Perspectives to intensify process of high-purity isobutylene production

**Farkhad A. Baiguzin**

Engineering Promotional Center “Ingehim”, Ph. D., senior engineer

Address: 14/83 Shalyapin Str., Kazan 420049, Russia

Phone: +7 (843) 570-23-18

e-mail: umns\_inform@rambler.ru

**Dmitri A. Burmistrov**

Engineering Promotional Center “Ingehim”, engineer

Address: 14/83 Shalyapin Str., Kazan 420049, Russia

Phone: +7 (843) 570-23-28

e-mail: d\_burm@inbox.ru

**Alexander V. Rakov**

Engineering Promotional Center “Ingehim”, engineer

Address: 14/83 Shalyapin Str., Kazan 420049, Russia

Phone: +7 (843) 570-23-28

e-mail: rakov@ingehim.ru

**Sergey A. Irdinkin**

Engineering Promotional Center “Ingehim”, engineer

Address: 14/83 Shalyapin Str., Kazan 420049, Russia

Phone: +7 (843) 570-23-28

e-mail: kep\_bene@mail.ru

**Alexander V. Klinov**

Kazan National Research Technological University, D. Sc., professor,

Chair of Chemical process engineering department

Address: 12 Sibirskiy trakt Str., Kazan, 420029, Russia

Phone: +7 (843) 231-40-50

e-mail: alklin@kstu.ru

**Keywords** tert-butanol dehydration, isobutylene production, strong acid ion-exchange resin, experimental study.

**Abstract** Presented that operating equipment had a limited potential to intensify tert-butanol dehydration. Alternative process scheme was given. Tert-butanol dehydration was experimentally studied with different strong acid ion-exchange resins KU-2FPP and Purolite СТ275 for the both process schemes – operating and alternative. Experimental study showed, that at alternative process scheme specific yield of isobutylene was higher with the same type and mass of catalyst, than at operating process scheme.

**References**

1. Kirpichnikov P.A., Liakumovich A.G., Pobedimskii D.G., Popova L.M. Chemistry and Technology of Monomers for Synthetic Rubbers. Leningrad.: Chimia, 1981. 264 p. (in Russ.).
2. Knifton J.F., Sanderson J. R., Stockton M. E.Tert-butanol dehydration to isobutylene via reactive distillation. Catalysis letters, 2001, V73, pp. 55-57.
3. Yelizarov D.V. Reactive distillation process modelling for the production isobutylene from tertiary-butanol (TBA). PhD Thesis. Kazan.,1998, (in Russ.).
4. Burmistrov D.A., Bayguzin F.A., Rakov A.V., Irdinkin S.A., Klinov A.V., Farakhov M.I. Distillation pilot unit for experiments in continuous mode and its performance. Vestnik Kazan. tekhnol. un-ta [Herald of Kazan Technological University], 2014, no. 2, pp. 243-248 (in Russ.).
5. Aerov M.E., Todes O.M., Narinskiy D.A. Apparatuses with a stationary granular bed. Leningrad.: Chimia, 1979. 176 p. (in Russ.).

**Physical and chemical hydrodynamics of cationic copolymerization of isobutylene with isoprene**

**Ulitin Nikolai Victorovich**

«Kazan National Research Technological University»**,** Professor of Department of Processing Technology of Polymers and Composite Materials,

Address:420015, Kazan, Karl Marks st. 68

Phone No 8(843)231-95-46

e-mail:n.v.ulitin@mail.ru

**Tereshchenko Konstantin Alekseevich**

«Kazan National Research Technological University», Associate Professor of Department of Processing Technology of Polymers and Composite Materials,

Address:420015, Kazan, Karl Marks st. 68

Phone No 8(843)231-95-46

e-mail:nucleurmind@yandex.ru

**Keywords:** butyl rubber, molecular-weight characteristics, suspension copolymerization, physical and chemical hydrodynamics.

**Abstract.** The physical and chemical hydrodynamics of cationic suspension copolymerization of isobutylene with isoprene was originally formalized mathematically (the catalyst is AlCl3, the solvent is CH3Cl, temperature ≥ 173 K) with the boundary conditions corresponding to reactor equipped with a mixer. It has been found that with the increase of catalyst concentration (from 4.10 to 1 mol / l) and reduction of the rotation rate of the mixer (from 4 to 0.5 rev. / sec.) the number average (from 1200 to 201 000) and weight average (from 39 400 to 406 000) molecular weight of butyl rubber will decrease at the slight change of its polydispersity index (close to 2).

