Design of PIC 18F4550 Based Pulse Echo Technique for Ultrasonic Velocity Measurements in Gelatin Gels

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Abstract: ***Ultrasonic technique is widely used for non destructive characterization of materials, since it does not change the properties or structures of materials. So far, much work has been reported in instrumentation in ultrasonics for characterization of liquids and solids. But very few researchers have reported work on design of instrumentation for ultrasonic characterization of gels, since gels are highly attenuating due to their structural, chemical and rheological properties; and require different approach in the design of instrumentation. In the present work, we have designed a pulse echo technique operated at 2 MHz, to measure travel time in gels, using microcontroller PIC 18f4550 and the other discrete electronic components. The ultrasonic velocity of propagation and temperature of the gel under test are displayed on the 16x2 LCD. The designed system was tested on gelatin gel at 3% and 5% concentrations. Variation of ultrasonic velocities at different temperatures and with time at constant temperature was also observed. The designed instrument is very effective and powerful for characterization of gels.***

Keywords: gelatin gels, PIC18f4550, pulse echo technique, travel time, ultrasound velocity

1. Introduction

Gels are substantially dilute cross-linked systems, which exhibit no flow when in the steady-state. Gels are basically aqueous known as hydrogels, the structure created by a hydrophilic groups or domains present in a polymeric network, upon the hydration in an aqueous environment. Gels consist of a solid three-dimensional network that spans the volume of a liquid medium and ensnares it through surface tension effects[1]. This internal network structure may result from physical bonds (physical gels) or chemical bonds (chemical gels), crystallites or the other junctions that remain intact within the extending fluid such as water, oil or air. Gels are used in food industries, pharmaceutical, cosmetics, and biomedical industries so there is need for synthesis of gels and characterizes them to find their structural, rheological, mechanical properties etc.

There are many methods for characterization of gels such as FTIR, SEM, Light scanning etc[1]. Most of these methods of characterization affect the medium or sample or specimen at the time of measurement[2]. Ultrasonic measurement is the one of the measurement techniques which overcomes this problem. Ultrasonic technique is well established tool for characterization of liquids. Liquid is less dense as compared to gels and solids, hence it is easy to design an instrumentation for its characterization. In order to design an instrumentation for characterization of gels, we need to consider the various parameters of gels such as viscosity, density, structural properties, chemical composition, concentration etc[2].

In the present work, we have designed an instrumentation for the measurement of ultrasonic velocity in gels. For testing our designed instrument we have synthesized gel using gelatin materials at various concentration. We observe the changes in velocity with respect to concentration and time.

2. Experimental

2.1 Synthesis of Gelatin Gel

Gelatin material (make HEMEDIA) and double distilled water is used to synthesis gel. Sol-gel method is used for synthesis of gel of 3% and 5% concentration. In the present measurements, around 20 ml of gel is required, hence 0.9 gm and 1.5 gm of gelatin for 3% and 5% concentration respectively in 30 ml of distilled water. This mixture is stirred continuously for nearly 2 hours at 55^{o}C, and was kept at room temperature for half hour to form gel.

2.2 Design of Pulser-Receiver Module

In pulse echo technique, a high frequency burst is introduced into the sample using a piezoelectric transducer. An ultrasonic pulse travels through the sample and an echo is registered each time it returns to the transducer. The amplitude of the successive echos decreases exponentially due to attenuation in the sample. To avoid damage to the receiving circuit, an attenuator is designed to attenuate high voltage transmitted pulse. The received echos are then fed to the amplifier and filtered. Both the transmitted and received signals are seen on the oscilloscope and the time between the transmitted pulse and first received echos or the time between the two successive echos is measured with the help of oscilloscope. Fig 1 shows the block diagram of the pulse echo system designed in our laboratory.

