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Short Communication

Microwave absorbent properties of nanosized cobalt ferrite powders prepared by coprecipitation and subjected to different thermal treatments

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ABSTRACT

Cobalt ferrite nanopowders were produced by means of two methods using a common precipitating agent. After precipitation, in the first method the cobalt ferrite was calcined, whilst in the second method the precipitation was followed by a hydrothermal treatment. Characterization of the obtained powders was achieved by X-ray diffraction and scanning electron microscopy–energy dispersive X-ray analysis (SEM–EDAX). Frequency dependence of the complex dielectric permittivity and complex magnetic permeability, over the frequency range 0.1–6 GHz, was also studied. By means of the above mentioned investigations, the structure, morphology and microwave absorbent properties of the powders obtained by both methods were compared.

1. Introduction

Two ferrite nanoparticle systems were investigated, both from a fundamental point of view and as promising materials to be used in various applications. Currently, due to the multiple applications of microwaves, the problem of electromagnetic interference has become a matter of serious concern. Consequently, there is increasing demand for the development of microwave absorbers. For instance, in Refs. [1–4] various ferrite nanoparticle systems were analyzed from the microwave absorbent properties point of view.

Cobalt ferrite is a part of the spinel ferrite group; it has cubic magnetocrystalline anisotropy, high coercivity, moderate saturation magnetization, large magnetostrictive coefficient [5,6] and has been proven to have photomagnetic properties [7].

Different synthesis methods, such as coprecipitation [8], electrochemical [9], hydrothermal [10], combustion [11] or mechanical alloying [12] are used to produce cobalt ferrite. Among the reported methods, the coprecipitation method is an efficient and economical way to mass production of ultrafine cobalt ferrite powder.

In Ref. [13], it is shown that cobalt ferrite particles obtained by precipitation from an aqueous solution can crystallize in the normal spinel form, whilst in Ref. [14] it is reported that cobalt ferrite has mixed spinel structure (both normal and inverse spinel). Changes in the cation distribution over the tetrahedral and octahedral sites lead to changes in the magnetic properties of the ferrite, even if the ratios of the constituent ions of the ferrite do not change. Since the structure of cobalt ferrite depends on the preparation conditions, its magnetic properties should also depend on these conditions.

From an economical point of view, it is important to obtain materials as fast as possible, with low energy consumption and with the best possible properties. In this paper we analyze cobalt ferrite nanopowders obtained by two synthesis methods. Both methods have a common coprecipitation stage. After precipitation, in the first method the cobalt ferrite was calcined, whilst in the second method the precipitation was followed by a hydrothermal treatment. The calcination and hydrothermal treatments were made at the same temperature and over the same time period. The objective of this work is to compare the structure and microwave absorbent properties of cobalt ferrite nanopowders obtained by the coprecipitation–calcination method (CC method) and by the coprecipitation–hydrothermal treatment method (CHT method). This paper reports, for the first time, on such a comparative study, underlining the benefits of the hydrothermal treatment on the microwave absorbent properties of cobalt ferrite nanopowders as opposed to the usual coprecipitation–calcination method.

2. Preparation methods

With both methods the same starting raw materials have been used in order to obtain $Co_{0.8}Fe_{2.2}O_4$ powder (i.e. ferric nitrate ($Fe(NO_3)_3{\cdot}9H_2O$) and cobalt nitrate ($Co(NO_3)_2{\cdot}6H_2O$) in a molar

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