Vibrating Sample Magnetometery Studies Modified and Doped Polyvinyl Alcohol Conjugates

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Abstract

The magnetic propertiesmodified polyvinyl alcohol conjugates and doped modified polyvinyl alcohol samples were studied.The magnetic property of the MPVAs and DMPVAs reveals that the magnetic properties of the metals ions are completely retained in the DMPVAs. The calculated value of saturation magnetizations and observed valued of saturation magnetization of all MPVA and DMPVA is near about same. It can be observed that these two values are in good agreement. These MPVAs and DMPVAs can act as flexible magnetic materials and can be permanently magnetized.

Keywords: VSM, Saturation magnetization, Remnance, Coercivity, MPVA and DMPVA

Introduction

Polyvinyl alcohol (PVA) is a water-soluble synthetic polymer, its molecular formula is $(C_2H_4O)x$, and density is between 1.19 and 1.31 g/cm^3. PVA has excellent film forming and adhesive properties. With higher humidity more water is absorbed, which acts as a plasticizer, and will then reduce its tensile strength. PVA is fully degradable and dissolves quickly. PVA has a melting point of 230°C. It decomposes rapidly above 200°C, as it can undergo pyrolysis at high temperatures [1]. PVA is used as an emulsion polymerization aid, to make polyvinyl acetate dispersions [2]. Some uses of PVA include: thickener, modifier, textile sizing agent paper coatings and release liner. When doped with iodine, PVA can be used to polarize light, and is not prepared by polymerization of the corresponding monomer. Studied optical properties of PVA coated In_2O_3 nanoparticles which were performed with photoluminescence [3]. The wider applications of PVA arise because of its chemical and physical properties. These properties come from its hydroxyl group. The hydrogen bonding between hydroxyl groups plays an important role in determining the properties of PVA. For example, high water solubility, a wide range of crystallinity, and high crystal modulus [4]. The polymer coated MNPs are expected to be hydrophilic exterior type having high water solubility and stability. The Structural and magnetic properties as well as spin dynamics of the $NiO_3.ZnO.7Fe_2O_4$ nanoparticles which is coated by the well-known biocompatible polymer, poly vinyl alcohol (PVA) have been studied [5]. The vibrating sample magnetometer (VSM), pioneered by S. Foner [6] is a simple yet effective technique for characterizing properties of magnetic materials. Due to its straight forward design and continued use among condensed matter physicists and materials scientists, the VSM provides an ideal laboratory exercise for students in an advanced materials physics course. This setup allows exploration of a common Experimental technique for measuring magnetic material properties such as hysteresis, saturation, coercivity, andanisotropy. The VSM is one of a number of techniques illustrated in our materials physics laboratory course [7] that emphasizes measurement and characterization of various materials. Poly vinyl alcohol (PVA) films filled with different concentrations of $CuSO_4$ were prepared by casting method. The optical, magnetic and morphological properties of these films were intensively investigated in this study. The optical absorption spectra were performed. The assignment of the main absorption peaks was done. The optical parameters such as the absorption coefficient, the electronic band structure, the band tail and the energy gap were estimated. The characteristic features of the electron paramagnetic resonance (EPR) spectra were discussed. The dependence of the g values, the hyperfine coupling constant, the peak to peak line width, the number of paramagnetic centers and the asymmetry ratio on filling were studied. The morphology of the polymeric films demonstrated structural modifications with filling. A correlation between the optical, magnetic and morphological properties was accomplished. Three types of Cu^{2+} were depicted in this study and were accompanied by three regions of filling, low and high FLs as well as an intermediate one, of interesting physical properties. The studied samples revealed significant changes of the physical properties with filling. This indicated the high sensitivity of these samples to filling and suggested their applicability in magnetic and optical devices [8]. Magnetic nanoparticles (MNPs)/polymer composite nanofibers were prepared via electrospinning of polyacrylic acid (PAA) / polyvinyl alcohol (PVA) aqueous solutions with homogenously dispersed magnetite Fe_3O_4 nanoparticles (NPs) [9].A study of the magnetic behavior of maghemite nanoparticles in polyvinyl alcohol polymer matrices prepared by physical cross-linking is reported [10].Thin films made from a composite of the polymer poly vinyl alcohol and cobalt oxide (Co_3O_4) nanoparticles were fabricated by spin coating [11].

