

## Effect of Elastic and Acoustic Properties of Human Blood and Its Plasma

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### ABSTRACT

Diabetes is a serious problem in public healthcare now days. This is spreading all over the world due to imbalance health related issues such as lack of proper diet, sleep, exercise etc. Due to diabetes, blood sugar level in human body increases from its normal level. Diabetes also leads to other health problems. In this paper, elastic parameters of water, normal blood, diabetic blood of human and its constituents. We have also studied these parameters at different ultrasonic frequencies of 1, 2, 3, 5 and 10 MHz.

Ultrasonic waves are used so that no destruction of blood occurs. This paper presents the data on acoustic and elastic properties of human blood and its plasma by using the nanofluid interferometer. The interferometer with multiple frequencies is used to find out the ultrasonic velocity of blood and plasma. By knowing the density of the blood and plasma, acoustic parameters like coefficient of absorption, modulus of elasticity are determined at different frequencies.

**KEYWORDS:** Diabetes, blood coagulation, ultrasonic waves, absorption coefficient, glucose level.

### 1. INTRODUCTION:

In this paper first of all we present detailed summary of interferometric ultrasound dispersion measurement in erythrocytes over a wide frequency range and the analysis of the experimental data determination of modulus of elasticity [1-3] of the fast chemical reaction, investigation of hydrogen phenomenon in these solution in order to explain a specific dependence of relaxation parameters across the series. As was emphasized by other authors [5, 6, 9, 21] our approach was unique and became possible due to high accuracy of measurements. Another group of experiments concerns ultrasound velocity measurements in biological liquids: synovial and cerebrospinal fluids with the aim of disease diagnostics, for blood coagulation studies, as well as acrylamide polymerization etc. The later ultrasonic interferometer were provide in single and multi channel small volume (<1ml) chambers. The multichannel approach revealed more detailed and unexpected information about the clot formation and the chemical polymerization processes, which are very similar from the ultrasonic point of view. Some of experiments concern investigations of water, blood and plasma of erythrocytes with radii are taken care based on the technological processes. Human blood is wonderful and highly complex substance which contains many chemical compounds to perform various functions .It is a red fluid that circulates in our blood vessel means veins and arteries. Blood is a mixture of cells and water liquid is called plasma. The main function of blood is to acts as body's transport system. Blood is pumped from heart through the networking of blood vessels is known as circulatory system and blood cells are produced in bone marrow, it is very thicker than the water and it has little bit salty in taste and also other things contains dissolved glucose nutrients, protein, hormones, clotting factors, carbon dioxide being main medium for excretory product transport phenomena. There are three main kinds of cell such as 1) Red blood cell (RBC): which carry oxygen from lungs to body tissues are major component found in blood. These are called as erythrocytes 2) White blood cell (WBC): which have major role in disease prevention and immunity. These

are called leukocytes.3) Platelets: These are colorless disc shaped cell fragments without nucleons key elements in blood clotting process. Other name is called as Thrambo cytes.

### **DIABETES MELLITUS:**

Diabetes is often referred to by doctors as Diabetes mellitus. This describes a group of metabolic diseases. Diabetes is a common lifelong health condition and also this is defect in which a person has high blood glucose (Blood sugar) or the amount of glucose in our blood is too high that time, the body cells doesn't respond properly to insulin. Insulin is the hormone produced by the pancreas that allows glucose to enter the body cells. So glucose is the main source of fuel for our body. When food is digested, it is changed into fats, proteins; food is that effect blood sugars are called carbohydrates. In diabetic patients absence or insufficient production of insulin causes hyper glycaemia. Chronic hyperglycaemia causes damage to eyes, kidneys failure and nerves damage, blood and heart vessels. Actually blood plasma is the yellowish liquid component of blood. In which blood cells the whole blood and diseased both are normally suspended, it is 55% of the total blood of volume, it is mostly contains 93% of water and also other things contains dissolved glucose nutrients, proteins, hormones, clotting factors, carbon dioxide being main medium for excretory product transport phenomena.

