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Effect of Calcination Temperature on Green Powder From Ensis sp. Shell Waste

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ABSTRACT

Ensis sp. is a primary source of protein from the Nyumbun Tradition in Jambi Province, and it is becoming solid waste after tradition. This study explored the effect of calcination temperature on green powder derived from *Ensis* sp. shell waste. Before characterization, the powder was treated at room temperature, 800 °C, and 900 °C. After that, the powder material was studied using Atomic Absorption Spectroscopy (AAS) and Scanning Electron Microscope (SEM) instruments. The material was shifted using a 200 mesh sieve. Temperature of 800 and 900 °C showed similar Ca content of 443 and 447,6 mg/g, respectively. The morphology of the two samples was different due to the other temperature conditions used. Higher temperatures induce decomposition, leading to a decrease in particle size. The product of this process could be used as a promising heterogeneous catalyst, so it reduced the existence of shell waste.

Keywords: shells waste, *Ensis* sp, heterogeneous catalyst

INTRODUCTION

Ensis sp. is an environmental problem; the shells are leftovers from the food industry [1]. As with other types of shellfish, the benefits of this waste have not been maximized for another function. Shell waste in Indonesia continuously increases, reaching 453,600 tons in 2018 [2]. Meanwhile, the world's total waste of around 16.1 million tons [3]. Of the large amount of waste produced by biomass, only a tiny portion is utilized by enterprises and scholars. The shellfish shell waste is used as concrete aggregate [4], accessories, decoration [5], acid soil processing, calcium supplements, and clean water treatment [6]. Therefore, optimizing the potential of this waste as raw material for making CaO powder is very promising. *Ensis* sp. shell waste will become a green powder material because it could be an alternative to limestone mining [5].

$CaCO_3$ present in powdered shellfish excrement has been observed to be greater than 90%. Because of this scientific fact, this waste has a high potential for being converted into materials with scientific and technological applications. The CaO content generated after heating the solid waste at a high temperature of roughly 600-1000°C is 98% [6]. The thermal decomposition process of the $CaCO_3$ compound yields high quantities of CaO. The CaO catalyst is a low-cost chemical with good basicity [7], is non-corrosive, has low solubility, and has low post-treatment costs [8]. The CaO catalyst is a low-cost chemical with good basicity [7], is non-corrosive, has low solubility, and has low post-treatment costs [8].

CaO catalysts from the Ensis genus are widely applied in biodiesel production. Aitlaalim et al. (2020) said that the catalyst that provides the best performance was created at a temperature of 900 °C. Calcination at a temperature of 900 °C can produce fatty acid methyl ester (FAME) up to 98% [10]. Catalyst modification was also carried out to increase catalytic activity by impregnation of KI and $BaCl_2$ and can produce a FAME yield of 96.99% [8], [11]. Apart from being biodiesel, the *Ensis* sp. shell waste catalyst is also used to degrade Jambi batik dye waste with a yield of 60.34% [12]. Because the use of *Ensis* sp. shell waste as a catalyst is still relatively limited, this study aims to investigate the potential of this type of shell as a heterogeneous catalyst and the effect of calcination temperature on the material that can be employed in various industries.

MATERIAL AND METHOD

Materials

This study is a part of a previous project [1]. For five days, samples of *Ensis* sp. shell waste were dried in the sun. The waste is reduced in size to assist the combustion process using a furnace (as indicated in Figure 1a). The research samples were separated into three groups: those without calcination and those with calcination at 800 and 900 °C. The combustion process takes two hours using a furnace. The samples were then sieved using 100 and 200 mesh sieves, yielding six samples as 1b-g.

Figure 1. (a) Smaller size of *Ensis* sp. shell Waste, (b) uncalcined, 100 mesh, (c) calcined 900 °C, 100 mesh, (d) calcined 800 °C, 100 mesh, (e) uncalcined, 200 mesh, (f) calcined 900 °C, 200 mesh, and (g) calcined 800 °C, 200 mesh

Characterization of Powder Material

To assess calcium levels arising from the decomposition process, all material samples from processing were examined using Atomic absorption spectroscopy (AAS). Meanwhile, characterization using Scanning Electron Microscopy (SEM) tries to establish the material's surface shape [13], [14].

