Adaptable hydrogels for regenerative medicine, 3D bioprinting, and human tissue models

While injectable hydrogels are able to be delivered in a minimally invasive way, they typically rely either on polymerization in situ, which is difficult to control in a surgical setting, or are designed to be shear-thinning, which results in mechanically weak gels with fast erosion rates. To address these limitations, we have designed gels with dynamic covalent bonds that are reversible under physiological conditions. Similar to physically crosslinked gels, these dynamic covalent gels are reversibly shear-thinning and self-healing, yet they display dynamic shear moduli that can be 10 to 100 times higher. Furthermore, with proper molecular-level design, the stress relaxation rate of these gels can be tailored without altering the stiffness, making these materials ideal for studies of cellular biomechanics. We have exploited these materials to study mechanisms of cartilage formation, to successfully deliver miRNA therapy to contractile heart tissue in a preclinical myocardial infarct model, as bio-inks for 3D printing of living constructs, and as scaffolds for the culture of patient-derived biopsy samples.