OPTOELECTRONIC AND DIELECTRIC PROCESSES IN KAPTON POLYPYROMELLITIMIDE FILM

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(BL Sharma)

PREFACE

The last few years have witnessed a spectacular growth of interest in the electronic properties of organic solids. The impetus for growth has been provided by a number of factors -technological as well as scientific. The successful development of trinitrofluorenone sensitised poly-n-vinylcarbazole for use as a photoreceptor in electrophotography in place of amorphous selenium has aroused hopes in the minds of scientific workers of achieving similar feats in other areas of technology as well, where polymers might provide cheap and better substitutes for expensive inorganic materials. The fact that PVK;TNF charge transfer complex -as the new material is called- equals the sensitivity of amorphous selenium is not an isolated instance of the potential of these materials. In a related area of technology the feasibility of fabricating organic solar cells of high cost-effectiveness has been demonstrated. Further, it has been proposed that the process of photosynthesis be utilized to generate electricity from solar energy using a synthetic membrane system.

From a purely scientific standpoint, the observation of subtleties in electrical response in polymers, have shed a great deal of light on the underlying microscopic structure and molecular dynamics of these materials. This has not only contributed to our understanding of polymer science but has also at the same time enabled the development of materials which meet exacting electrical engineering requirements.

Indeed, each small breakthrough in the field of electronic properties of organic materials brings man a step closer to his ultimate goal of first understanding and then duplicating nature's feat of producing the most sophisticated and compact electronic system --the human brain- using purely organic materials.

Kapton whose chemical name is poly (4-4' oxydiphenylene pyromellitimide) is a film forming polymer manufactured by Dupont (USA). The imide bonds in its aromatic heterocyclic structure give it excellent mechanical properties and thermo-oxidative stability. Polypyromellitimides or polyimides (for short) are amongst the most promising materials and have become established as the top performing high temperature insulating, adhesive and bonding agents.

The present interest in this polymer arose from the fact that the material has been found to be photoconductive in the visible, ultraviolet and the X-ray regions of the spectrum. Its photosensitivity (I_p/I_d) ranges from 10 to 300 or more in the raw form. This fact forms the basis of the present study which was undertaken to investigate the various optoelectronic and dielectric phenomena underlying the processes of charge carrier generation, transport and trapping in this polymer.

The presentation has been divided into eight Chapters. The first Chapter gives a background survey of the various electronic and dielectric processes in polymers. Since many of these are not very clearly understood, a critical review of

the different points of view on each aspect is presented. The Chapter includes a description of one of the most important applications of photoconductive polymers -electrophotography. The Chapter concludes with a statement of the scope of the present work.

Chapter II contains a summary of properties of Kapton and a description of preparation of samples of this material including heat treatment, electrode deposition etc. The various experimental techniques used to investigate electronic properties of interest to this work have been given in detail.

Electrical conduction in Kapton is the subject of Chapter III. The dependence of dark and photo currents on various parameters such as temperature, electric field, time and illumination has been studied and an analysis of data giving suitable interpretation of the conduction mechanism is presented here. The conclusions indicate the nature of conduction to be ionic. The data yields information on photosensitivity, response time, activation, energy and trap distribution in the material.

Thermally stimulated discharge of Kapton thermo-electrets prepared under different conditions and the relaxation processes uncovered by these are discussed in Chapter IV. Chapter V gives the results of investigations on the photoelectret state in Kapton. This includes a study of the dark depolarization current as a function of the

electric field, polarizing time, temperature and illumination intensity. A brief discussion of the autophotoelectret state in Kapton is also presented at the end.

The photoinduced discharge of corona charged films of raw Kapton as well as Iodine doped Kapton film is described in Chapter VI. Contrast potential and other useful optoelectronic parameters such as quantum efficiency, spectral sensitivity, acceptance potential, half decay time, reciprocity and fatigue have been measured for various types of samples under different conditions.

The concluding Chapter(VII) contains a brief summary of the results which are relevant to the possible use of Kapton as an optoelectronic material and suggestions for further studies on this material.

A part of the research work presented here has been published in the form of research papers. These are:

1. "Field dependence of photocurrent in Kapton polyimide film", Polymer, Vol.20, 1979, pp 1431-1433.
2. "Electrical conduction inKapton polyimide film at high electrical fields", Polymer, Vol.23, 1982, pp 17-20.
3. "Photoconduction in Kapton polyimide film at high electrical fields", Physica Status Solidi(a), Vol. 71, June 1982.
4. "Thermally stimulated discharge current studies in polyimide film electrets", Acta Polymerica, Vol. 33, 1982, pp 205-208.
5. "The photoelectret state in Kapton polyimide film - I", Acta Polymerica, Vol.33, 1982, pp 501-503.

6. "Surface potential decay characteristics of corona charged Kapton polyimide films", Proc. Silver Jubilee Physics Symposium, BARC, Bombay, Vol. 24-C, 1981, pp 579- 580.

7. "Thermally stimulated discharge currents from corona charged polypyromellitimide films", First Technical Conference on Polyimides, Ellenville, NY(USA), November 1982 - accepted.

8. "Photoinduced polarization and autophotoelectret state in polypyromellitimide film", First Technical Conference on Polyimides, Ellenville, NY(USA), November 1982 - accepted.

9. "Metal contact effect on the dielectric relaxation processes in polypyromellitimide film", First Technical Conference on Polyimides, Ellenville, NY(USA), November 1982-accepted.

10. "The photoelectret state in Kapton polyimide film - II" -communicated.

11. "Spontaneous currents from metal-Kapton-metal systems" -communicated.

12. "Electrophotographic characteristics of Kapton polyimide film -communicated.

C O N T E N T S