Determination of the Hydrophilic Properties

of the surface of AVINENT implants

PURPOSE

To determine the hydrophilic properties of the AVINENT surface by measuring contact and determining its surface energy.

MATERIALS AND METHODS

a. Specimen Preparation

Two types of specimens have been used in this study, polished and treated. Both were obtained from medical grade Ti discs 10 mm in diameter and 2 mm thick.

Smooth discs were prepared by initial polishing with silicon carbide paper and then with aluminum oxide with a particle size of 1 µm and 0.05 µm. Once the discs had been polished they were given an ultrasound wash.

The treated discs were prepared by varying one of the surface treatment parameters so as to be able to finally choose the best hydrophilia for optimum cellular response.

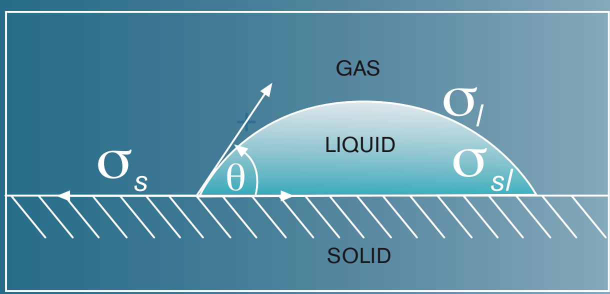

Figure 1. Balance of interfacial tensions for a drop of liquid placed on a solid. Where s_S = free energy of the solid, s_{Sl} = free energy of solid-liquid interface, s_l =surface tension of the liquid, and θ = contact angle.

02 Surface properties

Document prepared by the ***scientific committee of AVINENT Implant System S.L.*** *[(1)] with the collaboration of* ***CREB*** *(Centre de Recerca en Enginyeria Biomèdica) [(2)] and the* ***CTM*** *(Centre Tecnològic) [(3)]. Both these centers belong to the* ***UPC*** *(Universitat Politècnica de Catalunya).*

[(1)] ***Scientific committee of AVINENT Implant System S.L.****, A. Cortina, C. Vendrell, E. Falcó, J. Serra*
[(2)] ***CREB****: A. Mestre*
[(3)] ***CTM****: J. Caro, Ma D. Riera, J. M. Prado*

Figure 2. Contact Angle System OCA 15+ Equipment.

b. Measurement of Contact angle and Determination of Surface Energy

The *sessile drop* method was used for measuring contact angle, in which a volume of mili-Q grade water between 3-6 µl is placed on the surface to be studied with a syringe. Once the drop of liquid becomes stabilized, contact angle 0 is then measured as shown in figure 1 with Contact Angle System OCA 15+ equipment (Data physics, Germany) with SCA20 software (fig. 2).

Young's equation (Eq. 1) was used for calculating the surface energy of the sample (Eq. 1)

$$\sigma_S = \sigma_{Sl} + \sigma_l \cdot \cos q \qquad \text{[Eq. 1]}$$

The value 72.75 mN/m has been taken as the value of σ_l and Neuman's theory has been considered for the determination of σ_{Sl} where $\sigma_{Sl} = f(\sigma_l, \sigma_S)$. Berthelot's approximation has been used for this, which is defined by the following equation (Eq. 2).

$$\sigma_{Sl} = \sigma_l + \sigma_S - 2\sqrt{\sigma_l . \sigma_S} \qquad \text{[Eq. 2]}$$

By substituting [eq. 2] into [eq. 1] the following is obtained:

$$\sigma_S = \frac{\sigma_l (1 + \cos q)^2}{4} \qquad \text{[Eq. 3]}$$

RESULTS

Figure 3 shows contact angle values for the polished surface and for the different tests on the treated surface.

Figure 3. Table of contact angle and test values.

Determination of the Hydrophilic Properties

of the surface of AVINENT implants

Free surface energy values for each of the tests are presented on table 1.

	q(°)	s_S (J/m^2)
polished	84.9	21.56
test 1	84.9	21.56
test 2	55.0	45.03
test 3	56.0	44.22

Figure 4 shows some of the images obtained while the contact angle was being measured.

