Novel biofabrication approaches and biomimetic materials enabled by di-tyrosine crosslinking of silk fibroin

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Covalently crosslinked silk fibroin hydrogels have gained popularity over their physically crosslinked (via beta-sheet formation) counterparts due to their elastomeric nature, transparency and ability to support cell encapsulation, as well as compatibility with modern biofabrication approaches. Covalent crosslinking is achieved via di-tyrosine bond formation between tyrosines natively found in silk, without the need for any modification of the polymer chain. This reaction can be mediated through three broad strategies, including enzymatic-, Fenton reaction-, and photo-initiated crosslinking approaches.

This talk will discuss the broad utility of ruthenium-based photo-crosslinking of silk for multiple biofabrication approaches and material formats, including hydrogels, microgels, granular hydrogels and lyogels. We demonstrate the formation of rapidly crosslinking hydrogels at concentrations as low as 1% wt/v silk with tuneable compressive modulus (~1-100 kPa) and excellent optical properties (transmittance >90%). These hydrogels can be fabricated into complex high-resolution structures via sacrificial polymer templating or ice templating. Ice templating allowed formation of aligned pores and incorporation of complex structures such as channels, multiple material phases and drug encapsulation in large multi-centimetre scale constructs. Water-in-oil emulsion within a flow-focusing microfluidic device allowed the formation of small (~98±18 um) or large (~375±28 um) silk microgels which when annealed together resulted in scaffolds with microporosity and supported excellent cell encapsulation, proliferation and tissue ingrowth in vivo relative to their bulk hydrogel counterparts.

This work offers new silk biomaterial platforms for biomedical applications and novel insights into di-tyrosine bond formation and the dynamic nature of silk crosslinking.