CHARACTERIZATION OF TWIN FERROMAGNETIC CLUSTERS: HIGH FREQUENCY ESR INVESTIGATION

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Introduction

One of the most interesting points of spin tunneling is a possible parity effect caused by the phase factor of the wave functions. The phase factor changes/keeps the sign in odd/even spin systems, when a spin flips from upward to downward. Recently, we have succeeded in obtaining a high quality single crystal of Cr-doped Mn_{12}ac and found some evidence of parity effect in magnetization process. A ferromagnetic cluster Mn_{12}ac is a single molecular magnet with S=10 ground state. The ground state of Cr-doped Mn_{12}ac was found to be S=19/2. It is surprising that the anisotropy parameters of both systems are very close each other, which was found by our preliminary ESR measurement.

A set of spin systems with odd and even spin numbers with nearly identical spin Hamiltonian parameter will be ideal to study a parity effect of spin tunneling. The present system is very important candidate for such research and intensive experimental investigations are on going. To complete those study, we have examined the spin Hamiltonian parameter of the system very precisely by using high frequency ESR in a steady field, where a fine angular dependence measurement is possible.

Experimental

Single crystals of Cr-doped Mn_{12}ac have been used for ESR measurement. A simple transmission type ESR spectrometer and a quasi-optical ESR system have been used at the frequency of 285 GHz A 12 tesla superconducting magnet of EMR laboratory has been used for the experiments.

Results and Discussion

When a magnetic field is applied to the crystal c-axis, it is found that the anisotropy parameter D of the spin Hamiltonian is identical with that of un-doped Mn_{12}ac. A small splitting is found when a magnetic field is slightly tilted from the c-axis. It indicates that the easy axes of the molecules have a distribution in a single crystal and that the distribution is very small. This fact indicates that the lowering of the symmetry of each molecule is much suppressed, when one of Mn^{3+} ions is replaced by Cr^{3+} ion. It is strange because the anisotropy of a Cr^{3+} ion is much smaller than that of a Mn^{3+} ion. A possible mechanism is a sort of chemical pressure. Namely, the Cr-substituted molecule cannot distort much by the chemical pressure of surrounding non- substituted Mn_{12} clusters. The analysis of the peak intensity of the present ESR measurement indicates that the crystal contains both $Mn_{11}Cr$ and Mn_{12} clusters and the content of non-substituted and substituted clusters are nearly 1:1. If the arrangement of clusters is nearly random, a checker-board like stacking of two types of molecules can be happen. In this case, the $Mn_{11}Cr$ cluster cannot distort freely because of the chemical pressure from the surrounding Mn_{12} clusters.

Conclusions

By using a high frequency ESR, we have investigated the $Mn_{11}Cr$ ferromagnetic cluster. We found that the distortion of the cluster is much suppressed when it is embedded in the Mn_{12} clusters. This finding shows a possible symmetry control of molecular magnets by using a chemical pressure and ions substitution. The investigation of real space arrangement of twined molecules remains for future investigations.

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