**Joint sorption of Ca(II) and Mg(II) cations with glauconite from diluted chloride solution and media containing indifferent electrolytes**

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**Keywords:** calcium, magnesium, chloride, glauconite, sorption, indifferent electrolyte.

Sorption of Ca(II) and Mg(II) cations with 95% concentrate glauconite from diluted chloride solution containing 0,125 – 0,500 mmole-equ/l CaCl2 and MgCl2 at their separate and joint presence has been studied taking into account the demands of water clearance depth from cations of hardness for boilers of high pressure. Influence of cations concentration, their relative correlation in the solution, specific mass of sorbent, sorption duration, efficiency of one and two successive steps of clearance and a presence of indifferent electrolyte (10-3 M Na2SO4 or 2,4·10-3 M NaNO3 insertion of which induces the same change of the initial ionic strength of the working solution) is considered. It is shown that in the studied conditions the sorption clearance of working solution permits to reach the concentration of hard cations not more than 0,01 mmole-equ/l i.e. to decrease it more than by 90 times. The relative sorption ability of Ca(II) and Mg(II) as a function of studied factors is estimated.

**References**

1. GOST 2874-82 «Drinking water. Hygienic requirements and control of

quality» (in Russ.).

2. GOST R 51232-98 “Drinking water. General requirements for organization

and methods of control of quality” (in Russ.).

3. Nekrasov B.V. «Fundamentals of total chemistry». M.: Chemistry. 1967, V.

2. 408 p. (in Russ.).

4. Kulyuk V.N., Kulikova О.М., Karabin L.А. Product of solubility. Novosibirsk. Science. 1983. 229 p. (in Russ.).

5. Patent RF 2001114498. Method of water purification and demineralization. Magunov I. R., Magunov R.L. Public. 05.2000. (in Russ.).

6. Patent RF 94025655. Method of water purification . Trizin Yu.T., Tsygankov V.I. Public. 06.1996. (in Russ.).

7. Patent RF 2281257. Method of water deep demineralization. Yankovskii N.A., Stepanov V.A. Public. 08.2006. (in Russ.).

8. Vigdorovich V.I., Tsygankova L.E., Akulov A.I. PH influence on phenol extraction by glauconite and its fractions from running solution. Sorbtsionnye i khromatographicheskie protsessy [Sorption and chromatographic processes], 2011, v. 11, no. 2, pp. 256 – 263 (in Russ.).

9. Vigdorovich V.I., Bogdanova E.P., Tsygankova L.E. Influence of medium acidity on Fe (II) sorption by glauconite from running chloride solutions. Sorbtsionnye i chromatographicheskie protsessy [Sorption and chromatographic processes], 2012, v.12, no. 2, pp. 274 – 282 (in Russ.).

10. Vigdorovich V.I., Tsygankova L.E., Nikolenko D.V., Protasov A.S. Sorption purification of solutions from Pb (II) cations with glauconite concentration. Sorbtsionnye i chromatographicheskie protsessy [Sorption and chromatographic processes], 2013, v.13, no. 3, pp. 393 – 400 (in Russ.).

11. Eqirani D.E., Baker A.R., Andrews J.E. Copper and zinc removal from aqueous solution by mixed mineral systems: 1. Reactivity and removal kinetics. Colloid interface sci., 2005, v. 291, pp. 313 - 325.

12. Srivasava P, Singh B., Andrews J.E. Competitive adsorption behavior of heavy metals on kaolinite. Colloid interface sci., 2005, v. 291, pp. 588 - 592.

13. Zhao J., Zhu Y., Wu J., Zheng J., Zhao X., Lu B., Chen F. Chitosan-coated mesoporous microspheres of calcium silicate hydrate: Environmentally friendly synthesis and application as a highly efficient adsorbent for heavy metal ions. Colloid interface sci., 2014, v. 418, pp. 208 - 215.

14. Gellebrand V.F., Lendel G.E., Brayt G.A., German D.I. Applied direction for inorganic analysis. M.: Chemistry. 1966, 1112 p. (in Russ.).

15. GOST R 52407-2005. National standard of Russian Federation. Drinking water. Methods of hardness testing. (in Russ.).

16. Tarasevich Y.I, Ovcharenko F.D. Adsorption on clay minerals. Kiev. Naukova Dumka. 1975, 352 p.

17. Emely J. Elements. М.: Мir. 1993, 256 p. (in Russ.).

18. Rabinovich V.A. Thermodynamic activity of ions in electrolyte solutions. L.: Chemistry. 1985. 176 p. (in Russ.).

**Application of wave technology for preparation of sorption-active composite materials**

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**Keywords:** polymer composite materials, wave technology, viscosity, film-formation, non-woven materials.

