INFLUENCE OF NETWORK MODIFIERS ON THE SURFACE CHARACTERISTICS OF MESOPOROUS BIOACTIVE GLASS

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INTRODUCTION

Mesoporous bioactive glass (MBG) is a novel material which has been intensely researched over the past decade in the bone tissue engineering field. The properties of these particles (high porosity resulting in rapid apatite formation compared to bioactive glass) makes them attractive candidates to be used as fillers in dental bonding for the remineralization of dental tissue.

OBJECTIVE

The objective of this study was to prepare novel Mesoporous Bioactive glasses (MBG's) of varying network modifiers (CaO:Na2O) ratio in small (10g) and large scale (50g), and further characterize the varying network modifiers effect on the structural properties of glasses which plays a vital role in their bioactivity.

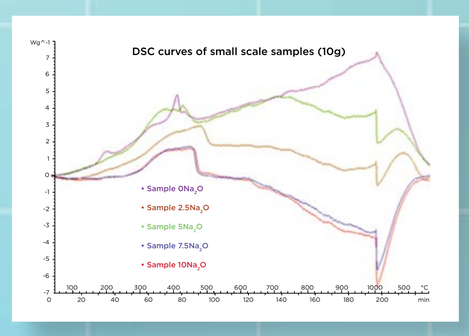
MATERIALS AND METHODS

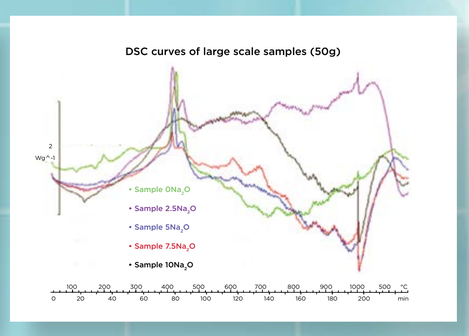
- The MBG of composition 75SiO2:XCaO:(15-X)Na2O:10P2O5 where X=5, 7.5, 10, 12.5, 15 have been synthesized by an acid catalysed sol-gel method assisted by an evaporation induced self- assembly (EISA) process. The glass precursors were tetraethyl orthosilicate (TEOS), triethyl phosphate (TEP), calcium acetate monohydrate (CaAc.H2O) and sodium acetate(NaAc), ethanol, acetic acid and non-ionic triblock copolymer P123 (EO20PO70EO20) as a surfactant.
- Briefly, the quantities of precursors were calculated based on the composition for 10g (small scale) and 50g (Large scale) end product. For both preparations, 2g of P123 surfactant was dissolved in a solution containing 30g ethanol, 37.5ml water and 214.5ml of acetic acid. The mixture was stirred for an hour followed by the addition of each glass precursor in an hour interval. After gelling it was allowed to undergo EISA for 4 days and dried at 60°C for 2 days. The gel was milled down and calcined at 480°C for small scale and 380°C for large scale samples at 1°C per minute for 5 hours. The calcination temperature was selected based on the TGA/DSC of the milled gels.
- TGA/DSC analyses were realised in a temperature range from 25°C to 1000°C, under air as reactive gas and with a heating rate of 5°C/min. The phase of the samples was characterized by X-ray diffraction (XRD). The surface area and pore volume parameters were determined by nitrogen adsorption/desorption isotherms and Brunauer-Emmett-Teller (BET) method, while Barret-Joyner-Halenda (BJH) was used for mean pore size determination.