Literature Survey reveals that the demands improvement of different properties of various form of MPVA materials. In the present research work, magnetic properties modified polyvinyl alcohol conjugates and doped modified polyvinyl alcohol conjugates was studied by using VSM method [12-20].

Methods and Materials

Vibrating sample magnetometer (VSM)is an excellent tool for the characterization of magnetic samples. Magnetization at varying external magnetizing fields can be accurately determined using VSM and the hysteresis behavior of the materials can be studied. Accurate determination of saturation magnetization (Ms), remnance (Mr) and coercivity (He) are possible in VSM studies. Both modified polyvinyl alcohol conjugates and doped modified polyvinyl alcohol samples were subjected to magnetic measurements using vibrating sample magnetometer at room temperature. Magnetic hysteresis was recorded and plotted for applied field varying from 0 to 15000 Oe at intervals of 150 Oe.A schematic diagram of VSM is shown in figure-1 bellow

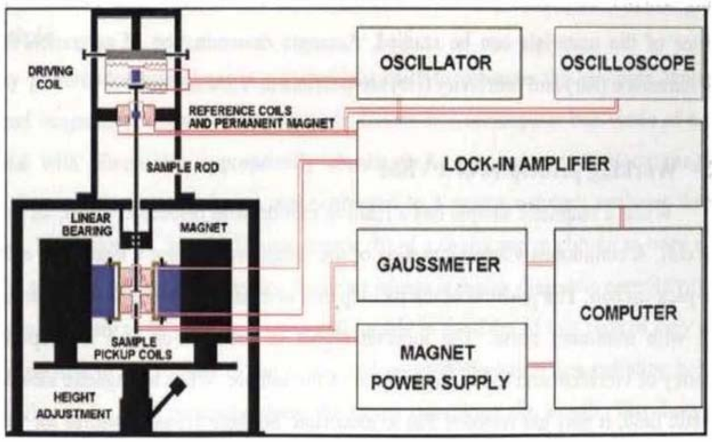

Fig.-1: schematic diagram of VSM

Results and discussions

Magnetic properties of modified polyvinyl alcohol

The magnetic properties of modified polyvinyl alcohol (MPVA) samples clearly indicate that the magnetic characteristics are observed in the MPVA samples.

1) The magnetic hysteresis of PVA and MPVA samples are shown in figure-2.
2) It was found that increase in saturation magnetization with modification of PVA.
3) The increasing order of saturation magnetization is given bellow,
   CMPVA > ACPVA > CAPVA > HEPVA.
4) Saturation magnetization of MPVA is summarized in Table-1
5) Saturation magnetization of modified PVA lies in the range of 0.48 to 0.87
6) The reason for a small enhancement in the coercivity observed in MPVAs is not clear. However it could be due to the higher shear modulus of MPVAs.
7) It was observed that the coercivity of the samples did not show any variation. Further the coercivity values remained nearly the same for all MPVAs as depicted in figure 3 which were the enlarged central region of the magnetic hysteresis loop.
8) The remanent magnetization keeps a linear variation with modification again keeping exactly the same characteristics in MPVAs