The obtaining of sorption-active composite materials on non-woven base was considered in this work. The technology of impregnation of compositions containing aqueous solutions of gel-forming polymers with dispersed of silica or ceolyte was used. The wave technology of filled polymer compositions allowed to receive stable impregnating compositions with high dispersed fillers. By this mode the high speed of impregnations regular filler particles were reached and it promoted the forming materials with improved filtering and sorption properties. It is important that materials obtained can be used during more continuous period of time (1,5- 2 times longer).

**References**

1. Fomin V.N. The influence of mechanical stress on the formation of multicomponent systems properties. – M. Nauka [Science], 2004, 82 pp. (in Russ.)

2. Ganiev R.F., Fomin V.N., Malyukova E.B., Chukaev A.G.,Belyaev U.A., Berlin A.A. To the question of the stability dispersed systems. Doklad RAN [Report RAS], 2009, v. 427, no. 2, pp. 291-295 (in Russ.).

3. Golikova O.A., Malyukova E.B., Gorchakova V.M., Fomin V.N., Belokurova G.A., Bulychev N.A. The influence of the nature of impregnation composition and condition of their preparation on nonwoven materials properties. Izvestiya VUZov. Tehnologiya text prom. [College news. Technology of textile industry], 2010, no. 4, pp. 71-74 (in Russ.).

4. Bulychev N.A., Fomin V.N., Arutyunov I.A., Eizenbach C.D., Zubov V.P., Abramov O.V. Changes in the structure of the adsorption layers of polymer in the aqueous disperse systems of the pigments under the influence of mechanical activation. Materialovedenie [Science of materials], 2008, v. 5 (134), pp. 28-31 (in Russ.).

5. Bulychev N.A., Fomin V.N., Arutyunov I.A., Eizenbach C.D., Zubov V.P., Malyukova E.B. Effect of mechanical activation on the structure of the adsorption layers of polymer in the aqueous dispersion of pigments. Doklad RAN [Report RAS], 2008, v. 40, no. 2, pp. 215-218 (in Russ.).

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**Keywords**: automated system, the monitor environmental-ring, air pollution, environment.

Analysis of the currently existing work in the field of environmental monitoring of atmospheric pollution by harmful substances has shown that they are accompanied by not only material losses, but also massive loss of life and deteriorating health of adjacent territories, so in terms of air pollution is important to the speed and accuracy of the information received . Industrial development requires increasing attention to the control of air pollution by harmful substances. The solution of such problems is not possible without creating an automated system for monitoring atmospheric pollution industrialized areas. The article describes an automated system for monitoring the state of the environment, which is designed for continuous monitoring of pollutants associated with accidental emissions, measurements of meteorological parameters, generate and transmit data to the center of the collection, processing and storage of data sets.

**References**

1. Device of security monitoring operation of the main gas pipelines / Ivanovskaya E.N., Gryazev M.V., Chebotarev A.L., Meshalkin V.P., Panarin V.M., Dorohina A.E., Kamahina S.A., Goryunkova A.A., Dabdina O.A. //patent na poleznuyu model RUS 105360 04.02.2011(in Russ.).

2. Meshalkin V.P. Computerized environmental impact assessment from main pipelines: uchebnoe posobie dlya studentov, obuchayuschihsya po napravleniyu 240800 "Energo- i resursosberegayuschie protsessyi himicheskoy tehnologii, neftehimii i biotehnologii" / V. P. Meshalkin, O. B. Butusov, V. M. Panarin. Moskva, 2008 (in Russ.).

3. Gladyishev N.G., Byikov D.E., Meshalkin V.P., Shishkanova A.A. Ecological and logistics audit. Ekologia i promishlennost Roccia.[ Ecology and Industry of Russia.] 2006. no. 11. pp. 32-35 (in Russ.).

4. Certificate of state registration of the computer № 2008615882 «TulGU: Ekomonitor» /Pravoobladatel: Tulskiy gosudarstvennyiy universitet. Avtoryi: Bizikin A.V., Sokolov E.M., Panarin V.M., Roschupkin E.V., Simankin A.F., Pushilina Yu.N., Zuykova A.A., Pavlova V.S. Zayavka № 2008615497. (in Russ.).