### **2. BASIS OF ULTRA SONIC'S:**

Ultrasonic is the branch of physics dealing with the study and applications of sound waves having frequencies which are beyond the range of human audible capacity (>20KHZ). It is divided into two sections: one dealing with low amplitude vibrations and the other with high energies. For low amplitude propagation, one is concerned with the effect of medium on the wave. Permanent changes do not take place in the medium. By passing low amplitude ultrasonic waves through a medium, the propagation constants of the medium namely the velocity and absorption coefficient can be measured. The techniques employed for this purpose can be applied to the non-destructing study of materials namely determination of Ultrasonic velocity, absorption coefficient and modulus of elasticity, detection of flaws in materials.

### **3. MEASUREMENT METHOD:**

The interferometer operates a fixed frequency with a micrometer least count of .0001cm. Ultrasonic measurement were made at frequencies 1,2,3,5 and 10 MHZ. Blood sample were introduced into the experimental chamber. The distance between reflector and transducer can be varied with the help of micrometer. The micrometer was rotated until it touches the surface of the muscle tissue. The rotation of the reflector was continued and the distance between two consecutive nodes at which the current is maximum; was noted down. The extremals were measured accurately with the help of micrometer. The maximum current intensities i.e.  $I_0$  and  $I$  were measured at two nodes separated by a distance 'X'. Then the absorption coefficient was calculated by the relation ( $I = I_0 e^{-2\alpha x}$ )

### **MEASUREMENT OF ULTRASONIC VELOCITY:**

Basics of ultrasonic is a branch of physics it deals with the study and applications of sound waves having frequencies which are beyond the range of human audible capacity (>20KHZ). Measurement of ultrasonic velocities is made in liquids in order to get an idea of their chemical and physical characteristics. This technique is generally employed for measuring ultrasonic velocities, density and velocity in present work.

### **MEASUREMENT OF MODULUS OF ELASTICITY:**

By the modulus of elasticity, we meant the magnitude the stress that must be applied for the strain of a material to be equal to unity. The dynamic modulus of elasticity  $M$  is the real part of complex modulus. It is equal to the ratio between the component of stress coinciding in phase with strain and the volume of strain.

The dynamic modulus characterize the amount of energy received and given up by unit of volume of given body during one period. It will be shown below that for oscillation of constant amplitude. The volume of M increases or remains constant with a growth in the frequency.

#### 4. STUDY OF BLOOD COAGULATION AND ITS INTERACTION:

Blood represents one of the most complex biochemical systems in living organism. Various components play integral roles in several life functions. Numerous studies have been carried out to acquire a more understanding of the properties of the blood coagulation process and increase the capability to diagnose various diseases. Ultrasonic method for investigation of whole blood coagulation is based on different principle:

spectroscopy[5,12] measurement of velocity[6,7,10,13] attenuation[14], impedance [15] or scattering in the whole blood[16].The interest in blood clotting ultrasonic monitoring increased during last year's[17,-21]. Measurement of ultrasound velocity variations reveals the main stages of the blood clotting [13]. However it was noticed that ultrasonic data depend on the measurement chamber inclination to the horizon. In order to reveal regularities a of a blood clotting both in the time and space domains a novel investigation method was created, say multi-channel ultrasonic method which enables to measure ultrasound velocity variations simultaneously in a few parallel channels thus enabling to monitor blood clotting process in different but closely located spatial domains [9]. Some small volume different geometry chambers operating in a pulse – echo mode with a number of separate transducers or with a linear array were developed. Numerous investigations revealed the fact that ultrasonic results may strongly depend on the transducers orientation. An optimal wave propagation direction and array orientation with respect to the gravitation vector was found, which gives the best information about the structure variation in different sections of the medium [11].

