Investigation of Structural and Magnetic Properties of Sm Substituted $LaYFe_2O_6$

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$La_{1-x}Sm_xYFe_2O_6$ (x = 0, 0.25, 0.50, and 0.75) are successfully synthesized by the sol-gel auto combustion method. The phase confirmation of the samples is done by the Rietveld refined X-ray diffraction (XRD) patterns and magnetic properties are investigated by the Vibrating Sample Magnetometer at the high temperature region. XRD study revealed that pristine (x = 0) sample shows biphasic crystallographic behavior [$P2_1nm$ (~95%) + Pbnm (~5%)], whereas Samarium (Sm) plays a crucial role in the manifestation of single phase double perovskite structure ($P2_1nm$ phase only) in the x = 0.25, 0.50, and 0.75 samples. Interestingly, the magnetic parameters show the drastic change by the Sm substitution. The coercivity, remanent magnetization, and maximum magnetization are significantly enhanced from 219 Oe to 7445 Oe, 3.7 memu/g to 254.2 memu/g, and 188 memu/g to 619 memu/g respectively for x = 0 to x = 0.75 sample and thus ferromagnetic order is established here.

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Abstract

$La_{1-x}Sm_xYFe_2O_6$ (x = 0, 0.25, 0.50, and 0.75) are synthesized by the sol-gel auto combustion method. XRD study revealed that pristine sample shows biphasic crystallographic behavior [$P2_1nm$ (~95%) + Pbnm (~5%)], whereas samarium (Sm) plays a crucial role in the manifestation of single phase double perovskite structure ($P2_1nm$ phase only) in the x = 0.25, 0.50, and 0.75 samples. Interestingly, the magnetic parameters like coercivity, remanent magnetization, and maximum magnetization are significantly enhanced from 219 Oe to 7445 Oe, 3.7 memu/g to 254.2 memu/g, and 188 memu/g to 619 memu/g respectively for x = 0 to x = 0.75 sample and thus ferromagnetic order is established here.

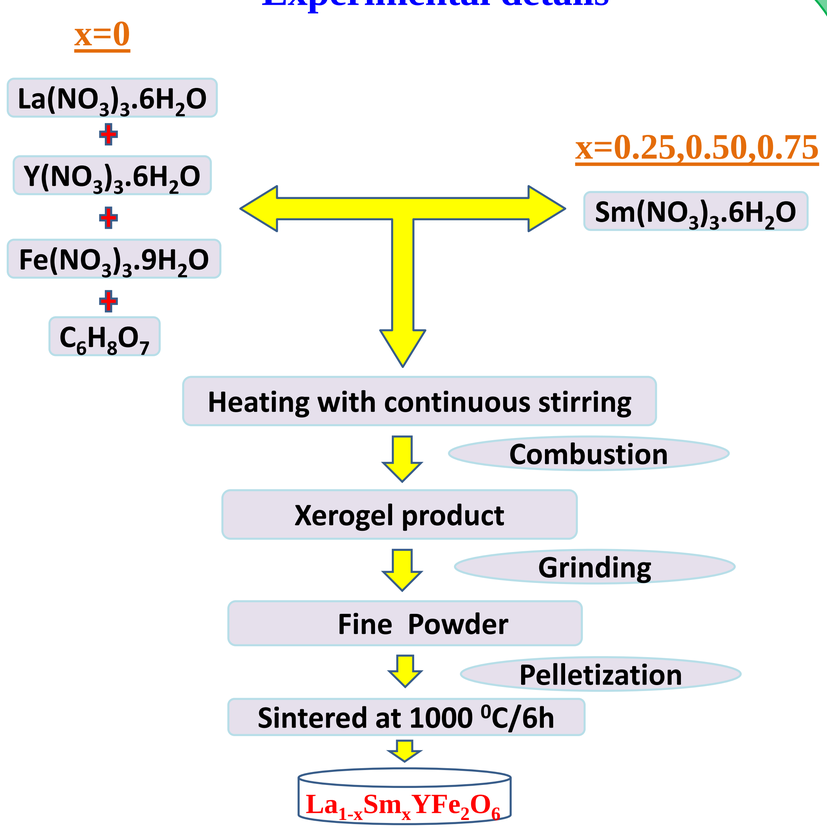
Introduction

- Double perovskite (DP) oxides have drawn great attention to scientific community.
- DP $La_{0.5}Y_{0.5}FeO_3$ (disordered) shows the emerging multiferroic properties and offers an extremely high ordering temperature (678 K), which are very essential for practical applications.
- $LaYFe_2O_6$ as an A-site ordered DP which offers an insulating behavior along with antiferromagnetism having magnetic transition 710 K.
- Ferromagnetic insulators can achieve breakthrough performance in the spintronics device applications, which motivated us to enhance the magnetic property of this material.

