

# Dielectric Properties of Malaria Parasite Infected Human Blood

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**ABSTRACT:** The paper reports dielectric properties of malaria parasite infected human blood. The malaria parasites under study are *Plasmodium vivax* and *Plasmodium falciparum*. Dielectric parameters such as dielectric constant, dielectric loss and electrical conductivity of malaria infected blood are measured *in vitro* at the frequency of 1 kHz. It is found that the values of dielectric constant, dielectric loss and electrical conductivity are high in malaria parasite infected blood, when compared to normal 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:** Malaria; *Plasmodium vivax*; *Plasmodium falciparum*; Dielectric parameters; 1 kHz frequency; LCR meter; Human blood.

## I. INTRODUCTION

Malaria is an infectious disease and one of the most widespread afflictions of mankind. Malaria is caused by one of four types of protozoa, *Plasmodium falciparum*; *Plasmodium vivax*; *Plasmodium ovale* and *Plasmodium malariae*. All forms are transmitted only by the bite of female anopheles mosquitoes, and humans are the only natural reservoir. Rajendra Kumar et al [1] investigated the heat shock protein (Hsp-90) of *Plasmodium falciparum* and antimalarial activity of its inhibitor - geldanamycin and suggested that an active and essential Hsp-90 chaperone cycle exist in plasmodium and the favourable pharmacology of benzoquinone ansamycin compound.

## II. RELATED WORK

Warhurst et al [2] studied the relationship of physicochemical properties and structure of the differential antiplasmodial activity of the cinchona alkaloids and examined ionization constant, water distribution and haematin interaction for eight alkaloids to explain the influence of small structural differences on activity.

Shiff [3], Najera [4] and Hyde [5] focused on finding a potent and reliable anti parasitic drug that would inhibit plasmodium infection and growth and suggested that in nearly all the malarial endemic populations, plasmodium has developed resistance against the Hall mark drug chloroquine and its derivatives.

Mohammed Gulam Ahmad et al [6] studied various viscometric parameters, such as velocity, volume flow rate and viscosity of malarial blood and suggested that the viscosity is high and velocity and flow rate are reduced.

Al-Omar et al [7] investigated the level of parasitaemia and its correlation with cholesterol level and platelet count in malaria patients. They concluded that low levels of cholesterol and platelets in malaria patients provided basis for the possible use of such clinical data in the diagnosis of malaria in the absence of a positive blood film.

Amar Alansi [8] measured size of erythrocytes of the blood infected with malaria parasites using the technique of laser diffraction and reported significant increase in diameter of erythrocytes in comparison with the normal blood.

Fedosov et al [9] studied biophysical characteristics of RBCs infected with *Plasmodium falciparum* parasite by three-

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dimensional mesoscopic simulations of flow in cylindrical capillaries in order to predict the flow resistance enhancement at different parasitemia levels. In addition, they explored the adhesive dynamics of Pf-RBCs for various parameters revealing several types of cell dynamics such as firm adhesion, very slow slipping along the wall, and intermittent flipping. Further, the parasite inside the RBC was modeled explicitly in order to capture phenomena such as *hindered tumbling* motion of the RBC.

Peter Gascoyne et al [10] compared dielectrophoretic properties of normal erythrocytes to those of cells infected with the malarial parasite *Plasmodium falciparum*. Normal cells provided stable electro rotation spectra which, when analyzed by a single-shelled oblate spheroid dielectric model. They concluded that the large differences between the dielectrophoretic crossover characteristics of normal and parasitized cells should allow straightforward sorting of these cell types by dielectrophoretic methods.

Acetiet al [11] investigated the effects of quinine treatment on membrane conductivity of erythrocytes infected with *Plasmodium falciparum*. They reported that the conductivity of erythrocyte membranes from blood samples collected before treatment with quinine was significantly higher than that of normal erythrocytes. Also, after initiation of chemotherapy, there was a marked reduction in conductivity to values below those of normal cells. They concluded that quinine reduces ion transport across the infected membrane and that this may make the cellular environment unfavourable for *P. falciparum* replication.

