Cell-polymer interactions

Schakenraad, Josephus Maria

SUMMARY

The application of artificial materials for the replacement or improvement of diseased or not optimally functioning organs, has increased enormously during the last two decades. We only mention pacemakers, hartvalves, bloodvessels, bone plates, artificial joints etc. More commonly applied are polymers for the construction of lenses, hearing aids, spectacles, arch supports and of course dental protheses. The application of polymers on the human body (as e.g. lenses) seems simple, but complications as e.g. allergy often occur. Polymers for implantation purposes are in very close contact with cells of the human body; the selection of these materials has to be performed with great care. The ultimate success of the implantation of a biomaterial in or on the human body depends on many parameters; some can be studied at laboratory scale, others can only be accurately studied under in vivo or in situ circumstances.

The aim of this thesis is to gain insight in the complicated process of cell-polymer interactions by measuring both physico-chemical and biological parameters in order to be able to predict the ultimate succes of the implantation of a biomaterial on basis of material characteristics.

In chapter 1, a literature survey of the present "state of the art" in the field of cell-polymer interactions is presented. The influence of substratum surface free energy, zeta potential, the interfacial free energy of adhesion and the adsorption of proteins on cellular adhesion and spreading are discussed.

In chapter 2, the influence of the substratum surface free energy (wettability) of a biomaterial on the spreading and growth of cells is studied. Cell spreading is determined by substratum surface free energy in the presence and absence of serum proteins. Substrata with a high surface free energy (wettable, hydrophylic materials) favour cell spreading, whereas low energy substrata (hydrophobic materials) disfavour cell spreading, both in the presence and in the absence of serum proteins.

In chapter 3, the thermodynamical aspects of cell spreading are discussed. Factors influencing cellular adhesion and spreading, next to substratum surface free energy, are: interfacial free energy of adhesion, cellular surface free energy and zeta potential of cell and polymer. When the interfacial free energy of adhesion is positive (indicating that energy is needed for adhesion) cellular adhesion and spreading are unfavourable and vice versa.

Immediately after implantation of a biomaterial in the body it will be covered by proteins. It is evident that protein adsorption complicates a thorough understanding of cellular adhesion and spreading.

It is shown in chapter 4 that indeed substratum characteristics determine the spreading area of a cell, most likely by influencing the amount of contact sites, whereas the

nature of the protein coating determines the distance between cell and substratum. The substratum surface free energy remains to influence cellular adhesion and spreading, despite the presence of a protein layer.

In chapter 5 the influence of protein adsorption on a biomaterial upon substratum surface free energy, infrared absorption and cell spreading is studied. Adsorbed proteins transfer the original substratum surface free energy to the interface with spreading cells, as demonstrated by shifts in infrared absorption bands and changes in surface free energy; therefore, the original substratum surface free energy most likely will remain to dominate cell spreading.

In chapter 6 we demonstrated that the results obtained in vitro from the single parameters (chapters 2 and 3) are not only valid under in vitro conditions, but also in a living organism. An in vivo model to study cell-polymer interactions was developed in which it was demonstrated that the pattern of in vivo cell growth was almost identical to the pattern of in vitro cell spreading.

Finally, in chapter 7 a "status praesens" of interfacial thermodynamics, protein adsorption and cellular adhesion is presented. Additionally some suggestions for future investigations and possible applications in the "surgical field" have been described.

The final conclusion of this thesis is that substratum surface free energy can be regarded as a suitable parameter to predict cellular adhesion, spreading and growth on biomaterials, and is therefore a very useful guide to select materials for implantation purposes.

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