

Specific heat of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ from 4.2 to 60 K

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Abstract. The specific heat of superconducting oxide compound, $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$, is studied using a quasi-adiabatic calorimeter from 4.2 to 60 K. The analysis of the specific heat data below 15 K gives a value of 17 mJ/mole K^2 for the electronic heat capacity coefficient. The value of $\theta_D(0)$ is determined to be $397 \pm 8 \text{ K}$. The variation of θ_D with temperature was calculated in the temperature range 4.2 to 60 K.

Keywords. High temperature superconductors; Y-Ba-Cu-O system; specific heat.

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1. Introduction

With the discovery of high temperature superconductor, $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (Wu *et al* 1987), intense research is going on to understand the mechanism of superconductivity in these materials. It is of interest to study the specific heat of these materials, since such measurement gives information on thermal parameters relating the energy states. In this paper we report the measurement of specific heat of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ compound from 4.2 K to 60 K. Similar measurements have already been reported by others on this compound (Brill *et al* 1987; Junod *et al* 1987; Nambudripad and Dhar 1987; Inderhees *et al* 1987).

The method of synthesizing the sample is described elsewhere (Subba Rao *et al* 1987). Basically, the method is to mix the compounds BaCO_3 , Y_2O_3 and CuO in proper ratio and heat to 950°C for 24 h twice. The black powder is pelletized and sintered at 950°C for 24 h, followed by a treatment in flowing oxygen for 24 h at 900°C and then for 24 h at 600°C and slow cooled to room temperature. X-ray diffraction measurements revealed that the samples were single phase materials exhibiting orthorhombic structure.

The resistivity and susceptibility measurements showed superconducting transition of these samples to be $90.5 \pm 0.5 \text{ K}$ (Srinivasan *et al* 1987). The specific heat was measured on two samples of masses 1.033 g and 0.6643 g from two different batches. The samples were taken in the form of pellets. The sample holder used was identical to that used by Gmelin and Ripka (1981). The calorimeter and its instrumentation described elsewhere, consists of a sapphire plate coated with a grid of Ni-Cr alloy which is used as sample heater. On this disc is placed a sapphire block with calibrated

germanium thermometer embedded in it. The sample is placed on this sapphire block. A very small amount of Apeizon-N grease is used to provide good thermal contact between the sample and the sapphire block. The specific heat is measured by the quasi-adiabatic method using pulse heating. The maximum error in the measurement is 5%. In the first run the specimen was cooled down to 35 K by filling the system with helium gas to expedite cooling. After the sample reaches 35 K the exchange gas was pumped out. In the second run the sample was cooled down only by radiation. The results obtained (figure 1) show that the agreement between the two runs is good. Our values of specific heat are slightly greater than those reported in the literature (Brill *et al* 1987; Junod *et al* 1987). The value of specific heat at 60 K seems to be in agreement with that obtained by Nevitt *et al* (1987). The value of specific heat below 60 K is not given in their paper.

The specific heat below 15 K could be fitted to an expression of the form

$$C_p = \gamma T + \beta T^3 + \alpha T^5. \quad (1)$$

The rms deviation of the fit obtained was better than 1%. The value obtained for the electronic heat capacity coefficient, γ , is 17 ± 3 mJ/mole K². From the coefficient of the T^3 term, the Debye temperature, $\theta_D(0)$ was estimated to be 397 ± 8 K. This is in agreement with the value reported by Brill *et al* (1987).

The variation of θ_D with temperature was found out from the data obtained after subtracting the contribution due to the electronic specific heat from the total specific heat. The results are represented graphically in figure 2. As the temperature increases the Debye temperature decreases, reaches a minimum value of 338 K around 25 K and then increases. The result obtained is in agreement with the results reported by Brill *et al* (1987).

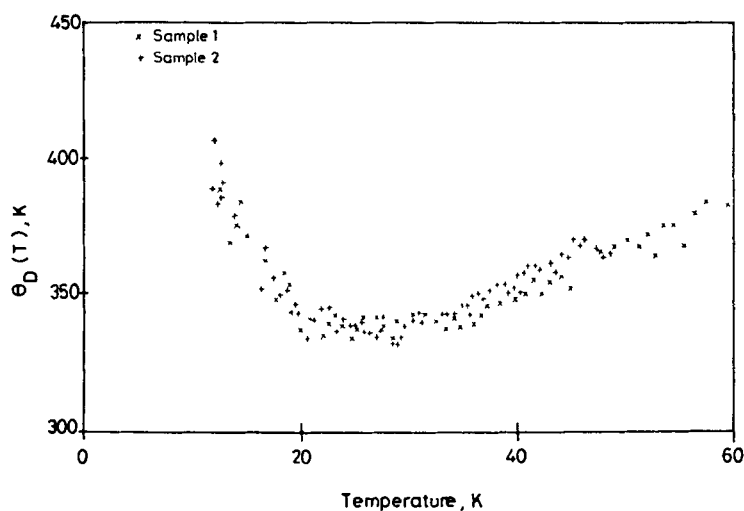


Figure 1. Variation of specific heat of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ with temperature from 4.2 to 60 K.

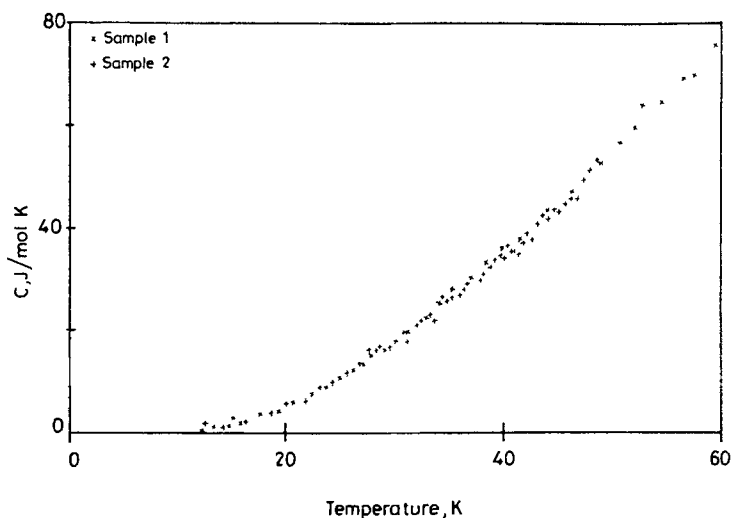


Figure 2. Variation of Debye temperature with temperature in $YBa_2Cu_3O_{7-x}$ from 4.2 to 60 K.

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