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## Investigation on surface characteristics of uncalcinated and calcinated mussel shells

**Sahra Dandil**, Department of Chemical and Process Engineering, Faculty of Engineering, Bilecik Şeyh Edebali University, Bilecik-11230, TURKEY.

**Deniz Akin Sahbaz**, Department of Chemical Engineering, Faculty of Engineering, Afyon Kocatepe University, Afyon-03200, TURKEY.

**Caglayan Acikgoz\***, Department of Chemical and Process Engineering, Faculty of Engineering, Bilecik Şeyh Edebali University, Bilecik-11230, Turkey.

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### Abstract

In recent years, developing economical adsorbents to treat with different types of pollutants has attracted great interest. Mussel shells are abundant in the sea and cause waste. In this study, the uncalcinated and calcinated mussel shells were characterised for their surface characteristics. Mussel shells washed with tap water and distilled water several times and dried for 12 hours in an oven. Then they were calcined at 900°C for 2 hours. The calcined sample was washed with distilled water and dried at 105°C. And then, the sample was calcined at 400°C with 2°C/min heating rate for 4 hours. The calcined and uncalcinated mussel shell samples were characterised by Fourier transformed infrared spectroscopy, scanning electron microscopy equipped with an energy dispersive spectrometer, Brunauer–Emmett–Teller and Zeta potential measurements. The results indicated that calcination studies improved the surface characteristics of the mussel shells and that the calcinated mussel shells can be used in adsorption studies as a low-cost, eco-friendly biosorbent efficiently.

Keywords: adsorption, calcination, characterization, mussel shell.

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\* ADDRESS FOR CORRESPONDENCE: **Caglayan ACIKGOZ**, Affiliation, Department of Chemical and Process Engineering, Faculty of Engineering, Bilecik Şeyh Edebali University, Bilecik-11230, TURKEY.

E-mail address: [caglayan.acikgoz@bilecik.edu.tr](mailto:caglayan.acikgoz@bilecik.edu.tr) / Tel.: +90 228 214 12 33

## 1. Introduction

The world has a very rich shellfish culture. Shellfish, both as a food and for commercial purposes, is in a continuous production and consumption cycle. Among the shellfishes, there are plenty of mussel shells all over the world. Mussel shells are an important species with interesting properties such as shell properties and pearl formation. In addition, mussel shellfish breeding is also done. Consumption of mussel shells of different species as nutrients and for commercial purposes is also being carried out in large quantities.

The mussel shells are composed of three layers: from the outside to the inside, periostracum, prismatic and psoriatic layer. The shell colors vary depending on the ambient conditions in which mussel live. There is a high content of calcium in shellfishes. Mussel shells with high calcium content (35-39%) have a common living area all over the world [1].

Large amounts of shellfish are thrown into the environment without evaluation in worldwide. In recent years, researchers are realized these low-cost, highly featured natural materials and begun to investigate their structure and use. Thus, shellfish culture is being evaluated by different methods rather than being decayed with the recycling of wastes, and new products are being obtained. In this way, by evaluating crustacean wastes, are benefited both economically and environmentally. In literature, easy obtainable, economical and biodegradable natural materials such as mussel shells has attracted great interest that can be used for different aims such as biodiesel production [2-3], nanoscience [4], dye [5-6-7] and metal removing [8-9-10-11-12] and synthesis studies [13-14-15-16].

The objective of this work was to characterise uncalcinated and calcinated mussel shells to understand differences between the structures and compose a different point of view as an economic material. For calcination process, the previous study of El Haddad et al. was followed. Characterisations of mussel shells were given by Fourier transformed infrared spectroscopy (FT-IR), scanning electron microscopy equipped with an energy dispersive spectrometer (SEM-EDS), Brunauer–Emmett–Teller (BET) and Zeta potential measurements.

## 2. Materials and methods

Mussel shells were supplied by seafood processing company in Bilecik-TURKEY. Mussel shells washed with tap water and distilled water several times and then dried overnight (about 12 hours) in an oven. After drying, they were crushed and powdered to small particles. For calcination, powdered mussel shells treated at 900°C for 2 hours in a tubular calcination oven The calcined sample was washed with distilled water and dried at 105°C. The sample was ground into different sizes (45–250 µm). The particles were washed and dried at 105°C. And then, the sample was calcined at 400°C during 4 hours with 2°C/minute heating rate [7]. Synthesised samples were stored for characterisation.

The calcined and uncalcined mussel shell samples were characterized by Fourier transformed infrared spectroscopy (FT-IR), Scanning electron microscopy equipped with an energy dispersive spectrometer (SEM-EDS), BET and Zeta potential measurements.

