Violation of Kohler's rule in Ta_2PdTe_6 and absence of same in Nb_2PdS_5: A high field magneto transport study

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Abstract. Here, we present the comparative study of magnetotransport properties of recently discovered Ta_2PdTe_6 and Nb_2PdS_5 superconductors. The XRD and magnetotransport measurements are performed on these samples to investigate structure and superconducting properties as well as normal state transport properties of these compounds. Both the compounds are crystallized in monoclinic structure within space group C 2/m. Here, we observe superconductivity in both the compounds Ta_2PdTe_6 (T_c =4.4 K) and Nb_2PdS_5 (T_c =6.6 K). We see a linear magnetoresistance in Ta_2PdTe_6 as well as violation of Kohler's rule in same compound. On the other hand, we find the absence of same in Nb_2PdS_5 compound.

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INTRODUCTION

The recently discovered Quasi 1 D chain containing compounds $(Nb/Ta)_2Pd_x(S/Se/Te)_y$ have attracted lot of attention in scientific community due to their low dimensional structures. $Ta_4Pd_3Te_{16}$ compound has been reported to be superconducting with T_c=4.5 K.[5] The several parameters such as structure, upper critical field and charge carrier type are important for understanding superconducting mechanism in any new superconductor. It has been shown in earlier reports that the significant impact of spin orbit coupling along with multiband effect on large upper critical field [3]. The first principle calculation of electronic structure provides evidence of multiband nature of Nb_2PdS_5 superconductor [1]. The normal state property i.e. magnetoresistance is very important in understanding the behavior of charge carriers [7]. Recently, Xiao feng et. al. have showed the presence of quasi linear magnetoresistance and violation of Kohler's rule in $Ta_4Pd_3Te_{16}$ compound.[6]

In this context, we have compared the magnetoresistance in normal state of Ta_2PdTe_6 and Nb_2PdS_5 compound. We have observed the presence of quasi linear magnetoresistance in Ta_2PdTe_6 while absence of same in Nb_2PdS_5 compound. Additionally, we have also found the violation of Kohler's rule in Ta_2PdTe_6 compound.

EXPERIMENTAL

Polycrystalline Ta_2PdTe_6 and Nb_2PdS_5 compounds have been synthesized via solid state reaction route followed by same procedure described in earlier reports [2, 4]. Room temperature XRD patterns have been recorded with Rigaku X-ray diffractometer using Cu Kα line of 1.54184 Å. The electrical measurements and detail study of magneto resistance in normal state have been performed with Quantum design Physical property measurement system (PPMS) equipped with 14 T superconducting magnet.

RESULTS AND DISCUSSION

Figure 1 represents the room temperature X-Ray diffraction (XRD) patterns for synthesized Ta_2PdTe_6 and Nb_2PdS_5 compounds. The crystal structure of studied samples has been determined by Rietveld refinement of room temperature XRD data using Fullprof software. Both the compounds are found to be well crystallized in monoclinic C2/m structure. The XRD peaks are found to be well matched with our previous work on same compounds.

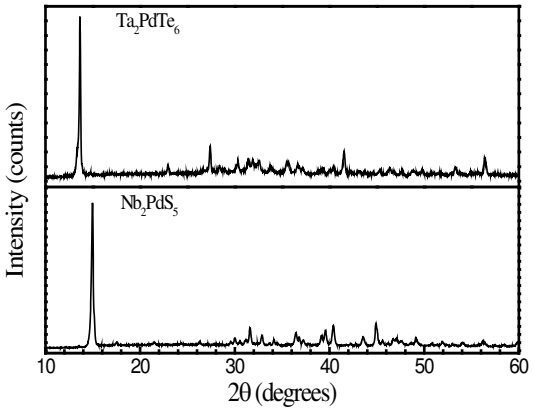

Figure 1: Room temperature XRD pattern for Ta_2PdS_5 and Nb_2PdS_5 compounds.

