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Research Article

Fabrication and Electromagnetic Absorbing Properties of Hexagonal Ferrites

Harun BAYRAKDAR[a,*]

Department of Mechanical Engineering, Faculty of Engineering, Düzce University, Düzce, TURKEY
** Corresponding author's e-mail address: harunbayrakdar@duzce.edu.tr*
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ABSTRACT

Nanocomposite materials were obtained by synthesizing $Ba_2Bi_2Co_2Fe_{12}O_{22}$ Nano Particles with polyaniline and polyacrylonitrile polymers. Composites in this nanostructure; structural, magnetic and electromagnetic absorption properties were examined. It was observed from the x-ray analysis that the nano-structured particles had crystalline structure and shown Y-type hexagonal structure. It can be also seen from the IR measurements that it has this structure at 878 and 650 cm^{-1}. The Electron Spin Resonance experiment of nanoparticles have been measured at room temperature and shown quite wide spectra and splitting factor. Vibration Sample Magnetometer measurements were made at 10-50 and room temperature. It can be said that nanoparticles useable so successful the magnetic recording media, applications of microwave technologies. Electromagnetic absorption experiments were measured approximately 5-20 GHz in the frequency band by used the free space method. These electromagnetic absorbers are using for 1,5 mm. thickness of the samples obtained 6 GHz. wide -50 db. loss of reflection was measured.

Keywords: *Hexagonal, Magnetic, Absorbing*

Hegzagonal Ferritlerin İmalatı ve Elektromanyetik Soğurma Özelliklerinin İncelenmesi

ÖZET

Nanokompozit malzemeler, $Ba_2Bi_2Co_2Fe_{12}O_{22}$ Nano Partiküllerin polianilin ve poliakrilonitril polimerler ile sentezlenmesi ile elde edilmiştir. Bu nanoyapıdaki kompozitler; yapısal, manyetik ve elektromanyetik soğurma özellikleri incelenmiştir. X-ışını analizinden nano yapılı partiküllerin kristal yapıya sahip olduğu ve Y tipi altıgen yapı gösterdiği görülmüştür. 878 ve 650 cm^{-1}'de bu yapıya sahip olduğu IR ölçümlerinden de görülebilmektedir. Nanopartiküllerin Elektron Spin Rezonans deneyi oda sıcaklığında ölçülmüş ve oldukça geniş spektrum ve bölünme faktörü gösterilmiştir. Titreşim Örneği Manyetometre ölçümleri 10-50 ve oda sıcaklığında yapılmıştır. Nanopartiküllerin, manyetik kayıt medyası, mikrodalga teknolojilerinin uygulamaları kadar başarılı olduğu söylenebilir. Elektromanyetik absorpsiyon deneyleri, frekans bandında serbest alan yöntemi kullanılarak yaklaşık 5-20 GHz ölçülmüştür. 1,5 mm. kalınlığındaki elektromanyetik soğurucu numuneler için 6 GHz. genişliğinde ve 50 db. yansıma kaybı ölçülmüştür.

Anahtar Kelimeler: *Hegzagonal, Manyetik, Soğurma*

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I. INTRODUCTION

The investigation of hexagonal ferrites has been intensively continued because of their technological and fundamental scientific importance due to their magnetic, electronic and electromagnetic absorbing properties. These hexagonal ferrites have wide range of applications in RADAR frequencies. If you want to give some example wireless systems, local area networks, medical and biomedical, etc. [1-6].

Hexagonal ferrites discovered in the 1950s and known as hexaferrite and have get of great importance magnetic nanoparticles mercantile and technological have a wide range uses and applications [6-8]. There are 4 types of Hexagonal ferrite and these are M, Z, W, Y-type [5]. Due to their magnetization properties, hexagonal ferrites have a wide absorption effect in high frequency regions. So, the hexagonal ferrites are useful Radar Absorbing Materials and are value of permeability (>1) [7].

In this work, nano-sized hexagonal ferrites were synthesized [8]. Crystal structures of these synthesized nanoparticles were characterized by X Ray Difraction. The magnetic feature of nanoparticles was measured by using Vibrating Sample Magnetometer. Electromagnetic wave absorption feature of nanocomposite materials was measured VNA.