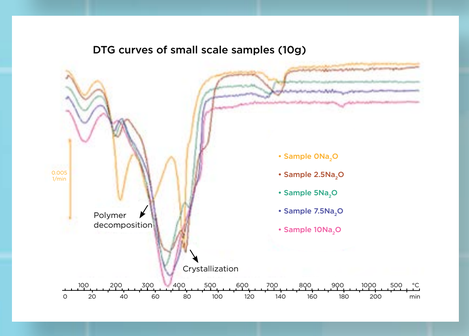
RESULTS AND DISCUSSION

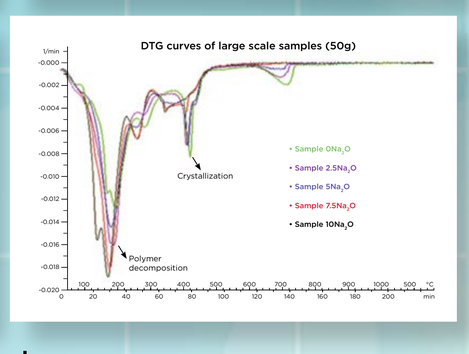
- The TGA/DSC analyses on the small scale (10g) samples revealed that the surfactant decomposition temperature and crystallization temperature were very close and hence the samples were calcined at 480°C to remove polymer and stabilise the glasses.
- The XRD analyses on these samples have shown that except for 10Na2O composition (highest sodium oxide) all the other samples (7.5%Na2O- 0%Na2O) exhibited some crystallinity (e.g. calcite phase) with the level of crystallinity increasing with the increased CaO in the composition. Interestingly, values of surface area and pore volume also increased with CaO content in the composition (390 m2g-1 and 0.2324 cm3g-1 for 0%Na2O) and the mean pore size decreased with increase in CaO in the composition, suggesting that the CaO increases the porosity of these samples.
- On characterizing the large scale (50g) samples we observed similar trends as above but with much higher values for surface area and pore volume (580 m2g-1 and 0.4273 cm3g-1 for 0%Na2O) and lower values for mean pore size compared to the small scale (10g) samples.
- Biological properties of such glasses are highly dependent of their chemical composition, but also on their surface area and pore volume. The relationship between CaO, crystal phase presence, micromorphology and size of samples is the key factor for an optimized elaboration process.

