# Plasma Surface Treatment of Commercial Polymers for use in Food Packaging

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In this work plasma immersion (PI) was applied to Low Density Polyethylene (LDPE) and Polyethylene Terephtalate (PET) to improve their characteristics for food packaging. The effects of 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 composed by a steel vacuum chamber containing two internal circular electrodes. Radiofrequency Power (13.56 MHz at 150 W) was applied to the lower electrode while the upper electrode was grounded. Preliminary results show the dependences of parameters with the new surface obtained by PI. Thus, is possible to obtain a hydrophilic or hydrophobic surface.

Through plasma technology, the packaging industry is becoming capable of three unique abilities: *(1)* To remove all unwanted ‘organic contaminants,’ *(2)* Surface treatment, or activation of a material for increased wettability, and *(3)* The deposition of substrates onto a material, adding desired new qualities [1]. Plasma is created through the addition of energy to a chosen gas. This energy is usually introduced via electric fields with either direct or alternating currents. The known ‘useable’ gases for this process are oxygen, hydrogen, argon, nitrogen, Fluorine containing gases and their mixtures. As research continues, however, more gases are becoming available. [2]. Typically, polymer packaging for food ought to exhibit good printability, gas permeation, chemical inertness, anti-microbial action and anti-mist formation. Plasma techniques may be used to obtain these surface properties. Although surface modification of the substrate, such as plasma treatment [3, 4], has been extensively investigated with regards to cleaning and functionalising the polyester for improved coating quality, less attention has been devoted to factors such as the substrate topography. Roughness on the scale of 10s of microns, caused by dust, debris and antiblock particles, has been shown to be responsible for defects, leading to loss of barrier [5]. The nanoscale surface morphology of poly(ethylene terephthalate) (PET) has been well examined [6, 7].

In this work, Plasma Immersion was used to modify the surface characteristics of LDPE and PET samples derived from soft drink, mayonnaise, mineral water and others bottle used for food packaging. Treatment times of 300 s to 900 s were used while the total pressure in the reactor was maintained at 1.33 Pa as measured using a Barocel 600 capacitive pressure sensor. The reactor is composed by a steel vacuum chamber containing two internal circular electrodes. Radiofrequency Power (13.56 MHz at 100 W) was applied to the lower electrode while the upper electrode was grounded.

Infrared Transmission Spectroscopy using an Jasco 410 FTIR Spectrophotometer was employed to identify molecular groups on the surfaces treated. Ultraviolet-Visible-Near Infra Red Spectroscopy was employed to obtain the UV absorbance of treated materials in the wavelength of range 190 nm to 3300 nm. Measurements of the surface contact angle, ϴ, for water and methylene iodide were obtained using a Ramé-Hart 100-00 goniometer. Surface energies were calculated from the values of ϴ. Oxygen permeabilities of the samples were measured using a model 2/61 OX-TRAN Oxygen Permeability oxygen transmission rate tester, according to the ASTM F1307-02 standard. Water vapor permeability was determined gravimetrically according to the ASTM D895-94 standard method.

Table 1 shows the conditions and results of the wettabilitty for PET polymer treated by two plasma techniques (PI) and (PIII) using $N_2$ and $SF_6$. High and low RF Power were applied, 25 W and 100 W, respectively, while the contact angle measurements for Θ, were performed on the same day as treatment, and 30 days after treament.

Table 1: Treatment conditions and contact angles measured on the day of treatment and after 30 days.

| **Technique** | **Gas** | **RF Power (W)** | **Θ (°) initial** | **Θ (°) 30 days** |
|---|---|---|---|---|
| PIII | $N_2$ | 25 | 39.9 ± 5 | 76 |
| PIII | $N_2$ | 100 | 0.4 | 103.5 ± 2 |
| PIII | $SF_6$ | 25 | 136.1 ± 1 | 129.6 |
| PIII | $SF_6$ | 100 | 136.6 ± 2 | 129.4 |
| PI cathode | $N_2$ | 25 | - | - |
| PI cathode | $N_2$ | 100 | 0 | 74.4 ± 3 |
| PI cathode | $SF_6$ | 25 | 126.7 | 91.7 ± 3 |
| PI cathode | $SF_6$ | 100 | 124.2 ± 1 | 127.8 ± 4 |
| PI anode | $SF_6$ | 25 | 120 ± 2 | 95.4 |
| PI anode | $SF_6$ | 100 | 109 ± 4 | 95.9 ± 1 |

Contact angle measurements show that the surface wettability depends on the plasma technique applied and the gas used. After treating the target by the PIII process, the PET layer remained transparent at visible ligth.

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