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COMPARITIVE STUDIES ON DIELECTRIC PROPERTIES OF HORN FROM DIFFERENT ANIMAL SPECIES

Abdul Gafoor Shaik[1] and Mohammed Abdul Aleem Siddiqui[2]

[1]Physics Unit, Department of Applied Science, Higher College of Technology, P.O Box 74, Al Khuwair, Postal code 133, Sultanate of Oman

[2]Physics Section, Department of Science, Humanities and Management, Deccan College of Engineering and Technology, Hyderabad – 500001, India

Abstract: The study of dielectric properties of macromolecules, cells and tissues of biological interest become part of the inter-disciplinary armory of the biological sciences. Advances in such studies certainly will benefit to some branches of medicine and bring a tremendous change in understanding biomedical applications. The current study reports the data on dielectric parameters such as dielectric constant, dielectric loss and resistivity of horns of the animals - Ox, Buffalo and Goat. For the dielectric measurements, a two terminal cell, constructed in Biophysics Laboratory, Nizam College, Hyderabad, was used. A significant variation in dielectric parameters is observed with respect to animal.

Keywords: Dielectric constant, Dielectric Loss, Resistivity, Ox, Buffalo, Goat, jig.

Introduction

The dielectric properties of matter are primarily of interest to the physicists and electrical engineers. These have also proved to be of importance and use in the understanding and development of other field knowledge, such as chemical and biological sciences. The study of dielectric properties of macromolecules, cells and tissues of biological interest become part of the inter-disciplinary armory of the biological sciences. Advances in such studies certainly will benefit to some branches of medicine.

Most of the soft tissues are flexible and highly elastic. In general their behavior is viscoelastic. In contrast, the hard tissues are more compact, rigid and less elastic and serve as endoskeleton and exoskeleton of the vertibrate body. Horn, contain both organic (keratin) and inorganic (calcium phosphate) materials. There exist considerable variation in the elastic parameters with respect to animal and tissue. The variation in the elastic parameters can be attributed to the degree of calcium phosphate deposition [1].

The physiological effects of electric currents had drawn the attention of the researchers in the 19th century. "Electrotherapy" came to be widely practiced by physicians. The early theories of Cole [2] and Danzer [3] for the dielectric properties of cell suspensions were further simplified and extended by Schwan and co-workers [4].

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Studies of dielectric properties of biological materials remain an active area of research. With the introduction of modern network analyzer and time domain measurement systems, the determination of dielectric properties of the biological samples is easier and this should encourage increased efforts in this field. Many opportunities exist and fundamental problems remain to be solved.

In earlier studies on dielectric properties of horns, certain spectroscopic techniques were employed for studying the organization of water in tendons, bones and horns. The measurement of dielectric loss and relative permittivity were carried out in the range of 10-100 MHz [5]. Dielectric measurements as a function of temperature and frequency were earlier reported for horn keratin. The measurements of dielectric constant epsilon' and loss factor epsilon", in horn keratin, were made in an electric field. The dielectric measurements were done in the frequency range 10^1-10^5 Hz and at temperatures from 22 to 220 degrees C. [6].

Today, work on dielectric properties of biological systems and their response to electric fields is being conducted at an increasing number of places. This work will surely provide new insights into how electrical fields can act on cells and tissues and will lead to beneficial applications of electric fields and currents. However, to get a deeper insight into the dielectric nature of the material, parameters like dielectric constant (ε'), dielectric loss (ε''), dissipation factor ($\tan\delta$) are needed.

In the present study a comparison has been made between dielectric properties of horns of ox, buffalo and goat. This paper will enlighten the application of dielectric measurements of horns.

Materials and method

Horns of ox, Buffalo and Goat were collected from slaughterhouse for present investigations. Specimens (pellets or discs) were cut from mid region of the horn.

