

Magnetic measurement model of nanoparticle properties

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Experimental research of magnetic nanoparticles and targeted drug delivery assisted by them opens new prospects for creation of biomedical systems. Over the past two decades, determining physical parameters involved in detection and localization of magnetic field generated by superparamagnetic particles have found many practical applications in engineering and medical sciences.

A proposed model describes magnetic field configuration depending on penetration depth of the drug enclosed in a biocompatible form with ferromagnetic material, and surface shape. The model provides more accurate and reliable delivery of nanocomposite, as well as determination of its location in human body. Determination of spatial distribution of nanocomposite will allow calculating the effective dose of its concentration as close as possible for subsequent administration into the object studied. By measuring magnetic induction and susceptibility, one can quantify the concentration and localization of magnetic nanoparticles in human body (Fig.1).

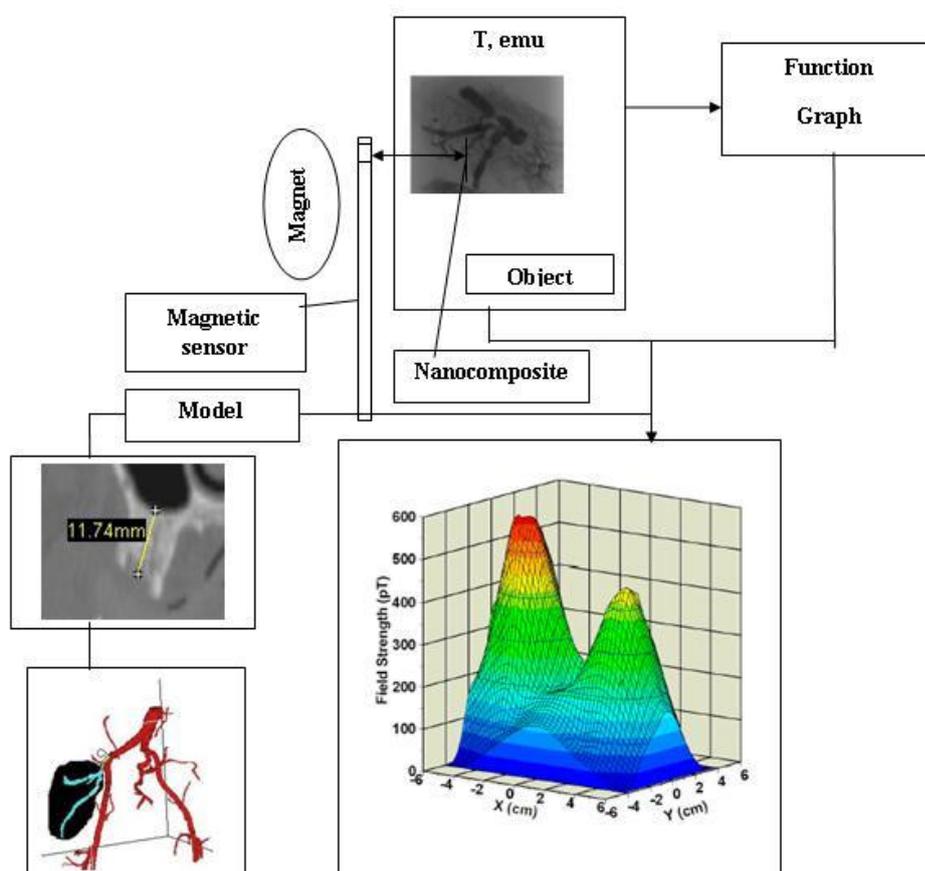


Fig.1. Magnetic measurement model of nanoparticle properties.

The model allows determining the ratio (functional dependence) of the amount of administered nanocomposite to the changes in magnetic susceptibility (magnetic induction) of the studied area over time.