### 3. Results and Discussion

#### 3.1. Surface morphology of uncalcinated and calcinated mussel shells

SEM image of uncalcinated mussel shells is shown in Figure 1. From the SEM micrograph, it is observed that the morphology of the mussel shells is not homogenous. Also, irregular forms and sizes are seen such as particles and rods on a wall type base.

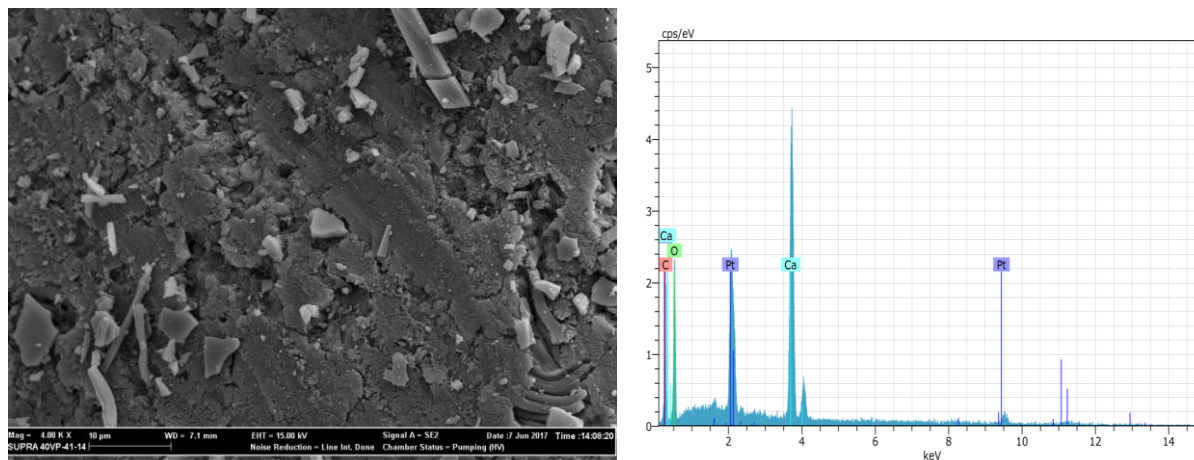


Figure 1. SEM- EDS images of uncalcinated mussel shells

Figure 2 shows the SEM images of calcinated mussel shells. As can be seen in the figure, after calcinations process, the form of the uncalcinated mussel shells changed. There is only one form as spherical. The structure is more uniform and particle sizes are in a range. And also, it's obvious that the pores are formed.