RESULTS AND DISCUSSION

The society is very interested in seafood Medium Small Enterprises as a source of protein. This enterprise is also practiced by the inhabitants of Kampung Laut, who are well-known for their Nyumbun Tradition. According to Utami (2022), the Nyumpun Tradition is a method of environmental protection because society can harvest *Ensis* sp. shells at that event. During the Nyumbun Tradition, visitors from inside and outside Kampung Laut can appreciate local customary decisions. When the Nyumbun tradition ended, all that remained was a pile of unprocessed *Ensis* sp. shells. The circular economy concerning garbage has yet to begin in that region. Previous research suggests that piles of solid shellfish waste left over from the food industry can become a source of bacteria if left for a long time. It can also cause an unpleasant aroma, which causes air pollution and becomes a source of disease [6], [15].

Ensis sp. shell waste and the like have great potential as a green heterogeneous catalyst. A previous study can be seen in Table 1, where a discussion of catalysts from *Ensis* sp. still needs to be completed. The $CaCO_3$ (aragonite phase) mineral contained in natural shells can be converted into several potential catalyst materials such as $CaCO_3$ (calcite), CaO (lime), and $Ca(OH)_2$ (portlandite) [9], [16]

Table 1. *Ensis* sp as raw material for green heterogeneous catalyst generation

No	Raw material	Year	Function	Country	References
1	*Ensis* Sp.	2023	Photocatalytic	Indonesia	[12]
2	*Ensis* Sp.	2022	Catalyst	Indonesia	[1]
3	Grooved Razor Shell (GRS)	2020	Catalyst	Morocco	[9]

4	Razor clam	2018	Catalyst	Thailand	[11]
5	Razor clam	2017	Catalyst	Thailand	[8]
6	Razor and surf clam shells	2015	Catalyst	Thailand	[10]

Atomic Adsorption Spectroscopy (AAS)

Table 2 shows the results of the characterization of catalyst material from *Ensis* sp. shell waste (*Ensis* sp) using AAS. The data shows that calcination at 800 °C has the highest Ca content in powder. However, the different particle sizes yield distinct Ca content, namely 436.6 mg g^{-1} for 100 mesh and 447.6 mg g^{-1} for 200 mesh, respectively. The increasing calcination temperature destroyed the Ca structure in the powder.

Table 2. Analysis of Ca content in material from *Ensis* sp. shell

Sieve	Calcination (°C)	Calcium Content (mg g^{-1})
100 mesh	*Uncalcined*	386.2
	800	436.6
	900	426.2
200 mesh	*Uncalcined*	390.3
	800	447.6
	900	443

Scanning Electron Microscopy (SEM)

The microscopic properties of the material surface were analyzed using SEM to determine changes in surface morphology caused by heat treatment (shown in Figure 2). In Figure 2. a, the morphology of *Ensis* sp. shell waste powder without calcination was sifted using a 100 mesh sieve. In Figure 2. a, it can be seen that the surface of the waste powder material without heat treatment is in the form of periodic layers and is accompanied by a few non-uniform granules on the surface. The granules are not clustered and tend to spread sparsely on the surface. The results of this research are also supported by previous research, which states that shell waste without any treatment showed a surface shape in the form of a distinctive layer [8], [16]. It also occurs in Figure 2.d. namely material without heat treatment, but this sample was sieved using a 200 mesh size. It makes sample 2.d smaller than sample 2.a. Figure 2.d also shows the surface shape of the layers, which are neatly arranged with small granules [10]. These granules are arranged spread out on the surface and are not clustered.

Heat treatment of the material is carried out to increase the effectiveness of the catalyst from *Ensis* sp. shell waste. Figures 2. b and 2. c showed the calcined catalysts at 900 and 800 °C for 2 hours. Calcination at 900 and 800 °C changes the surface morphology of the material from a typical layer to a micropore material. The spread Granules on the surface (in Figure 2. a) converted to form sharper aggregates at 900 °C treatment (Figure 2. b). A previous study stated that the change in surface morphology from layered to porous was due to heat treatment [17]. A different thing happened in the 800 C calcination treatment, resulting in a morphology agglomerating into lumps, and granules were not distributed on the surface [8]. The pores formed can increase the surface area so that this material has better catalytic activity [18].

