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Studies on Dielectric Properties of Animal Horns

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Abstract: ***Horns are pointed projections on the heads of various animals. These are primarily made up of keratin and other proteins like elastin surrounding the bone. Horns from different animals like antlers, goat, buffalo, cow etc…usually are found to possess a curved or spiral shape, often found with ridges. In many species only males have horns. In most of the animal species, horns grow soon after the birth and usually continue throughout the life of the animal. In this article, the authors have made an attempt to study and compare the dielectric parameters such as dielectric constant, dielectric loss and conductivity of horns of buffalo and cow at varying frequencies in the range of 20 Hz-2 MHz. A high precision digital LCR meter was used to measure the capacitance and dissipation factor. A significant variation in dielectric parameters was observed with respect to the type of animal selected.***

Keywords: Capacitance, Dissipation factor, Dielectric constant, Dielectric loss, Conductivity, Horn, Buffalo, Cow

1. Introduction

The study of dielectric properties of macromolecules, cells and tissues of biological interest has now very clearly become an integral and inseparable part of the inter-disciplinary area of biological sciences. Advances in such studies certainly will benefit many branches of medicine. The current article thus focuses on the measurement of dielectric parameters from horn samples of different animals, in order to emphasize its biological importance.

Among the hard tissues horn, hoof and hair are the derivatives of the skin. These tissues which form the exoskeleton serve as protective materials from various environmental influences. Horns are pointed projections on the heads of various animals. These are primarily made up of keratin and other proteins like elastin surrounding the bone. Horns exhibit remarkable dielectric properties. They characteristically show high dielectric constants at variable frequencies.

Horns are usually made up of a protein called keratin, which is the same material present in nails, feathers and hoofs. Antlers instead of having keratin have a true bone, which is a collagenous material. Horns have a central, conical bony core or cornual process that grows out from the frontal bone of the skull. The surface of the bone is ridged and porous and is covered with papillated dermis that is continuous with the periosteum and epidermis which keratinizes and forms the protective covering of the horn. It was found that in certain Rhino horns, dense mineral deposits made of calcium and melanin in the middle of the horn was observed. The calcium deposits make the horn core harder and stronger.

In the current article, the actual and factual data on dielectric parameters such as dielectric constant, dielectric loss and conductivity of horns of buffalo and cow are reported. The subsequent results obtained are systematically analyzed experimentally and graphically.

2. Materials and Method

Horn samples of buffalo and cow were obtained from the local slaughter house. Horns were then cut into suitable dimensions. A bench grinding machine was used to achieve required accuracy in dimensions of the materials. After preparing the samples in necessary shapes and dimensions for carrying out the dielectric measurements, an apparatus (jig-sample holder) consisting of a two terminal cell was used. The set up consists of two parallel circular metallic plates. A high precision digital LCR meter was used to measure the capacitance and dissipation factor (tanδ). The LCR meter adopted give instantaneous readings.

The dielectric constant ε' of the sample is given by

$$\varepsilon' = Cs/Ca \quad (1)$$

Where Cs = actual capacitance of the cell with sample
Ca = actual capacitance of the cell with air

Knowing the value of ε' and tan δ, the dielectric loss ε" was calculated by using the formula

$$\varepsilon'' = \tan\delta \times \varepsilon' \quad (2)$$

The specific alternating current conductance K is determined from the relation

$$\varepsilon'' = 1.8 \times 1012\ K/\nu \quad (3)$$

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

3. Results and Discussion

Among the many dielectric parameters, the dielectric constant, dielectric loss, conductivity and dissipation factor play a very prominent role in defining the nature, texture and character of the horn.

Tables 1.1 and 1.2 represent the average data on dielectric constant (ε'), dielectric loss (ε") and conductivity (K) on horn samples of buffalo and cow respectively in the frequency range of 20 Hz to 2 MHz.

Figures 2.1 through 3.3 are the plots of dielectric constant, dielectric loss and conductivity studies against frequency on horn samples of buffalo and cow.

From the experimental values, it is evident that the dielectric properties such as dielectric constant, dielectric loss and conductivity are highly dependent on frequency of the applied electric field. The dielectric constant and dielectric loss of horn reaches high values at low frequencies, but decreases rapidly with increasing frequencies. In contrast to dielectric constant and dielectric loss, the conductivity increases as a power function of frequency.

