The International Journal Of Engineering And Science (IJES)
|| Volume || 3 || Issue || 8 || Pages || 35-38 || 2014 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

# The Effect of Gamma Irradiation on the Radiofrequency Dielectric Dispersion Properties Of Bovine Blood.

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**ABSTRACT**

*The influence of gamma irradiation on the beta dispersion properties of bovine blood has been investigated. The dielectric permittivity, a. c conductivity, relaxation time and spread parameter were determined in the frequency range 0.5MHz to 50.0MHz using gamma irradiation facility (GS 1000), Boonton (7200) impedance meter, Dielectric cell and Signal Generator ( SG 4160). The irradiation doses ranged from 0 Gy to 85 Gy. The result of the investigation revealed that the damage done to the irradiated blood samples increased with gamma irradiation dose.*

***KEY WORDS**: Beta- dispersion, Blood, Gamma radiation, Relaxation time and permittivity.*

Date of Submission: 27 September 2013 Date of Publication: 05 August 2014

## I. INTRODUCTION

Gamma (ɤ)-radiation live other ionizing radiations are fairly energetic and produces a number of physical chemical and Biological effects when they interact with biological matter (Burshberg, 2002). Gamma rays are emitted from the nucleus of an atom following intra-nuclear energy transition from nuclear de-excitation process during radioactivity (Cember, 1978; Hallet et al, 2003). They can also be produced in annihilation reaction between matter and anti-matter (Delaney and Finch, 1992).When interaction occurs between gamma photon and an electron in tissue all or part of the photon energy is transferred to one or more electrons in the tissue. The energy deposited per unit mass of the tissue is very useful quality for the prediction of biological effects (Johns and Cunningham,1993). The biological damage created by ionizing radiation such as gamma rays is traceable to the chemical alteration of the biological molecules that are influenced by the ionization or excitation caused by radiation (Knoll, 1999).

The severity and permanence of these changes are directly related to the rate of energy deposition along the particle track known as Linear Energy Transfer (LET). Radiations with large values of LET ( e .g heavy charged particles ) tend to cause greater biological damage than those with lower LET (e .g electron) Knoll (1999). The three major interactions mechanism between gamma radiation and electrons are photoelectric effect, Compton effect and pair production. The resultant effect of these mechanisms is the production of secondary electrons which interact to produce free radicals or complex ions in the exposed biological tissues (Jozanov-stankov, 2003). Such reactive ions interfere with the chemical functions of the cell. Some of the induced bio-effects include; mutation of genes, induction of cancer and other forms of somatic effects, even death at higher doses (UNSCEAR, 1993; Roger, 2006, Russel and Bradley, 2007; and Edward , 1992). Recent researches also reported that exposure of human blood to ionizing radiation causes reduction of PVC .One third by weight of red blood cells is due to its haemoglobin content, the rest being chiefly water (Haris, 1963; Laogun et al, 1983). The Haemoglobin performs the vital function of carrying oxygen from the lungs to the tissues and facilitates the transport of carbon dioxide from the tissues to the lungs. The dielectric permittivity of red blood cells has been found to depend on the haemoglobin, water content, temperature and frequency (Schwan, 1966; Grant et al; Laogun et al, 1983). Since the permittivity of biological tissues depends on the integrity of the cells in the tissues, changes in the integrity of the tissue cells can be inferred from dielectric dispersion at radiofrequencies. Changes in dielectric properties of tissues after irradiation may also reflect the particular biological organization of tissues and some mechanisms of radiation damage to tissues. Changes in dielectric properties of tissues after irradiation may reflect the particular biological organization of tissues and some mechanisms of radiation damage to tissues.

## II. METHODOLOGY

Blood samples were collected from a certified adult white Fulani cow by vein puncture using a 10ml hypodermic needle attached to a disposable plastic syringe. The samples were introduced into heparinised tubes to prevent coagulation. Details about the gamma irradiation procedure is reported elsewhere (Agba et al, 2004). The gamma irradiation (Gs 1000) at the Gamma Irradiation facility (GIF) unit of National Nuclear Technology Center, Abuja was used for irradiation of the bovine Blood samples at the dose rate of 0.36 kGy/hr. The gamma irradiation doses ranged from 0 Gy to 85 Gy. Dielectric parameters were obtained using Booton (7200 ) capacitance meter and dielectric cells.

