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Probing ferroelectricity and magnetoelectric effect in RMnO3 (R = Tb, Dy) by Fe3+ B-site substitution

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Multiferroics, where spontaneous long-range magnetic and polar orderings coexist, represent an attractive class of compounds combining rich physics with potential for multifunctional applications. TbMnO3 and DyMnO3 are multiferroics compounds exhibiting magnetic ordering of Mn3+ ions, with a sinusoidal modulated collinear structure below TN = 41K and 39K, and a cycloidal one below Tlock = 27K and 18K, respectively, which is accompanied by the emergence of spontaneous electric polarization [1,2], accordingly to the Dzyaloshinskii-Moriya model [3].
Usually, the magnetoelectric coupling has rather small magnitude. However, larger magnetoelectric effect can be found in frustrated magnetic materials. In rare-earth perovskite manganites, the magnetic frustration can be induced by modifications of exchange interactions among nearest and next-nearest neighbors of Mn3+. To tune the balance between these ferro and antiferromagnetic interactions, we have studied the effect of Mn3+ substitution by Fe3+ on selected physical properties of TbMn1-xFexO3, with x = 0 to 0.05, and DyMn1-yFeyO3, with y = 0 to 0.03, since Fe3+ has the same ionic radius as Mn3+ but it is not Jahn-Teller active. This substitution induces small structural distortions and changes the magnetic interactions, which play an important role on the magnetoelectric properties.
We have found that already at x = 0.05 and y = 0.03 the ferroelectricity is lost. Interestingly though, within this range, as x/y increases there is a strong increase of the magnetoelectric effect. The polarization becomes so sensible to the magnetic field, that for the highest x/y, it can be almost suppressed. The magnetoelectric (x/y, T) phase diagrams are proposed.

1 N Aliouane et al 2008 J. Phys.: Condens. Matter 20 434215
2 T Kimura and Y Tokura 2008 J. Phys.: Condens. Matter 20 434204
3 Cheong SW and Mostovoy M 2007 Nature Materials Jan 6(1):13-20

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