

Metallic high-pressure phase in tetraselenotetracene chloride (TSeT)₂Cl

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At pressured above 5–7 kbar (depending on the temperature), the complex (TSeT)₂Cl undergoes a first-order phase transition into a new metallic state that is stable in the entire investigated temperature range. The resistivity of the high-pressure phase decreases with decreasing temperature and assumes a residual value of the order of 10^{-5} Ω-cm below 10–15 K.

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The structure and main properties of a new organic quasi-one-dimensional metal—tetraselenotetracene chloride, with composition (TSeT)₂Cl—were described in Refs. 1 and 2. In the region of 20 K this complex undergoes a transition from the metallic state into a semimetal state.^[3] As a result, its conductivity decreases in the interval from 25 to 10 K, but as $T \rightarrow 0$ it tends to a finite value of the order of the room temperature, equal to $2.1 \times 10^3 \Omega^{-1} \text{ cm}^{-1}$. In this paper we report a study of the influence of hydrostatic compression on the pressure on the properties of this compound.

The crystals of the complex were obtained by oxidizing TSeT with anhydrous CuCl₂ in dimethylformamide.^[4] Their transverse dimensions were 20–40 μm, and the length up to 4 mm. The pressure was produced in apparatus of the “piston—cylinder” type and was secured at room temperature. The investigated sample and a lead pressure pickup were mounted inside the chamber. The pressure-transmitting medium was GKZh-78 silicone liquid, which solidifies on cooling without crystallizing. This made it possible to maintain in the working volume a highly homogeneous pressure down to helium temperatures and by the same token protect the sample against cracking.

At room temperature, the pressure was estimated from the force of the press. At low temperature its value was estimated from the change of the temperature of the superconducting transition of the lead pickup. In the course of cooling, the pressure decreased by 3–4 kbar; its value in the intermediate temperature region was not recorded.

The sample conductivity was measured with direct current by a four-contact method in the direction of the “c” crystallographic axis. The temperature was measured with a Cu–Au + 0.07 at.%Fe thermocouple.

At room temperature, with increasing pressure to ~6 kbar, the resistance of the (TSeT)₂Cl complex decreases monotonically (Fig. 1). In the region of 6 kbar, the resistance decreases jumpwise to approximately half its value. This is evidence of a phase transition into a new metallic high-pressure phase. It appears that the crystal structure of the complex is altered in this transition, but it can be assumed that the

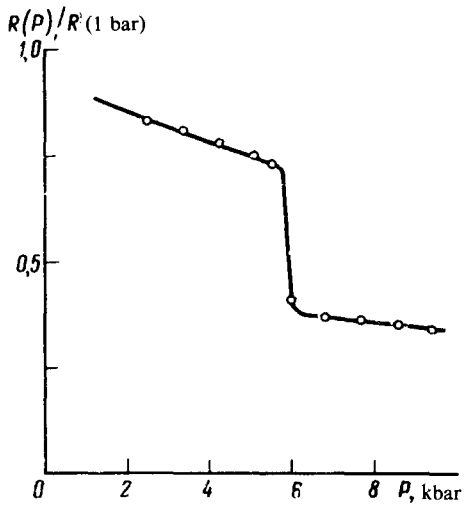


FIG. 1. Typical loading curve of the complex $(TSeT)_2Cl$ at room temperature.

