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High-pressure synthesis, Electrical and Magnetic Properties of New Filled Skutterudites

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Filled skutterudites $\text{LnT}_4\text{X}_{12}$ (Ln = lighter lanthanide, T = Fe, Ru and Os, X = P, As and Sb) show superconducting, semiconducting, metal-insulator transition, magnetic ordering, heavy fermion, intermediate-valence and non-Fermi liquid behavior at low temperatures. Further, skutterudite compounds exhibit the remarkable thermoelectric properties. These materials crystallize in a filled skutterudite-type structure (cubic, space group: $\text{Im}\bar{3}$). Filled skutterudites with lighter lanthanide were frequently prepared by fluxed methods. By use of a wedge-type cubic-anvil high-pressure apparatus, new filled skutterudites with heavy lanthanide, $\text{LnFe}_4\text{P}_{12}$ (Ln = Tb, Dy, Ho, Er, Tm, Yb, Lu and Y) were systematically prepared by reaction of stoichiometric amounts of each metal and red phosphorus powders at pressures between 4 and 5 GPa. Figure 1 shows the relationship between lattice constants and atomic numbers of lanthanide (including Y). The lattice constants of $\text{LnFe}_4\text{P}_{12}$ (Ln = lanthanide) basically decrease with increasing atomic number. However, some anomalies in this curve are observed for Ce, Eu and Yb compounds. These may closely be related to the valence states in the materials. Figure 2 shows dc magnetic susceptibility and inverse susceptibility of $\text{DyFe}_4\text{P}_{12}$ measured in a magnetic field of 1 tesla (T) at low temperatures. The susceptibility of $\text{DyFe}_4\text{P}_{12}$ follows a Curie-Weiss behavior at high temperatures. The magnetic feature at around 10 K in $\text{DyFe}_4\text{P}_{12}$ suggests the occurrence of ferromagnetic ordering below this temperature. The new compound $\text{YFe}_4\text{P}_{12}$ shows a superconducting transition at around 7 K.

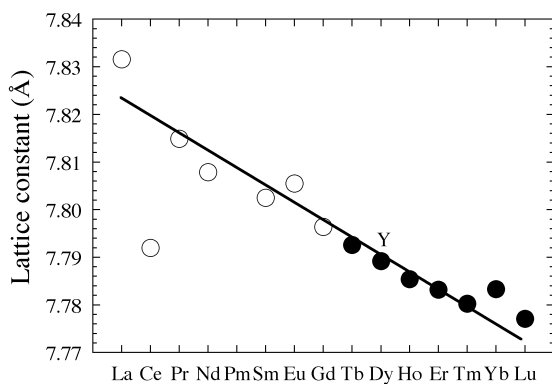


Figure 1: Relationship between lattice constants and atomic numbers of lanthanide (including Y).

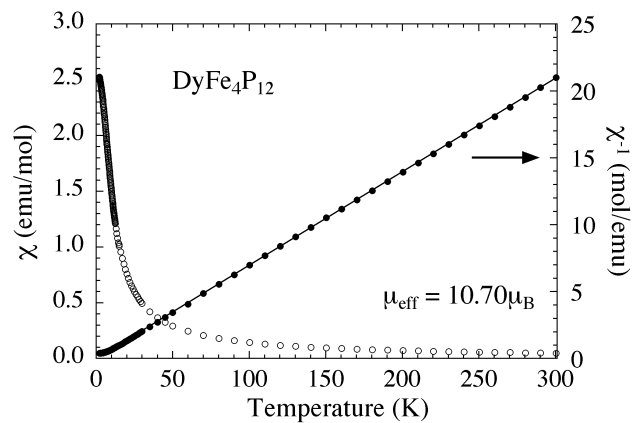


Figure 2: Magnetic susceptibility and inverse susceptibility of $\text{DyFe}_4\text{P}_{12}$ measured in a magnetic field of 1 tesla (T) at low temperatures.