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Fabrication, magnetic and microwave absorbing properties of $Ba_2Co_2Cr_2Fe_{12}O_{22}$ hexagonal ferrites

Harun Bayrakdar*

Çanakkale Onsekiz Mart University, Department of Materials Science and Engineering, Çanakkale, 17100, Turkey

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ABSTRACT

We have investigated the magnetic and microwave absorbing behavior of $Ba_2Co_2Cr_2Fe_{12}O_{22}$ Nano Particles (NPs)/polyaniline (PANI) and polyacrylonitrile (PAN) nanocomposite materials. Particles showed phase purity and crystallinity in powder X ray diffraction (XRD) analysis. Temperature dependence of magnetic parameters was observed. Microwave absorbing showed very broad and high reflection loss.

1. Introduction

In recent years, the applications of electromagnetic (EM) wave the high GHz ranges include wireless telecommunication systems, radar, local area network, medical equipment, etc. Ferrites serve as better electromagnetic interference (EMI) suppressors compared to their dielectric counterparts on account of their excellent magnetic properties. The physical properties of ferrites are related the structure of solids. Ferrites the transition metal oxides having a spinel structure are technologically important because of their interesting magnetic and electrical properties [1–4].

Hexaferrites have become very important materials commercially and technologically have a plurality of uses and applications. The important members of the hexaferrite family are M, Z, W, Y-phase materials [5]. The hexagonal type ferrite absorbs microwave energy by lossy interaction of the magnetic field of the wave with their individual magnetization. The hexagonal ferrite materials are suitable Radar Absorbing Materials due to a significant value of permeability (>1), high value of magnetization and planar anisotropic behavior in microwave frequencies [6].

In this work, CTAB-assisted hydrothermal method was used to synthesize $Ba_2Co_2Cr_2Fe_{12}O_{22}$ NPs and prepared $Ba_2Co_2Cr_2Fe_{12}O_{22}$/polyaniline (PANI) and polyacrylonitrile (PAN) nanocomposite materials. The synthesized nanocrystalline samples were characterized by X-ray diffraction (XRD) and the magnetic properties of samples were investigated using VSM and electromagnetic wave absorbing properties of composite structures were investigated vector network analyzer.

2. Experimental

$Ba_2Co_2Cr_2Fe_{12}O_{22}$ NPs were also synthesized with assisting a cationic surfactant, CetylTrimethylAmmonium Bromide (CTAB) a chelating agent. According to this method, 0.003 mol surfactant CTAB was dissolved in 35 ml deionized water to form a transparent solution. Then Barium chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), ferric nitrate ($Fe(NO_3)_2 \cdot 9H_2O$), cobalt nitrate ($Co(NO_3)_2 \cdot 4H_2O$), chromium nitrate $Cr(H_2O)_6 \cdot (NO_3)_3 \cdot 3H_2O$ were used as starting materials and mixed in an appropriate amount of de-ionized water. Deionized water added to make the solution for a total volume of 40 ml and then pH of the solution mixture was adjusted to 11. Before being transferred to teflon lined autoclave of 50 ml capacity, the solution mixture was pretreated under an ultrasonic water bath for 40 ml hydrothermal synthesis was carried out at 130 °C for 15 h in an electric oven without shaking or stirring. Afterwards, the autoclave was allowed to hot to RT gradually. The black precipitate collected was washed with distilled water several times in an ultrasonic bath to remove any possible impurities. The solid was then heated at 100 °C and dried under vacuum for 5 h [7,8].

PAN/PANI as the solvent for the polymer in dimethylformamide

* Tel.: +90 438 211 70 48; fax: +90 438 211 00 69.
E-mail address: h.bayrakdar@comu.edu.tr.

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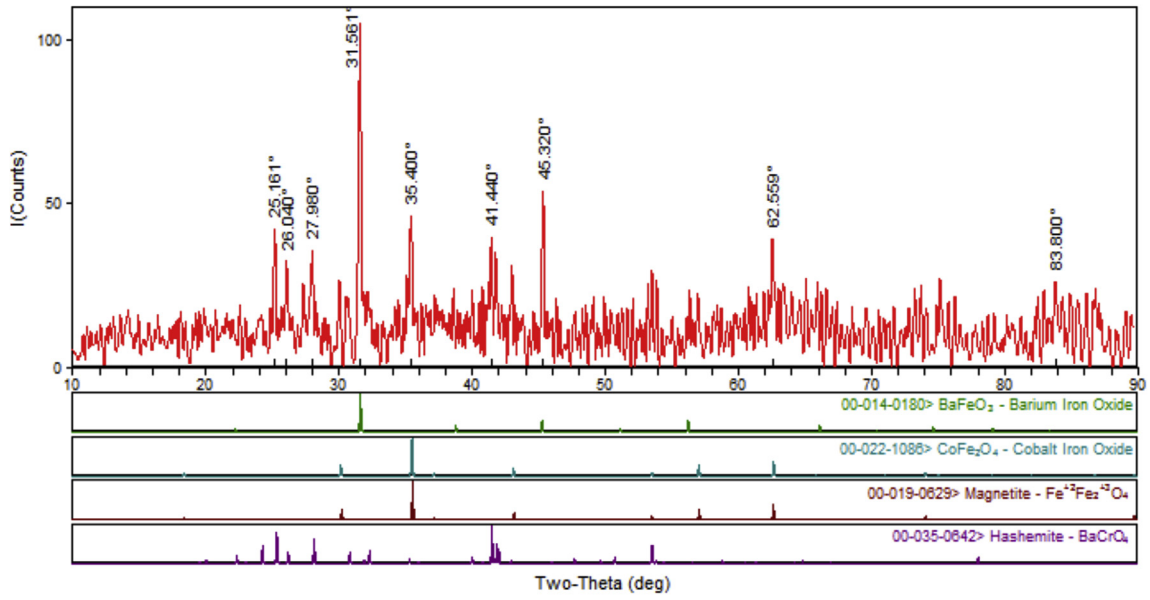

