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Comparison of Direct and Indirect Measurements of the Saturation Magnetization of Barium Hexaferrite Synthesized by Coprecipitation

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This paper compares the magnetic properties of barium hexaferrite (BaM) powder synthesized by the coprecipitation method as determined by two-magnon scattering theory (microwave spectroscopy) and a direct method (vibrating-sample magnetometry). The microstructural, structural, loss, and magnetic properties were measured by x-ray diffractometry, field-emission scanning electron spectroscopy, network analysis, and vibrating-sample magnetometry, respectively. By using the two-magnon scattering theory and the reflection loss data, the saturation magnetization was calculated. The results revealed that the saturation magnetization determined by the use of the two-magnon scattering theory is about 54.75 emu/g, which closely conforms to the experimental value of 55.00 emu/g obtained using vibrating-sample magnetometry.

Key words: Saturation magnetization, nanomagnetic, theory of two-magnon scattering, coprecipitation

INTRODUCTION

Magnetic ceramics or ferrites are some of the most important magnetic materials, especially for high-frequency applications.[1,2] Among these types of magnetic materials, Ba ferrites and Sr ferrites with hexagonal structure are two main classes which exhibit hard-magnetic properties. Barium hexaferrite ($BaFe_{12}O_{19}$ or BaM) is the most well-known compound M-type hexaferrite, having magnetoplumbite structure and unit cell dimensions of $a = b = 5.88$ Å and $c = 23.20$ Å.[3] BaM exhibits high coercivity, as required for permanent magnets.[4] Other properties of BaM are its large saturation magnetization (72 emu/g), high Curie temperature (450°C), large gyromagnetic effect, and excellent chemical stability and corrosion resistance.[5,6] In recent years, these ferrites have received special attention for use in magnetic recording media, magnetic resonance imaging devices, microwave applications, etc.[7] Such technological applications require that barium ferrite particles be single magnetic domains. For this purpose, the coprecipitation method has been considered as one of the most suitable for synthesis of fine, single-domain barium hexaferrite nanoparticles.[6] To date, several methods have been used to calculate the magnetization of magnetic powders. Each of these methods calculates the magnetization based on a specific method; For example, the vibrating-sample magnetometer (VSM) is based on the flux change in a coil when a magnetized sample is vibrated near it. It is worth mentioning that, in contrast to the current literature on the estimation of saturation magnetization, this paper pays special attention to comparison of the saturation magnetization obtained either by the two-magnon theory associated with reflection losses or by VSM for barium hexaferrite obtained by the coprecipitation method.

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