

THERMAL AND INFRARED ANALYSES OF ALUMINOSILICATE GLASS SYSTEMS FOR DENTAL IMPLANTS

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Aluminosilicate glasses containing fluorides are investigated by means of thermal analysis and Fourier transform infrared spectroscopy (FTIR). Both methods evidence different silanisation accomplishment in function of glass composition. The silane adheres better on samples also containing B₂O₃. The FTIR analysis does not evidence any changes in the vibrational properties of the samples immersed for seven days in simulated body fluid.

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1. Introduction

Bioactive glasses are surface-active bone substitutes that have shown good biocompatibility both in bone and in soft tissue and are used in oral and maxillofacial bone augmentation [1]. Implants may be solid, with a smooth or rough surface, or may be as porous structures with definite pore sizes and configurations. Other developments are directed towards the production of porous implants or implants with a suitable surface which will become invaded by bone or by connective tissue and thus held more securely but still mechanically in place. It would be preferable if chemical bonding could be achieved between the implant and the tissues and suggestions have been made that adhesion should be possible between the collagen of bone and a 'bioglass'.

The structural changes occurring in aluminosilicate glass systems containing fluorides are investigated by means of thermal analysis and FTIR spectroscopy.

2. Experimental

The composition of the investigated aluminosilicate systems is given in Table 1. The samples were prepared by quickly undercooling from 1300, 1350 or 1400 °C to room temperature. The finely ground samples were treated with silane A-174 for obtaining a better coupling with the biologic phase. On the surface of the powder glass samples coated with silane is expected the development of a bioactive layer in biologic media.

Table 1. Sample composition in wt %.

Code	G1	G2	G3	G4
SiO ₂	45	40	35	40
Al ₂ O ₃	10	10	10	12
B ₂ O ₃	17	10		5
BaO	20			
ZnO		30		
CaO			10	
Yb ₂ O ₃			3	
P ₂ O ₅			4.6	
ZrO ₂				8
SrO			22.4	27
fluorides	8	10	15	8

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In order to check the bioactivity the samples were exposed to simulated body fluid (SBF) for seven days at 37 °C. X-ray diffraction patterns and optical micrographs were recorded before as well as after soaking in SBF. Thermal analysis measurements were carried out using a MOM equipment. Thermogravimetric (TG), differential thermogravimetric (DTG) and differential thermal analysis (DTA) curves were recorded in the temperature range 20-1000 °C, with a rate of 10°C/min. The IR spectra were recorded on a FT/IR-610 JASCO spectrometer at room temperature in the wavenumbers range from 400 to 4000 cm^{-1} using the KBr disk technique.

3. Results and discussion

The vitreous state of the investigated samples is attested by the X-ray diffraction patterns that consist of a large line centred around $2\theta = 27^\circ$.

According to TG, DTG and DTA data the silane phase differently adheres on the powders obtained from the investigated glass systems. The wasting of silane starts at different temperatures, depending on glass composition (Fig. 1). These major exothermic events occur up to 400°C and are more pronounced in G1 and G2 samples. They indicate the decomposition of the adhered silane phase.

The results obtained by IR spectroscopy confirm the same behaviour with respect to the adhered silane phase. The vibration band at 1720 cm^{-1} (Fig. 2) associated to the silane adhesion is well evidenced for G1 and G2 samples while for G3 and G4 ones this band is very weakly developed. The weak bands at 2920 and 2848 cm^{-1} correspond to $\nu(\text{C-H})$ stretching modes [2] occurring from methylene group of silane source.

In samples G1, G2 and G4 enter two glass former oxides, i.e. SiO_2 and B_2O_3 while in G3 only SiO_2 forms structural units for the glass network. The IR spectra recorded from G1 and G2 glasses indicate that the boron structural units [3] give rise to the vibration band at 1403 cm^{-1} .

