MAGNETIC NANOPARTICLES AND NANOSYSTEMS FOR HYPERTHERMY OF DESEESED CELLS

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Abstract: Magnetic nanoparticle hyperthermia is based on a physical effect, where magnetic nanoparticles are introduced into the tumor tissue producing local heat when subjected to an alternating magnetic field. The destruction of cancer cells will occur at T = 42 - 44°C. However, higher temperatures can kill surrounding normal tissues. For a magnetic hyperthermia, it is necessary to receive magnetic nanoparticles with high values of specific absorption rate, as well as exercise control of heating temperature. The aim of the paper is elaboration of precise and minimally invasive heat mediators with high thermal energy transfer capability for magnetic hyperthermia treatment of cancer at the cellular level. This goal is achieved by using highly effective heating nanosystems of ferromagnetic nanoparticles encapsulated by carbon nanotubes or graphene nanostructures.

1. Introduction

Method of electromagnetic hyperthermia with magnetic nanoparticles have a strong potential to use as anticancer drugs [1]. It characterizing: by higher free-radical activity of magneto-sensitive nanocomplex due to the non-thermal magneto-spin effects ; The use of nanoparticles, which can combine both therapeutic and diagnostic capabilities in one dose, and has the potential to lead toward personalized oncology and better outcomes for patients. The method of magnetic nanotherapy can be used to treat tumors in all body parts without anesthesia[2]. At the same time the properties of nanoparticles of magnetic materials currently popular for the today's treatment technologies have: Weak surface selectivity of nanoparticles between malignant and normal cells; The need to create high local magnetic fields and appropriate thermal gradients for the treatment; Slow biodegradation of nanoparticles in the body and side effects of their accumulation in the liver, spleen, muscles, and other organs; Temperatures in the range of 41–50°C can be accompanied by the formation of thermal resistance at the cellular level; Targeted radio frequency therapy with magnetic nanoparticles is often not suitable [3].

2. Theoretical and experimental results

Depending on the parameters of the synthesis it is possible to prepare nanosystems with the necessary magnetic properties and frequency and amplitude of vibration plus size and structure of nanoparticles and carbon capsules.

Nowadays, there are several methods for obtaining metal nanoparticles such as solid-phase pyrolysis, chemical vapour and laser plasma deposition. In our work we mostly used the method of pyrolysis of organometallic compounds for the preparation of metal nanoparticles including Ni, Co, Cu, but also alloys and pure carbon micro and nano spheres [4,5]. Solid-phase pyrolysis is characterized by its simplicity and the ability to control the properties of the nanoparticles by pyrolysis parameters. In other words, using solid phase pyrolysis, it is possible to obtain materials with predetermined properties.

For development of high effective nanomaterials for hyperthermia process organization we consider to change the multi-domain ferromagnetic materials to single domain supermagnetic ones in connection with reducing the size of nanoparticles. For our works we choose the superparamagnetic and ferromagnetic (Ni-Cu)/C nanoalloys as well as Iron and Iron-oxide and Manganese based ferromagnetic and superparamagnetic nanocomposites. The important point is that the average size of the nanoparticles depends on the pyrolysis conditions and varies between 10 - 40 nm and 350 - 400 nm. This can be seen ar figure, where the bright spots correspond to the metal nanoparticles in a dark carbon matrix.

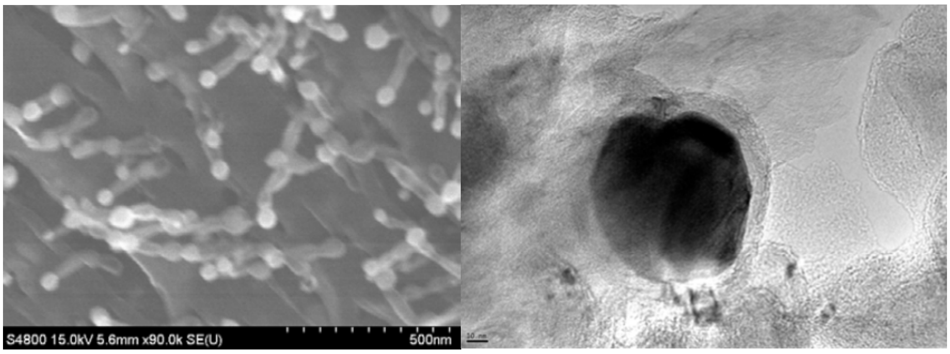

Fig. SEM and TEM images of nanocomposites Ni0.7Cu0.3/C, obtained by pyrolysis at Tpyr = 700 ° C and tpyr = 30 min. [4].

For obtaining the ferromagnet-graphene nanosystems we performed technological processes by using used laser plasma method of synthesis and deposition.

Modelling and simulation works we performed shown that carbon nanostructures (nanotubes, grapheme like systems) as coatings prevented the nano magnetic particles agglomeration, their protection of oxidation and biocompatibility.

Conclusions

Among the main results of our works aim farther development of hyperthermy methods and tools for cancer cells treatment it is necessary to underline: theoretical and experimental development and characterization (electron – optical analysis, electrical and magnetic measurements) of ferromagnet – carbon nanotube based nanosystems; elaboration, modeling and preparation of ferromagnet - graphene systems using laser plasma technologies.

References

[1] Thanos Mitrelias, Medical systems aimed at improving the outcome of cancer treatment. Cambridge, UK, The SECURE-R2I Project Final Dissemination and Brokerage Events – Presentations Septermber 29, 2015. Kiev Ukraine SECURE-R2I – Reinforcing cooperation with Eastern European Countries, secure-r2i.eu/index.php/en

[2] Kervalishvili P., Magnetic nanoparticles and nanomaterials for magnetic hyperthermia investigations, Presentation on Georgian medical society meeting, 11December, 2015.

[3] Berberashvili T., Buachidze Z., Chirakadze A., Chakhvashvili L., Jishiashvili D., Kervalishvili P., Aleqsanyan S., Gulasryan H., Manukyan A., Papoyan A., Saroyan E., Sajti L. Carbon coated Fe-FeC and Ag – doped Manganite (AgxLa1-xMnO3) nanocomposites for magnetic hyperthermia of cancer cells. 4th international conference "nanotechnologies" October 24-27, 2016 GTU Tbilisi, Georgia.

[4] Manukyan A.S., Mirzakhanyan A.A., Khachatryan T.K., Badalyan G.R., Abdulvakhidov K.G., Bugaev L.A., and Sharoyan E.G. Copper–Carbon Nanocomposites Prepared by Solid-Phase Pyrolysis of Copper Phthalocyanine, Journal of Contemporary Physics (Armenian Academy of Sciences), 47, 2012, p. 292–295

[5] Sajti L. Carbon coated Fe-FeC and Ag – doped Manganite (AgxLa1-xMnO3) nanocomposites for magnetic hyperthermia of cancer cells. 4th international conference "nanotechnologies" October 24-27, 2016, GTU Tbilisi, Georgia.