PL-CT-1

SUPERFICIAL MODIFICATION OF POLYETHYLENE BY PLASMA

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Introduction

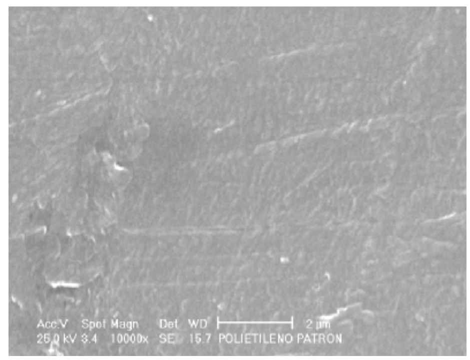
The modification of polymeric surfaces can be achieved fast and cleanly by plasma. The electronic rain of particles in the plasma can produce changes in the macromolecular structure, starting from the surface. The chemical reactivity promoted with the collisions can produce distinct effects such as the formation of active species that can diffuse in the material and react chemically forming new structures that modify the chemical and mechanical properties of the entire polymer.

In this work, the surface modification by plasma of polyethylene (PE) is studied. The objective is to analyze the superficial changes with different exposition conditions to the plasma, bearing in mind the hydrophobic nature of the polymer, since this material is not easily degradable because of its high resistance to wet in normal environment conditions.

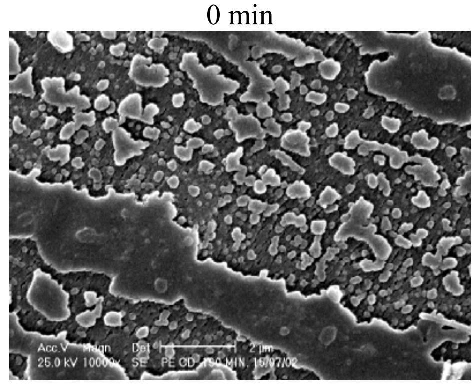
Results

The samples were commercial low-density polyethylene films of 3x5 cm, and 28 μm thickness. DC glow discharges were used at 30 W and $3x10^{-1}$ mbar with exposition times of 30, 60, 90, 120 and 180 min. The samples were characterized by SEM, IR spectroscopy, X–Ray diffraction and contact angle measurements.

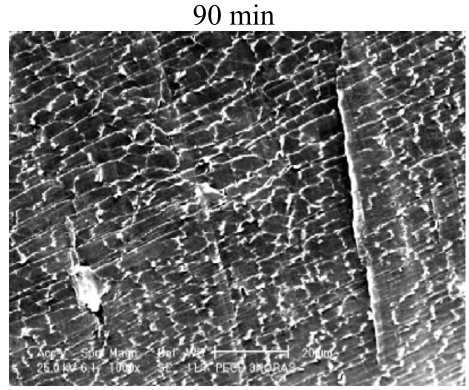
The PE morphology shows that the wrinkling increases with the plasma exposition time, as it can be observed in Fig. 1. In the sample without treatment, 0 min micrograph, the surface presents small granules and no uniform lines. However, in the PE exposed to the plasma the morphology is irregular with small granules and formation of agglomerates in some points of the surface.



0 min



90 min



180 min

Fig. 1 – PE Morphology with different exposition time to the plasma.

In Fig. 2, the X-ray diffraction corresponds to the structure of the polymers exposed to plasma. The PE samples without treatment presents diffraction in 21.4° and 36.1° with 42% of crystallinity, whereas the PE exposed to the plasma during 60 min presents five additional diffraction peaks at 9.4°, 19.1°, 23.7°, 28.6° and 36.1°. In the PE exposed for 30 and 90 min, only one additional diffraction peak appeared at 12.3°.
The peak at 19.1°, 21.4° and 36.1° belong to the beta-polyethylene, however, the peaks at 9.4° and 28.6° could be originated in another phase of PE or because of the changes in the chemical structure of the polymer. This evolution in the whole crystallinity of PE began in the surface bombarded by the plasma.

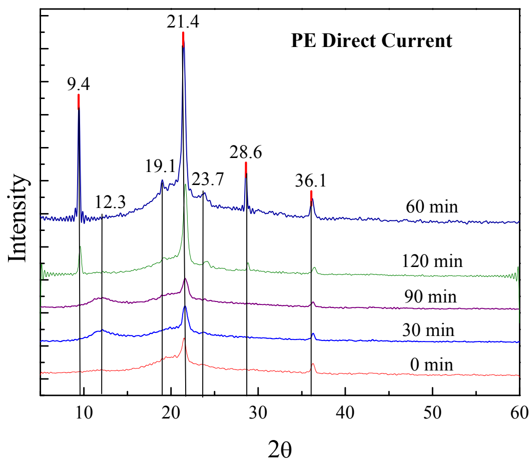


Fig. 2 - X–Ray diffraction of PE after different exposition time of plasma.

A form to measure the hydrophobic nature of surfaces is analyzing the angle of contact of a water drop with the surface of interest. In Fig. 3, the contact angle of water drops with the PE surfaces exposed to plasma is shown. The evolution of the angle indicates that when the time of exposition increases, PE becomes less hydrophobic, that is, the conditions for water penetration are favored and degradation can be carried out by microorganisms. This effect can be considered as fast aging coupled with accelerated oxidation. The curve has a change in the slope around 75 min of exposition time. After this point, the contact angle reduces rapidly.

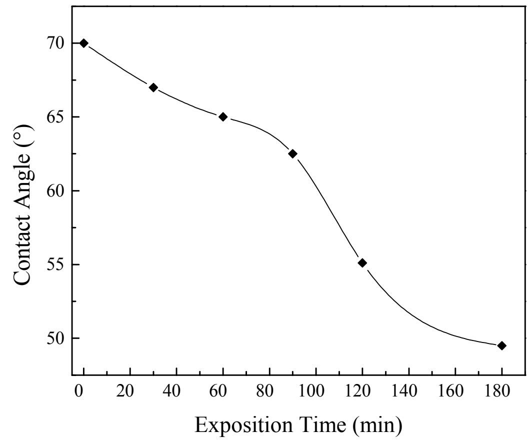


Fig. 3 - Contact Angle of PE as a function of the exposition time of plasma.

Conclusions

The PE surface begins to change from the first moment this polymer is exposed to the plasma, from a plain texture to a granular morphology. However, between 30 and 90 min occurs the main modification in the structure, the crystallinity increases and decreases in this interval. Beyond 90 min, the surface has been oxidized and another mechanism of degradation can take place.

Acknowledgement

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References

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