Use of Dielectric Spectroscopy for the Study of Concentration of Glyphosate in Distilled Water

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***Abstract*—In this paper, the capability of sensing low concentrations of glyphosate in water of two interdigital capacitive transducers are analyzed using numerical simulations and measurements. Each microwave sensor is analyzed using the surface electric field produced at the resonance frequency. In addition, the reflection coefficient of each transducer submerged in water with glyphosate is measured and compared with distilled water. Prepared samples with concentrations of 1ppm/L (1 part per million over a liter of distilled water) are used for the experimental tests.**

Keywords—dielectric spectroscopy, glyphosate, interdigital capacitor, microwave, sensor, water.

I. Introduction

A direct application of dielectric spectroscopy is the characterization of materials. Dielectric spectrometry technique is commonly used to calculate the content of water in materials or liquids; however, it can be also used to determine different specific properties of materials. Dielectric properties of materials vary depending on the content on water but also on the content of other component such as salts [1]. For this reason, this technique has been proposed for monitoring glyphosate in water using interdigital transducers [2].

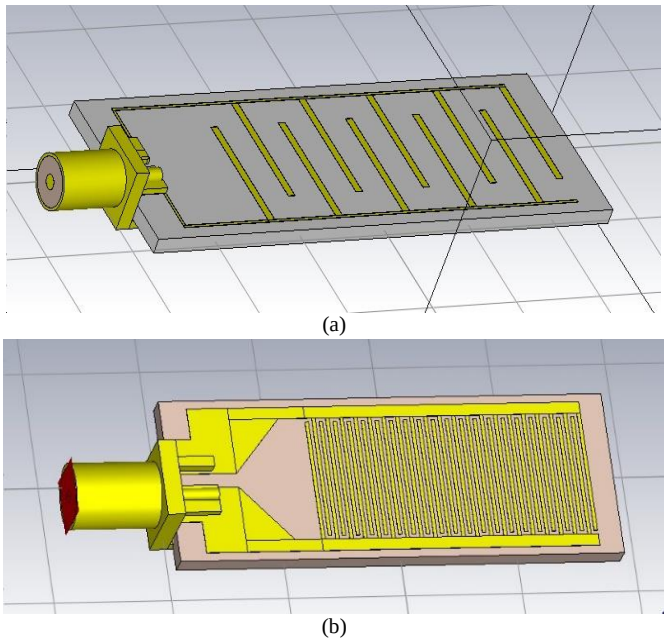
Glyphosate is a common component in a wide range of pesticide products used for the control of plantations and for intensive agriculture. However, some studies reveal that Glyphosate present health risk for amphibians and humans [3].

In this paper, the electromagnetic behavior of two interdigital capacitor (IDC) transducers is presented and the response of each transducer submerged in water with glyphosate is analyzed.

II. Transducer Selection

The intended transducer is especially designed to detect presence of glyphosate in water as a real time sensor. Small concentrations of glyphosate are required to consider. The IDC is a planar resonant structure, whose resonant frequencies and quality factors depend on the dielectric properties of the surrounding medium.

Two IDCs implemented in FR4 were analyzed to compare their behavior and to determine the geometric characteristics that increase the capability to determine concentration of glyphosate in water. IDCs of 5 and 20 digits, as shown in Fig. 1, were numerically simulated. The 5 digits IDC has a wider separation between digits, which could enable more interaction of the electric field and the material under test. On the other hand, the 20 digits IDC has a smaller separation between digits providing higher density of electric field between digits, as confirmed by the simulations shown in Fig. 2.



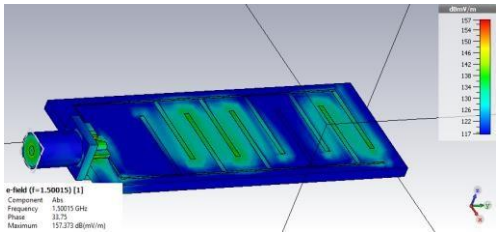
(a)

(b)

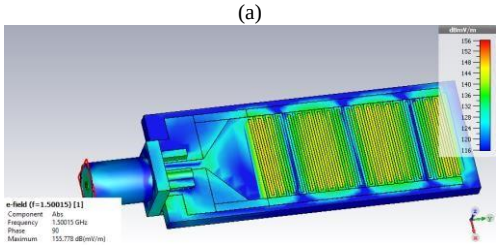
Fig. 1. Simulation models of IDCs with (a) 5 digits and (b) 20 digits.

