MASS ATTENUATION COEFFICIENTS OF X-RAYS IN CALCIUM PHOSPHATE BIOMATERIALS

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INTRODUCTION

The advances of the diagnosis methods in dentistry, mostly due to new radiograph techniques, provide a more conclusive diagnosis; however they lead to extensive uses of X-rays. Given the evolution of the diagnosis processes, the enhancement of the sensitivity of the radiographic methods alongside a simple and efficient quality control, represents the greatest achievement and efficiency enhancement in the area.

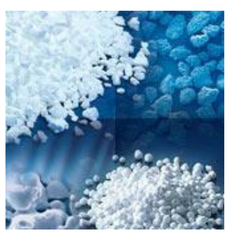
In modern dentistry and medicine, synthetic carbonated apatite ceramics are considered as promising to allograft materials for bone substitutes. Various investigations were carried out in organic and inorganic materials in order to make it useful in radiological diagnostic and dosimetry whose characteristics are based on the interaction between the radiation and the matter in low energies presenting specific medical and technological applications. However, there are no reports in literature concerning the use of dental biomaterials as attenuation materials.

MATERIALS AND METHODS

The mass attenuation coefficient (μ/ρ) was investigated in four dental biomaterials (Bio-Oss®, Osteogen®, Cerasorb® and BoneCeramic) at the interval between 10 and 200 keV. The inorganic and organic composition analysis in the four biomaterials was performed by Instrumental Neutron Activation Analysis (INAA), X-rays Fluorescence (XRF), Thermogravimetric (TGA) and Elemental Analysis (EA) at the laboratories of the Nuclear Technology Development Center (CDTN/CNEN). The weight fractions of each element present in the biomaterials were determined by analytical means mentioned above.

Bio-Oss®

Osteogen®



Cerasorb®

BoneCeramic®

In compliance with the Lambert Law – Beer, the mass attenuation coefficient, μ/ρ, is defined by the exponential absorption equation, which characterizes the passage of the electromagnetic radiation through matter, defined by:

$$I = I_0 e^{-(\mu/\rho)t}$$

Where I_0 and I are the incident intensity of photons without attention and the attenuation intensity of photons in the sample, respectively, *t* is the mass thickness of the sample that corresponds to the mass per unit area in g/cm^2, μ/ρ (cm^2/g) is the mass attenuation coefficient which is a density independent quantity. In case of a multi-element material constituting the sample, the mass attenuation coefficient can be obtained from the coefficients for the constituent elements which are assumed to be additive according to the weighted average:

$$\mu/\rho = \sum_i W_i (\mu/\rho)$$

In this research, the values of the mass attenuation coefficient (μ/ρ) of biomaterials samples were calculated by WinXCOM software.

RESULTS AND DISCUSSIONS

Table 1 – Element composition, in percentage, of calcium phosphate biomaterials by the following analyses: INAA, XRF, TGA and EA.

Elements	Bio-Oss®	Osteogen®	Cerasorb®	BoneCeramic®
H	0,38	-	0,027	0,39
C	1,12	-	0,12	0,23
Na	1,96	2	0,50	1,60
Mg	0,30	0,09	0,28	-
Al	0,40	0,32	0,36	0,38
Si	1,2	1,37	1,21	1,26
P	16,71	17,69	17,58	17,88
S	0,21	0,17	0,33	0,20
Cl	0,15	0,1	0,05	0,06
K	-	0,03	0,02	-
Ca	39,60	39,39	38,10	38,17

Table 2 – The mass attenuation coefficient (cm^2/g) of calcium phosphate biomaterials.

Energy(keV)	Bio-Oss®	Osteogen®	Cerasorb®	BoneCeramic®
10	47,120	46,17	47,31	46,01
20	6,547	0,641	6,568	0,639
30	2,090	2,054	2,101	2,047
40	0,986	0,968	0,988	0,965
50	0,586	0,577	0,587	0,575
60	0,406	0,401	0,407	0,400
70	0,313	0,310	0,313	0,309
80	0,259	0,257	0,259	0,256
90	0,225	0,223	0,225	0,223
100	0,202	0,201	0,202	0,200
150	0,150	0,150	0,150	0,150
200	0,130	0,130	0,129	0,129

CONCLUSION

The data presented on the photon interaction parameters are believed to be helpful in the dosimetry, diagnostic and other radiation physics-based applications. Further investigation on the photon interaction parameters in different compounds and/or composite materials are still needed in order to confirm the validity of both interpolation method and mixture rule at different incident photon energies.

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