Properties of Highly Conducting Polyacetylene

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1 Introduction

During the past 15 years, the synthesis and characterization of conducting polymers has attracted the attention of numerous groups of scientists /1/, stimulating a close cooperation of experimental and theoretical physicists, chemists, physico-chemists, materials research scientists and engineers.

On the one hand, this widespread interest is due to the high potential of possible technical applications. "Taylor-made polymers" are of increasing technological and economical importance. If chemists succeed in developing chemically stable electrically highly conducting polymers, there will be a wide range of applications ranging from rechargeable batteries containing no heavy metals to the production of new antistatic materials and electronic devices.

On the other hand, research on conducting polymers is an intriguing field within solid state physics, as the mechanisms of charge transport in these materials seem to be very different from those of conventional metals and semiconductors. This is partly due to the high degree of disorder in these materials and partly to the - at least locally - high anisotropy of many of their physical properties. New phenomena occur in systems with reduced dimensions: a Peierls transition /2/ is observed in quasi-onedimensional conductors. In many cases, band filling, energy gap and electron density of states can be deliberately varied by variation of dopant concentration. And there are many opportunities for the synthesis of new or modified systems with different band structures.

Within the class of conducting polymers, polyacetylene, (CH)x, due to its simple molecular structure, has become a model system for the investigation of charge transport /3/. Since about 1977, this substance has aroused considerable interest as a material, whose conductivity can be varied by "doping" (i.e. oxidation or reduction) /4,5/ over 16 orders of magnitude, ranging from values of typical insulators to those of typical metals (see fig. 1). In the past decade, numerous groups have investigated its transport properties /6-9/. However, no uniform picture of the electrical conductivity could be derived, partly due to sample imperfections and chemical instability of the substances, partly to different sample preparation techniques in different laboratories. Depending on the exact procedure of preparation, the maximum values of the room temperature conductivity varied between 10^2 and 10^3 S/cm /3/. SEM investigations showed a strongly disordered