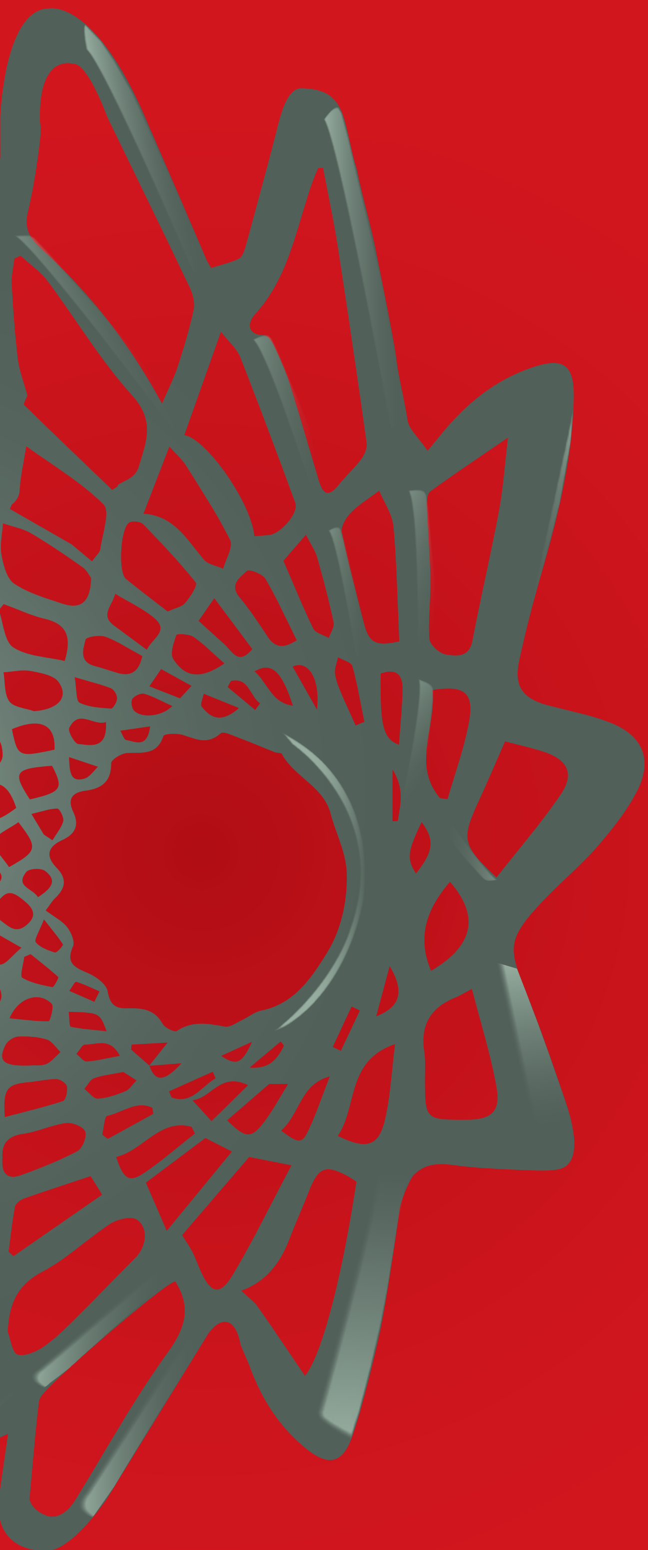


Surface Characterization of Biomaterials

Biomaterials are determined …

The desire for well-being and long life expectancy goes hand-in-hand with the use of non-viable materials to conserve health. 2000 years ago, the Romans and Chinese applied gold in dentistry as a first biomaterial. The targeted engineering of biomaterials began in earnest at the beginning of the last century.

