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Measurement of Thermal Diffusivity of Bone, Hydroxyapatite and Metals for Biomedical Application

Gabriel Peña Rodríguez[*‡], Antonio Calderón Arenas[*†], Rocío A. Muñoz Hernández[*], Suren Stolik[*], Alfredo Cruz Orea[**] and Feliciano Sánchez Sinencio[**]

* *Physics Laboratory, Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada del IPN, Legaria 694, Colonia Irrigación, México D.F., C. P. 11500, México.*
‡ *Universidad Francisco de Paula Santander, A.A. 1055, Cúcuta, Colombia.*
** *Department of Physics, Centro de Investigación y Estudios Avanzados del IPN, A. P. 14740, México D.F., C. P. 07000, México.*

We present a microstructural study and thermal diffusivity measurements at room temperature in two different sections of bull dense bone, bull bone and commercial hydroxyapatite, the last two in powder form. A comparison was made between these measured values and those obtained from metallic samples frequently used in implants such as high purity titanium and 316L stainless steel. Our results show that the porosity and its orientation in the bone are two important factors for the heat flux through the bone. The hydroxyapatite, in compact powder form, presents a thermal diffusivity value very near to those obtained for the bone samples which give a good thermal agreement between these materials. Finally, one order of magnitude of difference among the thermal diffusivity values of metallic samples and those corresponding values to bone and hydroxyapatite was obtained, this difference being greater in titanium than in stainless steel.
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Stainless steel and titanium are used in odontology and orthopaedia like screws, plates, prothesis, etc. These materials are also used as substrates that will be covered by bioceramics like hydroxyapatite,[1] improving the interface biocompatibility of implant with bone tissue. The biomaterials derived from calcium phosphates, have proven to be biocompatible with human bone tissues, which present a composition structure that consists, among others, of bioceramic crystals like hydroxyapatite (HA), which is in the bone in an organic matrix medium. The HA is the most important mineral component of bone tissue, 60 to 70% (by volume) in bone and up to 98% (by volume) in dental enamel.[2,3]

The study and determination of physical, chemical and biological properties of biomaterials used in implants for medical or dental applications is fundamental from the point of view of the biocompatibility that these materials must present with the tissue which they will replace because of the prolonged contact which they must maintain with alive tissues of the body.[2]

The thermal diffusivity (α) measures how fast (m/s) heat propagates through each meter (m) of material. Its importance lies in it is a unique value for each material.[4] It is know that, α is extremely sensitive to material microstructure and composition.[5,6] Thermal properties in porous materials, depend in addition, on the type of porous structure and its porosity degree.[7] Nowadays, this kind of materials has not been studied enough, however, its scientific and technological research are becoming very important in many applications.

In this work we report the thermal diffusivity measurements, by means of the photoacoustic (PA) technique in a heat transmission configuration,[8,9] of two different sections of bull dense bone, bull bone and commercial HA, the last two in compact powder form. We performed a comparison among them and those values that we obtained from metallic samples frequently used in biomedical applications, like titanium and stainless steel 316L. The microstructure of the samples was studied by means of scanning electron microscopy.

Experimental

The samples have a disk shape of 1 cm of diameter and thickness between 200 and 239 μm. In table 1 we show the set of the studied samples with their corresponding thickness. The samples 1 and 2 are stainless steel 316L and high purity titanium, respectively. The bone used in making the samples 3-5 comes from the upper part of one of the back legs of a 18 to 20 month old mature male bull. The bone was cleaned of flesh with a scalpel and boiled in

[†]To whom correspondence should be addressed
e-mail: tonino@mail.cicata.ipn.mx