AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 4, Issue 02, 2026 ISSN (E): 2993-2637

Influence of Type of Solvent and Preparation of Oil-Containing Raw Material on Kinetic Dependences of its Extraction Process

F. S. Qayimov
Bukhara state technical university. docent of the Department of "Food Technologies and Service"
fqayimov@bk.ru

B. S. Abdullayev
Bukhara state technical university. docent of the Department of "Food Technologies and Service"

Abstract: The influence of a solvent on the extraction processes of cotton cake is established. The kinetic equations of the extraction processes are determined. The dependences of the extraction coefficients on the type of solvent and the type of oil containing raw materials used are revealed.

Keywords: extraction, solvents, type of material, kinetic equations, dependency coefficients, process indicators, regularities.

Introduction

The extraction methods used in the oil extraction technology mainly depend on the technological modes of the processes [1-5]. The processes of extraction of oil-containing raw materials are intensified using methods of electrophysical processing of both raw materials and solvent [6-9]. In this direction, the works performed in the Russian Federation [10-12] and foreign [13-15] are known. The extraction process is estimated by the kinetic laws of its implementation [16-17]. In this regard, the study of the kinetic laws of cotton cake extraction by exposure to raw materials by pulsed electric field methods is of particular interest.

The purpose of the work is aimed at studying the influence of the type of solvent and the preparation of oil-containing raw materials on the kinetic dependences of the extraction process.

The objects of study were cotton cake, organic solvents.

Materials and methods

The process of extraction of raw materials was carried out in a laboratory setup using three types of solvents.

The material for extraction was three samples:

The first sample - a cotton industrial cake "shell" - was detailed to the state of a grain on a disk peel and fractionated on sieves with round holes. A fraction with a nominal diameter of 3-4 mm was used. 2nd sample - cotton industrial cake (extrudate). The cylindrical shape is D = 6 mm and L = 20-50 mm. The 3rd sample is the petal of the cottonless coreless cotton core, 0.2 mm thick.

For the analysis of raw materials and extraction products, modern methods of physicochemical research and methods of mathematical processing of experimental results were used [18,19].

Results and discussion

Kinetic dependencies are necessary for calculating and modeling the operation of extractors.

The influence of the type of solvent and the preparation of oilseed from cotton on the kinetic dependences of the extraction process of cottonseed oil was studied. The comparative results of laboratory studies of the extraction of cotton cake by hexane, diethyl ether and petroleum ether were used.

The kinetics of extraction in a solid-liquid system is described by the equation.

$$E = \frac{c_0 - c}{c_0 - c_m} = \frac{1}{1+\beta} - \sum_{n=1}^{\infty} A_n \exp\left(-\frac{\mu_n^2 Dt}{R^2}\right) \quad (1)$$

where E is the concentration simplex; c0 and c are, respectively, the initial and current concentration of extractive substances in the pore volume, kg / m3; cm = c1n - initial concentration of extractives in the volume of the solvent phase, kg / m3;

β is the ratio of the pore volume and the external volume of the solvent; D is the coefficient of internal diffusion, m2 / s; t is the current time, s; R is the characteristic particle size of the solid phase (for the plate, half the thickness of the plate; for the cylinder, radius; for the ball, radius), m; µn are the roots of the characteristic equation.

For the regular stage of the extraction process, the characteristic equations were determined for each particle shape using the equations:

Plate $$\mu_1^2 = \frac{2 - B\beta(1+\beta)}{B} \quad (2)$$

Plate $$\mu_1^2 = \frac{4 - 4B\beta(1+\beta)}{B} \quad (3)$$

Plate $$\mu_1^2 = \frac{6 - 9B\beta(1+\beta)}{B} \quad (4)$$

The diffusion coefficient was determined by the ratio:

$$D = C\frac{R^2}{\mu_1^2} \quad (5)$$

Two comparative extraction patterns were obtained: three different solvents of the same material (grains) (Fig. 1) and one standard solvent (diethyl ether) of three types of material (Fig. 2).

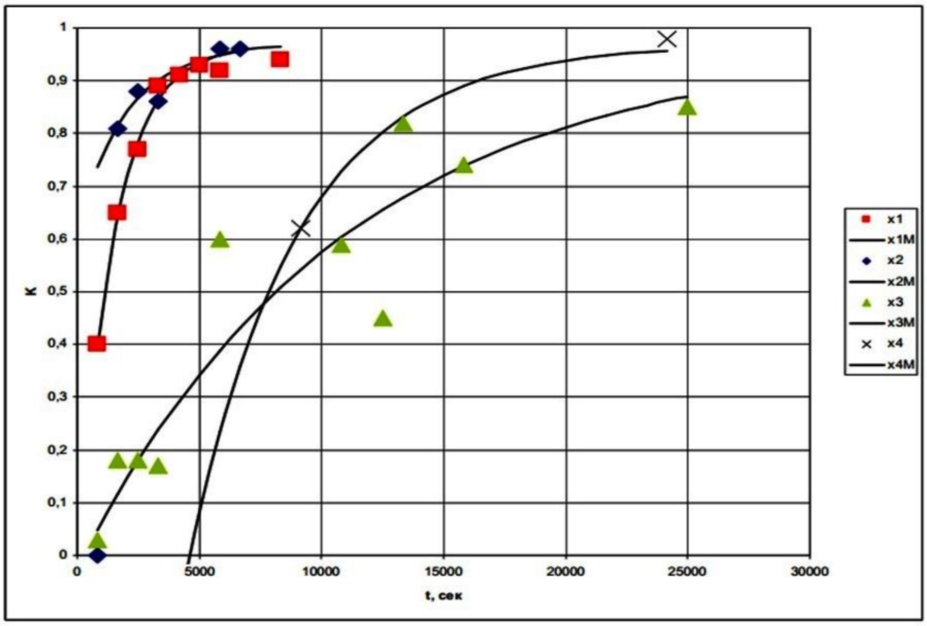

Fig. 1 - Results of grain extraction with three different solvents

(x1 (x1M-calculated curve) - diethyl ether; x2 (x2M-calculated curve) - petroleum ether; x3 (x3M-calculated curve) - hexane; x4 (x4M-calculated curve) - hexane soluble in diethyl ether)

