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Green Synthesis of Fe3O4 Nanoparticles: Structure and Magnetic Properties

Magnetite (Fe3O4) has drawn interest since its discovery since it is one of the naturally occurring minerals that has importance in paleomagnetic measurements used to study continental drift [1]. The compound is also found in the mantle wedge of subduction zones [1]. Magnetically, Fe3O4 orders ferrimagnetically with a Curie temperature of 850 K having an inverse spinel structure, AB2O4, with the A site occupied by Fe3+ and the B sites populated equally by Fe3+ and Fe2+ at room temperature [2]. As a result, A site contributes +5 μB, and the B sites contributing −5 μB and +4 μB, respectively, yielding a total spin moment of 4μB with no orbital moment [2]. Interestingly, Fe3O4 demonstrates a metal-insulator transition, popularly known as the Verwey transition, at a temperature TV = 120 K, below which two-fold increase in the resistivity occurs [2]. Fe3O4 plays an important role as a catalyst in inorganic processes such as the synthesis of ammonia and in organic methods such as the dehydrogenation of ethyl benzene to styrene [3]. The high demand for magnetic recording media coupled with the possibility of imaging the atomic structure and the electronic properties of the surface made it the potential candidate [3] for this use. Specifically, attention was focused on the study of the surface reconstruction of magnetite and its magnetic properties [3]. The inverse spinel structure is stable and can be retained even by application of pressures up to 10 GPa [4]. As a consequence, the B sites are randomly occupied by Fe2+ and Fe3+ even at high pressure. Charge ordering can therefore not be precluded to explain the Verwey transition under high pressure and low temperatures [5]. Looking at the importance of Fe3O4, the present work aimed at the synthesis of Fe3O4 nanoparticles using a novel green synthesis approach. For the green synthesis, native Aloe arborescens plant extract was used in the co-precipitation method. The average crystallite size was found to be 22.20 nm from the X-ray diffraction (XRD). Temperature and applied field dependent magnetization measurements confirm the retention of ferrimagnetic behavior up to 300 K. To manipulate the magnetic ordering Cr3+ was substituted at Fe3+ site. Effect of synthesis method, particle size and Cr doping on crystal structure and magnetism will be discussed in this work.

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