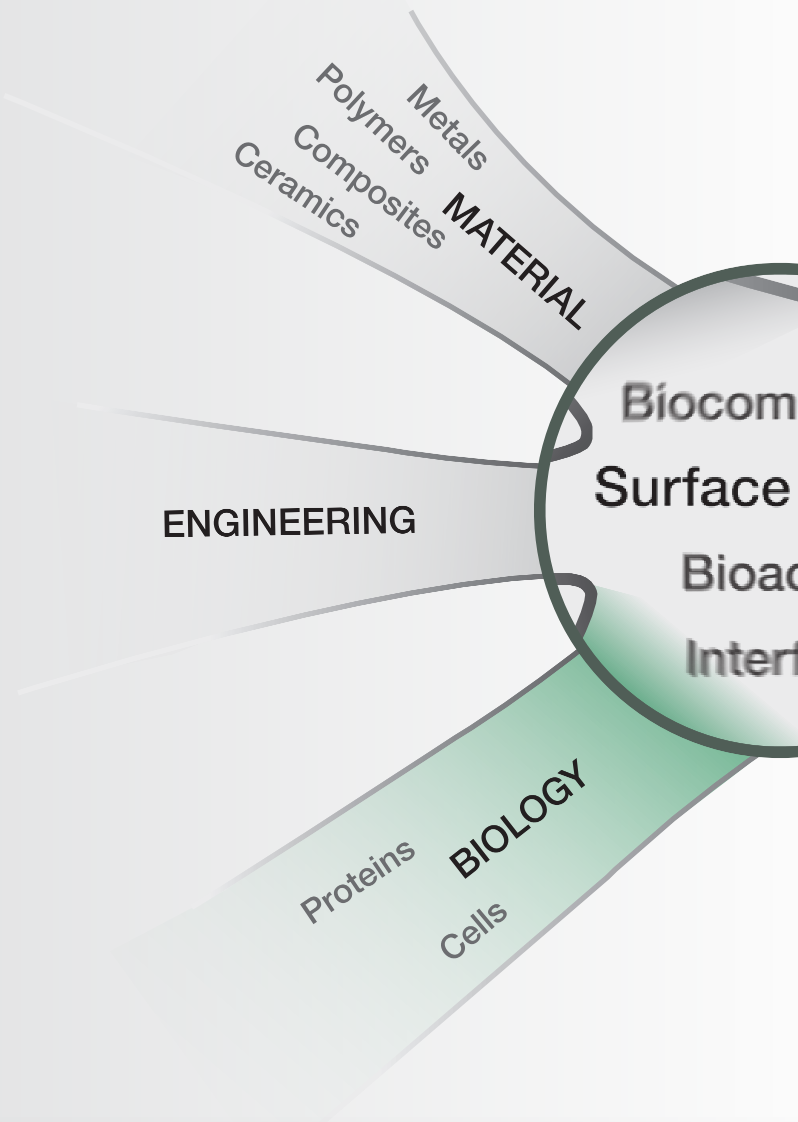
A biomaterial is a synthetic or natural material which is used for replacing and enhancing tissue and organs or accelerating wound healing. Biomaterials include permanent and temporary implants, and also medical devices for extracorporeal application.

Common to all types of biomaterials is their interaction with biological environments when performing their dedicated functions. Acceptance or repulsion of a biomaterial device by the human body is determined by the biocompatibility of the material's surface. Tailoring and controlling surface properties is therefore a major challenge in biomaterial engineering.

Surface analysis techniques provide the key to the successful development of biomaterials.

Property	Method
Composition	X-ray spectroscopy
Topography	AFM
Film thickness	Ellipsometry
Wettability	Contact angle
Surface charge	Zeta potential

➤ The zeta potential provides information about the surface charge and gives insight into the interaction of biomaterials with their environment.