Ibrahim et al [12] reviewed a number of non – invasive biomedical engineering approaches such as ultrasound, echocardiography and electrocardiography, bioelectrical impedance, optical detection etc. to help in the detection and treatment of tropical diseases such as dengue, malaria, cholera, schistosomiasis, lymphatic filariasis, ebola, leprosy, leishmaniasis, and American trypanosomiasis (Chagas). Also, reviewed the novel clinical diagnosis and management systems using artificial intelligence and bioelectrical impedance techniques for dengue clinical applications.

Mohammad Ali Safavieh et al [13] investigated the dielectrophoretic response of B cells infected with Kaposi's sarcoma-associated herpesvirus (KSHV) and compared to uninfected B cells. They evaluated the effect of applied voltage, signal frequency, and flow rate of the sample on the cell capture efficiency. Their results showed that latently infected B cell lines demonstrated significantly different electrical response compared to uninfected B cells and DEP-based microchips can be potentially used for sorting latently infected cells based on their electrical properties

### III. MATERIALS AND METHODS

Fresh samples of normal human blood of volume nearly 2 ml were collected from healthy donors at Ayesha Diagnostic Centre, Hyderabad. The blood samples from the patients suffering from malaria were collected from Govt. Fever Hospital, Hyderabad. The normal and diseased blood samples were transferred to siliconized glass bottles kept in a non-conducting flask. Ethylene di Amine Tetra Acetic Acid (EDTA) was used as anticoagulant at the rate of 30µl per 2 ml of blood sample. The collected blood samples were stored at about 10°C until use and all measurements were completed within 2 to 3 hours.

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. The malaria parasites of infected blood under study are *Plasmodium vivax* and *Plasmodium falciparum*.

### IV. RESULTS AND DISCUSSION

Fig. 1 depicts bar graphs that compares dielectric constant of human blood infected with malarial parasites - *Plasmodium vivax* and *Plasmodium falciparum* with those of normal blood drawn from healthy donors. It is to be noted that dielectric constant of malaria parasite infected blood is more than that of normal blood. But, the presence of the parasite *Plasmodium vivax* increases dielectric constant of the blood more significantly than the parasite *Plasmodium falciparum*.

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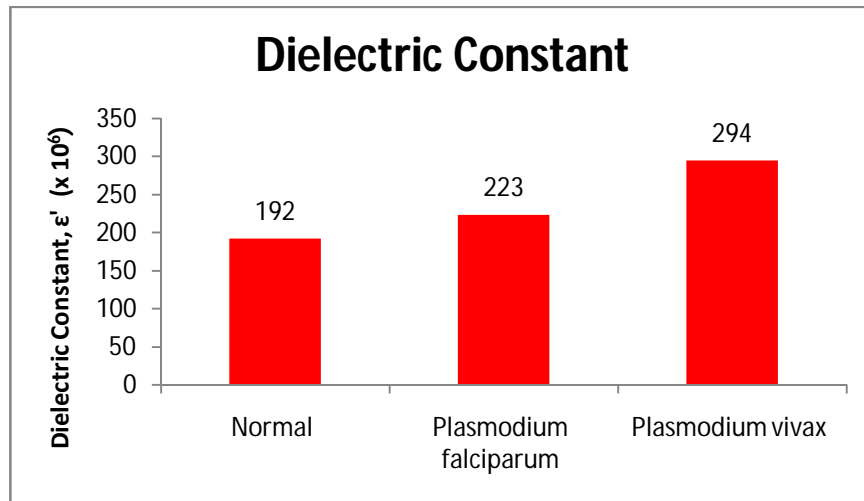


Fig.1. A comparison of dielectric constant of normal and malaria infected human blood

Fig. 2. shows bar graphs, which compares dielectric loss of malaria infected blood with the parasites *Plasmodium vivax* and *Plasmodium falciparum* with normal blood. Dielectric loss is also more in infected blood than the normal blood. The blood infected with *Plasmodium vivax* shows high dielectric loss in comparison with *Plasmodium falciparum* infected blood.

