Comprehensive Cleaning of Vegetable Oil

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***Abstract* - Treatment with highly dispersed adsorbents is a necessary stage of purification of vegetable oils, natural and hydrogenated fats, as well as fatty acids from coloring substances, trace amounts of phospholipids, sulfur compounds, fatty acid salts with alkaline and other metals, some oxidation products, etc. Adsorption capacity of the adsorbent is dependent on the concentration of the substance in the liquid or vapor phase, its partial pressure, temperature, and the initial state of the adsorbent. At the swelling a cellular porous structure is formed, total porosity that connects with the entered number and the content of the gaseous component masses. The rheological characteristics of porous masses have the decisive effect on the porous structure. The research results of the internal structure of adsorption layers by the adsorption isotherms means indicative of the internal surface of the porous layer is characterized by an extremely complex and developed form and can be described by means of fractal geometry. A model of the geometric structure of mica materials formed in the process of blistering during heat treatment is developed. The presented model has sufficiently general form and can be used both in the organization of systematic experimental studies of porization and adsorption in the adsorption layers of highly porous, and for the porization vermiculite optimization.**

Keywords: Adsorption, deodorization, distillation, vegetable oil, vermiculite

I. INTRODUCTION

The fat and oil industry is the leading branch of the food industry in the Republic of Kazakhstan and determines the food security of the country. Vegetable oils, both used directly in food and directed for processing, must be subjected to a full refining cycle in order to remove harmful substances for the body, improve the presentation, improve the organoleptic characteristics, and provide resistance to oxidation.

Adsorption refining (bleaching) is the most important stage in the purification of vegetable oils from pigments, as well as the residual quantity of phospholipids, salts of fatty acids remaining in the oils after the previous stages of refining, and metal ions.

As adsorbents, special activated bleaching earths are used, which have selectivity to the concomitant substances of vegetable oils.

Currently, in the fat-and-oil industry, the most widely used bentonite bleaching earths are the main producers of which are the USA, Malaysia, China, which determines their high cost in the market. In this case, the use of bentonite bleaching earth does not always ensure the obtaining of oils of the desired quality. Alternative raw materials for the production of bleaching earths are vermiculites. In connection with the foregoing, the improvement of the technology of adsorptive refining of vegetable oils, using domestic vermiculites, is topical.

Qualitative indicator of the adsorption process is often used the degree of purification (bleaching) of vegetable oils, which in each case is determined based on the type of refined oil, its purpose, etc.

In the traditional process of adsorption purification of vegetable oils, the main technological factors are: temperature, stirring intensity (number), pressure, amount of adsorbent, etc.

The technological stage of adsorption purification of oils, considered as a stage of the refining cycle before the final stage of processing-deodorization or distillation, has a high potential to influence the manufacturability of subsequent processing and the quality of the final product. Adsorption cleaning allows to reduce the content of coloring substances, phospholipids, Soaps, primary and secondary oxidation products, metals of variable valence and as a result to increase the oxidative stability of the oil [1].

The oil obtained by pressing contains more than 1% of the impurities. These include: cell tissue fragments, phosphatides, protein and mucous substances, dyes, free fatty acids and other components, most of them negatively affect the quality of the oil.

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There are mechanical methods of cleaning-to remove phosphate complexes and water, clean it on vibro-sieves or sedimentary centrifuges. 2. The second group – chemical methods-is used to remove free fatty acids, proteins, phosphotides from the oil, as well as to lighten the oil.

Chemical include acid and alkaline refining.

1) treatment is carried out with sulfuric acid, colorants are destroyed, salts of fatty acids decompose – drying oils, varnishes – obtaining.

2) alkaline refining-used to remove free fatty acids, it is carried out after heating the oil to 90 degrees. With alkali treatment.

3) hydration – it is in the handling of oil heated hot water – for removal of proteins, mucus, fosfatidov. Carried out before alkali refining.

3. Physical and chemical methods:

a) adsorption refining – to remove coloring substances, is to mix the oil with substances having a highly developed surface, then filter, to remove solids.

b) deodorization – removal of fat odorous substances by steam distillation in a special apparatus and adsorption after alkali refining, under vacuum.

A key factor in the effective absorption treatment is applied to the adsorbent, its activity and dosage.