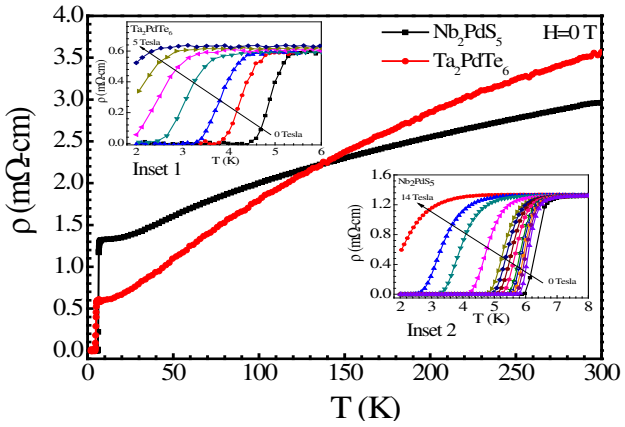

Figure 2: T dependence of resistivity ρ(T) for Ta_2PdTe_6 and Nb_2PdS_5 under zero applied magnetic field in range 2 K to 300 K. The inset 1 shows the same under different applied magnetic fields for Ta_2PdTe_6. The inset 2 shows the same under the applied magnetic field for Nb_2PdS_5.

Figure 2 represents the temperature dependence of resistivity for Ta_2PdTe_6 and Nb_2PdS_5 compounds. Ta_2PdTe_6 and Nb_2PdS_5 clearly exhibit a metallic behaviour with T_c =4.4 K and T_c =6.6 K where ρ=0. For both the compounds the zero resistivity point shifts clearly towards lower temperature with increase of applied magnetic field as shown in insets 1 and 2. Clearly, the effect of magnetic field is weak on Nb_2PdS_5 in comparison to Ta_2PdTe_6 compound.

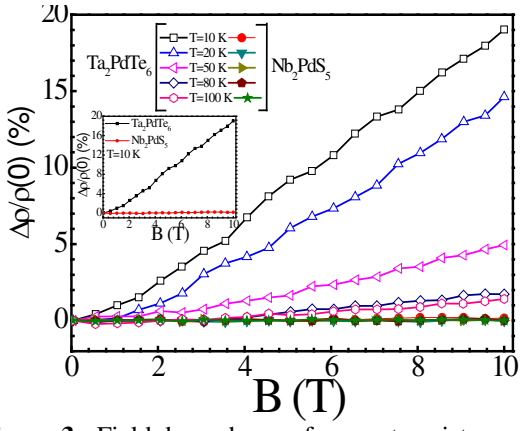

Figure 3: Field dependence of magnetoresistance for Ta_2PdTe_6 and Nb_2PdS_5 compounds at several temperatures. Inset shows same at T=10 K.

Figure 3 depicts the behaviour of ratio of magnetoresistance i.e. at different temperatures in normal state of Ta_2PdTe_6 and Nb_2PdS_5 compounds. Clearly, Ta_2PdTe_6 shows linear positive magnetoresistance at different temperatures and on the other hand Nb_2PdS_5 shows no change in resistance with applied field. Apparently, in Ta_2PdTe_6, the value of magnetoresistance increases with temperature at fixed value of magnetic field.

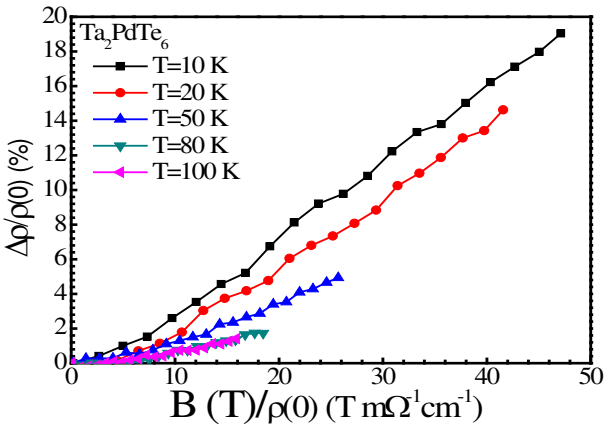

Figure 4: Kohler's plot for sample Ta_2PdTe_6 in a field range from 0 T to 10 T at several temperatures.

Kohler's plot for Ta_2PdTe_6 is illustrated in figure 4. Clearly, the data measured at different temperatures do not overlap and Kohler's rule is violated for Ta_2PdTe_6 compound. Since, Kohler's rule says that magnetoresistance, $\Delta\rho = [\rho(H) - \rho(0)]/\rho(0)$, plotted against $B/\rho(0)$ should give single curve for all temperatures. Kohler's rule was not observed in MgB_2 superconductor because of the multiband property.

CONCLUSIONS

We have successfully synthesized Ta2PdTe6 and Nb_2PdS_5 compound via solid state reaction route. The studied compounds Ta_2PdTe_6 and Nb_2PdS_5 show superconductivity at 4.4 K and 6.6 K. Also, Ta_2PdTe_6 compound shows linear magnetoresistance and absence of same in Nb_2PdS_5 compound. Also, the Kohler' rule is violated in Ta_2PdTe_6.

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