## III. RESULTS AND ANALYSIS

**Table 1: The a.c conductivity of ɤ-irradiated and non-irradiated bovine blood samples from frequency range 0.5MH$_Z$ to 50.0MH$_Z$**

| Conductivity (µS/m) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (KHz) / Dose (Gy) | 0.5 | 1.0 | 2.0 | 5.0 | 10 | 20 | 30 | 40 | 50 |
| 0 | 724.6±15.6 | 740.8±86.7 | 738.0±27.8 | 778.3±38.9 | 813.0±64.4 | 877.3±18.9 | 862.1±28.6 | 934.5±46.5 | 1015.3±55.2 |
| 1 | 738.0±54.3 | 751.9±68.2 | 751.9±57.8 | 809.8±72.1 | 813.0±37.5 | 892.9±64.2 | 975.5±38.0 | 992.6±61.8 | 1052.6±35.8 |
| 4 | 770.0±55.3 | 790.9±48.0 | 793.9±59.1 | 809.8±28.7 | 894.0±40.2 | 909.1±38.6 | 1020.4±48.1 | 1041.7±64.3 | 1075.5±68.2 |
| 11 | 800.1±27.4 | 809.8±42.8 | 813.0±46.2 | 837.6±38.1 | 934.9±29.7 | 975.7±38.2 | 1036.3±77.4 | 1052.8±58.1 | 1149.4±56.2 |
| 20 | 847.5±37.4 | 917.4±27.8 | 921.7±28.1 | 943.4±31.4 | 970.9±27.6 | 980.4±37.5 | 10.36.5±54.8 | 1064.4±66.1 | 1173.0±36.0 |
| 43 | 885.0±61.3 | 934.6±11.0 | 934.7±36.7 | 986.4±32.1 | 1000.4±42.4 | 1070.0±68.1 | 1081.2±74.1 | 1081.2±68.8 | 1262.3±59.2 |
| 60 | 934.5±34.2 | 1025.7±79.2 | 1030.9±49.2 | 1030.9±71.4 | 1110.7±92.1 | 1151.9±26.8 | 1174.5±77.2 | 1196.6±49.8 | 1411.5±34.7 |
| 85 | 1000.4±68.2 | 1041.7±35.6 | 1047.2±73.4 | 1047.2±24.3 | 1151.3±43.4 | 1211.2±68.4 | 1219.7±81.6 | 1264.0±48.0 | 1296.9±106.3 |

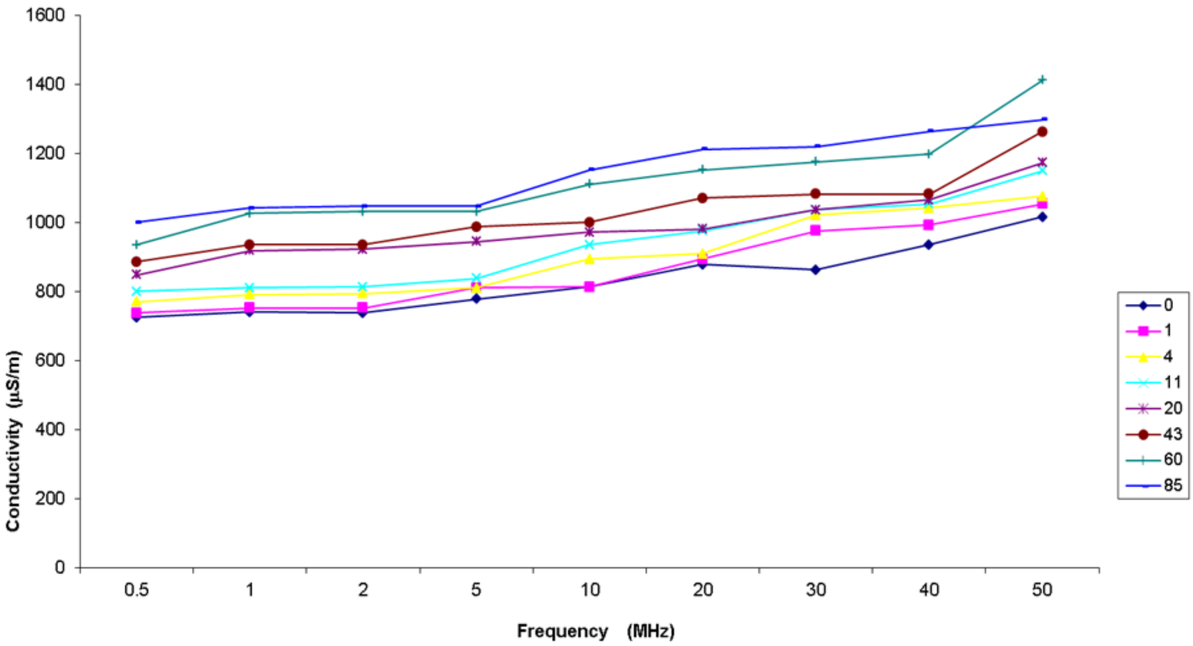


**Figure 1: The mean a.c Conductivity of ɤ-irradiated and non-irradiated bovine Blood from frequency range 0.5MHz to 50.0MHz**

