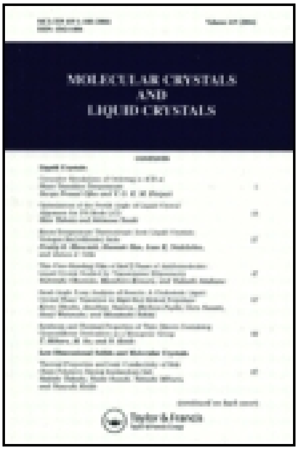

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Transport Properties of $[Ch(Fe\ Cl_4)_Y]_X$ in the Presence of Hydrostatic Pressure

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TRANSPORT PROPERTIES OF $[CH(Fe\ Cl_4)_y]_x$ IN THE PRESENCE OF HYDROSTATIC PRESSURE

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Abstract Temperature dependence of conductivity and thermopower in region 77-300 K and pressure dependence of conductivity up to 10 kbar have been measured for $[CH(Fe\ Cl_4)_y]_x$ for low values of y ($0.001<y<0.01$). The results are consistent neither with ISH model nor VRH model.

INTRODUCTION

Pauli susceptibility and Knight shift measurements[1] in $[CH(As\ F_6)_y]_x$ show a large increase in the number of conducting electrons when the dopand concentration reaches y = 0.06. On the other hand, the thermopower studies carried out for the same system[2] show that S is temperature independent only up to y = 0.002 and then its behaviour is metallic-like suggesting a disappearance of the energy gap at $y \simeq 0.003$. In addition, although the conductivity of undoped $(CH)_x$ is well described by Kivelson's intersoliton hopping mechanism (ISH)[3] no general theory of electrical transport for y>0.001 exists. The temperature dependences of conductivity and thermopower[4] seem to follow variable range hopping model (VRH)[5], but only over a limited range of dopand concentrations. In order to understand the band structure changes near S-M transition and to verify both models, we have studied the influence of pressure on the transport properties of $(CH)_x$ at a low dopand concentration limit since both models predict qualitatively different behaviour of conductivity with pressure.

EXPERIMENTAL

Trans polyacetylene, prepared using the modification of the method of Ito et al.[6] was used in all experiments. The dopings were carried out in 0.05 M nitromethane solutions of $FeCl_3$. The measurements of electrical conductivity were performed using a standard 4-probe dc method. To achieve hydrostatic pressure conditions, helium gas was applied as pressure transmitting medium. The thermopower measurements at ambient pressure were carried out identically as described in[4].

RESULTS AND DISCUSSION

Temperature dependences of the thermopower, for selected concentrations of $Fe\,Cl_4^-$ are shown in Fig. 1. Similarly as in the case of other systems it can be observed that, for y>0.002, S increases with temperature suggesting metallic properties.

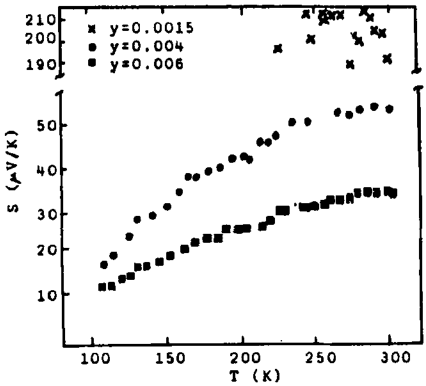

FIGURE 1 Temperature dependence of thermopower at ambient pressure for $[CH(Fe\,Cl_4)_y]_x$
(x) y = 0.001,
(•) y = 0.004,
(■) y = 0.006

In the dopand concentration range studied the conductivity strongly increases with the increase of $Fe\,Cl_4^-$ concentration and for a given concentration increases with the increase of the applied pressure. The maximum influence of the pressure is observed for the sample with lowest concentration, i.e. y = 0.002 (see Table I).

If the temperature dependence of conductivity is assumed to obey the general formula $\sigma = AT^{-1/2}\exp(-B/T^m)$, from the least square fit of the experimental data the power coefficient m can be determined. In the case of y = 0.0048, m adopts the following values: m = 0.26, for p = 1 bar and m = 0.18, for p = 8.5 kbar. The obtained values suggest the variable range hopping mechanism (VRH). However, neither a quantitative nor a qualitative agreement with VRH model can be found since the localization length determined on its basis is 0.1 Å and it predicts the decrease of the density of states by a factor of 13 when going from 1 bar to 8.5 kbar pressure.

TABLE I Conductivities of $[CH(FeCl_4)_y]_x$ measured at 77 K and 300 K, at ambient pressure and 8.5 kbar ($\Sigma(T) \equiv \sigma(8.5, T) / \sigma(0, T)$)

y	T K	$\sigma(0, T)$ Ω^{-1} cm^{-1}	$\sigma(8.5, T)$ Ω^{-1} cm^{-1}	$\Sigma(T)$	$\frac{d}{dT}\Sigma(T)$
0.002	300	$2.14 \cdot 10^{-2}$	$4.1 \cdot 10^{-2}$	1.92	-0.0087
	77	$3.32 \cdot 10^{-4}$	$12.8 \cdot 10^{-4}$	3.85	
0.0048	300	$7.3 \cdot 10^{-1}$	$11.2 \cdot 10^{-1}$	1.53	-0.0061
	77	$7.4 \cdot 10^{-2}$	$2.13 \cdot 10^{-1}$	2.88	
0.0074	300	3.4	4.9	1.44	-0.0035
	77	1.06	2.34	2.21	

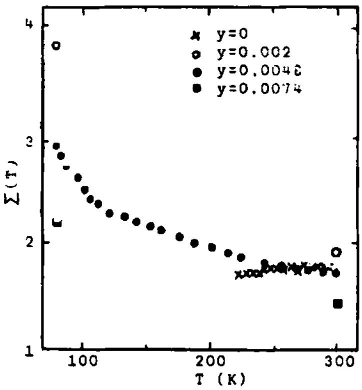

FIGURE 2 Ratio of the conductivity at 8.5 kbar and 1 bar vs: temperature for y = 0 (x) (after[7]), y = 0.002 (o), y = 0.0048 (•) and y = 0.0074 (■)

In Fig. 2 the temperature dependence of the ratio $\Sigma(T) \equiv \sigma(p, T) / \sigma(0, T)$, of undoped[7] and lightly doped $(CH)_x$ is shown. Σ decreases with temperature for the doped systems whereas it is almost constant ($d\Sigma/dT = +0.0009$) in the undoped $(CH)_x$. The behaviour of undoped $(CH)_x$ sample is thus properly described by the IHS model, but the results obtained for the doped samples are in strong disagreement with its predictions. Moreover, the average slope of Σ (i.e. $d\Sigma/dT$) decreases with lowering of y (see Table I) and then suddenly jumps changing its sign (from -0.0087 for y = 0.002 to +0.0009 for y = 0).

CONCLUSIONS

The presented results of pressure and temperature dependence of conductivity for lightly doped polyacetylene (y $\leq$ 0.0074) are consistent neither with the variable range hopping model nor with the intersoliton hopping model.

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