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Synthesis and Characterization of Nanosized Cobalt Manganese Alloys

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Co–Mn alloy nanoparticles are synthesized by chemical route by the decomposition of metal chlorides by sodium borohydride using oleic acid as the capping agent. SEM, TEM and XRD are used to determine structural and morphological properties of the samples. From XRD spectra analysis, it is confirmed that the sample contains cobalt–manganese alloy. Transmission Electron Microscopy (HR-TEM) is used to estimate the particle size of the Co–Mn sample where a bimodal particle size distribution with one maximum at (3.5 ± 1.8) nm and another maximum at (7.6 ± 2.5) nm is observed. Magnetic investigation employed by Vibrating Sample Magnetometry (VSM) shows that the samples are magnetic with saturation magnetization of 0.018 emu/g for the prepared sample and 0.457 emu/g for the annealed sample. The nature of chemical conjugation of Co–Mn nanoparticles and oleic acid is analyzed by Fourier transform infrared spectroscopy. Thermogravimetric measurements of Co–Mn indicate exothermic peaks at 545 K and 723 K revealing the structural transition from amorphous phase to crystallined form. The chemical composition of the sample is verified using EDX spectra.

Keywords: Alloy Nanoparticles, Co–Mn Alloy, Structural, Morphological, Magnetic, Thermal, FTIR Analysis.

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1. INTRODUCTION

In the recent few years, nanoalloys have been investigated extensively due to their miscellaneous range of physical properties in optics, magnetics, electronic, catalytic activity, corrosion resistance, electrochemistry, biotechnology and geometrics.[1–7] In particular, chemical and physical properties of these alloys have the ability to tune together with both the composition and size suiting the specific purpose. This provides attraction for the nanosized alloys leading to technological and biological applications in areas such as high density–recording, optics, catalysis and medicine.[8–11] The nanostructure and morphology of alloys have major characteristics for the utility in their future applications. Metal nanostructures like nanosheets, nanorods, nanomesh, nanonetwork, nanorings and nanochains have acquired more attention due to their potential applications.[12–15] Ferromagnetic Co and Ni based alloy are soft magnetic materials which have extensive applications in magnetic recording devices and ferrofluid dynamotors.[16,17]

Co–Mn alloy is one of the versatile candidates exhibiting very interesting properties in low dimensions. Manganese shows finite magnetic moment in reduced dimension though it is antiferromagnetic in the bulk. Cobalt provides enhanced magnetic moment at nanoregime compared to bulk.[18,19] Regarding the morphology, Co–Mn compound took the initiative on bimetal nanosized clusters and their organic co-ordination compounds.[20–24] Usually magnetic alloy syntheses in thin films using vacuum deposition techniques have been focused. This leads to random nucleation of particles resulting relatively in large crystalline size as well as broad size distribution that affects their magnetic performance.[25,26] Many reports suggest effective methods for tuning the size and self-assembly focusing on chemical processes like application of polyol reduction, using reverse micelle technique, decomposition of organometallic precursors.[27,28] Researchers used different techniques for the synthesis of Co–Mn alloy nanoparticles that include convectional method by incipient wetness impregnation using supporting materials like SiO_2, Al_2O_3. Here Co–Mn nanoparticles show a broad size distribution with particle size in the range of 5–20 nm in which the presence of manganese is less well defined.[29] Sebastian et al. reported mixed Co–Mn nanoparticles obtaining flower like structures due to aggregation of particles synthesized by polyol process.[28] By using standard reaction conditions, the particle size distribution of the material lies in the range between (7.8 ± 1.9) nm and (2.5 ± 1.1) nm. Junli and co-workers prepared microrod-structured Co–Mn compound by using hydrothermal method.[30]

In this present work, the authors report synthesis and characterization of cobalt manganese alloy nps prepared by employing the borohydride reduction method with an aim of establishing well-defined Co–Mn alloy nps leading to potential application in data storage for magnetic devices. Study of morphological, structural, magnetic, thermal and compositional properties are undertaken.

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