**References**

1. Sokolov A.V., Pautov P.G., Prokof’ev Ya.N. Polozov A.G., Tokar’ A.E., Golovachev A.M., Osovskiy E.L., Lavrinenko N.I. A method of butyl rubber producing. RU 2033997/ 30.04.1995 (in Russ.).

2. Petrova V.D., Prokof’ev Ya.N., Kosmodem'yanskii L.V., Polozov A.G., Arkhipov N.B., Bugrov V.P., Krapivina Kh.Ya., Bortsova A.V., Abramov N.V., Golovochev A.M., Tokar’ A.E., Osovskiy E.L.Method of producing high molecular butyl rubber. RU 1807699. 27.04.1996 (in Russ.).

3. Sangalov Yu.A., Minsker K.S., Zaikov G.E. Polymers derived from isobutylene. Synthesis, properties, application. Utrecht: VSP, 2001.

4. Ulitin N.V., Tereshchenko K.А. Model of chemical kinetics and identification of cationic copolymerization of isobutylene with isoprene kinetic constants. Khimicheskaya promyshlennost' segodnya [Chemical industry today], 2015, no., pp. (in Russ.).

5. Pletcher R.H., Tannehill J.C., Anderson D. Computational fluid mechanics and heat transfer. CRC Press, 2014.

6. Menter F.R. Two-equation eddy-viscosity turbulence models for engineering applications // AIAA Journal, 1994, V.32, no. 8, pp. 1598-1605.

7. Deberdeev R.Ya., Berlin A.A., Dyakonov G.S., Zakharov V.P., Monakov Yu.B. Fast chemical reaction in turbulent flows: theory and practice. Shawbury: Smithers Rapra Technology Ltd, 2013.

**Study of polysulfone and polyether sulfone rheokinetic laws on curing process epoxy-amine binder**

**Sopot Rostislav Igorevich**

Dmitry Mendeleev University of Chemical Technology of Russia, NPM Faculty, Department of plastic processing, post-graduate student.

Address: 125047, Moscow, Miusskaya Square, 9

e-mail: rostislav-sopotov@yandex.ru

**Gorbunova Irina Yurevna**

Dmitry Mendeleev University of Chemical Technology of Russia, NPM Faculty, Department of plastic processing, Professor, Doctor of Chemistry

Address: 125047, Moscow, Miusskaya Square, 9

e-mail: giy161@ya.ru

**Kerber Michail Leonidovich**

Dmitry Mendeleev University of Chemical Technology of Russia, NPM Faculty, Department of plastic processing, Professor, Doctor of Chemistry

Address: 125047, Moscow, Miusskaya Square, 9

e-mail: kerber32@mail.ru

**Doroshenko Uliy Evseevich**

Dmitry Mendeleev University of Chemical Technology of Russia, NPM Faculty, Department of plastic processing, Chief Researcher, Doctor of Chemistry

Address: 125047, Moscow, Miusskaya Square, 9

**Bornosuz Natalya Valer’evna**

Dmitry Mendeleev University of Chemical Technology of Russia, NPM Faculty, Department of plastic processing, student

Address: 125047, Moscow, Miusskaya Square, 9

e-mail: natasha\_bornosuz@mail.ru

**Keywords**: epoxy binder, epoxy oligomer, ED-20, modification, polysulfone, polyether sulfone, viscometer rheokinetic.

**Abstract.** Today, the most common type of matrix to produce adhesives, potting and impregnating composite materials are epoxy-amine composition. In the production of products based on epoxy compositions most important issue is the choice of the mode of curing, providing the desired combination of properties derived products. For information, it is advisable to use the kinetic rheokinetic approach. In this paper, we studied the effect of thermoplastic modifiers (polysulfone and polyether sulfone),on a change in viscosity during curing. The basic laws of the process are considered. The data gives an indication of the direction the process curing conditions change.

**References**

1. Piau J.-M., Piau M., The relevance of viscosity and slip early days in rheology and rheometry, J. Rheol., Vol 49, №6 2005 – pp. 807-818
2. Zukin S.V., Arinina M.P., Zhironkina N.V., Gorbunova I.Yu., Kerber M.L., The study of the influence of the content of the thermoplastic modifier and mode of curing properties of the epoxy-amine binder, Uspekhi v himii i himicheskoj tekhnologii [Advances in Chemistry and Chemical Technology], 2012, Volume XXVI, №3, pp. 106-109 (in Russ.).
3. Kulichikhin S.G., Gorbunova I. Yu., Kerber M.L., Samardukov E.V., Rheokinetic of epoxy-amine curing system in the glass, Vysokomolekulyarnye soedineniya [Macromolecular compounds], Serie A - 1995 - T.37, №3. - P. 533-536 (in Russ.).
4. Arinina M.P., Ilyin S.O., Makarov V.V., Gorbunova I.Yu., Kerber M.L., Kulichikhin V.G., Compatibility and rheological properties of bisphenol epoxy oligomer with aromatic polyesters, Vysokomolekulyarnye soedineniya [Macromolecular compounds], Series A, 2015, Volume 57, number 2, pp. 152-161 (in Russ.).
5. Malkin A.Ya., Kulichikhin S.G., Rheology in the formation and transformation of polymers, M, Chemistry, 1985 - 240 pp.