Objectives

To enhance magnetic properties, nonmagnetic La ion can be substituted by a magnetic ion (Sm) having comparable ionic radii with La ion.

Experimental details



➢ Structural analysis:

Rigaku Ultima IV X-ray diffractometer with monochromatic Cu-K_α (wavelength 1.5406 Å) radiation.

➢ Surface morphology:

Field Emission Scanning Electron Microscope (Zeiss Supra 40).

➢ Magnetic study:

VSM (Lakeshore 7400-S series, USA).

Results and discussions

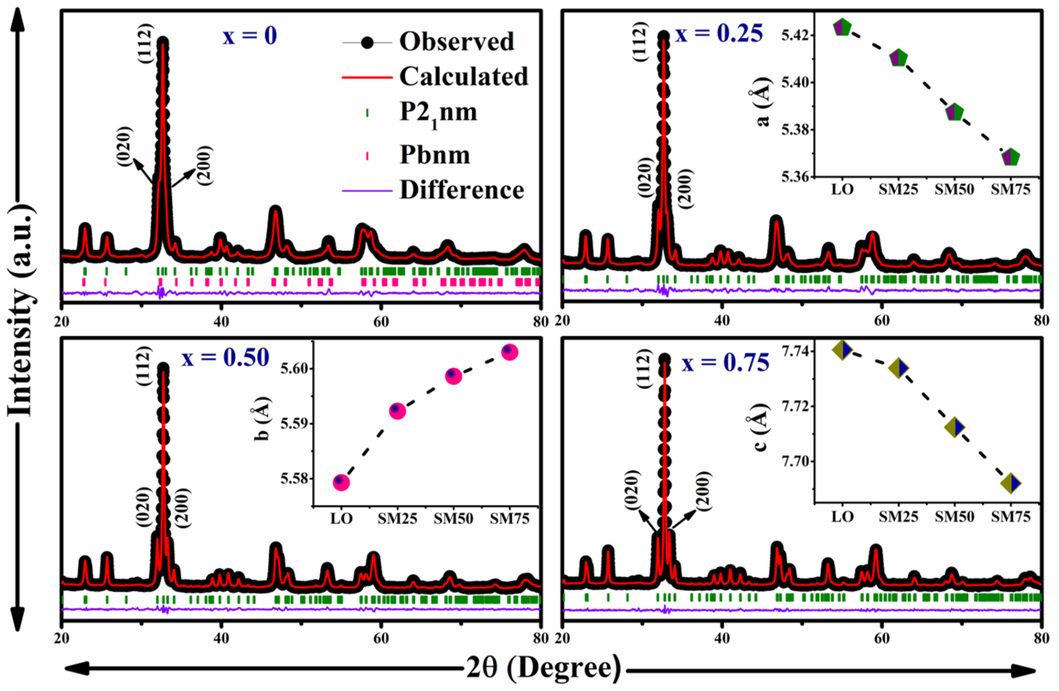


FIGURE 1. Rietveld refined x-ray diffraction (XRD) patterns of all the samples. Insets show the variation of lattice parameters (a, b, and c) with Sm content.

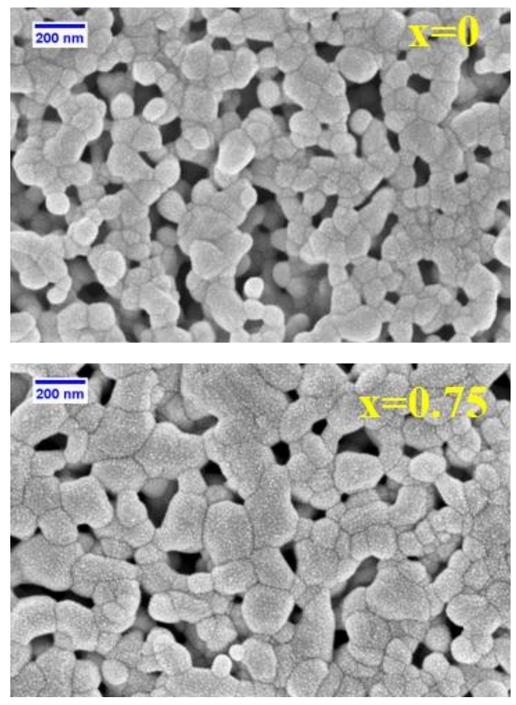


FIGURE 2. FESEM images of x=0 and x=0.75 sample.

‡ Structural distortion created in the system which could be associated with distortion of FeO_6 octahedra, affecting the magnetic properties of the material.

‡ Grain growth process is much improved in x=0.75 sample.

‡ Transition peak becomes intense and sharper with the increasing Sm percentage, suggests FM interaction is enhanced by the Sm substitution.

