

Thermal Conductivity and Electrical Characterization of High Temperature Phases of Oyster Shell

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Abstract- *In the present investigation, Anatomy of the oysters was studied. The XRD investigation and thermal conductivity measurements for oyster shells have been observed. From XRD investigations, the basic structure of the oyster shell was studied. The dc electrical measurements were made over a temperature range of (353K-673K). It has been found that the conductivity increases within the temperature range of (353K-453K) and (513K-673K). But the conductivity decreases at temperature range (433K-533K).*

Indexed Terms- Oyster shell, XRD, Thermal conductivity

I. INTRODUCTION

Oysters are high in calcium, niacin and iron, as well as a good source of protein. Any bivalve of two families, Ostreidae (true oysters) or Aviculidae (pearl oysters), found in temperate and warm coastal waters worldwide. Both valves (halves) have a rough, often dirty-gray outer surface and smooth white inner lining (nacre). The lower valve, which affixes to a surface, is nearly flat. The smaller upper valve is convex and has rougher edges. The oyster filters its food, minute organic particles, from water. Cultivated as food, oysters are regarded as a delicacy. Pearls are the accumulation of nacre around a piece of foreign matter.

Shells are the hard exteriors of living organisms and are formed for two main purposes. Firstly, they protect the organisms from predators and environmental stressors. Secondly, they provide rigidity and shape. One well-known group of animals that secrete shells is called mollusks. There are eight classes of mollusks grouped according to the characteristics of their shells. Single-shelled organisms are called Gastropods. The shelled animal

that is studied in this unit is called oyster. They have two valves that enclose the soft tissue of the mantle and other internal organs. The shells are hinged together.

Oyster shells are made from calcium that is extracted from the waters in which they live or from the food the oysters eat. There are two common forms of calcium carbonate, aragonite and calcite. The denser of the two forms, calcite, is found in the hard, outer shell of the oyster. Whether calcium carbonate becomes aragonite or calcite depends on the “seed” crystals growth pattern. Many mollusk shells are lined with aragonite. Abalones and some oysters, including Louisiana oysters, are examples. The substance they produce is called “mother of pearl” or nacre. Nacre is what gives oysters and abalones the shine on the insides of their shells.

All species of oysters share the same common anatomical parts. That is, there is a right shell and a left shell. The right shell is the top shell. The left shell is the one attached to the substrate and is called the bottom shell or cup. The left shell is usually more curved or cup-shaped than the right shell. Oysters belong to the group Bivalvia and have two shells hinged together. The end with the hinge is referred to as the anterior end. The opposite end is referred to as the posterior end. The mantle produces layers of tissue to form the shell. Calcium carbonate composes the chalky middle layer. The innermost layer is the nacre. The umbo is the portion of the shell that formed when the oyster was a veliger larva. It is on the anterior end of the shell near the hinge. One can see concentric growth lines around the umbo. These are not uniformly secreted since they can be influenced by environmental changes, such as temperature, food, stress, and disease. These factors affect the oyster’s ability to produce more shell tissue. The hinge is the area where the two valves

join together. It consists of three parts. On the hinge there are small projections, hinge teeth that align the valve and enable it to close correctly. Oysters have very small hinge teeth. Most bivalves have more prominent teeth that can be used to help identify the species. The hinge has two ligaments. The external ligament is flexible and provides the axis of movement for the two halves of the shell. The internal ligament is called the resilium. When the adductor muscle of the oyster is relaxed, the external ligament and resilium work together to open the shell. To close its shell, the oyster contracts its adductor muscle. The top view and the cross-sectional view of an oyster are shown in figure (1) and (2) respectively. Figure (3) shows the oyster picture. The oyster shell was composed of calcium, niacin and iron. So we measured the oyster shell with the X-rays diffraction (XRD) method. The calcium and iron are metal group elements. To know the electrical characterizations of the oyster shell we measured the conductivity of the oyster by thermal method.

Since 2001 oyster shell is pursuing the discovery of new active natural ingredients or new applications of known natural compounds, to make Bacterial biofilm inhibition. Today, oyster shell has elucidated and patented a natural compound, coded RF 2 that is able to prevent dental plaque almost entirely without killing bacteria, using antimicrobial agents or fluoride [1].

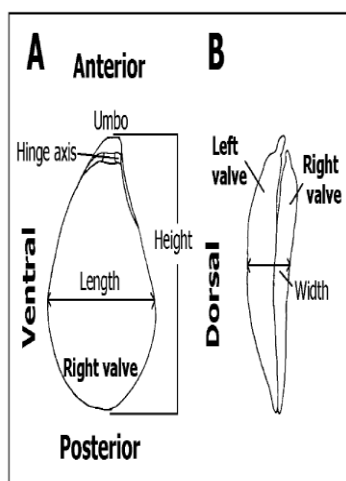


Figure (1) Top view and side view of an oyster



Figure (2) Cross-sectional view of an oyster



Figure (3) Oyster shell pictures

II. EXPERIMENTS AND RESULTS

A. X-ray Diffraction (XRD) Investigation

According to XRD investigation, oyster shell is composed of major compound calcite (CaCO_3) and minor metal magnesium (Mg). The compositions are 97% CaCO_3 and 3% Mg. The calcium (Ca) and magnesium (Mg) are group II elements, known as metal. The carbon and oxygen are group IV elements and are also non-metal. The XRD spectrum of oyster shell is as shown in figure (4).

