Purification of wastewater of some construction materials production

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Abstract. The wastewater of the wood-based industry contains toxic phenols that exceed the maximum allowable values. There is little data on the methods of purification of wastewater of woodworking plants from aromatic compounds and their derivatives in the literature. Therefore, the authors investigated the different effect of ozone on the wastewater of the Ufa plywood-slab plant for the purpose of purification. The flocculating effect of ozone and the physicochemical method (coagulation and flocculation) of wastewater treatment were investigated. The use of ozone in the first stage of wastewater treatment allows reducing the concentration of suspended substances to the required level with the help of an environmentally friendly method and preparing wastewater for oxidative purification from toxic substances. The suggested method is not only more environmentally acceptable, but also economically reasonable, because reagent acquisition costs are excluded.

1. Introduction

Technological features of the production of composite materials from wood are, firstly, the use of urea and phenol-formaldehyde resins, secondly, the consumption of large amounts of water per ton of finished products and, as a consequence, the formation of large volumes of wastewater with a high content of toxic phenolic compounds. It is known that oxidative cleaning methods with the application of ozone are effective for the destruction of such substances contained in wastewater [1-10]. When pretreated with ozone in small doses, its flocculating effect can be used [10]. The use of ozone as a flocculant allows to transfer solutes into a colloidal form, followed by precipitation on filters. Impurities that are in dynamic equilibrium in water, form emulsions that are stabilized by surfactants entering in the water. Ozone as a flocculant breaks these equilibria, facilitates to the separation of emulsions and precipitation of impurities. Methods of wastewater treatment of enterprises of the pharmaceutical and textile industry are described in literature [11-16]. Data on the method of wastewater purification of woodworking plants are not available. There is no information about the method of wastewater purification of woodworking plants. Therefore, we investigated the flocculating effect of ozone and for comparison, data on the physicochemical method (coagulation and flocculation) of wastewater treatment at the Ufa Plywood-Plate Plant (UPPP) are presented.

The effectiveness and efficiency of coagulation processes in wastewater are determined by the stability of the dispersion system, which depends on a number of factors: the degree of dispersion, the
nature of the surface of the particles, the value of the electrokinetic potential, the chemical nature of impurities (electrolytes, high-molecular substances), the concentration of impurities, etc. In practice, water treatment using different coagulants [17-20]. The most widespread are compounds of aluminum, iron, magnesium and calcium. There are several ways to coagulate wastewater, the reasonability of which is determined by the operating factors of their sustainability, as well as economic considerations. A characteristic property of coagulation wastewater treatment is the necessity to use coagulants that do not cause secondary water pollution.

2. Main part

We have selected the most effective coagulants and flocculants and their optimal doses for the treatment of wastewater UPPP. Solutions of aluminum sulfate, iron (III) chloride, iron (II) sulfate, and aluminum oxychloride (AOC) have been tested as coagulants. For maximum extraction of contaminations, the coagulation process was carried out in the range of optimally pH values, which are directly connected with the pH of the existence of hydroxides corresponding to the coagulants. The maximum effect of wastewater treatment, when coagulant based on aluminum salts are used, is achieved in the range of pH values of the medium from 6.5 to 8; when iron salts are used - in the range of pH values from 4.1 to 14.0 [21]. Previously it was found that the optimal concentration should be equal to 1% of the mass.

The dependence of the time of deposition of flakes from the dose of coagulants is presented in the Figure 1.

![Figure 1. The dependence of the time of deposition of flakes from the dose of coagulants. 1 – Al₂(SO₄)₃, 2 – FeCl₃, 3 – FeSO₄, 4 – AOC](image)

From the obtained data (Figure 1) the optimal doses of coagulants were determined: Al₂(SO₄)₃ – 268 g/m³, FeCl₃ – 80 g/m³, FeSO₄ – 180 g/m³, AOC – 165 g/m³.

As flocculants 0.1% solution of polyacrylamide (PAA), 0.5% solution of activated silicic acid (ASA), and 0.1% solution of cationic polyacrylamide of the brand REF FC were tested. The dependence of the time of deposition of flakes on the dose of flocculants is shown in Figure 2.

From the data shown in Figure 2, it can be seen that the optimal doses of flocculants are: PAA – 45g/m³, ASA – 53g/m³, REF FC – 40g/m³.

