DESIGN AND TAILORING OF POLYMERIC BIOMATERIALS SURFACES: PREVENTION OF BIOMATERIALS-CENTERED INFECTIONS

MONIKA GOLDA-CEPA[1]*, PAULINA CHYTROSZ[1], WOJCIECH PAJERSKI[1], MONIKA BRZYCHCZY-WŁOCH[2], ANDRZEJ KOTARBA[1]

[1] FACULTY OF CHEMISTRY, JAGIELLONIAN UNIVERSITY, KRAKOW, POLAND
[2] FACULTY OF MEDICINE, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE, KRAKOW, POLAND
*E-MAIL: MM.GOLDA@UJ.EDU.PL

[ENGINEERING OF BIOMATERIALS 158 (2020) 41]

Introduction

In the EU each year at least 500 000 patients undergo surgeries that required stabilizers and endoprostheses implantation and approx. 2% required revision surgery due to implant-related infections. Biomaterial-Centered Infection (BCI) may lead to secondary complications i.e. amputations, morbidity and even mortality. Indeed, infection treatment is associated with significant costs, approx. 6.5 times higher compared to patients without infection. Thus, the prevention of BCI is one of the most challenging issues in orthopedic and trauma surgery. Although several BCI preventive strategies have been developed i.e. the preoperative administration of antibiotics, standardized sterilization procedures with restricted, detailed protocols, still more than 25% of all hospital-acquired infections are medical devices-related. Therefore, the investigations on novel biomaterials should integrate biocompatibility and anti-infection functions and tuned them together, which is a real challenge for surface functionalization.

In the study different kinds of medical-grade polyurethanes materials are used, due to their versatility. These materials can be rigid, semirigid or flexible with excellent biocompatibility, outstanding hydrolytic stability, superior abrasion resistance, outstanding physical strength, and high flexure endurance. The availability of polyurethanes in several forms, i.e. of adhesives, coatings, sealants, rigid and flexible foams as well as textile fibers allow their use in pacemakers, catheters, vascular grafts, heart assist balloon pumps, artificial heart bladders and wound dressings.

The initial stage of the bacterial attachment process is governed by the interplay between the properties of the bacterium and solid surface, which is mediated by the body fluids ions, as summarized in FIG. 1. The ability of bacterial cells to adhere and form a biofilm is a crucial feature for their survival in complex environments (i.e. human body). As a result, microorganisms developed several strategies for specific and non-specific interactions with the surfaces. Despite enormous research efforts in the field of biomaterials, there is a lack of solutions preventing bacterial adhesion with excellent biocompatibility. The study aimed to optimize plasma treatment parameters of polyurethanes in such a way to obtain biocompatible and anti-infection surfaces.

Materials and Methods

The medical-grade polyurethane surfaces were plasma-functionalized with the use of different feed gases: air, O_2, CO_2, and N_2. The samples were characterized with the use of surface- (water contact angle measurements, XPS) and bulk- (XRD, TG/DTA, RS) dedicated methods.

For the selected functionalized samples, the microbiological tests were performed (live/dead fluorescent staining, adhesion rate).

Results and Discussion

The plasma treatment allows to obtain the polyurethane surfaces with controlled surface functional groups coverage. The parameters of plasma modifications were precisely adjusted in such a way to limit the functionalization to the surface, without changing the bulk properties of the materials (monitored by changes in crystallinity of the polymers and melting point determination).

It was revealed that the introduced functional groups are beneficial for biocompatibility, however, they increase the risk of infection. The obtained polyurethane surfaces differ significantly in terms of surface free energy (SFE) 80 mJ/m^2-20 mJ/m^2. Such surfaces can be used for further studies, however, their optimal biomaterial application will be diverse. Polymeric surfaces with high SFE (>50 mJ/m^2) are suitable for bone tissue while those with low SFE (<50 mJ/m^2) can be used for blood contact.

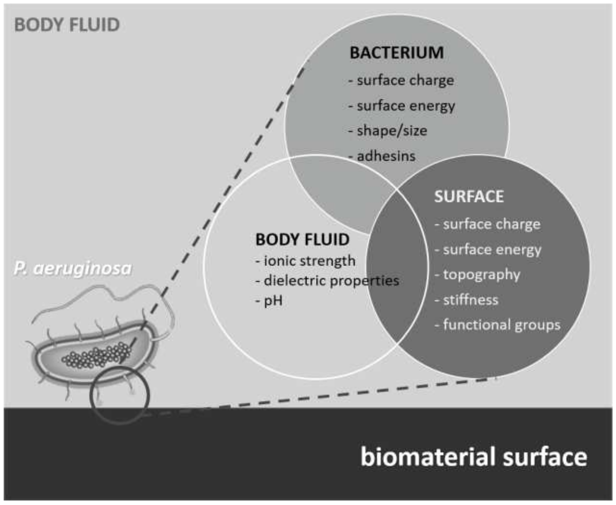

FIG. 1. A schematic representation of the main factors that influence initial bacterial attachment to abiotic surfaces.

Conclusions

Polyurethanes, as the most versatile polymeric family used as biomaterials, can be successfully surface modified by plasma. It is possible to obtain materials with dramatically different SFE and therefore, compatible with targeted tissues.

Acknowledgments

This work was supported by the National Science Centre, Grant 2019/35/D/ST5/03107.

References

[1] Shelke, N. B., *et al.* Natural and Synthetic Biomedical Polymers (Elsevier, 2014).