Fig. 1. XRD pattern of the $Ba_2Co_2Cr_2Fe_{12}O_{22}$ nanoparticles.

(DMF) solvent was used. PAN/PANI solution concentration of 75 mg/ml has been set. Homogeneous PAN/PANI heated solution is prepared from 1000 rpm at 333.15 K (60 °C) for 1 h with stirring on magnetic stirrer. When solution comes to room temperature, no settling was observed. PAN/PANI + magnetic composite nanoparticles solution, 20 ml 75 mg/ml solution of 10% by weight of PAN/PANI polymer is as prepared by mixing magnetic particles. Water in an ultrasonic bath to uniformly disperse the particles in the solution was stirred for 15 min. Solution to improve the homogeneity of the composite solution was stirred at 100 rpm in a magnetic stirrer. PAN/PANI + magnetic nanoparticles in the composite material 1.5 mm thick and 50 mm diameter, is obtained by pouring the solution prepared in the glass petri dish. DMF is a high boiling solvent in the composite is added to the petri dish to facilitate heating of the resulting material on a magnetic stirrer at 313.15 K (60 °C) in 2 h to remove DMF is accelerated. Heating magnetic stirrer are placed on a petri dish made every 15 min during the process stirred at 1000 rpm, thus ensuring homogeneity

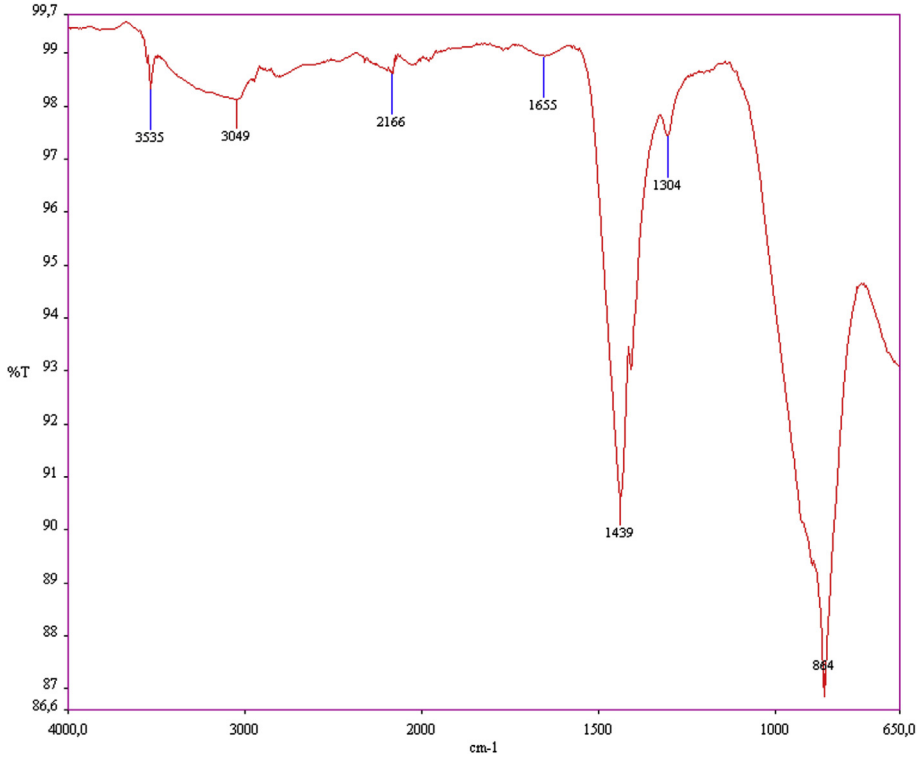

Fig. 2. FTIR spectra of the $Ba_2Co_2Cr_2Fe_{12}O_{22}$ nanoparticles.