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Experimental Study on Freezing of Liquids under Static Magnetic Field☆

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Abstract Freezing processes of several liquids under Static Magnetic Field (SMF) less than 50 mT were investigated. Central temperature of liquid samples held in glass test tubes immersed in a liquid bath were measured and collected. Nucleation temperature and phase transition time were obtained from freezing curves. Normality tests were performed for nucleation temperature of these liquids with/without magnetic field and normality distributions were justified. Analysis of variances was carried out for nucleation temperature of these liquids with magnetic field flux density as the influencing factor. Results showed that no significant difference was found for deionized water with or without SMF. However, differences exist in 0.9% NaCl solution and 5% ethylene glycol solution with and without SMF. Nucleation temperature of 0.9% NaCl with SMF is lower than that without SMF, while its phase transition time is shorter than that without SMF. Nucleation temperature of 5% ethylene glycol with SMF is higher than that without SMF, while its phase transition time is not modified with SMF.

Keywords: Liquid; Freezing; Static magnetic field; Nucleation temperature; Phase transition time

1 Introduction

Freezing is one of the most important methods to preserve food and other perishable goods [1-2]. Freezing process is critical for maintaining quality and flavor of food. Taking liquid food as an example, freezing is usually divided into three stages [3], as shown in Fig. 1: (1) liquid cooling period (a-b-c), at this stage the food is cooled by releasing sensible heat until it reaches the nucleation point c. In some cases the temperature of the cooled liquid may be lower than its freezing temperature, and the difference between them is called degree of supercooling. In this supercooling period from b to c, liquid is unstable and nucleation may occur at any time [4]. The temperature at which nucleation starts is called nucleation temperature, i.e., the lowest temperature of liquid state (point c). (2) phase transition period (d-e-f) , during which latent heat is removed, nucleation happens and most of liquid turns into solid; the temperature from point d to e keeps constant, and is called freezing temperature; The temperature at point f is 5 ℃ lower than the freezing temperature. (3) solid freezing period from point f to point g , during which temperature of frozen solid continues to drop and sensible heat is removed until the required temperature is reached. Freezing control is

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