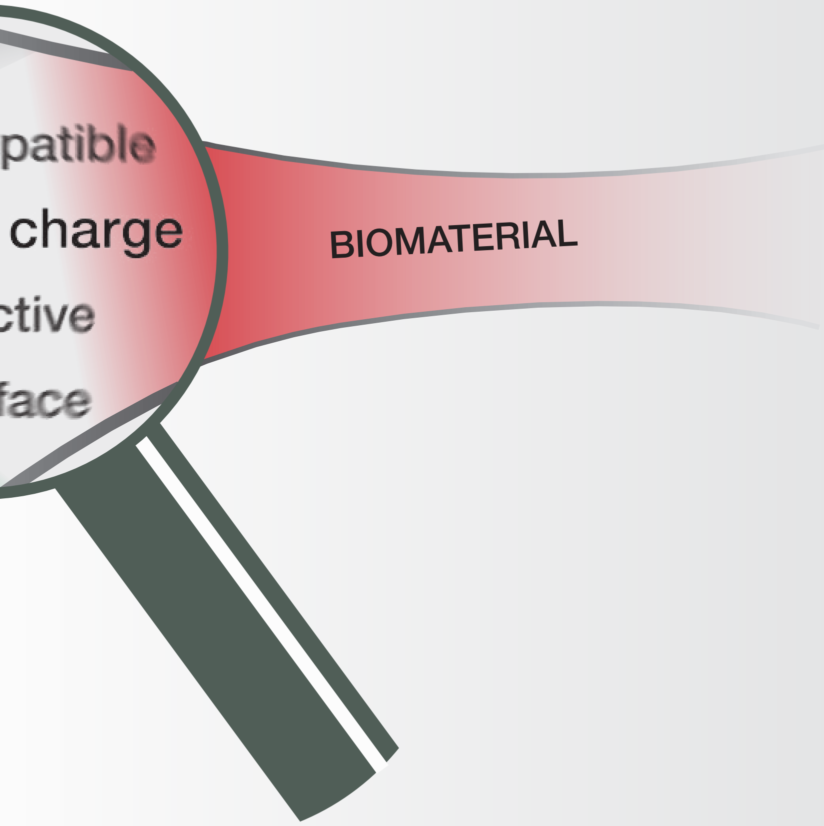
SurPASS™ 3 principle

The surface charge at the solid/water interface determines the electrostatic interaction between the biomaterial surface and dissolved components in the aqueous phase.

Surface charge is related to the electrokinetic or zeta potential. For macroscopic solids the zeta potential is determined by the measurement of streaming potential or streaming current.

Streaming potential and streaming current are electrokinetic effects that arise from the motion of the liquid phase relative to the solid surface.

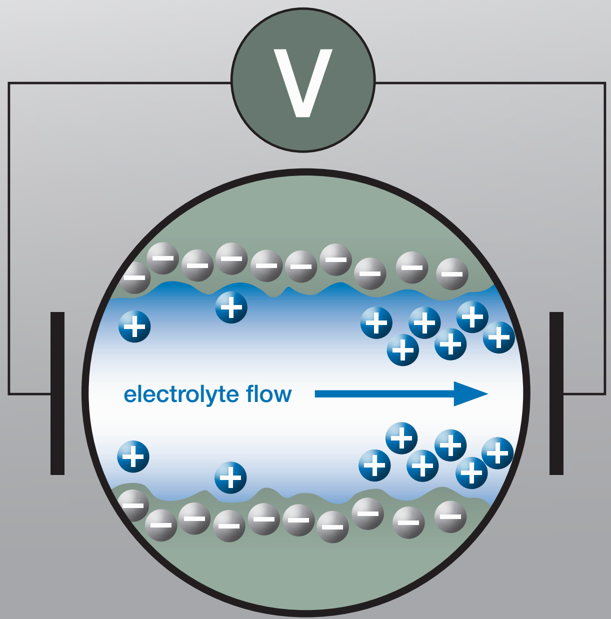
… by their Surface Characteristics



Biomaterial engineering is an interdisciplinary field which combines knowledge of material science with biology and medicine. Biomedical requirements drive the design and function of biomaterial devices.

The interface between the material surface and the surrounding fluid determines the compatibility with a biological environment. Interfacial properties are difficult to characterize and are commonly derived from separate analyses of solid surface and liquid phase.

The benefit of the SurPASS™ 3 method is the direct solid/water interface analysis by means of zeta potential. Besides being an indicator for solid surface charge, the zeta potential visualizes the interaction of biological compounds with the biomaterial surfaces. The isoelectric point, which is valuable information describing surface chemistry and electrostatic interactions, is determined fully automatically. The use of various buffer solutions simulates physiological conditions for the analysis of biomaterials. Time-resolved adsorption studies contribute to the understanding of protein-surface interaction. Tailored measuring cells can accommodate biomaterial samples of different shapes and geometry.



