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Studies on Acoustic and Elastic Parameters of Diabetic Blood, Plasma and Erythrocytes

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Abstract
For describing the dynamics of blood flow, the viscoelastic parameters such as viscosity and elasticity, should be obtained from the measurements under oscillatory shear flow.Viscoelastic materials have interesting properties. They exhibit both viscous behaviour as well as elasticity. When a constant displacement is applied, the stresses of a viscoelastic material gradually relax over time because of these properties. Conversely, under a constant applied force, elastic strains continue to accumulate, deforming further more. Because of this complex behaviour, the use of linear material properties is generally inadequate in accurately determining the final shape of viscoelastic material, the time taken to arrive at that geometry, and the stresses on the part. In these cases, the material's viscoelasticity must be taken into account in the simulation.
This paper presents the data on elastic and acoustic parameters of diabetic blood, Plasma and erythrocytes by using the ultrasonic interferometer. The ultrasonic interferometer with multiple frequencies is used to find out the ultrasonic velocity of blood. By knowing the density of blood, elastic constant and acoustic parameters like coefficient of absorption, modulus of elasticity and loss modulus are determined for different frequencies.
Key Words : Elastic Constant, coefficient of absorption, modulus of elasticity and loss modulus

I. INTRODUCTION

Blood is a vital fluid found in human beings. This provides nourishment to all body organs organs and tissues and carries away waste materials. It is a mixture of cells and watery liquid called Plasma. Blood also contains other things like nutrients, hormones, clotting agents etc. These blood elements are suspended in blood plasma which is yellowish liquid. From a hemorheological point of view blood is considered as 1) Newtonian liquid, 2) non-Newtonian liquid, and 3) Viscoelastic fluid based on the molecular composition, cellular constituents and diameter of tube (blood vessel) in which it is flowing.

Diabetes mellitus has high social and economic importance as the number of persons affecting with diabetes are increasing continuously at an unprecedented rate throughout the world. It is a syndrome characterized by disordered metabolism and abnormally high blood sugar generally known as hyperglycemia resulting from either low insulin level or insulin resistance at many body cells.

In this study an attempt has been made to examine the rheological behavior of blood as viscoelastic by determine the dynamic modulus of elasticity and loss modulus of diabetic blood its plasma and erythrocytes by measuring absorption coefficient of ultrasound at different frequencies.

II. MATERIALS AND METHODS

An ultrasonic Interferometer is used which is having multiple frequency ranges to measure the Ultrasonic Velocity of Diabetic blood. The frequency ranges are 1MHz, 2MHz,3MHz, 5MHz and 10 MHz. 10 ml of blood from diabetic patient was co;;ected and used EDTA as anticoagulant. Five samples were collected and stored at loe temperatures until use. Plasma was separated from the blood bt centrifuging the blood . The Elastic and Acoustic parameters were studied.

III. EXPERIMENTAL PROCEDURE

The blood samples were standardized with water before starting the experiment as water is Newtonian liquid. As stated above the ultrasonic velocity and elastic parameters were determined for different frequencies. The cell is inserted and the sample blood is pored .

The cell is connected to high frequency generator . When the micrometer is moved up and down in liquid, the number of maximum deflections in the meter is noted. The micrometer is moved slowly till the anode current on the meter shows a maximum. The anode current and the micrometer readings are noted fordifferent frequencies. The least count of the micrometer is 0.0001cm. By determine the density of blood, the elastic constant or bulk modulus and absorption coefficient are determined.

Table 1 shows the data on acoustic and elastic parameters of water. The parameters include ultrasonic velocity, absorption coefficient, modulus of elasticity and loss modulus. All these parameters are calculated at different frequency ranges.

Table 1: Data on Acoustic and elastic parameters of Water

Sample Code	Frequency, υ (MHz)	Ultra sonic Velocity m/sec	Absorption co-efficient, α (cm$^{-1)}$	Modulus of Elasticity (×10$^{11)}$ dyne/cm2	Loss modulus, (×10^{8})
W1	1	1457	0.016	0.217	0.158
	2	1463	0.015	0.219	0.077
	3	1470	0.014	0.221	0.048
	5	1477	0.013	0.223	0.0271
	10	1483	0.012	0.224	0.0127

Table 2 gives the data on average values of acoustic and elastic parameters of normal human blood and its constituents.Ultrasonic velocity,absorption coefficient,modulus of elasticity and loss modulus are calculated and tabulated.

Table 2: Data on Average values of Ultrasonic, Acoustic and Elastic Parameters of normal blood and its constituents.