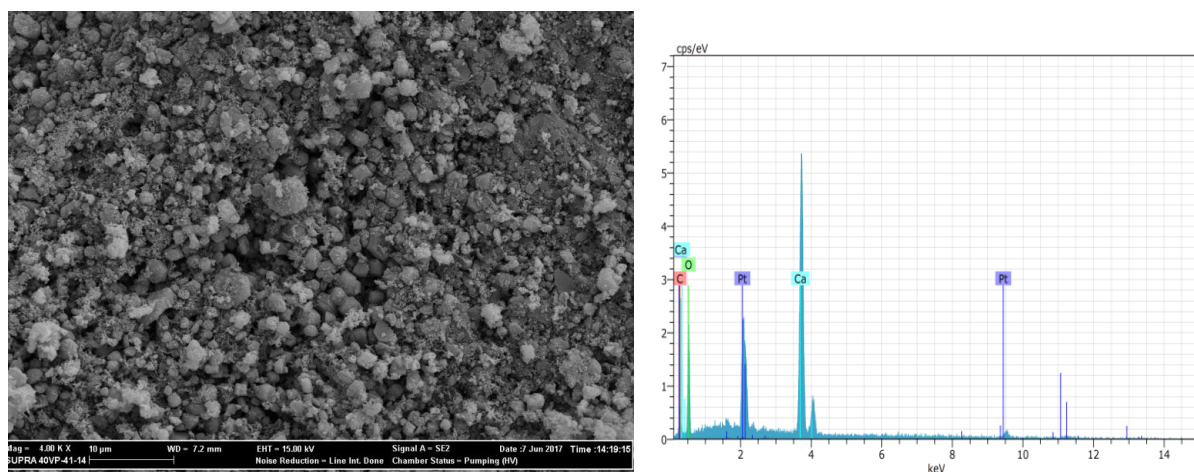
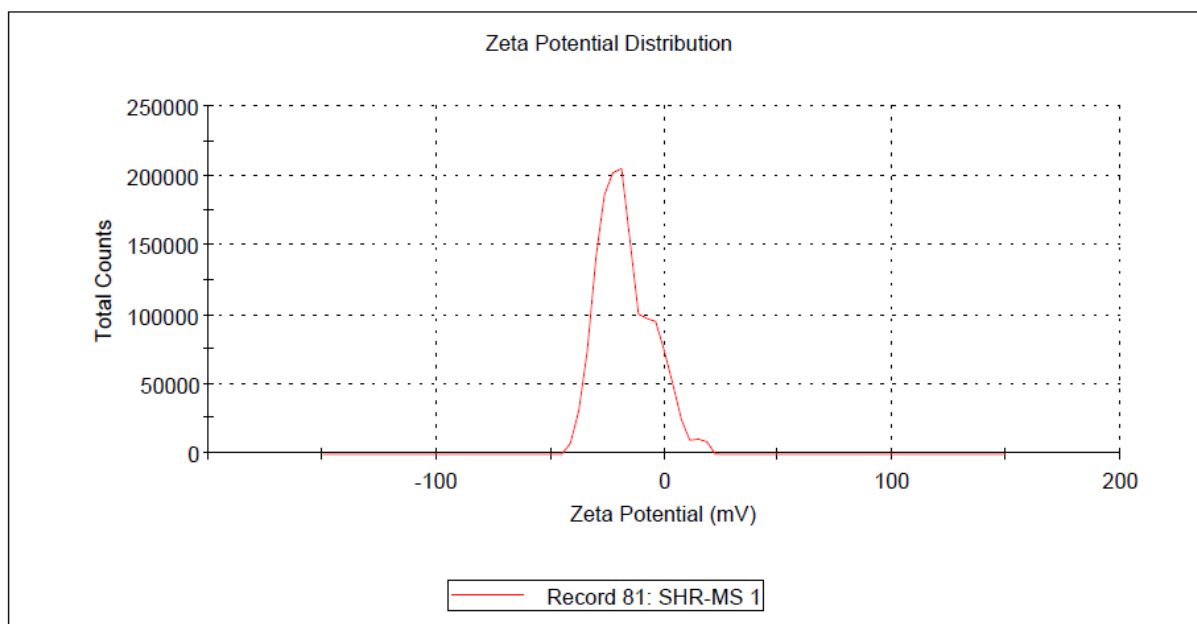


Figure 2. SEM-EDS images of calcinated mussel shells

Chemical analysis of EDS shows that high yield of Ca for uncalcinated and calcinated mussel shell samples and the major elements were C, O and Ca for both of them.

