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Recognition of the “fractional” kinetics in complex systems: Dielectric properties of fresh fruits and vegetables from 0.01 to 1.8 GHz

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Abstract

Based on the new theoretical approach and the self-consistent iteration procedure for calculating the limiting values ($\varepsilon(\infty)$ and $\varepsilon(0)$) of the frequency-dependent permittivity, it becomes possible to recognize the fitting function for the function $\varepsilon(j\omega)$ measured for a complex system representing plant tissues of fresh fruits and vegetables in the frequency range (10^7 – 1.8×10^9 Hz). The recognized fitting function is common for all of a set of nine fruits and vegetables (apple, avocado, banana, cantaloupe, carrot, cucumber, grape, orange, and potato) and contains seven fitting parameters. These parameters are varied for different fruits and vegetables, and their behavior with respect to temperature is different but nevertheless exhibits some common features. This fitting function containing power-law exponents and confirming the existence of relaxation processes described in terms of fractional kinetic equations for some complex biological systems can be used for practical purposes to construct a desired calibration curve with respect to quality factors, as for example, moisture content or degree of maturity. The discovered common “universality” in dielectric behavior of such complex materials as plant tissues opens a possibility to use dielectric spectroscopy as a nondestructive method of control in analysis of electrical behavior (measured in the form of complex permittivity or impedance) for other complex materials.

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1. Introduction

Dielectric spectroscopy (DS), as a non-resonant method for investigating electrical properties of different substances, is widely used for practical applications including measurements on biological

tissues and various materials of non-crystalline nature. But before one can increase the limits of applicability of this rather simple and effective method for investigating the structure of different materials, it is necessary to understand *how* the measured fitting parameters are related to the structure of the material considered. In fact, it is necessary to find a proper answer for a simple question: *what kind of information related to the structure of a material and its dynamic properties can*

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