Treatment with highly dispersed adsorbents is a necessary stage of purification of vegetable oils, natural and hydrogenated fats, as well as fatty acids from coloring substances, trace amounts of phospholipids, sulfur compounds, salts of fatty acids with alkaline and other metals, some oxidation products, etc.

Natural non-activated clays, synthetic silicates and aluminosilicates, activated carbons are used as adsorbents. However, bentonite clays activated by treatment with mineral acids (sulfuric, hydrochloric) have found the most widespread and versatile application.

The expansion of the applications of adsorption processes led to the improvement of the properties of older types of adsorbents (activated carbons and silica gels, alumogel, alumosilicate) and the creation of new materials with molecular sieve and other specific properties (zeolites, porous glass, polymers). Quite high adsorption, catalytic and ion exchange properties of minerals, the emergence of effective methods of regulation of their geometric structure and chemical nature of the surface, the presence of large industrial deposits make it economically feasible to use vermiculite as adsorbents.

Adsorption cleaning is based on the ability of adsorbents to absorb unwanted impurities present in the oils by its surface. To study the adsorption characteristics of vermiculite, vegetable oil was used. Adsorption methods are used in deep sewage from organic substances found in small concentrations. Applications of adsorption filtration water treatment is most effective for removing water from anthropogenic element-organic compounds for the improving the quality of process water for reuse of process water, as well as protection of water bodies. This method allows for a purification step to reduce the concentration of organic compounds till 90-99%.

Among the possible technical mineral sorbents for wider use, particularly in the technology of cleaning and refining of industrial emissions, deserve special attention adsorption-active materials of natural minerals. A promising source of such materials are layer silicates, particularly vermiculite [2-4].

There are deposits of vermiculite in the Republic of Kazakhstan. The demand of the Republic of Kazakhstan in vermiculite could reach tens of thousands tons per year, due to the a wide range of applications.

In the production of porous adsorbents one of the main objectives is the creation of a high porosity that characterized by uniformity of pore volume distribution layer. These requirements determine the method and parameters of the molding process, and the type of porous structure and properties of the products. From the rheological characteristics of the binder in the production of porous materials with cellular structure of thick liquid compositions by swelling depends binder consumption, duration of mixing and molding cycle [1-3]. Ensure of the optimum processes porization and achieving the necessary geometric characteristics of the adsorbed layer requires the understanding of the formation of the layer structure and the theoretical description of this complex process.

II. MATERIAL AND METHOD

As the study object was selected kulantau vermiculite that represents micaceous magnesium-aluminum silicate glandular of the intermittent chemical composition expanding the structural unit relating to the group trioctahedral hydromicas.

Vermiculite is mineral from the group of hydrous layered structure, the grain structure of the plate, shiny, can be gold, silver, red colour. At the heating till different temperatures in the 400-1000 °C, natural vermiculite expands 15-25 times and is converted into expanded vermiculite, which is widely used in various sectors of industrial activity.

Characteristic properties of vermiculite[2-3]: specific weight - 70-180 kg / m^3 (depending on granules sizes), water absorption capacity ~ 400-530%, pH 6.8-7.0 (neutral-weakly alkaline). Vermiculites variable chemical composition, %: MgO 14-15, FeO 1-3, Fe_2O_3 3-17, Al_2O_3 10-17, SiO_2 34-42, H_2O 8-15, as well as impurities such as a Ti, Ni , Zn.

The interlayer and inter-packet intervals vermiculite structure can be regarded as plate micropores having a size of 0.3 - 1.2 nm [5]. Vermiculite cation exchange capacity is in the range of 100-150 mEq/100 g, i.e. clay minerals from it one of the most exchange capable [3].

The physicochemical methods of research were used. The structure of the expanded vermiculite was investigated by X-ray method on the DRON-3 [4].

III. RESULTS AND DISCUSSION

In the process of adsorption purification of vegetable oils removed a significant amount of peroxides, dyes, as well as part of the remaining fat after hydration and alkaline refining phospholipids, sodium Soaps fatty acids.

The process involves mixing the oil with the adsorbent, holding for a certain time at a certain temperature under vacuum with stirring to ensure the adsorption process and separating the adsorbent with undesirable components from the oil by filtration. The use of the filter brand GNP can significantly increase the filtration rate, improves the ease of maintenance and reduces the loss of oil in the spent adsorbent.

