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ELECTRICAL PROPERTIES OF MANGANESE AND IRON PORPHYRINS

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Abstract. The purpose of this paper is to study electrical properties of manganese (Pr-Mn) and iron (Pr-Fe) porphyrins.
Measurements of the current flowing through a sample were performed in the temperature range from liquid nitrogen to 380K.
We suppose that a hopping with participation of tunneling was a predominant mechanism of conductivity in the investigated porphyrins.

INTRODUCTION

Electrical properties of semiconductors and insulators in the form of polycrystalline and amorphous layers are determined by their internal structure. By analysis of current-voltage characteristics one can obtain information on application possibilities of an investigated material.

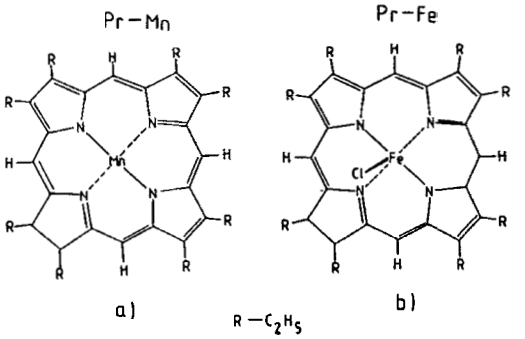
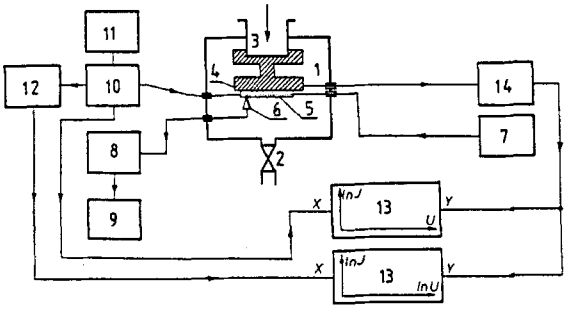


Fig.1. Structural patterns of investigated materials
a) manganese porphyrine (Pr-Mn)
b) iron porphyrine (Pr-Fe)

Particularity important it is in the case of organic materials which electrical properties are weakly recognized. The aim of this work it was to study electrical properties of iron (Pr-Fe) and manganese (Pr-Mn) porphyrins. Structural patterns of these materials are shown in Fig.1.

EXPERIMENTAL

Samples of manganese and iron porphyrines had a sandwich form with Au and Al electrodes. They were prepared by sublimation on the glass substrate (type BK-7) at the pressure $5 \cdot 10^{-5}$ Pa. By using a special system of masking 25 samples on a single substrate were obtained in the same conditions. Thickness of investigated materials was d = 0,402μm for manganese porphyrine and d = 0,483μm for iron porphyrine. A scheme of the measuring system is shown in Fig.2. Measurements of a constant current flowing through a sample were performed in the temperature range from liquid nitrogen to 380K. The current changed from 10^{-12} to 10^{-} [A] for the electric fields 10^{6} to 10^{8}V/m.