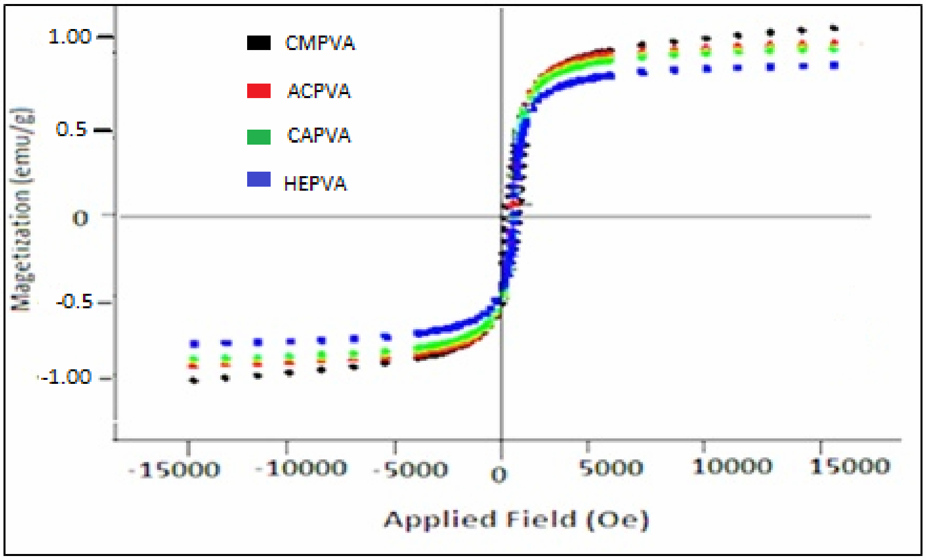

Figure-2 : Magnetic hysteresis of PVA and MPVA

Table-1: Observed and calculated magnetization of PVA and MPV

S. No.	Samples	Calculated Magnetization (emu/g)	Observed Magnetization (emu/g)
1	PVA	0.30	0.25
2	HEPVA	0.50	0.48
3	CAPVA	0.70	0.65
4	ACPVA	0.80	0.73
5	CMPVA	0.90	0.87

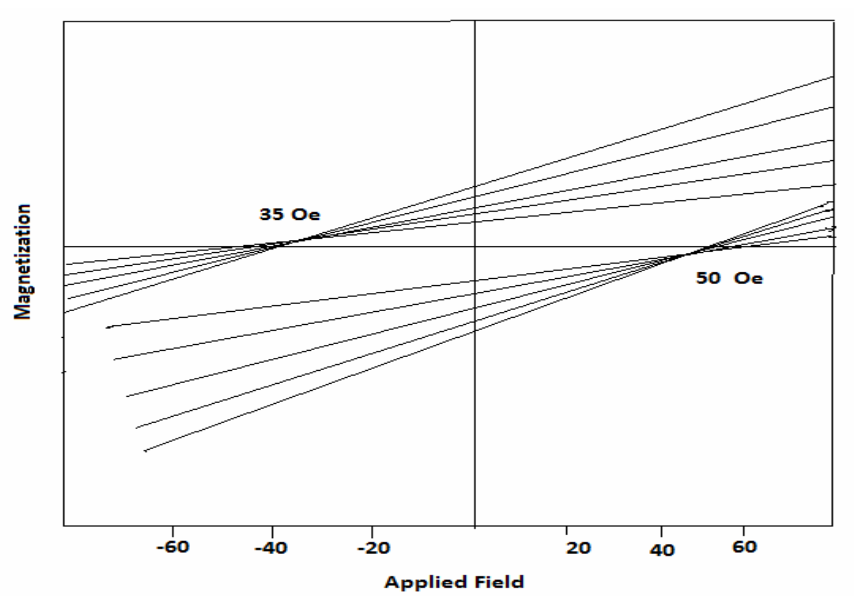

Figure-3 :Central region ofthe magnetic hysteresis of MPVAs showing the coercivity and remanant magnetizations

Magnetic properties of Doped HEPVA

The magnetic properties of doped HEPVAs samples clearly indicate that the magnetic characteristics are observed in the doped HEPVAs samples.