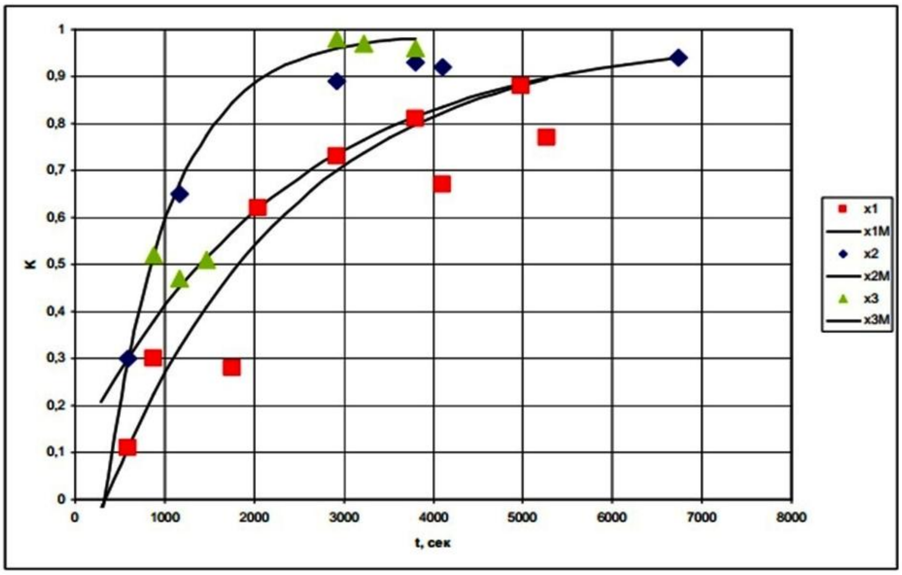

Figure 2 - Results of diethyl ether extraction of three different materials

(x1 (x1M-calculated curve) - extrudate; x2 (x2M-calculated curve) - nibs; x3 (x3M-calculated curve) - core lobe)

The experimental data were processed for the regular stage of the extraction curves in the form of:

$$K = A - B\exp(-Ct) \qquad (6)$$

where K is the relative yield of extractive substances; t is the current time, s; A, B and C are the coefficients of the kinetic equation.

The values of the coefficients A, B, and C according to the data in Fig. 1 are presented in Table 1 and according to the data in Fig. 2 are presented in Table 2. The relationship between the concentration simplex E and the relative extraction K can be represented: (6)

Since in all cases of different shapes of the extracted material A ≠ B, the values of the Bio criterion (Bim) [20], which is the ratio of the intensity of external and internal mass transfer, according to Bim → ∞, and this determines the choice of the corresponding dependences for calculating the parameters of the kinetic equation.Таблица1.

The values of the coefficients according to the experimental data are shown in Fig. 1 and calculated parameters of kinetic dependencies

Диэтиловый эфир		Петроленый эфир		Гексан		Гексан ДЭФ	
A	0,969216	A	0,969216	A	0,969216	A	0,969216
B	1,00002	B	0,347834	B	0,99426	B	2,692243
C	0,000671	C	0,000487	C	9,22E-05	C	0,000223
Диэтиловый эфир		Петроленый эфир		Гексан		Гексан ДЭФ	
β	0,031762	B	0,031762	β	0,031762	β	0,031762
μ	5,704947232	M	16,95467	μ	5,739704	μ	1,933691
D	3,59953E-10	D	8,8E-11	D	4,92E-11	D	3,53E-10

table 2

Coefficients according to experimental data in Fig. 2

and calculated parameters of kinetic dependencies

Экструдат		Крупка		Лепесток	
A	0,990443	A	0,990443	A	0,990443
B	1,161207	B	0,885828	B	1,524907
C	0,000473	C	0,000426	C	0,001339
Экструдат		Крупка		Лепесток	
B	0,009649	β	0,009649	β	0,009649
M	3,405722015	μ	6,685642	μ	1,301813151
D	1,24956E-09	D	1,95E-10	D	1,02883E-11

The experimental data (points) presented in Figures 1 and 2 and the calculated dependences (lines) show their good agreement.

Thus, the analysis of the data obtained made it possible to establish: comparative kinetic dependences of the extraction of raw materials with various solvents of the same shape. It is noted that, the diffusion coefficient decreases in a row diethyl ether> petroleum ether> hexane.

By determining the kinetic dependences of the extraction of cotton material with various solvents and various forms of material, it was found that the diffusion coefficient decreases in the series of solvents diethyl ether> petroleum ether> hexane in the series of forms of materials extrudate> grits> petal. The established parameters of the kinetic dependences can be used in the calculations of the extraction process.

Conclusion

The diffusion coefficient during extraction will decrease when using different solvents in the following order diethyl ether> petroleum ether> hexane and when using various forms of material extrudate> grits> peta.

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