American Journal of Biodiversity
https://biojournals.us/index.php/AJB
ISSN: 2997-3600

Physicochemical Processes Occurring in the Activation of Gileads and Their Inclusion Into Vegetable Oils

Norkulov D., Sayimova D.K., Sultanov Sh.A.
Navoi State University

Received: 2024 25, Sep
Accepted: 2024 21, Oct
Published: 2024 24, Nov

Annotation: The nature of the interaction of sorption properties of vegetable oils introduced for sorption purification of raw materials from impurities in the production of environmentally friendly food products and biologically active media is shown. Sorbents, in particular palygorskite clays, are used to purify vegetable oils from additives that complicate the processing of these raw materials into products with high energy and nutritional value. The introduction of palygorskite clays into vegetable oils through chemical processes seems to be a reasonable step, since on their surface (i.e., the basal surfaces and edges of the particles) there are both acidic and basic surface centers. By further separating such clays from the liquid phase, it is possible to obtain a very wide range of compounds of various nature, which are to some extent close to the main component of the oil-containing medium - triglycerides of fatty acids. So, for example, free fatty acids are characterized by the presence of a proton of the hydroxyl group and a coordination saturated carbonyl oxygen atom; the active part of peroxide compounds contains an electron donor oxygen atom, and the molecules of mixed phosphatides have donor-acceptor bonds at the oxygen atom and the amino group.

Keywords: activation, vegetable oils, sorption, palygorskite clay, Lewis centers, Bronsted centers.

INTRODUCTION

As is known, to change the sorption properties of palygorskite in relation to the components of vegetable oils, as a rule, the process of activation with acids is used. Further, “soft” activation is provided by exposure to organic acid sorbents, in particular acetic acid (AC); alkaline activation is rarely carried out, apart from acid treatment.

The purpose of this work is to attempt to scientifically substantiate the nature of the interactions between various local oil components and palygorskite clay activated by acidic and alkaline substances.

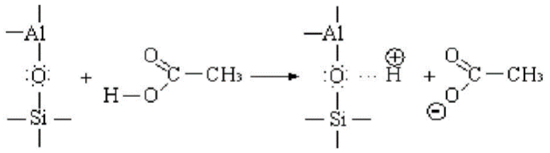
As a result of activation, the sorption properties change depending on the composition of the clay powders and the structural arrangement of the elements. The clay powder is weighed on a scale and mixed continuously with a solution of a certain percentage, the time of the chemical reaction process is carried out within 10 minutes. Then the process of activation of the suspension solution is continued in a closed and chemically resistant vessel (reactor). The temperature and activation time given to the pulp in the reactor depend on the composition of the clay powders. The sorption properties are determined by the surface activity of the clay powders and the diameter and depth of the surface pores. Therefore, the need for pressure during the activation process to expand the pore size is also taken into account. The process is carried out at the required pressure by the amount of pulp relative to the internal volume of the reactor. If the pressure is higher than 3 atm, it should occupy 90% of the internal volume of the vessel. In addition, the pressure is also affected by the activation temperature, and partly by the type of clays, the concentration of the solution and their proportions.

The experiments were conducted on samples of sunflower (K.h.=5.3 mg KOH/g) and linseed oils (K.h.=3.2 mg KOH/g), to which clays from the Navbahor and Azkamar deposits were added at 70 °C. After 30 minutes of treatment with the sorbent, the physicochemical parameters of vegetable oils were determined by the methods. Diffractograms of the crushed clay sample were obtained using the “DRON–3 M” (Si K-radiation, λ = 1.54 Å; tube voltage 40 kV, current 20 mA, scanning speed 1 deg./min).

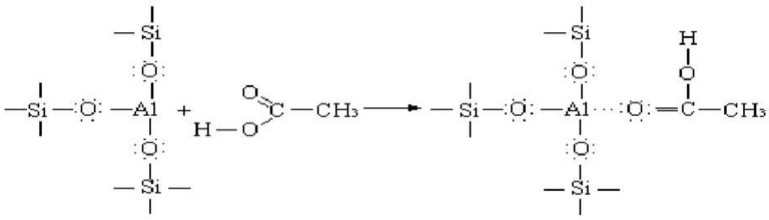
By the method of pk spectroscopy, Bronsted proton acid centers, Lewis aprotic acid centers and main proton acceptor centers were found on the surface of natural sorbent particles. Bronsted centers (17 mmol/g) are formed by surface hydroxyl groups near the aluminum atom bound to two silicon-oxygen tetrahedra of the palygorskite lattice. Lewis centers ((10 mmol/g) contain coordinately unsaturated atoms of aluminum). Main centers (13 mmol/g) represent surface oxygen atoms with a filled electron shell. Qualitative determination of the structure of the activated sorbents was carried out on the basis of infrared spectroscopy data, which were obtained in accordance with the quantitative assessment of their surface groups.

