HIGH FIELD ESR STUDY OF THE π-d INTERACTION EFFECT IN β – (BDA-TTP)$_2$MCl$_4$ (M=Fe,Ga)

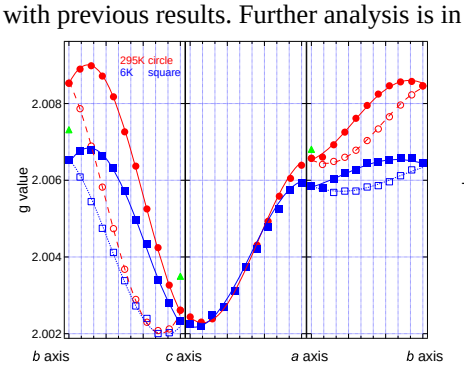
T. Tokumoto (FSU, Physics/NHMFL); J. van Tol (FSU/NHMFL); L-C. Brunel (NHMFL); E. S. Choi (NHMFL); J. S. Brooks (FSU, Physics/NHMFL); J. Yamada (U of Hyogo, Material Science); H. Akutsu (U of Hyogo, Material Science); T. Kaihatsu (U of Hyogo, Material Science)

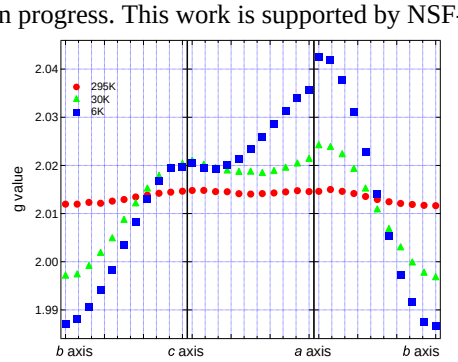
Introduction

Novel magnetic organic conductors with π-d interaction have commanded attention since the discovery of field induced superconductivity[1]. One of them, β-(BDA-TTP)$_2$FeCl$_4$, has alternating donor molecules and quasi 2D electrical properties, where BDA-TTP is 2,5-bis(1,3-dithian-2-ylidene)-1.3.4.6-tetrathiapentalene[2]. Previous studies of electrical and magnetic properties show a Metal-Insulator transition at 120K and an AF transition at T_N=8.5K, suggesting an exchange interaction between the conduction electrons and the Fe^{3+} d-electrons. The properties of β-(BDA-TTP)$_2$GaCl$_4$ are similar with the exception of the absence of the AF transition, which is apparently due to the absence of the π-d exchange interaction. We report angular/temperature dependent 240 GHz EPR measurements on both compounds to probe the magnetic properties.

Experiment, Results and Discussion

β-(BDA-TTP)$_2$MCl$_4$ single crystals are synthesized and provided by the Yamada group. The typical size of the samples is 0.1mm* 50um*1mm along the a, b, c axes, respectively. Angle/temperature dependent measurements on single crystals are carried out on a home built quasi-optical superheterodyne EPR spectrometer with a continuous He-flow system (from 2.5K to room temp) at the EMR facility. The angle dependence of the effective g values of the Ga compound at room temperature (red) and 6K (blue) are shown in Fig.1. The Ga compound exhibits two separate signals at high frequency (240GHz) (open and closed symbols), which merge on the mirror plane, and which can be assigned to each set of the alternating planes of donor molecules in which their molecular axes have a different orientation. This indicates that the inter-plane interaction is vanishingly small. We obtained the g anisotropy of the donor molecules from room temperature data. The largest g value corresponds with the longer axis of the donor molecule plan. The temperature dependent shift of the effective g values can be explained by a combination of demagnetization fields and an interplane coupling of the order of 2mK.
Fig.2 shows an angular dependence of the effective g value of the Fe compound in the paramagnetic metallic (red), the paramagnetic insulating (green), and the AF insulating (blue) states. Due to the addition of the localized spin from Fe^{3+} (S=5/2), angular/ temperature dependence of the Fe compound has no similarity with the Ga compound and no separate signals from the donor molecules can be observed, pointing to a significant π-d exchange interaction. The largest g value is observed in the direction of the Fe^{3+} chain along the a axis. Fig. 3 shows the temperature dependence of the effective g value along each crystal axes. Temperature dependence shows that the easy axis lies close to c axis, which is in good agreement with previous results. Further analysis is in progress. This work is supported by NSF-DMR 0602859 /0520481.





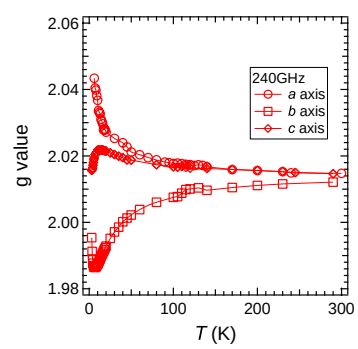


Fig. 1. Angular dependence of g value (Ga). Fig. 2.Angular dependence of g value (Fe). Fig. 3. Temp. dependence (Fe)

References

[1] Uji, S., *et al.*, Nature, **410**, 908-910 (2001).
[2] Yamada, J., *et al.*, Synth. Met., **133-134**, 189-191 (2003); Choi, E. S., *et al.*, Phys. Rev. B, **70**, 024517 1-8 (2004); Yamada, J., *et al.*, Chem. Commun., **2003**, 2230-2231 (2003).