1) The magnetic hysteresis of doped HEPVAs samples is shown in figure-4.
2) It was found that increase in saturation magnetization with doping of HEPVAs with lanthanide metal ions.
3) The increasing order of saturation magnetization is given,
   Zn(II)- HEPVA >Cu(II)-HEPVA> Ni(II)-HEPVA >Co(II)-HEPVA > HEPVA
4) Saturation magnetization of doped HEPVAs is summarized in Table-2
5) It was observed that the coercivity of the samples did not show any variation. Further the coercivity values remained nearly the same for all doped HEPVAs as depicted in figure -5 which were the enlarged central region of the magnetic hysteresis loop.
6) The reason for a small enhancement in the coercivity observed in doped HEPVAs is not clear. However it could be due to the higher shear modulus of doped HEPVAs.
7) The remanent magnetization keeps a linear variation with modification again keeping exactly the same characteristics in doped HEPVAs.
8) The magnetic properties of doped HEPVAs samples clearly indicate that the magnetic characteristics of lanthanide metals are retained in the DMPVA samples [21].
9) The permanent magnetization keeps a linear variation with doping, again keeping exactly the same characteristics in all doped HEPVAs [22].

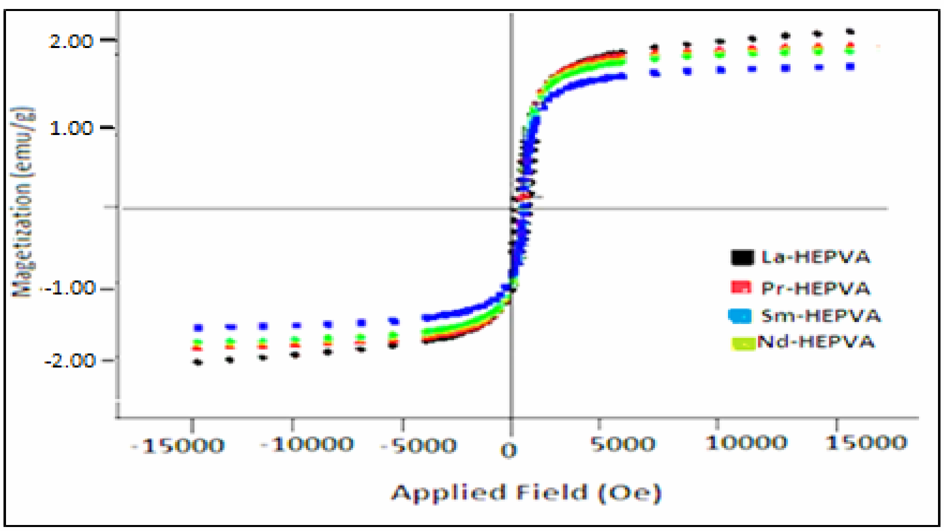

Figure-4: Magnetic hysteresis of Doped HEPVA

Table- 2: Observed and calculated magnetization of HEPVA and DHEPVA

S. No.	Samples	Calculated Magnetization (emu/g)	Observed Magnetization (emu/g)
1	HEPVA	0.50	0.48
2	HEPVA- Zn(II)	1.80	1.75
3	HEPVA-Cu(II)	1.60	1.50
4	HEPVA- Ni(II)	1.40	1.30
5	HEPVA- Co(II)	1.20	1.00