5. Formulation and solution of complex fundamental scientific problems pro-monitoring and forecasting of air pollution of large industrial cities / V.M. Panarin [i dr]. Prioritety Nauki u technologiy [ Priorities for Science and Technology: Reports of the VIII All-Russian scientific and technical conference] - Tula: Izd-vo «Innovatsionnyie tehnologii», 2010. – pp.55-60 (in Russ.).

**Comparison efficiency of extractive agents at the separation of mixture acetone – methanol**

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**Keywords**: acetone, methanol, separating agent, diagram of isolines, excess Gibbs energy, relative volatility, isoselectivity, extractive rectification.

A comparison of separating agents which proposed in the literature for the extractive distillation of azeotropic system acetone – methanol is conducted. The choice of separating agents is based on different approaches and rules of thumb. The diagram of isolines for the excess Gibbs energy, the relative volatility of components to be separated and the selectivity of separating agents for ternary systems acetone - methanol - selective agent in isobaric conditions are used for analysic. Tthermodynamic criterion linking excess Gibbs energy and the relative volatility of the components were performed for all selective separating agents.

**References**

**1.** Zhigang Lei, Chengyue Li, Biaohua Chen. Extractive distillation: a review. Separation & Purification Review, 2003, v. 32, no. 2, pp. 121-213.

**2**. Frolkova A.K. The separation of azeotropic mixtures. Physico-chemical principles and technological techniques. // M.: VLADOS, 2010 (in Russ.).

**3**. Frolkova A. K., Raeva V. M. Bioethanol dehydration: state of the art. Theoretical Foundations of Chemical Engineering, 2010, v. 44, no. 4, pp. 545-556.

**4.** Anohina E.A. Energy saving in the process of extractive distillation. Vestnik MITHT [Fine Chemical Technologies], 2013, v. 8, no. 5, pp. 3-19 (in Russ.).

**5**. Kogan V.B. Azeotropic and extractive distillation. // L.: Himiya [Chemisrty], 1971 (in Russ.).

**6.** Pretel E.J., Araya Lopez P., Bottini S.B., Brignole E.A. Computer-aided molecular design of solvents for separation processes. AIChE Journal, 1994, v. 40, no. 8, pp. 1349-1360.

**7.** Biaohua Chen, Zhigang Lei, Qunsheng Li, Chengyue Li. Application of CAMD in separating hydrocarbons by extractive distillation. AIChE Journal, 2005, v. 51, no. 12, pp. 3114-3121.

**8**. Hilal N., Yousef G., Anabtawi M. Z. Operating parameters effect on methanol–acetone separation by extractive distillation. Separation Science and Technology, 2002, v. 37, no. 14, pp. 3291-3303.

**9.** Gil I.D., Botía D.C., Ortiz Р., Sánchez O.F. Extractive distillation of acetone/methanol mixture using water as entrainer. Ind. Eng. Chem. Res., 2009, v. 48, no. 10, pp. 4858-4865.

**10**. Botía D.C., Riveros D.C., Ortiz P., Gil I.D., Sánchez O. F. [Vapor-liquid equilibrium in extractive distillation of the acetone/methanol system using water as entrainer and pressure reduction](http://pubs.acs.org/doi/abs/10.1021/ie901702h?prevSearch=acetone-methanol&searchHistoryKey=). Ind. Eng. Chem. Res.,2010, v. 49, no. 13, pp. 6176-6183.

**11**. Luyben W.L. [Comparison of extractive distillation and pressure-swing distillation for acetone-methanol separation](http://pubs.acs.org/doi/abs/10.1021/ie701695u?prevSearch=acetone-methanol&searchHistoryKey=). Ind. Eng. Chem. Res.,2008, v. 47, no. 8, pp. 2696-2707.

**12**. An-I Yeh, Berg L., Warren K.J. The separation of acetone-methanol mixture by extractive distillation. Chemical Engineering Communications, 1988, 68, no. 1, pp. 69-79.

**13**. Luyben W. L. Effect of solvent on controllability in extractive distillation. Ind. Eng. Chem. Res., 2008, v. 47, no. 13, pp. 4425-4439.

**14**. Harris R.A., Ramjugernath D., Letcher T.M., Raal J.D. Monoethanolamine as an extractive solvent for the n-hexane + benzene, cyclohexane + ethanol, and acetone + methanol binary systems. J. Chem. Eng. Data, 2002, v. 47, no. 4, pp. 781-787.

