Development of flame spheroidization process for S53P4 bioactive glass

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Introduction

Bioactive glass is a biomaterial used especially in orthopaedic and dental applications for hard tissue repair. The bioactivity of the glass is based on the osteoconductive and -stimulative properties.

The aim of this work was to develop a flame spheroidization process for S53P4 bioactive glass to produce microspheres from glass granules. Bioactive glass microspheres can be used in injectable healthcare applications to minimize the need for invasive implantation routes. The aim was to spheroidize glass granules without a change in the composition or bioactivity of the material.

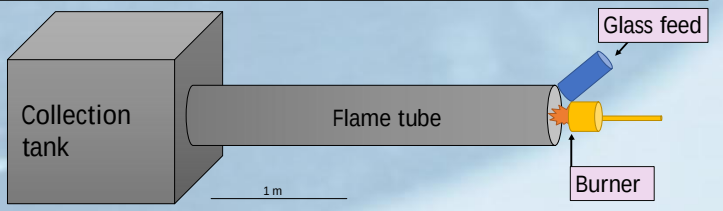

Figure 1. Illustration of the flame spheroidization process. Glass is fed into the flame where the particles soften and spheroidize. The spheroidized glass is carried by the flame through the flame tube into the collection tank.

Methods

A flame spheroidization process was developed to produce spheroidized particles from bioactive glass granules in the size fraction of 90-450 µm. Different process parameters were analysed during the development phase and four samples were collected for further analysis. The samples were spheroidized using propane gas or acetylene/air mixture. The samples were run once or twice through the process.

Method	Aim
X-ray fluorescence	Composition analysis to determine the effect of the flame process on the glass composition
Scanning electron microscope (SEM)	Size and shape determination. The visualisation of the reaction layers from cross section images
Phosphorus measurement	Determination of the reactivity of the spheroidized glass samples

Results

Parameter	Observation
Diameter of the flame tube	- Narrower tube keeps the particles longer in the flame
Length of the flame tube	- Affects the flame length which may increase spheroidization - Particles may not reach the collection tank
Material feed rate	- Too high feed rate decreases the spheroidization efficiency - Too slow feed rate decreases the yield
Gas mixture	- The temperature of the process can be controlled with different gas mixtures - Higher temperature enhances spheroidization of larger particles. However, it also increases the aggregation of smaller particles
Humidity	- The softening temperature of bioactive glass may decrease in humid conditions resulting in aggregation and foaming of the glass during the spheroidization process

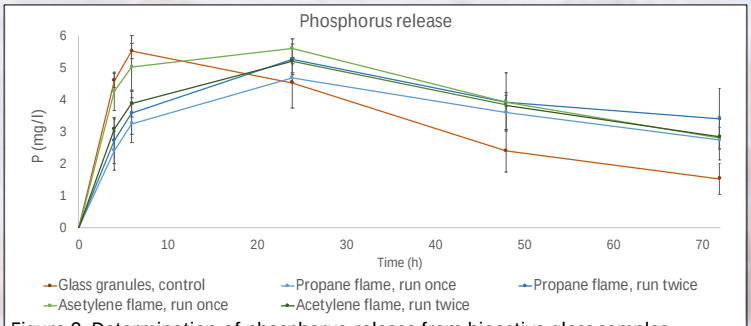

Figure 2. Determination of phosphorus release from bioactive glass samples.

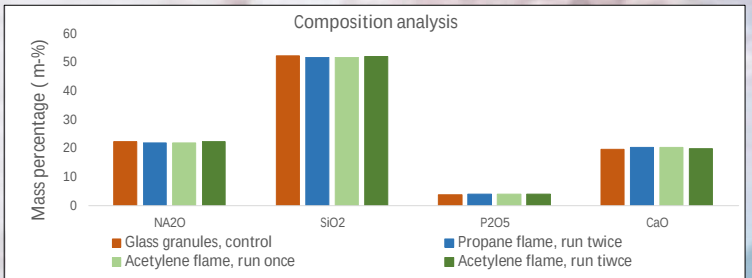

Figure 3. X-ray fluorescence results from bioactive glass samples.

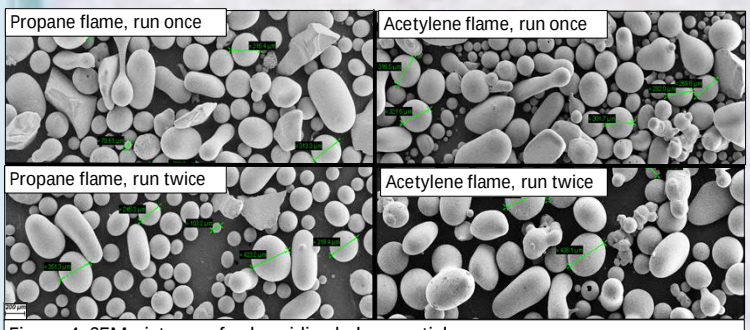

Figure 4. SEM pictures of spheroidized glass particles.

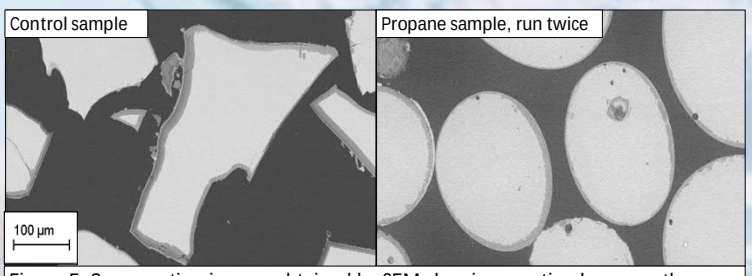

Figure 5. Cross section images obtained by SEM showing reaction layers on the surface of the particles after 24 hour incubation in TRIS buffer.

Conclusions

- Spheroidization achieved in smaller particles. However, process needs optimization for the spheroidization of larger particles
- No changes observed in glass composition
- Delayed phosphorus release observed in spheroidized particles
- Spheroidized particles form reaction layers in vitro indicating bioactivity
- More tests are needed to optimize the process and to further characterize the bioactivity of the spheroidized glass samples