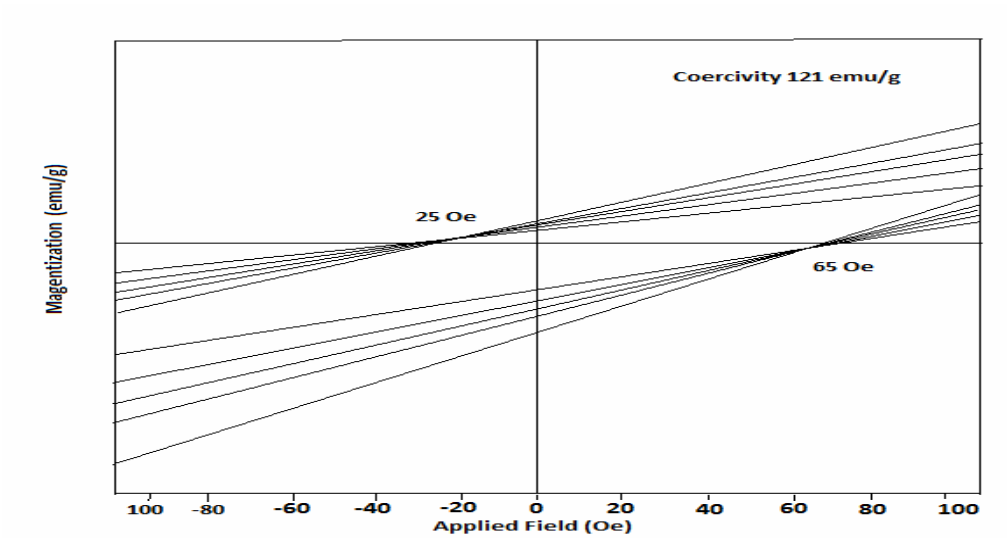

Figure-5: Central region of the magnetic hysteresis of doped HEPVA showing the coercivityand remanant magnetizations

Magnetic properties of Doped CMPVA

The magnetic properties of doped CMPVAs samples clearly indicate that the magnetic characteristics are observed in the doped CMPVAs samples.

1) The magnetic hysteresis of doped CMPVAs samples is shown in figure-6.
2) It was found that increase in saturation magnetization with doping of CMPVAs with lanthanide metal ions.
3) The increasing order of saturation magnetization is given,
   Zn(II)- CMPVA > Cu(II)-CMPVA> Ni(II)-CMPVA > Co(II)-CMPVA > CMPVA
4) Saturation magnetization of doped CMPVAs is summarized in Table-3
5) It was observed that the coercivity of the samples did not show any variation. Further the coercivity values remained nearly the same for all doped CMPVAs as depicted in figure -7 which were the enlarged central region of the magnetic hysteresis loop.

6) The reason for a small enhancement in the coercivity observed in doped CMPVAs is not clear. However it could be due to the higher shear modulus of doped CMPVAs.
7) The remanent magnetization keeps a linear variation with modification again keeping exactly the same characteristics in doped CMPVAs
8) The magnetic properties of doped CMPVAs samples clearly indicate that the magnetic characteristics of lanthanide metals are retained in the doped CMPVAs samples [21].
9) The permanent magnetization keeps a linear variation with doping, again keeping exactly the same characteristics in all doped CMPVAs [22].