B. Sample Preparation

The oyster shell was collected from the Myeik Township, Tanintharyi Division. This oyster shell

was cut into the rectangular shaped of dimension (1.13 cm x 0.89 cm x 0.17 cm) as a sample.

C. Electrical Conductivity Measurement

To measure the thermal conductivity, we used four LCR meters of Model-MT 4080A, MT 4080D, Sr No 5012 and steel chamber with temperature controller. The oyster sample was sandwiched between two copper plates that serve as two electrodes. For better electric conduction, silver paste was applied evenly on both surfaces of the sample. The sample was placed in a sample holder that was immersed in a heating steel cell. Figure (5) shows how sample is arranged for temperature dependent conductivity measurement. Thermal conducting mica shield is used between the sample and the chamber to have a good thermal conductivity and to protect from electrical conduction.

D. Results for Conductivity Measurement

By the thermal conductivity measurement, the variations of the dc conductivity with the temperature are shown in Table (1).

Table (1) $1000/T$ (temperature) and $\ln \sigma$ (dc conductivity)

Temperature (K)	$1000/T$ (K^{-1})	$\ln \sigma$
353	2.83	-19.7197
373	2.68	-17.3273
393	2.54	-18.353
413	2.42	-16.9937
433	2.31	-16.4729
453	2.21	-16.1221
473	2.11	-17.0277
493	2.03	-17.9296
513	1.95	-18.7792
533	1.88	-18.5689
553	1.81	-17.5575
573	1.75	-16.9986
593	1.69	-16.9271
613	1.63	-16.325
633	1.58	-15.8901
653	1.53	-15.3057
673	1.49	-15.2827

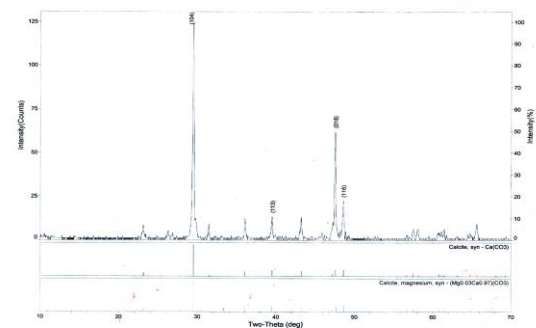


Figure (4) XRD spectrum of oyster shell

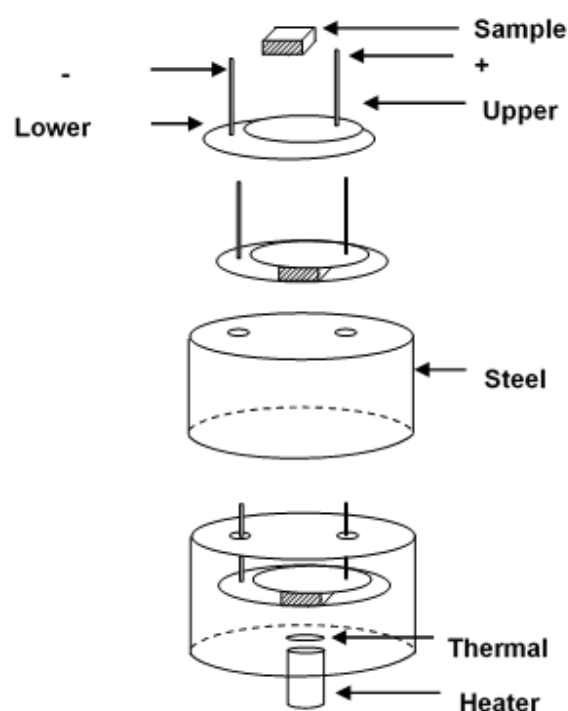


Figure (5) Arrangement for conductivity measurement

III. DISCUSSION

According to the XRD results, the oxide form of calcium and magnesium were found and the iron did not found in the oyster shell.

The temperature dependence of electrical conductivity for an n-type germanium is as follow: (i) at very low temperature (about 10K), the

conductivity increases with rise in temperature. This is due to the increase in the number of conduction electrons as a result of ionization of the donors. The conductivity attains a maximum value when all the donors are ionized. The temperature corresponding to this is about 50K for a moderately doped n-type germanium. (ii) The conductivity decreases with further increase in temperature up to about room temperature and is attributed to the decrease in the value of mobility with rise in temperature. There is also an increase in the intrinsic conductivity but to a lesser extent. (iii) The large increase in intrinsic conductivity causes the sharp rise in conductivity and which offsets the decrease in mobility.

