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Attension | [Application Note] 4

Influence of contact angles and surface free energies on biocompatibility of biomaterials

This application note illustrates how the Attension tensiometers can be used to study the biocompatibility of biomaterials.

Introduction

Biomaterials are either natural or artificial compounds that have the ability to integrate with biological cells. This ability enables the close contact of biomaterials with living cells and tissues as well as fluids. Biomaterials are often used for curing a tissue or replacing a function of a vital organ. Implant and medical devices such as artificial joint replacements, dental impressions and contact lenses contain biomaterials.[1]

The biocompatibility of a biomaterial defines the suitability of the material to be used in a certain application. A material with a good biocompatibility does not elicit an immune response in a given organism and is able to integrate in the biological environment, such as the human body.

Biomaterials can be inert or active: inert biomaterials do not react with the surrounding tissue or organ whereas active biomaterials enhance growth and implantation of the surrounding tissue. The activity of the biomaterial depends on the level of cell adhesion onto the implant. The cell adhesion should be especially good for example in artificial joint replacements, where the integration of the replacement to bone tissue is essential. However in catheter, cell adhesion should be as small as possible in order to avoid contaminations that can cause infections.

The adhesion properties of micro-organisms onto a biomaterial can be evaluated by using contact angle measurements. Small water contact angles and high surface free energies indicate good adhesion properties of the material. Contact angles and surface free energies can be evaluated with Attension force and optical tensiometers.

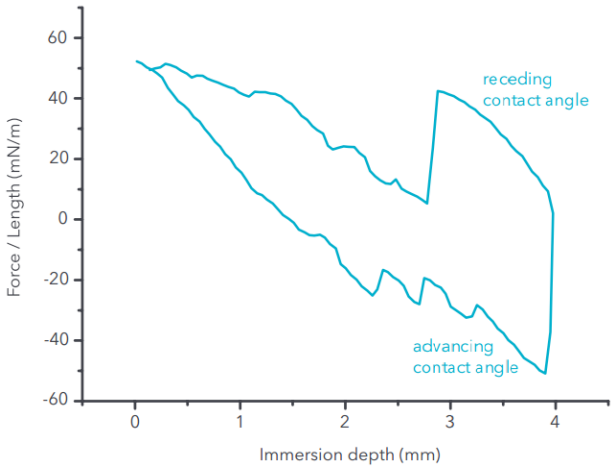
Case study: contact angles of dental implants

Biomaterials are used in many different areas of dental applications such as dental impressions and dental screws. Dental impressions are needed in the fabrication of crowns, dentures and models of dental braces. Dental screws are often made of different titanium alloys, such as Ti_6Al_4V. Due to the moist biological environment, the materials used in dental applications should have certain properties in order to avoid corrosion. The materials should also be hydrophilic for a better performance in biocompatibility.

Sigma force tensiometers

Contact angle studies give information on the wettability properties of the implant material. Figure 1 shows the wettability curve of a dental screw made of titanium. The experiment has been made with the Attension Sigma 700 Force Tensiometer by attaching the screw to the sample holder and lowering the sample to the air water interface. When the dimensions of the sample and the surface tension of water are known, the instrument is able to calculate the advancing and receding contact angles.

The advancing contact angle for the dental screw was calculated to be 66° and the receding contact angle 76°. This indicates that the screw was hydrophilic. Yet the hydrophilicity could be improved to obtain better biocompatibility. Surface modifications such as calcitite hydroxyapatite plasma sprayed coating have been found to be successful in the improvement of wettability of Ti_6Al_4V dental screws.[2] The suitability of different surface modifications can be detected by conducting contact angle measurements before and after the modification.



[Figure 1]: Wettability curve of a titanium dental screw made with Attension Sigma force tensiometer.

Conclusions

As the properties of a biomaterial are dependent on the characteristics of its surface, physicochemical studies of the surface are of great importance. The determination of contact angles and surface free energies are essential for the understanding of the material behavior in a biological environment. These studies can be used to evaluate the level of biocompatibility of the biomaterial.

References:

[1] K. L. Menzies ja Lyndon Jones, The impact of Contact Angle on the Biocompatibility of Biomaterials, Optometry and Vision Science, 2010, Vol. 87, S.387-399

[2] T. Mekayarajjananoth, S. Winkler, Contact angle measurement on dental implant biomaterials, Journal of Oral Implantology, 1999, Vol. 25, S. 230-236

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