Structural transformations of mechanically induced top-down approach $BaFe_{12}O_{19}$ nanoparticles synthesized from high crystallinity bulk materials

ABSTRACT

In this work, a top-down approach was applied to high crystallinity $BaFe_{12}O_{19}$ bulks, breaking them into smaller nanoparticles by mechanochemical route. The effects of milling time, reaction mechanisms and structural information were investigated. Interestingly, three distinct stages of the mechanochemical mechanism were observed. The XRD results indicated that the $BaFe_{12}O_{19}$ phase existed even though the mechanical energy had induced the formation of an amorphous phase in the material. The average crystallite size decreased during the first stage and the intermediate stage, and increased during the final stage of the mechanical alloying. A Rietveld refinement analysis suggested the deformation of a mechanically-triggered polyhedral in the magnetoplumbite structure. FESEM micrographs indicated that fragmentation predominated during the first and intermediate stages, until a steady equilibrium state was achieved at in the final stage, where a narrow particle size distribution was observed. HRTEM micrographs suggested the formation of a non-uniform nanostructure shell surrounding the ordered core materials at the edge-interface region. The thickness of the amorphous surface layer extended up to 12 nm during the first and intermediate stages, and diminished to approximately 3 nm after 20 h milling. VSM results showed a mixture of ferromagnetic, superparamagnetic, and paramagnetic behaviours. However, different magnetic behaviours predominated at different milling time, which strongly related to the defects, distorted polyhedra, and non-equilibrium amorphous layers of the material.

Keyword: Mechanochemical synthesis; Top down approach synthesis; Nanoparticles; Ferrites