



Contribution ID: 268

Type: Oral

## Impact of Pr 3+ on structural, electrical and magnetic properties of Mg-Zn nanoferrites

In the present research work, we have prepared  $\text{Mg}_{1-x}\text{Zn}_x\text{Pr}_y\text{Fe}_{2-y}\text{O}_4$  ( $0.0 \leq x \leq 1.0$  in steps of 0.2;  $y = 0.0, 0.1$ ) nanoferrites by novel solution combustion technique using pure Magnesium nitrate [ $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ], Zinc nitrate [ $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ], Ferric nitrate [ $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ ], Praseodymium nitrate [ $\text{Pr}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$ ] are used as oxidizers and urea [ $\text{CO}(\text{NH}_2)_2$ ] as reducing agents (fuel). The respective metal nitrates and urea weighed accurately in stoichiometric ratio. A clear solution is obtained by dissolving metal nitrates and urea in deionized water. The aqueous solution containing precursor solutions (redox mixture) is taken in a Pyrex dish was placed in a muffle furnace and heated up to 500 °C in air atmosphere. Initially, the solution begins to boil in muffle furnace then froths, ignites and liberate large amount of heat and gases ( $\text{N}_2\text{O}$  and  $\text{CO}_2$ ), vaporizes the entire solution instantly to yield fluffy voluminous nanoferrites fine powders. From the XRD studies, the lattice parameter enhanced from 0.82344nm to 0.84420nm owing to replacement of smaller ionic radius  $\text{Mg}^{2+}$  ions ( $r_{\text{Mg}^{2+}} = 0.066 \text{ nm}$ ) by larger ionic radius  $\text{Zn}^{2+}$  ions ( $r_{\text{Zn}^{2+}} = 0.084 \text{ nm}$ ). Further, on replacement of smaller ionic size ferric ions or  $\text{Fe}^{3+}$  ions ( $r_{\text{Fe}^{3+}} = 0.067 \text{ nm}$ ) by larger ionic size  $\text{Pr}^{3+}$  ions ( $r_{\text{Pr}^{3+}} = 0.113 \text{ nm}$ ), the lattice parameter decreased from 0.81924 nm - 0.83645 nm due to shrinking of the unit cell. The average crystallite sizes were in the range of 44.24- 22.144nm. It is observed that theoretical X-ray density enhanced from 4.567 to 5.625  $\text{gcm}^{-3}$  with substitution of  $\text{Zn}^{2+}$  ions and from 4.356 to 5.201  $\text{gcm}^{-3}$  with  $\text{Pr}^{3+}$  ions. This is due to fact that atomic weight of  $\text{Zn}^{2+}$  ion ( $M_{\text{Zn}} = 65.00 \text{ a.m.u}$ ) is greater than  $\text{Mg}^{2+}$  ion ( $M_{\text{Mg}} = 24.305 \text{ a.m.u}$ ) and atomic weight of  $\text{Pr}^{3+}$  ions ( $M_{\text{Pr}} = 140.90765 \text{ a.m.u}$ ) has greater than that of  $\text{Fe}^{3+}$  ion ( $M_{\text{Fe}} = 55.85 \text{ a.m.u}$ ). In FTIR spectra, the higher frequency absorption band  $\nu_1$ , lies in wavenumber range 526-518  $\text{cm}^{-1}$  assigned due to stretched vibrations of metal ion-oxygen complexes (tetrahedral complexes) at A-sites,  $\text{M tetra} \leftrightarrow \text{O}$  or  $\text{Zn}^{2+} \leftrightarrow \text{O}$ ; The lower frequency band  $\nu_2$ , formed in the wavenumber range 440-434  $\text{cm}^{-1}$  due to intrinsic stretching vibrations of metal ion-oxygen complexes (octahedral complexes or) at B-sites ( $\text{M octa} \leftrightarrow \text{O}$ ). It is clear that, with increase in  $\text{Zn}^{2+}$  ions content, the position of  $\nu_1$ , shifting towards lesser wavenumbers side or higher frequency side, 585 - 553  $\text{cm}^{-1}$ , due to molecular weight of  $\text{Zn}^{2+}$  ions ( $M_{\text{Zn}} = 65.0 \text{ a.m.u}$ ) is greater than  $\text{Mg}^{2+}$  ions ( $M_{\text{Mg}} = 24.305 \text{ amu}$ ) and  $\text{Fe}^{3+}$  ions ( $M_{\text{Fe}} = 55.845 \text{ a.m.u}$ ). Furthermore, the wavenumber of lower absorption band,  $\nu_2$ , shifting frequency side, from 440-434  $\text{cm}^{-1}$  due to transfer of  $\text{Fe}^{3+}$  ions from A-sites to B-sites. SEM micrographs explore that grains are almost spherical with an average size of 82.86 nm-183.5nm]. From DC electrical conductivity, it is observed that the variation of  $\log \sigma_{\text{DC}}$  with temperature [T] is a straight line graph with breaks or kinks due to Curie temperature ( $T_C$ ) for nanoferrites with compositions up to  $x \leq 0.60$  and  $y = 0.0$  and 0.10. These breaks suggest that there is change in conduction mechanism and materials transforming from ordered ferrimagnetic state to disordered paramagnetic state. The compositional dependence of  $\sigma_{\text{DC}}$  found to increase up to composition  $x = 0.2$ ;  $y = 0.0$  and  $x = 0.4$ ;  $y = 0.1$ , attains maximum and thereby decrease with increasing  $\text{Zn}^{2+}$  ion concentration. The room temperature magnetic properties that the loops are very narrow and revealed the soft nature magnetic material behaviour. Further, the saturation magnetization ( $M_s$ ) and the remnant magnetization ( $M_r$ ) attain the maximum value and thereby decreased with increasing  $\text{Zn}^{2+}$  and  $\text{Pr}^{3+}$  content.

**Primary authors:** Dr V., Dinesh (Jain (deemed-to-be) University); Dr K. S., Kiran (Jain (deemed-to-be) University); Dr E, Melagiriappa (2 Visveraya Technological University)

**Presenter:** Dr E, Melagiriappa (2 Visveraya Technological University)