Structural, Magnetic and Dielectric Properties of $Dy_{0.95}Gd_{0.05}MnO_3$ Prepared by Acrylamide Polymer Gel Template Method

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INTRODUCTION

- Rare earth manganites ($RMnO_3$, R = rare earth element) are drawing attention due to their interesting properties like stronger intrinsic magneto-electric behavior, low dielectric loss, colossal magneto-resistance, spin frustration etc.
- $DyMnO_3$ (DMO) crystallizes in orthorhombic as well as hexagonal phase depending upon the synthesis condition. However, orthorhombic phase show higher magneto-electric coupling as compared to hexagonal phase.
- Orthorhombic phase of DMO undergo various stages of magnetic ordering like AFM ordering of Mn ion (T_N(Mn)) around 38 K- 43 K, lock-in temperature (T_{lock}) around 18 K- 23 K below which ferroelectricity is observed and AFM ordering of Dy^{3+} ion (T_N (Dy)) around 6 K- 10 K respectively
- Lower concentration of Gd substitution at Dy site of $DyMnO_3$ will not change the crystal structure. Further substitution of rare earth ions at R-site of orthorhombic $RMnO_3$ system reported to be played an important role in enhancing ferromagnetic behavior.

SAMPLE PREPARATION

Dy_2O_3 | Gd_2O_3 | $Mn(CH_3COO)_2.4H_2O$

↓

Dissolved in distilled water and stirred

↓

Acrylamide and Bis-acrylamide are added to the solution

↓

10wt% APS + 2wt% TMED are added & placed in an oven maintained at 60^0C

↓

Gel is transferred to a furnace maintained at 350^0C/1 hour

↓

Resultant residue is ground and calcined for 1100^0C/10 hours & sintered at 1200^0C/10 hours

↓

Phase confirmation checked by X-ray diffraction

↓

Characterization

OBJECTIVES

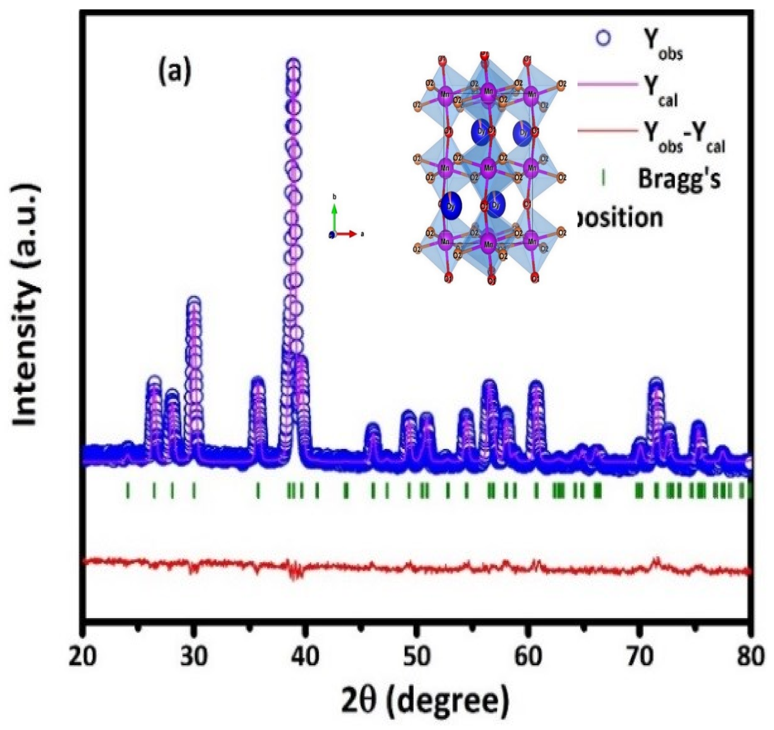
- Synthesis of single phase of DGMO system using Acrylamide polymer gel template method.
- Studies of structural and vibrational properties of the material.
- Studies of low temperature magnetic and Dielectric behaviour of orthorhombic DGMO system.