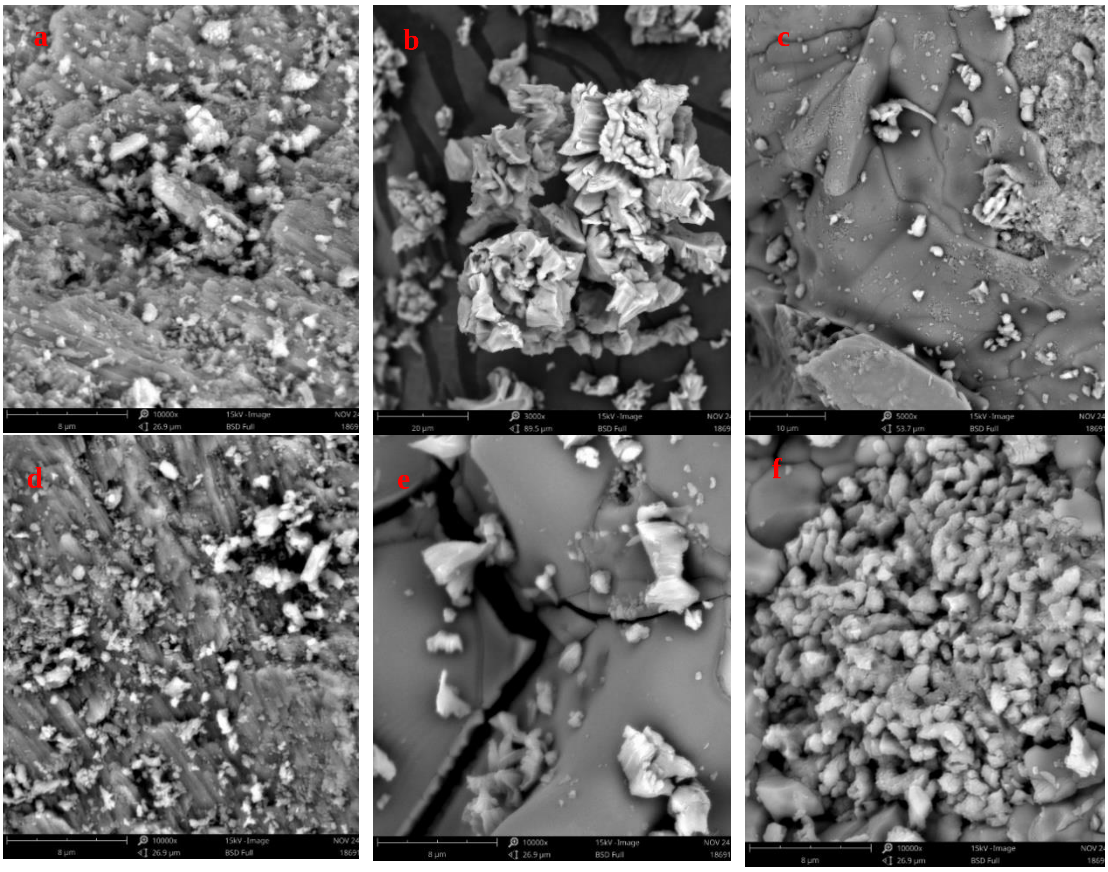

Figure 2. Catalyst morphology from *Ensis* sp. shell waste with a magnitude of 10.000, (a) uncalcined, 100 mesh, (b) calcined 900 °C, 100 mesh, (c) calcined 800 °C, 100 mesh, (d) uncalcined, 200 mesh, (e) calcined 900 °C, 200 mesh, and (f) calcined 800 °C, 200 mesh.

Figures 2. e and 2. f showed treatment temperatures of 900 and 800 °C, but the material was sieved using a 200 mesh sieve. A 200 mesh sieve provides a smaller material size than a 100 mesh sieve. Figure 2. e shows a maximum pore distribution compared to Figure 2. b. This result was also confirmed by the highest calcium content from the AAS analysis, 447.6 mg/g. Previous research explains that 900 °C heat treatment on Grooved Razor Shell can cause irregular particle agglomeration. Apart from that, the large pores that appear after calcination are caused by the release of H_2O, CO_2, and other organic compounds [9], [14], [16]. A different thing happens in Figure 2. f, which shows the surface morphology due to heat treatment at 800 °C, namely the formation of tiny granules evenly distributed on the catalyst surface. It is due to the decomposition of $CaCO_3$ into CaO [19].

CONCLUSION

Ensis sp. shell waste has the potential to be used as a green heterogeneous catalyst to accelerate specific reactions. The AAS characterization results confirmed that heat treatment caused an increase in the calcium content in the material. In addition, firing at temperatures of 800 and 900 °C causes material agglomeration and gives rise to pores. The pores formed are accompanied by irregular granules that spread across the catalyst's surface. It increases the particle size and porosity of the material, and these two characteristics indicate the quality of the catalytic activity provided by the catalyst.

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