Sample Code	Frequency, υ (MHz)	Wave length	Ultra sonic Velocity m/s	Absorption co-efficient, α (cm^{-1})	Modulus of Elasticity, M^{1} (×10$^{11dyne/cm2)}$	Loss Modulus, M^{11} (×10^{8} cm^{2}/dyne)
HB	1	0.1522	1555	0.029	0.2542	0.36
	2	0.0820	1634	0.025	0.2834	0.1845
	3	0.0549	1667	0.022	0.2952	0.1133
	5	0.0347	1770	0.020	0.3328	0.0731
	10	0.0188	1868	0.017	0.3704	0.0367

Sample Code	Frequency, υ (MHz)	Wave length	Ultra sonic Velocity m/s	Absorption co-efficient, α (cm^{-1})	Modulus of Elasticity, M^{1} (×10$^{11dyne/cm2)}$	Loss Modulus, M^{11} (×10^{8} cm2/dyne)
HP	1	0.1516	1510	0.026	0.2336	0.293
	2	0.0774	1561	0.021	0.2498	0.129
	3	0.0522	1597	0.019	0.2614	0.0825
	5	0.0324	1632	0.017	0.273	0.0469
	10	0.0175	1691	0.015	0.2932	0.0242

Sample Code	Frequency, υ (MHz)	Wave length	Ultra sonic Velocity m/s	Absorption co-efficient, α (cm^{-1})	Modulus of Elasticity, M^{1} (×10$^{11dyne/cm2)}$	Loss Modulus, M^{11} (×10^{8} cm2/dyne)
HE	1	0.1596	1590	0.031	0.2848	0.44
	2	0.0839	1644	0.027	0.3044	0.2197
	3	0.0564	1670	0.024	0.314	0.1356
	5	0.0347	1720	0.021	0.3286	0.077
	10	0.0177	1780	0.018	0.3578	0.036

Table 3 describes the data on average values of Ultrasonic, Acoustic and Elastic Parameters of diabetic blood and its constituents. Ultrasonic velocity,absorption coefficient,modulus of elasticity and loss modulus were determined at different frequency ranges and tabulated.

Table.3: Data on Average values of Ultrasonic, Acoustic and Elastic Parameters of diabetic blood and its constituents.

Sample Code	Frequency, υ (MHz)	Wave length	Ultra sonic Velocity m/s	Absorption co-efficient, α (cm^{-1})	Modulus of Elasticity, M^1 ($\times 10^{11 dyne/cm2}$)	Loss Modulus, M^{11} ($\times 10^8$ cm2/dyne)
DB	1	0.1565	1565	0.048	0.149	0.035
	2	0.0806	1612	0.044	0.158	0.178
	3	0.0554	1663	0.040	0.168	0.118
	5	0.0352	1757	0.003	0.188	0.063
	10	0.0184	1840	0.017	0.206	0.020

Sample Code	Frequency, υ (MHz)	Wave length	Ultra sonic Velocity m/s	Absorption co-efficient, α (cm^{-1})	Modulus of Elasticity, M^1 ($\times 10^{11 dyne/cm2}$)	Loss Modulus, M^{11} ($\times 10^8$ cm2/dyne)
DP	1	0.1506	1506	0.067	0.136	0.044
	2	0.0780	1560	0.042	0.146	0.153
	3	0.0528	1577	0.027	0.149	0.0678
	5	0.0337	1685	0.025	0.171	0.0517
	10	0.0179	1792	0.020	0.193	0.022

Sample Code	Frequency, υ (MHz)	Wave length	Ultra sonic Velocity m/s	Absorption co-efficient, α (cm^{-1})	Modulus of Elasticity, M^1 ($\times 10^{11 dyne/cm2}$)	Loss Modulus, M^{11} ($\times 10^8$ cm2/dyne)
DE	1	0.1640	1640	0.049	0.183	0.047
	2	0.0753	1664	0.043	0.188	0.0183
	3	0.0551	1671	0.030	0.190	0.01006
	5	0.0345	1727	0.027	0.203	0.006
	10	0.0178	1783	0.020	0.216	0.002

IV. RESULT AND DISCUSSION

The average values of elastic and acoustic parameters of blood at different frequencies and for the same parameters for Plasma and 90% of erythrocytes normal blood and Diabetic blood at different frequencies are presented in table1, table2, and table 3. Respectively. The ultrasonic velocity is determined for water for different frequencies and found there is no variation . But there is a significant variation observed in the case of absorption coefficient, modulus of elasticity and loss modulus of blood as shown in the tables.

V. CONCLUSION

For Newtonian liquids like water , the velocity is independent for different frequencies and thus the velocity is almost constant for water. But from the present study the observations are made that for Non-Newtonian or Viscoelastic fluids like blood there is a significant change in the values. The velocity increases with the increase of frequency. The coefficient of absorption decrease with increases of frequency. The modulus of elasticity increases with the increase of frequency and loss modulus decreases.

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