**Thermodynamic description of the process of adsorption of vanadium to carbon sorbent**

**Ordinartsev Denis P.,** Ural State Forest Engineering University, post-graduate student; e-mail: denis\_ordinartsev@mail.ru

**SviridovAleksey V.,** Ural State Forest Engineering University, docent; e-mail: asv1972@mail.ru,

**Sviridov Vladislav V.,** professor Ural State Forest Engineering University; e-mail: asv1972@mail.ru

**Keywords**: adsorption, sorption extraction of vanadium modified carbon sorbents, vanadium pentoxide, thermodynamics of adsorption, sorption isotherms.

**Abstract**. The possibility of adsorption of extract compounds of vanadium from acidic solutions on highly developed surface of the activated charcoal, the modified cationic surfactants. Found that mainly vanadium polyoxazolines are adsorbed . It is proved that the sorption extraction of vanadium from an aqueous solution do not interfere with ions of copper, nickel, iron, calcium, magnesium, sodium and potassium. Thermodynamic studies showed that the extraction of vanadium is reduced to the physical adsorption of polyoxoanion on the positively charged surface of charcoal (the recovery rate of 84%). The end products of the burning of saturated sorbent may be vanadium pentoxide or metal vanadium. The degree of purity of the final products is 99%. As impurities only discovered manganese compounds were discovered.

**References**

1. Ivankin A. A., Fotieva A.A. Chemistry of pentavalent vanadium in aqueous solutions. Sverdlovsk, Uralsky nauchniy center Akademii Nauk[Ural scientific center of the Academy of Sciences],1971.( in Russ ).

2. Rabinovich, E. M., V. Mizin G Complex processing of vanadium raw materials: the steel industry. Yekaterinburg: UrO RAN[Ural branch of RAS], 2005. ( in Russ ).

3. Mushin V. N., Khamzina L. B. Analytical chemistry of vanadium. M.: Nauka [science], 1981. ( in Russ ).

4. . Kozlov V. A., Razykov Z. A., E. Gusakov G. Sorption technology for producing vanadium oxide from recycled vanadium catalysts sulfate production. T. VIII all-Russia. Conf. "Vanadium. Chemistry, technology, applications". (Chusovoi, 2000.) p.p. 206-208 ( in Russ ).

5. Sittig M. the Extraction of metals and metal compounds from waste. Moscow: Metallurgiya [metallurgy], 1985. ( in Russ ).

6. Sviridov A. V., Ordinartsev D. P., Sviridov V. V., Uriev U. L. A method of producing pentoxide vanadium from vanadium-containing slag. RU 2515154. 2014. ( in Russ ).

**Membrane separation methods of organic acids**

**Shitova Veronika Olegovna,** post-graduate studentD. Mendeleyev University of Chemical Technology of Russia; e-mail: poloika-poloika@mail.ru

**Farnosova Elena Nikolaevna,** docentD. Mendeleyev University of Chemical Technology of Russia;e-mail: farelena\_85@mail.ru

**Kagramanov George Gaikovich,** professor, chief of the chair D. Mendeleyev University of Chemical Technology of Russia, tel. +7 (499) 978-82-60;

e-mail: kadri@muctr.ru

**Keywords:**membrane technology, baromembrane processes, lactic acid, succinic acid.

**Abstract**. There are many ways of the acids purification including extraction, adsorption and ion exchange. Technology of lactic and succinic acids by fermentation includes such stages as crystallization, dissolution, clarification and evaporation. The stages of purification and separation serving to get final product are very important as well. Membrane technology, especially baromembrane processes and electrodialysis are the most promising ones for the purification of lactic and succinic acids due to the relatively low capital cost and high exploitation characteristics – rejection (selectivity) and flux (permeation flow rates). The choice various baromembrane processes type depends on the nature of the impurities containing in liquid culture, their composition, as well as the purification data required. The analyzes of separation and purification steps shows that membrane technology is prospective alternative to traditional one.

