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Double Effect of Mg-Doping and Multiwalled Carbon Nanotubes Content Reinforcing on Structural and Properties of Hydroxyapatite Nanocomposite Ceramics

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Extended Abstract

The big problematic of modern medicine is to develop a new material with the properties to mimic the human tissue, from point of view architecture and chemical composition, in order to minimize the risk of rejection by the human body. In 2002, The American Association of Orthopedic Surgeons published a report, that indicate that bone implants are one of the most common transplants, outclassed by blood transfusions. To solve this problem, researchers' community was focused on getting a new class and improved materials with special properties for hard tissue replacement implants. For this objective, the field of biomaterials was explored [1], the biomaterials device market has increased relatively to two main categories of orthopaedic biomaterials: implants usually made of metals, ceramics, or hard polymers and scaffolds for bone tissue regeneration [2]. The second category of biomaterials is centred on biodegradable polymers and their composites [2]. The most frequently used biomaterial in orthopedic surgeries is hydroxyapatite (HA).

The latter, is defined as a biologically active calcium phosphate ceramic that is used in to replace and mimic bone. Therefore, HA has a significant ability to promote bone growth along its surface, but its mechanical properties are insufficient for major load bearing applications. To combat this problem, up-to-date devices use HA combined with other materials, such as yttrium-doped zirconia [3], polyethylene [4], or Bioglass [5]. However, theses reinforcing phases need to be added with an important quantity to reach the desired properties, and as these phases are either bioinert, significantly less bioactive than HA, or bioresorbable, the composite ability to form a stable interface with bone is poor compared with HA only. This is why, a perfect reinforcement material would impart mechanical integrity to the composite at low loadings, without diminishing its biological activity. Carbon nanotubes (CNTs), with their small dimensions, high aspect ratio (length to diameter), and high strength and stiffness, have excellent potential to accomplish this assignment. Chen et al. [6] found that adding multi-walled nanotubes (MWNTs) up to 20 wt% enhanced the wear resistance of HA. Meng et al. [7] reported an increase in flexural strength for HA-MWNTs composites upon adding approximately 10 vol% MWNTs. Magnesium-doped hydroxyapatite ($Ca_{10-x}Mg_x(PO_4)_6(OH)_2$) with $0 \leq x \leq 1$) was synthesized by surfactant -assisted hydrothermal method at 90°C. After heat treatment at 1000°C, a part of $Mg_{0.6}$-HA sample was converted to β-TCP phase. Experimental results confirmed the role of magnesium to degrade the sintering ability of Mg_x-HA ceramics, from 0.6 mol % concentration. Flexural strength (σ_f) was found to decrease as a function of Mg-doped HA. Carbon nanotubes was introduced as reinforcing agents to change the behavior of Mg-HA ceramics. The flexural strength of $Mg_{0.6}$-HA was then improved by nearly 20% from approximately 33 to 39 MPa with an optimum addition of 3 wt % of multi-walled nanotubes.

References

[1] F. Moussy, "Biomaterials for the developing world," *J Biomed Mater Res A.*, vol. 94, no. 4, pp. 1001–1003, 2010.
[2] D. Lahiri, S. Ghosh, A. Agarwal, "Carbon nanotube reinforced hydroxyapatite composite for orthopedic application: a review," *Mater Sci Eng C.*, vol. 32, no. 7, pp. 1727–1758, 2012.
[3] J. Li, H. Liao, L. Hermansson, "Sintering of Partially-Stabilized Zirconia and Partially-Stabilized Zirconia–Hydroxyapatite Composites by Hot Isostatic Pressing and Pressureless Sintering," *Biomaterials*, vol. 17, no. 18, pp. 1787–1790, 1996.

[4] W. Bonfield, M. D. Grynpas, A. E. Tully, J. Bowman, J. Abram, “Hydroxyapatite Reinforced Polyethylene - a Mechanically Compatible Implant Material for Bone Replacement,” *Biomaterials*, vol. 2, no. 3, pp. 185–186, 1981.

[5] G. Goller, H. Demirkiran, F. N. Oktar, E. Demirkesen, “Processing and Characterization of Bioglass Reinforced Hydroxyapatite Composites,” *Ceram. Int.*, vol. 29, no. 6, pp. 721–724, 2003.

[6] Y. Chen, Y. Q. Zhang, T. H. Zhang, C. H. Gan, C. Y. Zheng, and G. Yu, “Carbon nanotube reinforced hydroxyapatite composite coatings produced through laser surface alloying,” *Carbon*., vol. 44, no. 1, pp. 37-45, 2006.

[7] Y. H. Meng, C. Y. Tang, C. P. Tsui, and D. Z. Chen, “Fabrication and characterization of needle-like nano-HA and HA/MWNT composites,” *J. Mater. Sci. Mater. Med.*, vol. 19, no. 1, pp. 75–81, 2008.