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STUDY OF THE STRUCTURE AND HEAT GENERATION ABILITY OF Fe_2O_3 MAGNETIC MATERIALS

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ABSTRACT

In recent years, research on the use of magnetic nanomaterials in biomedicine, especially in hyperthermia treatment of tumors, has been developing rapidly. The basic principle of tumor heat therapy is to bring magnetic powder together with other drugs to the site of the tumor and, when exposed to a high-frequency alternating magnetic field, the particles release heat and stop the growth of tumor cells. Magnetic materials with the ability to release heat are powder magnetic materials with ferrimagnetic properties.
This article presents the results of a study of the microstructure and heat release ability of iron oxide ferromagnets synthesized by microwaves.

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Introduction.

Currently, theoretical and experimental studies of the magnetic properties of substances have deepened to the nanolevel, technologies for obtaining new types of magnetic materials with unique and special properties are rapidly developing, and the use of magnetic materials continues to expand [1].

A new direction is being developed for obtaining nanomaterials containing magnetic particles using nanotechnologies. For example, nanotechnology is increasingly being introduced into medicine, nanomedicine has emerged and is developing as a new direction. In some countries, they began to use magnetic materials with a unique property, to generate heat under the influence of a magnetic field, in clinical practice, including in the treatment of cancer. It is envisioned that the future “roadmap” or long-term goal of this type of research is to use this method for the treatment of cancer [1-3].

The advantage of this treatment is a small negative impact on the human body, no effect on healthy cells, and the ability to control the flow of the magnetic field using an external magnetic field. The heat generation occurs in cohere with the Néel relaxation of the reversal of the direction and regeneration of the magnetic moment of magnetic nanoparticle and the Brownian relaxation of the particle rotating around own axis. For a magnetic particle in an alternating magnetic field, heat and energy are released as a result of the interaction of an external magnetic field with its internal magnetic field. The time of change of the external alternating field is determined by the frequency and is less than the relaxation time of the internal field of the magnetic particle [4].

The purpose of this study is to determine the microstructure of an iron oxide ferromagnetic material, synthesized by microwave and the amount of heat release capacity in an alternating magnetic field.

Research materials and methods.

In this study, the measurements were carried out on samples of iron oxide ferromagnetic material, obtained by microwave synthesis. The microstructure analysis of iron oxide ferromagnetic material was performed using a Hitachi TM-1000 scanning electron microscope and a laboratory alternating magnetic field generator. To study the phenomenon of heat release of magnetic powder materials was used a water-cooled device, which created an alternating magnetic field with a frequency of 71 kHz. The main parameters of the assembled device for generating an alternating magnetic field and the measurement device scheme are below.

