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DIELECTRIC PROPERTIES OF HUMAN BLOOD OF PATIENTS SUFFERING FROM IRON DEFICIENCY ANEMIA

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Abstract: The paper reports dielectric properties of anemic blood and its 90% packed cells and plasma. Dielectric parameters such as dielectric constant, dielectric loss and electrical conductivity are measured at the frequency of 1 kHz. It is found that the values of dielectric constant, dielectric loss and electrical conductivity are high in plasma and low in 90% packed erythrocytes and in between whole blood. The study reveals that there is a significant variation in dielectric parameters, possibly due to the cellular concentration and also the variation in hemoglobin percentage.

Keywords: Human blood, Hemoglobin, Dielectric properties, LCR meter, Conductivity meter, Plasma, 90% packed cells.

1. Introduction

Blood consists of fluid plasma in which corpuscles called erythrocytes, leukocytes and platelets are suspended. The erythrocytes, in the great majority, are concerned with transport of oxygen from the lungs to all parts of the body and they send back carbon dioxide. The leukocytes are broadly concerned with protective functions. Hence blood is described as fluid of life.

Amy Zhu et al [1] reported that Occult GI bleeding remains the most common cause of IDA in the adult male and postmenopausal female populations. Trends of laboratory indices and the serum ferritin, especially when a higher upper limit of normal is used, are extremely helpful in the diagnosis of IDA. Alison et al [2] studied dielectric properties of human blood at microwave frequencies. Schwan [3] investigated electrical properties of biological cells and tissues at very low frequencies and discussed the mechanisms responsible for such properties. Schwan [4] analysed the dielectric data of biological material obtained from advanced dielectric techniques. He proposed three major and distinct relaxation effects, which characterize the total dielectric response from DC to GHz and several minor ones are superimposed. Perhar et al [5] reported that iron deficiency is a common cause of anemia worldwide. They concluded that iron deficiency is more than a hematological disorder and

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affects various other body organs. Recently Ateeba et al [6] studied dielectrodynamically the blood of patients suffering from iron deficiency anemia. The K_e spectra exhibited peaks at about 5 MHz for anemia, while 4 MHz in the case of normal blood. Further, K_e values were less in anemia when compared to that of normal irrespective of frequency of applied electric field.

2. Materials and Methods

The collection and handling of a sample are an integral part of obtaining valid results. Blood samples were obtained from anemic patients from Ayesha diagnostic centre, Hyderabad. Here, a disposable plastic syringe was used to draw venous blood. Blood was collected in blood collection tubes with anticoagulant Ethylene di Amine Tetra Acetate (EDTA) and were inverted gently as soon after collection as possible to prevent clotting. The blood samples were brought to the laboratory keeping them in ice cooled thermos. The samples were kept in refrigerator at 4^oC until used. Investigations were made within two to three hours after collection. The blood samples were centrifuged at the rate of 3000 rpm for five minutes. The plasma was separated, while residue contains 90% packed RBC.

To study dielectric behavior of anemic blood and its constituents, the dielectric parameters such as dielectric constant, dielectric loss were determined at the frequency of 1 kHz, using digital LCR meter (Systronics - 925). The electrical conductivity was measured using digital conductivity meter (Digisun - 909). A standard conductivity cell was used for dielectric studies of blood and its constituents.

The dielectric constant, dielectric loss and conductivity were calculated using the formulae given below.

Dielectric constant, $\in' = \frac{C_s}{C_a} = \frac{(C_s' - C_L)}{(C_a' - C_L)}$

where C_s: Actual capacitance of the cell with sample; C_L: Lead capacitance; C_a: Actual capacitance of the cell with air; C_s' : Measured capacitance of the cell with sample; C_a' : Measured capacitance of the cell with air i.e., without sample.

Dielectric loss, $\in'' = \in' \tan\delta$,

where $\in'$ is the dielectric constant and tan δ is the dissipation factor.

Electrical Conductivity, $k = \frac{GL}{A}$

where G: Conductance; L: Distance between the plates of the cell; A: Area of the plates.

