Compositional studies of collagen using IBA techniques

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Introduction and state of science

Ion beam techniques can be used both to modify the materials and to obtain structural and elemental information about the studied samples. In both cases there are many biological applications.

The knowledge of the elements, particularly trace elements, of biological samples can be very useful to resolve many medical problems. Ion Beam Analysis (IBA) techniques are a fast, effective and with high sensitivity (they can detect concentrations of about μg/g) tool to the detection of elemental concentrations.

Bones play a vital role in supporting our bodies. Bones are made up of 70% calcium and 30% collagen.

Collagen ($C_4H_6N_2O_3R_2.(C_7H_9N_2O_2R)_n$) is the most abundant protein in the body, presenting many biological signals and maintaining the mechanical integrity of many different tissues. It is the major fibrous element of skin, bone, tendon, cartilage, blood vessels, and teeth. Calcium is a mineral that people need to build and maintain strong bones and teeth. It is also very important for other physical functions, such as muscle control and blood circulation. About "structure" of bones, the U.S. Government's NAIMS Division of the National Institutes of Health said "Bone … is made mostly of collagen, a protein that provides a soft framework, and calcium phosphate, a mineral that adds strength and hardens the framework. This combination of collagen and calcium that makes bone both flexible and strong, which in turn helps bone to withstand stress." In our bodies, solid calcium is stored in our bones, it is also found in dissolved form flowing through our blood.

Previous results

In bone, the formation and mineralization of the extracellular matrix structure is a complex process highly dependent on intermolecular interactions. The most abundant matrix protein and one of the major constituents implicated in mineralization is type I collagen. The collagen represents more than 90% of the organic matrix. The major high Z mineral components in bone are calcium (Ca) and phosphorus (P) [1]. Collagen type I is typical fibrillary collagen that consists tropocollagen molecules: 3 polypeptide chains (*named -chains)* coiled around each other to form the tripe helix configuration. Each polypeptide chains contains specific amino acids – Glycine, Proline, Hydroxyproline and Arginine which are in turn built of carbon, oxygen and hydrogen [2]. Bulo et al. [7], by molecular dynamics simulations, find the salts (NaCl, $CaCl_2$ and Na_2SO_4) suppress the swelling of the collagen fibrils. Silvent et al. [3] pointed out that your new model will allow to explore the role played by either by the cells, the matrix or the proteins during the successive events leading to bone mineralization. Other studies [4, 5] suggest that the structure of the bone matrix are not exactly known and this can be modified during the demineralization process. From previous study on collagen by Rapid Access programme of JCNS at KWS-2 instrument ("Small-angle neutron scattering on solutions collagen", proposal no. 10138), we observed that the collagen has a fractal behavior of rough surfaces with multilevel structure. These are according to ref. [6].

Aim of proposed work

We would like to investigate the morphology and structural features of type I collagen in the presence of mineral components ($CaCl_2$). The main objective of this experimental study is to obtain a total major element analysis plus information on the concentration of a number of oligoelements.

Ion Beam Analysis (IBA) will be undertaken to check the elemental map and to quantify light elements, in particular C, H and O contents.

Proposed experiments

IBA experiments on type I collagen are proposed at 3 MV Accelerator. Two sets of measurements are proposed on collagen and collagen with calcium for different collagen concentrations of 1, 3, 5, 10 mg/ ml with different calcium concentrations of 10, 20, 40 mM

In total, 2 sets of collagen x 4 concentrations of type I collagen x 3 calcium concentrations = 24 measurements is proposed. Supposing an average time of few hours per measured sample and adding the time necessary for the detector movement, calibration and correction measurements we would like to ask for this study for 4 days (12 shifts) beam time at 3 MV Accelerator.

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