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Fig. 1 show the results of the degree of capture of various substances and the corresponding values obtained in the course of experimental studies, as well as experimentally determined swelling resources.

The graphs show that with the correct porosity resource chosen, acid treatment leads to a sharp increase in their specific surface area and the volume of transition pores. The error does not exceed 5%.

First, the adsorbent is in contact with the incoming concentrated solution. As a result of filtration through the adsorbent layer, almost all the dissolved substance is removed from the solution. The uppermost part of the layer is saturated, and the main adsorption occurs in a relatively narrow part of the sorbent layer, where the concentration changes rapidly. When this area reaches a predetermined limit value, consider that there was a slip.

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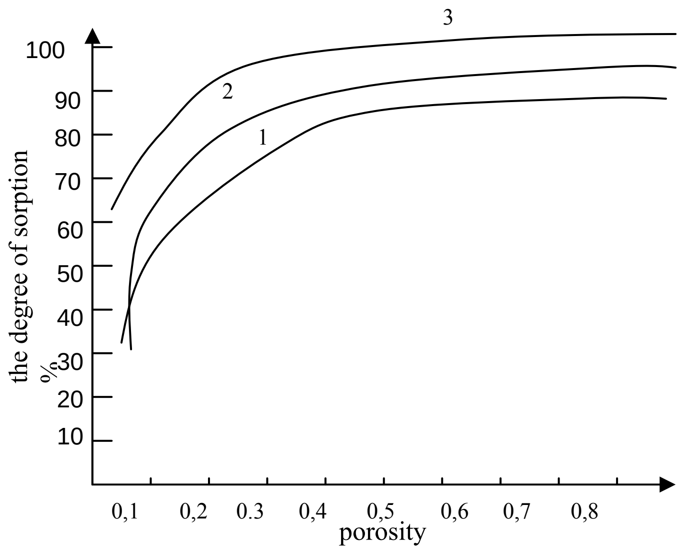
In the traditional process of adsorption purification of vegetable oils, the main technological factors are: temperature, stirring intensity (number), pressure, amount of adsorbent, etc.

In order to study the mechanism of interaction of adsorbents with adsorbent, the limiting stage of adsorption processes was determined.

In the general form, during the adsorption process, there are 3 stages:

- displacement of the adsorbent through the film surrounding the adsorbent particles (external diffusion);
-displacement of adsorbent inside the pores to the active centers of the adsorbent (internal diffusion);
- interaction of adsorbent with adsorbent (physical adsorption or chemisorption).



1-cotton oil; 2-sunflower oil; 3-safflower oil

Fig. 1. Degree of capture of substances depending on the porosity of the sorbent

One of the most common ways is the swelling. This method porization based on isolation in the plastic-viscous mass or introducing into it a gas phase as hydrogen, oxygen, carbon dioxide, water vapor, air, pentane, freon, etc. As a result of the saturation mass of the gas phase increases its volume - occurs swelling (foaming). Formed dispersion - air "fluid" hardening at further processed. When swelling is formed honeycomb porous structure, total porosity that depends on the number entered, and keep the masses of gaseous component. The rheological characteristic of porous masses has a decisive effect on the porous structure. Common for all versions is a swelling plastic-viscous state of masses porization during their porization, i. e. masses porization must be able to permanently deform (flow) without discontinuity. There is only one material swelling which occurs without his move to plastic-viscous (pyroplastic) state - vermiculite [5-6]. This formed plate porosity due separation mica platelets inter-packet with water, turning into vapor state by heating the vermiculite particles to high temperatures.

Therefore, the description of the structure of a porous material based on vermiculite requires the use of dynamic models that include the stage of evaporation in inter-packet space, and reorientation of mica elements under pressure generated steam.

Adsorption cleaning is based on the property of adsorbents to absorb by their surface undesirable impurities present in the oils. In the process of adsorption purification of plant oils, a significant amount of peroxide compounds, coloring agents, and also part of the fatty acids remaining in the fat after hydration and alkaline refining, sodium soaps of fatty acids (Fig. 2) are removed.

The process involves mixing the oil with the adsorbent, holding for a certain time at a certain temperature under vacuum with stirring to ensure the adsorption process and separating the adsorbent from the undesired components from the oil by filtration. The use of the GNP filter allows significantly increase the filtration rate, improves serviceability and reduces oil losses in the spent adsorbent.

