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# Bioresorbable glass fiber reinforced composite as a material for prolonged bone fixations

Ville Ellä *, Niina Ahola *, Mikko Huttunen *, Harri Heino *, Timo Lehtonen *
* Arctic Biomaterials OY, Finland

## Introduction

Bioresorbable glass fibre reinforced composites have previously been studied for bone fixation purposes [1]. Glass fibre reinforced composite offers great advantage by increasing mechanical properties compared to polymer. Currently, there is a need to manufacture stronger bone fixation devices in order to treat fractures in load bearing indications of the human body.

In this project, the objective was to produce very strong composites with altering degradation properties to be used either in sports medicine (arthroscopy) where shorter healing periods are required or in trauma and spine fixation where longer support times are needed.

## Experimental

Continuous silica based bioresorbable glass fibres were manufactured by means of fibre drawing from melt. Around 400 filaments were winded to a bundle of 130 TEX.

10 Glass fibre tows were impregnated by thermoplastic pultrusion with bioresorbable medical grade polymer to form a composite pin with ~ 40 wt-% glass fibre content.

The used polymers were PURASORB PLD9620 (PLDA 96/4) and PURASORB PLG 8523 (PLGA 85/15).

Manufactured pins were cut to length of 60 mm. They were studied in an *in vitro* test series according to ISO 15814:1999 for 26 weeks. During the *in vitro* study, mechanical and chemical properties were followed.

*Table 1. Composite pin residual monomer content (L-lactide (L) and glycolide (G)) at selected time points in vitro.*

| | 0-week (%) | 1-week (%) | 8-week (%) | 26-week (%) |
|---|---|---|---|---|
| PLGA 85/15* | 0.08(L) 0.09(G) | 0.08(L) 0.09(G) | 0.11(L) 0.12(G) | 0.51(L) 0.40(G) |
| PLDA 96/4* | 0.07 | 0.06 | 0.04 | N/A |

*Residual monomer in raw material Max 0.1%

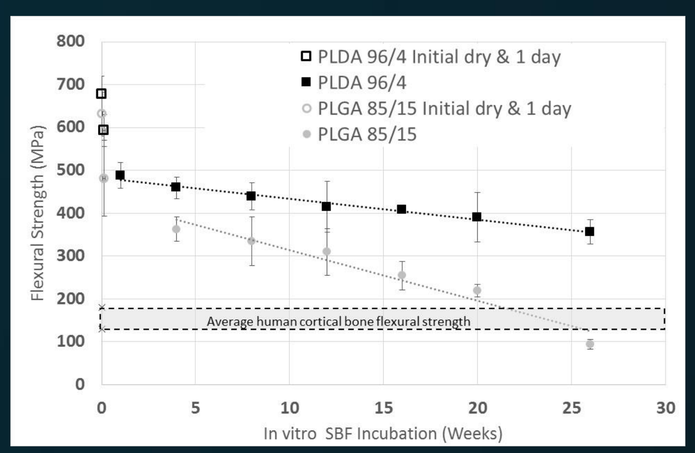



*Fig 1. Flexural strength of the composite pins as a function of time in vitro compared to human cortical bone [3].*

