

ACTIVE SCREEN PLASMA NITRIDING OF ULTRA HIGH MOLECULAR WEIGHT POLYETHYLENE

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Introduction

Active screen plasma nitriding (ASPN) has been proved an efficient method to modify the surface of ultra high molecular weight polyethylene (UHMWPE). [1,2]

Materials and methods

UHMWPE (MW=9,200,000 g/mol) sheet was supplied by Oadby Plastics Ltd. The ASPN treatment was applied for 10, 30 and 60 mins at 120°C under a pressure of 2.5 mbar, the atmosphere in the plasma chamber contained 25%N₂ and 75%H₂. Figure 1 shows a schematic diagram of the ASPN furnace. The treated UHMWPE samples were characterized by FTIR, SEM, XRD and AFM. 3T3 Fibroblasts cell line was used to evaluate cells adhesion on the surface of untreated and treated samples. 3T3 murine mouse cells were cultured for 10 days according to 3T3 protocol and count twice to control their viability. After sterilization of UHMWPE samples using an autoclave for 15 mins at T= 121°C, cell culture was conducted and the samples were collected after 4 days. Cells adhesion on untreated and treated UHMWPE surfaces was observed by SEM.

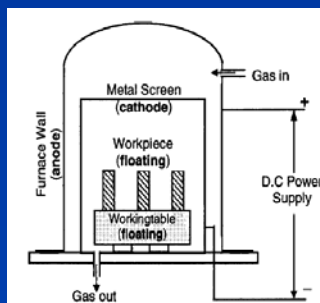


Figure 1

Results and discussion

Plasma treatment

FTIR

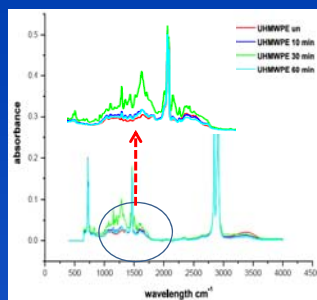


Figure 2

FTIR spectra showed clear differences between the untreated and treated samples especially in the area between 1500 and 1000 cm⁻¹. Table 1 shows the description of the main characteristic peaks and differences. We can conclude that there is an effect of the plasma treatment in the FTIR spectra of treated samples.

Characteristic peaks cm⁻¹

Table 1

	2901	2843	1471 1461	719		
untreated	2901	2843	1471 1461	719		
10mins	2907	2843	1471 1462	711		
30mins	2909	2843	1471 1461	719	1545	1283
60min	2917	2843	1471 1462	711	1544	
description	-CH 2- non-symmetric stretching vibration	-CH2- symmetric stretching vibration	-CH 2- non-symmetric stretching vibration	-CH2 - in plane vibration	-C=C- stretching vibration	-C-N- stretching vibration

AFM

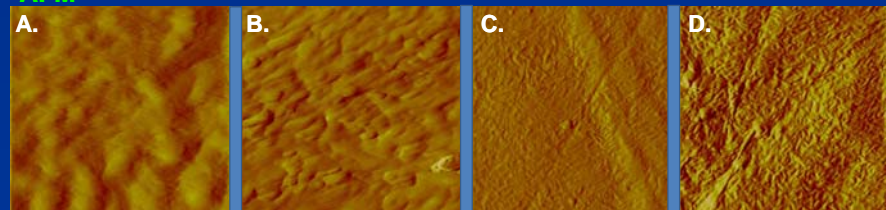


Figure 3: A.Untreated, B.10min, C.30min, D.60min treated
AFM studies revealed that surface roughness increased with the time of treatment.

XRD

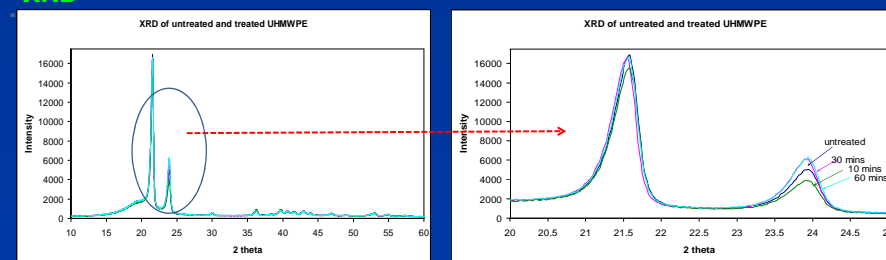


Figure 3

No particular differences have been observed in the XRD spectra except from a small difference in the intensity among the samples with no particular sequence. However, this can not be conclusive as the thickness of the surface layer is in the order of a few nanometers and the information taken by the XRD comes from a larger depth within the material, resulting in losing the information from the surface. In order to study the effect of the treatment on the crystallinity of the polymer surface wide angle X-ray diffraction should be applied.

Cell culture

SEM

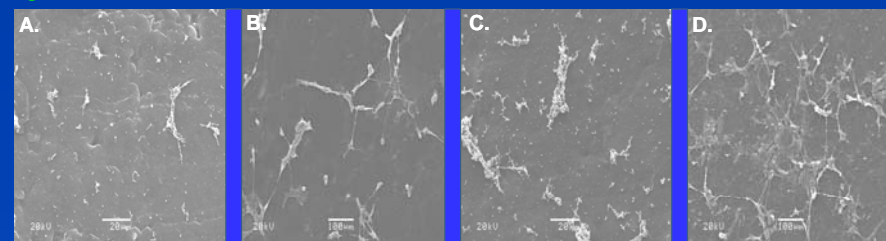


Figure 4

A.Untreated, B.10min, C.30min, D.60min treated

Figure 4 shows the cell preference to adhere on the treated surfaces rather the untreated one. The main reason is the presence of C-N groups on the surface of the treated samples as discussed in the FTIR section.

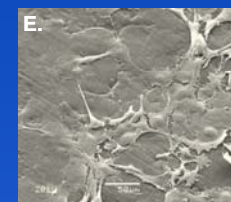


Figure 5

Higher magnification shows good adherence of the fibroblasts on the treated surfaces. Figures 5 and 6 show cells adhesion on 10 mins and 60 mins treated surfaces respectively.

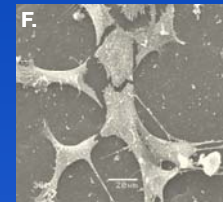


Figure 6

Conclusions

➤Surface treatment with ASPN seems to be more effective at higher than 30 mins of processing. 10 mins processing did not have a significant effect on the UHMWPE surface as revealed by FTIR and cell culture studies.

➤ The effect of ASPN treatment was identified by the presence of C-N groups and unsaturated carbon bonds on the surface of treated samples.

References

- [1] C.Zhao, C.X.li, H.Dong, T.Bell, Surface and Coatings Technology 210 (2006) 2320-2325
- [2] P.K.Chu, J.Y.Chen, L.P.Wang, N.Huang, Materials science and engineering R 36 (2002) 143-206