Continuous Complex Permittivity Extraction of Water-Glucose Solutions with a Resonant Microwave Cavity at 300 MHz

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I. INTRODUCTION

One particular field which has been recently studied is to monitor the permittivity change of blood at different glucose levels [1].

In this paper a method based on the small cavity perturbation theory [2] is proposed to measure complex permittivity noninvasively and continuously. In the proposed setup the liquid is circulating through a strong electric field (along the z-axis in Fig 1). The frequency response around the cavity's resonance frequency is measured by a Vector Network Analyzer (VNA). The method of determining the permittivity from the frequency response can be found in previous papers [1][3] but with different setups, higher frequencies and higher water-glucose concentrations compared to what are presented in these papers.

The setup is powerful enough to discern a trend in glucose concentrations ranging from 50-200mg/dl, the typical glucose range of human blood. The method is generic and can be usedin a variety of situations to monitor continuously and noninvasively small permittivity changes for the wear of lube oils, alcohol etc.

II. RESULTS

To evaluate the setup, measurements were made of water-glucose solutions with different glucose concentrations. 168(05) μl of glucose solution with a concentration of 1g/10ml was mixed with 5.00(50) dl DI-water. Between each measurement the concentration was increased by 10 mg/dl. The results are shown in Fig. 2 where the original measurements are shown as circles and a calculated temperature shift corresponding to a temperature difference between 0.000(03) to $\pm$0.007(03)^{o}C are shown as stars.

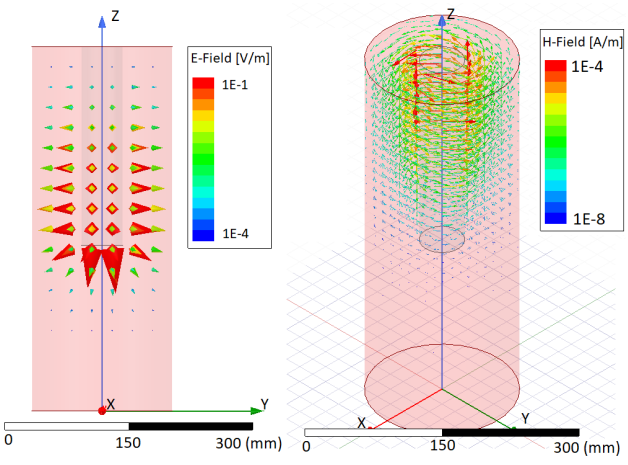

Fig. 1. A simulation of the cavity with HFFS

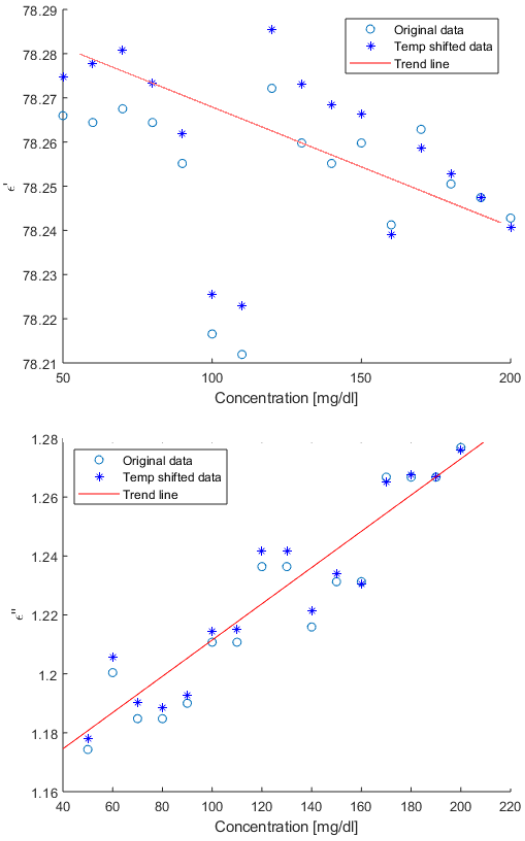

Fig. 2. Real and Imaginary part of c. permittivity, ϵ' and ϵ'' respectively vs concentration. Shifts in ϵ' and ϵ'' due to small temperature variations. The circles are the original data (No temperature compensation) and the stars are the temperature shifted points

III. CONCLUSIONS

In this paper we implement and evaluate a method of measuring the permittivity continuously and noninvasively the complex permittivity of a fluid using a cavity resonator. The method show a good correlation of the increase of permittivity with higher glucose concentrations in the medical range.

For improvements, the uncertainty in the permittivity can be reduced by using better reference values and improved concentration and temperature control.

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