Correlation between blood compatibility and physical surface properties of titanium-based coatings

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Layers of Ti nitride, Ti oxynitrides TiN\textsubscript{xOy} and Ti oxide were produced by means of metal plasma immersion ion implantation and deposition (MePIIIID) from a plasma produced by cathodic arc evaporation of Ti under addition of nitrogen and/or oxygen to the ambient near the substrate. The phase composition and structure of the layers are strongly dependent on the relation of the gas partial pressure. To study the correlation between blood compatibility and physical properties of the coatings, the thrombocyte adhesion and fibrinogen adsorption on the surface as well as wettability and surface energy were investigated. The blood compatibility of Ti oxide in part of the thrombocyte adhesion and fibrinogen adsorption can be improved by the addition of N into the layer. Thrombocyte adhesion and fibrinogen adsorption are lower for TiN\textsubscript{xOy} than for TiO\textsubscript{2}. This correlates with a lower hydrophobicity and higher polar component of the surface energy for TiN\textsubscript{xOy}.

Collaboration: ¹Lipetsk State Technical University, Lipetsk, Russia

Detection of copper(II) and nickel(II) uptake by Bacillus sphaericus and Pseudomonas stutzeri

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Two membrane permeable fluorescence dyes, the calcium indicator Oregon Green (OG) and the nickel sensitive dye Newport Green (NG) were used in membrane permeable forms for detection of the uptake of copper and nickel ions in common soil bacteria. NG fluorescence directly and highly specific reflects the uptake of nickel into the cells by enhancement of the fluorescence. OG as marker for intracellular calcium forms a fluorescent complex inside the cells, which is subsequently quenched by the competing copper ions in dependence on their concentration. Flow cytometry revealed a higher Cu\textsuperscript{2+} uptake by the gram negative P. stutzeri DSMZ 5190 than by gram positive B. sphaericus JG-A12 and NCTC 9602. For B. sphaericus JG-A12 a more effective Ca\textsuperscript{2+} dependent defence mechanism against Ni\textsuperscript{2+} was found than in NCTC 9602. This shows that the combination of flow cytometry with appropriate metal specific fluorescence dyes generally enables a fast and efficient look into single vital bacterial cells in presence of heavy metals while simultaneous monitoring of their physiological state.

Collaboration: ¹Institut für Werkstoffwissenschaft, Technische Universität Dresden

In-situ conformational analysis of fibrinogen adsorbed on Si surfaces

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Structural changes of fibrinogen were characterized in its adsorbed state. Specific enzyme linked immunosorption experiments show that the amount of adsorbed fibrinogen increases as the surface becomes more hydrophobic. AFM investigations reveal the trinodular shape of fibrinogen molecules adsorbed on hydrophilic surfaces, whereas all of the molecules appear globular on hydrophobic surfaces. The distribution of secondary structures in adsorbed fibrinogen was quantified by in-situ FTIR analysis. Substrates of identical chemical bulk composition but different surface hydrophobicity permit direct comparison among them. Adsorption properties of fibrinogen are different for each degree of hydrophobicity. Although there is some increase of turn structure and decrease of β-sheet structure, the secondary structure of adsorbed fibrinogen on hydrophilic surface turns out to be rather similar to that of the protein in solution phase with a major α-helix content. Hydrophilic surfaces exhibit superior blood compatibility as required for medical applications.

Collaboration: ¹University Antalya, Turkey; ²Institut für Analytische Chemie, TU Dresden; ³Ciencia de Materiales de Madrid (CSIC), Cantoblanco, Madrid, Spain
Ion implantation of ePTFE for increased wettability and improved cell adherence

Mechanically stretched, expanded polytetrafluorethylene (ePTFE) is a microscopically porous version of PTFE, possessing excellent chemical- and bio-stability. The application of ePTFE as blood vessel prostheses in vascular surgery is nowadays common, however problems such as thrombosis still occur in small diameter vessels. Attachment of endothelial cells as a vessel lining has been proposed as a method to reduce the event of thrombosis. However, due to the highly hydrophobic nature of the material, sufficient cell attachment cannot currently be realised. PIII has been used to modify the surface of PTFE, ePTFE and LDPE by 0.5 – 20 kV implantation of nitrogen, argon and oxygen ions, with doses varying from $10^{13}$ to $10^{16}$cm$^{-2}$. Hydrophobicity, measured by water contact angle, was reduced for PTFE and LDPE for low to medium doses ($10^{13} – 10^{15}$cm$^{-2}$) but increased again with high doses due to carbonisation and roughening of the surface. FTIR revealed the low to medium dose modifications as being due to increased oxygen containing chemical groups on the surface. Increase in the adhesion and survival of endothelial cells was observed on PIII treated ePTFE, with the high dose samples ($10^{16}$cm$^{-2}$) showing the most improvement. Chemical cross-linking of hydrophilic molecules like acrylamide to the newly formed reactive groups of the surface further improved the cell performance.

Collaboration: Boston Scientific SCIMED, USA