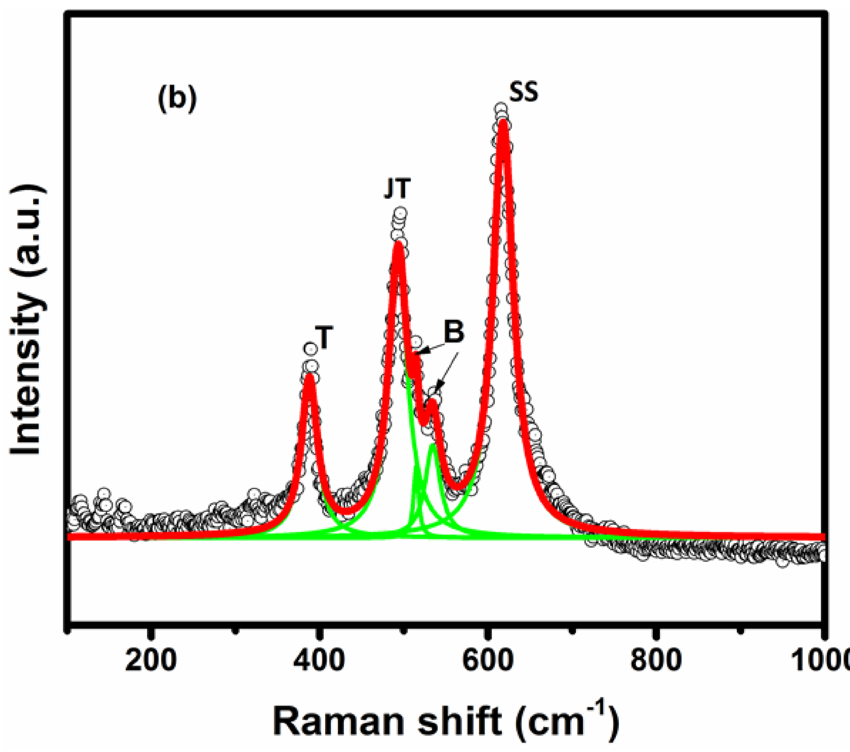
CHARACTERIZATION TECHNIQUES

- Structural & Vibrational Properties → X-ray Diffractometer & Raman Spectrometer
- Magnetic Properties → VSM (PPMS)
- Dielectric Properties → Wayne Kerr 6500B Impedance analyzer with CCR set up