Analysis of the diffraction patterns of a natural sorbent sample showed that its main component is palygorskite. According to infrared spectroscopy, when activating palygorskite clay with acetic acid, weak dealumination of the crystal structure of aluminosilicate and the formation of carboxylate groups are observed, and these processes are characteristic of concentrations of SK above 50 wt. %. In the rk spectra of clay activated by this agent, a group of acid centers was found in the region of 4...6 (140 mmol/g), while the main centers were absent.

This gives reason to believe that in the interaction between palygorskite and SK, primarily with insignificant (within a few percent) concentrations of acid, the interaction of its hydroxyl group with the main proton-accepting centers on the surface of palygorskite predominates, which leads to the neutralization of the latter:

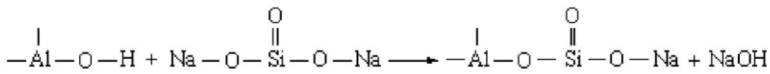


With increasing SK concentration (>6 wt. %), the electron-withdrawing Lewis centers of palygorskite clay react with carbonyl oxygen with a filled outer orbital:

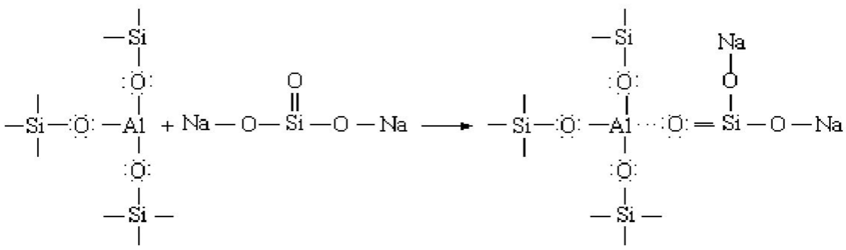


As a result, on the surface of the particles we have a coordination saturated Al atom and carboxylate in a monodetante form, the hydroxyl group of which provides a proton-donating center according to Brønsted. When dealuminizing palygorskite with acid, a Lewis center appears instead of the aluminum atom, which is formed from a silicon atom with an excess positive charge.

In the infrared spectra of azkamar clay mixed with sodium liquid glass in an amount of 5-15 wt. %, there are no vibrations of the surface hydroxyl groups of palygorskite. In the Rk spectra, only the peaks of the main centers in the region 11...12 are distinguished, the total content of which is ≈128 mmol/g. Thus, the Bronsted surface centers are neutralized in the type cation exchange.

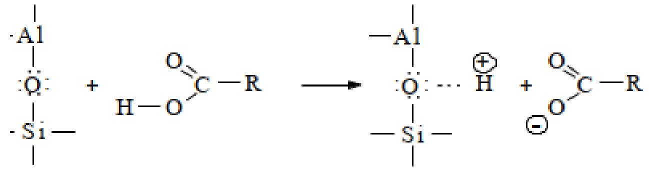


Lewis is due to the adsorption of FS silicate groups through electron-unsaturated oxygen atoms:

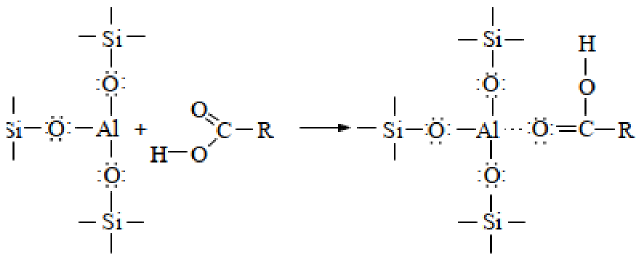


As a result, only the main centers are present on the surface.