The results of a comparative analysis of the influence of the nature of the coagulant and flocculant on the degree of purification of wastewater UPPP are given in Table 1.

| Coagulant   | Dose (g/m³) |
|-------------|-------------|
| Al₂(SO₄)₃   | 268         |
| FeCl₃       | 80          |
| FeSO₄       | 180         |
| AOC         | 165         |

Table 1 – The results of the study of the influence of the nature of the coagulant and flocculant on the degree of purification.
Figure 2. The dependence of the time of deposition of flakes on the dose of flocculants (coagulant – AOC). 1 – PAA, 2 – ASA, 3 – REF FC

Table 1. The results of the study of the influence of the nature of the coagulant and flocculant on the degree of purification.

| No sample | Flocculant | Coagulant        | COD, mgO₂/dm³ | Phenols, 10⁻¹ × mg/dm³ | Formaldehyde, mg/dm³ |
|-----------|------------|------------------|---------------|------------------------|----------------------|
| 1         | PAA        | Al₂(SO₄)₃        | 4400±660      | 2,50±0,38              | 0,05±0,01            |
| 2         | ASA        | Al₂(SO₄)₃        | 3400±510      | 2,60±0,39              | 0,12±0,03            |
| 3         | REF FC     | Al₂(SO₄)₃        | 2600±390      | 2,00±0,30              | 0,09±0,03            |
| 4         | PAA        | FeCl₃            | 2200±330      | 2,19±0,33              | 0,09±0,03            |
| 5         | REF FC     | FeCl₃            | 2530±380      | 1,50±0,23              | 0,07±0,02            |
| 6         | ASA        | FeCl₃            | 2600±390      | 2,30±0,35              | 0,12±0,03            |
| 7         | PAA        | FeSO₄            | 3590±539      | 2,60±0,39              | 0,06±0,02            |
| 8         | REF FC     | FeSO₄            | 2400±360      | 2,50±0,38              | 0,06±0,02            |
| 9         | ASA        | FeSO₄            | 3680±552      | 2,50±0,38              | 0,14±0,04            |
| 10        | PAA        | AOC              | 2100±315      | 2,10±0,32              | 0,05±0,01            |
| 11        | ASA        | AOC              | 3500±525      | 1,50±0,23              | 0,10±0,03            |
| 12        | REF FC     | AOC              | 2110±317      | 1,00±0,15              | 0,05±0,01            |

From the obtained results it can be seen that the best results were obtained with a combination of PAA + AOC (in this case COD reduced to 2100 mg O₂ / dm³) and REF FC + AOC (in this case COD reduced to 2110 mg O₂ / dm³); with a combination of PAA + Al₂(SO₄)₃ and REF FC + AOC, the formaldehyde content in water is reduced to 0.05 mg / dm³; usage of AOC coagulant in combination with the flocculant REF FC reduces the phenol concentration to 1.0 mg / dm³.

Thus, the most effective coagulant is AOC in the presence of the flocculant REF FC, in this condition the content of phenol has decreased 2.6 times, the COD decreases 3.6 times.

Further the flocculating effect of ozone was tested. First of all, the effect of the ozone dose on the purification efficiency was determined (Figure 3).

The results showed that, when the ozone dose was 2 mg/dm³, the concentration of suspended substances decreased 3 times compared with the initial concentration. A further increasing of the oxidizer dose does not lead to an increasing in the degree of purification; probably, under these conditions, the main amount of contaminants degrades.

At the next stage, a comparative analysis of the influence of the two considering methods on the efficiency of wastewater treatment was carried out as main characteristic the concentration of suspended substances was chosen. As main characteristic the concentration of suspended substances was chosen (Figure 4).
When ozone as a flocculant is used, after 5 minutes the concentration of suspended substances decreases from 3127 mg/dm³ to 1000 mg/dm³ and after 30 minutes the concentration reaches 117 mg/dm³. At the same time, purification with using of AOC as coagulant and REF FC as flocculant after 5 minutes leads to a decrease in the concentration to 880 mg/dm³, and after 15 minutes it goes directly at a concentration of 550 mg/dm³.

3. Conclusion
In such a manner, the use of ozone in the first stage of wastewater treatment makes it possible to reduce the concentration of suspended substances to the required level using an environmentally safe method and prepare wastewater for oxidative purification from toxic substances. The proposed method is not only more environmentally acceptable, but also more economically viable, since reagent acquisition costs are excluded.

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