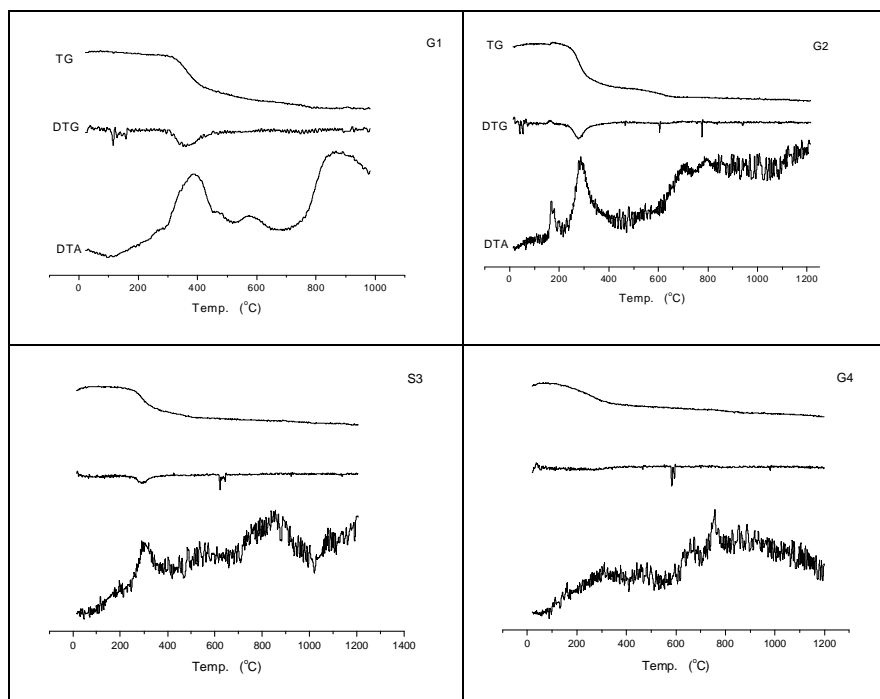


Fig. 1. The thermal analysis curves.

The peak around 460 cm^{-1} is assigned to Si–O–Si bend vibration [4]. The assignment of the intense IR band recorded around 1033 cm^{-1} may be considered according to the studies of the vibrational modes of Si–O–Si, in which the absorption signals of the asymmetric stretching of the

$\nu(\text{Si-O-Si})$ bridges are affected by adjacent oxygen atoms in two ways: executing the asymmetric stretching motion in phase with each other and out of phase [5-8]. In all samples is shown the existence of chemical bonds between aluminum and oxygen atoms forming coordination groups of AlO_4 and AlO_6 types [9], with characteristic stretching vibrations typical for the Al-O bonds in the AlO_4 tetrahedra ($900\text{-}650\text{ cm}^{-1}$) and AlO_6 octahedra ($650\text{-}500\text{ cm}^{-1}$) and relative intensity, before and after seven days immersion in SBF, but it is to be remarked a slight broadening of the absorption bands. This effect could be associated with a randomisation of the structural units on samples surface.

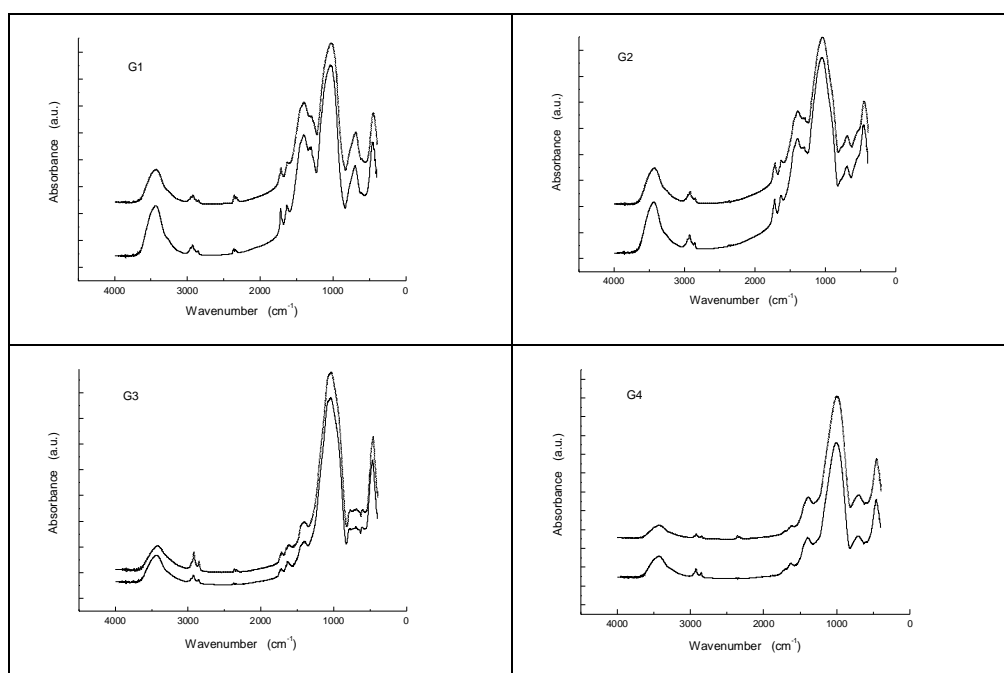


Fig. 2. FTIR spectra before (solid line) and after 7 days exposure to SBF (dotted line).

4. Conclusions

Thermal analysis and IR data indicate distinct deposition of silane coupling agent on powder glass samples usable as dental implant biomaterials. The structural changes depend on glass composition. According to IR results in the first seven days of soaking in SBF the structural units on glass surface are weakly modified without evidencing the development of new bonds.

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