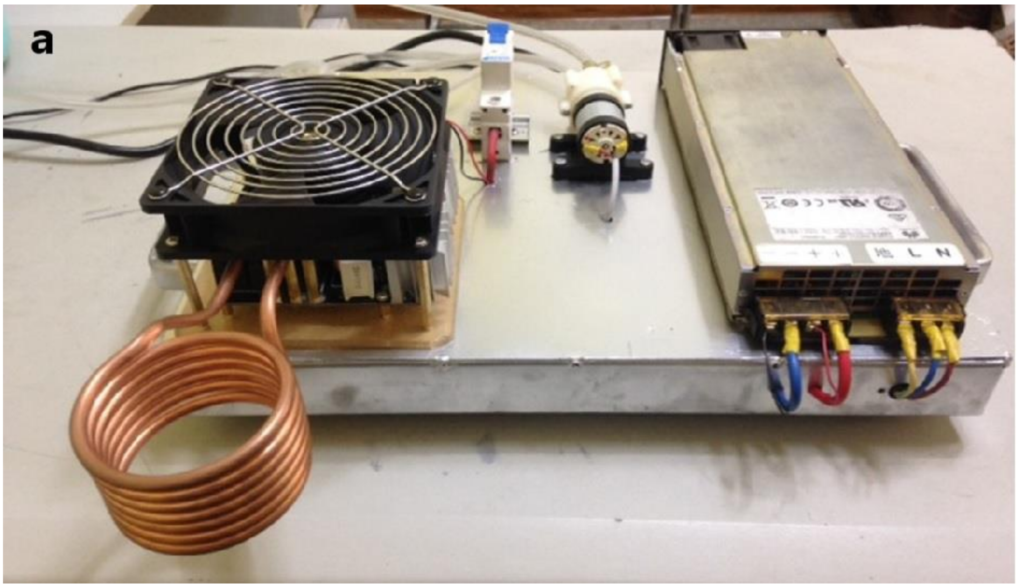

Fig. 1. The device for creating an alternating magnetic field

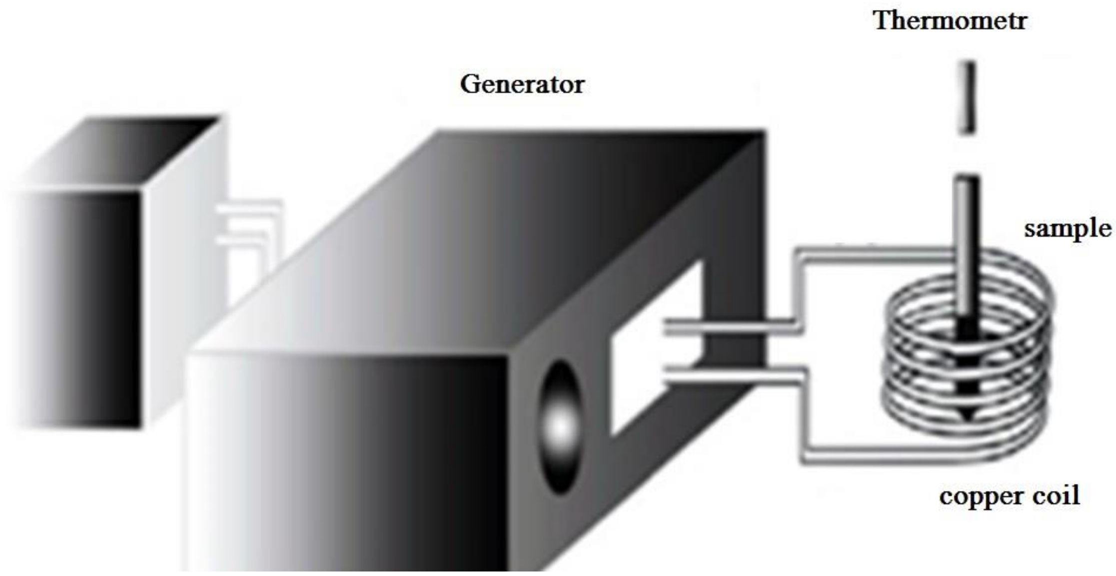

Fig. 2. The measurement device scheme.

The heat release of ferromagnetic nanomaterials was measured in an aqueous medium at room temperature. Magnetic samples weighing 50 mg, 100 mg, and 200 mg were placed in 2 ml of distilled water and heat release was measured.

Results and discussion. Ferrum oxide ferromagnetic material has a smooth flat surface. The particle size of the powder varies: the smallest average size is 3–4 µm, and the largest is 500–600 µm. For elemental analysis of magnetic materials, EDS measurements were performedThe results of the EDS measurement (graph) show that the sample contains elements of iron (Fe) and oxygen (O), and there are no impurities of other chemical elements. The compositions of Fe-O powder in shown table 1. The Fe-O ratio in composion is near 2:3 and can be regarded as the Fe_2O_3 magnetic powder.

Table 1. Composition of Fe-O magnetic powder.

