ACADEMIA ROMÂNĂ
SCOSAAR

Anexa nr. 6

ABSTRACT OF THE HABILITATION THESIS

TITLE: INSIGHTS ON PHYSICAL CHEMISTRY OF POLYMER MATERIALS IN SOLID PHASE AND IN SOLUTION

Habilitation domain: *chemistry*

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ABSTRACT

The habilitation thesis "Insights on physical chemistry of polymer materials in solid phase and in solution" describes the relevant scientific contributions of attained in the postdoctoral period (2010-present), the manuscript being divided into three sections.

The first part presents the stages completed in the professional career, but also a series of aspects that reflect the dynamics of the research activities undertaken especially after the award of the PhD title. The accumulated academic experience has facilitated the development of increasingly complex and innovative investigations in the field of physical chemistry of polymers. The scientific interest shown in the elucidation of the relationship between the chemical structure and the response of the materials to the action of external factors (radiations, mechanical forces, heat) allowed the formulation of new study directions, which are well delimited in regard to those already pursued in the institute, namely: polymers with modified surfaces via original mechanical methods, materials with controllable refractivity, eco-friendly dielectric media and phonon/electron transport in multicomponent polymer systems. Therefore, it can be considered that the addressing of these novel topics will contribute to expanding of the horizon of knowledge at national and international level and, via the elaborated publications and grants, new valences are brought to the institute's visibility. Collaborations with researchers from the institute or from other universities offered me the opportunity to work with PhD students, and the obtained results determined the theses finalization based on joint publications. The original character of the scientific ideas attracted funding of projects, in which I always aimed at the integration of human resources in the early stages of their careers (master's students, PhD students, postdoctoral students).

The second part of the thesis is composed of three chapters and describes in detail the main scientific achievements, which are centered on the following research directions:

- polymer systems in fluid phase under the action of the shear field in order to process them in solid state (coatings/films, fibers, liquid crystals, composites);
- polymer materials with adjusted surface features via mechanical approaches having applicability in optoelectronics or biomedicine;
- isotropic and anisotropic transparent polymer media in interaction with optical radiations for the design of components that can be implemented in liquid crystal displays (LCDs), photovoltaic cells, optical switches, interference filters or in information storage systems;

- single/multi-component polymer materials in which electrical or thermal transport phenomena occur with relevance for realization of electronic circuits with fast response, energy storage systems, electromagnetic shielding or heat dissipation elements.

To outline a perspective on the rheological behavior, I studied various polymer systems (solutions, dispersions, liquid crystals), pursuing the dynamics of the microstructure in the applied shear field from the perspective of the solid state processing conditions (Chapter II.1.1). These aspects are not explored in the literature, but they have practical implications in obtaining defect-free fibrous membranes, uniform films, homogeneous composites or molecularly ordered polymer systems.

The initiative to modify the surface of the polymer films by abrasion has opened a new field of research (Chapters II.1.2-II.1.4). I obtained original results that allowed the clarification of some fundamental aspects that derive from: (a) the structure of the polymer (the flexibility of the chain segments, the nature of the substituents, the balance between the flexibility and the degree of chain entanglements) and (b) the surface processing conditions (the type of textile fibers, the impact of their positioning in relation to the friction direction, the hardness of the abrasive materials). I have also developed new methods of modifying the surface morphology of polymer films, which involve the action of different types of mechanical deformation (abrasion, stretching, shearing, pressing), which sometimes can be combined with plasma exposure. These studies have practical relevance in controlling the alignment of nematic molecules on polymer supports or in modulating the interaction of the polymer with blood/fibroblast cells.

Another addressed topic is that of isotropic and anisotropic polymer optical media (Chapter II.2). Through the undertaken investigations, I deepened the relationship between the chemical structure and the linear optical phenomena that occur in polymers, mixtures or polymer composites. A series of studies aimed at obtaining and characterizing materials with refractivity adapted to the application requirements. I have elucidated for the first time in the literature: (a) the effect of the temperature and the incident photons energy on the refractivity with an impact on the reduction of the optical losses in photovoltaic cells and light emitting diodes and (b) the role of the chemical structure of the polymers in matching the dispersion of the refractive indices at the polymer interface with the nematic layers for improving the propagation of optical radiations in displays. Other personal contributions were focused on polymers with optical anisotropy, highlighting new aspects, such as: (a) photo-generation of birefringence by doping with specific chromophores and laser irradiation for attaining supramolecular polymer architectures with the ability to store optical information, (b) formulation of a new method of obtaining optical rotary dispersion starting from the peculiarities of the channeled spectrum of polymers in different solubilization media and (c) proposing of new methods of improving the birefringence of polymer films for the manufacture of optical retardation components in displays.

Other scientific concerns have been focused on the evaluation of electrical/thermal transport phenomena in single-phase/multiphase polymer materials (Chapter II.3). To describe thermal conduction in polymer composites, a new model has been formulated that takes into account the shape of the reinforcing agent and the microstructural aspects of the material. Other investigations have highlighted the effect of the positioning of conductive inclusions (with a high aspect ratio) relative to the heat flux propagation and the effect generated by the functional groups attached to the particles on the heat transfer in the composites. In the case of dielectric materials, it has been shown that the speed of signals in electrical circuits is improved by optimizing the balance between free volume and molecular polarizability - aspects determined by the structure of the tested copolymers. Furthermore, polymer composite films with high polarizability have also been investigated, focusing on the role of eco-compatible additives in controlling the permittivity and breakdown voltage for energy storage uses. Another direction was focused on semiconducting materials for transistors or for electromagnetic shielding.

The third section of the habilitation thesis outlines the integration of scientific expertise in future research directions. Starting from the scientific achievements in the addressed study areas, I intend to explore new related fields, which can expand the current scientific topics of the institute. The general objectives will include: the development of original methods for controlling the morphological/optical anisotropy of polymers, the application of exotic concepts (e.g. "giant" birefringence) to obtain innovative polymer materials, which can change the polarization state of radiations, but also elucidation of the interdependence between electron and/or phonon transport in multiphase polymer systems. The proposed studies also include the approach of new research areas, such as complex polymer architectures with non-linear optical response, chromogenic polymer systems and polymer electrets doped with additives from renewable sources. A series of strategies related to the proposed collaborations, research projects and perspectives of young researchers' integration in the planned activities, are also highlighted.

At the end of the habilitation thesis, the bibliographic references associated with the presented material are listed.