Vibrocavitation purification of industrial wastewater from organic pollutants

Liliya Shevchuk[1], Oksana Orobchuk[2], Ivan Aftanaziv[3]

1. Department of Technology of Organic Products, Lviv Polytechnic National University, UKRAINE, Lviv, St. S.Bandery, 12, E-mail: liliia.i.shevchuk@lpnu.ua oksana.m.orobchuk@lpnu.ua

2. Department of Descriptive Geometry and Engineering Graphics, Lviv Polytechnic National University, UKRAINE, Lviv, St. S.Bandery, 12, E-mail: ivan.s.aftanaziv@lpnu.ua

Abstract – The patterns of vibrocavitation purification of industrial wastewater from organic pollutants in the presence of nitrogen were studied. The optimal operating modes of the vibrocavitator were set: frequency – 37 Hz, temperature – 298 K, pressure – 0.1 MPa for cavitation treatment of wastewater. It is shown that the process of vibrocavitation destruction of organic compounds can be described by a first-order kinetic equation.

Key words: vibrocavitation, nitrogen, organic impurities, chemical oxygen consumption, wastewater.

Introduction

The main sources of pollution and clogging of natural reservoirs are insufficiently purified wastewater from industrial and communal enterprises. The water of surface reservoirs, together with impurities of natural origin, contains chemical pollution of various composition (pesticides, phenols, oil products, salts of heavy metals, etc.), which is due to the discharge of insufficiently purified industrial and domestic wastewater into the reservoirs. Therefore, the search for new highly effective and promising technologies based on the use of hydrodynamic cavitation energy is an urgent issue today. The use of these technologies on an industrial scale makes it possible to remove impurities of various origins from polluted wastewater [1].

The purpose of the work was to increase the level of ecological safety of the hydrosphere by using the vibrocavitation method for cleaning wastewater of industrial enterprises from organic pollutants.

The objects of research in this work were wastewater wastewater of JSC "Halychpharm" in Lviv with an initial value of COC = 9920 – 10400 mgO_2/dm^3. The study of industrial waste water of production was carried out in the laboratory using a vibrocavitator in the frequency range of 25 – 110 Hz, the amplitude of oscillations of deck-disturbers 1.5 mm, in the cavitation volume of the working chamber 1.5 dm^3, the duration of the process – two hours, the temperature – 298 K and pressure – 0.1 MPa, in a nitrogen atmosphere and without it. COC values were measured by the dichromatic method The process of purifying wastewater from organic pollutants of a pharmaceutical plant can be described by a first-order kinetic equation. Determination of the degree of oxidation of organic substances was calculated according to the formula:

$$D_{ox.} = 100 - \frac{COC*100}{COC_0}\ , [\%] \qquad (1.1)$$

where COC_0 is the initial value of COC, mg O_2/dm^3;

COC is the current value of COC at time t, mg O_2/dm^3.

Research results

During the study of cavitation effects on aqueous solutions of different chemical composition, in our previous studies, the effectiveness of nitrogen supply as a source of additional cavitation nuclei was established [2]. Therefore, research on the oxidation of organic pollutants in pharmaceutical plant wastewater and determination of the degree of destruction of organic compounds was carried out under vibrocavitation conditions in the presence of nitrogen and without it at different frequencies of the vibrocavitator. After one hour of nitrogen treatment at a

frequency of 37 Hz in vibrocavitation conditions, a noticeable decrease in the amount of organic substances by 3.25 times is observed, and the COC reaches a value of 3200 mg O_2/dm^3. And after two hours, there is a sharp decrease in the amount of organic substances by 6.5 times, compared to COC_{init} = 10400 mg O_2/dm^3 and reaches COC_{fin} = 1600 mg O_2/dm^3.

The correction in coordinates $\ln(COC/COC_0) - \tau$ confirms the passage of the process of oxidation of organic substances according to the kinetic equation of the first order. The calculated effective oxidation rate constants testify to the high efficiency of the combined use of nitrogen and vibrocavitation on the oxidation of organic substances in industrial effluents.

It follows from Table 1 that the effective rate constant of oxidation of organic substances of effluents of a pharmaceutical plant in a vibrocavitation field with nitrogen at a frequency of 37 Hz is 2.29 times higher than the rate constant without gas and is $27.42*10^5$ s^{-1}. After the first hour of treatment of the studied wastes under vibrocavitation conditions, the degree of oxidation of organic substances reaches 28.57%, compared to the combined use of vibrocavitation and nitrogen, which reaches a value of 69.23%. With an increase in the treatment time of the investigated effluents, we observe an increase in the degree of oxidation of organic substances. Comparing the degree of wastewater treatment, we observe that when using nitrogen in vibrocavitation conditions, a significantly higher degree of oxidation (84.62%) is achieved compared to the action of vibrocavitation itself (60.71%).

Table 1

Summary table of effective oxidation rate constants of organic substances of pharmaceutical plant effluents under different experimental conditions

Process conditions	COC $k \cdot 10^5$, s^{-1}	Degree of oxidation, %
N_2	0,86	5,65
Vibration	11,96	60,71
N_2/vibration	27,42	84,62

Conclusions

On the basis of the conducted experimental studies, the high efficiency of the joint action of nitrogen and vibrocavitation (84.62%) at the vibrocavitation frequency of 37 Hz has been proven, which opens up the prospect for further practical application of vibrocavitation for wastewater treatment of industrial enterprises.

References

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