3. Results and Discussion

The data on dielectric constant, dielectric loss and electrical conductivity of iron deficiency anemic blood, its plasma and 90% packed RBC, when measured at the frequency of 1 kHz, is tabulated in Table 1. The table also gives values of hemoglobin of blood drawn from anemic patients, which is ranging from 6.6 $gm.dl^{-1}$ to 8.9 $gm.dl^{-1.}$ The hemoglobin values are less than the normal range.

It is evident from Table 1, in the case of anemic blood, that the values of dielectric constant, dielectric loss and conductivity are high in plasma; low in 90% packed erythrocytes and in between whole blood (plasma + RBC). The study reveals that the significant variation in dielectric parameters could be attributed to the cellular concentration and also due to the presence of erythrocyte membrane, which separates the cell interior (hemoglobin) and cell exterior (plasma). Hence, it is the cell membrane, which characterizes the electrical properties of most biologically important tissue –the blood.

Table 1: Dielectric data on anemic blood and, its plasma and erythrocytes

Hb (gm/dl)	Plasma			90% Packed Erythrocytes			Blood		
	ε' ($x10^6$)	ε'' ($x10^6$)	k (m.mho/cm)	ε' ($x10^6$)	ε'' ($x10^6$)	k (m.mho/cm)	ε' ($x10^6$)	ε'' ($x10^6$)	k (m.mho/cm)
6.6	1.93	17.07	0.74	1.17	19.08	1.52	1.76	15.61	2.14
6.7	2.21	19.46	0.62	1.25	15.28	1.32	1.74	17.00	2.24
7.0	1.92	17.79	0.93	0.47	9.12	0.14	1.13	10.72	0.67
7.5	2.17	21.06	0.80	0.79	11.03	0.50	1.46	16.15	0.70
7.9	2.09	18.66	0.68	1.08	15.08	0.31	1.52	16.70	0.40
8.0	2.09	18.66	0.68	0.65	10.14	0.30	1.31	14.23	0.49
8.3	2.18	20.51	0.78	1.07	12.91	0.47	1.73	18.64	0.66
8.3	1.58	15.69	0.78	0.80	11.62	0.50	1.46	16.54	0.76
8.3	2.00	20.84	0.61	1.04	13.33	0.47	1.19	14.63	0.52
8.9	1.98	18.28	0.75	0.94	13.60	0.44	1.57	16.49	0.61

Figs 1-3 show the plots between percentage of Hemoglobin and dielectric parameters such as dielectric constant, dielectric loss and electrical conductivity of plasma, 90% packed erythrocytes and whole blood of different patients suffering from iron deficiency anemia. Dielectric constant, dielectric loss and electrical conductivity of blood plasma are more or less same with the increase in hemoglobin content. The reason may perhaps be the non-availability of erythrocytes in turns hemoglobin in pure plasma. But in the case of 90% packed cells and whole blood, dielectric parameters are minimum at about 7 – 7.5% of hemoglobin content in blood. The low value of R^2 is because of different anemic patients

under study. In conclusion, hemoglobin content influences significantly the dielectric parameters of blood and its constituents.

