

Dissolution & mechanical properties of bioresorbable glass fibres for use in Paediatric stents

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INTRODUCTION

Stents provide biological support in body conduits and are useful for counteracting stenosis (constriction) in cardiovascular, gastrointestinal, urethral and airway passages¹. However, the current widespread use of permanent metal stents that remain throughout the lifespan of a patient, threaten restenosis, thrombosis, or physical irritation if not surgically removed.

In infants the clinical requirement is for a stent that retains structural integrity for periods of several weeks up to many months *in vivo* during host tissue restoration² and from a materials perspective this requires an implant with appropriate mechanical and degradation characteristics.

Bioresorbable phosphate glass fibres have shown enormous potential for temporary implants and tissue repair, owing to their mechanical properties and solubility in aqueous media which can be modified by addition of various oxide compounds^{3,4}. Further, when combined with degradable polymers the resulting glass fibre polymer composites (GFRP) become ductile allowing them to be forged into supporting scaffolds with suitable mechanical and dissolution properties. To date however, their use for stenting applications has not been investigated possibly due to major difficulties of processing these compositions into fibre form.

In this study, two phosphate glass fibre compositions containing SiO₂ (silica) and B₂O₃ (Boron) were fabricated to test the hypothesis that B₂O₃ containing phosphate glass fibres present enhanced mechanical and dissolution behaviour for use as a degradable stent.

EXPERIMENTAL METHODS

Glass fibres: GF330 (Silica based) and GF331 (Boron) continuous fibre with target diameters ranging from 10-20µm were obtained (Giltch Ayrshire, UK).

Fibre dissolution and pH study: 200mg fibre bundles for each fibre formulation were immersed in 10ml glass vials containing phosphate buffered saline (Sigma Aldrich UK). Each sample (n=6 per formulation) was weighed (Denver Instrument) and the dissolution media pH recorded (Accument Basic AB15) before and after 3 and 7 days of incubation at 37°C. Before weighing, samples were dried in an air circulating oven at 60°C for 4 hours.

Tensile tests: Individual fibre filaments were placed on a paper frame (fig 2) with a gauge length of 25mm and the ends of each fibre attached to the frame using cyanoacrylate adhesive. Glass fibre diameters (n=20) were measured using optical microscopy (Zeiss Axiovert). Samples were mounted onto the specimen grips of a test machine (Instron 8841) fitted with a 10N load cell and tested at room temperature at 1mm/min. Tensile modulus and strength were calculated and

Student's t-test were performed using Prism v.5

RESULTS AND DISCUSSION

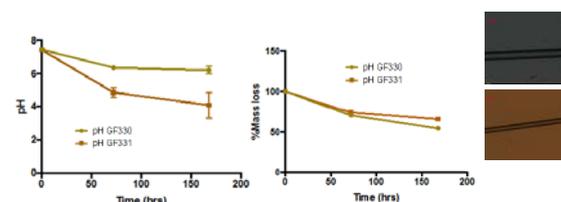


Fig1: Dissolution media pH (left) and % mass loss (centre) for GF330 and GF331 compositions after immersion in PBS, with light microscope images (right)

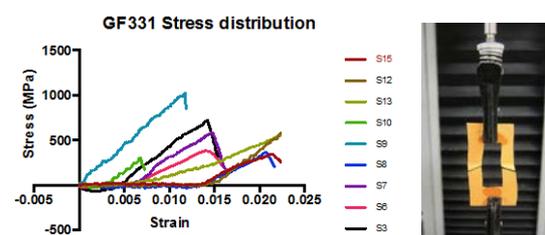


Fig2: Stress-strain curves for B₂O₃ based glass fibres (left) and paper frame and mounting technique (right)

Degradation media of the boron based GF331 displayed a more dramatic decline in pH after 7 days 4.09±0.76 compared with GF330 6.20±0.23 (fig1), however a greater quantity of fibre mass was lost in the Silica based composition after 7 days of immersion in PBS. On average boron containing glass fibres demonstrated a statistically significantly higher tensile strength and tensile modulus than silica based fibres (p<0.05) and this maybe attributed to increased cross link density in glass fibres containing B₂O₃ additions⁵.

CONCLUSIONS

Despite creating a noticeably higher acidic environment B₂O₃ fibres retain greater mass after days of immersion in PBS and are likely to perform with longer mechanical integrity *in vivo* than SiO₂ based fibres when used as part of a GFRP composite stent material.

REFERENCES

1. Zilberman *et al* J Biomed Mat Res 74B:792-799, 2005
2. Luffey *et al* J Biom Mat Res 102A: 611-620, 2014
3. Kowles *et al* J Mat Chem 13: 2395-240, 2003
4. Sharmin *et al* J Biomater Appl 29: 639 2014
5. Shah *et al.*, Bull Mater Sci 29: 43-48, 2006

ACKNOWLEDGMENTS

The authors would like to thank Action Medical Research and Yorkhill Children's Charity for providing financial support to this project.

