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PROOF-OF-CONCEPT EXPERIMENT REPORT

SURFACE ACTIVATION OF OLEFINIC POLYMER WITH O_2 PLASMA

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Proof-of-Concept experiment details

Received sample: large foils made of olefinic polymer with thickness of 180 μm.

Figure 1. Olefinic polymer films wrapped in aluminium foil.

Main aim: Olefinic polymer films have a good optical transmission and a lack of autofluorescence, a requirement for their application as plastic cartages bio diagnostic kits. However, they lack surface chemical radicals that allow the adhesion of toxins and viruses on the surface. To overcome this problem, treatment with an ozone producing UV light is used to activate the surface, followed by surface chemical modification with (3-Glycidyloxypropyl)triethoxysilane (GPTES). This last step is necessary to stabilize the plastic surface.

In our Proof-of-Concept experiment, we plan to use O_2 plasma treatment as an alternative method to the use of UV light. Using X-ray photoelectron spectroscopy (XPS) and surface roughness analysis, we plan to evaluate both methods and compare them in term of efficiency. Different exposure times are planned to find the optimal parameters. The expected results are the possibility to use the plasma treatment as an easier and more convenient method to prepare the cartages for the commercial production of the bio diagnostic kits.

Planned analysis:

- 1st step: O_2 plasma and UV light treatment of olefinic polymer films for surface activation.
- 2nd step: XPS and surface roughness analysis of the films.
- 3rd step: O_2 plasma and UV light treatment of new olefinic polymer films for chemical modification of the activated surface with GPTES.
- 4th step: chemical modification by immersion of prepared films into a solution made of ethanol, water and GPTES.
- 5th step: XPS measurements on the new samples.

Sample preparation: The foil was cut into approximately 1x1 cm stripes for different sample preparation.

Samples were exposed to O_2 plasma or UV light for the duration of either 1, 2 and 3 minutes.

Treated samples were immersed in a solution made of ethanol, water and GPTES heated at 60°C for 1 hour to chemically modify the plastic surface. Samples left drying at 120°C for an additional hour.

Measurement authors and place: the sample preparation and the reported measurements have been performed at IOM-CNR by Simone Dal Zillo, Erik Betz-Güttner, Marco Beltrami, Jurij Urbančič and Barbara Ressel.

Observation conditions:

Plasma: 20 watt with a pressure in the chamber of 0.55 mbar, and bias kept at 50 V through a manually operated throttle valve.

UV light: 20 watt with peak emission at 185 nm.

XPS: monochromatized Al K-alpha X-ray source at 1486.6 eV and a hemispherical electrons' spectrometer.

Optical profilometry: surface roughness measurements were performed using a Profilm3D optical profilometer.

Results

After O_2 plasma and UV + ozone treatment of the samples, the XPS spectra were taken in order to investigate the resulting change on the surface (see Figure 2). The spectra show that both treatments give rise to the appearance of oxygen peaks, hence indicating the formation of oxygen radical on the surface.

Also, a surface morphology analysis shows no significant difference after these treatments, with the average surface roughness of 15 nm.

