Study of flotation isolation of polyvinyl acetate

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Abstract. In this paper, the effectiveness of polyacrylamide-based collecting samples for the separation of polyvinyl acetate by flotation method is studied. It is determined that the collectors show maximum efficiency at a concentration of 2 mg/l. Maximum efficiency is observed in an alkaline environment and can reach 99\% depending on the conditions of the process.

1. Introduction
In the modern world, the issue of wastewater treatment is quite acute. Industrial enterprises of organic synthesis that discharge effluents containing various chemicals have an intensive impact on water bodies. An example of an organic substance that is widely used in industry is polyvinyl acetate. Polyvinyl acetate is a product of chain polymerization of vinyl acetate, which is an ester of acetic acid and vinyl alcohol. The main application of polyvinyl acetate is the production of polyvinyl acetate glue, water-based and acrylic paints, as well as further processing into polyvinyl alcohol and polyvinyl acetals. Polyvinyl acetate is highly soluble in ketones, esters, chlorinated and aromatic hydrocarbons, methanol and does not dissolve in water, aliphatic hydrocarbons, gasoline, and mineral oils\[1\].

The danger of organic substances for water bodies is that they stop the flow of oxygen into the water. This affects the ability of water to self-purify, as it worsens the living conditions of microorganisms and the course of oxidative processes. In this regard, the task of finding effective ways to clean wastewater from organic substances contained in it is urgent.

One of the ways to separate organic substances from wastewater is flotation treatment, which can reach 98\% efficiency. Flotation is aimed at extracting hydrophobic particles from the water using gas bubbles injected into the wastewater. This process is based on the molecular adhesion of particles of pollutants and bubbles of thinly dispersed gas in water. The size and number of gas bubbles affect the efficiency of flotation cleaning\[2, 3\].

An important factor that increases the efficiency of flotation cleaning is the presence of collecting reagents\[4, 5\]. These reagents create a hydrophobic layer around the contaminant particle, thereby simplifying the removal of the particle by an air bubble from the wastewater to the surface.

The purpose of this work is to study the effectiveness of polyacrylamide-based collecting samples for the separation of polyvinyl acetate by flotation method.

2. Methods
For the preparation of reaction mixtures, aqueous solutions of polyvinyl acetate (0.2 g/l), collector reagents (0.1 g/l), hydrochloric acid (1 N), and sodium hydroxide (0.1 N) were used.

Poly[acrylamide-dimethylaminoethyl-methyl chloride acrylate] substances were used as collectors. The properties of collectors are shown in Table 1.
Table 1. Characteristics of collector reagents.

| Type of collector reagents | Charge type | Charge value | Molar mass, million |
|----------------------------|-------------|--------------|---------------------|
| 1                          | cationic    | 9-11%        | 10-12               |
| 2                          | cationic    | 29-31%       | 10-12               |
| 3                          | cationic    | 3-7%         | 7-12                |
| 4                          | cationic    | 50-60%       | 7-12                |
| 5                          | cationic    | 21-23%       | 7-9                 |

The concentration of polyvinyl acetate was determined using a photocolorimetric method on a KFK-2 photoelectrocolorimeter at a wavelength of $\lambda = 364$ nm, in a cell with a 5-cm-thick layer. Distilled water was used as a comparison solution.

Preparation of reaction mixtures was performed in the following sequence: the required amount of collector was introduced into the polyvinyl acetate emulsion; then, if necessary, the pH value was corrected with an acid or alkali solution. The prepared mixtures were mixed for 3 minutes.

Flotation treatment was carried out after preparation of reaction mixtures. Flotation treatment of reaction mixtures was carried out in a non-flowing flotator with a solid porous partition. The initial mixture was poured into a flotation column, which had been already supplied with air using a microcompressor. The duration of the flotation was 10 minutes. The studies were conducted at room temperature. After the end of flotation (10 minutes from the beginning of the experiment), a sample of the solution was taken to determine the residual concentration of polyvinyl acetate and calculate the degree of its recovery.

The level of polyvinyl acetate extraction ($\alpha$) was calculated using the formula:

$$\alpha = \frac{c_0 - c_i}{c_0} \cdot 100\%$$  \hspace{1cm} (1)

where $c_0$ and $c_i$ – the concentrations of polyvinyl acetate in the solution before and after flotation, respectively.

3. Results

During the preparation of collector solutions, it was noted that they were characterized by different solubility (Table 2).

Table 2. The solubility properties of collector reagents.

| Type of collector reagents | Solubility properties               |
|----------------------------|-------------------------------------|
| 1                          | Well soluble in water               |
| 2                          | Dissolves to form a viscous emulsion|
| 3                          | Well soluble in water               |
| 4                          | Swells to form gel-like particles   |
| 5                          | Swells to form gel-like particles   |

Based on the solubility of collectors, it can be concluded that samples No. 4 and 5 are not suitable for using in flotation separation processes, because they are poorly soluble in water, which can lead to complication of wastewater treatment, including the complexity of creating and controlling the required concentration of the reagent. In this regard, samples No. 4 and 5 were excluded from further studies.

At the first stage of experiments, the effect of the collector concentration in the solution on the degree of polyvinyl acetate extraction was studied. The received data are presented in Figure 1.
Figure 1. The effect of collector concentration on the level of flotation release of polyvinyl acetate.

Figure 1 shows that the optimal concentration for all types of collectors is 2 mg/l: at this concentration, there is a high level of PVA recovery with low reagent consumption, which is an important factor that determines the cost-effectiveness of cleaning.

Further, the influence of the pH value on the degree of polyvinyl acetate extraction was studied. At the same time, the concentration of collectors in all experiments was 2 mg/l. The results of the study are shown in Figure 2.

Figure 2. The effect of solution pH on the flotation release of polyvinyl acetate.

Experiments have shown that changes in the pH of the solution have different effects on the effectiveness of the studied reagents-collectors. For collectors No. 1 and 3, the best results were obtained in a slightly acidic and slightly alkaline environment, in the pH range of 4-6 and 8-9, respectively. At the same time, for collector No. 3, lower values of the extraction degree were observed in almost the entire studied pH range. For collector No. 2, there is a linear dependence of the increase in the degree of extraction on the medium pH. The maximum values of the extraction degree were reached at pH ≈ 9. The maximum value of the extraction degree 99 % was reached with the use of collector No. 2.
4. Conclusion
According to the research conducted by collectors No. 1, 2, and 3, it can be concluded that these samples are effective at their low concentrations in aqueous solutions, which causes a relatively low cost of wastewater treatment when using them. Maximum efficiency is observed in an alkaline environment. The most versatile and effective collector turned out to be sample No. 1, which degree of flotation separation does not fall below 60% even in an acidic environment, where it has the least activity.

Thus, the optimal conditions for flotation extraction of polyvinyl acetate using polyacrylamide-based collectors are the following:
- collector – No. 1;
- concentration of the collector in the solution – 2 mg/l;
- the range of pH – 8-9.

References
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