The results presented in the current paper reveal that there exists a slight variation in dielectric values whereas the behaviour is similar in both the horn samples of buffalo and cow. The experimental values are slightly high in buffalo when compared with the values in cow.

The dielectric measurements in horn samples of buffalo and cow reveal that there is a considerable variation in dielectric properties associated with dielectric constant, dielectric loss and conductivity values. Such a considerable variation could be attributed to the basic composition of horn in terms of its keratin and mineral composition and depends on the animal as well as on the shape and hardness of the horns.

4. Acknowledgment

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Table 1.1: Average data on dielectric parameters of Buffalo horn

Frequency (Hz)	*Dielectric Constant*	*Dielectric Loss*	*Conductivity* (n℧/cm)
20	3.15	0.88	0.01
40	3.18	0.58	0.01
60	2.97	0.48	0.02
80	2.88	0.39	0.02
100	2.92	0.37	0.02
200	2.84	0.26	0.03
300	2.76	0.22	0.04
400	2.73	0.19	0.04
500	2.71	0.18	0.05
600	2.69	0.17	0.06
700	2.68	0.16	0.06
800	2.67	0.15	0.07
900	2.66	0.14	0.07
1000	2.66	0.14	0.08
2000	2.61	0.11	0.13
3000	2.59	0.10	0.17
4000	2.57	0.10	0.22
5000	2.56	0.09	0.26
6000	2.55	0.09	0.30
7000	2.54	0.09	0.34
8000	2.54	0.09	0.38
9000	2.53	0.08	0.42
10000	2.53	0.08	0.47
20000	2.49	0.08	0.87
30000	2.47	0.08	1.28
40000	2.46	0.08	1.69
50000	2.45	0.08	2.11
60000	2.44	0.08	2.51
70000	2.43	0.08	2.93
80000	2.43	0.08	3.35
90000	2.42	0.08	3.77
100000	2.42	0.08	4.20
200000	2.38	0.08	8.54
300000	2.36	0.08	12.96
400000	2.35	0.08	17.43
500000	2.34	0.08	21.93

600000	2.33	0.08	26.42
700000	2.32	0.08	30.95
800000	2.31	0.08	35.44
900000	2.31	0.08	39.95
1000000	2.30	0.08	44.48
2000000	2.27	0.08	89.36

Table 1.2: Average data on dielectric parameters of Cow horn

Frequency (Hz)	*Dielectric Constant*	*Dielectric Loss*	*Conductivity* (n℧/cm)
20	2.76	0.66	0.01
40	2.92	0.44	0.01
60	2.71	0.41	0.01
80	2.64	0.34	0.01
100	2.61	0.32	0.02
200	2.54	0.23	0.03
300	2.47	0.19	0.03
400	2.44	0.17	0.04
500	2.42	0.16	0.04
600	2.40	0.15	0.05
700	2.39	0.14	0.05
800	2.38	0.13	0.06
900	2.37	0.13	0.06
1000	2.37	0.13	0.07
2000	2.33	0.10	0.11
3000	2.30	0.09	0.15
4000	2.29	0.09	0.19
5000	2.28	0.08	0.23
6000	2.27	0.08	0.27
7000	2.26	0.08	0.31
8000	2.26	0.08	0.35
9000	2.25	0.08	0.38
10000	2.25	0.08	0.42
20000	2.22	0.07	0.78
30000	2.20	0.07	1.15
40000	2.19	0.07	1.51
50000	2.18	0.07	1.88
60000	2.17	0.07	2.25
70000	2.16	0.07	2.63
80000	2.16	0.07	3.00
90000	2.16	0.07	3.38
100000	2.15	0.07	3.76
200000	2.12	0.07	7.62
300000	2.10	0.07	11.54
400000	2.09	0.07	15.49
500000	2.08	0.07	19.45
600000	2.07	0.07	23.41
700000	2.06	0.07	27.39
800000	2.06	0.07	31.32
900000	2.05	0.07	35.30
1000000	2.05	0.07	39.26
2000000	2.02	0.07	78.53