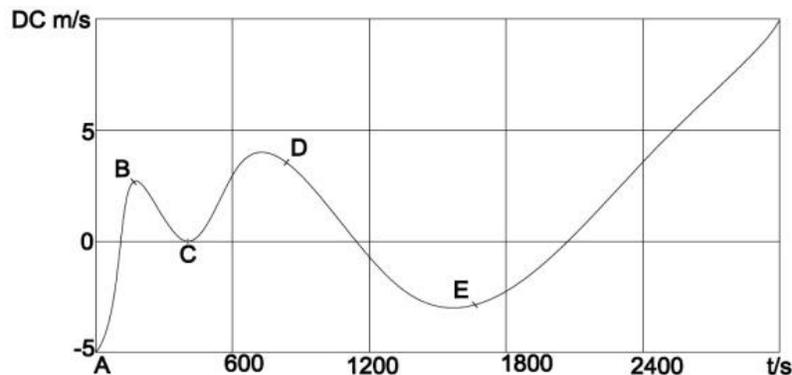


Fig presents peculiar stages of blood coagulation curve of healthy person characterized by their duration and intensities, i.e. ultrasound velocity changes [8]. The curve is distinctive for one and multi-channel approaches. Points B and D mark the beginning and end of blood clotting, at point C ultrasound velocity minimum is observed frequently. Interval DE represent so called latent refraction after which main refraction analysis take place. The most informative for diagnostic purpose is the blood clotting process B-C-D.

1. For the process of dynamic calibration of blood coagulo-meter [13] we proposed to use free radical chain polymerization reaction of acrylamide
2. Depending on composition it can be very similar to the blood clotting in the interval B-D from the point of view of ultrasound velocity variations. Twenty experiments were carried out the optimal composition of arcylamide compound mixture [8].

**RESULTS AND DISCUSSION:**

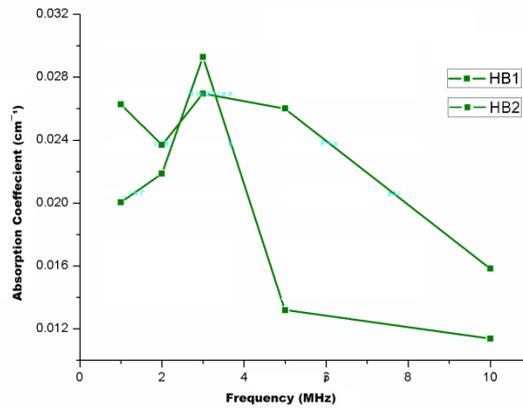


Fig 1(a)

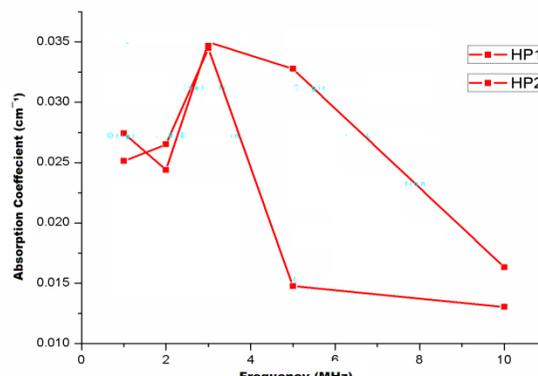


Fig 1(b)

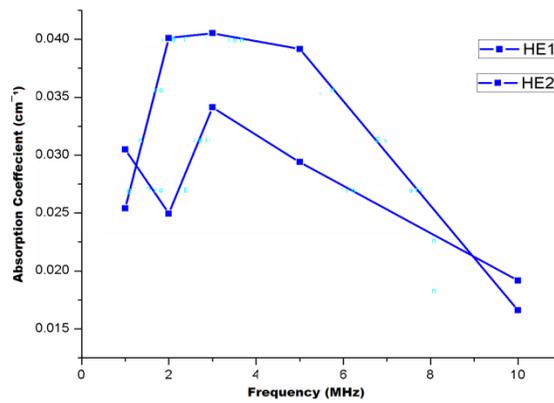
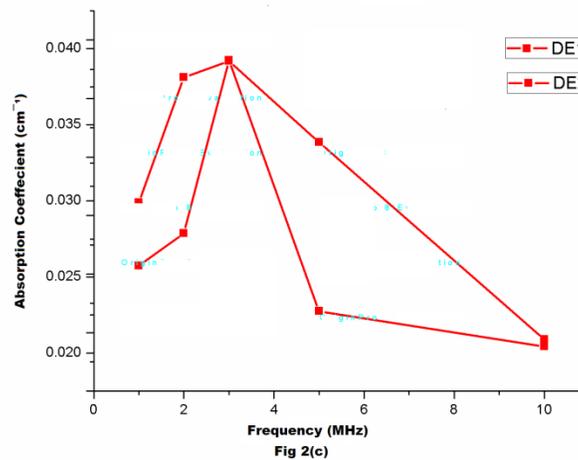
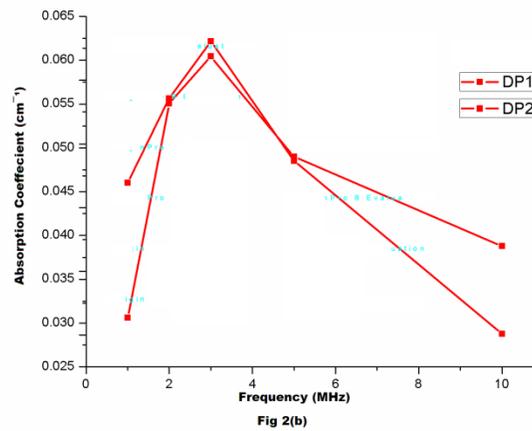
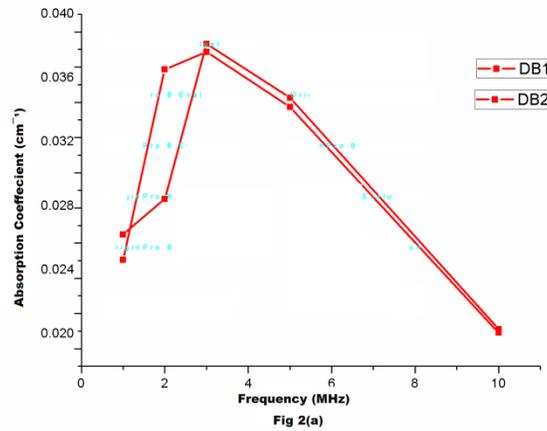