SurPASS™ 3 enables you to analyze

- Artificial implants
- Blood bags
- Catheters
- Contact lenses
- Hemodialysis membranes
- Scaffolds
- Vascular grafts

Applications

Dental implants

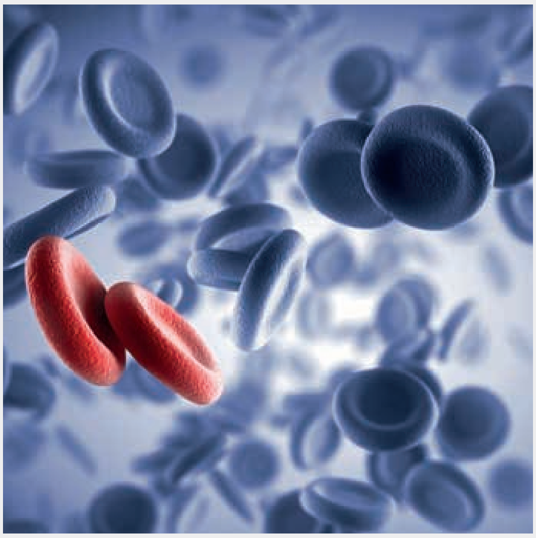
Biofilms form on any solid surface exposed to a biological environment. Protein adsorption is the initial step of biofilm formation and depends on surface characteristics. Synthetic materials used as artificial teeth have to cope with saliva proteins and oral bacteria. In dentistry, biofilm formation and the subsequent adhesion of bacteria are important topics since they affect the health of the human body.

SurPASS™ 3 provides an in-depth characterization of the interaction between proteins in solution and implant materials.

Hemodialysis membranes

For people with kidney disease, hemodialysis removes toxic substances from the blood, undertaking the job of the kidney. For this process, polysulfone ultrafiltration membranes arranged in a bundle of hollow fibers are widely applied. In order to improve the biocompatibility of the membrane, the inner surface of the hemodialysis membranes needs modification.

The zeta potential measurement assists in the improvement of the biocompatibility of hemodialysis membranes.



Cardiovascular grafts

Vascular grafts are fibers or membrane-like tubular biomaterials made of hydrophobic polymers. Thrombogenicity and infection are frequent problems associated with vascular grafts. Surface treatment increases hydrophilicity and improves the compatibility of the polymer surface with the biological environment.

The zeta potential is a valuable parameter for following polymer surface modifications and tailor-making biocompatible devices for medical applications.

Bioactive materials

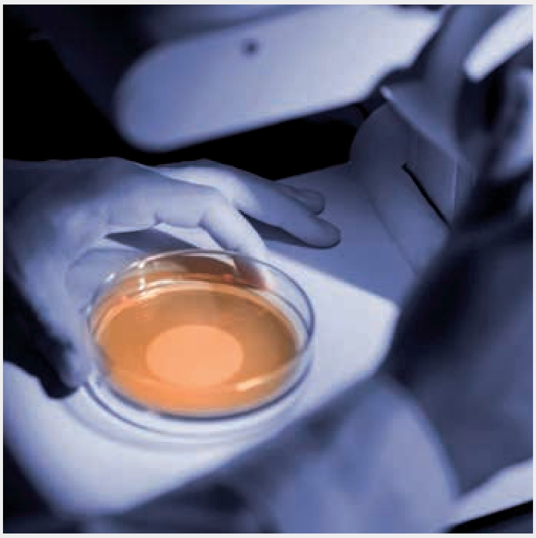
Hydroxyapatite is a main constitute of hard tissue such as bone, dentin and dental enamel. Its osteoconductive and osteoinductive properties make it the best option for bone-replacing implant material. Doping with silver affects the mechanical strength and introduces antimicrobial properties.

The zeta potential shows the presence of dopants on the hydroxyapatite surface and helps to estimate their effectiveness.

Tissue engineering

Polymers are favorable materials for scaffolds used in tissue engineering due to their light weight and ease of manufacture. Tuning the polymer surface is a prerequisite to promote cell adhesion. Biopolymers such as chitosan are preferable as they also accelerate wound healing. Electrospinning of chitosan nanofibers is an evolving technique for scaffold formation.

SurPASS™ 3 provides tailor-made sample holders which can accommodate various scaffolds used in tissue engineering.

