TRIBOCORROSION APPROACH TO WEAR OF IMPLANTS

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ABSTRACT

Joint arthroplasty is a very common and successful surgery to restore function in the musculoskeletal system of the body. However, it can be subjected to unexpected early failures or to progressive degradation of the metallic materials depending on the interplay of several factors (patient behaviour, implant design, clinical practice) that up to date can hardly be controlled. Nowadays it is known that the material degradation of biomedical alloys for joint implants is a consequence of the combined action of wear and the chemical reactivity of the body fluids (tribocorrosion). Mechanistic approach of tribocorrosion has led to the development of analytical models for describing this chemo-mechanical interaction by considering the main involved phenomena in tribocorrosion systems: mechanical wear, chemical wear or corrosion and lubrication [1,2]. Integration of corrosion principles together with tribological laws was the basis for these new tools in tribocorrosion modelling. For the specific case of biomedical implants, the established models allowed for better understanding the involved mechanisms occurring in tribocorrosion but also for quantifying the overall material loss as a function of a certain mechanical (load, sliding velocity, geometry), material (hardness, young modulus, density), environmental (viscosity) and electrochemical (potential) parameters.

This work was initiated with the aim to assess the wear of biomedical implants in patients knowing that the degradation of CoCrMo in water lubricated contacts is critically affected by the prevailing electrochemical conditions, Figure 1 [2]. To do this, a combination of tailored electrochemical experiments in-vivo and theoretical tools were used. The experimental campaign included a series of electrochemical measurements carried out on CoCrMo and Titanium alloys in synovial fluid directly extracted from patients suffering from different stages of orthopaedic diseases and/or already having an implant.

The results of the in-vivo experiments (characterising the crucial electrochemical factors for each patient) and tribocorrosion models, has allowed to quantify the degradation, and thus the implant lifetime in-vivo which may vary by a factor 25 among patients. This difference in wear rates of the CoCrMo implants depending on the patient was attributed to the different electrochemical properties of their synovial fluid. Furthermore, the calculated wear accelerated corrosion rates (which values corresponds well to the ones measured in simulators) have been found to be much larger than the corrosion rates under static conditions.

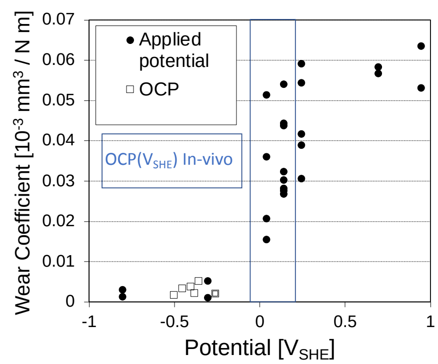

Figure 1 Influence of electrochemical conditions (Potential) on wear of CoCrMo biomedical alloys (extracted from [2]).

Our main conclusion is that the adequate use of predictive tribocorrosion models together with in-vivo electrochemical measurements appears as a promising way to anticipate the in-vivo degradation rate of joint implants for each individual patient. It may also constitute the tool for developing tailored surfaces, new materials and individual specific solutions for tribocorrosion applications such as the artificial joints within the biomedical field.

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