Investigation of the process of desorption of oil-saturated waste of felt production

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Abstract. Has been investigated the possibility of using keratin-containing waste of felt production - knop - as a sorption material for oils. The value of the activation energy was determined, which was 27.86 kJ/mol. It was found that the process of interaction of knop with oil is physical and occurs due to changes in the Van der Waals forces.

Petroleum products are the dominant pollutants that are entering the environment. The impact of petroleum products on aquatic environments is most noticeable, which leads to violation of the oxygen balance between the atmosphere and the hydrosphere, a decrease in the concentration of dissolved oxygen, the death of aquatic organisms, etc. 1 ton of oil or OP can pollute 12 km² of the water surface or 1 million m³ of water [1-4].

Sorption methods of wastewater treatment are used to minimize the anthropogenic impact of pollutants on water bodies, for the extraction of oil and oil products from water environments. The main advantages of the sorption method include the absence of secondary pollutants, the ability to remove pollutants of various origins of various concentrations until the latter are completely removed. However, despite the widespread practical use of sorption methods for industrial wastewater treatment, this method has several significant disadvantages, such as insufficient sorption capacity of sorbents, high cost, lack of effective methods of regeneration and utilization, and others [5].

In connection with the above, the world community is rapidly developing in a new innovative direction of water purification. Industrial and agricultural wastes are used as reagents for removing pollutants from wastewater and water surfaces [6]. Agricultural wastes, as a rule, are cellulose-containing waste from the processing of fruits, vegetables, cereals and bast crops. However, as shown by the studies [7], the latter have a relatively low sorption capacity for oil and oil products. Keratin-containing waste from wool processing has a much greater oil and oil absorption capacity. It was determined [8] that knop is a product of wool processing in felting-felt production, has high sorption characteristics in relation to oils of various brands.

From an economic and technological point of view, applying of desorption of a sorption material (SM) is justified, which also contributes to the return of absorbed oil for the purpose of its regeneration or utilization. In this regard, experimental work was carried out to squeeze oil-saturated SM at various values of the applied pressure.

Based on the graphs presented in figure 1, it was revealed that the general mass of the oil is removed from the sorption material, during the first 20 seconds of pressing and spinning, while a decrease in the sorption capacity of the knop is observed after the first regeneration.
The maximum oil extraction rate from sorption material was 87.5%. Based on this graph, it is shown that the rate of the oil recovery process depends on the applied pressure as well (figure 2).

Following on from the study, is considered the influence of the temperature factor on the flow of these products. The sorption material was immersed in oil until saturation at various temperatures, then it was extracted, the amount of flowing oil was measured at certain intervals. Based on the obtained data, the oil drainage rate $dQ/d\tau$ was calculated. Obtained dependence of the drainage rate from the amount of oil retained by the sorbent layer is presented at different temperatures, shown in figure 3.
When approximating of the experimental data, the named dependence is plotted in logarithmic
coordinates (figure 4).

\[ \frac{dQ}{d\tau} = k \cdot Q^2, \]  

(1)

where 2 is the tangent of angle of inclination of the lines obtained in figure 3 (conventionally assumed

to be the same for all); Q is the mass of flowing oil, g/g; \( \tau \) - time, s; k is the measured data (rate

constant) of the process. The results of calculating the rate constant of the process k at Q = 0.3 g/g are

presented in Table 1.

| T, °C | 10    | 25    | 40    |
|------|-------|-------|-------|
| T, K | 283   | 298   | 313   |
| 1/T  | 0.0035| 0.0033| 0.0032|
| k    | 0.0178| 0.0222| 0.0556|
| lnk  | -4.0298| -3.8067| -2.8904|

Figure 5 shows a graph of the dependence of the rate constant of the oil drainage process ln (k) on

the return temperature T⁻¹.

\[ y = -3327.2x + 7.6083 \]

**Figure 4.** Dependence of the oil drainage rate \( \frac{dQ}{dt} \) on the amount

of oil Q retained by the sorbent layer at different temperatures in

logarithmic coordinates: 1) 10 °C; 2) 25 °C; 3) 40 °C.

As we can see from the represented graphs, with an increase in temperature, the drainage rate

increases, however the mechanism of the process does not change. Therefore, we can assume that the

flow rate in all cases obeys equation 1.

**Table 1.** Estimated values of some parameters.

**Figure 5.** Dependence of the rate constant of the oil drainage process of the

inverse temperature.
The equation for the temperature dependence of the runoff process has the form:

$$\ln k = a - \frac{E}{RT}.$$  \hspace{1cm} (2)

The value of the activation energy of the process was determined by substituting the known values for 2 points of the straight line (Table 2) and solving the system of equations 3-5 with 2 (a and E) unknowns:

$$\begin{align*}
\ln k_1 &= a - \frac{E}{RT_1} \\
\ln k_2 &= a - \frac{E}{RT_2} \\
\Rightarrow \ln k_2 &= \ln k_1 + \frac{E}{RT_1} - \frac{E}{RT_2} \hspace{1cm} (4)
\end{align*}$$

$$\ln k_1 = -3.02 \text{ (at } T_1 = 313 \text{ K}), \quad \ln k_2 = -4.15 \text{ (at } T_2 = 283 \text{ K}). \hspace{1cm} (5)$$

Accordingly, the value of the activation energy was determined, which was 27.86 kJ/mol. Consequently, the process of interaction of knop with oil is physical and occurs due to changes in the Van der Waals forces.

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