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# Investigation on surface charasteristics of uncalcinated and calcinated mussel shells

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**Abstract**

In recent years, developing economical adsorbents to treat with different types of pollutants has attracted great interest. Waste mussel shells are common wastes produced by the seafood industry. They have some advantages over conventional process such as simplicity of design and low cost. In this study, the uncalcinated and calcinated mussel shells were characterisated for their surface characteristics. Mussel shells washed with tap water several times followed by distilled water and dried at 105°C for 12 hours in an oven. They were powdered to small particles and calcined at 900°C for 2 hours. The sample was finely ground into small particles of different sizes, washed with distilled water and dried overnight at 105°C. And then, the sample was calcined at a heating rate of 2°C/min to 400°C and maintaned at this temperature for 4 hours.The calcined and uncalcined 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 mesaurements. The results indicated that calcination studies improved the surface charasteristics of the mussel shells and that the calcinated mussel shells can be used in adsorption studies as a novel low-cost, eco-friendly biosorbent efficiently.

Keywords: Adsorption, calcination, characterization, mussel shell.

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## 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 colours vary depending on the ambient conditions in which mussel lives. 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 realised 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, easily obtainable, economical and biodegradable natural materials such as mussel shells have attracted great interest that can be used for different aims such as biodiesel production [2, 3], nanoscience [4], dye [5–7] and metal removing [8–12] and synthesis studies [13–16].

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. 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 several times followed by distilled water and dried at 105°C 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 sample was washed with distilled water several times and dried. The sample was finely ground into small particles of different sizes (45–250 µm), washed with distilled water and dried overnight at 105°C. And then, sample was calcined at 400°C during 4 hour with a heating rate of 2°C/minute. Synthesised samples were stored for characterisation.

The calcined and uncalcined mussel shell samples were characterised by FT-IR, SEM-EDS, BET and Zeta potential mesaurements.

## 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 SEM micrograph in Figure 1, 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.

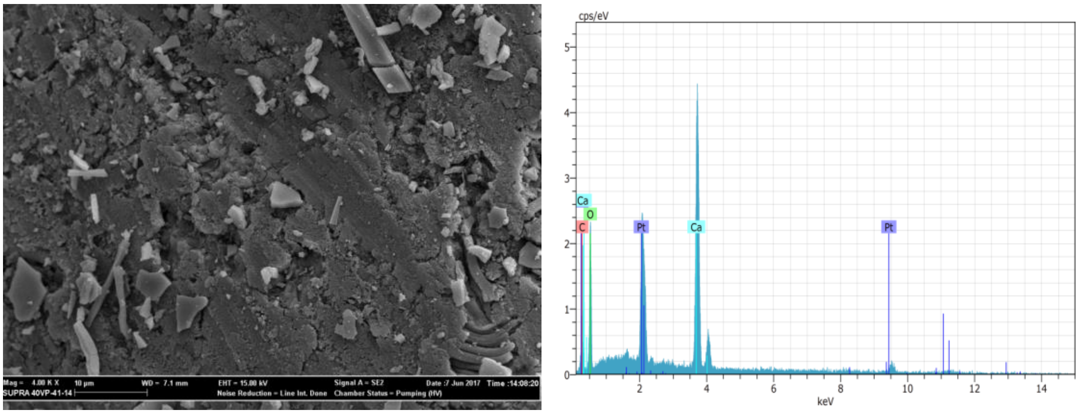



**Figure 1. SEM – EDS images of uncalcinated mussel shells**

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 is obvious that the pores are formed.

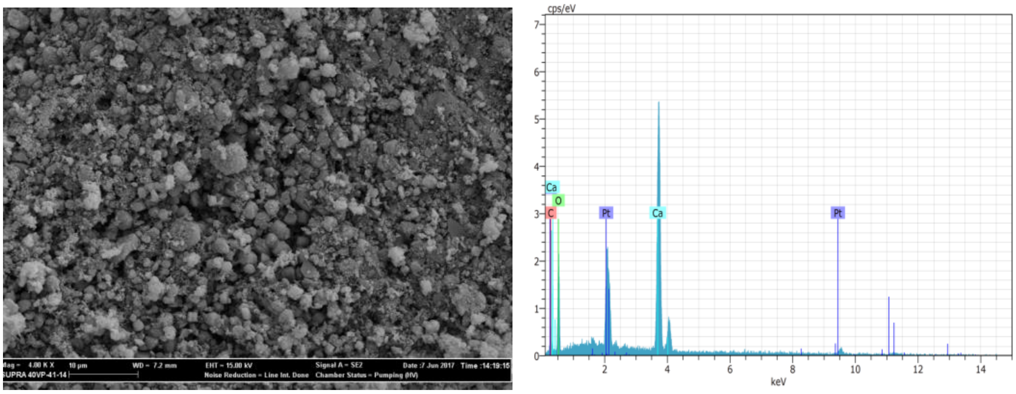



**Figure 2. SEM-EDS images of calcinated mussel shells**

**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. The surface charge density depends on the concentration of ions. 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.

