Method of Purification of Oily Wastewater by Oil-Soluble Hydrocarbon Adsorbents

N Farvazova¹, A Valeev¹, B Mastobaev¹
¹Department of Oil and Gas Transportation and Storage, Ufa State Petroleum Technological University, Kosmonavtov Street 1, Ufa, 450062, Russia

E-mail: anv-v@yandex.ru

Abstract. During exploitation of oil pipelines and storages oil spill can occur. For effective collecting spills sorbents are used. There are many types of sorbents, but sorbents that can be utilized in excess oil are very promising. The aim of the work is to study the properties of such substances, their applicability for oil spill collection and comparison with other sorbents. The object of the study was a sorbent that contains powdery polypropylene. A study of a number of basic working properties was carried out in laboratory conditions at room temperature of 20 °C. This sorbents creates a rubber-like formation like "carpet" that is easily removed from the surface. During experimental study the sorption capacity has been measured. Test of the buoyancy of the sorbent in water showed that after 20 days sorbent granules do not sink, do not swell and form no film on the surface, allowing water to evaporate freely.

1. Introduction
World experience in protection against environmental pollution by oil and oil products shows that for an operative response to emergency situations a complex of technical means is needed. The process of eliminating an oil spill can be divided into 3 stages [1]:
   1) spill location;
   2) the collection and extraction of the product from the surface of water or soil;
   3) transportation of the collected product to the place of processing or disposal.
Each stage has its own means and technologies. Modern means for the localization and elimination of oil spills and oil products can be divided into the following groups [1]:
- boom barriers;
- skimmers (devices for collecting oil from the surface of water);
- sorbents (materials that collect oil by adsorption and absorption);
- dispersants (special chemicals that accelerate the processes of biodegradation of oil);
- biochemical preparations (organic sorbents intended for liquidation of water and soil pollution by oil);
- microbiological agents;
- auxiliary means (boats, pumps, tanks, ground and air vehicles, communication facilities, etc.).
2. Description of experimental sorbent
Oil sorbents that can be utilized in excess oil are very promising. The goal of this Paper is study of powder sorbent with a polypropylene base. The experimental sorbent is a powdery hydrophobic material of white color. Granules have a size not exceeding 1 mm (Fig. 1).

![Figure 1. Experimental sorbent.](image)

It is experimentally established that at a room temperature (20 °C) with a uniform distribution of the sorbent on the surface of the oil, in a ratio of 1: 3 by weight, after 10-15 minutes, a rubber-like rug (Figure 2) is formed. If we carry out a similar experiment, simulating an oil spill on the water surface, we also observe the formation of a rug (Fig. 3), which is easily removed from the water surface without leaving an iridescent film after it. However, at negative temperatures (minus 5 °C) after 1 hour, the binding of granules of the sorbent, which absorbed oil, to a single rug was not observed.

![Figure 2. Formation of a rug.](image)  ![Figure 3. Rug on a water surface.](image)

3. Experimental study of sorbent capacity
An experiment to test the buoyancy of the experimental sorbent on the water surface was conducted. The experimental sorbent was spread in a glass with water and a sorbent was distributed throughout the surface (Figure 4). Even after 20 days sorbent hasn’t drowned and hasn’t increased in volume. It keeps staying of the water surface, i.e. it have good buoyancy property. Moreover, the water level decreased noticeably. It means that experimental sorbent allows water freely evaporate.
One of the main properties of sorbents is the sorption capacity - the amount of oil, accumulated by one kilogram of sorbent in one cycle [2, 3]. To determine this parameter, the following experiment was made:

1) a certain amount of oil \( m_o \) is collected in the tank;
2) the sorbent with mass \( m_s \) is distributed on surface of oil and left for a while (1 hour);
3) if it is necessary, the formed product is laid out on a filter paper to remove excess oil (not absorbed by the sorbent) and is compressed;
4) the obtained dry product is weighed \( (m_d) \);
5) sorption capacity is calculated due to formula

\[
C = \frac{m_{dry} - m}{m}
\]

The results of the experiment are presented in Tables 1 and 2.

**Table 1.** Experimental data.

| Number of experiment | Ratio of sorbent to oil |
|----------------------|-------------------------|
|                      | 1:6                     | 1:10                     | 1:20                     |
|                      | \( m_{io}, \ g \) | \( m_{io}, \ g \) | \( m_{io}, \ g \) | \( m_{io}, \ g \) | \( m_{io}, \ g \) | \( m_{io}, \ g \) | \( m_{io}, \ g \) |
| 1                    | 5,08   | 32,20   | 33,26   | 1,02   | 10,30   | 8,40   | 0,54   | 10,68   | 3,96   |
| 2                    | 5,10   | 30,18   | 33,12   | 1,10   | 10,12   | 6,66   | 0,52   | 10,36   | 2,88   |
| 3                    | 1,76   | 10,44   | 10,10   | 1,04   | 10,20   | 6,68   | 0,54   | 10,66   | 3,61   |

**Table 2.** Calculation of sorbent capacity (g/g).

| Number of experiment | Ratio of sorbent to oil |
|----------------------|-------------------------|
|                      | 1:6                     | 1:10                     | 1:20                     |
| 1                    | 5,55   | 7,24    | 6,33    |
| 2                    | 5,49   | 5,05    | 5,42    |
| 3                    | 6,33   | 4,54    | 5,69    |
| Mean value           | 5,56     |          |
| Mean square deviation| 0,82     |          |
It should be noted that when the ratio of sorbent to oil is less than 1:6, a rug is not formed. So, at a ratio of 1:6 after 1 hour, the rug was not observed, but the sorbent completely absorbed the entire volume of oil provided (Figure 5). At ratios of 1:10 and 1:20, the sorbent granules swelled, increased in volume and freely lay in excess of oil (Figure 6).

4. **Experimental study of sorbent rug dissolving**

So experimental sorbent, unlike most others, has 100% buoyancy for 20 days or more and does not absorb water.

The next study was to study of the dissolution of spent sorbent in excess oil as a method of its utilization, determining the minimum required amount of oil. General plan for this study is the following:

1) determination of a number of indicators of the quality of the initial oil;
2) creating a rug of the experimental sorbent;
3) oil heating up to 50 °C;
4) dissolving the rug in excess oil;
5) determination of the same oil quality indicators after the experiment;
6) analysis of changes in quality indicators.

At the ratio 1:30 of the sorbent rug to oil it is obtained that the rug has been particularly dissolved (Fig. 7).
The next step will be providing experimental with greater ratios for full dissolving.

5. Conclusions
Despite the fact that sorption capacity of the experimental sorbent is lower than most synthetic sorbents, taking into account all the features and advantages, the application of the sorbent is convenient and effective.

On the basis of the experimental data, it can be concluded that experimental sorbent has high properties; there is no contraindications for application for liquidation of oil spills. So a promising sorbent has been obtained.

6. References
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