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New Results on Two Synthetic Conductors $(TMTSF)_2BRO_4$ and $(BEDT\text{-}TTF)_2I_3$

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NEW RESULTS ON TWO SYNTHETIC CONDUCTORS $(TMTSF)_2BrO_4$ AND $(BEDT\text{-}TTF)_2I_3$

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Abstract We present experimental studies of transport properties of $(TMTSF)_2BrO_4$ and $(BEDTTTF)_2I_3$. The behaviour of the TMTSF salt suggests transport via variable-range hopping among localized states. The BEDTTTF-salt exhibits thermopower which indicates almost isotropic metallic behaviour in the ab-plane.

INTRODUCTION

Recent investigations of conducting charge transfer salts based on respectively the TMTSF and the BEDT-TTF molecules have added numereous new exciting characteristics to the family of synthetic conductors. In the present paper we report evidence of variable-range hopping in $(TMTSF)_2BrO_4$ and 2D metallic properties of $(BEDTTTF)_2I_3$.

VARIABLE-RANGE HOPPING IN A TMTSF SALT

The $(TMTSF)_2X$ salts with tetrahedral anions of the form MO_4^-, M=Re, Cl and Br, behave in spite of their chemical and structural similarities quite different. For all three compounds the physical properties are tightly related to the anion behaviour. In $(TMTSF)_2ReO_4$ and $(TMTSF)_2ClO_4$ the anions are at high temperature disordered over two possible crystallographic orientations, and the salts show properties typical of low-dimensional conductors. By

cooling both of these salts undergo anion ordering.[1] In the perrhenate salt a (2a, 2b, 2c) anion ordering at 180 K cause a MI transition. In the perclorate salts the ions order at 24 K into a (a, 2b, 2c) state, the material remains metallic and at ~ 1 K superconductivity is achieved. Quick cooling of $(TMTSF)_2ClO_4$, however, cause incomplete anion ordering and a low T SDW state appear.

In $(TMTSF)_2BrO_4$ the anions are ordered already at ambient temperature with a periodicity which double the stacking axis parameter.[1,2] However, the ordering is only over short ranges, namely of the order of one lattice distance. There is consequently only a pseudogap and the density of states N(E) is finite at the Fermi level. However, since the properties (Fig. 1) are not metallic, $N(E_F)$ must be much smaller than that of true metallic conductors. Thus, the charge carriers are localized.

The experimental results shown in Fig. 1, give evidence of transport via variable-range hopping among these localized carriers.[3] The conductivity agrees with the Mott prediction of VRH:

$$\sigma = \sigma_o \exp\left[-(T_o/T)^{1/4}\right] \qquad (1)$$

where $T_o = 16\ \alpha^3/kN(E_F)$, α^{-1} being the decay length of a localized state. The characteristic temperature, T_o, as determined from

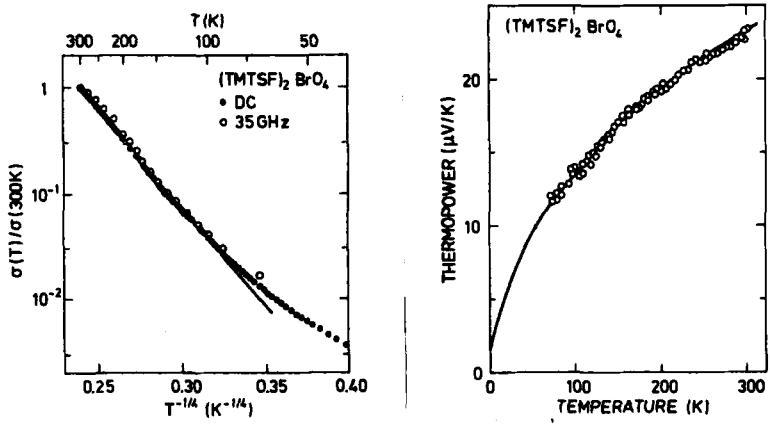

FIGURE 1 DC and MW conductivity (a) and thermopower (b) of $(TMTSF)_2BrO_4$.

the slope of log σ vs. $T^{-1/4}$ is of the order of $4 \cdot 10^6$ K. If a decay length of the order of the intermolecular distance is assumed this leads to $N(E_F) = 10^{21}$ eV^{-1} cm^{-3}. With these parameters there should be no frequency dependence until well above the microwave range, in agreement with the experimental results (Fig. 1a).

The thermopower of $(TMTSF)_2BrO_4$ (Fig. 1b) follows the $T^{1/2}$ dependence characteristic of VRH:

$$S = 1/2 \cdot k/e \cdot (kT_o \cdot kT)^{1/2} \, d\ln N/dE \qquad (2)$$

With T_o given by σ(T), the TEP yields $d\ln N/dE = 0.2$ eV^{-1}.

ANISOTROP THERMOPOWER OF $(BEDT\text{-}TTF)_2I_3$

The discovery of superconductivity in the β-phase of $(BEDTTTF)_2I_3$ by Schegolev et al.[4] has gained a lot of interests into this salt.

In Fig. 2 we present experimental thermopower data of plates of β-$(BEDTTTF)_2I_3$.[5] The measurements were performed in two perpendicular orientations. From the morphology of the samples we expect S_1 to be the thermopower component close to the crystallographic a direction and S_2 to be that of the b^* direction.

A striking result of these thermopower components is the almost exact identical T-dependencies. Above ~ 170 K S_1 and S_2 deviate by only a constant (~ 11 μV/K) and still to the lowest temperatures measured (7 K) the overall T-dependencies are similar.

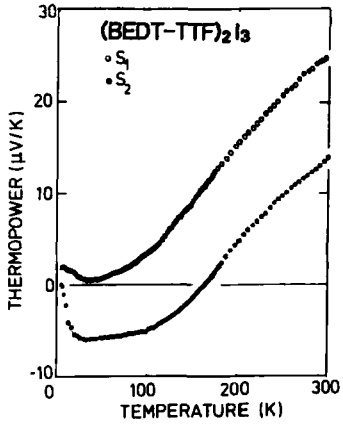

FIGURE 2 Thermopower versus temperature of $(BEDT\text{-}TTF)_2I_3$. S_1 is the component close to a, and S_2 is close to b^*.

This suggests that $(BEDTTTF)_2I_3$ is metallic in at least two dimensions, and that the material is almost isotropic in the ab-plane.[6] This is distinctly different from the TEP results of TMTSF salts, which suggested 2D metallic character only below ~ 100 K.[7] The origin of the constant difference between S_1 and S_2, which cause S_2 to change sign at 165 K, is still unknown.

$(BEDTTTF)_2I_3$ exhibits a slight deviation from exact linear S vs. T behaviour. This gives rise to a broad dS/dT maximum at ~ 170 K, in coincidence with the structural transition observed by X-ray[8]. However, compared to the T-dependent superstructure development, the dS/dT peak seems very broad. It is therefore questionable whether the peak really is related to the transition. Anyway, the TEP data show that the incommensurable structural transition has only little influence on the electronic properties.

At T ≈ 25 K a relative sharp change is observed in both $S_1(T)$ and $S_2(T)$. This may indicate some kind of transition, but can also be a matter of anisotropic phonon drag.

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