Section 9. Chemistry

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DEEP PURİFICATION OF MULTICOMPONENT SEWAGE WATER EMPLOYING ABSORPTION IN DYNAMIC CONDITIONS

Abstract. The work presents the calculation of parameters of the process of adsorption from the multi-component mixture using group calculation of the arguments. The modern technology of water purification using absorption is characterized by its complexity and variety of physicochemical effects. High-quality purified water can only be achieved using achieving a certain technological condition and by selecting the right equipment. The derived mathematical models of the process allow for performing the calculation for the projection of technological equipment with an appropriate level of precision required for engineering calculations.

Keywords: adsorption, sorption filter, purification, water.

We can attempt to create a common model, by complexly using quotient relationships in case of a wider set of parameters [1, 15–17]. However, in this case, it will be impossible to model the process based on an analysis of consequential relations between argument and function. Moreover, in practicing multi-component sorption processes one can face the lack of information about the content of each of the components in the hard phase (weighting of the adsorbent will only indicate the total weight of the ingredients).

That is why the modern conception of the process of mutual displacement of components and the forecast of different groups of solutions, in this case, is significantly subjective [2, 10–13]. That impacts the trustworthiness of the existing mathematical description of the processes. Nonetheless, to project the sorption appliances a reliable forecast of the exit parameters of the

sorption is required. That is why it is necessary to search for methods of forecast based on limited but still trustworthy information about the processes. The authors decide that this task can be solved with a sufficient degree of precision required for practical purposes using group calculation of the arguments. Applying this method will allow significantly decrease the impact of subjective factors on the outcome so the calculation.

The task can be formulated as follows. There are many arguments: the initial and the final concentration of the substances, the speed of filtration, the height of the layer of the adsorbent, and the value of standard reduction of the free energy of adsorption of organic substances, which comprise the dual-component mixture [3, 19–23]. It is necessary to find an equation that will allow identifying with minimal error the time of shielding effect of the sorption filter for two substances of organic nature, which have the value of standard reduction of free energy of adsorption (–F adsorption) within the borders which characterize the process of adsorption of these substances based on a specific adsorbent as effective.

During the conducted experiments, the pairs of organic substances were targeted with limiting concentrations, which constituted the dual-component solution. In addition, the first substance is a more adsorbing ingredient. During the variation of the pace of filtration, the height of the layer of adsorbent, and the variation of the constituent components with their initial concentrations, the timing of the shielding effect of the adsorbent of each of the two substances was measured.

The so-called randomization of the experiment took place, in other words, unsystematic variations of the above-mentioned parameters of the experiment. The overshoot of the substances into the filtrate was controlled using the analysis performed by controlling the methods of chromatography and infrared spectroscopy.

For a greater depth of information, it was presented as a set of dimensionless complexes, the number of which was defined by π-theorem

Therefore, the dimensionless complexes were:

$C_1 = \frac{C_{o1}}{C_{ult\,1}}$ – (dimensionless concentration of the first substance in the flow)

$C_1 = \frac{C_{02}}{C_{ult\,2}}$ – (dimensionless concentration of the second substance in the flow)

$F_1 = \frac{-\Delta F_1^0}{-\Delta F^0}$ – (dimensionless value of standard reduction of the free energy of adsorption of the first substance from the solution)

$F_2 = \frac{-\Delta F_2^0}{-\Delta F^0}$ – (dimensionless value of dimensionless standard reduction of the free energy of adsorption of the second substance from the solution)

$L = \frac{L_0}{d}$ – (dimensionless length of the adsorption layer)

$\mathrm{Re} = \frac{\nu l_0}{\nu}$ – (Reynolds number)

$\theta_1 = \frac{\theta_{01}}{\frac{l_0}{\nu}}$; $\theta_2 = \frac{\theta_{02}}{\frac{l_0}{\nu}}$ – (dimensionless duration of the shielding effect of the absorbent)

The dimensional parameters meant:

C_{01}, C_{02} – initial concentration of substances, molecule/liter

$C_{ult\,1}$, $C_{ult\,2}$ – overshoot concentration of substances, molecule/liter

$-\Delta F_1^0$, $-\Delta F_2^0$ – standard reduction of the free energy of adsorption of the substances from the solution kilo joule/molecule

L_0 – the length of the adsorption layer

d – effective diameter of the granule, adsorbent, m

ν – kinematic viscosity of water, m^2/c

In its whole volume, the mass data contained 48 positions.