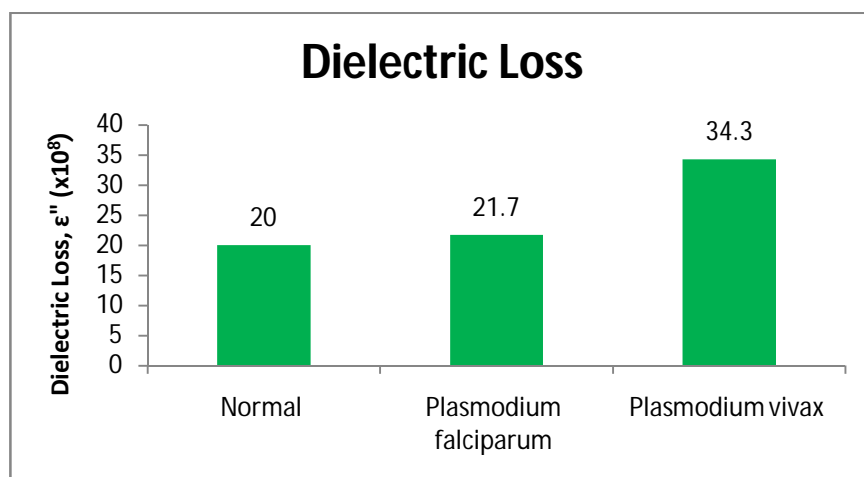


Fig.2. A comparison of dielectric loss of normal and malaria infected human blood

Fig. 3. presents bar graphs of electrical conductivity for normal and the blood infected with two types of malarial parasites. Electrical conductivity is high in infected blood compared to normal blood. But the conductivity is more in *Plasmodium vivax* infected blood than that of the blood infected with *Plasmodium falciparum*.

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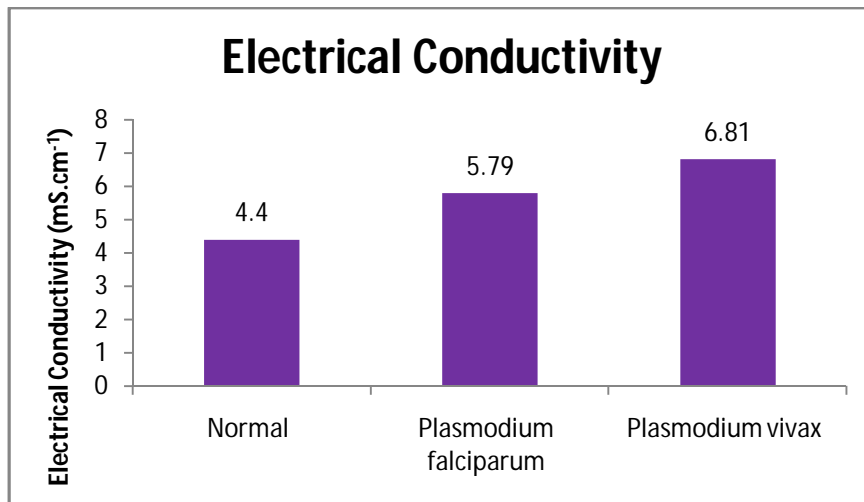


Fig.3. A comparison of electrical conductivity of normal and malaria infected human blood

This dielectric behavior can perhaps be attributed to decrease in cell concentration in turn hemoglobin content. Further, perturbation and alteration in capacitance and as well as conductance of the erythrocyte membrane may influence electrical makeup of the blood, when infected with malarial parasites like *Plasmodium vivax* and *Plasmodium falciparum*.

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