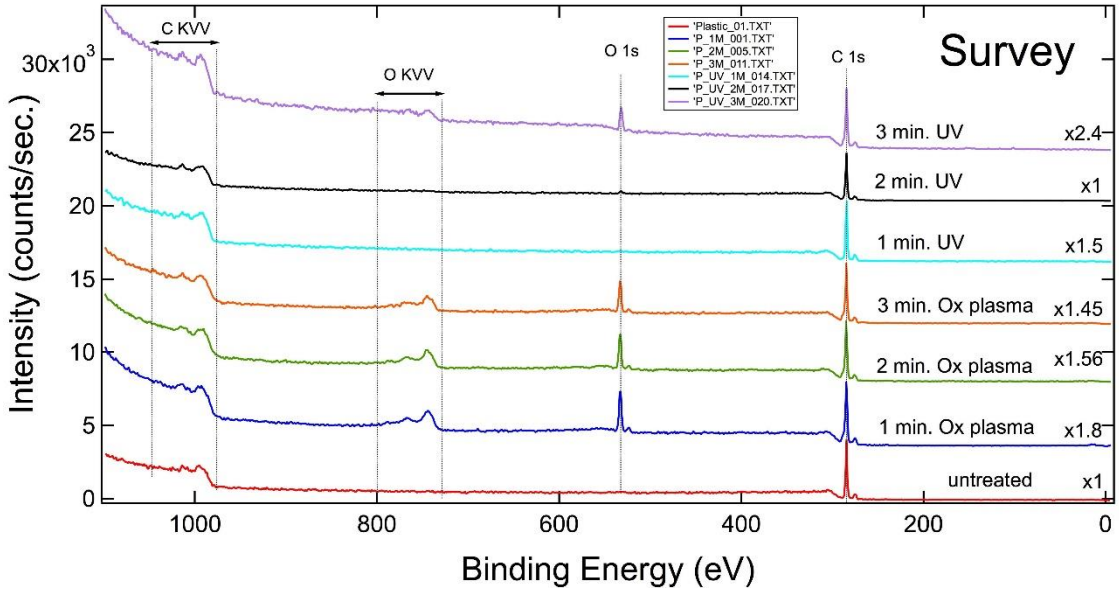

Figure 2. XPS spectra of polymer films after treatment with O2 plasma and UV light. Different exposures were investigated.

XPS measurements were also performed on another set of samples which were first treated with either plasma or UV light (same parameters and exposure as before) and then immersed in a solution of ethanol, water and GPTES. The XPS results are summarized in Figure 3. This was done in order to check the sustainability of the treated polymer for the required application and to compare the methods.

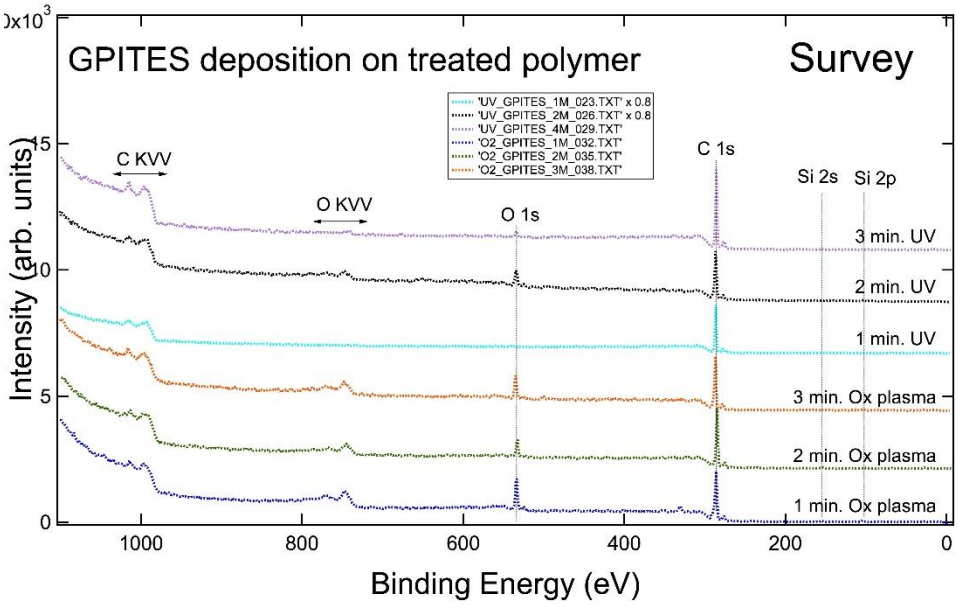

Figure 3. XPS spectra of polymer films with GPTES.

Summary

The results given by the XPS, show the appearance of oxygen peaks in samples treated both with O_2 plasma and UV light. However, in the case of UV they appear only after 2 minutes exposure, while in the case of plasma, they are present even after 1 minute and more pronounced. Both O_2 plasma and UV treatment of olefinic polymer shows no significant change in the surface roughness.

Thus, plasma method is confirmed to be an effective technique for surface activation, and the comparison of the two techniques on the same plastic surface show that the plasma method is better for surface activation and GPTES deposition.

This report has been written by Jurij Urbančič (Ajdovščina, 30 June 2022)