**Table 2: The mean permittivity of ɤ-irradiated and non-irradiated bovine blood tissue from frequency range 0.5MH$_Z$ to 50.0MH$_Z$**

| | Permittivity | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (KH$_Z$) / Dose (Gy) | 0.5 | 1.0 | 2.0 | 5.0 | 10 | 20 | 30 | 40 | 50 |
| 0 | 3246.3±23.8 | 3151.0±54.2 | 3103.4±76.0 | 3071.6±44.2 | 2722.4±87.3 | 2021.5±81.9 | 1783.3±33.2 | 1688.3±63.7 | 1468.5±68.1 |
| 1 | 3055.8±44.8 | 2960.6±83.0 | 2881.1±25.1 | 2849.4±65.2 | 2516.1±70.9 | 1897.0±98.7 | 1592.9±79.6 | 1468.5±47.0 | 1579.6±40.7 |
| 4 | 2746.5±38.0 | 2690.7±76.2 | 2659.0±35.7 | 2627.2±96.1 | 2436.7±48.7 | 1976.4±74.2 | 1531.9±69.2 | 1402.4±22.6 | 1325.6±39.6 |
| 11 | 2182.8±64.3 | 2135.1±58.6 | 2087.5±29.1 | 2039.9±72.8 | 2021.5±54.8 | 1672.3±88.2 | 1262.1±71.0 | 1103.4±68.2 | 1071.7±54.3 |
| 20 | 1881.2±62.4 | 1801.8±42.1 | 1785.9±88.2 | 1674.8±68.6 | 1640.5±61.9 | 1452.6±74.1 | 1182.7±76.8 | 1008.2±80.2 | 944.7±55.0 |
| 43 | 1532.0±38.2 | 1389.1±48.5 | 1293.9±73.2 | 1182.8±40.7 | 1135.1±38.5 | 1071.7±72.1 | 976.4±89.9 | 865.3±98.6 | 770.0±88.1 |
| 60 | 1278.0±97.5 | 1246.2±86.7 | 1119.3±72.8 | 992.3±39.8 | 928.8±44.6 | 833.6±87.5 | 770.1±90.0 | 674.8±28.6 | 627.1±54.3 |
| 85 | 1135.1±89.7 | 1055.8±77.4 | 1024.0±61.9 | 944.7±28.1 | 849.4±52.9 | 738.3±47.8 | 706.7±81.4 | 643.1±56.6 | 595.4±22.4 |

