

Effect of non-N-containing bisphosphonates on nucleation of Nan needle Hydroxyapatite of calcium phosphate cements in SBF exposure

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Statement of Purpose: calcium phosphate cements (CPC) forms hydroxyapatite (HA) in an aqueous environment at body temperature, hence it is more similar to biological apatites than sintered hydroxyapatite formed at high temperatures. Conversion of the cements reactant to hydroxyapatite especially nano needles of Ha is very important in biomaterial world, because of its optimum mechanical properties.

Methods: The starting materials used in the present work are respectively, β -tricalcium phosphate (β -TCP, Merck company Inc.) and dicalcium phosphate dihydrate (DCP, Merck company Inc.). Tiludronate, Clodronate and Etidronate as a member of non-N-containing bisphosphonates group were added to powder phase in 0-200 mg. In order to prepare the cement paste, the powder phase (P) was mixed with the liquid phase (L), that was water with no more additives. control samples was without any bisphosphonates.

Results: Powder X-ray diffraction analysis (XRD) and Scanning electron microscopy (SEM), were done. The fractured surfaces of all samples were gold-coated before the SEM observation.

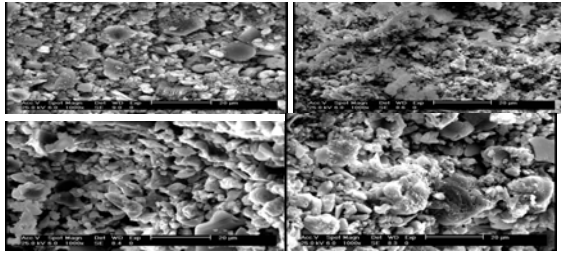


Figure 1. left: controle Sample, right: sample with 90mgTiludronate ,right below sample with 90mg Clodronate and left below sample with 90mg Etidronate ,after 7days in SBF.

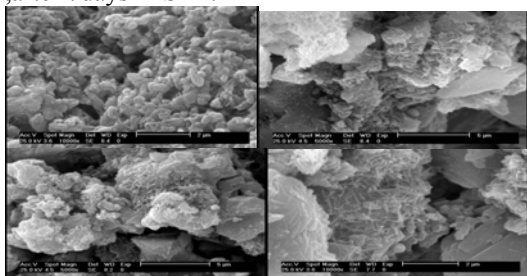


Figure 2. left: controle Sample, right: sample with 90mgTiludronate ,right below sample with 90mg Clodronate and left below sample with 90mg Etidronate ,after 28days in SBF.

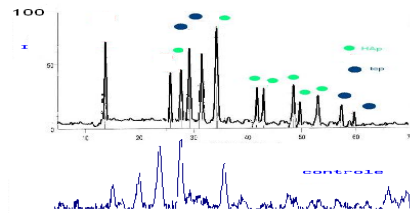


Figure 3. comparison of Xrd in control and bisphosphonate samples after 7days

There were no significant differences between the 4 samples in figure one that means no special effect of Bisphosphonates in 7 days. Figure 2 shows that samples after 14 days are same in apatite formation but also different in morphology. Figure 3 shows that after 7 days, content of apatite in bisphosphonates contained samples is not distinctly different from control sample but XRD picks are sharper that is related to morphology.

Conclusions: Hydroxyapatite precipitation is result of driving force that is: $\Delta G = -RT \ln(S)/n$.

Chelation cause to Ca^{2+} decrease in solution and S that is super saturation will decrease also. finally, ΔG will decrease. According to this effect, setting reaction will be retarded, so as shown in SEM image of sample that is contained any types of bisphosphonate, and have more nano needle apatite in comparison to control sample.

Cement apparently has enough time to precipitation, nano needle apatite crystals. In other word, Bisphosphonate decreased the rate of apatite formation in CPC paste by decreasing the surface active places for the particles. It is led to formation of a very stable paste by decreasing the rate of both apatite formation and aggregates association.

References: 1-Liu C, Gai W, Pan S, Liu Z. The exothermal behavior in the hydration process of calcium phosphate cement. *Biomaterials* 2003;24:2995-3003.

2-Smith SY, Recker RR, Hannan M, Müller R, Bauss F. Intermittent intravenous administration of the bisphosphonate ibandronate prevents bone loss and maintains bone strength and quality in ovariectomized cynomolgus monkeys, *Bone*, 2003 Jan; 32(1):45-55.

3- Oreffo R et al .Growth and differentiation of human bone marrow osteoprogenitors on novel calcium phosphate cement. *J.Biomaterials*1845- 1854, 1998, Vol 19.

4-S. M. Rabiee , S. M. J. Mortazavi , F. Moztaezadeh , D. Sharifi , F. Fakhrejehani , A. Khafaf , S. A. Houshiar Ahmadi , N. Nosoudi , and R. Ravarian Association of a Synthetic Bone Graft and Bone Marrow Cells as a Composite Biomaterial. *Biotechnology and Bioprocess Engineering*. 2009 14, 1:1-5.

5-Robinson, Janine; Cukrowski, Ignacy;

Marques, Helder M. Modelling the interaction of several bisphosphonates with hydroxyapatite, *Journal of Molecular Structure*, 2006. Volume 825, Issue 1-3, p. 134-142.