UDC 658.012.66 http://doi.org/10.5281/zenodo.2271372

FORECASTING OF OPTIMAL PARAMETERS PRODUCTION DIELECTRIC FLUID FOR PULSE CAPACITORS USING FUZZY INFERENCE MODELS

©***Sultanova A.,*** *Ph.D., Azerbaijan State Oil and Industry University, Baku, Azerbaijan*
©***Abdullayeva M.,*** *Ph.D., Azerbaijan State Oil and Industry University,*
Baku, Azerbaijan, mayaabdullayeva@hotmail.com

ПРОГНОЗИРОВАНИЕ ОПТИМАЛЬНЫХ ПАРАМЕТРОВ ПРОИЗВОДСТВА ДИЭЛЕКТРИЧЕСКОЙ ЖИДКОСТИ ДЛЯ ИМПУЛЬСНЫХ КОНДЕНСАТОРОВ С ИСПОЛЬЗОВАНИЕМ МОДЕЛИ НЕЧЕТКОГО ВЫВОДА

©***Султанова А. Б.,*** *канд. техн. наук, Азербайджанский государственный университет нефти и промышленности, г. Баку, Азербайджан*
©***Абдуллаева М. Я.,*** *канд. хим. наук, Азербайджанский государственный университет нефти и промышленности, г. Баку, Азербайджан, mayaabdullayeva@hotmail.com*

Abstract. The article is devoted to the determination of the optimal parameters of a dielectric fluid as an impregnant in power capacitors. The optimal parameters for the synthesis of the ester are found on the basis of a not clear Mamdani model. The model providing optimization of the chemical process is offered and on the basis of statistical data, the algorithm of training of the fuzzy model is developed. The goal was solved with fuzzy data and a regression model of the three-stage process was obtained. Optimization was carried out and optimum parameters were found. Based on the statistical data, a fuzzy Mamdani model was compiled.

Аннотация. Статья посвящена определению оптимальных параметров диэлектрической жидкости в качестве пропитки в силовых конденсаторах. Оптимальные параметры синтеза сложного эфира найдены на основе нечеткой модели Мамдани. Предлагается модель, обеспечивающая оптимизацию химического процесса, и на основе статистических данных разработан алгоритм обучения нечеткой модели. Цель была решена с помощью нечетких данных, и была получена регрессионная модель трехэтапного процесса. Была проведена оптимизация и найдены оптимальные параметры. На основе статистических данных была составлена нечеткая модель Мамдани.

Keywords: power capacitors, sec.hexyl-o-xyleole, dielectric fluids, fuzzy model of Mamdani, fuzzy data.

Ключевые слова: силовые конденсаторы, вторичный гексил-о-ксилол, диэлектрические жидкости, нечеткая модель Мамдани, нечеткие данные.

Analyzing the findings of world practice, it turns out that, for carrying out chemical processes, it takes enough time and finance. For the increase the efficiency of these processes it is important to use new technologies, models and methods. Solving the problem with a fuzzy one allows you to control the time of the chemical process and the amount of waste substances.From this point of view, the problem is actual and of scientific and practical value.

One approach that supports such research, as mentioned above, is the use of fuzzy mathematics. Today, significant results have been obtained in this direction in basic research, but with regard to applied research, this is mainly the control of technological processes. But, the use of fuzzy mathematics for the study of chemical structures is a single study. Thus, the use of fuzzy sets, into chemistry and chemical technology makes it possible to solve by computer means not only a wide range of technical problems associated with uncertainty, but, what is especially important, creates the conditions for generating new scientific and technical problems and new ways of solving them in the field of chemistry and chemical technology.

Formulation of the problem. Under the concept is implied of fuzzy, the mathematical formulation of fuzzy information. For the formed object–devices by complex, used traditional methods, the fuzzy logic based on fuzzy logic is mainly.

The theory of fuzzy sets (TFS) was proposed 40 years ago by the US mathematician Lutfi Zadeh. TFS — provides an opportunity to describe the fuzziness and knowledge of the quality of the environment, complex objects, and devices and provides an opportunity for obtaining new knowledge for creating fuzzy models [1–3].