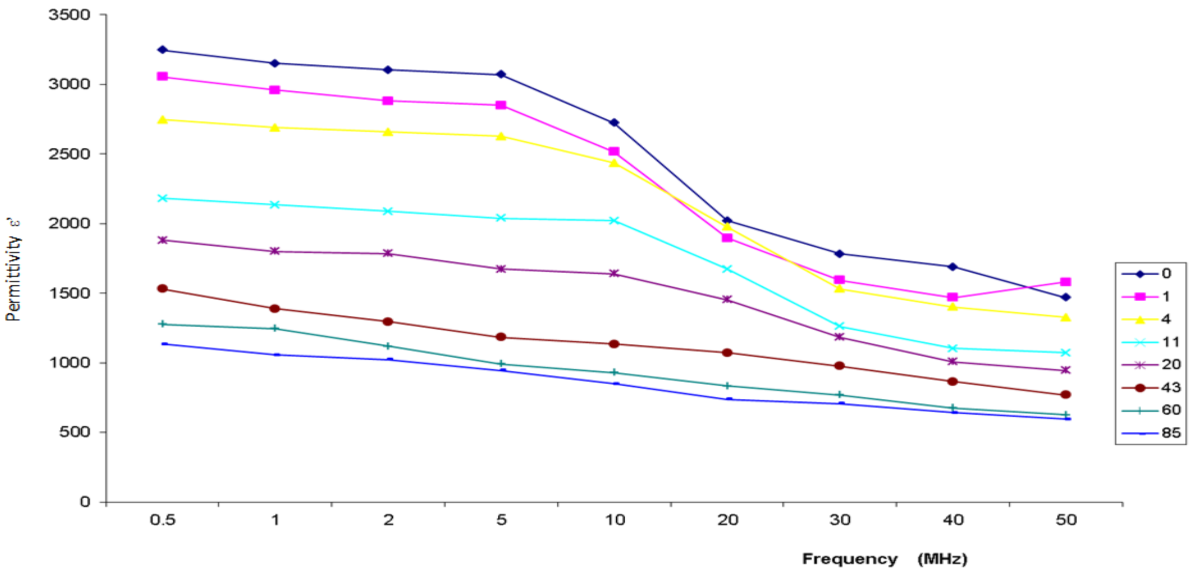


**Figure 2: The mean Permitivity ε' of ɤ-irradiated and non-irradiated Bovine Blood from frequency range 0.5MHz to 50.0MHz**

**Table 3: Dielectric parameter obtained from Dielectric Dispersion and Cole-cole for gamma irradiated and non-irradiated Bovine Blood.**

| Dose (Gy) | $\varepsilon_s$ | $\varepsilon_\infty$ | $\Delta$ $(\varepsilon_s - \varepsilon_\infty)$ | τ(µs) | $\alpha$ |
|---|---|---|---|---|---|
| 0 | 3246.3±230 | 1468.5±198 | 1777.8±230 | 0.132±0.004 | 0.100±0.001 |
| 1 | 3055.8±234 | 1468.5±105 | 1567.3±234 | 0.132±0.004 | 0.105±0.001 |
| 4 | 2746.5±176 | 1325.6±083 | 1420.9±176 | 0.132±0.004 | 0.106±0.002 |
| 11 | 2182.8±100 | 1071.7±045 | 111.1±100 | 0.122±0.002 | 0.106±0.002 |
| 20 | 1881.2±122 | 944.7±078 | 936.5±122 | 0.113±0.002 | 0.104±0.001 |
| 43 | 1532.0±098 | 770.0±070 | 762.0±098 | 0.113±0.002 | 0.157±0.005 |
| 60 | 1278.0±110 | 627.1±067 | 650.9±110 | 0.099±0.001 | 0.227±0.011 |
| 85 | 1135.1±135 | 595.4±081 | 539.7±135 | 0.098±0.001 | 0.223±0.005 |

## IV. DISCUSSION

The dielectric permittivity ε' of the irradiated tissue is found to be smaller than those of the non-irradiated blood samples . The permittivity decreased as gamma-irradiation doses increased. Since the permittivity ε' values of tissue depends on the charging and integrity of cell membranes, the observed decrease in the permittivity ε', following the gamma irradiation tissue may be attributed to the changes in the integrity and structure of the components of the cellular membranes along with the reduction in the Maxwell-Wagner, interfacial polarization effects responsible for the permittivity values at radiofrequency. The increase in dielectric loss factor ε'' with gamma irradiation doses can be attributed to more ionization produced in the tissues as the gamma irradiation dose increase. This in turn would contributed more polarized charges thereby increasing the movement of polarizable charges in the electric field.The reduction in the dielectric decrement Δ, following gamma irradiation of bovine blood follows naturally from the decrease in the permittivity of the irradiated tissue. The irradiated bovine blood have larger relaxation distribution or spread parameter $\alpha$, than their non-irradiated (Control) tissues. The ionizations produced in the irradiated tissues may have increased the heterogeneous distribution of ions each of which may have its characteristics polarization time. This may explain the observe increase in the spread parameter $\alpha$ of the gamma irradiated bovine blood.

## V. CONCLUSION

The results of the dielectric dispersion parameters obtained in this work reveals that gamma irradiation doses usually encountered in diagnostic and therapeutic radiology has some influence on the mammalian blood. The effect is seen to increase with irradiation doses. The bovine blood samples were found exhibited more than a single relaxation time with the irradiated tissues displaying higher degree of heterogeneity than the non- irradiated blood samples. This also supports the assesion that ,the cole - cole model is a suitable model for explaining the structural relaxation properties of bovine tissues.

## VI. ACKNOWLEDGEMENT

We are grateful to Director General, Nigeria Atomic Energy Commission and the Director, Gamma Irradiation Facility, Nigeria Nuclear Technology Centre Abuja for irradiation our sample in the course of this research. We are also grateful to Department of Physics and Biology of Benue State University for making available the laboratories and equipment to use throughout the period of this research . thank you .

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