

Novel Procedures for the Synthesis of Transition Metal Doped TiO₂ and ZnO and Their Magnetic Properties

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Transition metal-doped oxides such as TiO₂ and ZnO are of importance for possible applications in spintronics [1-8]. Synthesis of such materials without any impurity phases is necessary for wide array of electronics and optical device applications which involve fundamental aspects of science and technology. A number of methods, such as sputtering, chemical vapor deposition and sol-gel are commonly employed for the synthesis of these transition metal doped oxides. In most of these methods, the nature of the produced material is amorphous and an additional high-temperature processing step is required in order to obtain crystallinity. However, high temperature processes can lead to significant constraints and the formation of other phases together with substantial costs for manufacturing.

In this work we have followed several experimental approaches in order to synthesize single phase M (M=Cr, Mn, Fe, Co, Ni) doped TiO₂ and ZnO by simple Sol-Gel and microwave techniques. Recent results from our laboratory has shown that 10% Co doped ZnO and TiO₂ prepared by sol-gel synthesis is paramagnetic at room temperature, but hydrogenation at 573 K changes the magnetic behavior from paramagnetic to ferromagnetic [9-11]. We have extended this study by doping Cr, Fe, Mn and Ni into these oxides and investigated their magnetic properties. X-ray diffraction, electron magnetic resonance (EMR) spectroscopy, X-ray photoelectron spectroscopy (XPS) and transmission electron microscopy (TEM) were also used to characterize these nanoparticles. It is significant to note that Co doped oxides did not show clear evidence for the presence of cobalt metal nanoparticles indicating successful doping. Careful temperature dependence of the magnetic susceptibility from 2 K to 350 K and magnetic field dependence of the magnetization at 2 K were carried out to determine the valence states of the dopants. Following these studies, the samples were reduced in H₂ at 573 K to determine changes in the magnetic properties. Similarly temperature dependence of the EMR spectra was investigated from 5 K to 300 K. Details of these results will be presented.

The primary goal of this work is to synthesize transition metal doped oxides without any impurities using sol-gel technique at room temperature and microwave at higher temperature in a shorter time. These methods provide the opportunity for the development of materials with unusual composition at low-cost. The associated magnetic studies provide the nature of the magnetic states of the dopants.

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