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Tunable mechanical properties of gellan gum/poly (ethylene glycol) di-acrylate hydrogels for articular cartilage engineering

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INTRODUCTION: Articular cartilage (AC) is a complex multi-layered structure organized into four zones, namely superficial, middle, deep and calcified layers [1]. Its mechanical properties are varying with depth, and the compression modulus of the superficial and middle zone can achieve the value of 0.28 ± 0.16 MPa and 0.73 ± 0.26 MPa, respectively [2].
This paper reports the preliminary results concerning mechanically tunable gellan gum/poly (ethylene glycol) di-acrylate hydrogels for mimicking the compression mechanical properties of the first two layers of the AC tissue.

METHODS: Gellan gum (GG, Sigma-Aldrich) was dissolved 1.5 % wt. in deionized water while stirring for 30 minutes at 80 °C. Then, poly (ethylene glycol) di-acrylate (PEGDA, Mn: 575, Sigma-Aldrich) was added to the GG solution at two concentrations (10 and 15 % wt.), while keeping the temperature at 50 °C. Successively, the photoinitiator (Irgacure 2959, 0,5 % wt. Sigma-Aldrich) was added, and the solution were left to stir for 1 h, and then degassed.
For the mechanical testing, each solution was poured in cylindrical wells (diameter: 6 mm, height: 5 mm) and photocrosslinked with UV light (5 and 10 minutes). Later, samples were immersed in magnesium chloride ($MgCl_2$-$6H_2O$, 1 % wt. in deionized water, Sigma-Aldrich) for 10 minutes and culture medium (Dulbecco's modified eagle medium, DMEM) for 24 hours, or directly in DMEM for 24 hours.
Then, each sample underwent to compression (Instron 2444, load cell ± 10 N), and the Young's modulus was calculated (first linear 10 %).
Data were statistically analyzed with ANOVA.

RESULTS: Compression data (Figure 1) revealed values close to the superficial zone in case of PEGDA10 (~ 200 MPa), and the middle zone in case of PEGDA15 (~ 600 MPa), with statistical differences for all the crosslinking approaches ($p<0.05$). At constant PEGDA concentration, the effect of UV exposure time and ionical crosslinking implicated only a slight change of the modulus. However, the contribution of ironical crosslinking was more evidenced at 5 minutes of exposure ($p<0.05$ against $p<0.0001$).

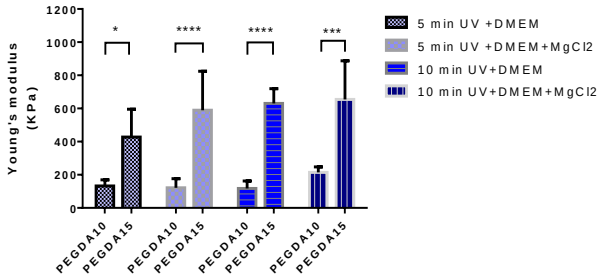

Figure 1: Young's modulus of different concentration of PEGDA (10 and 15 % wt.) while varying UV exposure (5 and 10 minutes) and ionically crosslinking conditions.

DISCUSSION & CONCLUSIONS: Data illustrate that the mechanical properties of GG/PEGDA hydrogels can be tuned for matching the stiffness range of AC layers.

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REFERENCES

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