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Specific heat of Sm-based filled skutterudite phosphides SmT_4P$_{12}$ (T=Fe, Ru and Os)

K. Matsuhira[1], Y. Doi[2], M. Wakeshima[2], Y. Hinatsu[2], H. Amitsuka[3], Y. Shimaya[4], G. Ram[4], C. Sekine[4] and I. Shirotani[4]

1 - Faculty of Engineering, Kyushu Institute of Technology,
Kitakyushu, 804-8550, Japan
2 - Division of Chemistry, Graduate School of Science, Hokkaido University,
Sapporo, 060-0810, Japan
3 - Division of Physics, Graduate School of Science, Hokkaido University,
Sapporo, 060-0810, Japan
4 - Department of Electrical and Electronic Engineering, Muroran Institute of Technology
Muroran, Hokkaido, 050-8585, Japan

Sm-based filled skutterudite phosphides SmT_4P$_{12}$ (T=Fe, Ru and Os) synthesized at high temperatures and high pressures have been studied by specific heat measurements in a magnetic field. Figure 1 shows the temperature dependence of magnetic specific heat. $SmFe_4P_{12}$ shows an anomaly at 1.5 K attributed to a ferromagnetic transition [1]. $SmRu_4P_{12}$ has a large peak due to metal-insulator transition at 16 K [2]. This transition is caused by two successive transitions, which suggest an orbital ordering and antiferromagnetic ordering [3,4]. $SmOs_4P_{12}$ indicates a sharp anomaly at 4.5 K due to an antiferromagnetic ordering [5]. These compounds have a broad peak at $\sim$ 30 K which is considered to be a Schottky anomaly. The level splitting of crystalline electric fields (CEF) is estimated to be $\sim$ 70 K. The magnetic entropy in $SmRu_4P_{12}$ and $SmOs_4P_{12}$ reaches nearly Rln4 at the ordering temperature. Therefore, the CEF ground state for $SmRu_4P_{12}$ and $SmOs_4P_{12}$ is Γ_{67} quartet. Interestingly, the variation of magnetic entropy in $SmFe_4P_{12}$ is only $0.16R$ln2 below the ferromagnetic ordering temperature: this is consistent with the previous result of single crystal prepared by a flux growth method [1]. It should be noted that the magnetic specific heat shows a shoulder at $\sim$ 10 K (See Fig. 1). This suggests a local spin fluctuation of 20 K. From the temperature dependence of magnetic entropy, the CEF ground state of $SmFe_4P_{12}$ is considered to be Γ_5 doublet rather than Γ_{67}.

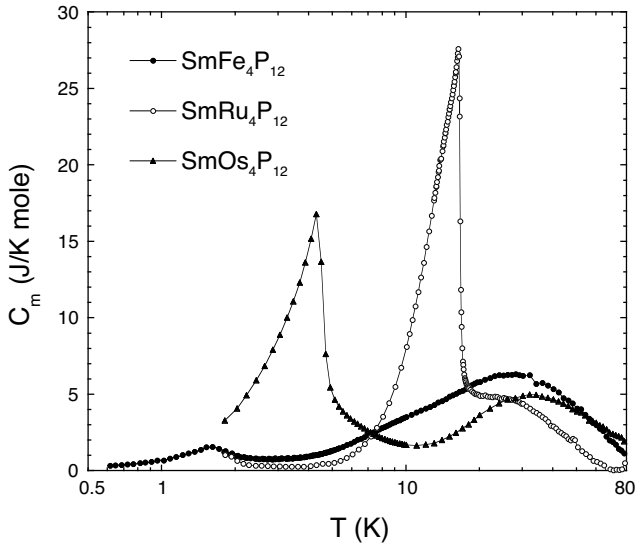

Figure 1: Magnetic specific heat of SmT_4P$_{12}$ (T=Fe, Ru and Os)

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