Probing Interactions between Aggrecan and Mica Surface by the Atomic Force Microscopy

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Aggrecan is a bottlebrush shaped macromolecule found in the extracellular matrix of cartilage. It consists of negatively charged glycosaminoglycan (GAG) chains attached to a protein backbone. The bottlebrush structure enables aggrecan to maintain an extended conformation with high charge density, in turn responsible for the osmotic pressure and frictional drag it exerts in cartilage sustaining compressive loads in cartilage. Alterations in aggrecan bottlebrush structure with age and disease leads to bone deformities, dwarfism, arthritis, and other pathological conditions. In solution, aggrecan bottlebrushes show distinct osmotic pressure versus concentration regimes. They self-assemble and form micro-gel clusters, and the structure of the bottlebrush and assemblies is insensitive to the presence of calcium ions. These are novel polyelectrolyte feature and we investigated if they were also retained on surface. Using Atomic Force Microscopy, the conformation of the aggrecan adsorbed on controlled mica surfaces was imaged. On positively charged APS mica, the average extension and height of the bottlebrush side chains was unaffected by the presence of Calcium ions. With increasing aggrecan concentration, the bottlebrushes transition from dispersed, non-interacting state to forming clusters of conforming chains. At higher concentrations they form a continuous monolayer of conforming molecules. These surface observations reflect aggrecan properties in solution. On negatively charged mica, aggrecan shows interesting network patterns at higher concentrations. Since aggrecan adsorption on mica is governed by 2-dimensional equilibration, the surface patterns provide clues to its behavior and interactions in solution. Moreover, understanding aggrecan adsorption onto a charged

surface provides insight into its interactions with bone and implant surfaces in the biological milieu.

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