Fe	O	phase
61.7	38.3	Fe_2O_3

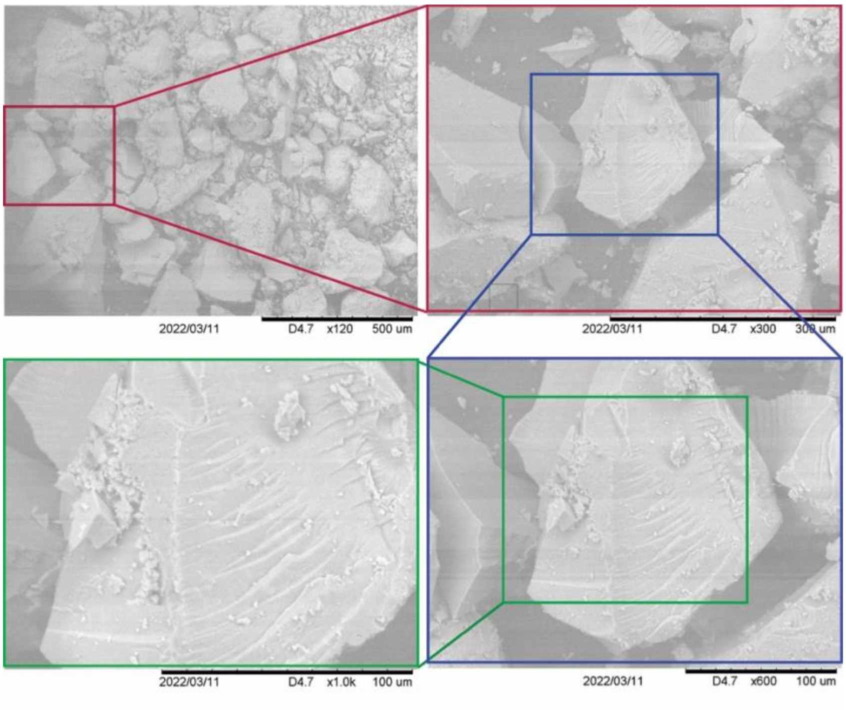

Fig. 3. Microstructure of samples of iron oxide powder

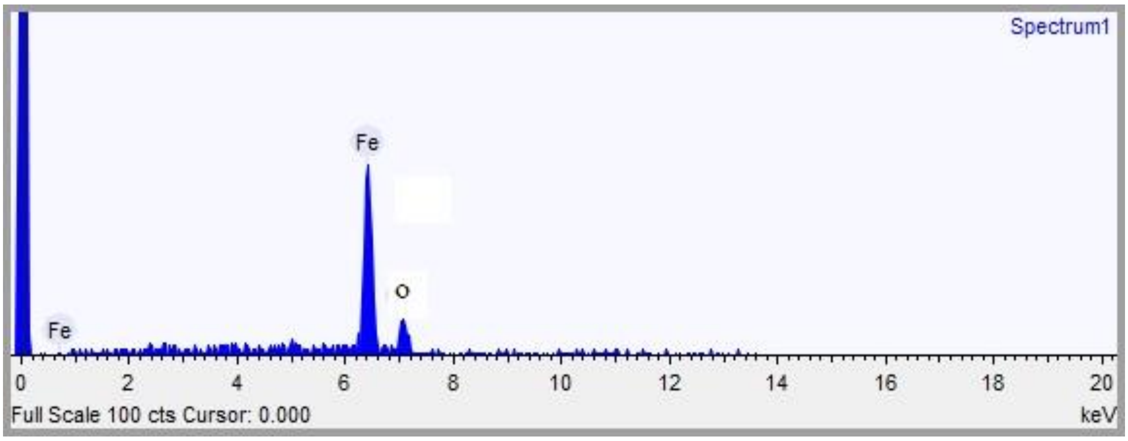

Fig. 4. EDS measurement results.

When the samples are placed in an alternating magnetic field, their temperature stabilizes and reaches the saturation value after about 20 minutes. The maximum or saturation temperature values for the 50 mg, 100 mg, and 200 mg samples are 37 °C, 41 °C, and 48 °C respectively. Figure 5 shows the variation of heat release temperature depending on the sample size.