For the dielectric measurements, a two terminal cell was constructed in Biophysics Laboratory, Nizam College, Hyderabad. The cell consists of two parallel circular plates made up of copper. The diameter and thickness of the plates are 2 cm and 0.2 cm respectively. The lower circular plate electrode plugs directly into the live terminal of the capacitance measuring bridge while the upper one, at earth potential is moved by means of a micrometer having least count 0.001 cm. This serves two purposes. One is to apply a slight pressure on the specimen placed between them and the other is to measure the separation of the plates or the thickness of the sample. To eliminate capacitance due to leads, the

capacitance (C_a) of the cell for different inter-electrode spacing (d) was measured. A plot is drawn between air capacitance on y-axis and 1/d on x-axis. The plot is linear and the capacitance (C_a) at infinite distance of the plates (i.e. 1/d = 0) gives the value of lead capacitance (C_L) of the cell. This value is to be subtracted from the measured value of capacitance with the sample (C_s') and with air (C_a') to have an exact value of the capacitance with sample (Cs) and with air (Ca).

$$i.e\ C_s = C_s' - C_L\ and\ \ C_a = C_a' - C_L$$

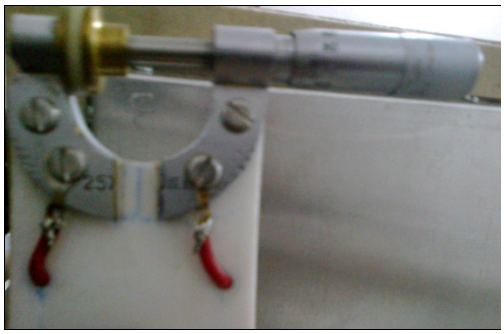

Fig:1- Jig

A commercial digital LCR meter (Systronics, SDLCR 925) was used to measure the capacitance and dissipation factor (tanδ). To have a comparative study of dielectric behavior of horns of ox, buffalo and goat in the applied alternating filed of frequency 1 kHz capacitance and dissipation factor were measured with and without the sample in the cell. All the measurements were taken at room temperature. The dielectric constant of the sample is given by $\varepsilon' = \frac{C_s}{C_a} = \frac{C_s' - C_L}{C_a' - C_L}$

where C_s = actual capacitance of the cell with the sample; 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; C_L = lead capacitance.

The dielectric properties were investigated by applying electrical current to samples through dielectric cell using commercial LCR meter (Systronics, SDLCR 925).

Knowing the value of ε' and tanδ, the dielectric loss was calculated by using the formula,$\varepsilon'' = \tan\delta \times \varepsilon'$

The specific alternating current conductance σ was calculated from the relation. $\varepsilon'' = 1.8 \times 10^{12} \frac{\sigma}{\nu}$

where ν is the frequency of the applied field in Hz.

The dielectric constant and dielectric loss of bone specimen were measured along its z-direction. But it was not possible to measure along x and y - directions due to the limitations in the dimensions of the specimens.

Results & discussion

Tables 1- 3 represent the data on the dielectric parameters such as dielectric constant (ε'), dielectric loss (ε''), resistivity (ρ), conductivity (σ) and density of horns of ox, buffalo and goat, taking 20 samples of each in normal condition. The parameters were determined at 1 kHz frequency at room temperature. Here, the standard deviation values of the parameters reveal the variation among the different horn specimens, but not the uncertainty of the measurement. It is evident from the data that there exists a considerable variation in the observed parameters (Table 1 – 3).

Table 1: Data on dielectric parameters of Ox horn in normal condition

Sample Code	C_a' (pF)	C_s' (pF)	Tan δ	ε'	ε''	ρ ($\times 10^9 \Omega \cdot cm$)	σ ($\times 10^{-9} S \cdot cm^{-1}$)	Density (g/cm^3)
CH01	1.9	6.1	1.64	5.67	9.29	0.19	5.16	1.25
CH02	1.7	4.6	2.02	5.14	10.39	0.17	5.77	1.26
CH03	1.7	4.9	1.98	5.57	11.03	0.16	6.13	1.24
CH04	1.7	4.9	1.97	5.57	10.98	0.16	6.10	1.25
CH05	1.7	4.9	1.99	5.57	11.09	0.16	6.16	1.25
CH06	1.8	5.3	1.88	5.38	10.11	0.18	5.61	1.23
CH07	1.8	5.3	1.93	5.38	10.37	0.17	5.76	1.26
CH08	1.8	5.0	1.98	5.00	9.90	0.18	5.50	1.26
CH09	1.7	4.7	2.14	5.29	11.31	0.16	6.28	1.27
CH10	1.8	5.3	1.98	5.38	10.64	0.17	5.91	1.27
CH11	1.7	5.2	1.96	6.00	11.76	0.15	6.53	1.23
CH01B	1.7	7.5	1.65	9.29	15.32	0.12	8.51	1.27
CH02B	1.7	8.3	1.55	10.43	16.16	0.11	8.98	1.27
CH03B	1.7	8.0	1.56	10.00	15.60	0.12	8.67	1.25
CH04B	1.7	8.0	1.56	10.00	15.60	0.12	8.67	1.26
CH05B	1.6	5.8	1.95	8.00	15.60	0.12	8.67	1.27
CH06B	1.8	9.5	1.46	10.63	15.51	0.12	8.62	1.24
CH07B	1.6	9.1	1.5	13.50	20.25	0.09	11.25	1.25
CH08B	1.6	9.4	1.49	14.00	20.86	0.09	11.59	1.27
CH09B	1.6	8.2	1.54	12.00	18.48	0.10	10.27	1.29
Average:				**7.89**	**13.51**	**0.14**	**7.51**	**1.26**
Standard Deviation:				±3.05	±3.61	±0.03	±2.01	±0.02