**15**. Raeva V.M., Sebyakin A.Yu., Sazonova A.Yu., Frolkova A.K. The choice of possible entrainers for the extractive distillation of binary mixture benzene- cyclohexane. Vestnik MITHT [Fine Chemical Technologies], 2011, v. 6, no. 1, pp. 43-53 (in Russ.).

**16.** Raeva V. M., Sazonova A.Yu., Sebyakin A. Yu., Kudryavceva D.Yu. The selection criterion of potential separating agents for extractive distillation. Vestnik MITHT [Fine Chemical Technologies], 2011, v. 6, no. 4, pp. 20-27 (in Russ.).

**17**. Orchilles A.V., Miguel P.J., Vercher E., Martinez-Andreu A. Ionic liquids as entrainers in extractive distillation: isobaric vapor-liquid equilibria for acetone + methanole + 1-ethyl-3-methylimidazolium trifluoromethanesulfonate. J. Chem. Eng. Data, 2007, v. 52, no. 1, pp. 141-147.

**18.** Kurzin A. V., Evdokimov A. N., Antipina V. B., Pavlova O. S. Liquid-vapor equilibrium in the system acetone - methanol-N-butylpyridinium hexafluorophosphate. Russian Journal of Applied Chemistry, 2007, v. 80, no. 12, pp. 2049-2050.

**19**. Orchillés A.V., Miguel P.J., Llopis F.J., Vercher E., Martínez-Andreu A. [Influence of some ionic liquids containing the trifluoromethanesulfonate anion on the vapor–liquid equilibria of the acetone + methanol system](http://pubs.acs.org/doi/abs/10.1021/je200305n?prevSearch=%255BAbstract%253A%2Bacetone-methanol%255D&searchHistoryKey=) . J. Chem. Eng. Data,2011, v. 56, no. 12, pp. 4430-4435.

**20**. Orchillés A.V., Miguel P.J., González-Alfaro V., Vercher E., Martínez-Andreu A. 1-[Ethyl-3-methylimidazolium dicyanamide as a very efficient entrainer for the extractive distillation of the acetone + methanol system](http://pubs.acs.org/doi/abs/10.1021/je200972w?prevSearch=%255BAbstract%253A%2Bacetone-methanol%255D&searchHistoryKey=). J. Chem. Eng. Data, 2012, v. 57, no. 2, pp. 394-399.

**21**. [Matsuda](http://www.sciencedirect.com/science/article/pii/S0378381212005869) H., [Liebert](http://www.sciencedirect.com/science/article/pii/S0378381212005869) V., [Tochigi](http://www.sciencedirect.com/science/article/pii/S0378381212005869) K.,  [Gmehling](http://www.sciencedirect.com/science/article/pii/S0378381212005869) J. Influence of sulfate-based anion ionic liquids on the separation factor of the binary azeotropic system acetone + methanol. Fluid Phase Equil., 2013, v. 340, pp. 27-30.

**22**. Castellanos-Suárez A. J., Lozsan А. [Salt effects on liquid-vapor equilibrium: Semi-regular diagrams](http://www.sciencedirect.com/science/article/pii/S0009250912003326). Chemical Engineering Science, 2012, v. 79, no. 10, pp. 119-124.

**23**. [Iliuta](http://www.sciencedirect.com/science/article/pii/037838129402586P) М.С.,  [Thyrion](http://www.sciencedirect.com/science/article/pii/037838129402586P) F.C. Vapour-liquid equilibrium for the acetone-methanol-inorganic salt systеm. [Fluid Phase Equil.,](http://www.sciencedirect.com/science/journal/03783812) 1995, v. 103, no. 2, pp. 257-284.

**24**. [Iliuta](http://www.sciencedirect.com/science/article/pii/037838129402586P) М.С.,  [Thyrion](http://www.sciencedirect.com/science/article/pii/037838129402586P) F.C. Salt effects of the acetone-methanol system // [Fluid Phase Equil.,](http://www.sciencedirect.com/science/journal/03783812) 1996, v. 121, no. 1-2, pp. 235-252.

**25**. [Iliuta](http://www.sciencedirect.com/science/article/pii/037838129402586P) М.С.,  [Thyrion](http://www.sciencedirect.com/science/article/pii/037838129402586P) F.C., Landauer O.M. [Vapour-liquid equilibrium of the acetone-methanol system in the presence of KSCN and comparison with other salts](http://www.sciencedirect.com/science/article/pii/S0378381296031998). Fluid Phase Equil., 1997, v. 130, no. 1-2, pp. 253-269.

