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Dielectric Properties of Seawater Molluscan Shells

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ABSTRACT

The paper presents Dielectric data on different types of molluscan shells collected from Chennai seashore. It is observed that irrespective of species, the mineralogical from of $CaCO_3$ is aragonite. This is due to the fact that Mg present in the shell material acts as a regulator for the deposition of $CaCO_3$. It is interesting to note that dielectric parameters of aragonite are low when compared to shells and calcite. The significant variations in dielectric parameters such as dielectric constant, dielectric loss and electric conductivity of molluscan shells may be attributed to the free water that present in the shell as the composition if calcium carbonate and the components of the organic matrix of the shell is more or less the same irrespective of species.

Keywords: Dielectric constant, molluscan shells, electrical conductivity, dielectric loss

The dielectric properties of matter are primarily of interest to the physicist and electrical engineers. As a result the theory of dielectrics has been developed with the various contributions to the subject often reflecting the requirements and interest of the scientific field.

Dielectrics are the materials in which electrostatic field can persist for a longer time and offer a very high resistance to the passage of electric current under the action of the applied D.C. voltage and hence sharply differ in their basic electric behavior from conducting materials. Much is known about the structure of matter from measurement upon polar liquids and solids, at extreme frequency and often involving absorption of electrical energy as shown by the measured dielectric loss and frequency dependence of relative permittivity.

The importance of dielectric constant and dielectric loss is found in practical life, since suitable insulating materials or dielectrics play a vital role in the electrical intallations. Therefore, it becomes very important not only to be able to measure the dielectric properties of the existing dielectrics but also to have sufficient knowledge of fundamental behavior to produce new materials having desirable dielectric properties. In view of this extensive work has been done in the past on dielectric behavior of biomaterials. Attempts were made to develop theories and techniques for the study of dielectric properties of macromolecules, tissues and cell membranes.

Schwan and his co-workers[1-4] did extensive work on electrical properties tissues and suspensions by developing new techniques and evaluating data critically. Pethig[5] reviewed various studies of the electrical and dielectric properties of low hydration content in order to indicate that proton transport processes provide a major contribution to the effects that have been observed. Adeel Ahmad and his co-workers made investigations on dielectric properties of soft tissues[6,7], blood[8, 9], derivatives of integument[10] and hard calcified tissues[11-14] in order to understand physiological adaptations for the life processes. A comparative account on dielectric properties of various animal tissues and biological materials was presented and dielectric data was critically reviewed[15].

A perusal of literature reveals that extensive work is being done on biological materials, but information on dielectric properties of molluscan shells is scanty. Hence, an attempt has been made to study dielectric properties of different types molluscan shells collected from madras sea shore.

MATERIAL AND METHODS

The molluscan shells were collected from Chennai seashore. The samples were crushed, powdered and made into circular discs of radius 1 cm and thickness varying from 5 mm to 7 mm. No binder was used in making the discs. It was found that disc was formed easily at a pressure of 30 – 40 kg.cm^{-2}. The surface of the sampleswas coated with silver paste, so as to have good electric contact with electrodes.

For dielectric measurements were made using LCZ meter (Make: Scientific, Model: LCR meter SM6020) and dielectric cell, constructed at Biophysics Research Laboratory, Nizam College, Hyderabad. The details of the jig (dielectric cell) were mentioned elsewhere [10]. The capacitance of dielectric cell without and with the sample in between circular parallel plate electrodes of the cell and also dissipation factor (tan δ) with the sample was measured. The lead capacitance (CL) of measuring device was determined. The actual capacitance of the jig without and with the sample was calculated as:

$C_a = C'_a - C_L$

$C_s = C'_s - C_L$

Where C_a: Actual capacitance of jig without sample

C'_a: Observed capacitance of the jig without sample

C_s: Actual capacitance of jig with sample

C'_s: Observed capacitance of the jig with sample

C_L: Lead capacitance

Knowing C_s, C_a and tan δ, the dielectric parameters were calculated using the relations,

Dielectric Constant, $\varepsilon' = C_s/C_a$

Dielectric Loss, $\varepsilon'' = \varepsilon' \tan \delta$

Table 1 presents the data on dielectric parameters such as dielectric constant, dielectric loss and electrical conductivity, measured at the frequency of 1 kHz of

Table 1: Dielectric data on different types of molluscan shells collected from Chennai seashore

Frequency: 1 kHz

Sample Code	Scientific Name	Dielectric constant	Dielectric Loss	Electrical Conductivity (nS.cm^{-1})
MSC1	*Murex tenuispina*	30.6	5.8	3.2
MSC2	*Cardium edule*	34.3	8.6	4.8
MSC3	*Baccinum undatum*	26.4	3.2	1.8
MSC4	*Anodonta cygnea*	34.7	6.1	3.4
MSC5	*Pteroceras rugosum*	16.8	1.4	0.8
MSC6	*Anodunta sp.*	23.4	3.2	1.8
MSC7	*Cerithium colomna*	21.6	1.7	0.9
MSC8	*Helix zonata*	20.7	2.3	1.3
MSC9	*Mytilus edulis*	10.1	0.8	0.4
Aragonite		2.6	0.1	0.1
Calcite		5.2	1.6	0.9

all the shells understudy along with aragonite and calcite rock samples. It is evident from the data that the dielectric parameters vary considerably among different types of shells collected from Chennai seashore. The variation in dielectric constant is in the range of 10 – 30. The dielectric loss lies in the range of 1 to 10. The electrical conductivity ranges from 0.4 to 5 nS/cm. It is interesting to note that dielectric parameters of aragonite are low when compared to shells and calcite. The significant variations in dielectric parameters such as dielectric constant, dielectric loss and electric conductivity of molluscan shells may be attributed to the free water that present in the shell as the composition if calcium carbonate and the components of the organic matrix of the shell is more or less the same irrespective of species.

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