Dielectric constant was found to be similar in ox and buffalo, but was comparatively less in goat horns. Dielectric loss was found to be alike in ox and buffalo, but was reasonably less in goat horns. There was parallel variation in the resistivity, conductivity and density

measurements of the ox and cow samples but there was considerable variation in goat horn samples. Thus the results on dielectric parameters of ox, cow and goat horns reveal significant variation in different horn samples, as shown in fig-2.

Table 2: Data on dielectric parameters of Buffalo horn in normal condition

Sample Code	C_a' (pF)	C_s' (pF)	Tan δ	ε'	ε''	ρ ($\times 10^9 \Omega \cdot cm$)	σ ($\times 10^{-9} S \cdot cm^{-1}$)	Density (g/cm^3)
BH_01	1.6	5.5	1.78	7.50	13.35	0.13	7.42	1.27
BH_02	1.5	5.2	1.84	8.40	15.46	0.12	8.59	1.24
BH_03	1.7	5.8	1.66	6.86	11.38	0.16	6.32	1.23
BH_04	1.7	6.1	1.63	7.29	11.88	0.15	6.60	1.26
BH_05	1.5	5.8	1.78	9.60	17.09	0.11	9.49	1.26
BH_06	1.5	5.1	1.94	8.20	15.91	0.11	8.84	1.26
BH_07	1.5	5.3	1.86	8.60	16.00	0.11	8.89	1.27
BH_08	1.5	5.4	1.85	8.80	16.28	0.11	9.04	1.25
BH_09	1.6	5.5	1.82	7.50	13.65	0.13	7.58	1.28
BH_10	1.5	5.7	1.80	9.40	16.92	0.11	9.40	1.28
BH_11	1.5	4.6	2.04	7.20	14.69	0.12	8.16	1.25
BH_12	1.6	5.1	1.95	6.83	13.33	0.14	7.40	1.24
BH_13	1.7	5.8	1.76	6.86	12.07	0.15	6.70	1.25
BH_14	1.5	4.5	2.20	7.00	15.40	0.12	8.56	1.26
BH_15	1.7	5.7	1.84	6.71	12.35	0.15	6.86	1.25
BH_16	1.6	5.4	1.86	7.33	13.64	0.13	7.58	1.23
BH_17	1.6	5.5	1.85	7.50	13.88	0.13	7.71	1.26
BH_18	1.6	5.2	1.85	7.00	12.95	0.14	7.19	1.24
BH_19	1.7	5.1	2.00	5.86	11.71	0.15	6.51	1.25
BH_20	1.6	5.9	1.58	8.17	12.90	0.14	7.17	1.22
Average:				**7.63**	**14.04**	**0.13**	**7.80**	**1.25**
Standard Deviation:				±0.96	±1.80	±0.02	±1.00	±0.02