Experimental part

The process of obtaining the dielectric liquid of acetoxymethyl–sec.hexyl–o–xylene consists of three stages: alkylation, chloromethylation and acetoxylation.

In accordance with the task, it was required to ensure, at each stage of synthesis of the ester, the maximum possible high purity and yield of reaction products. In this connection, the $AlCl_3CH_3NO_2$ complex, which exhibits high selectivity, was used as alkylation [2].

Using the methods of mathematical statistics, these processes are optimized in terms of the parameters [4–6].

In work, using the method of planning experiments [7], studies on the synthesis of the ester as an impregnant with the aim of constructing a regression mathematical model on the basis of its optimization are presented.

The task is carried out in three stages:

1. Alkylation of o–xylene with hexene-1 in the presence of cataliyst $AlCl_3CH_3$ NO_2
2. Chloromethylation of sec.hexyl–o–xylene in the presence of paraform in acetic acid in the presence of zinc chloride.
3. Acetoxylation of monochloromethyl–sec.–hexyl–o–xylene in the presence of a Makoshi catalyst.

Based on our numerous experiments were determined the main input and output parameters of the three-stage process under study. The main output parameter of the process is the yield of sec.hexyl–o–xylene–, monochloromethyl sec.hexyl– and acetoxymethyl–sec.hexyl–o–xylene. Factors influencing the output parameters of the process are X_1 — process temperature, X_2 — reaction time, X_3 — the amount of catalyst. Table 1–3 gives the main levels of factors and the limits of their changes.

On the proposed improved design, there are also such elements, for this reason the solution of the problem requires the use of the theory of fuzzy sets.

Table 1.

THE MAIN LEVELS OF FACTORS AND THE LIMITS OF THEIR CHANGES (stage I)

Names	*Natural input values of factors*			*Output values*
	X_1	X_2	X_3	y_{pract}
Basic level	50	2	0.15:0.45	70
Limits of change	2	0.1	0.01	5
Lower limit of change	40	1	0.2:0.5	55
Upper change of limit	60	3	0.1:0.4	90

Table 2.

THE MAIN LEVELS OF FACTORS AND THE LIMITS OF THEIR CHANGES (stage II)

Names	*Natural input values of factors*			*Output values*
	X_1	X_2	X_3	y_{pract}
Basic level	60	4	0.70:0.20	65
Limits of change	2	0.5	0.01	3
Lower limit of change	50	3	0.40:0.15	42
Upper change of limit	70	5	1.0:0.25	85

Table 3.

THE MAIN LEVELS OF FACTORS AND THE LIMITS OF THEIR CHANGES (stage III)

Names	*Natural input values of factors*			*Output values*
	X_1	X_2	X_3	y_{pract}
Basic level	60 (100–120)	100 (2–2.5)	0.12	80
Limits of change	2	5	0.01	5
Lower limit of change	50	90	0.10	70
Upper change of limit	70	110	0.14	100

Problem solution: To solve the problem with the proposed method, the following algorithm is proposed:

1. Determination of the number of input and output linguistic variables. The definition of quantity by the term is for each linguistic variable;
2. Determination of the name of linguistic variables and their terms (belonging);
3. Determination of the type and universe of the membership function for the terminology of linguistic variables;
4. Determination the structure of logical rules as “if ... then”;

As input linguistic variables, X_1 is the process temperature, X_2 is the reaction time, X_3 is the number of catalysts, the Yi– acetoxymethyl–.sec.hexyl–o–xylene was taken as output linguistic variables.