**References**

1. Vaidya A. N., Pandey R. A., Mudliar S., Suresh Kumar M., Chakrabarti T., Devotta S. Continuous Production of Lactic Acid in Production and Recovery of Lactic Acid for Polylactide—An Overview // Critical Reviews in Environmental Science and Technology, 2005, v.35, №5, pp 429-467;

2. Gonzaґlez M.I., Aґlvarez S., Riera F., Aґlvarez R. Production and Recovery of Lactic Acid for Polylactide—An Overview // Journal of Food Engineering, 2007, v. 80, pp 553–561;

3. Sauer M., Porro D., Mattanovich D., Branduardi P. Microbial production of organic acids: expanding the markets // Trends Biotechnol, 2008, v. 26, pp: 100–108;

4. Rathin Datta, Shih-Perng Tsai, Patrick Bonsignore, Seung-Hyeon Moon, James R. Frank. Technological and economic potential of poly(lactic acid) // Microbiology reviews, 1995, pp 221-231;

5. Garlotta D. A. Literature Review of Poly(Lactic Acid) // Journal of Polymers and the Environment, 2001, vol. 9, №2, pp 63-84;

6. Obolensky S.V. Reamberin, a new tool for infusion therapy in the practice of critical care medicine, Guidelines, St. Petersburg, 2001, 19 p. (in Russ.)

7. Spiridonov N.A, Bakaneva VF Erokhin NS Succinic acid in medicine, food industry, agriculture, Sbornik nauchnih trudov [Collection of scientific works], Pushchino, 1996, pp 187-195 (in Russ.).

8. Cok B., Tsiropoulos J. Succinic acid production derived from carbohydrates: An energy and greenhouse gas assessment of a platform chemical toward a bio-based economy // Biofuels, Bioproducts and Biorefining, 2014, v. 8, №1, pp 16–29;

9. Kozlov N.I., Recrystallization substances using binary solvent, Thesis abstract. М., 2012. (in Russ.).

10. Harold B. Tinker, Production of lactic acid, patent US 4072709 A, 1978;

11. Miller C., Fosmer A., Rush B., McMullin T. Industrial production of lactic acid, in book Comprehensive Biotechnology, 2011, pp.179-188;

12. Caixia Wang, Wei Ming, Daojiang Yan. Novel membrane-based biotechnological alternative process for succinic acid production and chemical synthesis of bio-based poly // Bioresource Technology, 2014, v.156, рр: 6–13;

13. Sauer M., Porro D., Mattanovich D., Branduardi P. Microbial production of organic acids: expanding the markets // Trends Biotechnol, 2008, v. 26, pp: 100–108;

14. Mizrahi J., Eyal A., Riki C., Hazan B., John N. Starr, Process for producing a purified lactic acid solution, patent US 7026145 B2, 2002;

15. Department of membrane technology, electromembrane processes [electronic resource]. Access: http://www.membrane.msk.ru/books/?id\_b=14&id\_bp=414 (date treatment 10.15.15);

16. Company Media filter membrane elements and devices [electronic resource]. Access: http://www.mediana-filter.ru/kh3\_55.html (date treatment 07.12.15);

17. Parimal Pal, Jaya Sikder, Swapan Roy, Lidietta Giorno. Process intensification in lactic acid production: A review of membrane based processes // Chemical Engineering and Processing, 2009, №48, pp 1549–1559;

18. Russian nuclear community. Application flow ultrafiltration [electronic resource]. Access: http: //www.atomic-energy.ru/articles/2013/06/04/42026 (date treatment 08.11.15);

19. Department of membrane technology, the theoretical basis of reverse osmosis [electronic resource]. Access: http://www.membrane.msk.ru/books/?id\_b=10 (date treatment 07.11.15);

20. Datta R., Tsai S.P., Bonsignore P., Moon S.H., Frank J.R. Technological and economicpotential of poly(lactic acid)and lactic acid derivatives // FEMS Microbiol.Rev., v. 16, 1995, pp 221–231;

21. Tanaguchi M., Kotani N., Kobayashi T. High-concentration cultivation of lactic acid bacteria in fermentor with cross-flow filtration // J. Ferment. Technol., 1987, v. 65, pp 179–184;

22. Nishikawa A., Dunn I.L. Performance of a two-stage fermentor with cell recycle for continuous production of lactic acid // Bioprocess Eng., 1999, v. 21, pp 299–305;

23. Persson A., Jonsson A-S., ZacchiG. Separation of Lactic Acid-Producing Bacteria from Fermentation Broth Using a Ceramic Microfiltration Membrane with Constant Permeate Flow // Biotechnologyand Bioengineering, 2001, v. 72 №3, pp 269-277.

