252nd American Chemical Society National Meeting
August 21-25, 2016, Philadelphia, PA
Division of Polymer Chemistry, Abstracts

Structure and Biomechanical Properties of Cartilage

Ferenc Horkay, Emilios K. Dimitriadis, Peter J. Basser

[1]Section on Quantitative Imaging and Tissue Sciences, National Institutes of Health, Bldg. 13, Room 3W16, 13 South Drive, Bethesda, MD 20892, USA, horkayf@helix.nih.gov

[2]Laboratory of Bioengineering and Physical Science, National Institute of Biomedical Imaging and Bioengineering, National Institutes of Health 13 South Drive, Bethesda, MD 20892, USA

In cartilage extracellular matrix (ECM) there are two major load-bearing polymers: collagens (mainly, type II) and proteoglycans (mainly aggrecan). Collagen is the most abundant macromolecule in cartilage ECM. Type II collagen represents 90% to 95% of the collagen and forms a matrix in which proteoglycans are embedded. The triple helical structure of the collagen provides cartilage with shear and tensile properties. Proteoglycans consist of a protein core with covalently attached linear glycosaminoglycan chains. The most abundant cartilage proteoglycan is aggrecan that forms complexes with linear hyaluronic acid (HA) chains. The aggrecan/HA complexes occupy the interfibrillar space of cartilage ECM and provide cartilage with its unique osmotic properties. Age strongly affects the composition and organization of the ECM. With increasing age, there is a decrease in the hydration, with a corresponding increase in the compressive stiffness of the tissue. Such changes can be studied by magnetic resonance imaging (MRI). The size of proteoglycan aggregates within the ECM decreases with age while the concentration of HA increases with age. In addition, the ratio of keratin sulfate to chondroitin sulfate also increases.

Cartilage is a heterogeneous tissue. Model studies have been made to determine the osmotic properties of the individual components (aggrecan, hyaluronic acid, collagen) and the aggrecan/hyaluronic acid complexes. Structural investigations were made by small angle scattering methods. The local variation of the mechanical properties was determined by the atomic force microscope (AFM). The dynamic response of the solutions were studied by dynamic light scattering and rheological measurements.