DSC/DTG analyses

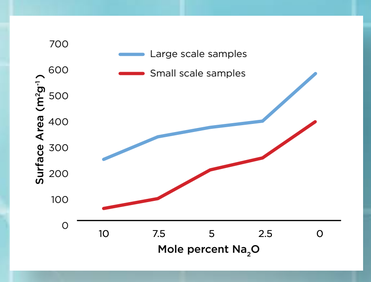


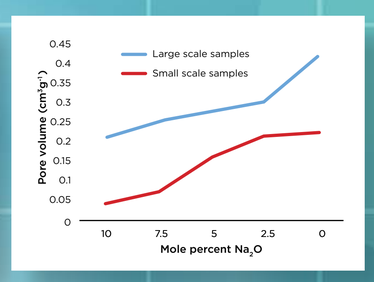


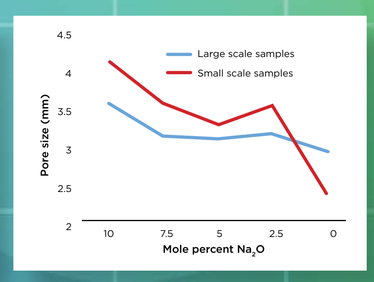




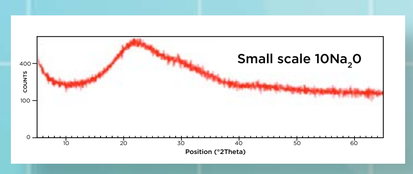
BET/BJH analyses

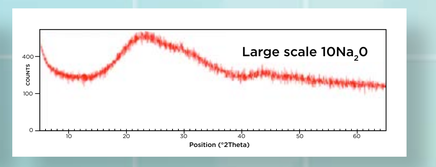


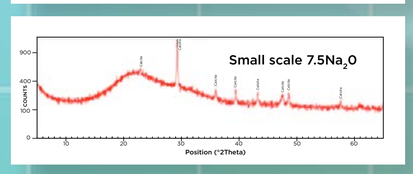


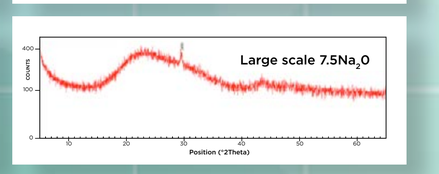


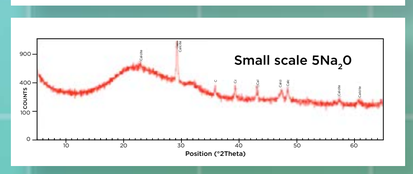
XRD analyses

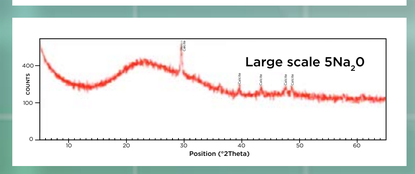


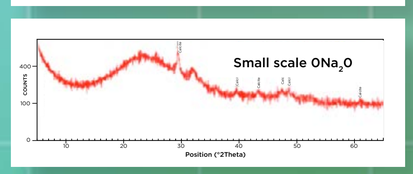


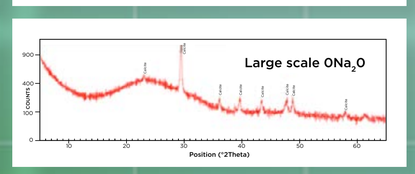


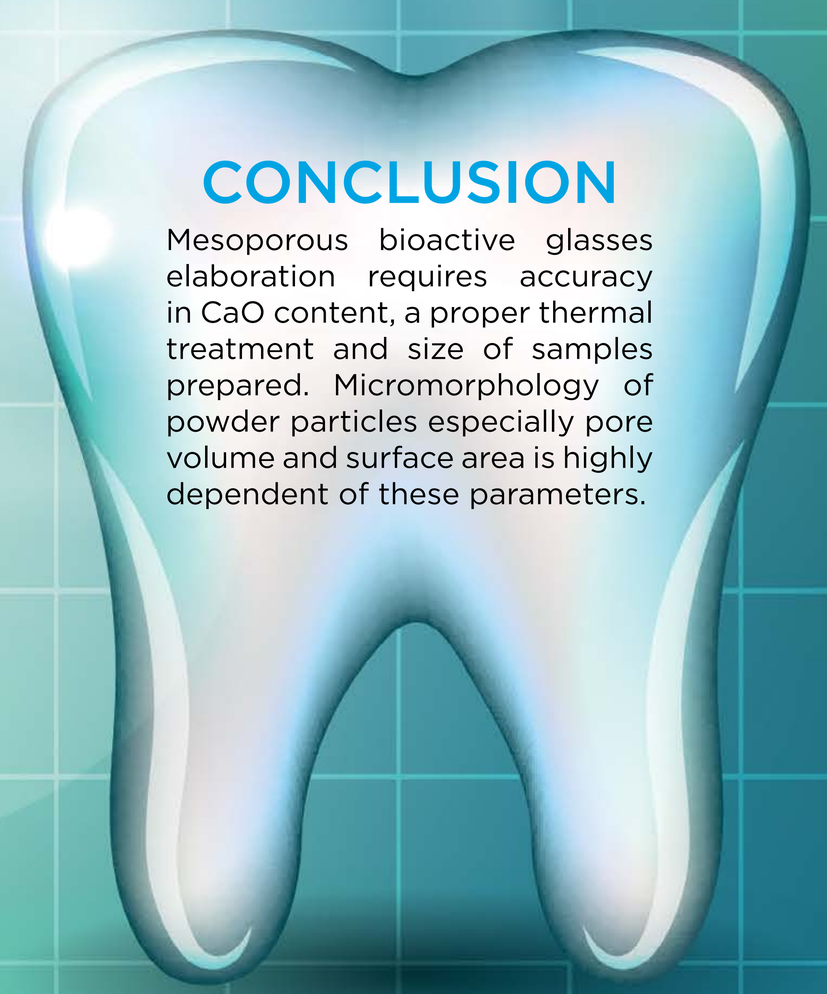












CONCLUSION

Mesoporous bioactive glasses elaboration requires accuracy in CaO content, a proper thermal treatment and size of samples prepared. Micromorphology of powder particles especially pore volume and surface area is highly dependent of these parameters.