Rheologic Properties of a Novel Gelatin Methacrylate Bioink for 3D Printing Musculoskeletal Grafts

SARA PEPER, NEELAM AHUJA, THY VO, KAMAL AWAD, and VENU VARANASI

Bone-Muscle Research Center; College of Nursing & Health Innovation; The University of Texas at Arlington; Arlington, TX

Category: Masters

Advisor / Mentor:Varanasi, Venu (venu.varanasi@uta.edu)

ABSTRACT

According to data published in The Burden of Musculoskeletal Diseases in the United States (BMUS) nearly 18% of the US population experienced a sports-related musculoskeletal injury in 2012. The field of Tissue Engineering has made strides towards 3D printing musculoskeletal grafts in the past few years to treat these injuries. Despite these advances, producing bioinks that are highly printable and also imitate the dynamic viscoelastic properties of soft tissue types in order to stimulate regeneration remains a challenge. An ideal bioink for 3D bioprinting must possess proper mechanical, biological, and rheological properties for specific tissue applications. The most important rheologic properties of the bioink are shear rate, shear stress, viscosity, and critical shear point of the material to determine if the bioink displays shear-thinning behavior for enhanced print fidelity without compromising the internal bonding structure of the bioink. Shear thinning behavior is determined using the power law regression model and is defined as a flow behavior index (n) of less than 1. Gelatin methacrylate (GelMA) is one commonly used polymer for 3D printing soft tissue constructs due to its concentration dependent viscoelasticity and biocompatible similarities to collagen, however, adjusting the concentration of a GelMA bioink to match specific tissue viscoelasticity influences the rheologic properties and printability of the ink. **PURPOSE**: The purpose of this study was to determine the rheologic properties of a 10% w/v gelatin methacrylate bioink in order to establish the critical shear point and subsequent shear-thinning behavior for potential applications in 3D bioprinting soft tissue grafts. **METHODS**: The rheologic properties of a 10% w/v gelMA ink were determined by performing a steady state flow sweep using an MCR702 twindrive rheometer and 25mm Parallel Plate. The test shear rate ranged from $0.002s^{-1}$ to $500s^{-1}$ and the lower plate temperature was set to 25°C. The test was programmed using the software RheoCompass to collect 50 data points as shear rate logarithmically increased. A power law regression model of the shear stress vs shear rate was used to determine the critical point and shear-thinning behavior of the bio-ink. **RESULTS**: The critical shear point occurred at shear rate $0.0326s^{-1}$ with shear stress 3.92Pa and bioink viscosity of 120.25Pa · s. Following power law regression analysis of the shear rate vs the shear stress it was determined that the shear behavior index (n) of the material was 0.16, indicating that the GelMA bioink was exhibiting strong shear thinning behavior. **CONCLUSION**: These preliminary results indicate that 10% gelMA bioink displays shear thinning behavior at low shear rates. These results provide insight into the development of a biomaterial that possesses good printing fidelity and can be covalently crosslinked to enhance mechanical properties for soft musculoskeletal tissue applications.