MAGNETIC TORQUE MEASUREMENT OF ANTIFERROMAGNETIC TRANSITION IN MOLECULAR CONDUCTORS USING A MICROCANTILEVER

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Introduction

A series of BETS salts, where BETS is bis(ethylenedithio)tetrathiafulvalene, is a good candidate for a systematic study of π-d interaction between the conduction electrons and local magnetic moments in organic molecular conductors. The anion part, MX₄⁻ (M = Ga, Fe; X = Cl, Br), can be continuously replaced to form mixed crystals with compositions, FeₐGa₁₋ₐBrₓCl₄₋ₓ. In case of the replacement of magnetic Fe with nonmagnetic Ga, only iron-rich mixed crystals show antiferromagnetic transition at low temperature. Since κ-(BETS)₂FeCl₄ was reported to exhibit successive antiferromagnetic and superconducting transitions (T_N = 0.45 K, T_C = 0.1 K) without magnetic field[1], we can expect to elucidate an interplay between magnetism and superconductivity in the π-d system. However, the magnetic easy axis of κ-(BETS)₂FeCl₄ is not clear. Although Otsuka reported that the easy axis is almost parallel to the a axis [1], there were several reports in which the easy axis was parallel to the b axis.[2-4] So the determination of magnetic easy axis was the most crucial problem. Therefore, we tried to measure magnetic torque using AFM microcantilever, which method is so sensitive that it only needs a tiny crystal less than 1 µg.[5]

Experimental

We performed the magnetic torque measurements of various magnetic transitions such as spin flop transitions at SCM1, between 20-1000 mK. We mount a very tiny single crystal with a small amount of resin on a piezo resistive microcantilever for atomic force microscopy (AFM) developed by Seiko Instruments Inc. We prepared several microcantilevers with crystals mounted in various orientations. The AFM microcantilevers were mounted on a sample rotator of SCM1 and measured to determine the precise direction of magnetic easy axis.

Results and Discussion

Since κ-(BETS)₂FeCl₄ was reported to exhibit successive antiferromagnetic and superconducting transitions (T_N = 0.45 K, T_C = 0.1 K) without magnetic field[1], we tried to detect the signals from these transitions. At first, we tried to find the spin flop signal by rotating sample in several directions. The signals changed drastically near the a-axis. Then we tried to scan magnetic field and the signals which can be caused from spin flop antiferromagnetic transition was observed around 0.3-0.4 T below 360 mK, but disappeared over 450 mK. We also tried to scan magnetic field around the b- and c-axes, however, we could not observe sharp signals like the case of a-axis direction. The magnetic field 0.37 T where the spin flop signal observed in the a-axis seems to be smaller than the field reported in the previous paper.[3] A similar tendency was observed in κ-(BETS)₂FeBr₄. In this salt, the antiferromagnetic transition field estimated from SQUID measurement was 1.6 T [6], but the transition field from microcantilever measurement was 1.24 T.

Conclusions

The direction of magnetic easy axis we decided was parallel to the a axis, and we also confirmed that κ-(BETS)₂FeCl₄ shows antiferromagnetic transition below 360 mK with the spin-flop field around 0.37 T. However, no superconducting evidence was observed down to 20 mK, in spite of several trials with various batch of samples.

References