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ORIGINAL PAPER

Structural Confinement Assisted a Robust Superparamagnetic State in $MgNi_2O_3$ and $MgNi_{1.5}Co_{0.5}O_3$ Nanoparticles at Room Temperature

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Abstract
In this study, ideal spherical-shaped cubic metal oxide nanoparticles of <30 nm in size were prepared by a citric acid sol-gel combustion method. The detailed structural analysis and microscopic techniques clearly support the existing grade of structural confinement effect in $MgNi_2O_3$ and $MgNi_{1.5}Co_{0.5}O_3$. Temperature-dependent magnetisation studies at various applied fields revealed a moderate change of T_B near room temperature by distinct particle size. Magnetic crystalline anisotropy and energy barrier density theoretical model results suggested the importance of innermost magnetic particle stability-aided spin orientation with a fascinating magnetic moment in superparamagnetic region exerted by Ni and Co remarkably postured as a significant part of these nanoparticles.

Keywords Magnetic nanoparticle · Sol-gel technique · X-ray diffraction · Structural confinement · Superparamagnetism · Magnetic crystalline anisotropy

1 Introduction

The stabilisation of perfect nanomaterials with desired dimensions are tremendously challenging by the chemical approach. However, such nanomaterials get immense attention because of its interesting physical properties especially magnetic, optical and transport properties [1–6]. In comparison with other properties, the magnetic characteristics of nanoparticles are strongly stimulated by its size where it approaches a critical diameter for the emergence of single magnetic domain below the blocking temperature (T_B). A chemically activated single magnetic domain in nanoparticles at this temperature along with better chemical homogeneity has vast technological advantages [7–10]. Due to randomisation of magnetic spins in agglomerated surroundings and oxidation of metal particles during synthesis, it is quite hard to fabricate metal oxide nanoparticles with desired particle size for attaining the large surface-to-volume ratio. Nevertheless, many researchers have already prepared several types of magnetic nanoparticles to achieve various interesting properties using appropriate chemical approaches under atmospheric conditions [11, 12]. To prepare nanomaterials suitable for biosensor applications, one has to achieve a maximum saturation magnetisation from nanoparticles for acquiring higher sensitivity and efficiency [13]. Obviously, many interesting nanoparticles play an important role in biomedicine applications and thus the need for its biocompatible activity when it is targeted to diseased cells in the human body is prevalent [14, 15]. To bring forth the capability of magnetic nanoparticles in biomedicine usages, it is better to have a high magnetic saturation, lower coercivity and remanence at low magnetic field and hence the superparamagnetic temperature limit is of great importance.

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