PREFACE

Introduction and objective of the present work:

MANY millennia ago, the discovery that fire would irreversibly transform clay into ceramic pottery led to an agrarian society and an enormous improvement in the quality and length of life. Further, another revolution occurred in the use of ceramics during the past four decades to improve the quality of life. This revolution is the innovative use of specially designed ceramics for the repair, reconstruction and replacement of diseased or damaged parts of the human body. Ceramics used for this purpose are termed ''bioceramics''. The field of bioceramics encompasses single crystal and polycrystalline alumina, zirconia or partially stabilized zirconia (PSZ), hydroxyapatite, bioactive glasses, bioactive glass-ceramics, A/W glass ceramics as well as bioactive composite (polyethylene–hydroxyapatite). Several special ceramics and glasses have been designed and developed during this century for use in the health care such as eyeglasses, diagnostic instruments, chemical wares, thermometers, tissue culture flasks, fiber optics for endoscopy and carriers for enzymes & antibodies. Ceramics are also used widely in dentistry as restorative materials, gold porcelain crowns, glass-filled ionomer cements, dentures, etc. The materials used in these applications are called dental ceramics.

Bioceramics have been earlier produced in several forms and phases which serve different functions in the repair of the body. In different area of applications ceramics are used in the form of bulk materials of a specific shape as *implants*, *prostheses*, or *prosthetic devices*. Bioceramics are also used to fill space while the natural repair processes restore functions. In other situations the ceramic is used as a coating on a substrate, or as a secondary phase in a composite which combine the characteristics of both into a new material with enhanced mechanical and biochemical properties.

Bioactive glasses

It was discovered by Hench and his colleagues in 1969 that bone can bond chemically to certain glass compositions. This group of glasses was known as bioactive glasses, based upon definition of bioactive materials as given earlier: ***"A bioactive material is one that elicits a specific biological response at the***

***interface of the material which results in the formation of a bond between the tissues and the material*"**. Bioactive glasses have got their numerous applications in the repair and reconstruction of diseased and damaged tissue, especially hard tissue (bone). One aspect that makes bioactive glasses different from other bioactive ceramics and glass-ceramics is the possibility of controlling a range of chemical properties and rate of bonding to tissues. The most reactive glass compositions develop a stable, bonded interface with soft tissues. It is possible to design glasses with properties specific to a particular clinical application. This is also possible with some glass-ceramics but their heterogeneous microstructure restricts their versatility.

The main goal of this work is to contribute gaining a better understanding of the process of bioactive glass reactivity. As previously shown, a lot of work has been carried out in the past few years to study bioactive glass dissolution and re-precipitation in simulated body fluid (SBF), mostly focusing on the characterization of the HCA layer deposited. Improvement in composition and synthesis procedure of bioactive glasses has been obtained mostly by trial-and-error, and by comparing in-vitro and in-vivo results. Still, the actual surface sites of HCA deposition are not completely known, and the role of the different elements that bioactive glasses are made of is not fully understood.

A reason for this lack of knowledge is that the most important interactions occur at the bioactive glass/solution interface, which is a nanometer-sized continuously changing region of space. A thorough study of this region should involve analysis of changes in surface morphology, cristallinity, composition, hydroxylation, acidity, potential and charge of the material as well as composition and pH of the solution. Definitely, such large and varied information cannot be obtained with only one analytical technique. Moreover, only a few techniques can analyze the changes of a material immersed in solution without being affected by the presence of the liquid.

In my work, I faced the problem from different sides, using many analytical techniques to study the changes occurring both on the material and in the solution, although the main focus of the work was the analysis of changes in the material surface. The importance of biomaterials surface analysis has been recently pointed out.

Nevertheless, this type of study is still quite limited, especially if compared with the years long research carried out on the surface properties of other materials. I hope that the following work may contribute extending the application of some of the typical surface chemistry analytical tools to the field of biomaterials science.

The subject matter of the thesis has been divided into the following eight chapters:

- **Chapter 1** is the introduction and literature reciew of the research work, comprising of a general introduction of bioceramics and bioglasses.
- **Chapter 2** presents the experimental procedures which are used in present research work with detail.
- **Chapter 3** is a compiled research work related to the preparation and characterization of Li_2O-CaO-Al_2O_3-P_2O_5-SiO_2 glasses as bioactive material. Further, studies on their structural, physico-mechanical properties, bioactivity as well as biocompatibility of glasses using human osteoblast (MG-63) cell lines have been included.
- **Chapter 4** discusses the structural characterization and *in vitro* bioactivity assessment of SiO_2–CaO–P_2O_5–K_2O–Al_2O_3 glass as bioactive ceramic material. Their structural, physico-mechanical properties, bioactivity and cytotoxicity, cell viability, proliferation, apoptosis and cell attachment were assessed using human osteosarcoma U2-OS cell lines have been extingiusly studied.
- **Chapter 5** is devoted to the structural characterization and in-vitro bioactivity assessment of SiO_2–CaO–P_2O_5–SrO–Al_2O_3 glass as bioactive ceramic material. A comparative study on structural and physico-mechanical properties as well as bioactivity of glasses was reported. The structural properties of glasses were investigated by XRD, FTIR spectrometry, SEM and the bioactivity of the glasses was evaluated by in vitro test in simulated body fluid. The cytotoxicity and cell viability were assessed using human osteosarcoma U2-OS cell lines.

- **Chapter 6** displays the studies on preparation, characterization and antibacterial properties of CuO substituted 45S5 bioactive glass as bioactive ceramic material. the role of CuO in the system of 45S5 bioactive glass for improving the bioactivity as well as other physical and mechanical properties of 45S5 bioglass have been studied. Antibacterial tests of these glasses had shown that after introducing CuO from 0.5-2.5 mol% these glasses develops an antibacterial property.

- **Chapter 7** discusses the studies on preparation and characterization of 45S5 bioactive glass doped with (TiO_2 + ZrO_2) as bioactive ceramic material. A comparative study on structural and mechanical properties as well as bioactivity of the glasses has been reported.

- **Chapter 8** combines the overall conclusive statements of all the works as mentioned chapter wise. It is finally followed by references and list of publications and their reprints.