II. RESULTS AND DISCUSSION

$Ba_2Bi_2Co_2Fe_{12}O_{22}$ NPs were also synthesized by hydrothermal method in detail by Bayrakdar [8]. Also, PAN/PANI was used for nanocomposites [8]. All measuring instruments used are given in reference 8.

2.1. X-Ray Diffraction

XRD measurement results are shown in figure1. The nanoparticles of $Ba_2Bi_2Co_2Fe_{12}O_{22}$ are shown the crystal structure. The XRD measuremts show the reflection planes (110), (1013), (116), (119), (024), (300), (2113), (1025), and (220). We can say from these results Y type hexaferrite structure [8,9].

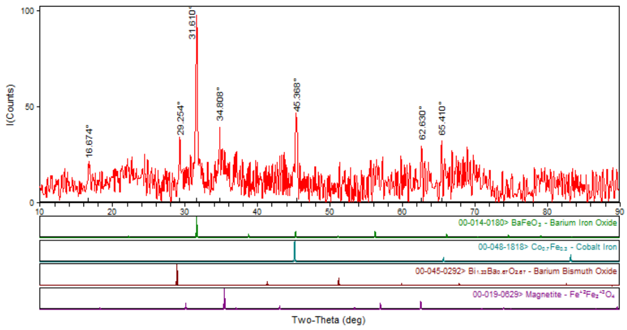


Figure 1. *XRD pattern of the $Ba_2Bi_2Co_2Fe_{12}O_{22}$ nanoparticles.*

It can be seen that (1013) is the highest peak and dominant peak. The lattice parameters were calculated by reference 9. So, we measured the lattice parameters (a= 5.85 Å, c = 43.98 Å) and unit cell volume (1303.43 Å3). These results are very close to Ref. 10.

2.2. Fourier Transform Infrared

Figure 2 shows the FTIR measurement results at 300K in wavenumber range from 4000 to 650 cm^{-1}. You can see that at 3537 and 2940 cm^{-1} were OH vibrations. Also, 2250, 1774, 1427, 1306 and 947 cm^{-1} oscillation of C=O, H-C-H, C-H and C-C respectively and 878 and 650 cm^{-1} metal oxygen M–O.

These results were shown hexagonalferrite due to octahedral and tetrahedral complexes present Y-type hexagonal ferrites [8-10]. O-H-, and NO_3 bands is not visible because the y hexagonal structure is dominant.

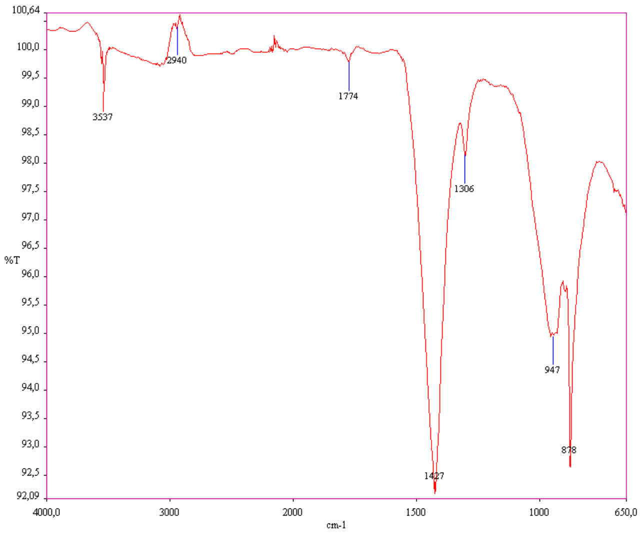
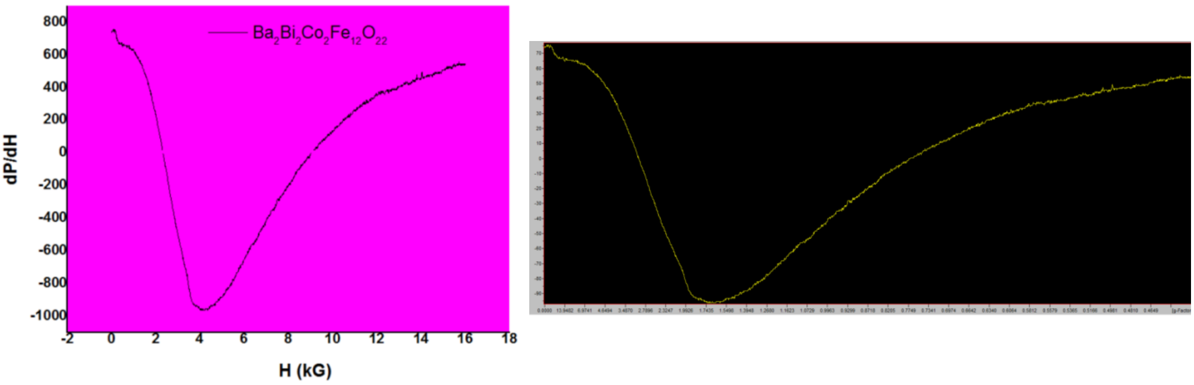