**26**. [Iliuta](http://www.sciencedirect.com/science/article/pii/037838129402586P) М.С., Landauer O.M., [Thyrion](http://www.sciencedirect.com/science/article/pii/037838129402586P) F.C. Salt effect of LiCl on vapor–liquid equilibrium of the acetone - methanol system. Fluid Phase Equil., 1998, v. 149, no. 1-2, pp. 163-176.

**27**. Sameer Al-Asheh, Fawzi Banat. Isobaric vapor-liquid equilibrium of acetone + methanol system in the presence of calcium bromide. J. Chem. Eng. Data, 2005, v. 50, no. 6, pp. 1789-1793.

**28.** Vercher E., Orchilles A.V., Miguel P.J., Gonzalez-Alfaro V., Martinez-Andreu A. Isobaric vapor-liquid equilibria for acetone + methanol + lithium nitrate at 100 kPa. Fluid Phase Equil., 2006, v. 250, no. 1-2, pp. 131-137.

**29.** Golberg Yu.A., Serafimov L.A. K voprosu otsenki metodov predstavleniya mnogokomponentnyih smesey v vide psevdobinarnyih smesey. Teoreticheskie osnovy khimicheskoi tekhnologii [Theoretical Foundations of Chemical Engineering] 1968, v. 2, no 6, pp. 835-840 (in Russ.).

**30.** Bittrih G.J., Gajle A.A., Lempe D., Proskuryakov V.A., Semenov L.V. Separation of hydrocarbons using selective solvents. // L.: Himiya [Chemisrty], 1987 (in Russ.).

**31.** Serafimov L.A., Frolkova A.K., Raeva V.M. Termodinamicheskiy analiz polnogo prostranstva izbyitochnyih funktsiy smesheniya binarnyih rastvorov. Teoreticheskie osnovy khimicheskoi tekhnologii [Theoretical Foundations of Chemical Engineering], 1996, v. 30, no. 6, pp. 611-617 (in Russ.).

**32.** Belousov V.P., Panov M.Yu. Thermodynamics of aqueous solutions of non-electrolytes. // L.: Himiya [Chemisrty], 1983 (in Russ.).

**33**. Sazonova A.Yu., Raeva V.M., Frolkova A.K .Comparison of extractive agents efficiency at mixture separation of acrylonitrile and water . Izvestiya VUZov. Himiya i himicheskaya tekhnologiya [Proceedings of the universities. Chemistry and chemical technology], 2013, v. 56, no 11, pp. 50-56 (in Russ.).

**34.** Sazonova A.Yu., Raeva V.M., Chelyuskina T.V., Frolkova A.K.Choice of extractive agents for separating benzene–perfluorobenzene biazeotropic mixture based on thermodynamic criterion. Teoreticheskie osnovy khimicheskoi tekhnologii [Theoretical Foundations of Chemical Engineering], 2014, v. 48, no. 2, pp. 163-172 (in Russ.).

**35.** Rid R., Prausnic Dzh., Shervud T. The properties of gases and liquids. Perevod s anglijskogo pod redakciej Sokolova B.I. Izdanie tret'e. // L.: Himiya [Chemisrty], 1982 (in Russ.).

**36.** Kossack S., Kraemer K., Gani R., Marquardt W. A systematic synthesis framework for extractive distillation processes. [Chem. Eng. Res. Des](http://academic.research.microsoft.com/Journal/1945/chem-eng-res-des-chemical-engineering-research-%26-design)., 2008, v. 86, no. 7, pp. 781-792.

**37.** Momoh S. O. Assessing the accuracy of selectivity as a basis for solvent screening in extractive distillation processes. Separation Science and Technology, 1991, v. 26, no. 5, pp. 729-742.

**38.** Thermodynamics of vapor-liquid equilibrium. Pod red. Morachevskogo A.G. // L.: Himiya [Chemistry], 1989 (in Russ.).

**39.** Anohina E.A., Shlejnikova E.L. Timoshenko A.V. Energy efficiency of complexes with partially coupled thermally and material flows for extractive distillation of methyl acetate – chloroform. Vestnik MITHT [Fine Chemical Technologies], 2013, v. 8, no. 2, pp. 18-25 (in Russ.).

**40.** Раева В.М., Себякин А.Ю. Extractive distillation research of binary heterogeneous mixtures. Vestnik MITHT [Fine Chemical Technologies], 2012, v. 7, no. 2, pp. 31-37(in Russ.).

