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Balaji Subbiah, Ken R. Morison

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Electrical conductivity of viscous liquid foods

Balaji Subbiah, Ken R. Morison

Department of Chemical and Process Engineering, University of Canterbury, Christchurch, New Zealand

Abstract

The electrical conductivities of foods are used for quality assurance, electrical tomography studies and are required for effective simulation of electrical heating processes such as ohmic and microwave heating. Solutions containing milk solids, whey proteins, sugars and sodium carboxymethyl cellulose (NaCMC), with and without electrolytes were prepared and tested. The electrical conductivity was measured using an RCL meter connected to a parallel plate probe. At low concentrations the conductivity increased with concentration, but in some viscous solutions the reduced ion mobility caused a drop in conductivity. The conductivity of sugar solutions could be related to following the modified Walden equation, but that of NaCMC solutions was not influenced by the bulk viscosity. Instead an ion "diffusion viscosity" was defined and calculated from the conductivity. It was found to correspond to the likely viscosity of the solution at a molecular scale.

Keywords

milk; whey protein; sucrose; glucose; carboxymethyl cellulose; ion mobility

1 Introduction

Foods such as honey, milk, and yogurt are solutions and colloidal dispersions containing carbohydrates, fat, sugars, proteins, minerals, and other minor components in water. Knowledge of physical properties is required for accurate design and simulation of processes and in this study electrical conductivity is the main property of interest, especially in the way it is affected by viscosity.

Sharifi & Young (2012, 2013) measured the conductivity of milk solutions with up to 47% solids and used the results for electrical tomography. They used multiple linear regression to relate the solids content and temperature to electrical conductivity, but they did not consider the effect of viscosity directly. St-Gelais et al. (1995) measured conductivity and viscosity of milk solutions as the pH was reduced in an attempt to monitor gelation. While their data show that both conductivity and viscosity changed, the variables appeared to be independent of each other. When the pH changed rapidly from 5.6 to 5.0, the viscosity increased about 100 times, while the conductivity only doubled. Henningsson et al. (2005) stated that proteins and lactose affected electrical conductivity of milk via viscosity, and that the charged proteins contributed to only 0.5% of conductivity by carrying charge. They suggested that the effect of proteins on viscosity and hence on conductivity was important.

In liquid foods, with the exception of a few such as soy sauce and fish sauce, the concentration of electrolytes is relatively low. For example concentrated skim milk with 50% solids content will contain only about 5% salts and organic acids only some of which are present as dissociated ions (Walstra, Wouter & Geurts, 2006), and honey has at most 2% ash