



~~~~ Polymer Physics Seminar ~~~~

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301 Steidle Bldg.

State of Water in Starch-Water Systems as Investigated using Dielectric & NMR Relaxation Methods

The dynamics of water in confined biopolymer environments has attracted huge scientific interest. Starch is a biopolymer of plant origin and undergoes an order to disorder phase transition upon heating in presence of water. This phase transition, known as gelatinization, plays a critical role in textural modification of food products, and starch-water interactions are critical for developing a mechanistic understanding of the gelatinization process. The overall goal of this project was to investigate the mobility and dynamics of water in the gelatinization temperature range using dielectric and NMR relaxation methods. In the first part of the project, the dielectric spectra of native wheat starch-water slurries were measured at seven different starch concentrations between 5-60% starch (w/w) in the frequency range of 200 MHz-20 GHz at 25°C. The deconvolution of dielectric spectra using the Debye model revealed presence of up to three relaxation processes. The three relaxations, termed as high, intermediate and low frequency relaxations, exhibited a relaxation time range of 4-9 ps, 20-25 ps and 230-620 ps, respectively. The high frequency relaxation was attributed to bulk water, while the intermediate and low frequency relaxations were assigned to rotationally confined water molecules present in the starch-water system. To investigate the mobility of water during gelatinization, the dielectric spectra of 10%, 30% or 50% starch slurries were measured after heating the slurries to six different temperatures between 40-90°C for 30 min. The high frequency relaxation time for 10% starch slurry dropped significantly ($P < 0.001$) upon heating up to 60°C while that for 30% & 50% starch slurries was not significantly influenced ($P > 0.159$) by heating up to 80°C. The intermediate and low frequency relaxation times as well as the relative relaxation strengths of the three relaxations were not significantly influenced ($P > 0.187$) by heating at all starch concentrations. In the second part of the project, wheat starch- $^2\text{H}_2\text{O}$ interactions were investigated in $^2\text{H}_2\text{O}$ -hydrated, freeze dried ungelatinized and gelatinized starch samples using ^2H NMR quadrupole echo spectral analysis and spin-lattice relaxation time (T_1) measurements. Spectral analysis of both gelatinized and ungelatinized starch samples revealed the presence of an isotropic sharp central peak at 25°C, which was attributed to high symmetry jumps of O- ^2H groups of strongly restrained $^2\text{H}_2\text{O}$ molecules associated with starch. Spin-lattice relaxation times of the sharp central peak were almost two orders of magnitude shorter than those of bulk $^2\text{H}_2\text{O}$, and exhibited magnetic field dependence which indicated that the $^2\text{H}_2\text{O}$ associated with the freeze dried starches was in solid state at the room temperature. This research showed that dielectric and NMR relaxation methods can be used to monitor the state of water during starch gelatinization. This approach can be used to develop sensors for monitoring food processing operations involving starch-based foods.