobalt and includes combinations of these and other metals and alloys. It is known that nanoparticles especially magnetic ones are already being used in MRI, tissue repair, immunochemical analyses, detoxification of bio-fluids, hyperthermia, drug delivery, and other biomedical applications [4]. Some promising applications of nanoparticles remains in defending human habitat, clean water from microbiological contamination, and biotechnological problems [5-9].

A new step in development of these areas can be achieved by using magnetic nanoparticles (MNP) for the modification of biological cells [2, 9]. This procedure makes it possible to control the magnetically modified cells (MMC) and biostructures by an external magnetic field [10]. Bacteria, micromycetes and algae interact with the nanoparticles, which are adsorbed on the cell' wall, or localized in intracellular compartments [7]. Concentration and basic substance of the embedded nanoparticles can impact on cell viability and give additional properties to both dead and living cells. Cell modification by MNP is particularly important and MMC have been successfully used in many applications [2, 7, 8]. Magnetic properties of MMC make it possible to develop new methods of separation [8], deposition, and control of the cells and their aggregates [10].

Useful feature of MNP and MMC for the practical application is their directed movement under the magnetic field effect [11, 12]. For instance, bionanotechnology, biomedicine and biorefinery processes already use magnetically responsive materials and magnetic separators enabling catching, removal and delivery of magnetic active materials from biological suspensions. Herewith, a mathematical model of areas and boundaries of the magnetic field effect on the MMC are required. Classical approach used in continuum mechanics allows the development of the mathematical models of magnetic fluids with uniform magnetization or conductive liquids and gases, where magnetization is a result of external EMF [13]. Result of direct boundary problems solution, in these cases, is a field of the particles' velocities under the