

## Synthesis and Characterization of Pure, Co and Fe-Doped ZnO Nanoparticles†

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Pure, Co and Fe doped ZnO nanoparticles have been successfully synthesized by chemical route technique. The synthesized samples were subjected to calcinations and sintering. The functional groups of the synthesized nanoparticles have been examined by FT-IR analysis. The XRD patterns of ZnO nano crystalline powder, Co-doped and Fe-doped ZnO have been successfully studied. The thermal analysis (TGA/DTA) of synthesized particles has been carried out. FE-SEM images of ZnO have been taken and analyzed.

**Key Words:** Nanoparticles, Thermal analysis, ZnO.

### INTRODUCTION

There is a wide class of semiconducting materials which is characterized by the random substitution of a fraction of the original atoms by magnetic atoms. These materials are commonly known as semi magnetic semi conductors (SMSCs) or diluted magnetic semiconductors (DMS)<sup>1-3</sup>. That is DMSs are semiconductors with some magnetic materials as impurities in the host lattices. Diluted magnetic semiconductors is one of the doped magnetic substances is usually doped to a percent contraction up to 10 %. Generally, DMSs are synthesized by semiconductors properties are maintained. Magnetic semiconductors have attracted considerable attention due to their potential application in spintronics<sup>4-7</sup>. The history of magnetic semiconductors started in the late 1960's and were aimed reading new properties by combining electrical transport and magnetism.

Several studies on the synthesis of zinc oxide (ZnO) particles have been performed in recent decades because of the diversified industrial applications of this material. In the literature, chemical routes are presented as the most commonly used methods for synthesizing ZnO. Precipitation processes make possible the production of large quantities of ceramic oxides in a reproducible way<sup>8-10</sup>. Nevertheless, intermediate compounds, depending on the zinc precursor salt, are usually precipitated and then transformed into zinc oxide by thermal decomposition processes. The goal of our work is to synthesize ZnO nanoparticles and Fe-doped ZnO diluted magnetic semiconductors at room temperature and we preferred chemical

route method in which the ZnO and DMS particle were allowed to precipitate directly at room temperature.

### EXPERIMENTAL

All were of 99 % purity (Aldrich 99 %). Zinc nitrate ( $Zn(NO_3)_2 \cdot 6H_2O$ ) was used as the source material for semiconductor and this acted as the parent. Cobalt nitrate ( $Co(NO_3)_3$ ) and ( $Fe(NO_3)_3$ ) was used as the source material for magnetic dopant. In the case of the synthesise of diluted magnetic semiconductors, the magnetic component is usually doped to a percentage of *ca.* 1-25 %. In this work, the percentage of dopant used was 2 % and therefore the percentage of zinc nitrate (parent) was 98 %.

### RESULTS AND DISCUSSION

**Powder X-ray diffraction analysis:** Fig. 1 represents the XRD pattern of pure, Co and Fe doped ZnO nanopowders. Fig. 1 represents the XRD pattern of Co-doped ZnO diluted magnetic semiconductor. The XRD analysis of pure ZnO and that of Co-doped ZnO confirm the crystalline structures of both pure ZnO and Co-doped ZnO diluted magnetic semiconductor. The peaks corresponding to ZnO match well with standard values. The JCPDS file number to which the XRD data match is 89-1397.

**FT-IR analysis:** The FTIR pattern of pure ZnO nanopowders and that of co-doped nano powder shown in Fig. 2. The functional groups where identified from the FTIR analysis.

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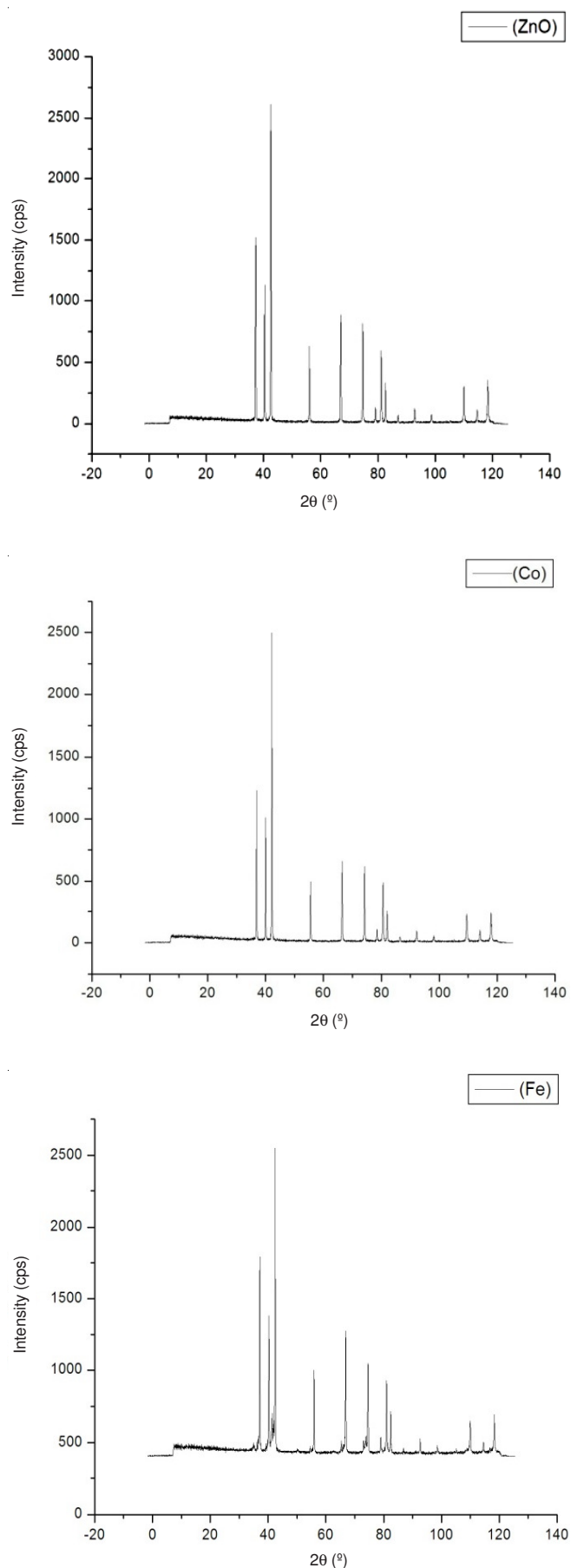