The described surface properties of palygorskite allow us to understand the essence of the physicochemical phenomena during the sorption processes accompanying the purification of vegetable oils from combined substances. Thus, free fatty acids present in vegetable oils at concentrations up to 0.1 mol/l (and sometimes higher) can be adsorbed, firstly, by neutralizing the hydroxyl groups with the main proton-accepting centers on the sorbent surface according to the Bronsted mechanism:

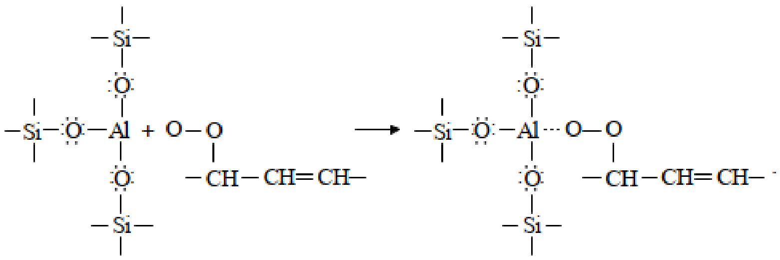


The second pathway occurs due to the interaction of the COOH groups of the coordinatively unsaturated Lewis centers in palygorskite with the filled electron shell of the carbonyl oxygen (e.g., acetic acid K):



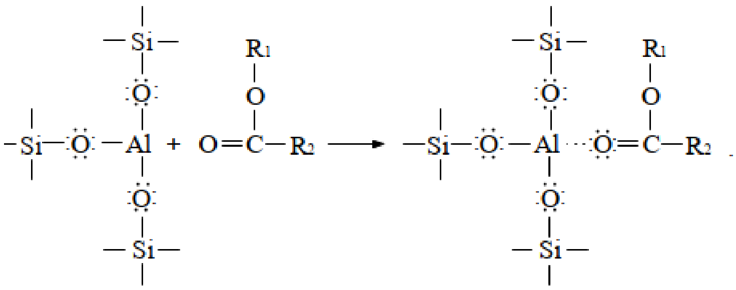
The presence of mobile sodium cations in FS significantly increases the degree of neutralization of fatty acids. This is confirmed by the data on the purification of sunflower oil [8, 9]: the maximum removal of free fatty acids from it is observed when using clay compositions of the Azkamar deposit, including FS additives (up to 10 wt. %), and the minimum degree of purification is achieved by introducing sorbents pre-activated by SK.

In turn, peroxide compounds have a free pair of electrons in the external sphere and interact with surface centers that withdraw electrons according to Lyuis:

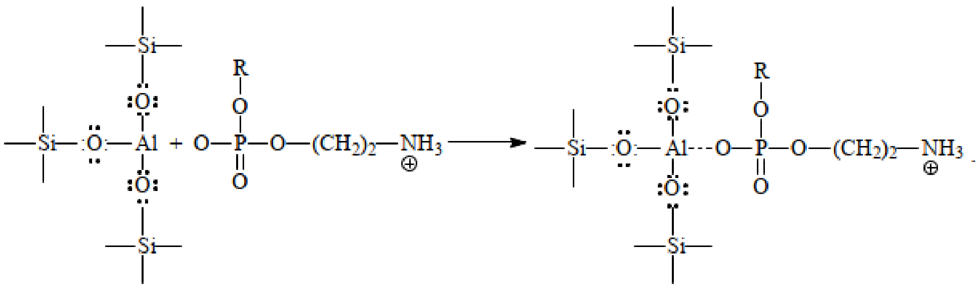


This can be explained by the increase in the degree of purification of sunflower and linseed oils from peroxide compounds on palygorskite clay sorbents activated by SK.

As for the impurity waxes (up to 1.5 wt. %), the active center of their molecules contains carbonyl oxygen. This structure supports the adsorption of these vegetable oil conjugates on the Lewis acid centers of palygorskite according to the scheme:

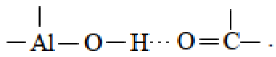


Experimental data [3, 10] confirmed that the use of acid-activated sorbents from palygorskite clays gives more significant results in the separation of waxes from oil-containing media. Phosphatides also contain oxygen atoms that form bonds with coordinately unsaturated aluminum atoms:

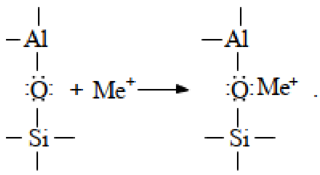


Accordingly, a high degree of purification of vegetable oils from phosphatides can be achieved by introducing activated clay sorbents into oils by SC [9].