Input linguistic variables:

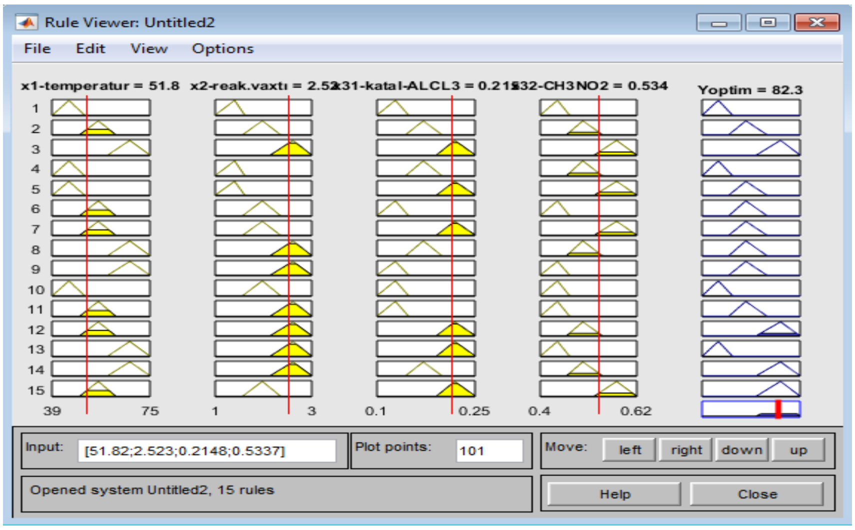
X_1 — process temperature → <small, normal, many>, (40–60) (1)
X_2 — reaction time → <small, normal, many>, (1–3) (2)
X_3 — the amount of catalyst → <small, normal, many>, (0,1–0,45) (3)

Output linguistic variables:

Yi → <below norm, norm, above norm>, (57.2–81.0) (1)

Modeling, based on the basis of logical rules, was implemented using an algorithm based on a mathematical apparatus with fuzzy logic. The description of input and output linguistic variables (terms) was used for the function of triangular membership.

The computer implementation of the algorithm was performed in the Matlab environment (FIS–editor of the Fuzzy Inference System Editor), and the results (Figure 1–3) were obtained.



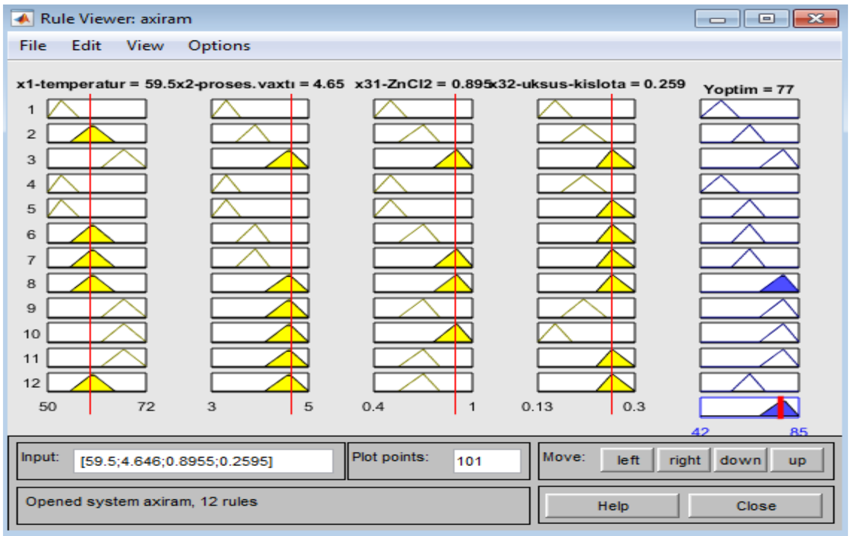
x1-temperatur = 51.8 x2-reak.vaxtı = 2.52x31-katal-ALCL3 = 0.215x32-CH3NO2 = 0.534 Yoptim = 82.3

Input: [51.82;2.523;0.2148;0.5337]

Plot points: 101

Opened system Untitled2, 15 rules

Figure1. Alkylation of o–xylene with hexene-1 in the presence of the catalyst $AlCl_3 \cdot CH_3NO_2$.