The developed system of nanocomposite delivery provides directed drug delivery to the focus of pathological process, and complex application of such methods and technologies allows to:

- prolong the effect of drugs, and as a consequence, reduce the frequency of drug administration;
- provide necessary biocompatibility;
- protect drugs from premature biodegradation;

- increase bioavailability of substances with non-optimal transport properties;
- overcome biological barriers; provide directed drug delivery;
- provide controlled release of drugs (feedback, local or remote activation);
- maintain optimal therapeutic concentration of drugs;
- minimize side effects of drugs and their metabolites.

A suitable model was built on the basis of the developed system with specified magnetic parameters, which was calculated by finite element method and boundary value problems. Corresponding calculations were made on the basis of experimental measurements to build the most realistic model of constant magnetic field, used for nanocomposite delivery. Magnetic field configuration was measured in three xyz - dimensions. Based on the tables of the data obtained, the graphs of magnetic field distribution were built as well as empirical functions that were derived using analytical method of least squares by decreasing regression (Fig. 2).

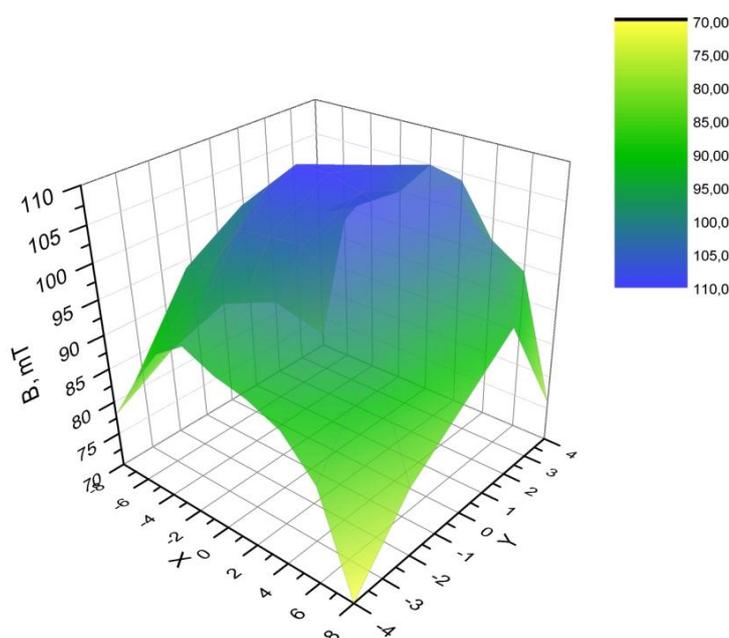


Fig.2. Magnetic field surface mapping.

The model is based on a comparison of magnetic susceptibility (induction) of nanocomposite in artificial system of the same quantity, which is administered to live system. For precise delivery of magnetic nanoparticles to the desired location, particle motion in a fluid flow (blood) in artificial magnetic field was analyzed. Thus, the proposed system provides accurate and efficient directed drug delivery comprising ferromagnetic material to the focus of pathological process. Determination of the physical parameters of nanocomposite comprising superparamagnetic particles will allow detecting and localizing magnetic field generated by them against diamagnetic properties of human body.

References

1. Caruthers S.D., Wickli ne S.A., Lanza G.M. *Nanotechnological applications in medicine. Curr. Opin. Biotechnol.* 2007; 18: 1: 26-30.
2. Ebbesen M., Jensen T.G. *Nanomedicine: techniques, potentials, and ethical implications. J. Biomed. Biotechnol.* 2006; 2006: 5: 51516.
3. D. E. Farrell, J. H. Tripp, P. E. Zanzucchi, J. W. Harris, G. M. Brittenham, and W. A. Muir, "Magnetic measurement of human iron stores," *IEEE Trans. Magn.*, vol. MAG-16, no. 5, pp. 818-823, Sep. 1980.
4. Li Y. *Magnetic field – based eddy-current modeling for multilayered specimen / Y. Li, T. Theodoulidis // IEEE Trans. Magn.* – 2007. – Vol. 43. – №11. – P. 4010–4015.
5. Cohen D. *Review of measurements of magnetic fields produced by natural ion currents in humans / D. Cohen // IEEE Trans. Magn.* – 1970. – Vol. 6. – №2. – P. 344–345.