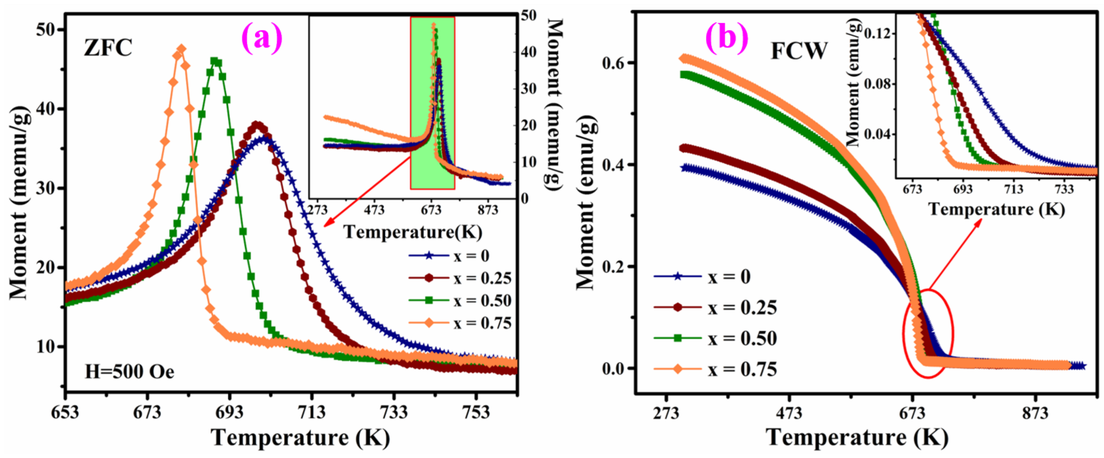


FIGURE 3. Temperature-dependent magnetization plots for all the samples (a) expanded view of ZFC mode around T_0 region and full-scale view is shown in the inset, and (b) FCW mode and inset shows the zoomed view near the T_0.

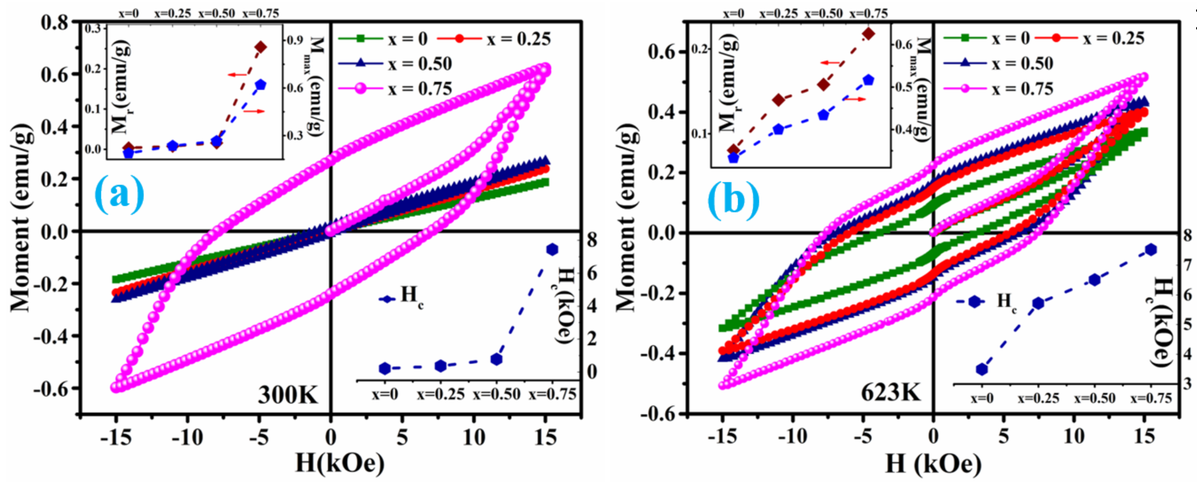


FIGURE 4. Magnetic field dependent magnetization plots for all the samples at (a) 300 K and (b) 623K. Upper insets show the corresponding M_r and M_{max} values and lower insets show the H_c values as a function of compositions.

‡ Magnetic parameters are dramatically enhanced by the substitution at room temperature (RT) shown in Table 1.

Table 1. RT magnetic parameters of all the samples.

Samples	H_c (Oe)	M_r (memu/g)	M_{max} (memu/g)
x = 0	219	3.7	188
x=0.25	373	7.4	235
x=0.50	786	15.8	265
x=0.75	7445	254.2	619

Conclusions

- XRD study confirm the $P2_1nm$ (~95%) and Pbnm (~5%) biphasic structure for x = 0 and $P2_1nm$ phase are determined for all other compositions.
- Grain growth as well as particles sizes are enhanced by the substitution.
- Magnetization study revealed that the ferromagnetic ordering is established by the Sm substitution and the transition temperature drops from ~710 K to ~684 K with increasing Sm-substitution.
- Magnetic parameters like H_c, M_r, and M_{max} (extracted from M-H study) are greatly enhanced by virtue of Sm substitution.

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Publications

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