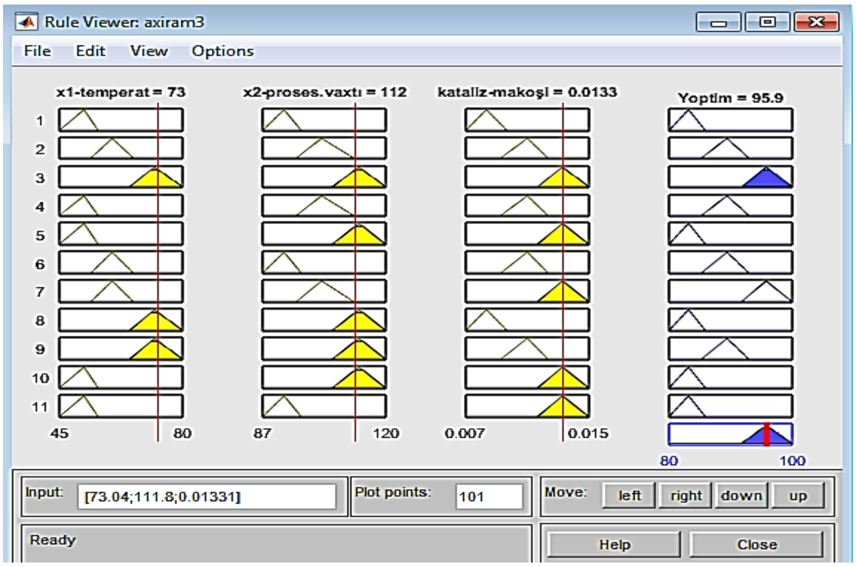
x1-temperatur = 59.5x2-proses.vaxtı = 4.65 x31-ZnCl2 = 0.895x32-uksus-kislota = 0.259 Yoptim = 77

Input: [59.5;4.646;0.8955;0.2595]

Plot points: 101

Opened system axiram, 12 rules

Figure 2. Chloromethylation of sec.hexyl–o–xylene in the presence of paraform in acetic acid in the presence of zinc chlorid.



x1-temperat = 73 x2-proses.vaxtı = 112 katalİz-makoşl = 0.0133 Yoptim = 95.9

Input: [73.04;111.8;0.01331]

Plot points: 101

Ready

Figure 3. Acetoxylation of monochloromethyl–avr.hexyl–o–xylene in the presence of a Makoshi catalyst.

The resulting conclusions from the Matlab program (a mechanism for fuzzy extracts): a) for sec.hexyl–o-xylene; b) monochloromethyl–sec.hexyl–o–xylene; c) acetoxymethyl–sec.hexyl–o–xylene.

Conclusion

1. Is proposed fuzzy model of the process of obtaining acetoxymethyl–sec.–hexyl–o–xylene is proposed and a learning algorithm for the fuzzy model is developed on the basis of statistical data.

2. Dependence of the ester yield between the temperature, the reaction time and the amount of catalyst was determined.

The experiments carried out with the optimum operating conditions found fully confirmed the reliability of the results obtained.

The acetoxymethylation of chloromethyl–sec.hexyl–o–xylene with sodium acetate in the presence of the Makoshi catalyst, carried out under the optimum operating conditions, completely confirmed the reliability of the results obtained.

As a result of the solution of the problem was found, an optimal mode condition for the process of acetoxymethyl–.t.–hexyl–o–xylene production, as well as the conditions under which the process of alkylation of 0-xylene with hexene, the chloromethyloranation of sec–hexyl–o–xylene and acetoxymethylation of chloromethyl–sec.hexyl–o–xylene:

a) alkylation of 0-xylene with hexene:
–process temperature $X_1 = 50.8$
–reaction time $X_2 = 2.94$
–amount of catalyst $X_3 = 0.24: 0.61$
b) chloromethylation of sec.hexyl–o–xylene in the presence of a catalyst:
–process temperature $X_1 = 60.8$
–reaction time $X_2 = 4.9$
–amount of catalyst $X_3 = 0.45: 0.2$
c) acetoxymethylation of chloromethyl–sec.hexyl–o–xylene:
process temperature $X_1 = 118.9$
–reaction time $X_2 = 4.9$
–amount of catalyst $X_3 = 0.012$
Y_{optim3}=95.9%

References:

1. Zadeh, L. A. (1975). The concept of a linguistic variable and its application to approximate reasoning-III. *Information sciences,* 9(1), 43-80.