In the process of purification of vegetable oils from all the above-mentioned types of compounds, hydrogen bonds between the oxygen atom of the recovered components and the terminal hydrogens of the hydroxyl groups of palygorskite are of great importance (Brønsted acid centers):



At the same time, they also act as Lyuis acids, interacting with the electron donor main center formed by the surface oxygen atom of the sorbent material:



The study of the dynamic capacity of sorbents showed that sorbents made of palygorskite clay activated by acetic acid, in particular, in combination with FS or dolomite, are characterized by stable work in the purification of sunflower oil. The consumption of these sorbents is within 100 kg/t of oil (sunflower, linseed) purified to the “highest grade” qualification. This result, as mentioned above, is explained by the presence of all types of centers on the surface of natural and activated palygorskite sorbents, as a result of which biologically active oil-containing media of interest for environmentally friendly food products and pharmacology are obtained.

Conclusions

1. The essence of the physicochemical processes occurring during the introduction of palygorskite clays into vegetable oils is shown and the nature of the interaction between various fatty substances and active centers on the sorbent surface is determined.

2. Activation of clay from the Azakamar deposit with acetic acid and alkaline substances (liquid glass, dolomite), with a sorbent consumption of up to 100 kg/t, provides a level of purification of the latter up to the qualification of "highest grade".

REFERENCES

Sobirov B.B., Amonov M.R., Sultonov Sh.A., Sayimova D.Q. (2023). Patent Uz № IAP 07496. Method for obtaining a sorbent for clarifying vegetable oils. *29.09.2023.*

Kholov Kh.M., Sobirov B.B., Allanazarov Kh., Sultonov Sh.A. (2021). Methodology for improving the adsorption properties of palygorskite clay soil. *Universum: Technical Sciences*, Issue 2(83), February 2021, Part 3, Moscow, pp. 62-67.

Sultonov Sh.A., Kholov Kh.M., Asrorova F.A. (2021). Activation of palygorskite clay soil for oil bleaching. *International Scientific and Educational Electronic Journal "Education and Science in the XXI Century,"* Issue 20 (Volume 5), November 2021, pp. 1276-1278.

Sultonov Sh.A., Rakhmonova Kh.Q. (2024). Physical and chemical processes in the activation of palygorskite clays and purification of vegetable oils. *Engineering and Economics Electronic Publication,* November 2024, p. 508.

Tarasevich Yu.I. (1988). Structure and surface chemistry of layered silicates. Kyiv, 248 pages.

Prokofiev V.Yu., Razgovorov P.B., Smirnov K.V., et al. (2007). Extrusion molding of sorbents based on kaolin. *Glass and Ceramics*, Issue 8, pp. 29–32.

Razgovorov P.B., Sitanov S.V., Prokofiev V.Yu., Smirnov K.V. (2007). Prediction of the quality of wax removal from vegetable oils in the presence of white clay. *Chemistry of Plant Raw Materials,* Issue 4, pp. 111–116.

Bekturova, M. B., & Smagulova, Z. N. (2015). Adsorption properties of clay minerals and their application in oil purification. *Journal of Applied Chemistry*, 88(3), 289-298.

Jones, R., & Smith, A. (2010). Advances in bleaching technologies for edible oil processing. *Food Technology Journal*, 12(4), 334-341.

Yagmur, E., Ozmak, M., & Aktas, Z. (2008). A review of modified clay adsorbents for oil bleaching. *Applied Clay Science*, 38(4), 232-239.

Oliveira, C., Santos, P., & Lima, J. (2022). The role of activated clays in the bleaching of vegetable oils. *Chemical Engineering Journal*, 200(5), 456-467.

Wu, H., Lin, J., & Chen, Y. (2017). Evaluation of palygorskite as an adsorbent in oil bleaching. *Journal of Materials Science*, 52(3), 1234-1245.

Tan, H., & Wang, L. (2020). Thermal activation of natural clays for oil processing. *Clay Minerals Journal*, 55(2), 245-254.

Al-Zahrani, S., & Al-Farraj, A. (2014). Improving the quality of vegetable oils using activated clay technology. *Journal of Food Chemistry*, 156, 128-135.

Zhang, Y., Huang, X., & Li, W. (2019). Innovative approaches in clay activation for industrial applications. *Industrial Chemistry and Engineering Quarterly*, 25(4), 765-774.