Electrical Properties of Some New l-Asparagic Derivatives in Thin-Films

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Abstract

The temperature dependences of the electrical conductivity and the Seebeck coefficient for some new L-asparagic derivatives with metallic ions in molecules are studied. The investigations have been performed using thin-films samples deposited from solution. It was found that respective compounds have interesting semiconducting characteristics. The compounds containing Ag^+ in their molecules are defined by larger values of σ and of the Seebeck coefficient α, and smaller values of ΔE.

Keywords: organic semiconductors, electrical conductivity, Seebeck coefficient, thin-film

Introduction

In recent years, organic semiconductors have been one of the theoretical and experimental research areas of solid-state science [1 to 4].

The interest in this topic is stimulated by the wide applications of these materials in different domains of modern science and technology.

In this paper, the electrical properties of some new L-asparagic derivatives with metallic ions in molecules are studied. The possible mechanisms of electrical conduction are discussed.

Material and Methodes

The general chemical formula of the investigated compounds is presented in **Figure1**. The substituents R_1 and R_2 are listed in **Table 1**.

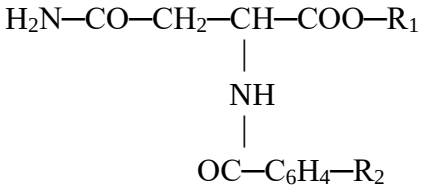

Figure 1. The general chemical formula of the investigated compounds.

Table 1. The substituents R_1 and R_2

Compound	R_1	R_2
CS.H1	-H	-NO_2.orto
CS.H2	-H	-NO_2.meta
CS.H3	-H	-NO_2.para
CS.A1	-Ag	-NO_2.orto
CS.A2	-Ag	-NO_2.meta
CS.A3	-Ag	-NO_2.para

The synthesis and some chemical and physical properties respective compounds have been described in [5]. For the study of the temperature dependence of electrical conductivity σ and Seebeck coefficient α, thin films (d= 0.25 – 2.75 μm) deposited onto glass substrates from the dimethylformamide solutions of the mentioned compounds have been used [6]. The experimental arrangements used were similar to these described in [5,7].

Results and Discussion

In order to obtain samples with stable structures and reproductibile electrical and thermoelectrical properties, all films were submitted to a heat treatment. This consists of several heatings and coolings within a given temperature range ΔT, ascribed to each compound in **Table 2.**

After heat-treatment, the temperature dependences of σ and α become reversible. For heat-treated samples the temperature dependences of the electrical conductivity are typical for semiconducting materials.

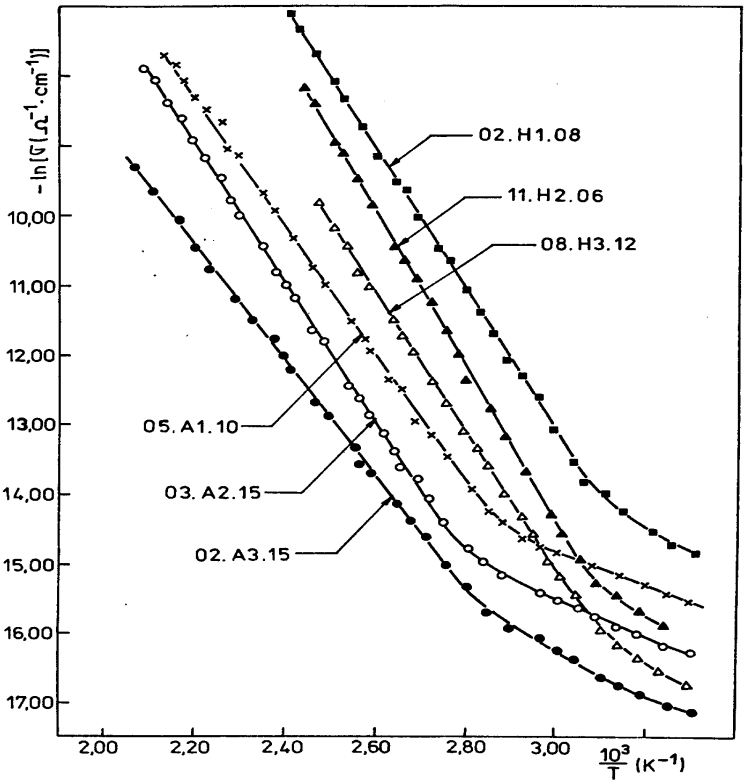

Figure 2. Dependences of the electrical conductivity with temperature.