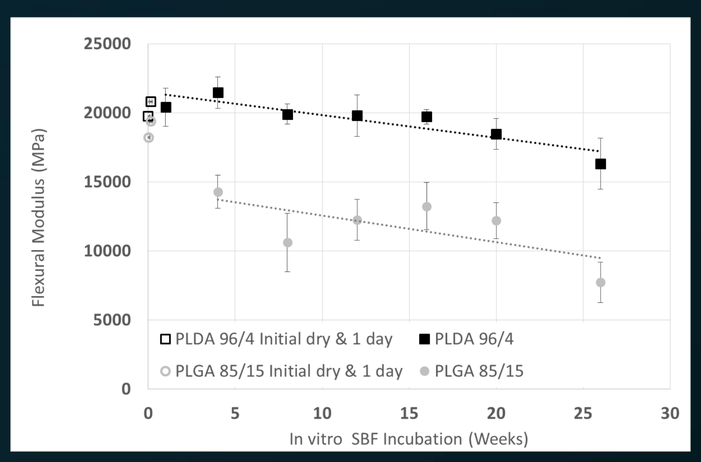



*Fig 2. Flexural modulus of the composite pins as a function of time in vitro.*

## Results and Discussion

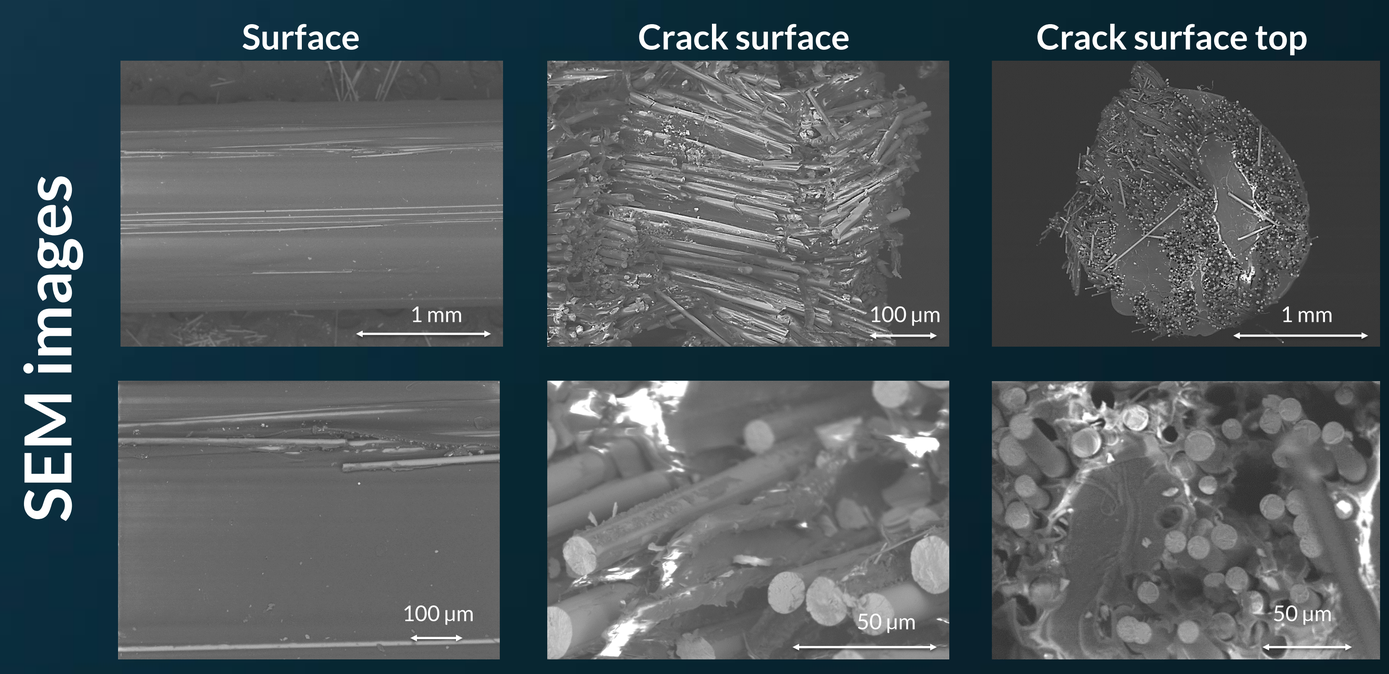
After the impregnation process the residual monomer content of the polymers remained below 0.1 % in the composite (Table 1).

Scanning Electron Microscopy (SEM) images reveal the formation of the composite pin and show clearly the adhesion of matrix polymer on to the glass fibres.

A rapid decrease of flexural strength was noticed during the first day in vitro (Fig 1). This is a normal local stress relaxation behaviour for glass fibre reinforced composites [2]. The flexural modulus showed only minor decrease for the PLDA whereas for PLGA a decrease was noticed after the first weeks (Fig 2).

After the first day, the flexural strength of the pins decreases continuously, but remains over 350 MPa for PLDA composite pin until 26 weeks in vitro.

The PLGA composite degrades faster, as shown in inherent viscosity data (Fig 3), and thus shows faster decline of the flexural strength (Fig 1).



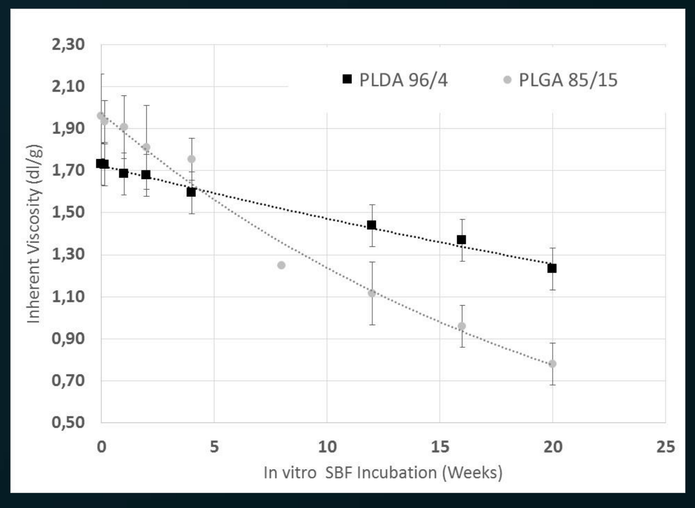




*Fig 3. Inherent viscosity of the two studied composite pins as a function of time in vitro.*

## Conclusions

- Very strong resorbable composite was developed that retains its strength for a desired period of time to be used for spinal and trauma devices that require a prolonged healing period.
- To our knowledge , for the first time the biodegradable material retained its strength this high at least 26 weeks. Thus, the property gap from 12 to 26 weeks has been resolved using this bioresorbable composite.
- The faster resorption time of the composite with PLGA 85/15 enables the use of this material in devices that are needed for operations with shorter support times such as sports medicine.

References
[1] Lehtonen T J. *et al.*, Acta Biomaterialia, 9(1): 4868-4877, 2013 [2] Hull D. & Clyne T W., An introduction to composite materials, 2nd ed. 1996 [3] Zimmermann E A. *et al.*, Scientific Reports, 6:21072, 2016