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

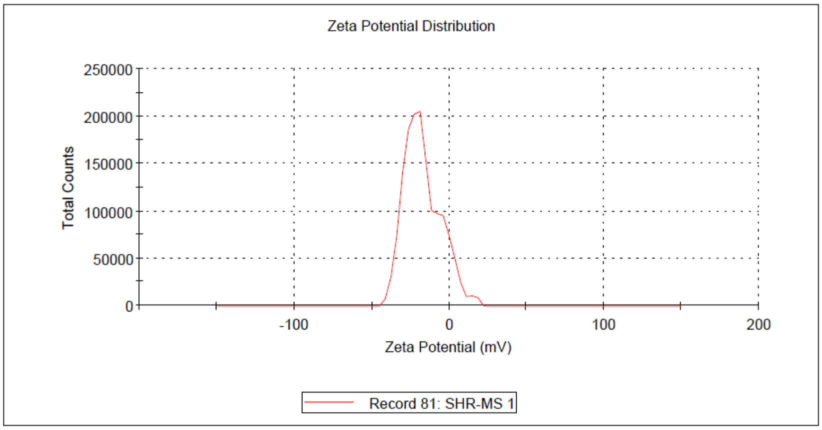



**Figure 3. Uncalcinated mussel shells**

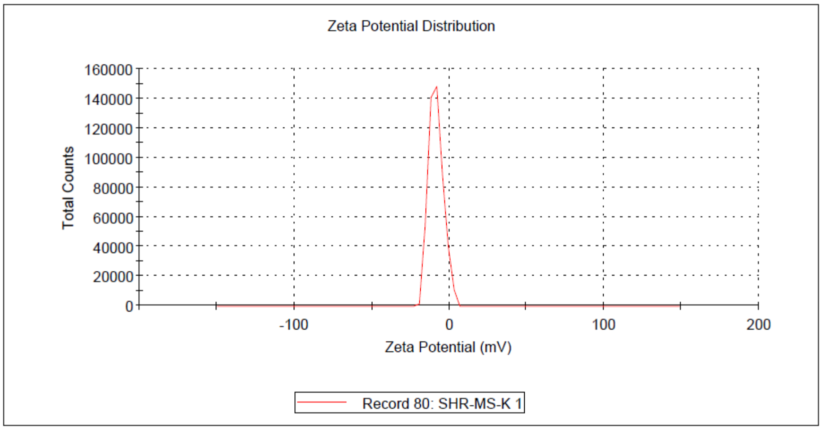
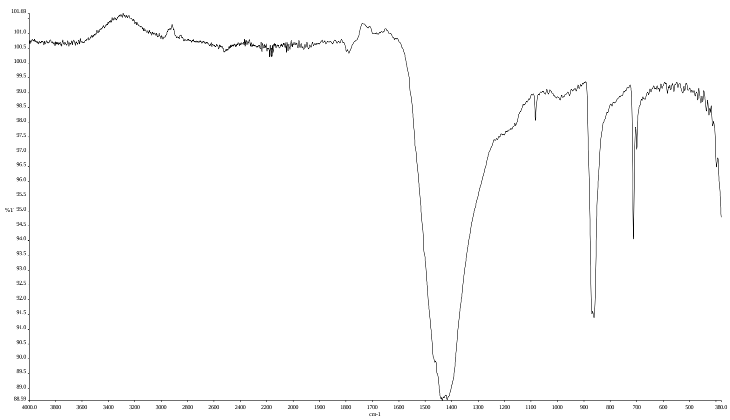


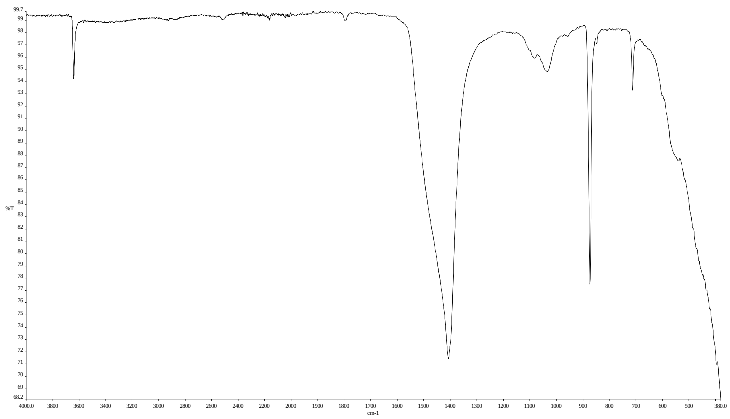

**Figure 4. Calcinated mussel shells**

### *3.3. FT-IR analysis of mussel shells*

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



(a)



(b)

