In vivo evaluation of Fe in human skin employing X- Ray Fluorescence Methodology (XRF)

Marcelo Estevam and Carlos Roberto Appoloni

State University of Londrina, CCE, Dep. of Physics, Laboratory of Applied Nuclear Physics, C.P. 6001, CEP 86051-990, Londrina-PR, Brazil

Marcelo Estevam

Universidade Estadual de Londrina – Depto de Física

Rodovia Celso Garcia Cid

Pr 445 Km 380

P.O. Box 6001

Zip Code 86051-990,

Londrina - PR, Brazil

Fax: 0055-21-43-33714166

E-mail: marceloestevam@yahoo.com.br

ABSTRACT

Recent technological improvements allow the method of *in vivo* XRF to provide useful sensibility for diagnostics or monitoring in biomedical applications. In cases of hereditary sanguine disorders as the β -thalassaemia or a genetic disorder like Haemochromatosis [2], there is a high concentration of elements as Fe, Zn and Cu in the skin and internal organs, due to the treatment of those abnormalities or due to the own dysfunction caused by the disease. The levels of Fe related to the patient bearers of the β -thalassaemia are determined, at the moment, measuring a protein in the sanguine current, called ferritin. The monitoring of the protein is ineffective in several situations, such as when the patient

suffers any disturbance of health. Nowadays, the main forms of measuring the levels of those metals through hepatic storage are the biopsy of the liver, that is invasive and potentially dangerous, presenting a rate of mortality of 0,1% [2], and through magnetic susceptibilities that employs a quantum superconductor, which is highly expensive and there are only three main world centers with this equipment. This work investigates the use of a Si PIN-diode detector and a 238Pu source (13 and 17keV; 13%; 95.2mCi; 86y) for the measurement of Fe skin levels compatible with those associated to the disease β - thalassaemia. XRF spectra were analyzed using a set of AXIL-WinQXAS programs elaborated and disseminated by the IAEA. The correlation coefficient of the calibration model (sensitivity curve) was 0.97. Measurements on skin phantoms containing concentrations of Fe in the range from 10 to 150 parts per million (ppm), indicate that we are able to detect Fe at levels of the order of 15ppm, using monitoring periods of 50 seconds and skin entrance dose less than 10 mSv. The literature reports skin Fe levels from 15.0 to 60.0 ppm in normal persons and from 70 to 150 ppm in thalassaemics patients. So, the employed methodology allows the measurement of the skin Fe concentration [1, 2, 3].

INTRODUCTION

Non-invasive techniques for determination of heavy metal concentrations in vivo have been developed during the last 25 years. In trace amounts, some metals are essential for the function of the human body. On the other hand, a number of metals are toxic to man if present in too high a concentration. Is important to increase our knowledge of the relations between metal concentrations in man and observable toxic effects.

The extent to which an *in vivo* XRF method can provide useful sensitivity for diagnostic or monitoring applications in biomedicine is subject to a number of critical factors. These include, the atomic numbers of elements of interest, their levels in tissues, the incident beam energy, the levels in tissues, the incident and emerging beams are attenuated and number of counts detected per unit dose.

One potential application involves monitoring of the efficacy of chelation of Fe, a therapy used to alleviate the tendency of Fe to build-up as result of treatment of the hereditary blood disorder β-thalassaemia [2].

XRF METHODOLOGY

X-ray fluorescence spectrometry is used for elemental analysis based on the detection of emitted X-ray radiation from excited atoms. X-rays are short wavelength electromagnetic radiation, a conventional x-ray spectrometer generally utilizes the region of about 0.1→11 nm.

This technique is a two-step process that begins with the removal of an inner shell electron of an atom. The resulting vacancy is filled by an outer shell electron. The second step is the transition from the outer shell electron orbital to an inner shell electron orbital. This transition is accompanied by emission of an X-ray photon [4].

The energy of the fluorescent photon is characteristic of the element and is equal to the energy difference between the two electron energy levels. Thus the energy of the fluorescent photon provides qualitative information concerning the elements' identity. The number or intensity of fluorescent photons is characteristic of the amount or concentration of the elements present.

The emission process is similar to other fluorescent measurement techniques. The photon energies are designated (anachronistically) as K, L, or M X-rays depending on the energy level being filled [5].

LEVELS OF Fe

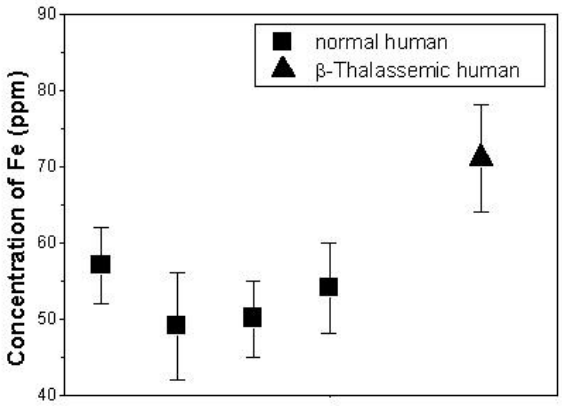

Figure 1. Concentration of Fe (ppm) for normal human and β-thalassemic human by *in vivo* XRF.

CONCLUSIONS

The *in vivo* XRF system can measure the difference between healthy people and bearers of β-thalassaemia. The difference is of approximately 20 ppm of Fe. The low limit detection was below 15 ppm. The radiation dose was smaller than 10 mSv, which is 2 to 3 times smaller than the dose of a normal radiography of the thorax.

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