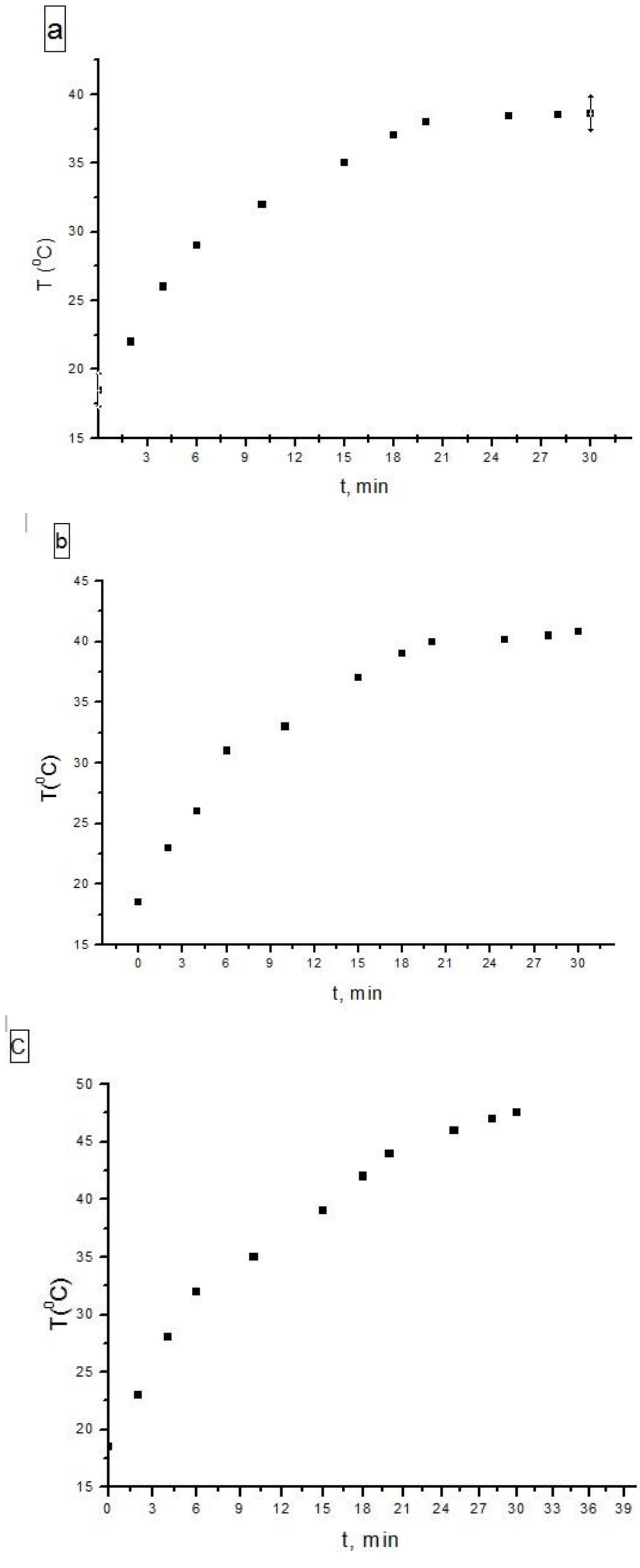

Fig. 5. The heat releasing rate depending on the concentration of the sample:
a) 50 mg; b) 100mg; c) 200 mg.

This result indicates that it is possible to control the heat release rate of the sample by changing the direction of the alternating magnetic field and the size of the sample.

Conclusion.

In this study, we investigate the heat release rate of the iron oxide magnetic material, synthesized under the action of microwaves depending on the microstructure and concentration. The nanoparticle sizes of the iron oxide magnetic sample varied, with the smallest average size being 3–4 µm and the largest being 500–600 µm. The maximum or saturation temperature values for the 50 mg, 100 mg, and 200 mg samples are 37 °C, 41 °C, and 48 °C respectively, indicating that these samples are producing enough heat to meet the requirements of thermal therapy for tumor.

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