The processed raw materials are fed to the vacuum-whitening apparatus E1. The adsorbent is also supplied here. In the vacuum-whitening apparatus E1, intensive mixing of the oil with the adsorbent is carried out. From the vacuum-whitening apparatus E1, the suspension is pumped by the H2 pump through a vertical filter Ф4, onto the grids of which the filtering layer is pre-washed. The filtered oil enters through the police filters Ф7 and Ф8 and is fed for further processing.

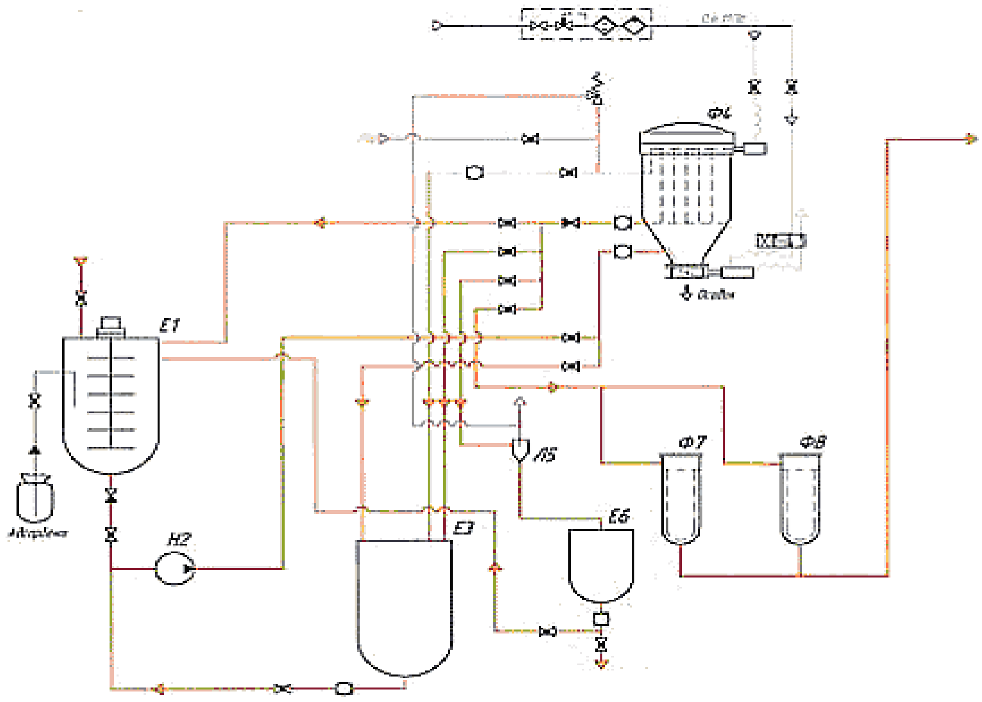


Fig. 2. The line of adsorption treatment (whitening) of plant oils

When the pressure drop is increased on the running filter Ф4, the supply of oil to it stops. The remaining volume of oil is drained into the tank E3. The filter cake was dried with steam, while the oil from the sediment was squeezed into a tank E6 equipped with L5 trap. In the tank E6, oil separates from the condensed vapor. Oil from the tank E6 is periodically removed to the vacuum-whitening unit E5, and water to the grease trap. After drying, the sludge vibrates from the filter housing F4. The filter F4 is filled and the filter layer is poured onto the grids from the vacuum-whitening apparatus E1.

IV. CONCLUSION

Based on the study of the chemical composition and structure of various adsorbents, it is theoretically substantiated and experimentally proved that the vermiculite of the Kulantau deposit can be used in the adsorption refining of vegetable oils.

The dependence of the filtration rate and oil capacity on the granulometric composition of vermiculite was revealed.

The fractal dimension of the cluster is determined by the physicochemical characteristics and the conditions of formation of a porous layer. A critical component and the degree of anisotropy may depend on the physicochemical characteristics of the reactants and the geometric characteristics of the layer. Unusual flow regimes of complex multicomponent fluids in porous media appear in a nonuniform distribution of the adsorbed substance in the adsorbed layer.

The presented information in the model can be used in the organization of systematic experimental studies of porization and adsorption of highly adsorptive layers, as well as for the optimization of porization materials.

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