2. Abdullaeva, M. Yu., & Yusubov, F. V. (2017). Opredelenie optimal’nykh parametrov polucheniya dielektricheskoi zhidkosti dlya impul’snykh kondensatorov c nechetkoi model’yu. *Open innovation,* 108-112.

3. Leonenkov, A. V. (2003). Nechetkoe modelirovanie v srede MATLAB i fuzzyTECH. St. Petersburg. 736.

4. Duviychul, O. Yu., & Rudakov, V. V. (2006). Experimental determination of reliability indices of sections of capacitors with paper-castor insulation. *Elektroelekmechanika i elektrotekhnika,* (1). 71-75.

5. Benjamin, S. F., & Roberts, C. A. (2007). Three-dimensional modelling of NOx and particulate traps using CFD: A porous medium approach. *Applied Mathematical Modelling, 31*(11), 2446-2460.

6. Shafeeyan, M. S., Daud, W. M. A. W., & Shamiri, A. (2014). A review of mathematical modeling of fixed-bed columns for carbon dioxide adsorption. *Chemical engineering research and design,* 92(5), 961-988.

7. Yusubov, F. V., Babaev, R. K., & Mamedov, E. A. (2012). Optimization of adsorption processes in the oil and gas industry. *Chemistry and technology of fuels and oils,* (2). 48-51.

8. Abdullayeva, M. Ya., & Yusubov, F. V. (2017). Determination of optimal parameters of tree–staged obtaining of acetoxy methyl-sec.hexyl-orth-oxylol as dielectric liquids for impulse condensators. *Herald of Science and Education, 9*(33), 21-31.

Список литературы:

1. Zadeh L. A. The concept of a linguistic variable and its application to approximate reasoning-III // Information sciences. 1975. V. 9. №1. P. 43-80.

2. Abdullayeva M. Y., Yusubov F. V. Determination of optimal parameters obtaining of dielectric liquid for pulsed condensers with the fuzzy model // Open innovation. 2017. P. 108-112.

3. Leonenkov A. V. Fuzzy modeling in the environment of MATLAB and fuzzy TECH. St. Petersburg, 2005. 736 p.

4. Duviychul O. Yu., Rudakov V. V. Experimental determination of reliability indices of sections of capacitors with paper-castor insulation // Elektroelekmechanika i elektrotekhnika. 2006. №1. P. 71-75.

5. Benjamin S. F., Roberts C. A. Three-dimensional modelling of NOx and particulate traps using CFD: A porous medium approach // Applied Mathematical Modelling. 2007. V. 31. №11. P. 2446-2460.

6. Shafeeyan M. S., Daud W. M. A. W., Shamiri A. A review of mathematical modeling of fixed-bed columns for carbon dioxide adsorption // Chemical engineering research and design. 2014. V. 92. №5. P. 961-988.

7. Yusubov F. V., Babaev R. K., Mamedov E. A. Optimization of adsorption processes in the oil and gas industry // Chemistry and technology of fuels and oils. 2012. №2. P. 48-51.

8. Абдуллаева М. Ю., Юсубов Ф. В. Оптимальных параметров трехстадийного получения ацетоксиметил-втор.гексил-о-ксилола в качестве диэлектрической жидкости для импульсных конденсаторов // Вестник науки и образования. 2017. №9 (33). С. 21-31.

Работа поступила
в редакцию 01.11.2018 г.

Принята к публикации
06.11.2018 г.

Cite as (APA):

Sultanova, A., & Abdullayeva, M. (2018). Forecasting of optimal parameters production dielectric fluid for pulse capacitors using fuzzy inference models. *Bulletin of Science and Practice, 4*(12), 332-337. (in Russian).

Ссылка для цитирования:

Sultanova A., Abdullayeva M. Forecasting of optimal parameters production dielectric fluid for pulse capacitors using fuzzy inference models // Бюллетень науки и практики. 2018. Т. 4. №12. С. 332-337. Режим доступа: http://www.bulletennauki.com/12-67 (дата обращения 15.12.2018).