Figure 2. *FTIR spectra of the $Ba_2Bi_2Co_2Fe_{12}O_{22}$ nanoparticles.*

2.3. Electron Spin Resonance

Figure 3 shows the ESR measurement results at room temperature. It can be seen that from Figure 3. quite wide spectra and (g) splitting factor. The metallic character of $Ba_2Bi_2Co_2Fe_{12}O_{22}$ NPs can be estimated from ESR spectra. It can be seen that Fig. 3. very broad linewidth and g factor. The results of ESR measurement are about in the reference 8. We can say from these spectra, as the Bi^{2+} doped hexagonal type ferrite NPs is increasing, g-values are increasing or decreasing. The g-values of nearly symmetric spectra have been found electron’s g-value. Broadening ESR signals may be connected hard Co materials and magnetostatic interaction fields. Because, Co^{2+} ions are settles the tetrahedral sides in the spinel structure.



(a) *(b)*

Figure 3. *ESR spectra **a)** x-axis is H (kG) **b)** x-axis is splitting value.*

2.4. Vibration Sample Magnetometer

Figures 4 exhibits the magnetic evolution of hysteresis loops for samples $Ba_2Bi_2Co_2Fe_{12}O_{22}$ at some selected temperature. The magnetic field evolution of hysteresis loops of $Ba_2Bi_2Co_2Fe_{12}O_{22}$ sample is pretty much called near the paramagnetic regime at 300 K. Especially, the coercive fields expanded in the $Ba_2Bi_2Co_2Fe_{12}O_{22}$ sample at low temperature (=10 K). It can be seen from figures that the coercivity and the magnetization of the samples increase with the decrease in temperature, in general. The magnetization decreases, indicating the spins become superparamagnetic behavior. We can say comfortably that these samples can be used very successfully the magnetic recording, electromagnetic absorbing technologies applications. The potential applications of y type nanoparticles are very attractive for magneto-sensor, bio-sensor, magneto-electronics, microwave electronic devices, etc.

10K 50K 300K

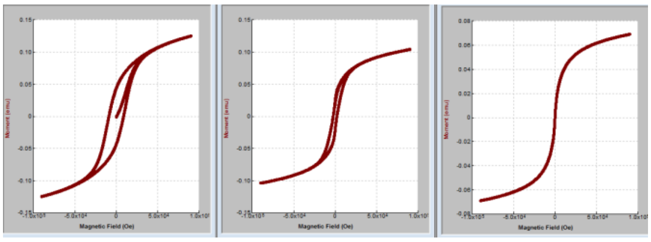


Figure 4. *VSM measure of $Ba_2Bi_2Co_2Fe_{12}O_{22}$ nanoparticles.*

2.5. Electromagnetic Absorbing

Experimentally were investigated the electromagnetic absorption properties of these nanocomposite materials at 8-18 GHz in free space method [11]. The antennas are homemade antenna. The electromagnetic absorbing measurements were made with S_{11} parameter value by vector network analyzer [8]. The two methods generally are used for materials characterization with network analyzer. They are: 1. Free Space Method 2. Transmission Line Method. These methods are explain Ref. 10. The microwave absorption, EMI shielding, of $Ba_2Bi_2Co_2Fe_{12}O_{22}$ NPs + PAN/PANI polymer nanocomposite was analyzed and detail in Fig. 5 and 6. These microwave absorbers are using synthesized prepared composite has been fabricated, and successfully demonstrated for a maximum reflection loss of -50 dB at 14 GHz with a bandwidth of approximately 6 GHz in a sample thickness of 1,5mm. Our results indicate that the nanocomposite structure exhibit good absorption performances. This reflection loss is measured very high and this bandwidth is higher than normally reported. It can be said that this samples will provide great benefits for electromagnetic applications and EMI shielding characteristics. In conclusion, the nanocomposites ($Ba_2Bi_2Co_2Fe_{12}O_{22}$ + PAN/PANI) exhibited good EM absorption properties.