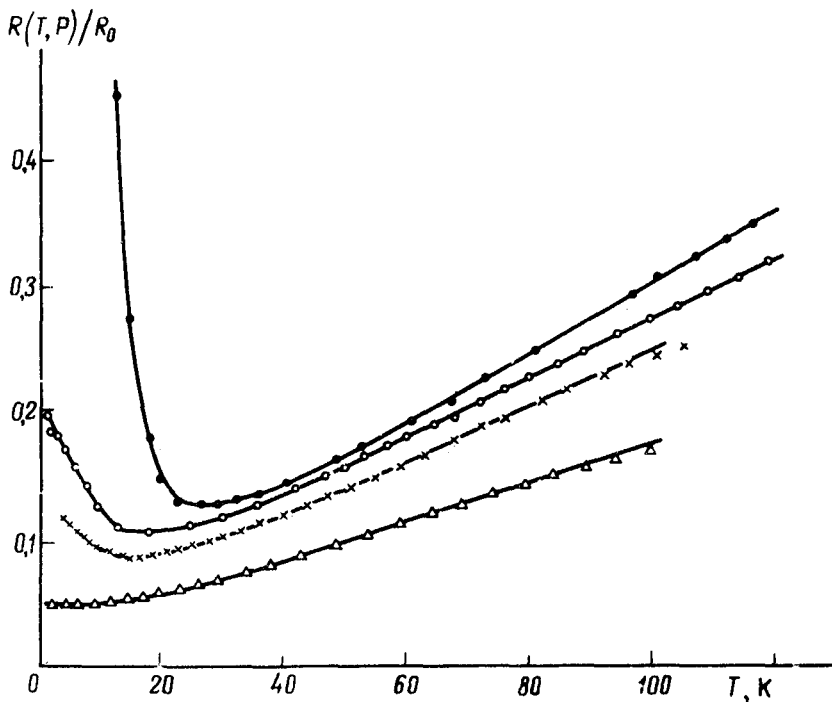


FIG. 2. Temperature dependence of the resistance of the low-pressure phase at different pressures: ●—1 bar, ○—3 kbar, ×—4 kbar, △—4.5 kbar.

main character of the structure does not undergo radical changes, because the conductivity anisotropy measured by the Montgomery method¹⁵¹ does not change radically:

its variations in the entire range of pressures do not exceed 20%. The transition is subject to hysteresis whose value increases with decreasing temperature.

We shall henceforth refer to the low-pressure phase existing at $p < 6$ kbar as phase I and to the high pressure phase produced at room temperature at $p \gtrsim 6$ kbar as phase II.

Figure 2 shows the temperature dependence of the resistance of phase I at various pressures in the temperature region below 100 K. It is seen that with increasing pressure the low-temperature metal-semimetal phase transition shifts towards lower temperatures. The conductivity of the complex increases in this case, particularly noticeably in the region of temperatures near the conductivity maximum. At $P \approx 4.5$ kbar there is no clearly pronounced maximum at all: the conductivity remains constant below 10 K, and is approximately 20 times larger than the room-temperature conductivity at $P = 1$ bar.

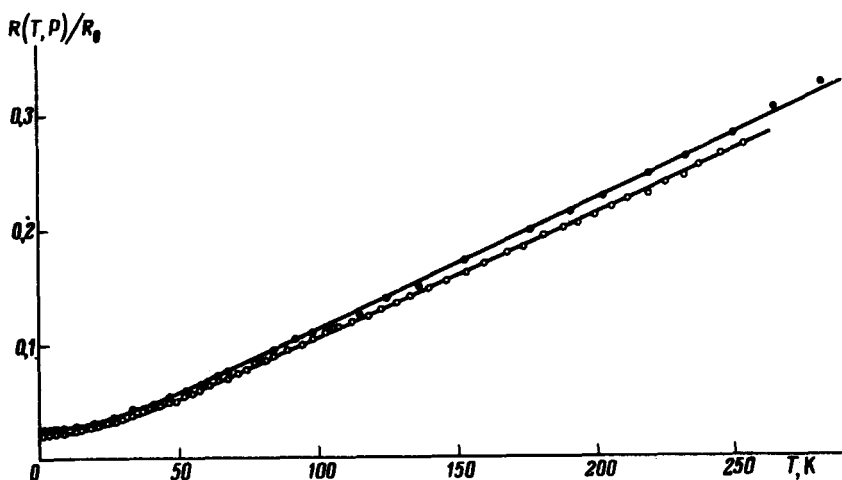


FIG. 3. Temperature dependence of the resistance of the high-pressure phase: ●—5 kbar, ○—5.6 kbar, R_0 —sample resistance at $P = 1$ bar and $T = 293$ K.

The resistivity of phase II (Fig. 3) decreases monotonically with decreasing temperature and assumes below 10 K a residual value $1.1 \times 10^{-5} \Omega\text{-cm}$. We note that the true temperature dependence of the resistivity of this phase can differ somewhat from linearity because of the decrease in pressure upon cooling. For the same reason, if the phase II is to be preserved in the entire temperature range, the pressure prior to cooling must be higher than the transition pressure. Otherwise a transition to phase I occurs upon cooling, and a return to phase II, with appreciable hysteresis, upon heating. It is the presence of the hysteresis which apparently makes it possible to preserve the phase II up to pressures on the order of 5 kbar at 4.2 K.

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