Submitted On: September 10, 2020
Accepted On: September 10, 2020

https://doi.org/10.47037/2020.ACES.J.351171



(a)



(b)

Fig. 2. Electric field simulated at the resonant frequency 1.5 GHz for the IDCs with: (a) 5 digits and (b) 20 digits surrounded by air.

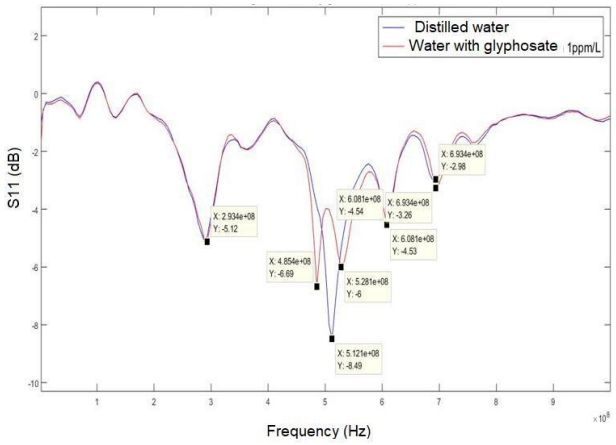


Fig. 3. Comparison of the S11 parameter of 5 digits IDC surrounded by water and water with glyphosate.

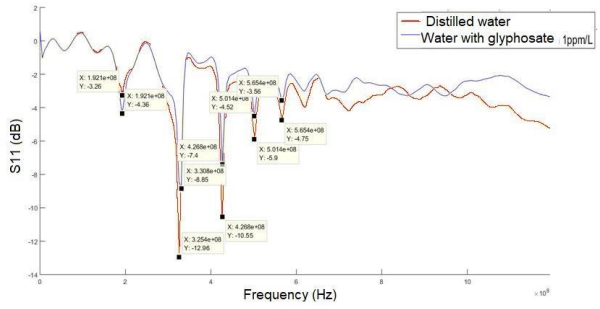


Fig. 4. Comparison of the S11 parameter of 20 digits IDC surrounded by water and water with glyphosate.

III. Experimental Results

In order to characterize the response of the considered IDCs, the S11 parameter was measured between 100 kHz and 1 GHz. Each IDC was submerged in previously prepared samples of distilled water and water with glyphosate with a concentration of 1 ppm/L (i.e., 1 part per million over a liter of distilled water). Each sample was prepared using microliter pipette.

Figs. 3 and 4 show the comparison of S11 parameter measured for both transducers surrounded by water and water with glyphosate. Experimental results show that both IDCs present a notable change of the response at the resonance frequencies. As mentioned before and verified with the electromagnetic simulations, the interaction of the electric field with the material under test in the sensor with 5 digits is higher than with the 20 digits sensor. This is expressed in Fig. 3, where the frequency response is modified and an additional minimum value in the S11 is presented for the test of water with glyphosate. On the other hand, the 20 digits IDC maintains the same number of minimums in the S11 and with almost the same frequencies for distilled water and water with glyphosate, as shown in Fig. 4. This indicates that the resonant structure is not strongly perturbed. However, the variation is obtained in the magnitude of the S11. Water with glyphosate case present magnitudes closer to zero dB with could be due to additional losses of the mixture.

IV. Conclusions

Two interdigital capacitive transducers used to detect glyphosate in water where analyzed with numerical simulations and experimental results. Two approaches for the design of the sensor were assessed. For one side, a 5 digits IDC showed lower concentration of electric field on the surface of the sensor which enable higher interaction of the electric field with the material under test. As a consequence, the frequency response is perturbed as the glyphosate is added to the water; for example, a minimum in S11 parameter at 512 MHz disappears but two new minimums at 485 MHz and 528 MHz are generated. For the other side, a 20 digits IDC, which presented a higher intensity of electric field on the surface, showed a more persistent frequency response as the glyphosate was added to the water. Nevertheless, experimental results showed that both approaches can be used to distinguish water from water with low concentrations of glyphosate from S11 measurements.

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