256th American Chemical Society National Meeting
Division of Polymer Chemistry
August 19-23, 2018, Boston, MA
Abstracts

Cartilage Dynamics and Function

Ferenc Horkay and Peter J. Basser

Section on Tissue Biophysics and Biomimetics, Program in Pediatric Imaging and Tissue Sciences, Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health, 13 South Drive, Bethesda, MD 20892, USA

Articular cartilage exhibits excellent load bearing properties owing to its hierarchical organization at both molecular and supramolecular levels. It also provides joints with a nearly frictionless articulating surface. It is known that the extracellular matrix (ECM) of cartilage is a composite gel-like material consisting of approximately 60–70% water, 20–30% collagen (mainly type II collagen), 10-15% proteoglycans (PGs) and small quantities of other materials, e.g., proteins and DNA. Chondrocytes (cartilage cells) occupy less than 5% of the total volume of the tissue. The most abundant PG is the bottle-brush shaped aggrecan, which consist of a central core protein to which many glycosaminoglycan (GAG) chains (mainly chondroitin sulfate and keratan sulfate) are covalently attached. In cartilage ECM aggrecan molecules are non-covalently bound to long hyaluronic acid (HA) molecules (like bristles to the backbone in a bottlebrush). The complex formation between aggrecan and HA is facilitated by link proteins. The ratio of aggrecan to HA is approximately 100:1. These highly charged microgel-like PG assemblies occupy the pores of the collagen matrix, generate a large osmotic swelling pressure and provide osmotic resistance to deswelling under external load.

We investigate the structure and dynamic behavior of the major macromolecular components of cartilage ECM as well as their assemblies, using complementary microscopic (small-angle neutron scattering, neutron spin echo, static and dynamic light scattering, Atomic Force Microscopy) and macroscopic techniques (osmotic swelling pressure measurements, rheological measurements). The results reveal how the hierarchical bottlebrush organization of cartilage PGs defines the load bearing properties of the tissue.