In **Figure 2** the curves ln σ = f(10^3/T) for six investigated samples are presented. An exponential increase of the electrical conductivity with temperature was observed for all temperature ΔT.

The semiconducting properties of investigated compounds are determined from their specific chemical structure which allows to obtain an extended conjugation.

For heat-treated samples the calculated value of ΔE from the ln σ = f(10^3/T) curves in the intrinsic range is given in **Table 2**.

Table 2. Values of some characteristic parameters of the investigated samples

Compound	Sample	d (μm)	ΔT (K)	σ_c ($\Omega^{-1}.cm^{-1}$)	ΔE (eV)	b
CS.H1	02.H1.08	0.83	300-440	$5.86.10^{-7}$	1.75	0.8
CS.H2	11.H2.06	0.65	300-415	$1.02.10^{-7}$	1.90	0.9
CS.H3	08.H3.12	1.24	300-410	$5.59.10^{-8}$	1.65	0.9
CS.A1	05.A1.10	1.06	300-500	$1.86.10^{-7}$	1.50	0.7
CS.A2	03.A2.15	1.47	300-490	$8.76.10^{-8}$	1.60	0.7
CS.A3	02.A3.15	1.50	300-485	$3.75.10^{-8}$	1.40	0.7

In **Table 2** the following characteristic parameters of the respective samples have been also indicated: d-film thickness, σ_c-electrical conductivity at room temperature before heat treatment, b-ratio of carrier mobilities. The activation energy ΔE is smaller when the conjugation in molecule develops to a large extent.

The compounds containing Ag^+ in their molecules are defined by larger values of σ and smaller values of ΔE.

The Seebeck coefficient is positive for all investigated samples which means that they have a p-type electrical conduction.

The values of α and its temperature dependence also depend on the molecular structure of the compounds. We remark that the compounds containing Ag^+ are characterized by larger values of the Seebeck coefficient.

For six investigated samples, the temperature dependences of the Seebeck coefficient are presented in **Figure 3.** It can be observed that within the higher temperature range (domain of intrinsic conduction) the Seebeck coefficient decreases with temperature for all investigated films.

Using the dependences ln σ = f(10^3/T) and α = f(10^3/T) it is posible to determine the values of some characteristic parameters of studied compounds [6].

We observe that the aspect of curves ln σ = f(10^3/T) and α = f(10^3/T) shows that the model based on the band electrical conduction could be suitable for the explanation of carrier transfer in studied compounds. But the obtained values of some characteristic parameters do not concur with the commonly estimated values of organic semiconductor crystals [1].

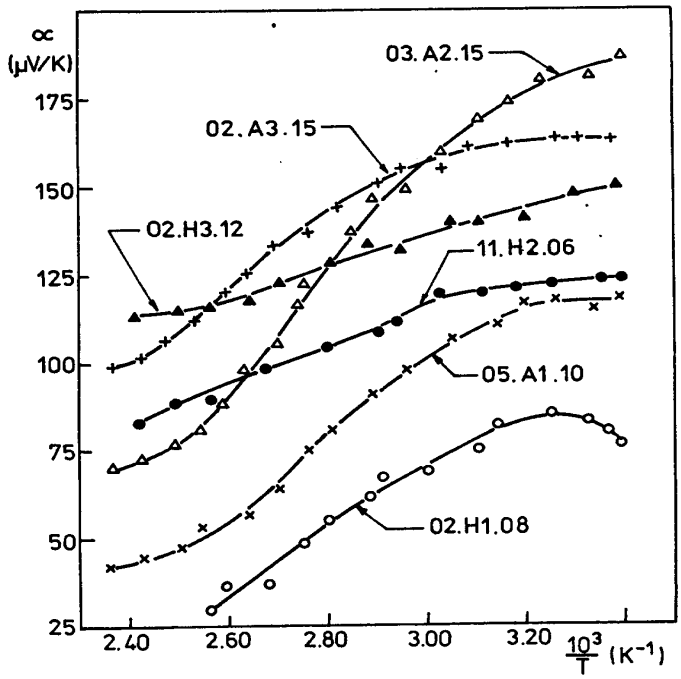

Figure 3. Dependences of the Seebeck coefficient with temperature.

However, other mechanisms of charge carrier transfer may be actioned in studied samples.

The films have a granular structure. In this case, the grain size and shape as well as the characteristics of the contacts between them influence the kinetical phenomena developing within these films. The electrical conduction is also controled by the transfer of carriers from one granule to another [8].

In the case of the films with grains of different size, the distribution of the electric field intensity within films is strongly nonhomogenous.

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