Numerical Simulation Of Freeze-Thaw Process For Protein In Aqueous Solution

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Abstract

During the biopharmaceutical manufacturing process, proteins stored in aqueous solutions are frozen and thawed. Frozen aqueous solutions provide an excellent medium for storing and transporting the protein without degradation. In this work, the freezing and thawing of an aqueous solution is simulated to determine the time required to freeze and thaw a volume of solution. The simulations represent the natural convection via the Laminar Flow and Heat Transfer in Fluids interface. The fluid flow and heat transfer are coupled through the Nonisothermal Flow interface to represent the change in density of the fluid as a function of temperature. Forced convection on the exterior of the carboy provides the ability to assess blast freezing of the liquid. The liquid-solid interface is tracked in these simulations, and the interface agrees with experimental data with the developing at the top surface. The simulation results are compared against experimental data. The simulation includes parametrization of the geometric dimensions, and a simulation application was developed to enable non-expert users to conduct these simulations. The SimApp was compiled using COMSOL Compiler™.

Figures used in the abstract

Figure 1 : Thawing of aqueous solution in carboy. Gray region shows frozen region, and red region shows the thawed section. Natural convection occurs in thawed region.