

The Kinetics of Oxypropionic Acid on Natural Zeolite

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Abstract – This paper presents the results of experimental studies of the kinetics of ion exchange adsorption of lactic acid by zeolite in the periodic conditions. The results of experimental studies make it possible to determine the kinetic coefficients of the diffusion process.

Key words – kinetic, zeolite, hydroxypropionic, wastewater, internal diffusion.

I. Introduction

The need to find and develop new technologies for dairy plants wastewater treatment proved low efficiency of existing wastewater treatment facilities. The proposed adsorption technology of wastewater treatment of dairy plants allows to solve the problem of reducing the aggressiveness of the environment, has low power consumption, and can be implemented in a wide range of changes in the composition of wastewater [1,2].

The aim was to investigate the kinetics of internal diffusion of ion adsorption process of hydroxypropionic acid on natural zeolite and determine the effective rate of internal diffusion. Investigated the static and kinetic adsorption of lactic acid on klynoptylote of Sokyrnytsa deposite [1]. Sorption properties of natural zeolite on hydroxypropionic acid were investigated. The use of natural zeolite of Sokyrnytsa deposits as high effective sorbent is appropriate in the treatment of industrial waste water from dairy processors from hydroxypropionic acid it was established [1,2]. The adsorption properties of natural zeolite and activated carbon were compared. As a result of studies have found that activated carbon adsorbs better the lactic acid than the zeolite. Proved that molecules of lactic acid via carbon radical exhibit affinity to non-polar sorbents, i.e. the activated carbon. The dependence of the mass transfer coefficient to the intensity of mixing was established. The maximum degree of intensification of internal diffusion process was shown.

II. The results of investigations

Investigation of sorption of hydroxypropionic acid on natural zeolite in propeller type agitator was carried out. The experiment was carried out in the process of mixing a solution of lactic acid (concentration $C = 0,002 \text{ mol} / \text{dm}^3$) with 50 g of zeolite with different speed. The above graph shows the difference absorption process lactic acid adsorbent at different speeds. The concentration of lactic acid was determined by pH - using ionomer IM-160. The experimental setup is on the Fig.1.

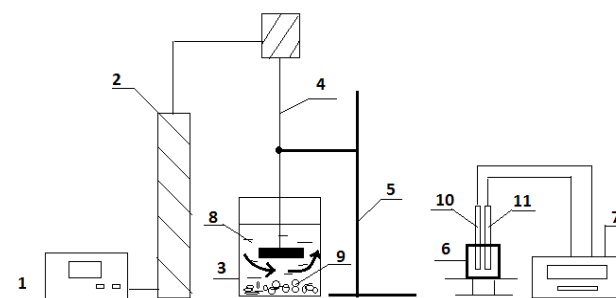


Fig. 1. Experimental setup

- 1 - digital mixer controller; 2 - motor of the mixer;
- 3 - vessel with a solution of lactic acid and zeolite;
- 4 - propeller type agitator; 5 - tripod; 6 - tube;
- 7 - ionomer IM-160; 8 - lactic acid solution; 9 - zeolite;
- 10 - ionoselective electrode; 11 - electrode

Kinetic curves are shown in Fig. 2.

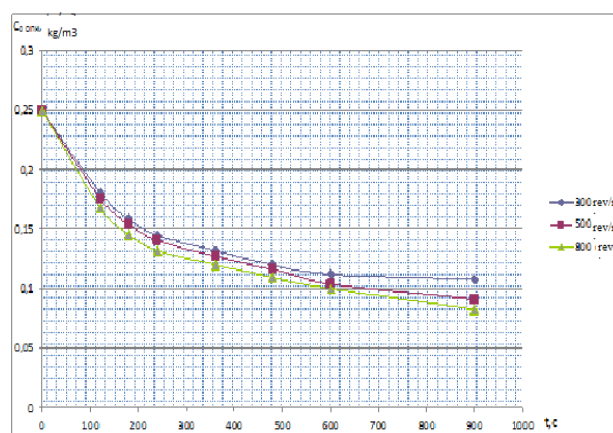


Fig. 2. Kinetic of adsorption of oxypropionic acid (DIC) by zeolite for different numbers of turns:
• - 300 rev / min ; ■ - 500 rev / min ; ▲ - 800 rev / min