RESULTS & DISCUSSION

Structural & Vibrational Study

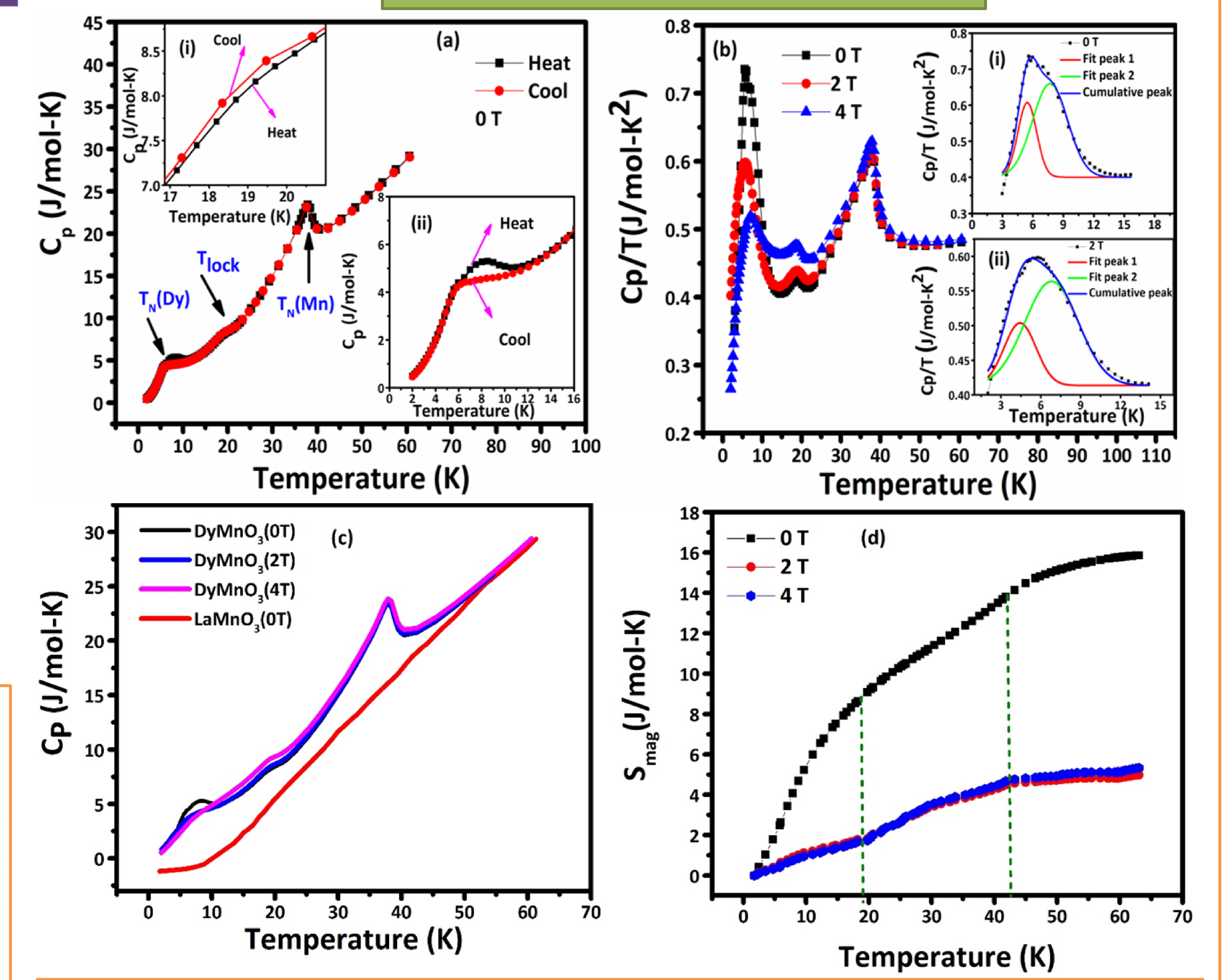




The XRD pattern confirms the formation of single phase compound with orthorhombic crystal structure having lattice parameters (A^0): a = 5.8329 (1), b = 7.3826 (2), c = 5.2796 (1). Inset shows the orthorhombic crystal structure of DGMO system.

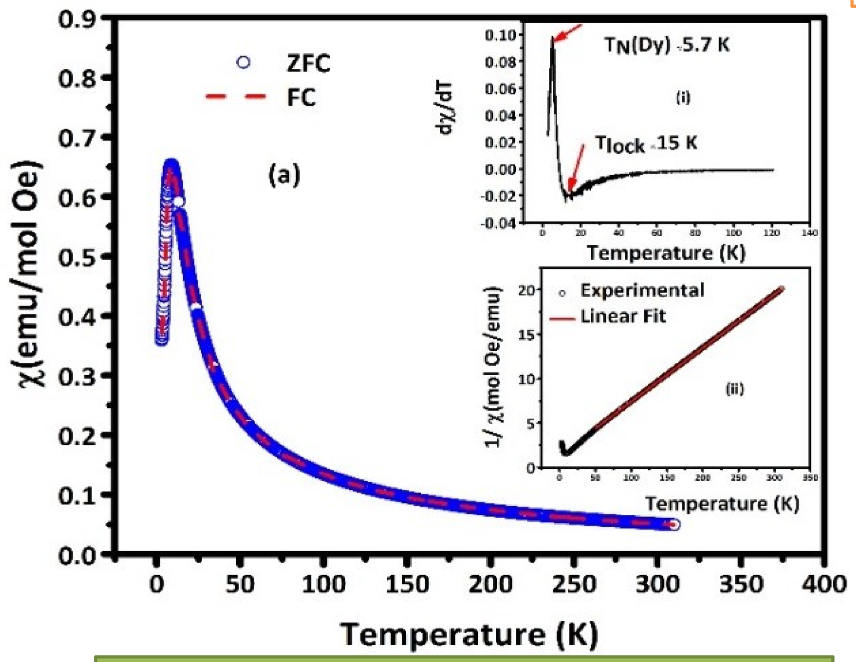
- Raman spectra of DGMO shows two most intense Raman modes at 480 and 617 cm^{-1} corresponding to antisymmetric Jahn-Teller stretching mode and symmetric stretching mode respectively.
- Raman mode at 387 cm^{-1} represents tilting of MnO_6 octahedra.
- Two Raman modes at 514 and 534 cm^{-1} are assigned to the bending of MnO_6 octahedra.

