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Mechanical Properties of Alginate Hydrogel for Biofabrication

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Abstract – Alginates are linear unbranched polysaccharides containing β-(1-4) linked D-mannuronic acid and α-(1-4) linked L-guluronic acid. The alginate hydrogels are produced by mixing the alginate with a proper cross-linking agent. During the gel formation, cross-links between the alginate chains and the cationic species are formed, changing the elastic behaviour of the material that controls the volume change phenomena of gels. The whole research focuses on to produce three-dimensional scaffolds in alginate hydrogels for tissue engineering applications. These scaffolds must have sufficient strength and stiffness to withstand stresses in the host tissue environment. In this sense, this paper discusses the mechanical behaviour of alginate as so as the phenomenological model describing the viscoelastic behaviour which describes the effect of the alginate composition on the mechanical behaviour of such structures.

Tissue engineering represents a interdisciplinary field of science that consists on applying principles and methods of engineering and life sciences focusing the perception of relations structure-function in human tissues and development of replacing tissues and organs. Hydrogels have been receiving much attention due to their potential use in a wide variety of biomedical applications, including tissue engineering scaffolds, drug delivery, contact lenses, corneal implants and wound dressing [1].The use of hydrogels in tissue engineering has become popular due to their viscoelastic characteristics [2], biocompatibility, amiability of fabrication into specific shapes and their ability to allow transfer of gases and nutrients. One of the major challenges facing the use of hydrogels for tissue engineering is the ability to replicate the tissues' mechanical and viscoelastic characteristics. Hydrogels are particularly useful as engineering scaffolds for soft viscoelastic tissues. Alginate hydrogel is a most versatile hydrocolloid, known for its ability to form gels and films, enhance viscosity, and stabilize aqueous systems. Alginates are formed by agglomeration of many pieces of G-blocks (Guluronic) and M-blocks (Mannuronic). Figure 1 illustrates the internal chain of alginate with the constitutive G and M blocks. Alginate is soluble in aqueous solutions and forms stable gels at room temperature in the presence of non-cytotoxic concentrations of certain divalent cations (Ca^{2+}, Ba^{2+}, Fe^{2+}, Sr^{2+}, etc.) or trivalente ones (Al^{3+}) through the ionic interaction between guluronic acid group. Alginates being hydrogels own viscoelastic properties. The studies of the mechanical behaviour of structures in alginate were performed with aiding of Dynamical Mechanical Analysis (DMA) device. The experiments, using parallelepiped body-proofs, were executed under a room temperature of 23ºC for different levels of loadings. With the creation of various mechanical stimulation conditions, the monitoring of mechanical properties of hydrogel constructs is of paramount importance to optimize stimulation conditions for facilitating tissue engineering applications. Finally, Figure 2 presents the viscoelastic model adopted in this work and Figure 3 shows the creep behaviour of an alginate structure (2% (w/v) of alginate and 3% of $CaCl_2$) under different load conditions.

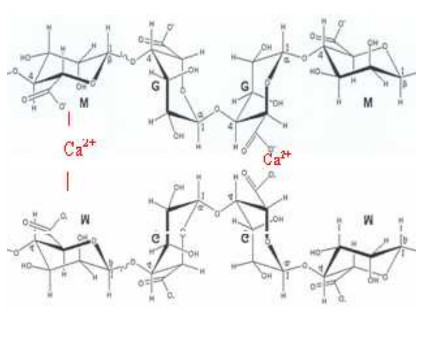

Figure 1: Alginate structure (G and M blocks)

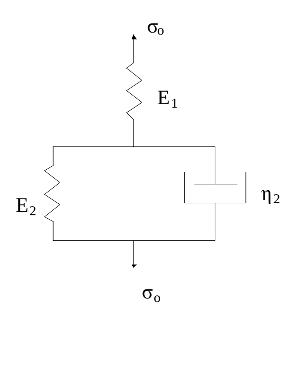

Figure 2: Viscoelastic scheme

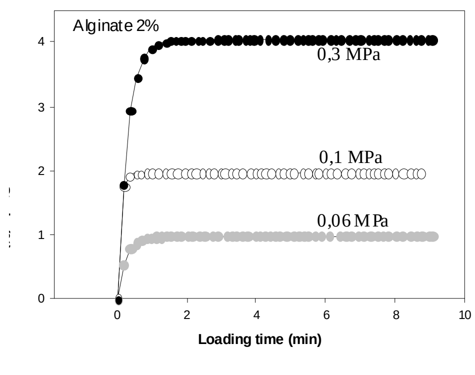

Figure 3: Alginate structure (G and M blocks)

References

[1] L.G. Griffith and G. Naughton, *Science* 295 (2002), 1009-1014.
[2] R.A. Rezende, P.J.S. Bártolo, A. Mendes, R. Maciel Filho, Journal of Applied Polymer Science (2009), *in press*.