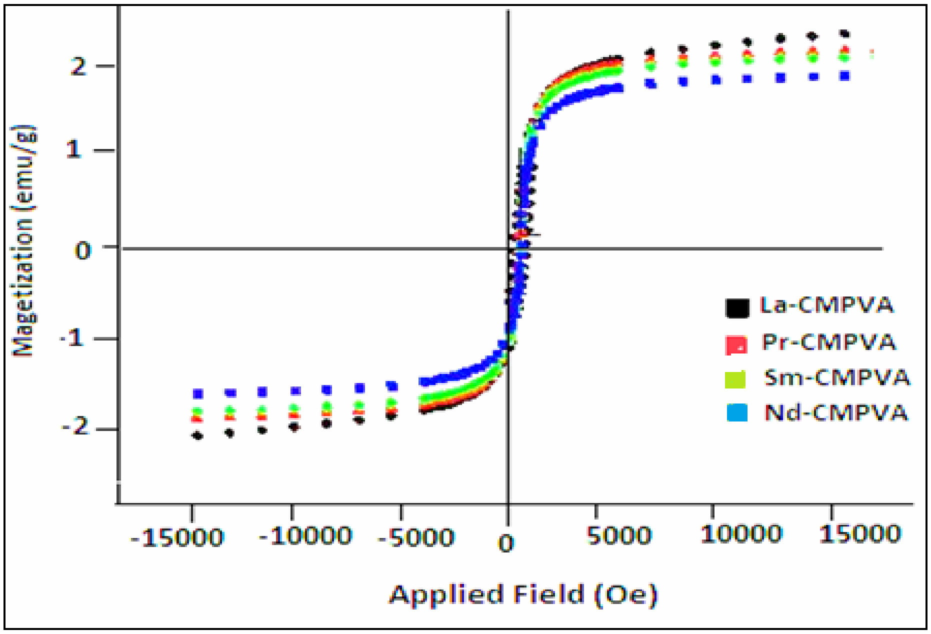

Figure-6: Magnetic hysteresis of Doped CMPVA

Table-3 : Observed and calculated magnetization of CMPVA and DCMPVA

S. No.	Samples	Calculated Magnetization (emu/g)	Observed Magnetization (emu/g)
1	CMPVA	0.90	0.87
2	CMPVA – Zn(II)	2.5	2.1
3	CMPVA –Cu(II)	2.00	1.9
4	CMPVA – Ni(II)	1.5	1.5
5	CMPVA – Co(II)	1.80	1.75

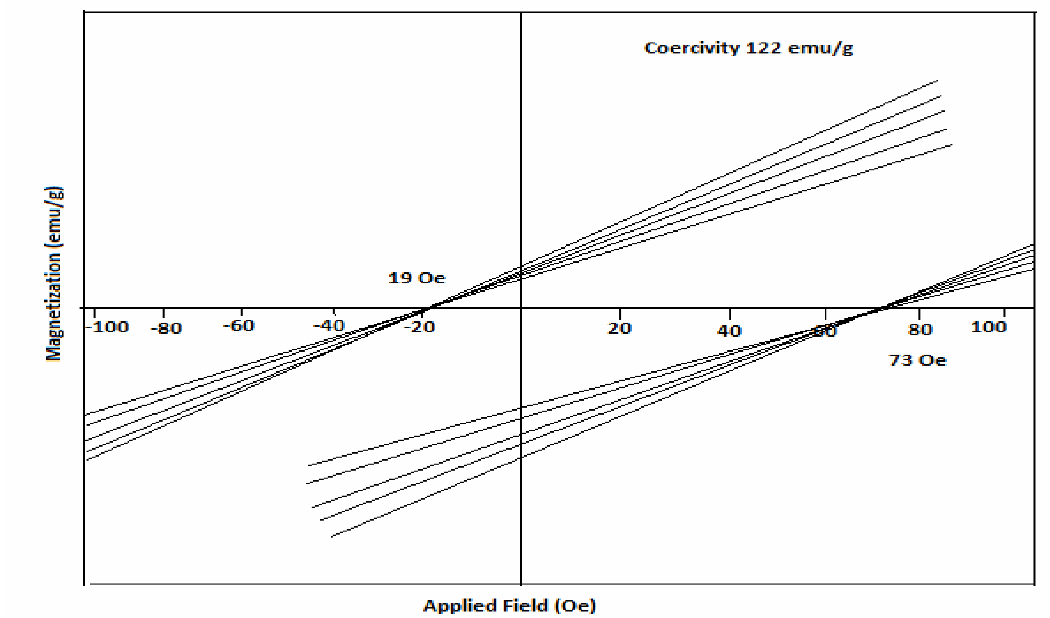

Figure-7: Central region of the magnetic hysteresis of doped CMPVA showing the coercivity and remanant magnetizations

Conclusion:

Evaluation of the magnetic properties of the MPVAs and DMPVAs reveals that the magnetic properties of the metals ions are completely retained in the DMPVAs. The calculated values of saturation magnetizations of all MPVA and DMPVA are presented in Table 1, 2 and 3 (MVPAs and DMPVAs respectively) along with the measured saturation magnetization of each sample of MPVAs and DMPVAs. It can be observed that these two values are in good agreement. These MPVAs and DMPVAs can act as flexible magnetic materials and can be permanently magnetized [23-25].

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