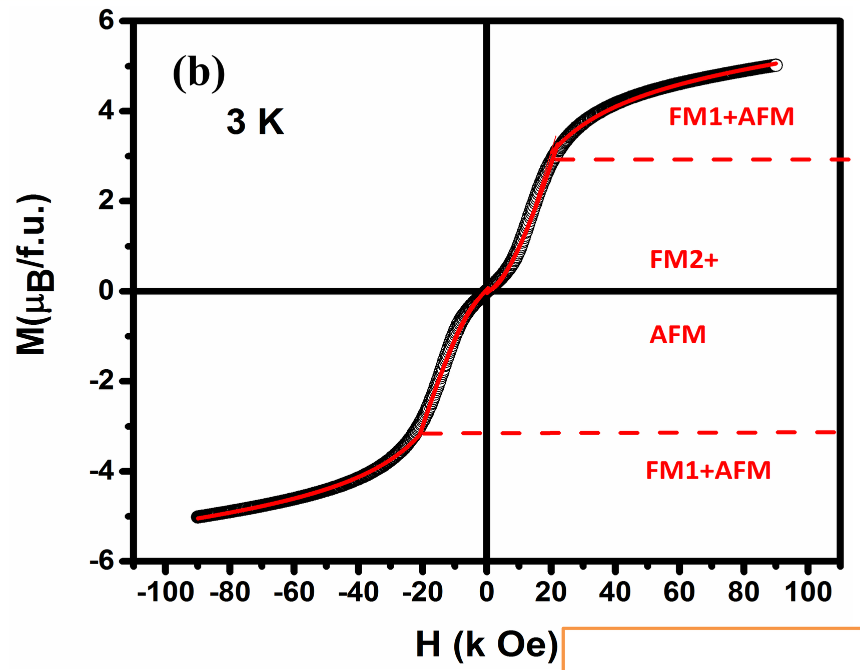
Specific Heat Study

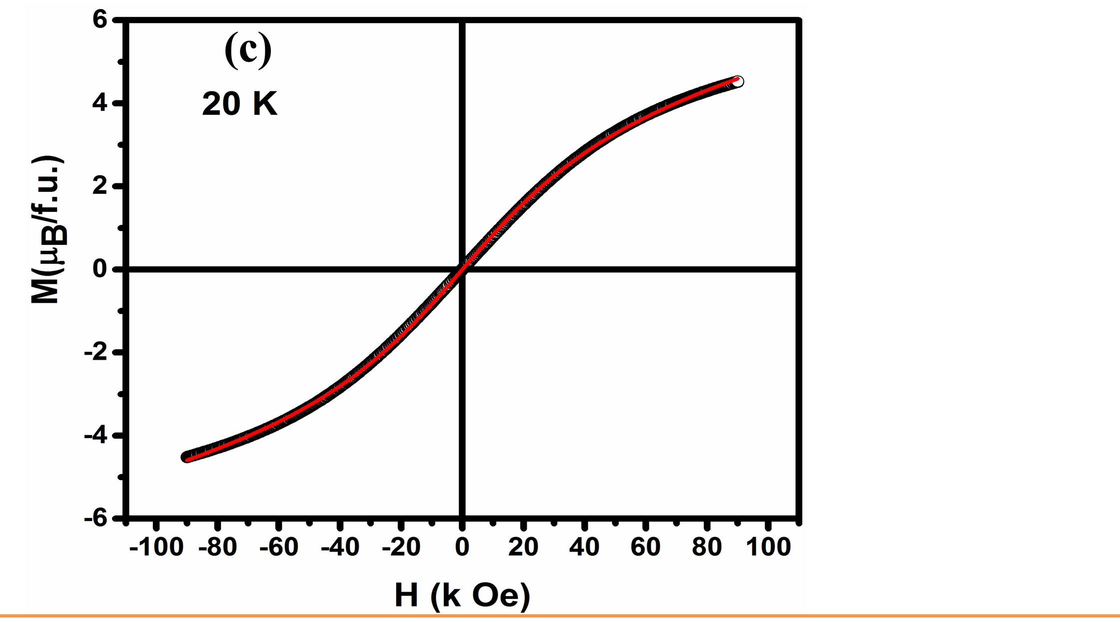


- C_p/T versus T plot shows all the transitions of DMO system.
- The peak intensity of T_N(Dy) decreases on the application of magnetic field whereas peak intensity of T_{lock} increases with increase in magnetic field in specific heat measurement

Magnetic Study







- For T > 50 K, the experimental data is fitted via Curie-Weiss law using the relation:

$\chi = \frac{C}{(T-\theta_N)}$, where C = Curie constant, θ_N= Curie temperature.

