Abstract

The introduction of mesh implants to the market in the second half of the 20th century was a breakthrough in the treatment of both hernias and stress urinary incontinence in women, and resulted from the ineffectiveness of conventional surgery. The most commonly used material for mesh implants, due to its proven biocompatibility, is monofilament polypropylene yarn. Obtaining the required physical properties of a knitted implant that result in the effectiveness of the operation depends mainly on the parameters of the thermal stabilization carried out and constitutes a technical and technological challenge for new types of mesh implants. Despite years of research and experience, polypropylene implants do not meet all the criteria for an ideal prosthetic material, due to the risk of rejection, extrusion, infection, wound healing disorders, uncontrolled adhesion and allergic reactions. To reduce the occurrence of adverse events and increase the biocompatibility of the implanted material, one solution is to use surface functionalization. Atomic layer deposition (ALD) technology provides new opportunities to obtain biocompatible and homogeneous layers with using metal oxides. This creates opportunities to modify the surface properties of polypropylene surgical implants, for example, by depositing titanium dioxide.

The research presented in this dissertation focused on the use of the thermal stabilization process and the ALD technique to develop non-resorbable synthetic mesh implants for use in surgical treatments for female urinary incontinence and causal or preventive occurrence of parastomal hernia.

Scanning electron microscopy, atomic force microscopy and energy dispersive X-ray spectroscopy were used to analyze the surface morphology and chemical composition of the deposited titanium dioxide layers. Changes in the structure of the material of mesh implants, i.e., polypropylene, were evaluated using wide-angle X-ray diffraction and Fourier transform infrared spectroscopy. Thermal properties of polypropylene were characterized by differential scanning calorimetry. The effects of structural changes were evaluated using strength tests. In addition, the changes in the surface properties of polypropylene caused by ALD modification with TiO_2 were evaluated and the biological response was assessed.

With the obtained results, it was possible to develop mesh implants with the required physical and mechanical properties, as well as to determine the parameters of the ALD process at which it is possible to form a homogeneous, conformal layer of titanium dioxide without leading to changes in the supramolecular structure of polypropylene.

The manufactured implants are characterized by hydrophilic properties and biocompatibility, which is crucial because of their future use.