STUDY OF ELETRICAL PROPERTIES OF THE LDPE-g-AAm BY IMPEDANCE SPECTROSCOPY

[1]Liana R.M. Santos, [2]Alvaro A.A. de Queiroz,[1] Celia M.A.Freire, [3]Olga Z. Higa. [1]DEMA-FEM-UNICAMP, PoBox: 6122-SP, [2]Escola Federal de Engenharia de Itajubá-ICI, PoBox: 50-MG, [3]Instituto de Pesquisas Energéticas e Nucleares-IPEN, PoBox: 11049-SP.

Introduction

Radiation induced graft copolymerization is a versatile technique which can be used to alter the surface and/or bulk characteristics of a polymeric substrate[1].

In this work, the effect of acrylamide graft on the electrical properties of polyethylene was studied by electrochemical impedance spectroscopy (EIS). The graft copolymer PE-g-AAm was caracterized by FT-IR spectrometry using a reflection method, contact angles measurements and swelling behaviour.

Experimental

Commercially available low density polyethylene film was used as base polymer for grafting. The films were washed with acetone and dried in vacuum at room temperature and weighed before use. Reagent-grade acrylamide AAm (Sigma Co) was used as received. Graft copolymer of PE-g-AAm was prepared by simultaneous radiation-induced grafting technique. Thus, a weighed sample of LDPE film was placed in a glass ampoule and a certain concentration of acrylamide monomer (30% m/v) in the presence of methanol was added into the glass ampoule. After bubbling nitrogen (N_2) in the solutions, the ampoules were sealed and irradiated with γ-rays from a ^{60}Co source at a irradiation dose and dose rates of 16.2 kGy and 0.11-1.08 $kGy.h^{-1}$, respectively, at room temperature. After irradiation, the films were washed with water to extrate the homopolymer, dried in vacuum and the degree of grafting of LDPE film was gravimetrically determined. Contact angles were measured by the sessil drops technique.

The electrical properties investigated was the resistivity measurements of the films. The resistivity was measured at room temperature using a electrochemical impedance spectroscopy (EIS)[2]. For LDPE-g-AAm, an electrical equivalent circuit was constituted by the solution resistance, resistance and capacitance representing the double layer at the LDPE-g-AAm interface and resistance and capacitance assigned to the bulk polymer layer.

Results and Discussion

The trunk polymer used in this study is hydrophobic and its swelling in water is very poor. They, however, become hydrophilic and swell in water after the grafting with acrylamide monomer. Table 1 shows the water uptake as a function of grafting degree of LDPE films. It can be seen that water uptake percent increases with degree of grafting due to the introduction of hydrophilic groups of acrylamide chain.

Table 1- Physical data of LDPE-g-AAm graft copolymers

Grafting degree (%)	Contact angle (grau)	Swelling (%)	Resistivity ($k\Omega.cm^{-2}$)
0	90	0	63
20	71	32	15
131	45	78	1

The contact angles between water and LDPE-g-AAm graft copolymers (Table 1) becomes smaller when the grafting degree increases. This means that the graft of the acrylamide monomer enables the polarity on the LDPE surface to become stronger.

Polymers can be considered to be insulators, that is, their resistance to current flow is rather high. Thus, polymers typically have resistivities millions of times larger than those of metals[3].

The resistivity of the LDPE was found to decrease with the acrylamide grafting, and with 131% grafting degree, it was found to be 1 $k\Omega.cm^{-2}$ (Table 1). The decreasing of resistivity of grafted films indicate that the LDPE-g-AAm is more conductor that the ungrafted LDPE films. The electrical conductivity of polymers depends on the presence of free ions not connected chemically with the macromolecules[4]. Therefore, the electrical conductivity of polymeric materials depends on the presence of low molecular mass impurities which are the major source of conductivity. Polyacrylamide is non-ionic in nature, however, the electrical conductivity is slightly improved in its presence as grafted side chains in LDPE films can act as impurities attributed to its mobility of an electrons of PAAm acts as side chains.

On the grafting of AAm onto LDPE, certain changes will be encountered in the attenuated total reflectance IR (ATR-FTIR) spectrum of the grafted films. The main characteristic features of the IR spectra of the grafted LDPE films is the appearence of new band characteristic for the structure of PAAm at 1650 cm^{-1} (C=O stretching). The intensity of this band increases with increasing of the grafting degree.

Scanning electron microscopy (SEM) showed that surface morfological changes occurred with increase of the grafting degree.

References

[1]V.T.Stannet, *Radiat.Phys.Chem.*, 35 (1-3), 82, (1990).

[2]A.J. Bard, L.R. Faulkner, *Eletrochemical methods-fundamental and applications*, N.Y., John Wiley & Sons Inc., 1980. p.316-70.

[3]D.A. Seanor, *J.Polym.Sci., Part C*, **17**, 195, (1967).

[4]M.E. Baired, *J.Polym.Sci.*, **2**, 739, (1970).