

**THREE-PHASE MODEL FOR SIMULATING FREEZING PROCESS OF  
AQUEOUS SOLUTIONS**

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**ABSTRACT**

A simulation model has been developed for predicting freezing phenomena for aqueous solution systems. In the model the thermal equilibrium state and also the existence of 3 phases such as unfrozen, frozen and moving boundary layers were assumed during freezing. The moving rate of freezing front was calculated by using the variable space network method proposed by Murray and Landis, and the heat transfer equations were introduced to these 3 layers. To demonstrate the validity of the model, it was applied to the freezing processes of coffee solutions.

Since the model required the phase diagram of the material to be frozen, the initial freezing temperatures of 1-55% coffee solutions were measured by the DSC method. The obtained phase diagram was found to be determined by assuming it as the binary component system. The plots of freezing temperatures against solid concentrations were agreed well with a theoretical curve for glucose solutions. Thus the phase diagram was utilized as input information to the model. The effective thermal conductivity for coffee solutions was estimated as a function of temperature and solute concentration by using the Maxwell – Eucken model.

Based on these information, one-dimensional freezing processes of coffee solutions were simulated to investigate the applicability of the model, and then the results showed that the model could describe the changes in the location of freezing front as well as the distributions of temperature and ice fraction during a freezing process.