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Deformation Behaviour of Gellan Gum Based Scaffold Subjected to Compression Loading

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Abstract: This work presents deformation behaviour of gellan gum and gellan gum - bioactive glass composites as novel hydrophilic materials for production of scaffolds in the field of bone-tissue engineering. According to recent studies such materials are attractive for personalized design of implants thanks to their biocompatibility and wide range of available fabrication methods. Batch of samples was subjected to uni-axial compression loading in a custom designed loading device to obtain their elastic and plastic characteristics. Deformation response was derived from full-field optical strain measurements based on digital image correlation method. The acquired results show a reinforcement effect bioactive glass and its significant influence to the elastic modulus.

Introduction

Gellan Gum (GG) has been recently very popular for tissue engineering applications because of its tunable physical and mechanical properties [1]. To expand its use in bone tissue regeneration bioactive glass (BG) particles (highly bioactive and osteogenic material) were added to the polymer matrix [2]. For the clinical application description of deformation response to the external loading is an essential property for every newly synthesized material. However, proper estimation of overall mechanical properties of such a material with complex microstructure requires employment of optical strain measurement together with precise position control and force readout.

Gellan gum scaffold samples

Pure GG and GG-BG composite samples in shape of cylinder with diameter $4.0 - 4.5$ mm and height $6.0 - 8.0$ mm were synthesized based on procedure in detail described in [2]. Faces of the samples with porosity $80 - 90$ % (weight of $80 - 130$ mg) were carefully polished to obtain suitable plan-parallelism for compression testing.

Experimental procedure

Compression test was performed using custom uni-axial loading device designed with respect to high-precison testing of small biological samples and artificial tissues. Planetary gear unit P42-25

(Transtecno, Italy) with minimal backlash attached to micrometer screw 7T173-20 (Standa, Lithuania) enabled $2\,\mu\mathrm{m}\cdot\mathrm{s}^{-1}$ loading rate. The device was equipped with high accuracy load-cell HBM U9C (Hottinger Baldwin Messtechnik, Germany) with $50\,\mathrm{N}$ load capacity connected to OM 502T (Orbit Merret, Czech Republic) programmable indicator for force readout. Strains were derived from optically measured deformations evaluated using digital image correlation (DIC). For this purpose images of the loaded specimens were acquired by high-resolution CCD camera (Manta G-504B, AVT, Germany) attached to bi-telecentric zoom lens TCZR 072 (Opto Engineering, Italy). Homogeneous illumination of loading scene was povided using laboratory LED light source KL 2500 (Shott, Germany). Strain was evaluated from the acquired image sequence using custom DIC software [3] based on Lucas-Kanade tracking algorithm [4].

Results and conclusions

Compressive material properties of GG cylindrical scaffolds were measured. Stress-strain curves were derived from optically measured deformations. From the slope of elastic linear parts in the stress-strain diagrams Young's moduli were estimated. However full field strain evaluation was limited by depth of field corresponding to $25\,\%$ of samples diameter nevertheless preliminary results showed suitability of the method for testing of highly porous soft synthetic materials. Reinforcement effect of the BG was observed. Elastic modulus of GG-BG composite was significantly higher compared to pure GG samples.

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