Biopolymers Summit 2018: Plasma Surface Treatment of recycled polymers for Food Packaging - Péricles Lopes Sant'Ana- State University of Sao Paulo

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In this work, it was used a vacuum system on a set up well exploited, in order to use Plasma Immersion Ion Implantation (PIII) and Plasma Immersion (PI cathode or PI anode), which were suitable techniques for the surface treatment over the Polyethylene Terephthalate (PET) substrates, from Coke bottles of 2 LTM. The purpose was: to change their wettability, surface morphology and optical transmittance at visible light. Some papers regard the physic-chemical alterations on the surface of PET samples. However, the selectivity of those plasma treatments, results in a notable and partial combination of surface properties, even with serious restrictions. It's reasonable to reveal the results founded holder at the room temperature during the treatment time of 900 s. The wettability behavior depends on the plasma technique applied and the gas employed to them. In some cases, the surface hydrophilization was not stable as seen by the temporal evolution of the contact angles roughness Rz, increased only a few tens of nanometers, in relation to the virgin PET (1.8 nm), even in a strong ion bombardment during the treatment. As a general trend, the roughness increases slightly for all radiation, depends on the parameters of the plasma treatment. PIII technique and N2 bombardment are more indicated than the plasma immersion and SF6 bombardment to increase the transmittance of PET at visible region. In general, those parameters selected imply in a positive plasma conditions, considering the overview to try out a technological destination for recycled commercial polymers.

Introduction

Packaging has a fundamental role in ensuring safe delivery of goods throughout supply chains to the end consumer in good condition. It also has great potential to contribute to sustainable development. The increasing environmental concern among consumers in their selection of food products also seems to include the packaging as reported by Rokka and Uusitalo. Packaging plays an important role in preserving, protecting and marketing products during their storage, transport and use . In this sense, the introduction of new technologies could lead to a reduction of the processing time or an improvement in operating conditions, thereby decreasing both cause several chemical and physical changes on the plasma-polymer interface, which improve the surface properties. Plasma-induced effects on the polymer surface are nowadays exploited in surface functionalization of the packaging polymers, for promoting adhesion or sometimes, enhanced printability, assuring anti-mist properties, improving the polymer's adhesion of antibacterial coatings, which is interest for food packaging.

As mentioned, plasma treatment can improve surface properties of polymers such as wettability and surface functionalization, and consequently also adhesion properties. This may be important for coating the food-packaging foils with antibacterial layers . lists the most common polymers in packaging materials, their functions in the packaging and some applications. Polyethylene is used as heat sealable food contact layer moisture barrier which can be combined with gas/aroma barriers. Polyethylene terephthalate (PET) can provide gas/aroma and moisture barrier to provide mechanical strength heat resistance. However, some recent studies show the migration of chemical substances from PET to water in bottles from 40 ºC and 60 º C of storage. Fang et al [18] concluded the migration increase with the storage temperature. These studies reinforce the opportunity of applying surface treatment in polymers for food packaging. There are many techniques that can be used to modify or alter the surface properties of materials by addition of particles; coatings and functional groups however, the growing interest in ion-implanted polymeric materials is due to its increasing demand in various disciplines. Recent results from PET treated by plasma at low temperature atmosphere the improvement on wettability, and the changes on the surface roughness and optical transmittance in the visible region for the PET (from coke 2 L.) treated by plasma immersion techniques .A gradual increase of the applications of PET bottle formats, were reported in other recent studies The partial hydrophobic nature of PET results in poor uptake and adhesion of dyes, particles and microcapsules which reinforce the importance of treatment for improve the PET wettability. Recent studies associated the improvement of wettability with the increase of oxygen groups on the PET surface after plasma treatment In this study it was used plasma immersion techniques (PI and PIII), in order to improve the wettability of PET polymer, to promote low surface roughness and high optical transmittance in the visible range, because these PET surface features are in agreement with food packaging industries. Experimental Methodology The apparatus used consists of a stainless-steel vacuum chamber with two internal electrodes. Substrates were placed on the stainless-steel electrode and the system was evacuated by a rotary pump (18 m3/h) down to 10-1 Pa. Needle valves were employed to control the gas feed and, a Pirani pressure gauge, to monitor the chamber pressure. PET samples were exposed directly to the plasma environment established by application of 25 W or 100 W of Radiofrequency Power (13.56 MHz) to an atmosphere composed of N2 or SF6. In all conditions, the total pressure in the reactor was constant at 6.66 Pa (50 mtorr), while the treatment time was 900 s for each condition. Three different arrangements were applied to this work keeping the temperature inside the reactor constant at (298 k):

(i) The substrate holder and the chamber walls were grounded while RF power was fed to the opposite electrode - PI anode.

(ii) The RF power was supplied to the substrate holder while the opposite electrode and the chamber walls were grounded - PI cathode.

(iii) The RF power was applied to the opposite electrode while negative pulses of high voltage were applied to the substrate holder (300 Hz, 30 µs and -2400 V) - PIII.The wetting of the PET samples was evaluated by the contact angle measurements of the samples, using a Rame-Hart 100-00 Goniometer; in other to obtain the wettability of the PET samples after plasma treatment. The Atomic Force Microscope XE-100 from Park Instruments was employed to report the RMS (The mean square roots) roughness of PET samples taking 5 µm × 5 µm areas and, the optical transmittance was measured by a Lambda 750 Spectrometer UV-VIS-NIR, ranged from 190 nm to 3300 nm of electromagnetic spectra. Results technique using deionized water at room temperature.

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Conclusion

The overwhelming majority of papers report results from of the plasma treatment in the samples were positive on the basis of selectivity in the character of wettability and optical transparency, thereby increasing the hydrophobicity by means of SF6 hydrophobicity using N2 maintaining the optical transparency to visible light of PET samples through the techniques of plasma at low pressure system. AFM images show no considerable changed in the roughness for the samples treated with different gases. It is a good evidence of oxygen etching, independent of the temperature substrate system, which explains the recovery proper to promote good stable wettability in until 30 days. Both plasma immersion techniques are indicated to maintain the low surface roughness (bellow 5 nm), and to increase the optical transmittance at visible region (up to 80%).