Abstract

Electromagnetic interference (EMI) pollution is caused by the interaction of electromagnetic waves with the input signal of electronic devices, which is threatening human health and also regressing the efficiency of electronic equipment. It has been found that magnetic materials, such as ferrous alloys and metallic materials, predominate over other types of EMI materials. Metals have thickness and corrosion issues. Rare-earth magnets are expensive and difficult to synthesize. Ferrites are cost-effective and corrosion-resistant. Spinel ferrites exhibit good shielding characteristics but operate in a low frequency range. Hard ferrites (hexaferrites) operate in a high frequency range. Y-type and Z-type hexaferrites have low coercivity (like spinel ferrites) and show good EMI shielding properties, but they are synthesized at high temperatures, which is not very desirable. Among the hexaferrites, M-type hexaferrites have emerged as the most promising candidate, due to their high coercivity compared to other EMI shielding materials, chemical stability (inertness), low cost, light weight, simple preparation methods, and low synthesis temperature. To tailor the magnetic and dielectric properties of M-type hexaferrite, three new and different combinations of barium hexaferrite (M-type) are synthesized and analyzed. Coercivity, complex permittivity, dielectric tangent loss, and AC conductivity are the four most important characteristics for the material's employment as a high frequency operative and an EMI shielding material. Moderate coercivity and saturation magnetization allow the material to be operative at high frequency. The complex permittivity, dielectric tangent loss, and conductivity values of the shielding material increase in direct proportion to the amount of EMI waves that are absorbed in it and the amount of EMI waves that are reflected. In the current study, barium hexaferrite co-doped with praseodymium and chromium ($Pr_xBa_{1-x}Cr_yFe_{12-y}O_{19}$), barium hexaferrite and perovskite composite ($BaFe_{12}O_{19}/Pr_{1-x}Sr_xMn_{1-y}Co_yO_3$), and cobalt doped barium hexaferrite and multi-walled carbon nanotube are synthesized and analyzed for EMI shielding and high frequency application. Powder x-ray diffraction (XRD, X'Pert Pro PANalytical) technique using Cu-K_α radiation (=1.54) is employed to examine the crystal structure. Through the use of field emission scanning electron microscopy (FESEM), the structural morphology was observed. Energy-dispersive x-ray spectroscopy (EDX) was used to conduct the compositional analysis. An impedance analyzer is used to investigate dielectric characteristics.

The produced samples' magnetic responses are examined using a vibrating sample magnetometer (VSM). In the first experiment, sol-gel auto-combustion was used to create praseodymium and chromium co-doped barium hexaferrites $Pr_xBa_{1-x}Cr_yFe_{12-y}O_{19}$ (x = 0, 0.1, 0.2, 0.3 and 0.4; y = 0, 0.4, 0.8, 1.2 and 1.6) at 1050°C. The sample (PBCF3) with highest doping content (x = 0.4; y = 1.6) has shown the most optimum results, e.g., lowest coercivity (1757 Oe), highest dielectric constant (215), highest dielectric loss (111), high tangent loss (0.518) and highest AC conductivity (0.0062 Ωcm^{-1}). In the second experiment, the sol-gel auto-combustion method was used to create the barium hexaferrite and perovskite composite $BaFe_{12}O_{19}/Pr_{1-x}Sr_xMn_{1-y}Co_yO_3$ (x = 0.0, 0.25, 0.5, 0.75 and 1.0; y = 0.0, 0.25, 0.5, 0.75 and 1.0) at 1100 °C. The sample BF/P2 (i.e. x= with 0.5; y = 0.5) has shown the most optimum results, e.g., low coercivity (775 Oe), high dielectric constant (17.5), highest dielectric loss (22.5), highest tangent loss (1.3) and highest AC conductivity (0.00125 Ωcm^{-1}). In the third experiment, cobalt doped barium hexaferrite ($BaFe_{11.6}Co_{0.4}O_{19}$) was synthesized at 950 °C using the micro emulsion synthesis technique. It was then mixed with multi-walled carbon nanotubes (MWCNT) using ultra sonication technique to form composite of multi-walled carbon nanotubes and cobalt doped barium hexaferrite ($x(BaFe_{11.6}Co_{0.4}O_{19})/y(MWCNT)$). The sample BF/C3 (i.e. x = 79%; y = 21%) has shown the most optimum results, e.g., low coercivity (939.7 Oe), high dielectric constant (438.6), highest dielectric loss (2094.3), highest tangent loss (4.78) and highest AC conductivity (0.1164 Ωcm^{-1}). Among all produced samples, composite of multi-walled carbon nanotubes and cobalt doped barium hexaferrite ($x(BaFe_{11.6}Co_{0.4}O_{19})/y(MWCNT)$) has shown the best combination of low coercivity with high dielectric properties. Hence, sample BF/C3 (i.e. x = 79%; y = 21%) is considered to be most suitable for EMI shielding and high-frequency applications due to their hard magnetic nature and good dielectric properties.