Table 3: Data on dielectric parameters of Goat horn in normal condition

Sample Code	C_a' (pF)	C_s' (pF)	Tan δ	ε'	ε''	ρ ($\times 10^9 \Omega \cdot cm$)	σ ($\times 10^{-9} S \cdot cm^{-1}$)	Density (g/cm^3)
GH_01	1.7	5.5	1.68	6.43	10.80	0.17	6.00	1.23
GH_02	1.7	5.3	1.78	6.14	10.93	0.16	6.07	1.22
GH_03	1.6	5.1	1.82	6.83	12.44	0.14	6.91	1.26
GH_04	1.5	4.75	1.96	7.50	14.70	0.12	8.17	1.23
GH_05	1.7	5.2	1.82	6.00	10.92	0.16	6.07	1.24
GH_06	1.75	6.15	1.6	6.87	10.99	0.16	6.10	1.24
GH_07	1.6	4.9	1.94	6.50	12.61	0.14	7.01	1.22
GH_08	1.7	5.7	1.77	6.71	11.88	0.15	6.60	1.16
GH_09	1.95	6.2	1.57	5.47	8.59	0.21	4.77	1.19
GH_10	1.8	6.2	1.63	6.50	10.60	0.17	5.89	1.22

GH_11	1.7	4.9	1.98	5.57	11.03	0.16	6.13	1.20
GH_12	1.7	5.8	1.78	6.86	12.21	0.15	6.78	1.23
GH_13	1.6	5.9	1.78	8.17	14.54	0.12	8.08	1.24
GH_14	1.8	6.1	1.63	6.38	10.39	0.17	5.77	1.21
GH_15	1.7	4.9	1.98	5.57	11.03	0.16	6.13	1.21
GH_16	1.7	5.5	1.8	6.43	11.57	0.16	6.43	1.26
GH_17	1.6	5.4	1.86	7.33	13.64	0.13	7.58	1.24
GH_18	1.7	5.5	1.82	6.43	11.70	0.15	6.50	1.23
GH_19	1.6	4.5	2.17	5.83	12.66	0.14	7.03	1.20
GH_20	1.75	5.4	1.86	5.87	10.91	0.16	6.06	1.22
Average:				**6.47**	**11.71**	**0.16**	**6.50**	**1.22**
Standard Deviation:				±0.68	±1.45	±0.02	±0.81	±0.02

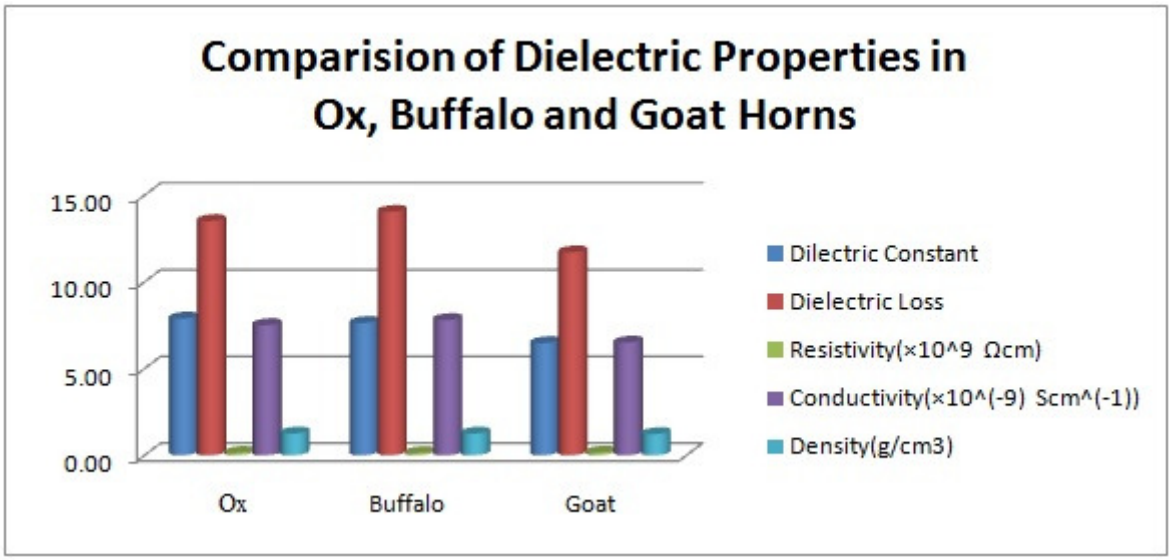

Fig: 2: Comparison on Dielectric properties of ox, buffalo and Goat horns

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