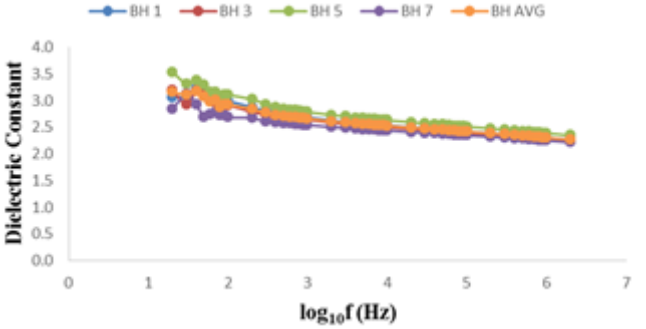

Figure 2.1: Plot of dielectric constant against frequency on Buffalo horn

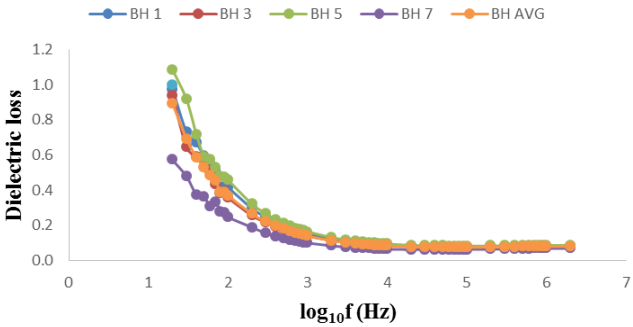

Figure 2.2: Plot of dielectric loss against frequency on Buffalo horn

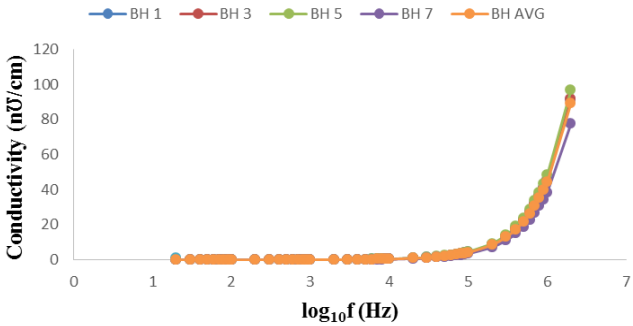

Figure 2.3: Plot of conductivity against frequency on Buffalo horn

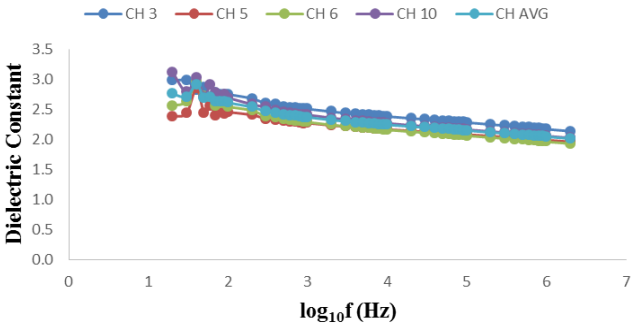

Figure 3.1: Plot of dielectric constant against frequency on Cow horn

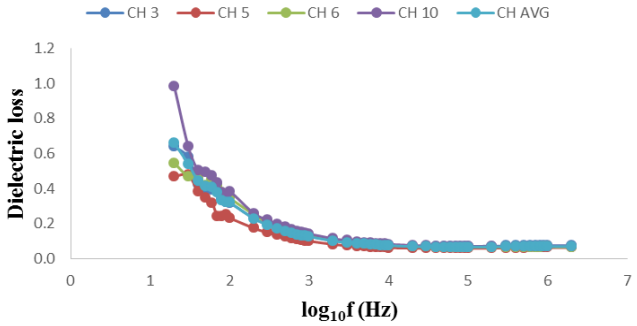

Figure 3.2: Plot of dielectric loss against frequency on Cow horn

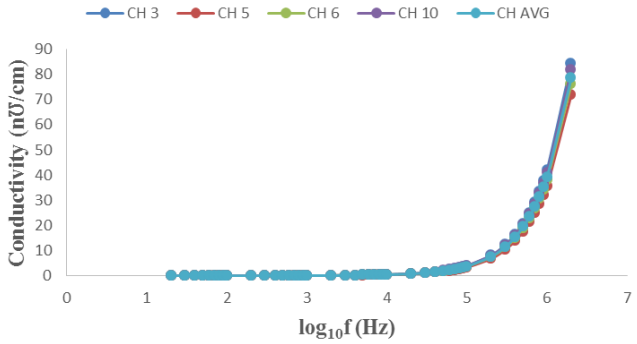

Figure 3.3: Plot of conductivity against frequency on Cow horn