

SAMARIUM-IRON GARNET NANOPOWDER OBTAINED BY CO-PRECIPITATION

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Abstract— In this work, samarium-iron garnet nanopowder ($\text{Sm}_3\text{Fe}_5\text{O}_{12}$) was obtained and characterized by TG/DTA, XRD, SEM and EDS. The synthesis of this magnetic material was carried out by the co-precipitation method, using hydrated chlorides of the rare-earth elements and ferrous sulfate. PVA was added to the calcined powder in order to facilitate the production of a toroidal compact specimen, which was submitted to sintering in the range of 1200 °C to 1400 °C, to establish a correlation of its magnetic properties with morphology.

Keywords—garnet, co-precipitation, magnetic properties and nanomaterial.

I. INTRODUCTION

Billions of soft ferrites are used in every conceivable electronic devices. Rare-earth garnet-structure ferrites, $\text{R}_3\text{Fe}_5\text{O}_{12}$ (where R is yttrium or rare-earth cation), have attracted great attention for applications such as both microwave devices and magnetic recording media (Sugimoto, 1980; Rodic *et al.*, 1999).

Recently, garnets are widely used in microwave communication through mobile and satellite communications and are of significant interest for numerous applications, including magnetic materials, lasers, phosphorescent sources, and electrochemical devices (Waerenborgh *et al.*, 2004).

The garnet materials possess unique optical, thermophysical and mechanical properties, in particular, excellent creep and radiation damage resistance, fracture toughness, moderate thermal expansion coefficients, high thermal conductivity and energy-transfer efficiency (Waerenborgh *et al.*, 2004).

Samarium-iron garnet ($\text{Sm}_3\text{Fe}_5\text{O}_{12}$) is of considerable interest for its potential use as a broadband material in microwave application (Cunningham and Anderson, 1960).

In this work, this material was synthesized by co-precipitation method and its magnetic properties were studied. The resulted garnet shows nanometric size and better magnetic properties than others prepared by traditional methods.

Co-precipitation is a chemical route which plays a crucial role in preparing the final product by minimizing

problems associated with diffusion, impurities and agglomeration. In solid state methods, mechanical mixing of oxides followed by calcination, result in final products with worst electrical, mechanical and magnetic properties (Lax and Button, 1962; Horvath, 2000; Dionne, 1971; Adair, 1991).

II. EXPERIMENTAL PROCEDURE

The synthesis of the material was carried out by the co-precipitation method, using as reagents the rare-earth element hydrated chlorides ($\text{SmCl}_3 \cdot 6\text{H}_2\text{O}$, purity 99%, Aldrich) and ferrous sulfate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, purity 99%, Reagen). These solutions were all mixed together in a 500 mL recipient and the pH of the total solution was kept in the range 2 - 3.

This solution was heated up to 6 °C under intensive agitation for about 30 minutes, followed by KOH addition to increase the pH value in 10 - 11 range, while allowing easy elimination of the K^+ ions, by simple washing of the precipitate with distilled water (Adair, 1991).

Thermodynamic analysis (Caffarena and Ogasawara, 1999) shows that the final pH for co-precipitation method shall be in the range 9 - 12, so the synthesis has been repeated three times with pH values from 10 to 11.

The co-precipitated solids were separated from the initial solution by vacuum filtration, after several washings with distilled water, until Cl^- and SO_4^{2-} anions were no more detectable by test reactions with AgCl and BaSO_4 , respectively (Morita and Assumpção, 1972).

The drying of the precipitate was carried out according to Reed's recommendation (Reed, 1991) with initial drying inside a desiccator for 24 hours, followed by heating at 75 °C for 4 hours. The dried co-precipitate was submitted to thermal analyses using Shimadzu 50H Differential Thermal Analyzer and Shimadzu TGA-50 Thermogravimetric Analyzer (Sorrel, 1991).

Subsequent calcination (Halloran, 1991) of co-precipitates was carried out under conditions suggested by thermal analysis, corresponding to heating up to 1000°C (rate of 5 °C/minute); holding time of 4 hours, followed by natural cooling down inside the furnace.

The powder was characterized (JCPDS, 1977) by X-ray fluorescence (Philips model PW2400), scanning electron microscopy (Zeiss SEM model DSM 940A and