Fig 1(c)

**Fig 1: Shows the Graph of various frequency vs. absorption Coefficient of Normal Human Blood**



**Fig 2: Shows the Graph of various frequency vs. absorption Coefficient of Diseased Human Plasma**  
Rheology is the study of the flow and deformation behavior of materials, under the conditions of materials being fluids, including liquids, gases and solids. The study of the flow and deformation behavior of blood and its formed elements is called Hemorheology.

If we look at it from a biological point of view, blood can be taken as a tissue which comprises different types of cells viz, RBCs, WBCs and platelets, also a liquid intercellular material which is called plasma. If seen from a rheological point of view, blood can be considered as a two phase liquid; it can also be thought

of as a solid –liquid suspension, with the cellular elements as the solid phase. On the other hand, blood can also be thought of as a liquid-liquid emulsion depending on the liquid-like property of RBCs under shear.

From a hemo rheological angle, blood can be taken as

- 1) Newtonian fluid
- 2) Non –Newtonian fluid
- 3) Micropolar fluid and
- 4) Viscoelastic fluid

Depending on the cellular constituents, molecular composition and diameter of tube in which the blood is flowing. Based on this, several mathematical models have been made, instruments are designed, and experiments are being done. The different schools of thought have totally different observations. But, still it is a most disputable point to define the type of hermorheological behavior of blood which belongs to different environmental and physiological conditions.

## CONCLUSION:

Based on the data and graphs, an endeavor has been made to scrutinize and assign the rheological behavior of blood and its plasma as viscoelastic. To arbitrate dynamic modulus of elasticity absorption of ultrasound at varying frequencies have been observed, while we can confirm a Newtonian behavior of blood plasma in the pure extensional flow of a capillary breakup using nanofluid interferometer. The influence of the viscoelasticity of blood plasma on capillary blood flow is tested. As shown in fig 1 various frequencies with absorption coefficients as HB(Human Blood), HP(Human plasma), HE(Human Erythrocytes), it shows that at  $0.015 \text{ cm}^{-1}$  value of absorption coefficient a sudden drop in the frequency is seen in human plasma as compared with HE1 and HP1 that attributes the clear behavior is not same as compared with HE1 and HB1, again by seeing in fig 2 with DB (Diabetes Blood), DP(Diabetes Plasma), DE(Diabetes Erythrocytes) as there is a abrupt change in the elastic behavior of DP1 as compared with DP2 at  $0.030 \text{ cm}^{-1}$  the absorption coefficient is changes with  $0.045 \text{ cm}^{-1}$  of DP1, there is a change in  $0.015 \text{ cm}^{-1}$  which signify that results can be monitored in Bio- Medical field and clinical aspects. Our findings show that the viscoelastic properties of plasma should not be ignored in future studies on normal and diseased blood flow.

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