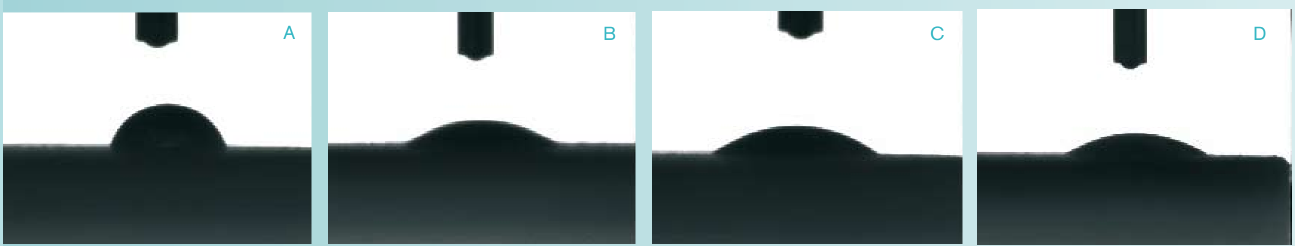

Figure 4. Images obtained during measurement of contact angle on each of the surfaces studied: (a) polished, (b) test 1, (c) test 2 and (d) test 3.

CONCLUSIONS

Contact angle indicates the wettability of a surface and thereby its hydrophilicity or hydrophobicity. Results indicated that the contact angle between the water and the different surfaces would decrease significantly for tests 2 and 3 in comparison with the polished specimens and the first test. This increase in hydrophilicity, due to chemical and topographical variations in the AVINENT surface, translates into an increase in the surface energy of the treated surface.

There are several studies where the preference of using surfaces having high surface energy for endosteal implants is specified due to the fact that an increase in wettability improves interaction between the implant and the biological medium, producing an increase in cellular dissemination and in the cellar layer

[1, 2, 3, 4, 5 and 6]. *Eriksson et al*. performed live tests where they related the hydrophilicity of an implant to its osseointegration capability [7]. Therefore, the hydrophilicity of a surface is one of the factors determining the biocompatibility of a biomaterial, and it is directly dependent on surface energy.

REFERENCES

[1] G. Zhao, Z. Schwartz, M. Wieland, F. Rupp, J. Geis-Gerstorfer, D. L. Cochran, B. D. Boyan. *High surface energy enhances cell response to titanium substrate microstructure*. Published online 27 May 2005 in Wiley InterScience (*www.interscience.wiley.com*).

[2] Schrader ME. *On adhesion of biological substances to low-energy solid-surfaces*. J Colloid Interface Sci 1982; 20:773-784.

[3] Schakenraad JM, Busscher HJ, Wildevuur CR, Arends J. *The Influence of substratum surface free energy on growth and spreading of human fibroblasts in the presence and absence of serum proteins*. J Biomed Mater Res 1986, 20:773-784.

[4] Baier RE, Meyer AE, Natiella JR, Natiella RR, Carter JM. *Surface properties determine bioadhesive outcomes: methods and results*. J. Biomed Mater Res 1984;18:327-355.

[5] Hurbert TA, Ratner BD, Schakenraad JM, Schoen FJ. *Some background concepts. In Ratner B, Hoffman A, Schoen F, Lemons J, editors. Biomaterials Science. An introduction to materials in medicine*. New York. Academic Press; 1996. p. 133-164.

[6] Kilpadi DV, Lemons JE. *Surface energy characterization of unalloyed titanium implants*. J Biomed Mater Res 1994; 28:1419-1425.

[7] Eriksson C, Nygren H, Ohlson K. *Implantation of hydrophilic and hydrophobic titanium discs in rat tibia: cellular reactions on the surface during the first 3 weeks in bone*. Biomaterials, 2004, 25:4759-4766.