INTELLIGENT HYDROGEL DESIGN: TOWARDS MORE PERFORMING HYDROGEL PROCESSING

Sandra Van Vlierberghe, Ghent University, Belgium
sandra.vanvlierberghe@ugent.be
Annemie Houben, Polymer Chemistry & Biomaterials Group, Ghent University, Belgium
Jasper Van Hoorick, Polymer Chemistry & Biomaterials Group, Ghent University, Belgium
Aleksandr Ovsianikov, Vienna University of Technology, Austria
Penny Martens, the University of New South Wales, Australia
Peter Gruber, Vienna University of Technology, Austria
Marica Markovic, Vienna University of Technology, Austria
Patrice Roose, Allnex, Belgium
Hugues Van Den Bergen, Allnex, Belgium
Heidi Declercq, Tissue Engineering Group, Ghent University, Belgium
Dirk Bontinck, Allnex, Belgium
Peter Dubruel, Ghent University, Belgium

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Despite their highly attractive properties, 3D printing of hydrogel materials can be rather challenging. Herein, we present a novel hydrogel material that can be easily processed into three-dimensional scaffolds using different 3D printing technologies. An acrylate-terminated, urethane-based PEG was prepared by reacting PEG 2000 with isophorone diisocyanate (IPDI) and monoacrylated PEG (336 g/mol) in a 1:2:2 molar ratio (WO 2017/005613 A1). For melt 3D-printing, pure polymer was used (T_m 38°C). For bioprinting, a 50 wt% solution with 3 wt% Laponite was used.
A first characteristic of this material is its unique reactivity. In contrast to other materials, it can be photo-polymerized in the solid state, as characterized by photo-DSC. This allows for the material to become printed from the melt, similar to other conventional thermoplasts (e.g. poly-(ε-caprolactone)). Material crosslinking can be performed in a separate UV-A curing step (15 mW/cm^2). By applying a gelatin-methacrylamide coating, excellent cell adhesion and proliferation of MC3T3 cells and adipose tissue-derived MSCs (Figure 1, A) can be obtained. Interestingly, the material is highly reactive, even in the absence of a photo-initiator (PI). Rheology has shown that without a PI, the reaction is slower (about 30% slower for a 50 wt% solution). However, similar moduli were obtained with and without PI after complete curing.
Next, extrusion bioprinting was explored as a method to eventually allow printing of cell-laden constructs. To allow shape fixation after printing, a nanosilicate additive (Laponite) was added which results in shear-thinning behavior due to physical crosslinking. Furthermore, this additive results in excellent cell adhesion on the printed scaffolds up to 23 days using MC3T3 cells (Figure 1, B). In addition, preliminary experiments have shown that L929 cells encapsulated in a solution of polymer and Laponite maintain high viability during 21 days and was further increased by adding 1 wt% gelatin (Figure 1, C).

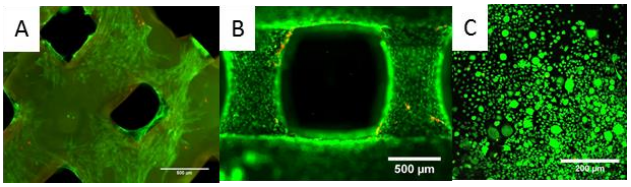

Figure 1 – (A) Vital staining of adipose tissue-derived mesenchymal stem cells (d23) on 3D scaffolds coated with methacrylamide-modified gelatin. (B) Vital staining of mouse calvaria preosteoblast cells (MC3T3-E1, d14) on 3D scaffolds containing 50 wt% AUP and 3 wt% Laponite. (C) Vital staining of L929 cells after encapsulation in AUP containing Laponite and 1wt% gelatin.

In a final part, alternative processing methods including two-photon polymerization and electrospinning have also been pursued successfully.