Photochemical Modulation of Hydrogel Scaffolds and Nanoindenter-based Stiffness Quantification

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Biomechanical properties of the extracellular matrix, such as stiffness and porosity, are known to influence cell adhesion, migration, and differentiation. A key area of interest in tissue engineering is developing 3D in vitro models that recapitulate the ECM to better understand how these properties contribute to development and disease. Here, we present an approach to modulate the stiffness of a 3D hydrogel scaffold that relies on photochemical reactions and the electronic excitation of a photosensitizer. Using benzoporphyrin-derivative (BPD)-mediated photodegradation and riboflavin (RF)-mediated photocrosslinking, we photochemically modulated the stiffness of Matrigel hydrogels and quantified these changes using nanoindentation. Despite challenges with a poor signal-to-noise ratio, we demonstrated a significant decrease in stiffness between control groups and groups with BPD and 20 J/cm² of light that followed a similar trend to bulk rheology measurements. We also found a significant increase in stiffness between control groups and groups with RF and 10 J/cm² of light. However, the heterogeneous composition and batch-to-batch variability of Matrigel may influence the extent and replicability of this stiffness modulation. Despite these limitations, the spatiotemporal resolution of these light-based modalities has significant potential for further optimization in different hydrogels and future work with optical patterning.