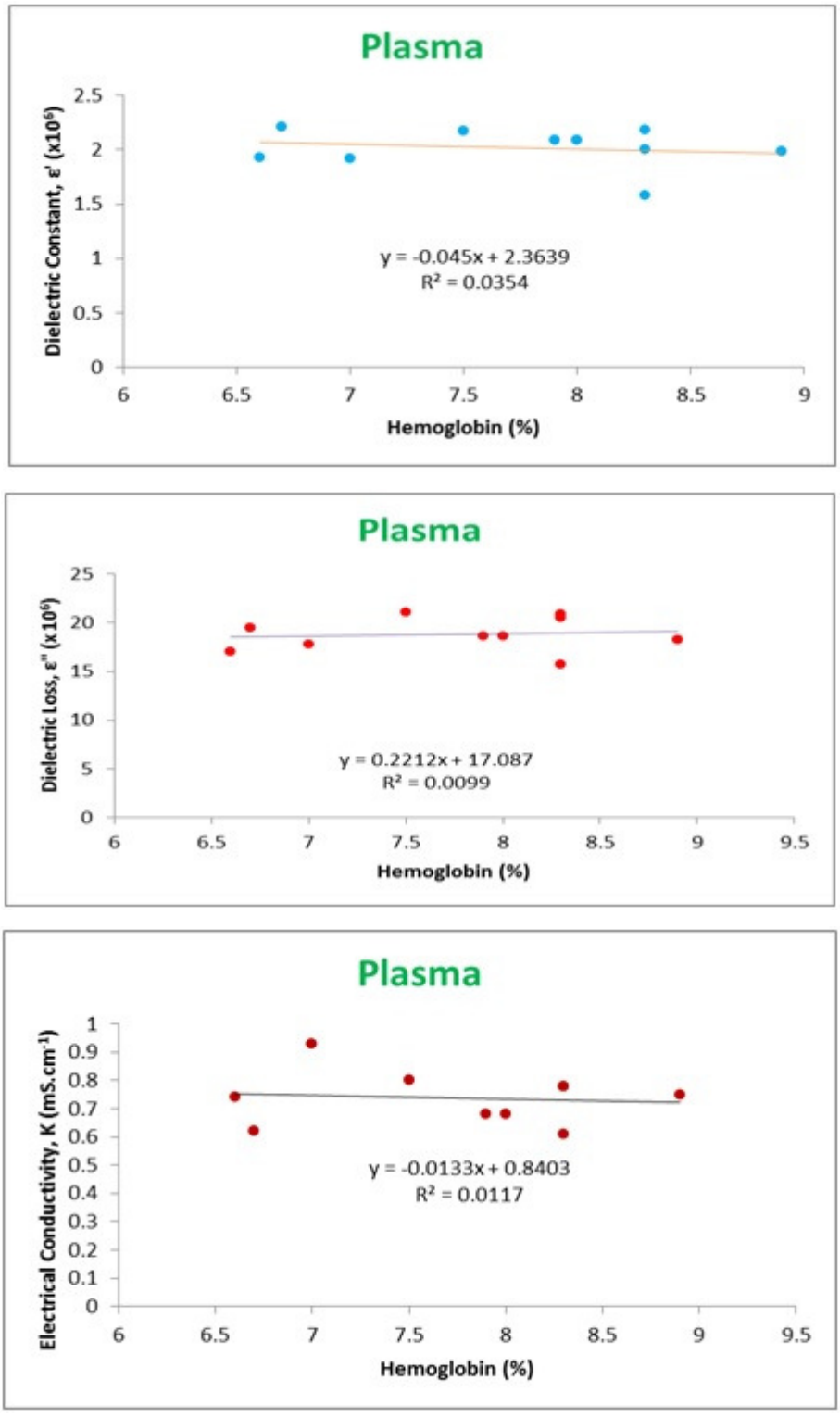
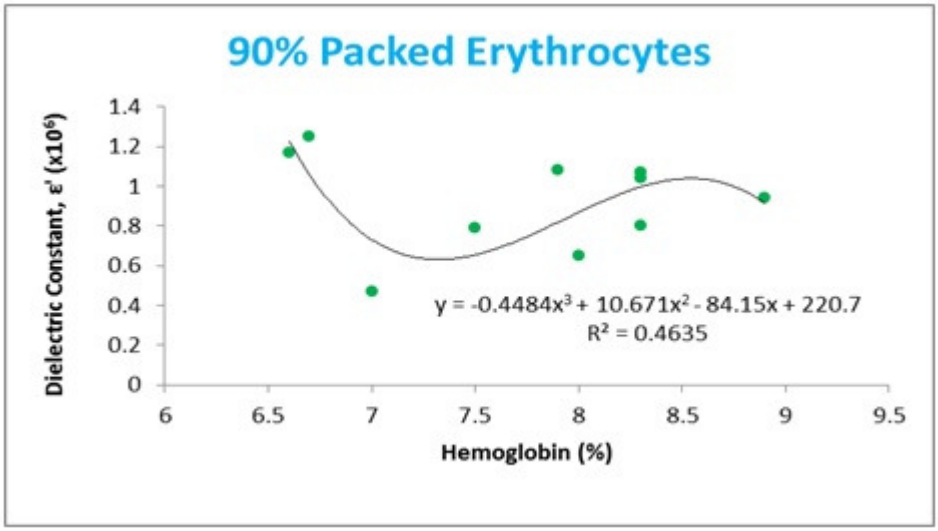
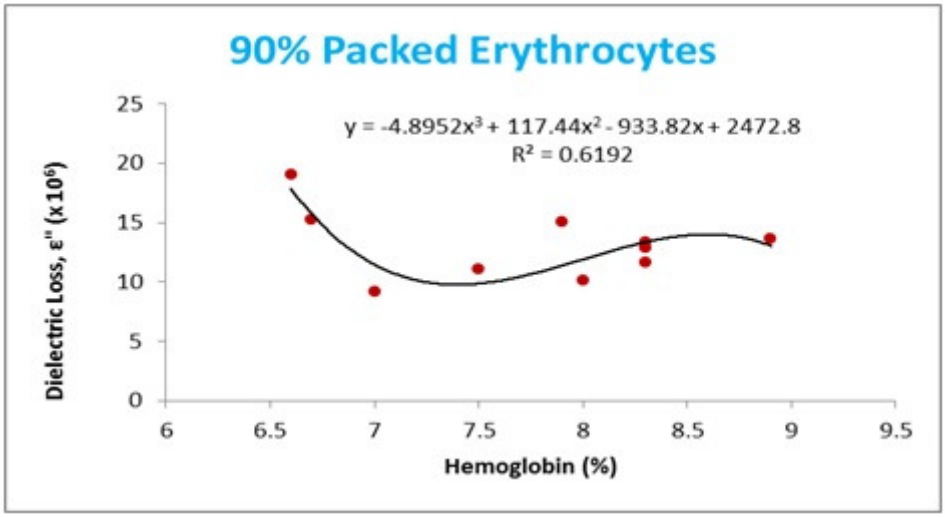


