FUNCTIONALIZATION OF POLYURETHANE SURFACES FOR IMPROVED BIOCOMPATIBILITY

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Introduction

Esophageal cancer is at the forefront of the most commonly diagnosed cancers, and the sixth main cause of cancer–related mortality. The polyurethane membranes of esophageal stents, that prevent tumor overgrowth, should be stable and ensure reliable support against dysphagia, although, in long-term use, a significant loss of biostability is observed. Thus, the functionalizations of polyurethanes are necessary individually for the inner and outer sides of the stent. In order to obtain cover's best performance and stent durability, the outer side, constantly in contact with esophageal epithelium, has to be biocompatible while the inner side to prevent the clogging of the medical nutrients has to be antifouling. Such dual functionalization can be obtained with the use of plasma treatment by the introduction of surface functional groups. The superiority of the proposed method is based on its simplicity, efficiency, and environmental friendliness. Such an approach opens the doors to the development of polymeric biomaterials with a novel class of functionalized surfaces to help patients' palliative treatment and increase their quality of life.

A key starting point for designing cell–adhesive polymeric materials is to activate surfaces with functionalities that promote the adhesion and survival of selected cell types involved in the wound healing or tissue regenerative process. The proposed approaches for improvement of biomaterials include enhancement of adsorption of specific proteins and material modification by immobilization of cell recognition motives to control interaction between cells and polymeric substrates. The RGD sequence ((R: arginine; G: glycine; D: aspartic acid; Arg-Gly-Asp) is the most effective cell-recognition motif and has been used to stimulate cell adhesion on synthetic surfaces.

In this study we focus on exploring two different ways of surface functionalization of the polyurethane which are used as a cover of self-expandable nitinol esophageal stent.

Materials and Methods

The commercially available polyurethane samples provided by American Polyfilm, Inc were modified using oxygen plasma using a Diener electronic Femto plasma system (Diener Electronic GmbH, Nagold, Germany) at pressure of 0.2 mbar. The varied parameters were the time of exposure to the plasma, which was in the range of 6 s to 10 minutes and the plasma generator power with the range of 50 to 100 W.

The changes within the surface were followed by contact angle measurements, using a Surftens universal instrument (OEG GmbH). Static contact angles of water were calculated using Surftens 4.3 — windows image processing software for digital images for determination of contact angles and surface tension.

Changes in surface morphology of the polyurethane films were observed with the scanning electron microscope (Hitachi S-4700).

Results and Discussion

Plasma parameters, such as applied power, and exposition time have to be carefully adjusted based on the specific polymer and its application. Detailed characterization of the oxygen plasma treated surfaces is crucial, because the biological moieties are rigorously sensitive to the geometrical and/or chemical modifications of material.

The introduction of oxygen functional groups has a significant influence on hydrophilic properties of the examined material. Such modifications were followed by contact angle measurements. The changes in surface properties are represented directly by water contact angle. The unmodified polyurethane surface, with the Θ_{H2O} = 105° ± 3°, are hydrophobic. The water contact angles for the samples treated with oxygen plasma systematically decrease, for 30 s Θ_{H2O} = 60° ± 3°, for 1 minute Θ_{H2O} = 50° ± 2° and for 10 minutes Θ_{H2O} = 35°±3°. The observed changes in polyurethane surface induced by oxygen plasma treatment are significant in terms of its biocompatibility.

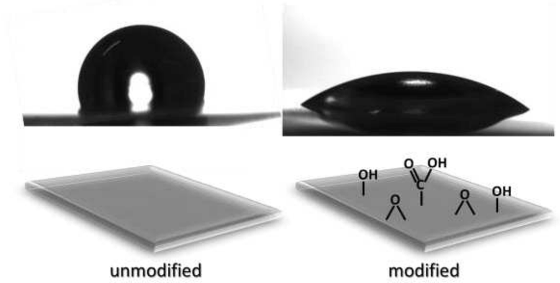

FIG. 1. Water contact angle measurement for unmodified polyurethane surface and for 1 min oxygen plasma modified (the introduced oxygen functional groups were spectroscopically identified).

Conclusions

The oxygen plasma modification on polyurethane surfaces, have a significant impact on the biocompatibility in terms of increased hydrophilicity. Since the assumptions for the functionalization procedure are of a general nature, the obtained results can be easily extended for other plasma feed gases and polymeric materials.

Acknowledgments

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