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Thermoregeneration Of Spent Perlite After Freezing Vegetable Oil

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Abstract: This article presents the possibility of regenerating spent perlite after the freezing process of vegetable oil. It was established that the composition of spent perlite contains up to 70% wax-like substances. Their combustion leads to the restoration of perlite as a filtration material or as a secondary raw material for obtaining silicon dioxide. It was determined that after calcination at 500–550°C for 120 minutes, the yield of calcined perlite amounts to 25%, while further temperature increases have little effect on yield, which indicates that the entire organic fraction burns out within this temperature range.

Keywords: Perlite, silicon dioxide, regeneration, spent perlite, filtration material, wax-like substances, vegetable oils.

Introduction

According to various geological studies [1,2], perlite is formed as a result of hydration of volcanic glass. The main components of perlite are SiO_2 (up to 75%) and Al_2O_3, along with minor amounts of Fe_2O_3, MgO, CaO, and other minerals. Perlite is characterized by its high expandability—when heated to 900–1100°C, its volume increases by 4–20 times due to the evaporation of bound water.

In industry, perlite is widely used as a filtering material, a filler in paint and varnish products, as well as a sorbent for wastewater treatment and for eliminating oil spills [3].

Recent research has focused on the modification of perlite for specific purposes, such as the adsorption of heavy metals, carbon, and organic pollutants [4,5]. Increasing attention is also being paid to the environmental safety of production processes and the possibility of reusing perlite waste in various industries. Perlite represents a valuable natural resource with a broad spectrum of applications. The development of processing and modification technologies opens up new prospects for more efficient and environmentally sustainable utilization. Continued scientific research in this field will enable the creation of innovative materials and solutions based on perlite [6,7].

At present, in the republic, perlite is applied as a filtering reagent in the freezing of sunflower black oil. Approximately 1,000 tons of perlite are imported annually; after use, it is employed as an additive for bird feed and for candle production.

Considering that perlite is rich in silicon dioxide, its targeted utilization is of significant relevance.

Methods

Spent perlite was thermally regenerated at 550 °C for 120 min to remove organics. The material was then treated with NaOH solution, followed by acidification with HCl to precipitate SiO_2, which was washed and dried. Additional SiO_2 gel was obtained via direct HCl treatment.

Results

As the initial material, spent perlite was used, with its chemical composition presented in Table 1.

Sample	Oxide content, wt.%										LOI
	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	CaO	MgO	Na_2O	K_2O	SO_3	(wt.%)
Perlite	73,98	13,24	0,94	0,14	0,07	0,78	0,86	2,77	3,08	-	4,12

From Table 1, it is evident that the main component of perlite is SiO_2, which can be obtained through chemical decomposition. The material also contains up to 70% vegetable oils and wax-like substances absorbed during the vegetable oil freezing process.

Table 2. Spent perlite was regenerated through thermal treatment, with the results presented in

Treatment temperature, °C	Treatment time, min	Color after regeneration	Yield after calcination, %
450	60	Surface shows yellow coloration	65
	90	Residual fat present	65
	120	Localized yellow spots	55

500	60	Localized yellow spots	50
	90	Faded yellow coloration	35
	120	Transitioning from yellow to white	42
550	60	Residual fat, partially white	40
	90	Residual fat, transitioning to white	25
	120	White	25
600	60	White	25
	90	White	24
	120	White	23

As can be seen from Table 2, with increasing temperature from 300°C, the organic fraction absorbed in perlite begins to combust, and at 550°C (120 minutes) complete regeneration is achieved. It is noteworthy that even at 550°C (60 minutes), residual fats were still present. Longer calcination at this temperature enables complete burnout of residual fats and wax-like substances.

Based on the calcination yield, it can be observed that with an increase in temperature from 450°C to 550°C, the yield decreases from 65% to 23%. Further increases in temperature result in negligible changes in yield, which once again confirms that the organic fraction has almost completely combusted.

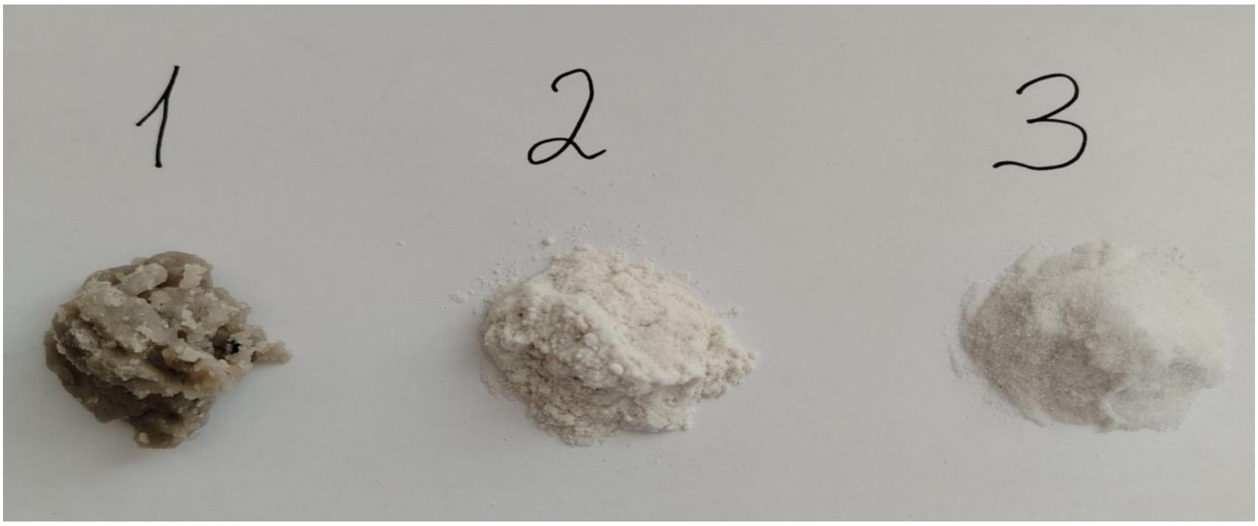

Fig. 1. Effect of temperature on the degree of regeneration
1 – sample of spent perlite after freezing sunflower oil;
2 – treated at 450°C; 3 – treated at 550°C.

From Fig. 1, it is visually evident that as the temperature increases and the organic fraction burns out, the color of the spent perlite changes. This once again confirms the combustion of the organic fraction.

Thus, spent perlite obtained after freezing vegetable oil can be reused as a secondary raw material for silicon dioxide production after thermal regeneration. Since perlite itself is rich in silicon dioxide, its regeneration provides the possibility for further application as a sorbent material.

Conclusion

It has been established that the composition of spent perlite contains up to 70% wax-like substances. Their combustion leads to the restoration of perlite either as a filtration material or as a secondary raw material for producing silicon dioxide. It was determined that after calcination at 500–550°C for 120 minutes, the yield of calcined perlite is about 25%, and further increases in temperature have virtually no effect on the yield. This indicates that the entire organic fraction has been completely combusted at this temperature range.

In future studies, detailed investigation will be carried out on obtaining SiO_2 from regenerated perlite, as well as its adsorption and textural characteristics.

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