BEHAVIOR OF SILICON NITRIDE IN SIMULATED BODY FLUID (SBF)

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Introduction

Silicon nitride based ceramics are a potential candidate as material for orthopedic implants due to their chemical stability associated with suitable fracture toughness and propitious tribologic characteristics [1]. In vitro tests using the MG-63 cell line model have indicated the potential of this material for clinical applications [1]. Additionally, researches [2,3] have proved the biocompatibility of Si_3N_4-bioglass composite by solubility tests in SBF (simulated body fluid) and by experiments using MG63 and human bone marrow osteoblastic-like cells.

In this work, dense silicon nitride components are investigated considering their suitability as biomaterial. In vitro experiments with sintered samples of silicon nitride in SBF were carried out in order to evaluate the solubility of this material.

Materials and Methods

As starting materials, powders of Si_3N_4 (M11, Hermann) Y_2O_3 (Hermann C. Starck); Yb_2O_3 (Aldrich Chemical) and α-Al_2O_3 (16 SG Alcoa) were employed. The studied compositions (see Table 1) were ground, dried, pressed and fired to 1750°C for 60 min in a carbon resistance furnace under normal nitrogen atmosphere.

Table 1: Materials contents (% wt)

composition	Si_3N4	Al_2O_3	Y_2O_3	Yb_2O_3
SN-1	91	3	3	3
SN-4	90	6	4	-

Previous research [4] has demonstrated the noncytotoxicity of silicon nitride samples shown in Table 1 through in vitro test of cytotoxicity, using Chinese hamster ovary K-1 cells.

The solubility of sintered samples with compositions SN1 and SN4 in SBF was evaluated based on Si concentration. Samples were immersed in 45 ml of simulated body fluid (SBF) at a starting pH of 7.54 at 37°C, for 3, 7 and 14 days. Each sample surface area was about 2cm² and thus the ratio between sample surface and SBF-volume was kept constant at 0.044 cm^{-1}.

After equipment calibration with a standard aquous Si-solution, the Si concentration was analyzed by ICP (inductive couple plasma spectroscopy) considering the:

a) pure SBF (control) after 3, 7 and 14 days,
b) sample SN1 in SBF after exposure for 3, 7 and 14 days,
c) sample SN4 in SBF after exposure for 3, 7 and 14 days.

Results and Discussion

The Table 2 shows the Si content for different samples 0.2 mg/ml, since no Si content can be present in the control's solution. Therefore, the Si concentration identified in analyzed solutions for different immersion times suggests that the silicon nitride samples have negligible solubility in SBF.

Although the solubility measurements of the samples have been negligible, it is possible to observe that the Si content is greatest for SBF with sample SN1 after exposure for 14 days than the others. This fact is probably associated with the different composition of the sample SN1 which contains Yb_2O_3 additions and lower Al_2O_3 content than the sample SN4 (see Table 1) .

Table 2: Si content found in the SBF solutions

	Immersion time (days)	Si content (mg/l)
control	3	0.15
	7	0.20
	14	0.20
SN1	3	0.22
	7	0.25
	14	0.53
SN4	3	019
	7	0.20
	14	0.23

Conclusion

The small Si contents found in analyzed SBF which contained samples of sintered silicon nitride demonstrated the low solubility of this material. This result, together with observations by in vitro test of cytotoxicity made in an earlier study [4], indicates that silicon nitride is a good candidate as biomaterial, in application where no biological interaction with the living tissue is required.

References

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11231