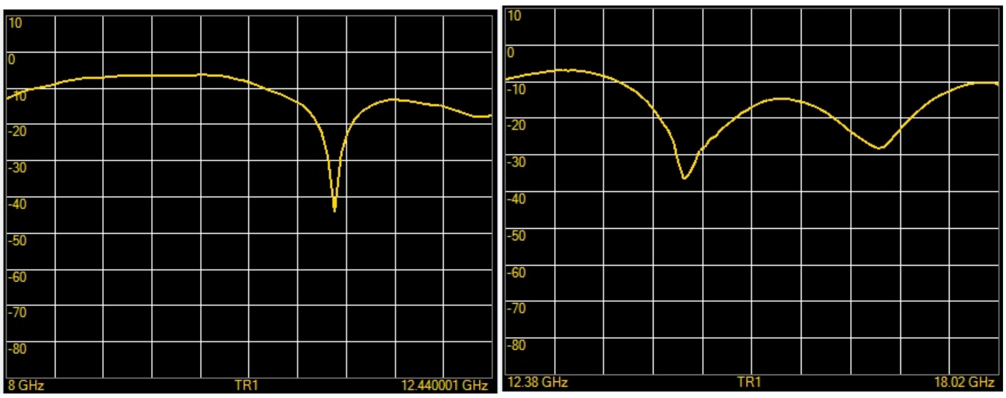


Figure 5. *Electromagnetic absorption measurements of nanocomposite structure with PAN.*

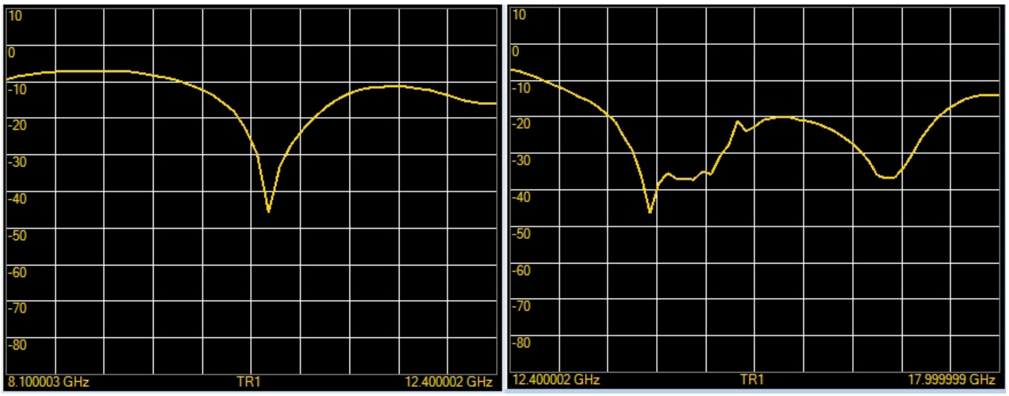


Figure 6. *Electromagnetic absorption measurements of nanocomposite structure with PANI.*

III. CONCLUSION

Structure, magnetic and absorption behavior of $Ba_2Bi_2Co_2Fe_{12}O_{22}$ NPs were investigated. Magnetization measurement of nanoparticles was investigated using by the VSM and ESR techniques. ESR spectra was shown great wide linewidth and g factor. The magnetization value of the nanoparticles was measured at 300, 50-10 K. VSM experiments were demonstrated superparamagnetism. Also, this particles values very light coercivity and soft ferrite materials. So, these nanoparticles can be used in high-frequency transformers. Synthesized nanocomposites indicated higher radar absorbing frequency (RL < -20 dB). Polymer-magnetic nanocomposites was measured wider absorbing bandwidth. The nanocomposites ($Ba_2Bi_2Co_2Fe_{12}O_{22}$ + PAN/PANI) are fulfill as well EM absorbing material from 5 to 20 GHz range. We can say "these nanocomposites will supply perfect advance for radar applications and EMI shielding features".

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