Kinetics of bone-like apatite formation in simulated body fluid

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If a material induces apatite formation in SBF (simulated body fluid) it is likely to exhibit bioactive behavior. Apatite formation kinetics can help to estimate bioactivity of material and also to describe the formation mechanism. In present study, apatite formation on the surface of titanium was investigated using microscope image analysis and by weighing the precipitated apatite.

A microscope image analysis of the sample surface was used to describe apatite formation kinetics during the initial stages of precipitation, when isolated apatite spherullites were formed. These are parameters evaluated by the image analysis: mean and maximum diameter of apatite spherullites, their number per unit area and the percentage of apatite covered surface. Due to low reproducibility it was not possible to interpret the values of spherullites number and percentage of covered surface. The time dependence of maximum diameter was used to determine the apatite growth rate and to estimate the induction times. It was found that not immediate but continuous nuclei formation occurs. It was shown that it is possible to characterize the initial stages of apatite precipitation by the induction times evaluated using extrapolation of the time dependence of spherulite maximum diameter. The induction times can be used to determine the apparent interfacial energy for nucleation. This value could serve as a measure of an substrate's ability to induce apatite formation and thus it could help to estimate the bioactivity of a material on the basis of in vitro tests.

Because during the interaction of titanium with SBF no significant release of any component occurs, the apatite growth rate can be evaluated by weighing the precipitate. It is possible to describe the growth rate using equation $R=k(S-1)^n$, in which S is the supersaturation and n is the effective order of reaction indicating the rate controlling mechanism. The calculated value of $n\approx2.8$ indicates that the rate controlling process of apatite formation on the surface of chemically treated titanium is polynucleation.

keywords: apatite, titanium, kinetics, nucleation, crystallization, bioactive materials

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