Applications of IBA methods for dental research

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In the last decades remarkable progress took place in the field of dental materials and dental tissues' treatments aiming at the prophilaxy and therapy of dental impairments such as caries, periodontal disease, etc. Such new approaches develop at a high rate and require detailed characterization of the physical and chemical interactions involved in view of improving their efficiency and reducing side effects. On the other hand the new materials bring foreign elements in the organism and may present toxicologic and occupational risks for the patient and for the medical personnel. Both the use of the new dental materials such as composites and the modifications of dental enamel or dentin, e.g. by laser irradiation or by fluoride application involve surface phenomena which produce structure and composition changes in the outermost layer of the material, tooth or both. Therefore, surface characterization methods are needed for new developments in dental research. Besides surface microscopy methods such as SEM and AFM, surface analysis methods from the field of X-ray spectroscopy (XRS) such as XRF, EXAFS and XANES and of ion beam analysis (IBA) such as PIXE, PIGE, ERDA and RBS helped a deeper insight of the dental pathology and its prevention mechanisms.

We hereby propose a new project aiming to extend our IBA studies (PIXE, PIGE, ERDA, RBS including microbeam) in dental research from previous years (review [Preoteasa et al 2012]) and to approach new subjects, using mainly the new 3 MV Tandetron as well as the 9 MV Tandem accelerator for particular applications. In this project – which may continue for several years – we intend to study both hard dental tissues (enamel, cementum, dentin) and new dental materials (nanocomposites, sealers, etc.) in various preparative conditions relevant for the clinical applications. We envision a large variety of applications including for instance laser treatments of dental enamel, in vitro demineralization, fluoride and other topical applications on enamel, as well as characterization of native and demineralized dental composites and of their interface with enamel, corrosion of dental alloys, migration and diffusion of metals form dental materials in the dental tissues, etc. We intend to use the IBA methods not only for elemental analysis, but also for depth profiling of the surface layers and for surface mapping of elements using the 20 μm microbeam facility of the 3 MV Tandetron.

Our previous experience include on one hand IBA, SEM and AFM applications in dental research (Preoteasa et al 2002 – 2013, Gomez et al 2006) and on the other IBA, SEM and XRD studies on various thin layers deposited on inorganic materials (Pantelica et al 2005 – 2006, Filipescu et al 2011, Scarisoreanu et al 2008, Branescu et al 2006, Gyory et al 2005, Balaceanu et al 2000 – 2002, Goldenblum et al 2002).

In the initial phase, we intend to explore and evaluate the potential of broad beam IBA methods available at the 3 MV Tandetron (PIXE, PIGE, ERDA, RBS), using protons and α particles. XRF will be used as a complementary method. Various standards and reference materials (e. g. pelleted and thin layer hydroxyapatite, dental materials and alloys with known composition, feldspat, bone standard) will be characterized for calibration of the analytical techniques.

At the same time, various types od samples (dental enamel, dental nanocomposites, dental alloys) will be examined by the various techniques in view of identifying the most relevant approach. This will help guiding the further studies.

In this phase we will start as a research topics the problem of damage produced by the ion beam during the analysis of dental composites as a function of cummulated electric charge density. Preliminary AFM studies have shown that the structure and texture of the surface layer of these materials is strongly damaged in ERDA and micro-PIXE studies and, to a less extent, in PIXE and PIGE analysis. To this purpose, ERDA of hydrogen ions with α beams bombardment will be used, because the dental composites contain a matrix of organic polymers which is charred during irradiation. Our working hypothesis is that the damage involes also the ejection of hydrogen ions from the polymers and that this process depends on the cummulated charge density and energy of the incident beam.

Beam time request: 50 – 100 hours for a time period of about 6 months.

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