θ_1, θ_2 – the duration of shielding effect of the adsorbent as related to the first and second substances

$-\Delta F^0$ – the value of the standard reduction of the free energy of absorption from the solution = 20-kilo joule/molecule

So, our task can be presented as follows: there are the following arguments:

$$x = \{C_1, C_2, F_1, F_2, L_1, \mathrm{Re}, \lg l_1, \lg C_2\} \quad (1)$$

It is necessary to find the equations:

$$\theta_1 = \lambda_1 \{C_1, C_2, F_1, F_2, L_1, \mathrm{Re}, \lg l_1, \lg C_2\} \quad (2)$$

$$\theta_2 = \lambda_2 \{C_1, C_2, F_1, F_2, L_1, \mathrm{Re}, \lg l_1, \lg C_2\} \quad (3)$$

$$\frac{\theta_1}{\theta_2} = \lambda \quad (4)$$

This would allow for the identification of the shielding effect of the adsorbent given the provided parameters for any pair of organic substances, the value of the standard reduction of the free energy of absorption of which is between 20 to 50-kilo joule/molecule.

The vector components $\overline{X} - (C_1 C_2 \ldots)$ and their reverse values $\left(\frac{1}{C_1}, \frac{1}{C_2} \ldots\right)$ have served as bearing functions for the means of selection of group calculation of the arguments. The mathematical models were restored using the selection of the claimant models with the help of the criterion of unblended regularity until the criteria started rising again on the next round of selection, i.e. after achieving the minimum criteria of selection.

The sorting out of the best models according to their selection of criteria and their experimental testing has taken place.

Based on the observations the following interdependences were derived:

$$\lg \theta_1 = 3.37 - 0.223 \lg C_1 - 0.58 \cdot 10^{-4} \frac{\mathrm{Re}^2}{l} - 0.26 F_1 \quad (5)$$

$$\lg \theta_2 = 2.23 - 0.368 \lg C_2 + 0.0021 - 0.000 \mathrm{Re} - 209 F_2 \quad (6)$$

$$\frac{\theta_1}{\theta_2} = \frac{20 F_2^2 \cdot F_1 \lg C_2}{C_1} \quad (7)$$

After the appropriate solution of expression, we will have:

$$\theta_1 = 2344 C_1^{-0,368} \exp\left(0.26 F_1 - 0.58 \cdot 10^{-4} \frac{\mathrm{Re}^2}{1}\right) \quad (8)$$

$$\theta_2 = 1700 C_2^{-0,368} \exp\left(0.0021 - 0.003 \mathrm{Re} - 209 F_2\right) \quad (9)$$

the independence –(8) in the dimensional form:

$$\frac{\theta_1}{\theta_2} = 20 \frac{C_{ult\,1}\left(-\Delta F_1^0\right)}{C_{01}\left(-\Delta F^0\right)} \left(\frac{-\Delta F_2^0}{-\Delta F^0}\right)^2 \lg \frac{C_{02}}{C_{ult} \cdot 2}$$

The correlation coefficients of the derived models are 0.883; 0.848; 0.838

As we can see from the meaning of the correlation coefficients on fronts of dual-component mixtures in the conditions outlined above.

As we can see from the presented equations, knowing the structure of the adsorbent substances and their initial concentrations we can calculate how long the sorption filter will function until the deriving components appear in the filtrate of defined overshoot concentrations.

Since the position of the functional group in molecule 2 is unimportant, the values – ΔF_{ads}^0 which define the values – $\Delta F_{1\,ads}^0$ for the absorption on various coals are also unimportant. That is why the equations can approximate the dynamic process of sorption of the dual-component mixture on all types of active coals. The minimum amount of experimental information is required to make calculations based on the derived models. To be more precise we need trustworthy qualitative identification and quantitative interpretation of the flow. The substances similar in their structure and different values – ΔF_{ads}^0 not more than 5- kilo joule/molecule, can be combined, and therefore the multi-component

system can be turned into a dual-component and calculated based on the derived interdependences with an appropriate level of precision required for engineering calculations.

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