Fig. 1. Plots between dielectric parameters and percentage hemoglobin of plasma of iron defeciency anemic human blood of different anemic patients





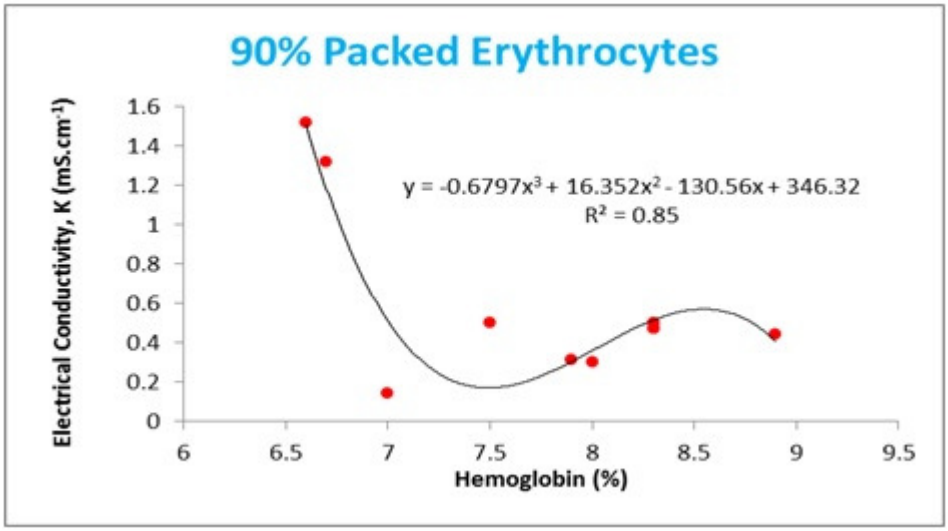


Fig. 2. Plots between dielectric parameters and percentage hemoglobin of of 90 % packed erythrocytes of iron defeciency anemic human blood of different anemic patients

