Alginate-based photocurable hydrogels

Alginate is a polysaccharide from brown seaweeds, composed of a-L-guluronic acid and b-D-mannuronic acid units. It has been studied on bone, cartilage, and skin tissue engineering as well as drug delivery (Chou et al. 2009; Higham et al. 2014; Lewandowska-Lancucka et al. 2017; Rouillard et al. 2011; Samorezov et al. 2015). Alginate can be conjugated with MAA via hydroxyl groups to be photocurable (Chou et al. 2009). The preparation method was first to dissolve alginate in deionized water with pH adjustment at 8. Subsequently, MAA was added into the solution while pH of the reaction solution was maintained at 8 at 4ºC. The obtained photocrosslinked alginate hydrogel showed greater maintenance of its mechanical integrity and provided better support for nucleus pulposus repair, compared with the ionically crosslinked alginate hydrogel. To further reinforce the stiffness of photocrosslinked alginate hydrogels, additional ionic crosslinking can be employed (D'Arrigo et al. 2012; Matricardi et al. 2008). The hybrid materials of photocurable alginate methacrylate/gelatin methacryloyl and silica particles induced mineralization under simulated body fluid conditions, showing potential for bone tissue regeneration (Lewandowska-Lancucka et al. 2017).

Conclusions and Outlook

Photocurable hydrogels from synthetic and natural materials have been extensively explored for drug delivery system, cell encapsulation, and 3D printing owing to their biocompatibility, facile and fast fabrication of complex scaffolds, and excellent spatiotemporal control over gelation process. In addition, they are amenable to versatile bio-functional modifications, which further have widened their bioapplications. From a design perspective, researchers need to choose types of photocurable materials, additional features (degradation, biofunctionality, etc.), and a light source based on a photoinitiator for their specific hydrogel applications. Recently, hydrogels for mimicking 3D microenvironments with *in vivo*-like gradients of bio-functionality and mechanical properties have been highly coveted. To this end, the hybrid materials of combining photocurable natural polymers with photocurable synthetic polymers are preferred for engineering 3D constructs with tailorable biofunctionality and mechanical properties.

As to the photocurable hydrogel design for cell encapsulation and implant applications, researchers need to notice that photoinitiators, their reactive species (free radicals) and UV light sources are harmful to cells and tissues, potentially inducing DNA damage. Even the most commonly used I2959 suffers from low water solubility and cellular toxicity of its reactive species as well as UV light, which depends on the concentration of I2959, and the intensity and exposure time of UV light. On the other hand, visible light photoinitiators such as Eosin Y are highly water soluble but show relatively low photoreactive efficiency in polymerization. Thus, researchers should optimize the concentration of photocurable polymers, the concentration of initiators, and the intensity/exposure time of light sources in their experiment setups to obtain the desirable properties of hydrogels and to not compromise cell viability.