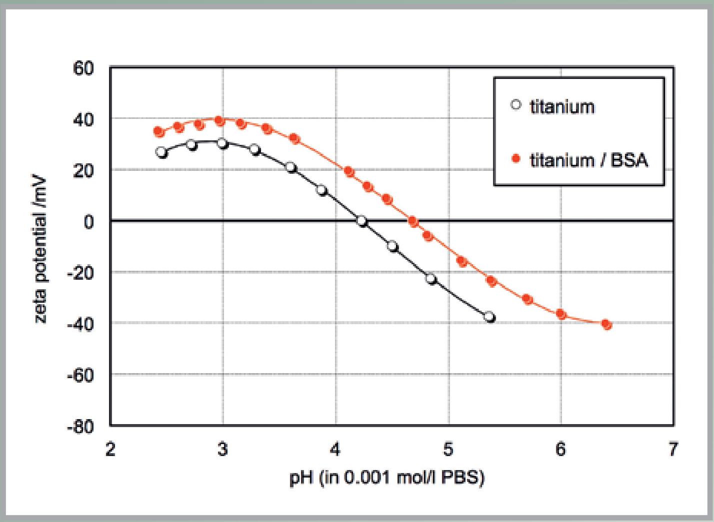


Contact lenses

Soft contact lenses have to comply with demands for oxygen permeability, wettability and wearing comfort. Coatings of phosphorylcholin or polyvinylalcohol diminish the formation of biofilms and bacterial adhesion on the surface and reduce the risk of eye infections. Eyelid movement and the exposure to tear liquid are expected to degrade such polymer coatings.

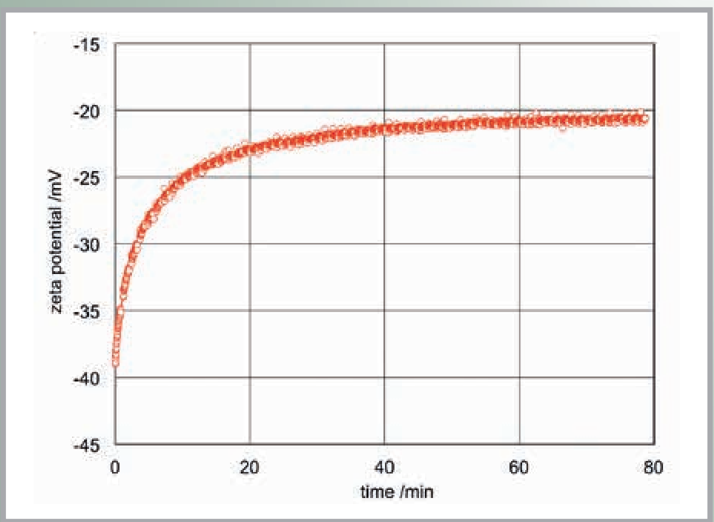
The zeta potential indicates changes in the surface chemistry of contact lenses due to wear and is therefore suited for studying biocompatible surface coatings.