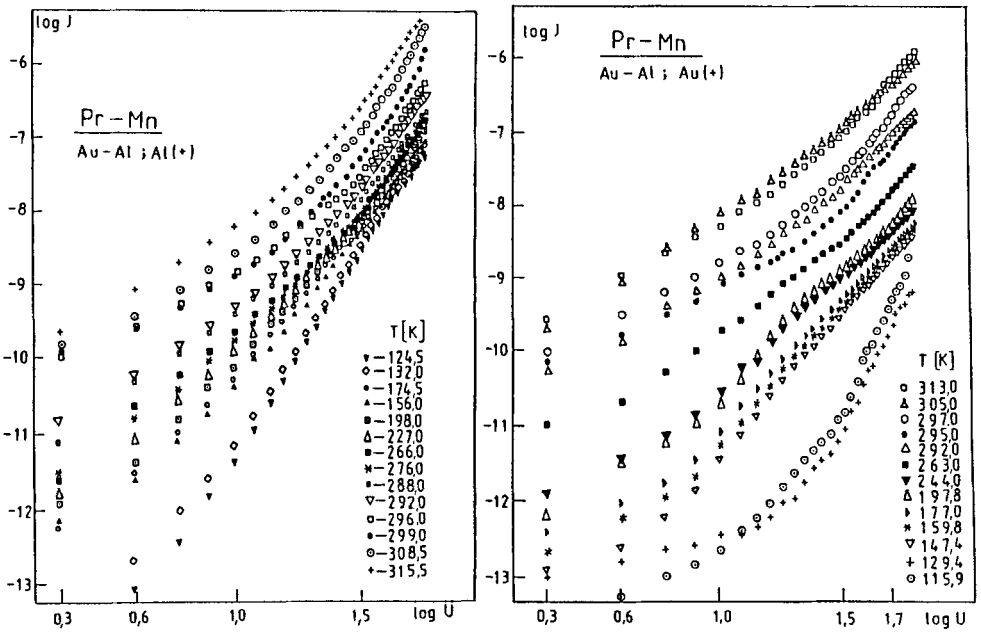
MEASURING SYSTEM

1 – Cryostat
2 – Vacuum valve
3 – Liquid nitrogen supply
4 – Measuring table
5 – Sample
6 – Thermocouple
7 – Constant-Temperature regulator
8 – Thermocouple amplifier
9 – Temperature indicator
10 – Linear voltage increase unit
11 – Power supply
12 – Logarithmic unit (lnU)
13 – Recorder
14 – Electrometer + logarithmic unit (lnJ)

Fig.2. Scheme of the measuring system.

RESULTS AND DISCUSSION

Current-voltage characteristics for manganese (Pr-Mn) porphyrine in the logarithmic coordinates logI = f(logU) at different temperatures and polarizations are shown in Fig.3. Similar characteristics were obtained for (Pr-Fe) iron porphyrine



a) b)

Fig.3. Current-voltage characteristics for manganese porphyrine (Pr-Mn)
a) for Al(+) polarization
b) for Au(+) polarization

On the basis of current-voltage characteristics, thermal characteristics $\ln I = f(T)^{-1}$ were made and activation energies for both investigated materials were calculated . From analysis of Fig.4. one can see that both porphyrines have two domains of different slope thus diffe-

rent activation energy (E_1,E_2). Values of these activation energies change in dependence of a voltage:

Pr-Mn; E_1(0,04 - 0,2eV); E_2(0,35 - 0,62eV)

Pr-Fe; E_1(0,013 - 0,08eV); E_2(0,08 - 0,18eV)

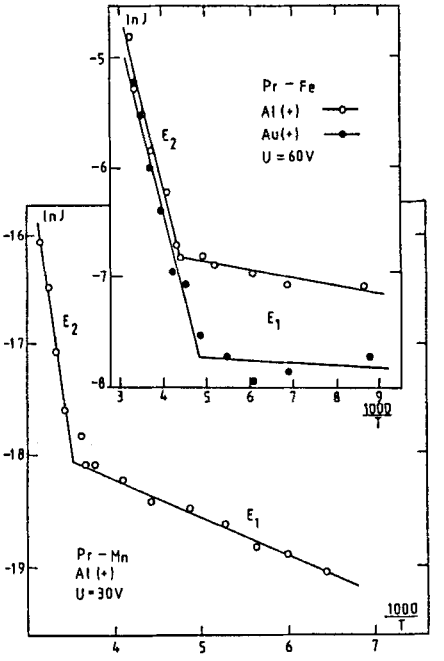


Fig.4. Characteristics $\ln I = f(T^{-1})$ for iron and manganese porphyrines.

Determination of the conduction mechanism, which is an essential aim of this study, has appeared rather difficult in this case. For this reason characteristics $\ln I = f(T^{-1/3})$ (Fig.5) and $\ln I = f(T^{-1/4})$ (Fig.6) were made.

Analysis of these figures does not give a univocal answer to the question of conduction mechanism.