- The M-H data obtained at 3 K and 20 K are fitted using the relation:

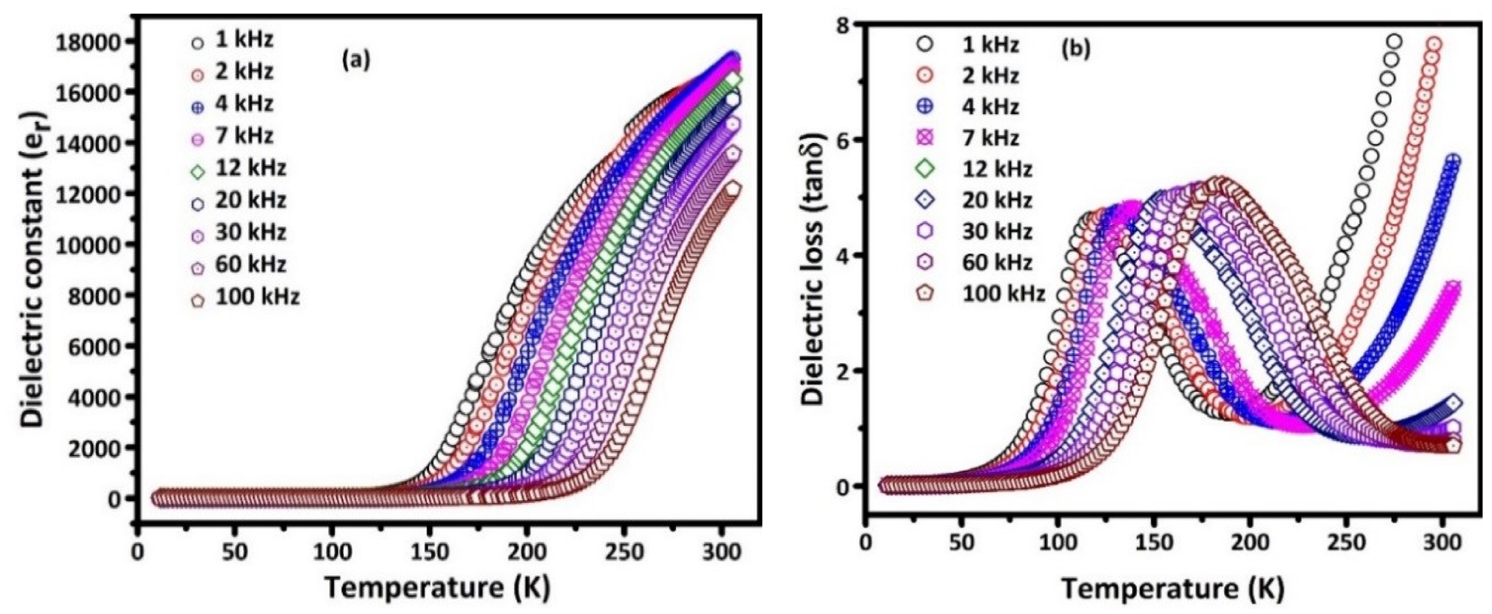
$$M(H) = \left[\frac{2M_s}{\pi}\tan^{-1}\left\{\left(\frac{H \pm H_{ci}}{H_{ci}}\right)\tan\frac{\pi M^R_{FM}}{2M^S_{FM}}\right\}\right] + \chi H$$

Where M_s, M^R_{FM} and H_{ci} are saturation magnetization, remanent magnetization and co-ercivity respectively.

Table.1 Various magnetic parameters obtained after fitting the magnetic data.

Sample	Curie-Weiss Fitting	M-H Fitting				
DGMO		Temp.	H_c (Oe)	χ (μ_B/f.u Oe)	M^S_{FM} (μ_B/f.u.)	M^R_{FM} (μ_B/f.u.)
	C = ≈ 16.54 (cm^3Kmol^{-1})	20 K	≈ 6.56	≈ 2.35× 10^{-5}	4.46	4.45× 10^{-4}
	Θ_N = ≈ -22.75 (K) μ_{eff} = ≈ 11.50μB	3 K	≈ 48.54 (FM1) ≈ 182.7 (FM 2)	≈ 5.96 × 10^{-6} ≈ 2.55 × 10^{-4}	4.92 2.92	0.012 0.043

Dielectric Study



The intrinsic dielectric behavior of the material is observed up to 160 K and above 160 K there is large increase in dielectric behavior, which may be due to the contribution from extrinsic Maxwell-Wagner polarization phenomena.

SUMMARY & CONCLUSIONS

- Acrylamide polymer gel template method has been adopted to prepare the high quality of DGMO samples without any impurity phase.
- The fitting of M-H curves give the presence of two weak FM components and AFM components at 3 K, while M-H curve at 20 K is due to single weak FM and AFM/PM contribution.
- The intrinsic dielectric behavior of the material is observed up to certain low temperature range.

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