**41.** Anohina E.A., Pankova I.A., Timoshenko A.V. The efficiency investigation of complex columns with the side rectifying section for the extractive distillation of acetone – methanol different initial composition. Himicheskaya promyshlennost' segodnya [Chemical industry today], 2009, no 3, pp. 44-49 (in Russ.).

**42.** Anokhina E. A., Sidorova Yu. I., Timoshenko A. V. Extractive distillation of acetone – methanol mixture with water as the extractive agent in the partially thermally coupled columns. Vestnik MITHT [Fine Chemical Technologies], 2011, v. 6, no. 5, pp. 118-124 (in Russ.).

**Energy-saving schemes for extractive distillation of benzene-cyclohexane-toluene mixture with N-methylpyrrolidone as entrainer. Part 2. Schemes with partially thermally coupled columns**

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**Keywords:** benzene, extractive distillation, schemes with partially thermally coupled columns, energy saving.

One way to reduce energy consumption to the extractive distillation process is to use schema including complex column with partially coupled heat and material flows. The aim of this work is to evaluate the energy efficiency of such schemes in comparison with conventional. Study uses as object separation of benzene, cyclohexane, toluene mixture with N-methylpyrrolidone as the entrainer.  Seven new schemes with the partially coupled heat and material flows were constructed on the basis of the transformation of the three conventional extractive distillation schemes. Study used for schemes optimization criteria of the total energy consumption in the column’s boilers. All 10 schemes were compared by this criterion. The schema having maximum energy consumption decreasing (28.7%) consists of a complex column which includes main column, side extractive distillation column and a side stripper.

**References**

1. Anohina E.A., Shleynikova E.L., Timoshenko A.V. Energy efficiency of complexes with partially coupled thermally and material flows for extractive distillation of methyl acetate - chloroform mixture depending on entrainer. Vestnik MITHT [Fine Chemical Technologies], 2013, no. 2. pp. 18–25 (in Russ.).

2. Rudakov D.G., Anohina E.A., Timoshenko A.V. Energy efficiency of systems with partly coupled thermal and material flowsin extractive distillation. Khimicheskaya Technologiya [Chemical Engineering], 2013, no. 3, pp. 163–171 (in Russ.).

3. Wang S.-J., Huang H.-P. and Yu Ch.-Ch. Plantwide Design of Transesterification Reactive Distillation to Co-Generate Ethyl Acetate and *n*-Butanol. Ind. Eng. Chem. Res., 2010, no. 2, pp. 750–760.

4. Gutiérrez-Guerra R., Hernández J.G.S., Hernández S. Reducing energy consumption and CO2 emissions in extractive distillation. Chem. Eng. Res. and Des., 2009, v. 87, pp. 145–152.

5. [Timoshenko A.V.](http://elibrary.ru/author_items.asp?authorid=47617), [Morgunov A.V.](http://elibrary.ru/author_items.asp?authorid=153998), [Anokhina E.A.](http://elibrary.ru/author_items.asp?authorid=153994) Flowsheet synthesis for the extractive distillation of azeotropic mixtures in systems consisting of columns with partially coupled heat and material flows. [Theoretical foundations of chemical engineering](http://elibrary.ru/contents.asp?issueid=367825), 2007, no. 6, pp. 845–850.

6. Anohina E.A., Pankova I.A., Timoshenko A.V. Study on effectiveness of complex columns with side section for extractive distillation of acetone-methanol mixtures with different composition. Khimicheskaya promyshlennost' segodnya [Chemical industry today], 2009, no. 3, pp. 44–49 (in Russ.).

7. Anohina E.A., Sidorova Ju.I., Timoshenko A.V. Extractive distillation of acetone – methanol mixture with water as the extractive agent in the partially thermally coupled columns. Vestnik MITHT [Fine Chemical Technologies], 2011, no. 5, pp. 118–124 (in Russ.).

8. Anohina E.A., Rudakov D.G., Timoshenko A.V. Extractive distillation isobutyl alcohol - isobutyl acetatemixture with *N,N*-dimethylformamide. Khimicheskaya Technologiya [Chemical Engineering], 2011, no.10, pp. 627–633 (in Russ.).

9. Ivanova L.V. Development of thermodynamically efficient schemes of multicomponent industrial mixtures distillation: Ph.D. in technical sci. thesis. M., 2005.

10. Dolmatov B.B. The optimal regions of initial feed composition by extractive distillation: Ph.D. in technical sci. thesis. M., 2009.