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Chitosan Membranes for Biodegradable Microfluidics

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Angiogenesis is a vital requirement for the formation of healthy tissue and bone; this currently is one of the greatest challenges in the field of tissue engineering. A promising strategy to achieve formation of suitable, intrinsic vasculature is the use of biodegradable microfluidic networks [1]. Pre-seeding the microfluidic medical devices with angiogenic growth factors, stem cells, collagen, specific proteins and bone cells will allow for successful soft tissue and bone regeneration. Biodegradable scaffolds may be constructed by a numbering up operation where several layers of microfluidic medical devices are compiled together via a multi-scale design; thus enabling scaffolds to be moulded into specific shapes and sizes depending upon the patients requirements. The micro-channels would support better cell proliferation aiding in enhanced attachment between implants and biological material while the enhanced capillary forces will allow for the circulation of the nutritional components which are necessary for the growth of cells.

In recent years an influx of biodegradable polymeric materials being utilised as potential scaffolding materials have included polymers such as poly(lactic acid) (PLA), poly(glycolic acid) (PGA), (PGS) and also poly(latic-co-glycolic acid) (PLGA) [2]. However for the development of strong and flexible microfluidic networks, these materials lack the mechanical strength (PLGA) and also do not exhibit long half-lives (PGS) thus degrade too quickly. In order to address this issue, materials which are engineered for tissue and bone replacement must have tunable properties in order to enhance the potential of the scaffold and also implant material [3]. In this work we are investigating chitosan a biopolymer for the fabrication of biodegradable microfluidic networks as this material presents a unique combination of cationic and osteoconductive properties. Highly porous microfluidic network scaffolds could have the potential to improve overall cell proliferation, the channels formed upon the scaffold layers would aid in nutrient and waste transport thus allow for better bone in growth throughout the scaffold. We were able to use a femtosecond pulsed laser (1 kHz repetition rate), emitting at 800 nm to successfully form the microfluidic network without causing damaging to surrounding membrane areas (Fig.1).

(a) (b)

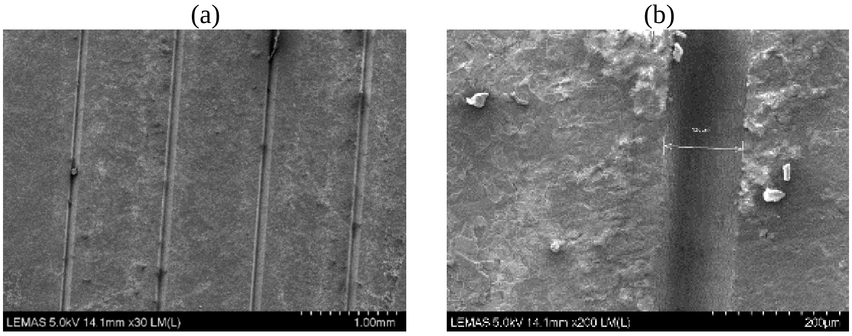

Fig. 1 Chitosan-brushite membrane with micro-channels (a) untreated chitosan-brushite (b) close up of micro-channel

Flexibility and strength are vital properties which scaffold materials must possess; the material must be flexible and yet able to exhibit excellent mechanical properties this is especially important with regards to the scaffold having adequate strength in order to support bone growth. Hence the mechanical properties of the membranes have been enhanced with the addition of brushite mineral forming various membrane mixtures. The Young's modulus was measured for numerous temperatures between 20-100 C. X-Ray diffraction, Scanning Electron Microscopy (SEM), Fourier Transform and Infrared Spectroscopy (FTIR) have been used to fully compare and characterize the membrane mixtures. Additionally the swelling index was determined as well as the overall rate of degradation of NaOH treated membranes when subjected to water.

References

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