Fig. 1. Powder X-ray analysis of pure ZnO and Co, Fe doped ZnO nanoparticles

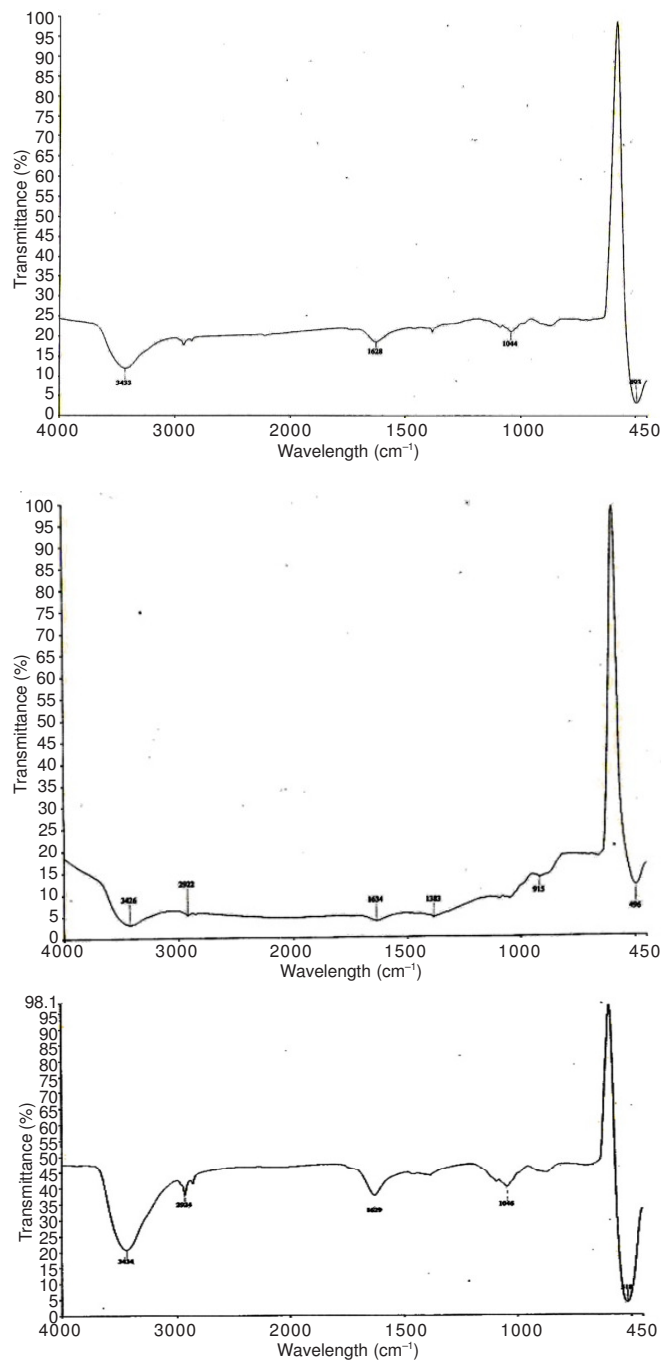


Fig. 2. FT-IR analysis of pure ZnO and Co, Fe doped ZnO nanoparticles

**Thermal analysis:** The initial weight loss at lower temperature range is due to desorption of water. From the TGA graph (Fig. 3), it is found that major weight loss is between 200 and 350 °C. This may be due to not only desorption of water and also may be due to decomposition of nitrates. There is no considerable weight loss around 350 °C. The analysis therefore illustrates the optimum temperature for ZnO is around 400 °C.