Niklasson and Brautervik gave in [1] a review of conduction mechanisms at high electric fields for thin dielectric layers. On the basis of their considerations a dependence $\log \Delta = f(\log E)$ was drawn where: $\Delta \simeq nAE^{1-n}$;

$n = 1 - "n"$

"n" - slope on a plot $\log \Delta = f(\log E)$

E - strength of electric field in [V/m]

A - function of temperature

n - value which depends on the conduction mechanism

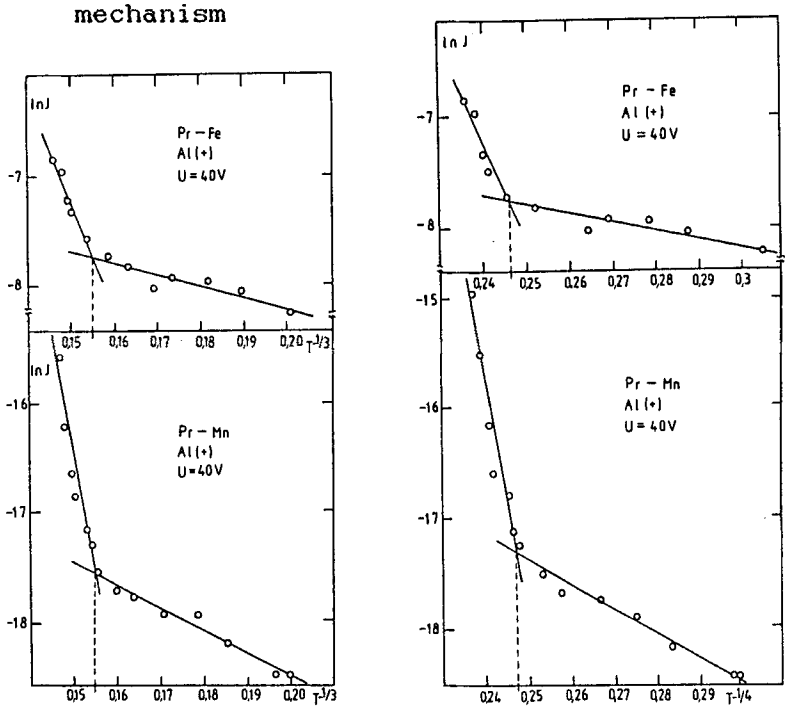


Fig.5. Characteristics $\ln I = f(T^{-1/3})$ for iron and manganese porphyrines.

Fig.6. Characteristics $\ln I = f(T^{-1/4})$ for iron and manganese porphyrines.

Values of n (n = 0,22 - 0,27) determined here would suggest that a high field hopping with tunneling was a dominating mechanism of conduction in the investigated porphyrins. This is also consistent with dependencies observed in Fig.5 and Fig.6 at temperature above 268K. Studies of current intensities in dependence of material thickness will give a unequivocal answer whether it is a two- or three- dimensional hopping.

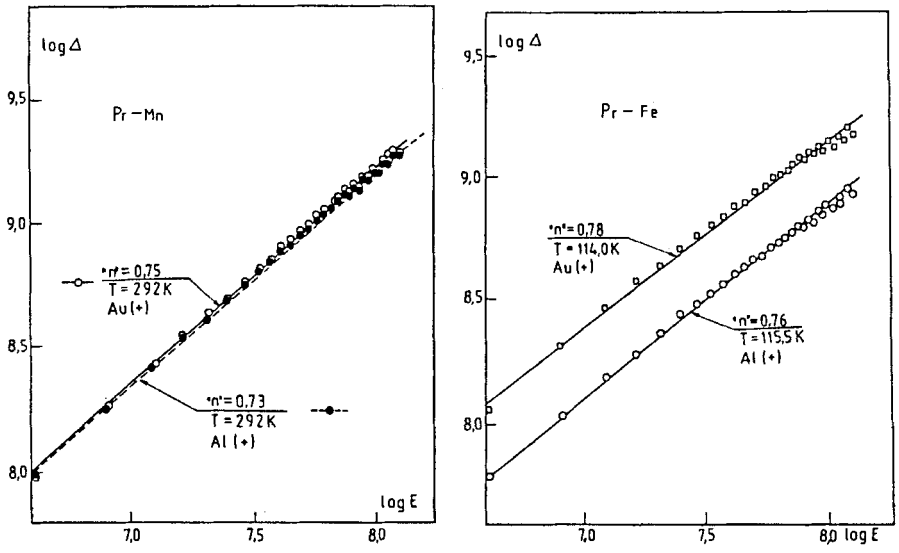


Fig.7. Dependence log Δ = f(log E)
a) for manganese porphyrinep(Pr–Mn)
b) for iron porphyrine (Pr–Fe)

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[1] G.A.Niklason and K.Brantervik, J.Appl.Phys. 59, 3 (1986).