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MANUFACTURING EFFECT ON THE LOCATION OF ZINC USED AS A DOPING IN HYDROXYAPATITE BIOMATERIAL

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Introduction

Hydroxyapatite (HAP) is used as coating of metallic implants in orthopaedic surgery. We have studied the biological behaviour after implantation in ovine femur of pure HAP and HAP doped with zinc manufactured by Bioland (Toulouse, France) [1]. This element is selected for its biological properties and mainly for its capacity to enhance ossification. We observed that the doped HAP is better resorbed than pure HAP. One of the different hypotheses is that zinc induces modifications in the structure of hydroxyapatite. We have used the EXAFS (Extended X-ray Absorption Fine Structure) experiment station of LURE (Orsay, France) to clarify the atomic surrounding of zinc.

The first experiment shows that zinc atoms in doped hydroxyapatite are in agreement with two models: the substitution of calcium in site I and the insertion between two hydroxides [2]. But, the measurement uncertainty does not permit to select one of these models.

In order to have more information about the zinc location, we perform new experiments with higher zinc concentrations. It is known that the presence of zinc interferes with hydroxyapatite formation and we attempt that the location of zinc can be modified. The aim is to have a better sensitivity and to study the effects of a megadoping.

Materials and methods

The SPCTS laboratory in Limoges (France) prepared by coprecipitation some hydroxyapatites doped with zinc. We have considered that the isomorphic incorporation of zinc in the structure of the hydroxyapatite is possible [3]. We respect the molar ratio $(Ca+Zn)/P = 1.68$ to determine the quantity of the different elements to introduce. The concentration of zinc is determined by atomic absorption and X-ray diffraction is used to control the presence of apatite structure and to calculate the ratio [4]. Then, we use EXAFS experimental station of LURE. We record the absorption spectrum of the sample at the K edge of zinc in fluorescence mode on the line XAFS 2.

Results and conclusion

The zinc concentrations obtained in our samples, compared with the zinc quantities introduced, are presented in table I. X-ray diffraction confirms the apatite structure that allows the determination of the $(Ca+Zn)/P$ ratio which is around 1.68.

Figure 1 shows the comparison of the different edge absorptions of zinc between our samples and references like zinc phosphate and hydroxyapatite doped with 3000 $\mu\text{g/g}$ of zinc manufactured by Bioland. We can observe that the spectrum (a) is in agreement with the HAP from

Bioland (b) whereas the spectrum (c) have a similar threshold as the zinc in hopeite structure (d).

Table I: Concentration ($\mu\text{g/g}$) of zinc in the different doped hydroxyapatites.

	Sample 1	Sample 2
Zinc introduced	5000	2000
Zinc obtained	3050	1570

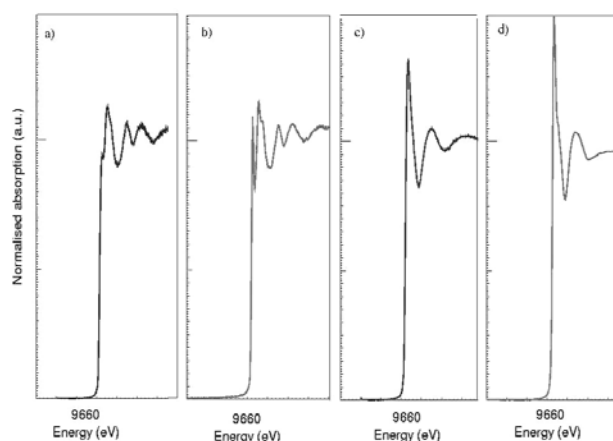


Figure 1: Absorption spectra of hydroxyapatite doped with a) 3050 ppm b) 3000 ppm, c) 1570 ppm of zinc and d) the hopeite form.

This study shows that the obtaining of zinc hydroxyapatite with high quantity of zinc is quite difficult. This adding of zinc induces formation of a biphasic system composed by an apatite structure with the presence of CaO. These results obtained by absorption spectrometry experiment prove that zinc can have different locations: Zn can be included in HAP crystalline structure as in sample (1) or can form hopeite as in sample (2). In conclusion, the way of preparation has a definite influence in the Zn location in hydroxyapatite.

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