24. Kwon S., Yoo I.K., Lee W.G., Chang H.N., Chang Y.K. High rate continuous production of lactic acid by Lactobacillus bulgaricus in two-stage membrane cell-recycle bioreactor // Biotechnol. Bioeng., 2001, v. 73, pp 25–34;

25. Chakkrit Umpucha, Sylvain Galier, Sunthorn Kanchanatawee, Heґlene Roux-de Balmann. Nanofiltration as a purification step in production process of organic acids: selectivity improvement by addition of an inorganic salt // Process Biochemistry, 2010, № 45, pp1763–1768;

26. Sunhoon Kwon, Ik-KeunYoo, Woo Gi Lee, Ho Nam Chang, Yong Keun Chang. High-rate continuous production of lactic acid by Lactobacillus rhamnosus in a two-stage membrane cell-recycle bioreactor // biotechnology and bioengineering, 2001, v. 73, №1, pp 25-34;

27. Liew M.K.H., Tanaka S., Morita M. Separation and purification of lactic acid: Fundamental studies on the reverse osmosis down-stream process // Desalination, 1995, v.101, pp 269–277;

28. Timmer J.M.K., H.C. van der Horst, Robbertsen T. Lactic acid separation from fermentation broths by reverse osmosis and nanofiltration // Membr. Sci., 1994, v. 92, pp 185–197;

29. Glassner D.A., Datta R. Process for the production and purification of succinic acid, 1992, patent US 5,143,834.

**Comparison of calculations of double-pipe en-closed heat exchanger using typical of integral and differential techniques**

**Golovanchikov Alexander Borisovich**

Volgograd State Technical University, D. Sc. (Engineering), Professor, Chair Head ‘Chemical Production Processes and Equipment’;

e-mail: pahp@vstu.ru

**Vorotneva Svetlana Borisovna**

Volgograd State Technical University, graduate student Chair ‘Chemical Production Processes and Equipment’;

e-mail: svetlanavorotneva@yandex.ru

**Dulkin Boris Aleksandrovich**

National Research University Moscow Power Engineering Institute;

e-mail: dulios@mail.ru

**Keywords:** integral technique, differential technique, double-pipe enclosed heat exchanger blasting air, diesel fuel.

**Abstract.** The calculations of basic parameters of double-pipe enclosed heat exchanger using typical integral and differential techniques were performed. It is shown that when heated blasting air both techniques provide almost identical results in terms of technological and geometrical parameters and when heated diesel fuel parameter deviations can reach tens of percent. The article shows the estimation of influence of fouling resistance on the geometrical parameters of double-pipe enclosed heat exchanger when heated liquids (diesel fuel) and gases (blasting air). Revealed that an increase in the fouling resistance by 2 times leads to the necessity to increase the heat transfer surface when heated liquids on 37% and when heated gases – on 1÷2%. Therefore, heat exchangers, which are heated fluids, require regular periodic cleaning of sediments. For heat exchangers in which the gases are heated, the period between cleanings of sediments can significantly increase.

**References**

1. Pavlov K.F., Romankov P.G., Noskov A.A. Examples and problems at the rate of processes and devices of chemical engineering: manual for high schools // М.: Alliance, 2005 (in Russ.).
2. Borisov G.S., Bryikov V.P., Dyitnerskiy Yu.I. Basic processes and devices of chemical technology: manual to designing // М.: Alliance, 2008 (in Russ.).
3. Golovanchikov A.B., Simonov B.V. The use of computers in chemical technology and ecology: manual for high schools. Part 1 // Volgograd: VSTU, 1994 (in Russ.).
4. Bobylev V.N. Thermal design of the heater, taking into account the structure of the heat-transfer flow. Khimicheskaya promyshlennost' segodnya [Chemical industry today], 2009, no. 7 pp. 45-50 (in Russ.).
5. Ivanitskiy M.S., Griga A.D., Fokin V.M., Griga S.A. Physical and chemical processes of mechanisms of formation of benzo (a) pyrene by burning hydrocarbon fuel. Vestnik VolgGASU [VSUACE], 2012, no. 27(46). pp. 28-33 (in Russ.).
6. Ivanitskiy M.S., Griga A.D., Fokin V.M., Griga S.A. Building a model for determining the concentration of benzo (a) pyrene by burning hydrocarbon fuel in boilers heating systems. Vestnik VolgGASU [VSUACE], no. 28(47). pp. 143-150 (in Russ.).
7. Mischenko K.P., Ravdel A.A. Quick Reference physic-chemical variables // М.: Book on Demand, 2012 (in Russ.).
8. Perri Dzh. Directory of chemical engineer. Part 1 // L.: Сhemistry, 1969 (in Russ.).