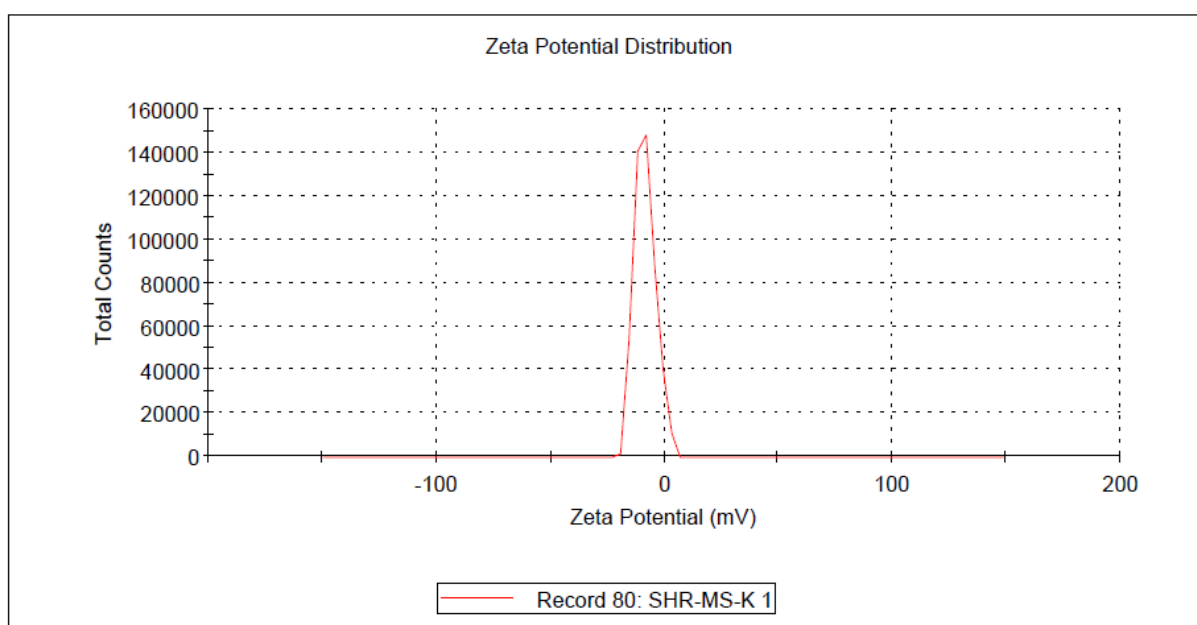
### 3.2. Zeta potential measurements

Solid surfaces measurable potential is zeta potential, which is related to surface charge density. Zeta potential measurements are made to determine the charge and size of the layer around the particle. Surface properties and events related to surfaces are understood by zeta potential measurements.



**Figure 3.** Uncalcinated mussel shells

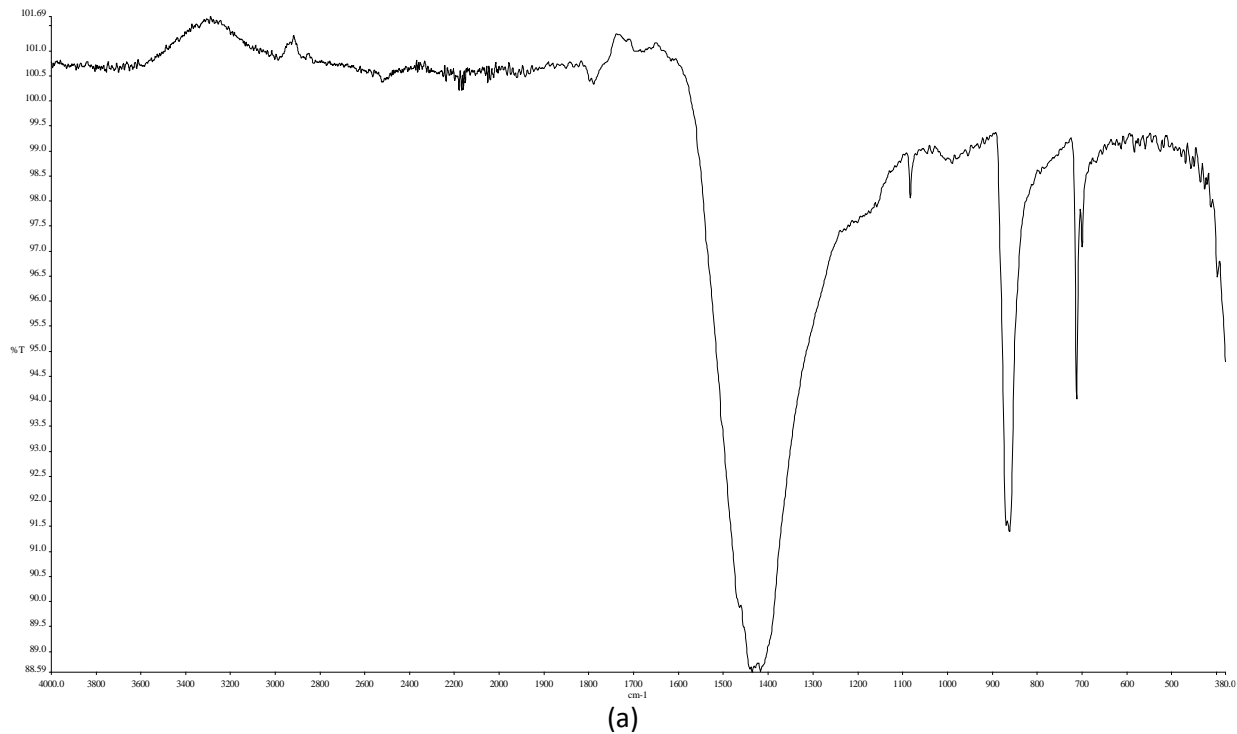
Interactions between the particles depend on surface charges. As can be seen from Figure 3 and 4, calcinated and uncalcinated mussel shell samples have negative zeta potential values. Thus, this results indicate that they can interact with positively charged particles. Also, Figure 4 shows that calcination reduces the negative value of zeta potential.

