New Bioactive Glass Fibers for Soft Tissue Regeneration

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Statement of Purpose: Bioactive glasses are widely known to be able to form a chemical bond with bones and to promote regeneration of hard and soft tissues [1]. However, one factor that restricts their application is that most of these glasses tend to easily crystallize hindering most manufacture processes. The great majority of bioactive glass compositions do not support repeated heat-treatments, since this procedure results in uncontrolled crystallization that normally degrades their mechanical properties and sometimes substantially diminishes their bioactivity [2]. This trait causes many problems in the manufacturing of shaped devices, fibers or scaffolds. Consequently, for clinical purposes, the use of bioactive glasses has mainly been limited to particulates.

To overcome this phenomenon, a new bioactive glass composition was recently developed at the Vitreous Materials Laboratory (LaMaV - UFSCar, Brazil) that shows very high glass stability when compared to other bioactive glasses, coupled to high bioactivity, thus allowing one to make bioactive fibers, meshes and 3D shapes. In fiber form, this bioactive glass has an elevated bioactivity, is bioresorbable and flexible, making this material a potential alternative for soft tissue regeneration. Therefore, the aim of this study was to characterize some bioactive properties and explore the effects of this new bioactive glass and glass fibers on fibroblast proliferation.

Methods: Glass fibers 25µm glass were obtained by drawing process using reagent grade chemicals (SiO_2, Na_2HPO_4, $CaCO_3$, Na_2CO_3). SBF-K9 in vitro tests were performed to analyze the fibers' bioactivity from 4 to 48 hours, confirmed by FTIR and SEM analyses. ICP-OES was also utilized to monitor the release of certain ions present in the bioactive glass, such as Ca, Na, P and Si, for the same experimental period.

To analyze the effects of these new glass fibers on soft tissue regeneration, a preliminary in vitro study using human fibroblast cells was conducted. Cell viability was demonstrated using 65 year old patient cells. The fibroblasts were seeded in RPMI-1640 medium with a 3 cm diameter fiber mesh for 7 days (the medium was substituted every two days).

Results: The results indicate a highly bioactive material, with the formation of the HCA layer in only 4 hours of soaking in SBF solution. The ICP technique revealed a highly reactive biomaterial, with the dissolution of cations, such as Ca, Si, Na and P, in a similar trend to the gold standard Bioglass 45S5. Regarding the in vitro tests, fibroblast cells proliferated in a satisfactory rate, increasing their number from $5 \cdot 10^4$ to $3 \cdot 10^5$ in 7 days. In addition, the cells were well spread and in intimate contact with the biomaterial (Figure 1).

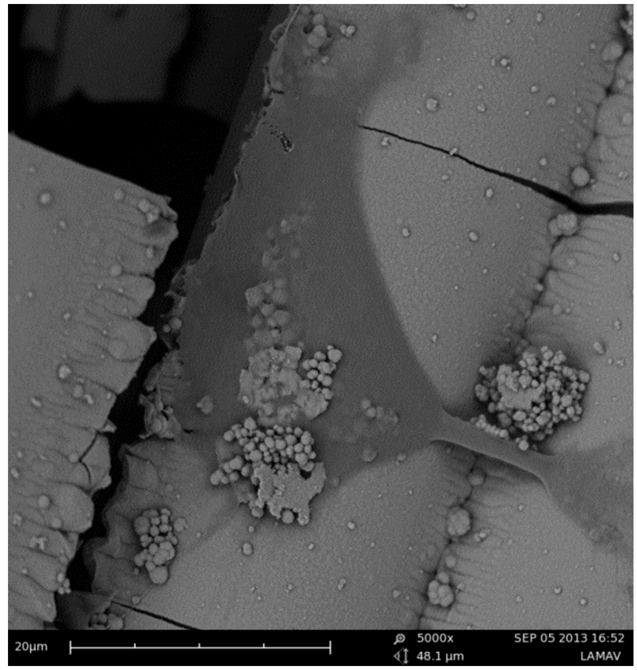

Figure 1 – Fibroblast cell attached to the glass fiber and surrounded by globular structures, linked to HCA precipitation.

Conclusions: This newly developed biomaterial demonstrated very satisfying results regarding its bioactivity and degradation rate in vitro. Hence, these highly reactive fibers could be a potential alternative in applications that aim soft tissue regeneration. Future in vitro and in vivo investigations should be carried out aiming to prove its effectiveness for clinical trials.

References:

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