Thermodynamics of Aqueous Solutions of (Neutral, Charged and Crosslinked) Synthetic Polymers

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Water soluble polymers (either biopolymers or synthetic polymers) are of interest in many fields such as medicine, pharmacy, biotechnology, chemical industry etc.. The thermodynamics of aqueous solutions of polymers is an extremely broad field also caused by the variety of the encountered substances, for example, neutral polymers, polyelectrolytes and crosslinked polymers. Despite considerable efforts over the last century, the state of the art is much less developed as in those areas that are related to the production of bulk chemicals in the petrochemical industries. This statement holds not only for biopolymers but also for synthetic polymers. A sufficient characterization of the polymer (monomer and comonomer units, polymer mass distribution etc.) is an essential prerequisite for a successful study of the thermodynamics of aqueous solutions of water soluble polymers. Such characterizations are only available for some synthetic polymers whereas it is nearly completely missing for biopolymers. The development and testing of thermodynamic models for aqueous polymer solutions is therefore mostly based on experimental data for aqueous solutions of synthetic polymers. In this presentation, some examples for important thermodynamic equilibrium properties of aqueous solutions of synthetic polymers will be discussed. The example includes osmotic coefficients of aqueous solutions of neutral polymers as well as of polyelectrolytes, the liquid-liquid phase equilibrium that is often observed when two hydophilc, but incompatible solutes such as (neutral polymer A + polyelectrolyte B), (neutral polymer A + low molecular salt C), and (polyelectrolyte B + low molecular salt C) are simultaneously dissolved in water (i.e., aqueous two-phase systems), and the phase equilibrium as well as the swelling/shrinking of crosslinked hydrophilic polymers (hydrogels) in aqeuous solutions. Some important experimental methods will be shortly addressed, typical examples for experimental results will be presented and some models for the correlation/description of the phenomena will be discussed.