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Bronisław Jachym^a & Gerard Wiśniewski^a

^a Institute of Physics, Technical University, Gdańsk, Poland

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A CONCEPT OF ELECTRICAL CONDUCTIVITY IN DOPED POLYMERS

BRONISŁAW JACHYM AND GERARD WIŚNIEWSKI

Institute of Physics, Technical University, GDAŃSK,
POLAND

Abstract The coupling of the aliphatic macro-molecules into the conduction mechanism, may be accomplished solely through either a significant, or a total liquidation of the barrier of potential upon the boundary between the macro-molecules - and the admixed conductivity. This achievement may be realized as a consequence from the recombinations between macro-radicals with unpaired spins; upon the surfaces of the admixed conductivity; i.e. - carbon black.

INTRODUCTION

The behaviour of arrangements of polyacetylene type is known¹. Not only is electrical conductivity of pure acetylene high, but also it may be increased by suitable admixtures e.g. AsF_5 . The material thus obtained is characterized by conductivity of a level equal to that of a metal over a wide temperature range. It is known that polyacetylene molecules are chain structures of conjugated double bonds. Electron delocalization in such an arrangement is high and extends throughout the molecule. The transition mechanism is of considerable importance for pure polyacetylene conductivity. Admixing, suggestively speaking, still lowers the potential barriers at the ends of the macromolecule. In the language of theory, it corresponds to a change of electron hole hamiltonian.

EXPERIMENTAL DATA

When any carbon black of ESR signal higher than 10^{15} spin/gram, as well as radical polymerization initiators and catalysts are added to uncured polyester resin constituting a mixture of styrene, fumaric acid esters and polyglycols, a composite characterized by electrical conductivity of $10^{-4} \Omega^{-1} \text{cm}^{-1}$ level may be obtained after polymerization at carbon black content as small as 0.4% by weight². Dependence of electrical conductivity on carbon black concentration, typical for this kind of composites³. The comparison shows that chemical reactions in the course of radical polymerization have decisive influence on electrical properties of the composite obtained in this way. Decisive influence of chemical bonds on physical properties of composites is also shown by the ESR signal observed in samples of various carbon black contents. This is shown in fig.1.

CONCLUSION

The sudden jump observed in electrical conductivity of the described composite arrangement at such a small content of the conductive component is explained by creation of covalent bonds resulting from recombination of radicals on the carbon black globules³. In arrangements of polyacetylene type, where the π electron delocalization extends throughout the whole molecule, the last conduction band is unfilled, the potential barriers for the transition of a carrier from one molecule to another one are so low that considerable conductivity is observed. Even weak molecular bonds may still considerably enhance the conductivity, which is achieved by creating suitable

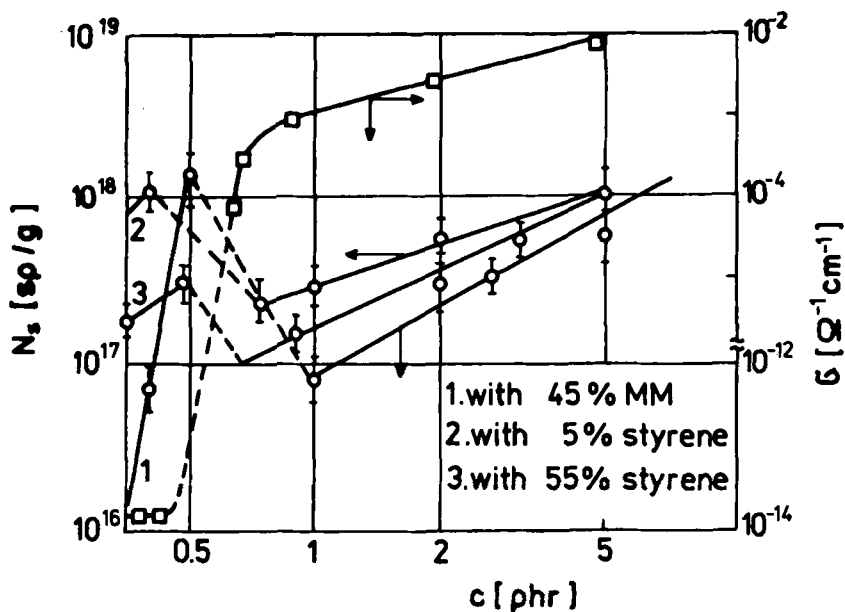


FIGURE 1 Conductivity and ESR signal for compositions with various contents of styrene on concentration of carbon black.

complexes. Materials of this type are called one-dimensional metals. The composition described above may be treated in categories similar to those for polyacetylene arrangement, although it must be noted that "opening" of the structure follows only as a result of covalent bond between carbons, that is as a result of a total elimination of the potential barrier between the molecules.

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