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Synthetic and Biopolymer Gels - Similarities and Difference.

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Ion exchange plays a central role in a variety of physiological processes, such as nerve excitation, muscle contraction and cell locomotion. Hydrogels can be used as model systems for identifying fundamental chemical and physical interactions that govern structure formation, phase transition, etc. in biopolymer systems. Polyelectrolyte gels are particularly well-suited to study ion-polymer interactions because their structure and physical-chemical properties (charge density, crosslink density, etc) can be carefully controlled. They are sensitive to different external stimuli such as temperature, ionic composition and pH. Surprisingly few investigations have been made on polyelectrolyte gels in salt solutions containing both monovalent and multivalent cations. We have developed an experimental approach that combines small angle neutron scattering and osmotic swelling pressure measurements. The osmotic pressure exerted on a macroscopic scale is a consequence of changes occurring at a molecular level. The intensity of the neutron scattering signal, which provides structural information as a function of spatial resolution, is directly related to the osmotic pressure. We have found a striking similarity in the scattering and osmotic behavior of polyacrylic acid gels and DNA gels swollen in nearly physiological salt solutions. Addition of calcium ions to both systems causes a sudden volume change. This volume transition, which occurs when the majority of the sodium counterions are replaced by calcium ions, is reversible. Such reversibility implies that the calcium ions are not strongly bound by the polyanion, but are free to move along the polymer chain, which allows these ions to form temporary bridges between negative charges on adjacent chains. Mechanical measurements reveal that the elastic modulus is practically unchanged in the calcium-containing gels, i.e., ion bridging is qualitatively different from covalent crosslinks.