INVESTIGATION OF SOME PROPERTIES OF NYLON-6 SURFACE TREATED BY CORONA DISCHARGE IN HELIUM

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Introduction

Plasma treatments of the materials have been extensively studied and, particular, a great deal of research has been devoted to polymer surface modification. Various methods of treatment, i. e., low temperature plasma, RF plasma, corona discharge, etc., to modify the mechanical, chemical and biological properties have been used [1,2,3].
In this work an easy and less expensive method of treatment has been used by corona discharge. This allows to modify the surface properties and especially to improve the compatibility of polymers with biological tissue. We chose nylon-6 as a test material because it is one of the biological compatible materials preferred, i. e. in surgeon sutures [4,5]. For example, monofilaments nylons provoke minimal inflammation and less tissue reaction than natural materials [6].

Experimental

Surface treatments were performed using a corona discharge in helium produced by a plasma generator ("Plasmed-1") with variable frequency, amplitude and polarity. Conditions of our experiments were: gas pressure of about 10^5Pa, power 40W, diameter of plasma beam 2mm and its length about 2-3cm, treatment duration 5,10,15sec. Elapsed time between the plasma treatment and biological tests was approximately 1h. The most common monomer usually used for nylon-6 preparation is ε-caprolactam. Then were used monofilament fibers of 22μ diameter and foil samples of 400μ thickness. In terms of ease to handling, surface of samples was of about 2cm×2cm.
A scanning electron microscope to visualise the morphology of the surface and an IR spectrophotometer able to identify the amide groups and other as well, have been used.

Results and discussion

SEM photograph shows a drastic change of surface after treatment (Fig. 1a and 1b).
The polymer sample and the monofilament were exposed to corona helium plasma. Interaction between the energetic plasma beam and the polymer surface consists of the following stages [1]:
-surface bombardment by ions, neutrals, metastables of helium and excited species;
-desorption of O_2 and N_2 molecules from the polymer surface;
-formation of lattice damage, generating active sites which extend several monolayer below free surface;
-reaction of free radicals on polymer in the presence of N and O containing species;
-bond scission in macromolecular chain of polymer.
We consider that the treatment makes both a crosslink structure (a "worm-like" structure - Fig. 1b) and an etching/sputtering of nonocristallyne domains as well [5].
We tried to compare the biological compatibility of treated and untreated surfaces.

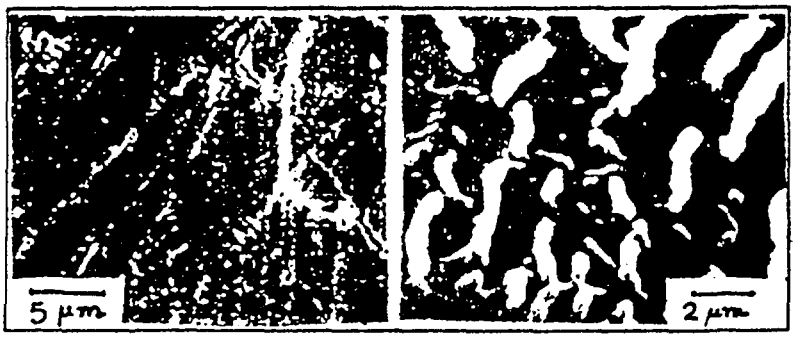

Fig. 1.a (before treatment) *Fig. 1.b (after treatment)*

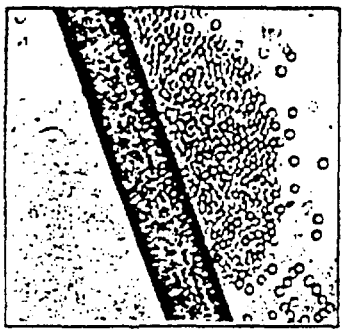

Fig. 2

Escherichia coli, Staphylococcus aureus, Bacillus subtilis and Saccharomyces strains have been used for biological tests. Micro-organisms have been cultivated in stationary conditions, at 28°C. Growing up of the cultures has been appreciated on biomass and number of germs/ml using successively dilution method. The presence of nylon-6 treated in liquid culture medium has as results a biomass growth until at 32%.

Under the microscope (×300) had been observed that after about 30 minutes, cells are attached by filament on treated surface: bacteria forming coniform laying down, and the yeast forming compact mass (Fig.2).Yeast cells that come from cultures with treated fiber manifest a high attraction to the fiber, when coming near it, and start rotating around themselves. After a mechanical moving off, cells return to their place and they have a similar behaviour. On agarised medium, in Petri disc, growing ratio of colonies ismodified; then, these appear faster (at 24hs), are bigger and they have a translucent surface. There are less cells in suspension culture comparatively with control, but the weight of treated fiber grows up with about 7%.

Supplementary, a test of blood coagulation on the polymer surface was made. We found a 4-5 times while clotting on the treated surface by comparison with the untreated surface. Some plasma proteins were tested, but electrophoresis method [6] showed no modification of them. Also, the calcium replacement clotting time (to measure possible deterioration of any of proteins involved in the clotting mechanisms) remains unchanged.

Conclusions

-Morphology of the treated surface by corona discharge emphasises an etching and/or a crosslinking of amorphous domains, generally important to improve the properties as wetting, dyeing, adhesion , etc.

-Over all treated surface there is significant blood compatible properties without the need of heparinization of surface.

-The treated surface influences the biological behaviour of micro-organisms, respectively, that surface is a favourable medium for division of cells and may increase their lifetime.

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