Effect of Hydration on Structural and Thermodynamic Properties of Mucin

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The mucus barrier and its transport properties are essential for proper functioning of the digestive, respiratory and reproductive systems of vertebrates, including humans. The principal components of mucus are the glycoprotein mucin and water. Mucin forms the macromolecular matrix of mucus and dominates its rheological properties. From an engineering point of view, mucin is an outstanding water-based lubricant.

Mucin molecules obtained from different sources have different structures that can be described by models ranging from bottle brush to dumbbell type. It is known from literature that mucin can form liquid crystalline phases and that the phase behaviour of mucin is dependent on the hydration level. However, the exact phase behaviour of mucin at different temperatures and hydration levels has yet to be determined.

We present results obtained using several experimental techniques. Samples were prepared from porcine gastric mucin (PGM), from bovine submaxillary gland mucin (BSM) (both from Sigma) and from a recently slaughtered pig. To characterise the molecular structure of PGM, we used atomic force microscopy (AFM) operated in the tapping mode. AFM indicates the presence of a dumbbell structure as well as fiberlike structure at higher concentrations. SAXS measurements indicate the presence of lamellar structure at concentrations of mucin higher than 15 wt% and show that repeat distance is dependent on mucin concentration. A phase transition was observed at temperatures above 60ºC. A slight birefringence was observed in most samples, but polarised light microscopy discovered that birefringence arises mostly from insoluble particles of PGM. Strongly increased birefringence was observed close to the fluid – air interface which indicates that the presence of interfaces induces structuring of mucin. To observe the phase behaviour of the mucin – water system differential scanning calorimetry (DSC) and isothermal sorption calorimetry were used. To characterise the glass transition of mucin at isothermal conditions, the water content and the change of the partial molar enthalpy of mixing of water at the transition point were measured. Sorption calorimetric results suggest that at low water contents mucin is in a glassy state and at higher water contents mucin is in an elastic state. Using DSC data we calculated the amount of non-freezing water as a function of concentration. Combining results obtained with different techniques we constructed a phase diagram of mucin covering a wide range of mucin concentrations and temperatures.