This data shows that for the initial concentration of oxypropionic acid $C_0 = 25 \text{ mg} / \text{dm}^3$ the kinetic curves of a different nature, and with increasing intensity mixing achieved a significant rate of absorption, especially in the initial time. This is evidence that in the initial moments kinetic is determine by the diffusion what makes them different, so it is the transport of acid molecules to the outer surface of the adsorbent. After filling the outer layer diffusion begins in the domestic law of the adsorbent. The dependence of absorption kinetics of the number of turns n shows that the number of turns $n = 400$ kinetics is independent of the number of turns, that plays a major role inside the diffusion process in which the number of Bio wich tends to ∞ . At its greatest intensity observed in the range of initial concentration. Assuming spherical particle shape for the mathematical description of the sorption component mixing conditions for internal diffusion process using equations obtained solution of differential equation of molecular diffusion in spherical particles with a mechanical stirring apparatus for $Bi = \infty$. The solution makes it possible to determine the change in the concentration of component C in the liquid phase over time in Eq. (3),(5).

$$\frac{C}{C_0} = 1 - \frac{1}{1 + \alpha} \left[1 - \sum_{n=0}^{\infty} A_n \exp(-\mu_n^2 Fo) \right] \quad (1)$$

where:

$$A_n = \frac{6\alpha(\alpha + 1)}{9 + 9\alpha + \alpha^2 \mu_n^2} \quad (2)$$

where:

μ_n - positive roots of the characteristic equation are determined from dependence;

Fo - Fourier criterion $Fo = \frac{D_{ef} \cdot t}{R^2}$;

Def - effective internal diffusion coefficient, m / s;

τ - time, s;

R - radius of grain adsorbent, m;

$\alpha = \frac{VC_0}{m_{ad} \cdot a^*}$ - system Settings; V - volume of fluid m³;

m_{ad} - the mass of adsorbent, kg.

$$\frac{tg \mu_n}{\mu_n} = \frac{3}{3 + \alpha \mu_n^2} \quad (3)$$

For large values of root μ_n and large value of time τ the exponent tends to zero, so the first one can restrict root characteristic equation μ_n (region regular mode) and Eq. (1) can be reduced to the form:

$$\left(\frac{C}{C_0} + \frac{\alpha}{\alpha + 1} \right) / \left(\frac{1}{\alpha + 1} \right) = A_1 e^{-\mu_1^2 Fo} \quad (4)$$

Logarithm (4) shows that in the semi logarithmic coordinates $\ln \left(\frac{C}{C_0} + \frac{\alpha}{\alpha + 1} \right) / \left(\frac{1}{\alpha + 1} \right) = f(\tau)$ gives a straight line.

After converting of the Eq. (4) put in value to the average concentration of oxy propionic acid $\bar{C} = C_0 - C_i$ and adsorbate concentration in the sorbent $C_a^* = C_0 - C_0^*$, where C_0^* corresponds to the equilibrium concentration of the starting solution at adsorption oxy propionic acid zeolite in static conditions in Eq. (5), we obtain:

$$tg \alpha = \mu_1^2 \frac{D_{ef}}{R^2} \quad (5)$$

The coefficient of internal diffusion hydroxypropionic acid zeolite $D_{ef} = 2,62 \cdot 10^{-12}$ m²/s was set.

During the process of lactic acid adsorption on zeolite the release of sodium ions in the solution was indicated.

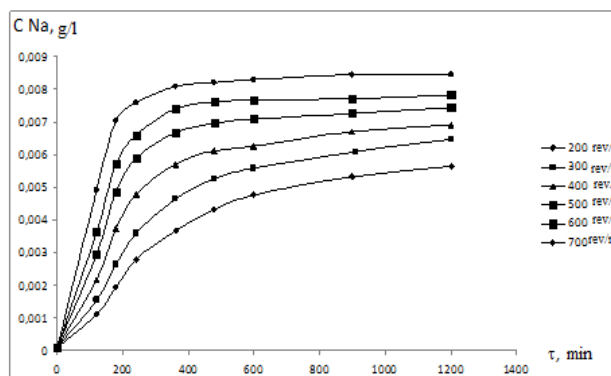
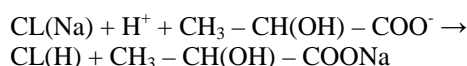
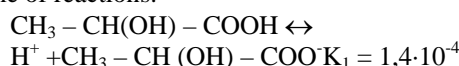


Fig. 3. Kinetic of the release of sodium zeolite adsorption oxypropionic acid agitators

During the experiment, calcium and magnesium cations weren't observed, indicating the formation of insoluble calcium lactate and magnesium on the surface and in the pores of the sorbent.

These compounds can increase the diffusion resistance of sorbent and reduce its sorption capacity.

As shown in Fig. 3 the number of turns enhanced ion exchange process that can be described by the following scheme of reactions:



Conclusion

Analyzing the experimental results we can conclude that the adsorption capacity of sorbents for lactic acid correlated with a decrease of acidity of model wastewater.

The results of experimental studies make it possible to determine the roots of the characteristic equation and effective coefficients of internal diffusion process of ion exchange sorption of hydroxypropionic acid by zeolite.

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