Magnetic Field Induced Ferroelectric Transition of Quasi One-Dimensional Frustrated Quantum Spin Chain System $Rb_2Cu_2Mo_3O_{12}$

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Magnetic and dielectric properties have been studied for quasi one-dimensional spin 1/2 systems which are formed of edge-sharing CuO_4 square planes called CuO_2 ribbon chains. Due to the geometrical characteristic of the crystal structure of these systems, the nearest-neighbor exchange interaction J_1 between spins is relatively weak and often ferromagnetic, and the second neighbor interaction J_2 is antiferromagnetic. Under these situations, the helical ordering is often realized. Actually, $LiVCuO_4$ with the CuO_2 ribbon chains has the helical magnetic structure. For $LiVCuO_4$, we found that ferroelectric transition takes place simultaneously with a magnetic transition at T_N=2.4 K (multiferroic) [1] as theoretically discussed in ref. 2. We have also found that $PbCuSO_4(OH)_2$ with the CuO_2 ribbon chains has the helical magnetic structure and multiferroic behavior [3,4]. The quantum spin system can be considered as a new kind of multiferroics which may provide different aspects of physics from classical spin systems consisting of Fe^{3+} and Mn^{3+} with $S > 1$.

Here, magnetic and dielectric properties of $Rb_2Cu_2Mo_3O_{12}$ with CuO_2 ribbon chains are presented. The system does not exhibit a magnetic transition owing to quantum fluctuation and low dimensionality of crystal structure. We have observed anomalous increase of dielectric constant ε with decreasing T below ~50 K, which is originated from growing a short range ordering of a helical magnetic structure. For an external magnetic field $H > 0.1$ T, a peak structure is observed in the ε-T curve of $Rb_2Cu_2Mo_3O_{12}$ at T_c~8 K and the ferroelectric polarization has been observed below T_c. However, the temperature dependence of magnetic susceptibility and specific heat do not have anomaly at T_c in the magnetic field. These results indicate that the ferroelectric transition is found to be induced by applying field without magnetic transition. Then, these results strongly suggest that the magnetic field induced ferroelectric transition is a new type ferroelectric transition triggered by the magnetism of frustrated quantum spin systems.

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Figure caption
Temperature dependence of polarization of $Rb_2Cu_2Mo_3O_{12}$ taken under various magnetic fields.