Bio-inspiration of the natural amorphous silica source: the potential use of diatom particles for bone regeneration

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Abstract

Silicon/silicon ion is recognized an essential trace for both bone formation and maintenance. Silicon, in fact, is considered as a nucleation facilitating of the early stage of mineralization as well as an inhibiting factor of bone resorption.

Here we were to take inspiration from the natural source of amorphous silica/silicon, diatomite/diatom skeletons, for the fabrication of bone tissue scaffold containing silicon as bioactive component. Diatom microparticles – DMPs (1 - 10 µm) and nanoparticles - DNPs (around 150nm of average particle size) were successfully produced by fragmentation of purified diatom skeletons under the alkaline condition. Both DMPs and DNPs were able to release silicon detected by inductively coupled plasma optical emission spectrometry (ICP/OES); and moreover, these particles showed minimal or non-cytotoxic effects in-vitro as determined by lactate dehydrogenase assays on cell cultures. These results suggest that diatom particles-derived from diatom skeletons could be used as a silicon donor for bone tissue engineering.

To handle this goal, silk fibroin scaffolds loaded diatom particles with different amounts and size of diatom particles were fabricated by using the salt leaching method. In comparison to the pure silk fibroin scaffold, scaffolds loaded with diatom particles strongly enhanced cell adhesion, cell proliferation as well as the early bone formation in terms of collagen type I synthesis evaluation, osterix expression and alkaline phosphatase induction assessed on human osteosarcoma cell line MG63. These findings provided strong evidence for a potential use of diatom particles-derived from natural diatom skeleton in biological applications, in particular for bone tissue regeneration.

References

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Figures

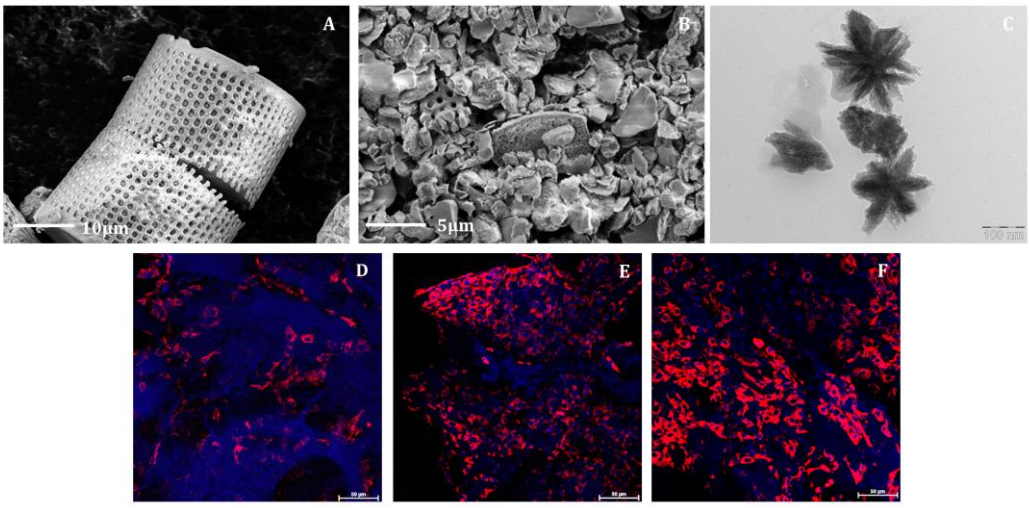

Figure 1: SEM micrographs of diatom frustules (A) and diatom micropartilces -DMPs) - derived from its frustules (B), TEM micrograph diatom nanoparticles - DNPs) (C); Confocal scanning laser microscopy of sample stained with specific antibody for collagen type I (red) occurred after 7 days of culture of the pure silk fibroin - SF (D), the SF loaded DMPs (E) and SF loaded DNPs (F) and DAPI for nuclei (blue).