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High Temperature Weak Ferromagnetism in Fe Doped $PbTiO_3$

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Abstract—*$PbTiO_3$ has attracted considerable research interest in the recent years because of its high value of spontaneous electric polarization and high ferroelectric T_C (495 °C). It is among one of the potential candidates for type-I multiferroic-a material where ferroelectricity and ferromagnetism (FM) co-exist simultaneously in the same phase of material at room temperature. However, $PbTiO_3$ is not magnetic, and literature suggests magnetism can be induced in $PbTiO_3$ at the expense of its ferroelectric nature. Hence it is very challenging to induce magnetism in $PbTiO_3$ without deteriorating its ferroelectric nature. Here we report the observation of room temperature weak FM in Fe doped $PbTiO_3$ compounds. $PbTi_{1-x}Fe_xO_3$ (x = 0 - 0.3) compounds were prepared by solid state method. As per the XRD patterns, samples are in single phase and the patterns could be Rietveld refined using P4mm space group in tetragonal unit cell. Lattice parameter a increases, while c and tetragonality (c/a) decreases with increase in Fe concentration upto x = 0.25. As per the temperature variation of magnetization, x = 0.25 and 0.3 undergoes a transition to paramagnetic state at 653 K. The susceptibility data in paramagnetic region could be fitted to Curie-Weiss law with negative Curie temperature. Such negative Curie temperature and unsaturated hysteresis (M-H) loop revealed the weak-FM nature. The observed weak-FM is due to the competition between superexchange interaction in Fe^{3+}-O^{2-}-Fe^{3+} networks and Dzyaloshinskii-Moriya (DM) antisymmetric exchange interaction. A decreasing trend in temperature variation of coercivity with decrease in temperature below 150 °C is attributed to the reduction in the effective magnetocrystalline anisotropy due to magneto-electric coupling provided by DM interaction. The M-H loops were analyzed using the law of approach to saturation, and the temperature dependence of saturation magnetization, magnetocrystalline anisotropy constant will be presented.*