Streaming Answers:
SurPASS™ 3



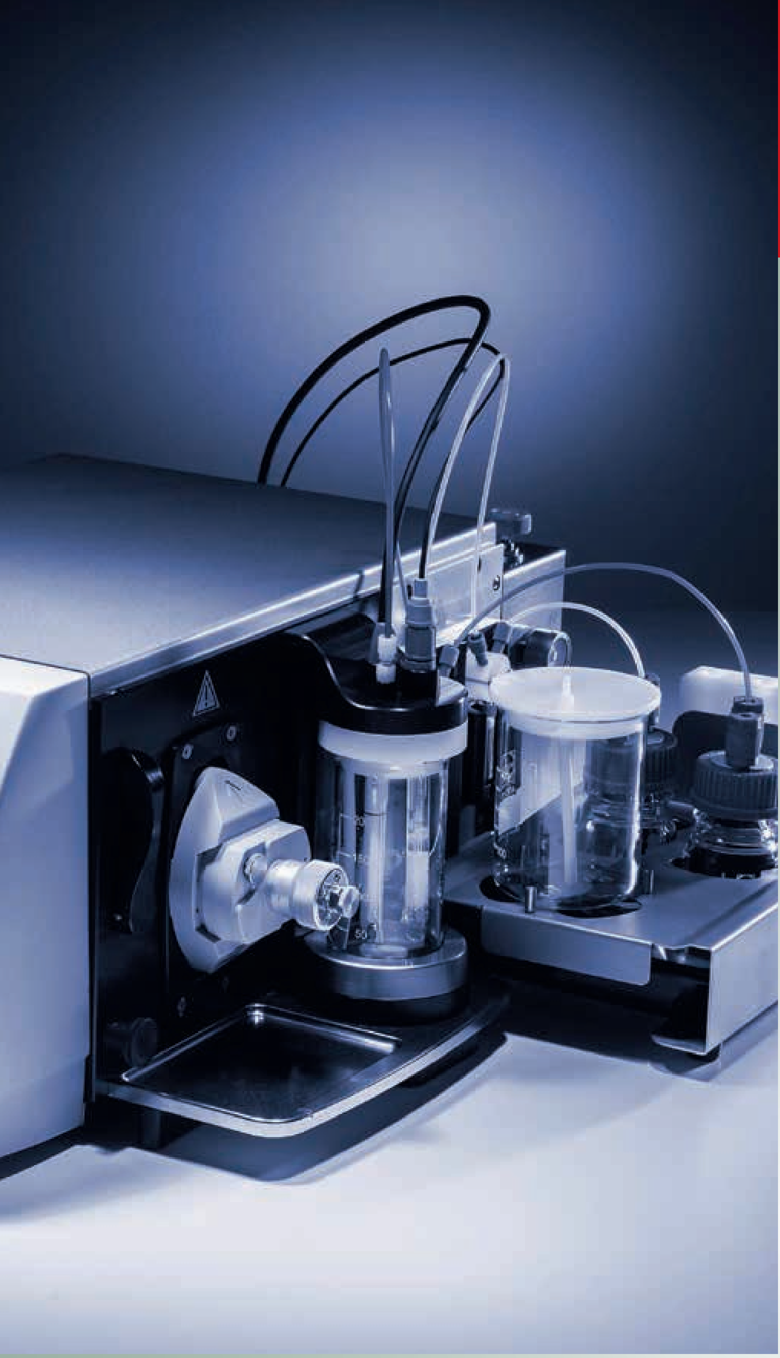
The pH dependence of zeta potential reveals information about solid surface charge when a material is exposed to aqueous media. Furthermore, the isoelectric point (IEP) at the pH of charge reversal indicates the chemical functionality of the outermost surface. Titanium shows negative surface charge at physiological pH and an IEP at pH 4.2 due to its amphoteric behavior. Adsorption of bovine serum albumin (BSA) on the titanium surface shifts the IEP to pH 4.7. This coincides with the IEP of BSA in solution, which confirms complete surface coverage by this globular protein.

The sign and magnitude of zeta potential allow estimation of the electrostatic interaction between the solid surface and a charged species dissolved in the surrounding aqueous solution.



Being a surface-sensitive parameter, the zeta potential is well-suited for indicating adsorption and desorption processes. The adsorption of BSA on a titanium surface at physiological pH shows complex kinetics with an initial fast protein attachment and a subsequent slower rearrangement on the solid surface. Although the overall surface charge remains negative, the adsorption process is clearly represented by the zeta potential.

Zeta potential analysis combines the measurement of adsorption kinetics with the validation of the chemistry of the adsorbed surface layer.



SurPASS™ 3 Benefits

Real samples

SurPASS™ 3 can characterize biomaterials of different shape and geometry in the presence of biological model fluids.

Easy sample mounting

The elaborate design of the SurPASS™ 3 measuring cells facilitates reproducible sample mounting.

Fully automated analysis

SurPASS™ 3 enables fully automated zeta potential analysis over a wide pH range and at different electrolyte compositions.

Time-resolved measurement

SurPASS™ 3 allows the measurement of fast and slow adsorption kinetics in real time.

Unsurpassed sensitivity

SurPASS™ 3 is extremely sensitive to surface modification and detects even the smallest changes in surface properties.

Ready-to-use data

SurPASS™ 3 is operated by an intuitive software with a lean structure that gives fast access to the zeta potential at the click of a button.

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