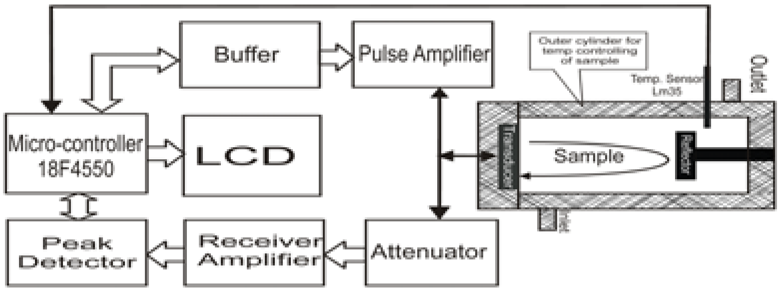


Figure 1: Block diagram of the designed instrument

Microcontroller PIC 18f4550 is used as the main block to handle most of the tasks. Most of the tasks such as generation of rf pulses, high speed counter, processing on data and user interface are done by microcontroller 18f4550. A burst of 2MHz, with pulse width of 0.5μs and 5 pulses is fed to the rf amplifier at 30V. These amplified pulses are then fed to the 2MHz PZT transducer. The sound waves are generated by transducer and propagate through sample (gel) present in the sample holder. The reflected echos are received by the same transducer. These received echoes are then fed to the receiving circuit. To prevent the receiving circuit from high voltage transmitted pulse, an attenuator circuit is designed using two back to back fast switching diodes. These received echos are amplified in two stages using op-amp LM7171. An active filter is designed using LM7171 to remove the noise created by the back reflection, resonator circuit etc. These filtered echos are then converted to a single pulse by envelope detector circuit, using schottky diode. For peak detection, 12 bit DAC and a high frequency analog comparator are used. The echos are compared with the help of analog comparator and when the echos are same of amplitude, it gives a single pulse. This single pulse is reshaped by monoshot 74221 to be fed to the microcontroller. The time difference between the 1st and 2nd echo gives the total time of flight. The velocity is estimated as:

$$u = \frac{2d}{t} \qquad \text{....(1)}$$

Where, u= ultrasonic velocity
d = path length of the sample
t = time of flight

Time of flight and velocity are displayed on 16x2 LCD interfaced to the microcontroller PIC18f4550. The path length is calibrated with double distilled water at 20°C as a standard sample.

3. Result and Discussion

The designed system is tested for the measurement of ultrasonic velocity in gelatin gel at concentrations of 3% and 5%. Fresh samples were prepared for each concentration and temperature. Fig 2. shows the variation of ultrasonic velocity with temperature at 3 and 5% gelatin gel concentration.

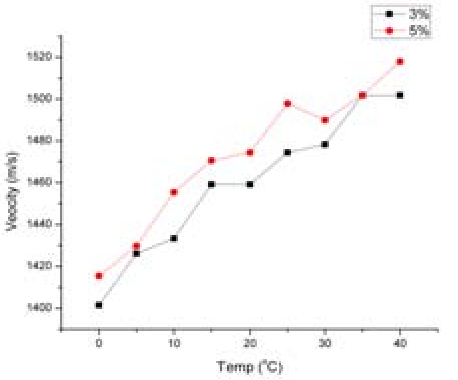
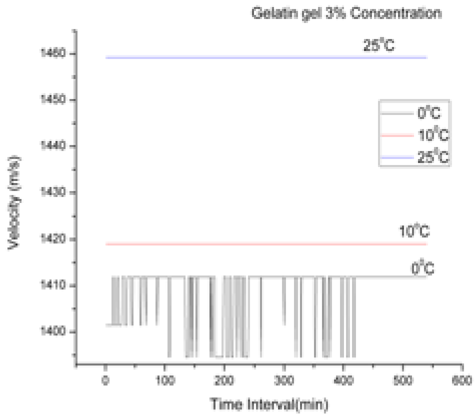
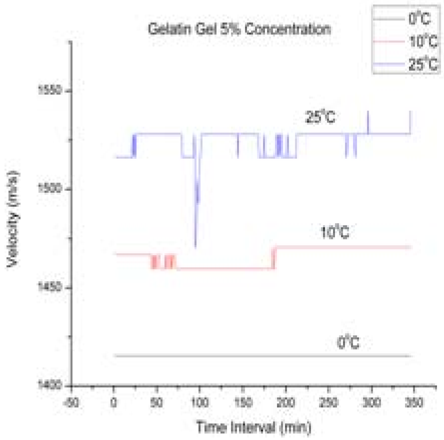


Figure 2: Variation of Velocity with temperature



(a)



(b)

Figure 3: Variation of Velocity with time (a) for 3% concentration (b) for 5% concentration

Fig 3 shows the variation of the ultrasonic velocity with time at 0°C, 10°C and 25°C, for 3% and 5% concentrations. It is found that at 3% concentration the velocity remains stable for 10°C and 25°C for a considerable time of about 500mins but at 0°C the ultrasonic velocity is observed to be vary randomly. At 5% concentration, cross linking of molecules of gel takes place, the velocity varies randomly with time at 25°C. It is also found that at some point the velocity fluctuates rapidly at 25°C and in small ranges at 10°C. It is also observed that velocity changes are found around 1hr of time interval. At 0°C velocity remains constant for long durations.

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