Interpenetrating polymer network (IPN) hydrogels consist of two independently cross-linked polymer networks that cannot separate due to physical entanglements. Certain combinations of neutral and ionized polymers have been used to synthesize aqueous IPN hydrogels with both high water content (>80%) and mechanical properties significantly exceeding the additive properties of the component systems. We will describe our initial studies of poly(ethylene glycol)/poly(acrylic acid) IPNs and suggest that the observed enhancement of modulus compared to single network hydrogels is a consequence of stretching of network chains beyond their Gaussian configuration. Inspired by these results, we have recently examined IPNs of polyacrylamide (PAAm) and poly(acrylic acid) (PAA) with our focus being on topological constraints and their influence on structure, swelling and mechanical properties. IPN hydrogels prepared from contrasting networks of PAAm and PAA exhibited composition and structure that depended on the sequence of network formation. We identified critical IPN compositions above which an increase in water content improved the hydrogel modulus. Finally, we examined the influence of constraint by the PAAm network on the calcium-induced contraction of PAA network chains. In the presence of divalent cations, PAAm/PAA IPN hydrogels exhibit a correlation peak in small-angle x-ray scattering that corresponds to an interdomain spacing of 15 nm, which is not seen for PAAm or PAA single network hydrogels. We attribute the correlation peak to nanophase aggregation, with the coalescence of PAA-rich domains prevented by the presence of the more swollen PAAm network.

Curt Frank was trained in chemical engineering (BChemEng, University of Minnesota, 1967; MS, University of Illinois, 1969; PhD, University of Illinois, 1972) and then worked as a Member of Technical Staff at Sandia National Laboratories in Albuquerque, NM 1972-1976, where he was first exposed to polymer science and engineering. In July 1976, when the tall ships were in the San Francisco Bay, Curt and his new wife Sara moved to Stanford, where Curt had been appointed as an Associate Professor of Chemical Engineering. Curt was promoted to Professor of Chemical Engineering in 1985 and received the W.M. Keck, Sr. Chair in Engineering in 1994. In that same year, he co-founded the Center on Polymer Interfaces and Macromolecular Assemblies (CPIMA), an NSF-sponsored Materials Research Science and Engineering Center, which he directed until it was closed in 2010. CPIMA initially included participants from Stanford, IBM Almaden Research Center, and UC Davis; it was later expanded to include UC Berkeley. Curt was Chair of Chemical Engineering 2001-2006 and has been Senior Associate Dean for Faculty and Academic Affairs in the School of Engineering since January 2009. His research interests are in soft materials and have recently included studies of thin films and interfaces, interpenetrating network hydrogels, phospholipid assemblies, biodegradable polymers and ion transport in fuel cell membranes. In addition, he and Sara have taught an Introductory Sophomore Seminar on “Art, Chemistry and Madness: the Science of Art Materials” since 2007. Curt is a member of the National Academy of Engineering.