(O1-11)

Electronic Properties of Heavy Rare Earth Based Filled Skutterudites LnFe$_4$P$_{12}$

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The heavy rare earth based filled skutterudites LnFe$_4$P$_{12}$ (Ln=Ho, Tb, Tm, Yb) synthesized at high temperatures and high pressures have been characterized by specific heat, thermoelectric power and electrical resistivity measurements. Figure 1(a) shows the specific heat divided by temperature C/T of HoFe$_4$P$_{12}$ and TbFe$_4$P$_{12}$. The C/T of HoFe$_4$P$_{12}$ and TbFe$_4$P$_{12}$ exhibit a sharp anomaly due to the ferromagnetic ordering at 4.5 K and 10 K, respectively [1,2]. The variation of magnetic entropy below T_C is close to Rln4 for HoFe$_4$P$_{12}$ and TbFe$_4$P$_{12}$. Therefore, their CEF ground state are suggested to be quasi-quartet or quasi-quintet. Figure 1(b) shows the C/T of TmFe$_4$P$_{12}$ and YbFe$_4$P$_{12}$ (sample #1). TmFe$_4$P$_{12}$ exhibits a paramagnetic behavior down to 2 K [1]. The C/T of TmFe$_4$P$_{12}$ has a shoulder around 30 K and increases below 7 K. The shoulder around 30 K is related to the CEF Schottky anomaly. The increasing below 10 K is easily suppressed by applying field. For YbFe$_4$P$_{12}$, intermediate valence states between Yb^{2+} and Yb^{3+} is suggested from the lattice parameter and the magnetic susceptibility. The specific heat measurement reveals the increasing of C/T below 8 K and the λ-type anomaly at $\sim$ 0.7 K [3]. Recently, we found the strong sample dependence of the peak height observed at $\sim$ 0.7 K. In the micro-focus XRD measurements on the sample #2 (not shown) that indicates a larger peak at $\sim$ 0.7 K than that of sample #1, we confirmed impurity phases of YbP and FeP$_4$. Therefore, we consider that the anomaly observed at $\sim$ 0.7 K is attributed to a small amount of impurity YbP that indicates a very sharp peak at T_N=0.53 K [4]. We can consider that the increasing of C/T below 8 K and the resistivity minimum around 50 K is intrinsic.

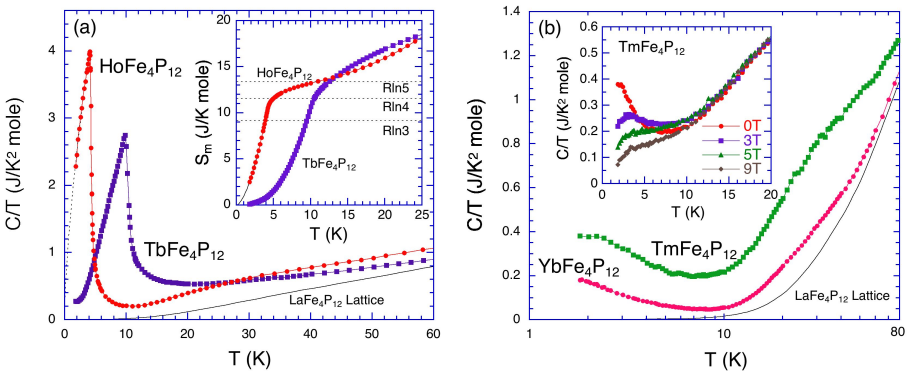

Figure 1: (a) Specific heat divided by temperature C/T of HoFe$_4$P$_{12}$ and TbFe$_4$P$_{12}$. Inset shows the temperature dependence of magnetic entropy. (b) C/T of TmFe$_4$P$_{12}$ and YbFe$_4$P$_{12}$ (sample #1). Inset shows the C/T of TmFe$_4$P$_{12}$ under a magnetic field.

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