The DTA curve of dried precursors of ZnO is shown in Fig. 3. There is a sharp exothermic at around 100 °C and a broad exothermic range after around 500 °C. This shows the formation and transitions of crystalline phase of ZnO. There is a sharp endothermic with maximum at around 150 °C. This is due to desorption of water. There is a broad endothermic range 300-550 °C. This may be due to the decomposition of nitrates.

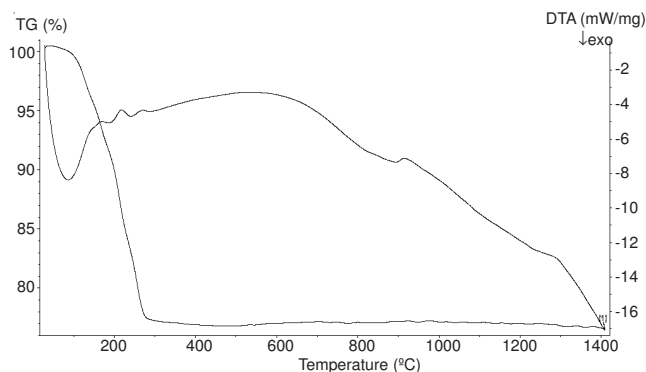


Fig. 3. Thermal analysis of pure ZnO nanoparticles

**Scanning electron microscope:** Fig. 4 represents the field emission scanning electron microscopy images of ZnO.

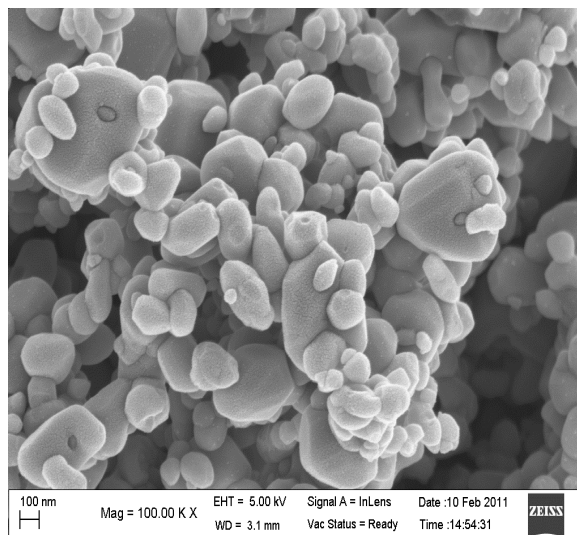
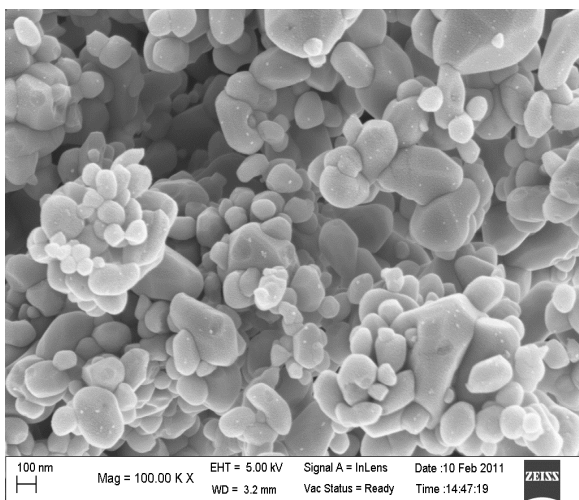
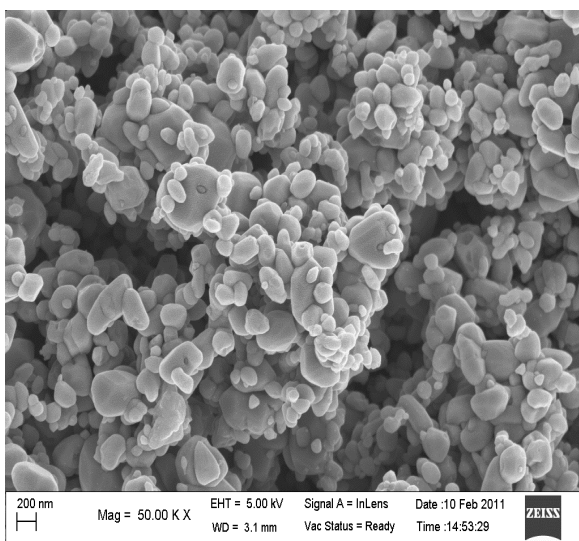


Fig. 4. SEM images of pure, Co and Fe doped ZnO nanoparticles

## Conclusion

Pure ZnO nano particles and Co-doped ZnO nano crystalline powders have been successfully synthesized by chemical technique. The thermogram analysis (TG/DTA) of synthesized ZnO precursors. The synthesized sample was then subjected to calcinations and sintering. The functional groups in the Co-doped ZnO diluted magnetic semiconductor have been found by FTIR analysis. The X-ray patterns of ZnO nano-crystalline powder and Co-doped ZnO have been successfully studied. FE-SEM images of ZnO have been taken.

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