Surface Treatment of Commercial Polymers for Food Packaging by Plasma Immersion Ion Implantation

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In this work plasma immersion ion implantation (PIII) was applied to polymers to improve their characteristics for food packaging. The effects of the plasma composition were investigated by comparing treatments using N_2 and SF_6. Different treatment times were used at a total reactor pressure of 1.33 Pa. Radiofrequency Power (13.56 MHz at 100 W) was applied to the lower electrode while the upper electrode was grounded. Preliminary results show the dependences on the gas employed and the pulsed substrate voltage of the new surfaces obtained by PIII. Thus, is possible to obtain a hydrophilic or hidrophobic surface.

Ion beam implantation and its variant plasma immersion ion implantation (PIII) are powerful methods of polymer surface modification [1,2]. Plasma processes offer a suitable way to achieve surface chemical and physical modifications of the topmost layers of materials while retaining their bulk mechanical, physical, and chemical properties. The flexible substrate materials should meet specific and advanced demands, to be integrated in the production of FEDs (Flexible Electronic Devices), such as high optical transparency and high barrier–low permeability response in atmospheric gases such as oxygen and water vapour [3, 4, 5]. These properties are determined and controlled by the bonding structure of the polymer substrates, the surface nanostructure and chemistry,which controls the functionality of the subsequent functional layers that are developed onto the polymer substrates, and finallyon the film-substrate adhesion.

In this work, PET (Polyethylene Terephthalate) from 'Coke' bottles (2 liters) and LDPE (Low Density Polyethylene) courtesy of "The Dow Chemical Company" have been applied to food packaging with good mechanical and optical properties. Some properties, however, are still restricted such as gas barrier and permeability to water vapour. Thus, plasma immersion was applied to this material to improve these barrier properties for food packaging.

The effects of plasma composition were investigated comparing the treatments using N_2 and SF_6. Different treatment times were used at a total reactor pressure of 1.33 Pa as measured using a Barocel 600 capacitive pressure sensor in a reactor containing two paralel circular electrodes. Radiofrequency Power (13.56 MHz at 150 W) was applied to the lower electrode while the upper electrode was grounded.

Infrared Transmission Spectroscopy using an Jasco 410 spectrophotometer was employed to identify molecular groups on the treated surface. Ultraviolet-Visible-Near Infrared Spectroscopy was employed to verify the UV absorbance of the treated materials. Surface contact angle measurements for water and methylene iodide obtained using a Ramé-Hart 100-00 goniometer allowed calculation of the surface energy. AFM (Atomic Force Microscopy) operating in the non-contact mode over 5 µm × 5µm was used to obtain the surface morphology of the samples.

Adhesion was evaluated via SEM images obtained using a LEO 1430 VP scanning electron microscope [6] in the LABEM (Packaging Laboratory). Determinations of the rupture-tension and polymer stretching were made using a Universal Testing Machine (Instron, model 3367 Q 1126) on PET and LDPE. The results of these tests were then used to determine the mechanical resistance [7], the maximum load (of 30 kN) and the relative deformation at maximum load (%).

The three-dimensional AFM surface morphology of the PET samples before (a) and after the plasma treatment (PIII) using SF_6 as shown in Figure 1.

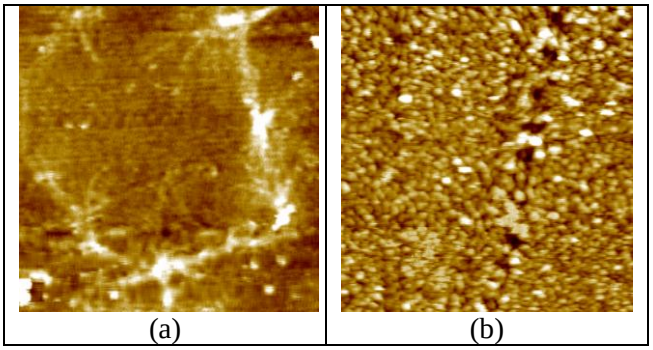

Fig. 1: AFM images of PET samples: (a) untreated; (b) treated with an SF_6 plasma (50 mtorr, 25 W, 15 min by PIII – R = 4.7 nm)

Note that the surface of untreated PET Fig. 1(a) is smooth showing no holes (pinholes), and the average surface roughness is 1.8 nm RMS. Also in relation to virgin PET, there was a slight increase in surface roughness of the samples that were implanted, which was 4.7 nm and 4.4 nm for the powers of 25 W and 150 W of RF Power, respectively.

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