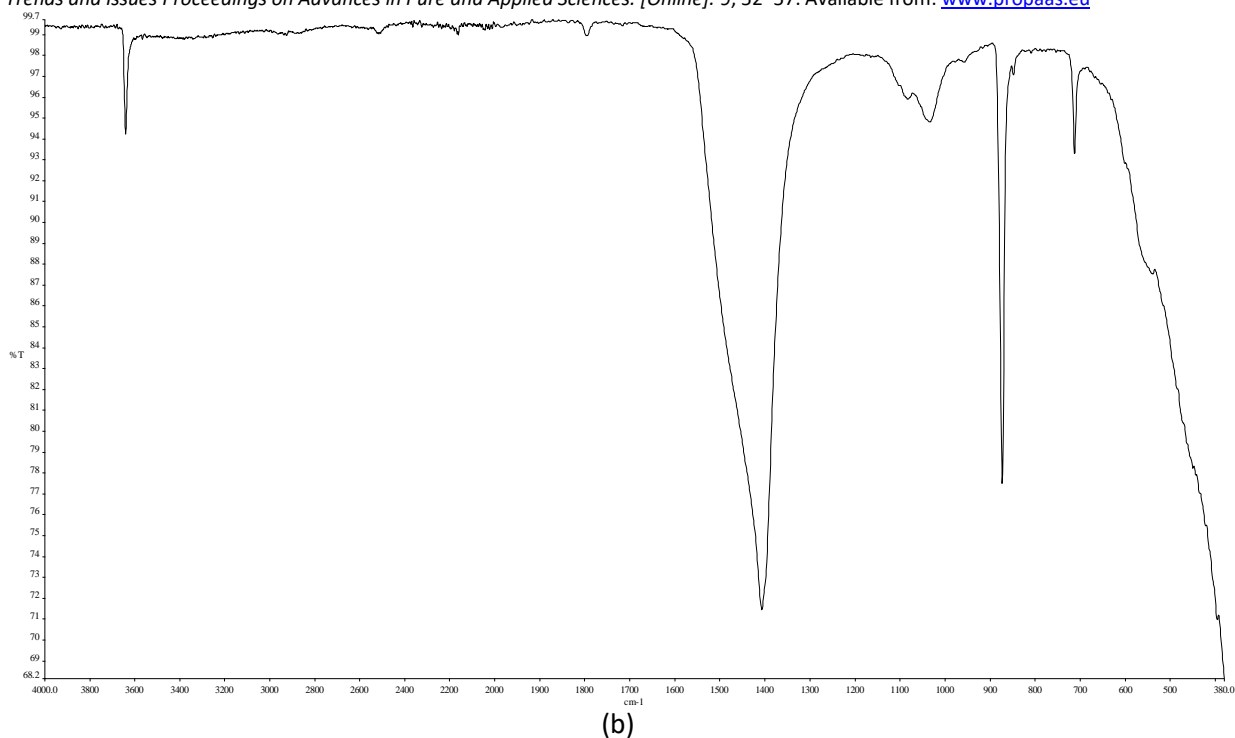


**Figure 4.** Calcinated mussel shells

### 3.3. Fourier transformed infrared spectroscopy analysis of mussel shells

The FT-IR spectra of uncalcinated mussel shell and calcinated mussel shell are presented in Figure 5(a) and 5(b). The FT-IR analysis demonstrates that functional groups for the calcinated mussel shell sample. The band at around  $3500\text{ cm}^{-1}$  in Fig. 5(b) is belongs to hydroxy group stretching modes. The bands at  $1437\text{ cm}^{-1}$  and  $874\text{ cm}^{-1}$  present the carbonate group. And this results are consistent with literature [17].





**Figure 5.** FT-IR spectras of uncalcinated (a) and calcinated mussel shells (b)

### 3.4. BET analysis

The determination of surface area and porosity, usually refers to the measurement of Brunauer-Emmett-Teller (BET) surface area. It is a conventional method used for characterization of surface characteristics of adsorbents, catalyst, etc. for the specific surface porosity. The surface characteristics of materials effects the application of materials. The BET surface of uncacinated and calcinated mussel shells were  $0.3379 \text{ m}^2/\text{g}$  and  $7.6139 \text{ m}^2/\text{g}$  respectively. It can be seen from the BET surface area values a relatively larger surface area of calcinated mussel obtained with calcination. Calcination has big effect on making larger the surface area of the material.

### 4. Conclusion

In recent years, developing economical alternatives from natural materials has attracted great interest Mussel shells are abundant in the sea and cause waste. In this study, the structure of mussel shells investigated to find alternative applications as an economic material. Also, mussel shells were calcinated to improve surface properties. And then, the uncalcinated and calcinated mussel shells were characterized for their surface characteristics. All characterization results indicated that calcination studies improved the surface characteristics of the mussel shells. Thus we offer that the calcinated mussel shells can be used in adsorption studies as a low-cost, eco-friendly biosorbent efficiently.

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