NON-INVASIVE FLUID PROPERTY MEASUREMENTS USING ACOUSTIC METHODS

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RESULTS

ABSTRACT

LIQUID LEVEL MEASUREMENT

To possible contamination and/or consumption of the fluid sample. When only very small amounts of a valuable sample exist, non-invasive measurement methods are preferred.

Acoustic Wave Response Analysis is based upon the idea that a fluid can be excited with acoustic energy and the response can be measured using an acoustic measurement technique. When a fluid is placed in a microtiter plate it occupies a roughly cylindrical volume with height, the surface tension of the fluid in the well. The higher the surface tension, and the smaller the well diameter, the higher the frequency of oscillation. The (0,1) and (0,2) modes also contribute to the symmetric oscillation of a circular membrane. The (0,3) mode oscillates at 2.265 times the frequency of the (0,1) mode. The (0,3) mode oscillates at 3.566 times the frequency of the (0,1) mode's frequency.

HYPOTHESIS

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MATERIALS AND METHODS

LIQUID LEVEL MEASUREMENT

The amount of liquid in a well can be measured by a sonar technique. A small burst of acoustic waves is directed toward the surface of the liquid. The sound waves travel through a coupling fluid, the bottom of the well plate, and through the liquid. The waves reflect off the surface of the fluid and back toward the source. Using the speed of sound of the coupling fluid, the depth of the liquid can be calculated and when it's reflection is received to calculate the depth of the liquid in the well.

SPEED OF SOUND MEASUREMENT

Similarly, the speed of sound is measured by putting a known amount of a fluid in a well. The fluid is placed in a well slightly overflowing. A glass cover is then placed over the well displacing the fluid and preventing any air from being trapped. In this situation, the depth of the well is known precisely based of the construction of the wellplate. The travel time of the pulse is then measured and the speed of sound for each concentration is measured (Figure 2).

SURFACE TENSION MEASUREMENT

The surface tension can be determined by stimulating the surface of the fluid, continuously measuring the position of the surface, and detecting the oscillation (Figure 3). The frequency of the oscillation is related to the tension of the membrane or surface of the fluid. In general, three modes of oscillation are excited when the surface is stimulated. A Fast Fourier Transform (FFT) is performed on the data (Figure 4) and the values of the three frequencies are extracted.

Similarity, viscosity can be determined by measuring the dampening of the oscillation. By selecting the data in the FFT plot around the (0,1) frequency peak, the time domain data can be reconstructed using an Inverse Fast Fourier Transform (IFFT). The result is a reconstructed (0,1) waveform extracted from the data using the FFT (Figure 5). The absolute values of the peaks are fitted to an exponential function. The decay time constant is plotted for different DMSO/water concentrations (viscosities between 1-4 cP) as a function of liquid level (Figure 7).

SUMMARY

Acoustic Wave Response Analysis measures fluid properties to a high certainty. This microfluidic method has been integrated into EDC Biosystems' True Non-Contact Technology® for liquid dispensing. An acoustic DMSO solution dispensed in to an apparatus, the system is able to alter the volume dispensed in order to transfer the proper amount of sample to the target. This is demonstrated with the use of a resonance described in 100% DMSO. Water has been added to the solution to produce various concentrations of DMSO and water. The difference between non-compensation and compensation is shown (Figure 8).