Design & Characterization of a Low Friction Zwitterionic Hydrogel for use as an Articular Cartilage Replacement

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ABSTRACT

Treatment of focal chondral defects is a widespread and intractable problem; especially with people living longer, or accumulating damage from progressive debilitating diseases such as osteoarthritis. In response, use of hydrogels has been investigated to repair this necrotic tissue in an inexpensive, non-invasive manner. These investigations routinely focus on mimicking the biomechanics of the natural tissue or the fluid pressurization mechanism. However, these approaches neglect the surface boundary lubrication mechanism, making these potential load-bearing substitutes incompatible with natural cartilage, resulting in construct wear, failure, and healthy cartilage damage. Therefore, there is a need to develop a material with combined mechanical and tribological properties comparable to articular cartilage. Poly (vinyl alcohol) (PVA) hydrogels are an attractive option due to their inherent biomimetic properties. However, their use for weight bearing applications is limited due to inferior tribological properties. This presentation will report on the effectiveness of two fabrication approaches to enhance the tribological properties of PVA hydrogels with a zwitterionic boundary lubricant. The first approach consists blending ratios of PVA with 2-(Methacryloyloxy)ethyl(dimethyl-(3-sulfopropyl) ammonium hydroxide) (MEDSAH) to form a hydrogel blend. In the second approach poly(MEDSAH) is functionalized to the surface of PVA hydrogels, resulting in the formation of a zwitterionic brush layer. The structure-property relationships of the hydrogels were investigated by evaluating the chemical composition (ATR), physical properties (water content, contact angle), elastic compressive modulus and coefficient of friction. Preliminary results suggest the functionalization of these zwitterionic polymers result in as much as a 40% reduction in average coefficient of friction.
BIOGRAPHY

Michelle M. Blum received her B.S. in Physics from the State University of New York at Albany and a second B.S. in Mechanical Engineering from Rensselaer Polytechnic Institute in 2007, M.S. and Ph.D. in Mechanical Engineering from the University of Notre Dame in 2011 and 2012, respectively. Prior to beginning her doctoral work, she worked for the National Aeronautics and Space Administration at the Kennedy Space Center in Florida in the Fluid Systems Design Branch and the Electrostatics and Surface Physics Laboratory. She joined Syracuse University in July 2012 in the Mechanical and Aerospace Engineering Department where she currently holds an Assistant Professor position. Dr. Blum’s research and teaching interests are in the areas of Finite Element Analysis, Tribology & Lubrication, and Solid Mechanics. She specializes in high performance materials development and characterization for tribological (friction and wear), structural, and biomedical applications. Her primary research interests are in the development of orthopedic biomaterials, and biomaterial characterization utilizing a combination of experimental techniques, nanoindentation, and computational modeling. Dr. Blum is also interested in characterizing the tribological performance of biological tissues using soft material contact mechanics and simulation.