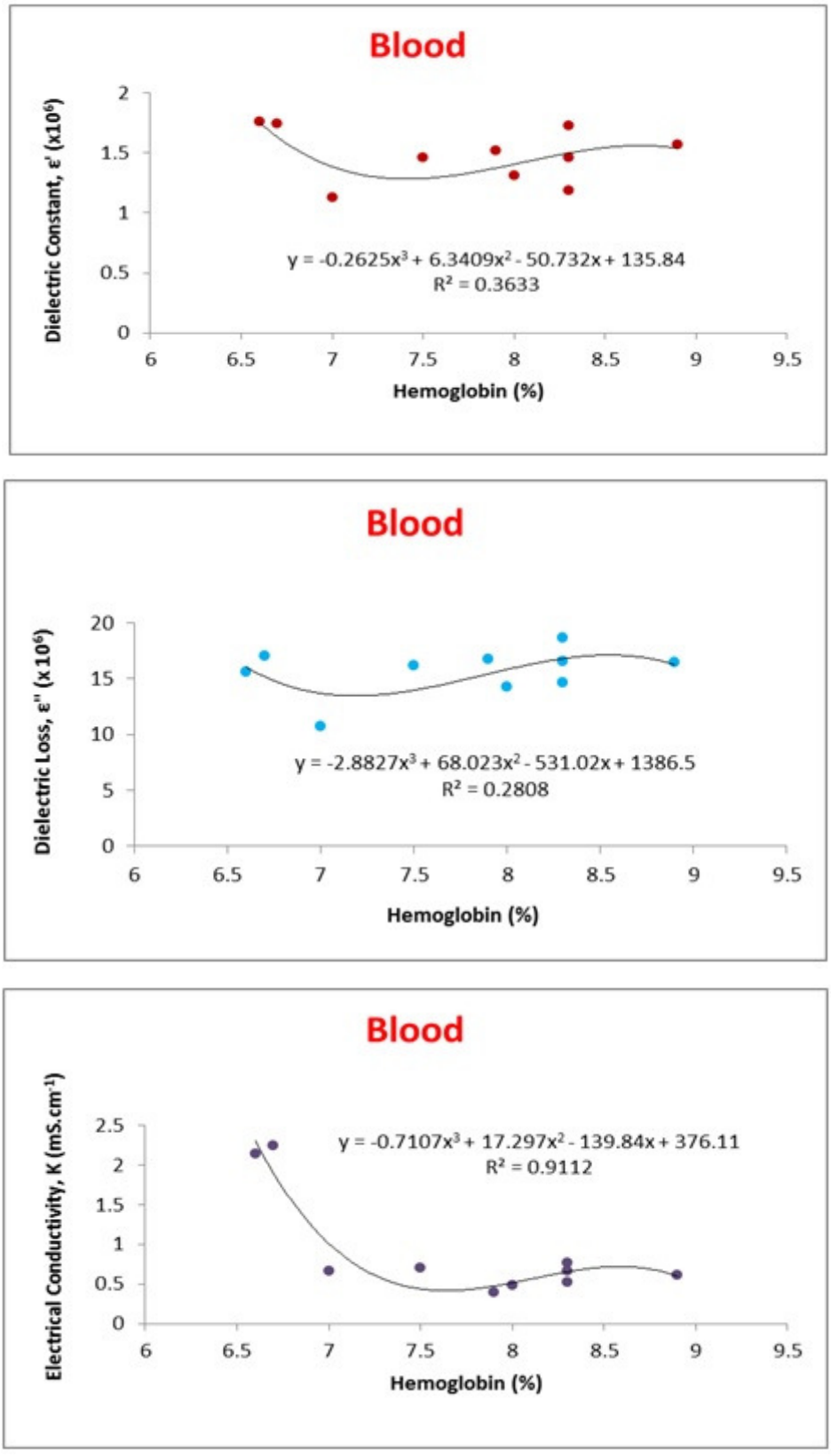


Fig. 3. Plots between dielectric parameters and percentage hemoglobin of iron defeciency anemic human blood of different anemic patients

References

[1] Amy Zhu, Marc Kaneshiro and Jonathan D. Kaunitz, Biomed. Engg., Vol. 55, No. 3 (2010), pp. 548–55.

[2] J M Alison and R J Sheppard, Phys. Med. Biol. Vol. 38(1993), pp. 971– 978.

[3] H P Schwan, Trans. Elec. Insulation, Vol. 120, No. 6(1985), pp. 913.

[4] H P Schwan, Stud. Bio. Phys, Vol. 110(1985), pp. 915.

[5] Perhar, R Shukla, N. Mishra, PARIPEX, Vol. 4 (2015), pp. 100 - 103.

[6] Ateeba Shazi, S. Chandra Lingam and Adeel Ahmad Int. J. Sci. Env. Tech., Vol. 4, No. 6 (2015), pp. 1633 – 1639.