# ON SOME PROPERTIES OF POLYMERIC SEMICONDUCTING MATERIALS

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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

## Abstract

## Full Text

## PHYSICAL CHEMISTRY

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# ON SOME PROPERTIES OF POLYMERIC SEMICONDUCTING MATERIALS

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In semiconducting polymers based on polyacrylonitrile and polyvinyl chloride that have recently been obtained, the dependence of electrical conductivity on temperature is exponential in character:

$$\sigma \sim e^{-\Delta E/2RT}. \quad (1)$$

The activation energy $\Delta E$ of these materials lies in the range from 1.7 to 0.18 eV, depending on the nature of the treatment of the initial polymer ([1,2]).

**Fig. 1.** Dependence of electrical conductivity on temperature for some samples of polyacrylonitrile.
*a* –sample No. 1, $\Delta E = 0.18$ eV;
*b* –sample No. 2, $\Delta E = 0.26$ eV;
*v* –sample No. 3, $\Delta E = 0.32$ eV;
*g* –sample No. 4, $\Delta E = 0.39$ eV;
*d* –sample No. 5, $\Delta E = 0.51$ eV.

**Fig. 2.** Dependence of the differential thermoelectric emf on temperature for the same samples of polyacrylonitrile.

If one assumes, as is usually done, that $\sigma = enu$, where $e$ is the electron charge, $n$ is the concentration of current carriers, and $u$ is the mobility of the current carriers, then such a dependence of electrical conductivity on temperature may be caused either by an exponential increase in the number of current carriers $n$, in which case $\Delta E$ is the width of the forbidden band (if, in considering semiconducting polymers, one uses the band model), or by an exponential increase in the mobility of the current carriers,

$$u \sim e^{-\Delta E/RT}.$$

The answer to the question posed above may be provided by studying the temperature dependence of the differential thermoelectric power. If the increase in electrical conductivity is due to an increase in the carrier concentration, then it should be accompanied by a decrease in the differential thermoelectric power.

In this case, if one follows band theory,

$$\alpha = \frac{k}{e}\left(A - \frac{\Delta E}{2RT}\right), \quad (2)$$

where $A$ is a coefficient almost independent of temperature. If, however, the carrier concentration does not depend on temperature, the thermoelectric power should increase logarithmically with increasing temperature ([3]).

Figure 1 shows the temperature dependences of the conductivity of several polyacrylonitrile samples. Figure 2 shows the temperature dependences of the thermoelectric power of these same samples*. For comparison, Fig. 2 also gives the curves of the theoretical dependence of thermoelectric power on temperature, constructed on the basis of formula (2) for $\Delta E = 0.18$ (dotted curve) and $\Delta E = 0.51$ (dash-dotted curve).

It is evident from the figures that the thermoelectric power changes little with temperature, or does not change at all.

From this, apparently, one may conclude that, in the materials studied, the temperature dependence of conductivity is determined mainly by the exponential increase in the mobility of the current carriers with temperature.

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## CITED LITERATURE

[1] A. V. Topchiev, M. A. Geiderikh, B. E. Davydov, V. A. Kargin, B. A. Krentsel, I. M. Kustanovich, L. S. Polak, DAN, 128, No. 2, 312 (1959).
[2] M. A. Geiderikh, B. E. Davydov, B. A. Krentsel, I. M. Kustanovich, L. S. Polak, A. V. Topchiev, R. M. Voitenko, International Symposium on Macromolecular Chemistry, Section III, 1960, p. 85.
[3] A. F. Ioffe, *Physics of Semiconductors*, Publishing House of the USSR Academy of Sciences, 1957.

* For samples 3, 4, and 5, the integral thermoelectric power was recorded as a function of the temperature gradient by the capacitor-charging method. The

figure shows the differential thermoelectric powers obtained by differentiating the experimental dependence.

*Note: Figure translations are in progress. See original paper for figures.*