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

### *3.4. BET analysis*

The determination of surface area and porosity, usually refers to the measurement of the BET surface area. It is a conventional method used for characterisation of surface characteristics of adsorbents, catalyst, and so on for the specific surface porosity. The surface characteristics of materials affect the application of materials. The BET surface of uncacinated and calcinated mussel shells were 0.3379 $m^2/g$ and 7.6139 $m^2/g$, respectively. It can be seen from the BET surface area values that a relatively larger surface area of calcinated mussel was obtained with calcination. Calcination has a 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. Waste mussel shells are common wastes produced by the seafood industry. They have some advantages over the conventional process such as simplicity of design and low cost. In this study, the structure of mussel shells investigated to find alternative applications as an economic material. Also, mussel shells were calcinated to improve the surface properties. And then, the uncalcinated and calcinated mussel shells were characterisated for their surface characteristics. All characterisation results indicated that calcination studies improved the surface charasteristics of the mussel shells. Thus we offer that the calcinated mussel shells can be used in adsorption studies as a novel low-cost, eco-friendly biosorbent efficiently.

## References

[1] A. U. Catli *et al*., "Karma Yemlere Et-Kemik Unu ve Midye Kabugu Unu Katilmasinin Yumurtaci Tavuklarin Verim Performansi Uzerine Etkileri," Kumes Hayvanlari Kongresi, 2010.

[2] R. Rezaei *et al*., "Optimization of biodiesel production using waste mussel shell catalyst," *Fuel*, vol. 109, pp. 534–541, 2013.

[3] S. Nurdina *et al*., "Economical biodiesel fuel synthesis from castor oil using mussel shell-base catalyst (MS-BC)," *Energy Procedia*, vol. 79, pp. 576–583, 2015.

[4] E. J. M. Edralin *et al*., "Sonochemical synthesis, characterization and photocatalytic properties of hydroxyapatite nano-rods derived from mussel shells," *Mater. Lett.*, vol. 196, pp. 33–36, 2017.

[5] M. E. Haddad, "Removal of basic Fuchsin dye from water using mussel shell biomass waste as an adsorbent: equilibrium, kinetics, and thermodynamics," *J. Taibah Univ. Sci.*, vol. 10, pp. 664–674, 2016.

[6] M. E. Haddad *et al*., "Assessment of the biosorption kinetic and thermodynamic for the removal of safranin dye from aqueous solutions using calcined mussel shells," *J. Ind. Eng. Chem.*, vol. 20, pp. 717–724, 2014.
[7] M. E. Haddad *et al*., "Calcined mussel shells as a new and eco-friendly biosorbent to remove textile dyes from aqueous solutions," *J. Taiwan Inst. Chem. Eng.*, vol. 45, pp. 533–540, 2014.
[8] S. Pena-Rodriguez *et al*., "Mercury removal using ground and calcined mussel shell," *J. Environ. Sci.*, vol. 25, issue 12, pp. 2476–2486, 2013.
[9] S. Pena-Rodriguez *et al*., "Kinetics of Hg(II) adsorption and desorption in calcined mussel shells," *J. Hazard. Mater.*, vol. 180, pp. 622–627, 2010.
[10] C. Osorio-Lopez *et al*., "As(V) adsorption on forest and vineyard soils and pyritic material with or without mussel shell: kinetics and fractionation," *J. Taiwan Inst. Chem. Eng.*, vol. 45, pp. 1007–1014, 2014.
[11] D. Fernandez-Calvino *et al*., "Influence of mussel shell on As and Cr competitive and non-competitive sorption–desorption kinetics in a mine soil: stirred flow chamber experiments," *Geoderma*, vol. 232–234, pp. 300–308, 2014.
[12] R. Paradeloa *et al*., "Phosphorus removal from wastewater using mussel shell: investigation on retention mechanisms," *Ecol. Eng.*, vol. 97, pp. 558–566, 2016.
[13] G. S. Kumar *et al*., "One step method to synthesize flower-like hydroxyapatite architecture using mussel shell bio-waste as a calcium source," *Ceram. Int.*, vol. 43, pp. 3457–3461, 2017.
[14] H. He *et al*., "Mussel-inspired PLGA/polydopamine core-shell nanoparticle for light induced cancer thermochemotherapy," *Acta Biomater.*, vol. 59, pp. 181–191, 2017.
[15] A. Shavandi *et al*., "Microwave-assisted synthesis of high purity β-tricalcium phosphate crystalline powder from the waste of Green mussel shells (Perna canaliculus)," *Powder Technol.*, vol. 273, pp. 33–39, 2015.
[16] M. Li *et al*., "The antibacterial activity and mechanism of mussel shell waste derived material," *Powder Technol.*, vol. 264, pp. 577–582, 2014.
[17] M. El Haddad *et al*., "Calcined mussel shells as a new and eco-friendly biosorbent to remove textile dyes from aqueous solutions," *J. Taiwan Inst. Chem. Eng.*, vol. 45, pp. 533–540, 2014.