The Effect of Glucose on the Electrical Properties of Blood Plasma

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Implantable biosensors that continuously monitor a person's vital signs have received and continue to receive research interest from a number of different scientific and engineering disciplines. Of particular interest are biosensors that measure blood glucose levels. The current state of the art is based on detecting interstitial glucose levels using enzyme technologies; these sensors (for example Enlite™ by Medtronic) provide a high level of specificity and accuracy but suffer from degradation and rejection by the body. There is, therefore, a need to investigate other sensor modalities that provide improved longevity while providing the same level of specificity and accuracy. One proposed method to achieve this is to characterize the dielectric properties of glucose-infused liquids. This would allow us to investigate glucose sensor technologies that rely exclusively on electrical changes in the dielectric properties of glucose to detect glucose concentrations in any liquid.

In this study, the frequency-dependent dielectric properties of glucose blends of specific glucose concentrations were measured from 500 MHz to 50 GHz using a Keysight 85070E dielectric probe kit and a Keysight N5225A PNA network analyzer. These measurements were then fitted to a single-pole Cole-Cole model. The expanded range of frequencies allowed us to directly define specific Cole-Cole parameters through examination of the results, while the rest were extrapolated through particle swarm optimization. Using the ANSYS-HFSS simulator, we examine the classic circuit model of the Cole-Cole parameters and model the behavior of distributed filter topologies designed using dielectrics that match the values calculated for the glucose mixes; in addition, 3-D printers are used to print scaled models of circuit components that will be used to confirm the ANSYS-HFSS results experimentally. Results are analyzed to determine if the changes in dielectric properties of glucose blends of known concentrations are such that they can be utilized in the design of a glucose sensor.