The curves of the variation of dc conductivity of oyster shell with temperature (353K- 673K) are shown in figure 6 (a-d). From the plots, it is obvious that the conductivity increases within the temperature range of (353K-453K) and (513K-673K). But the conductivity decreases at temperature range (433K-533K).

Although the transition temperature points of oyster shell is different from the n-type germanium, their curve natures are in the same fashion. This difference is due to the internal structure of the shell. According to the XRD results, the major composition of the oyster shell is calcite (CaCO_3) and the calcium has high melting point temperature (1473K).

IV. CONCLUSION

The present study was carried out in order to investigate the nature and electrical conductivity of oyster shell. From the experimental results, the conductivity increases at some temperature range and also decreases at certain temperature range. It may be due to the carbon composition of the shell. Although the curves of temperature dependent conductivity are not much smooth, they can be the member of semiconductor material.

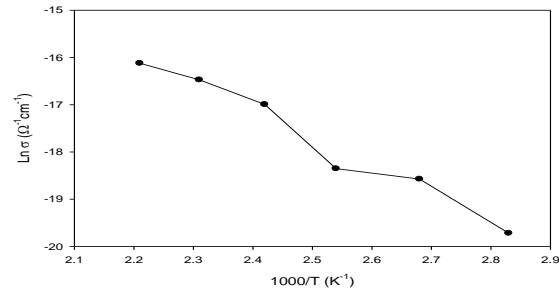


Figure 6(a) the result for temperature dependent conductivity measurement on oyster shell at (353K-453K)

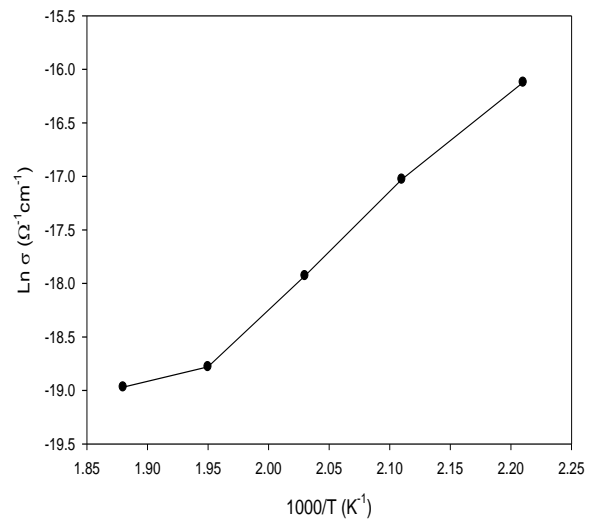


Figure 6(b) the result for temperature dependent conductivity measurement on oyster shell at (453K-513K)

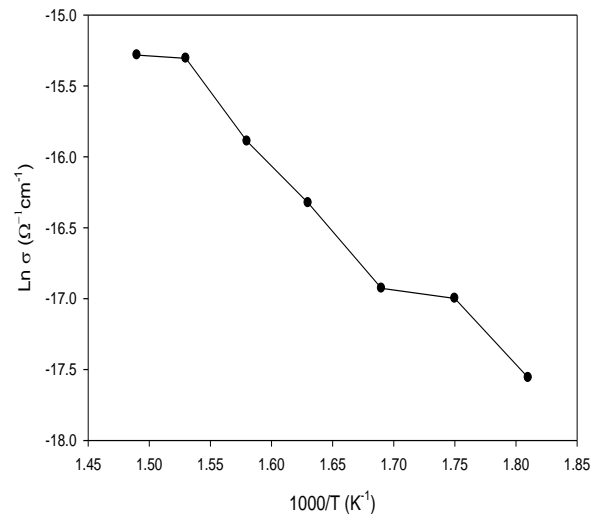


Figure 6(c) the result for temperature dependent

conductivity measurement on oyster shell at (513K-673K)

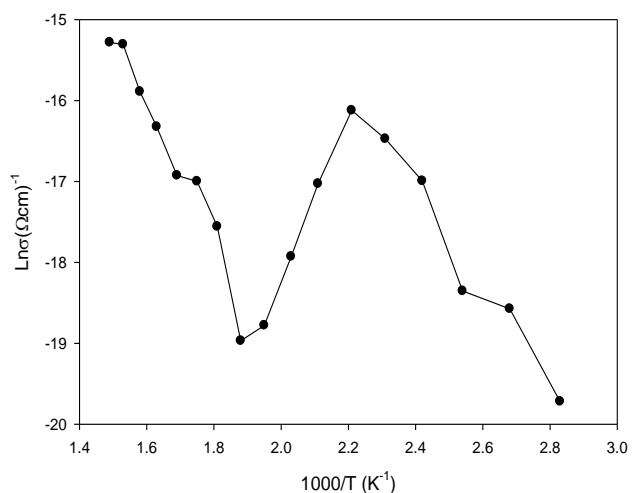


Figure 6(d) the result for temperature dependent conductivity measurement on oyster shell at (353K-673K)

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