ABSTRACT AND REFERENCES

TECHNOLOGY ORGANIC AND INORGANIC SUBSTANCES. ECOLOGY

INFLUENCE OF THE NATURE, SIZE AND SHAPE OF THE SOLVENT MOLECULES ON THEIR DIFFUSION IN THE POLYMER (p. 4-11)

Inessa Burtna, Otar Gachechiladze

Using polymeric membranes for separating mixtures of liquid hydrocarbons, such as crude oil, gas condensate, shale oil, pyrolysis liquid is very important and promising direction for the oil refining industry and obviously can be an alternative to convection technologies. The paper investigates the possibilities of using non-porous polymeric membrane based on silicone synthetic rubber with stiff matrix. The stiffness of the matrix was achieved by increasing the degree of crosslinking. The high degree of crosslinking decreases sharply macromolecular segmental mobility, which in turn allows to reduce the permeability of the membrane elements for complex heavy molecules. Thus, by adjusting the pervaporation parameters, only those substances can be extracted from a gas condensate in the temperature range of 35–65 °C, which are components of the gasoline fraction with a boiling point of 35 °C and the end boiling point of 215 ºC. Moreover, using the differences between the values of diffusion activation energies and diffusion coefficients of various substances in the gasoline fraction, as well as the dependence of these values on the temperature and time allows to achieve the decomposition of fraction into components. Using an experimental membrane setup at atmospheric pressure and relatively low temperatures (35–65 °C), all the gasoline fraction components were extracted, which were in turn were decomposed into four groups of substances depending on the size, shape and nature of the molecules.

Keywords: membrane, polymer, diffusion, segment, energy, activation, crosslinking, pervaporation, sorption.

References

1. Burtna, I. (2013). Transfer processes in polymer membranes. Part 2. Eastern-European Journal of Enterprise Technologies, 2/11(61), 41–44. Available at: http://journals.uran.ua/eejet/article/view/11731/9873
2. Burtna, I., Gachechiladze, O. (2014). Experimental determination of possible models of diffusion during pervaporation process in polymer membranes. Eastern-European Journal of Enterprise Technologies, 5/6(71), 26–32. Available at: http://journals.uran.ua/eejet/article/view/27661/25044
3. Hansen, C. M., Smith, A. L. (2004). Using Hansen solubility parameters to correlate solubility of c 60 fullerene in organic solvents and in polymers. Carbon, 42 (8-9), 1591–1597. doi: 10.1016/j.carbon.2004.02.011
4. Shao, D., Huang, R. Y. M. (2007). Polymeric membrane Pervaporation. Journal of Membrane Science, 287, 162–179. doi:10.1016/j.memsci.2006.10.043
5. Buckley-Smith, M. K. (2006). The Use of Solubility Parameters to select membrane materials for Pervaporation of organic mixtures. The University of WAIKATO, Hamilton, NewZealand, 18–56.
6. Moller, K., Gevert, T. (1994). An FTIR solid-state analysis of the diffusion of hindered phenols in low-density polyethylene (LDPE): The effect of molecular size on the diffusion coefficient. Journal of Applied Polymer Science, 51/5, 895–903. doi: 10.1002/app.1994.070510512
7. Koszinowski, J. (1986). Diffusion and solubility of n-alkanes in polyolefins. Journal of Applied Polymer Science, 32/5, 4765–4786. doi: 10.1002/app.1986.070320501
8. Blyholder, G., Prager, S. (1960). The diffusion of hydrocarbons in polyisobutylene. Journal of Physical Chemistry, 64/5, 702–703. doi: 10.1021/j100834a520
9. Koszinowzki, J. (1986). Diffusion and solubility of hydroxy in polyolefines. Journal of Applied Polymer Science, 31/8, 2711–2720. doi: 10.1002/app.1986.070310826
10. Kulkarni, M. G., Mashelkar, R. A. (1981). On the role of penetrant structure in diffusion in structured polymers. Polymer, 22 (12), 1665–1672. doi: 10.1016/0032-3861(81)90383-9
11. Chen, S. P., Ferry, J. D. (1968).The Diffusion of Radioactively Tagged n-Dodecane through Rubbery Polymers, 1/3, 270–278. doi: 10.1021/ma60003a014
12. Brandt, W. W. (1959). Model Calculation of the Temperature Dependence of Small Molecules Diffusion in High Polymers,Journal of Physical Chemistry, 63/7, 1080–1085. doi: 10.1021/j150577a012
13. Vrentas, J. S., Duda, J. L. (1977). Diffusion in Polymer – Solvent Systems; I. Re-examination of the Free-Volume Theory. Journal of Polymer Science: Polymer Physics Edition, 15, 403–416. doi: 10.1002/pol.1977.180150302
14. Vrentas, J. S., Duda, J. L. (1977). Diffusion in Polymer – Solvent Systems; II.A Predictive Theory for the Dependence of Diffusion Coefficient on Temperature, Concentration and Molecular Weight. Journal of Polymer Science: Polymer Physics, 15/3, 417–439. doi: 10.1002/pol.1977.180150303
15. George, S. C., Thomas, S. (2001). Transport phenomena through polymeric systems. Progress in Polymer Science, 26, 985–1017. doi: 10.1016/S0079-6700(00)00036-8
16. Burtna, I. A., Gachechiladze, O. O., Shafarenko, N. V. (2012). Membranes allocation of kerosene and diesel fractions of a mixture of heavy oil and gas condensate. Industrial Service, 1 (42), 2–3. Available at: http://www.nitu.ru/tpps/2012_1.pdf

ANALYSIS OF THE TOTAL RHEOLOGICAL MODEL OF THE POLYMER MELT FLOW (p. 11-16)

Vitaly Levanichev

Plastics processing is regulated by the shear strain rate, so developing the flow models in a wide range of shear rates is an urgent task.

A comparative analysis of the total rheological curves of the polymer melt flows using two flow models was performed. The Levanichev “slug” flow model is based on a physical model and assumes that the non-Newtonian flow area occurs when the melt flow rate approximates to the relaxation rate. The Carreau model is semi-empirical, viscosity limit values and relaxation time are taken into account, non-Newtonian flow area is described by the flow index.

As a result of the analysis, the viscosity prediction errors were identified, and advantages of the “slug” flow model were shown. The method for calculating the flow of non-Newtonian fluid, where viscosity is understood as a change in the interaction area, resistance to the melt compression and overcoming melt adhesion to the channel walls was given, a new viscosity dimension was proposed.

A number of effects that arise during the plastics processing and engineering methods based on the physical model, describing the total rheological curve (“sharkskin”, “diedroop”, “discopurgeprocedure”) was qualitatively considered.

Keywords: non-Newtonian fluid, rheology, flow model, relaxation, polymer melt, viscosity, flow rate, “sharkskin”.

References

1. Rauwendaal, C.; Volodin, V. (Ed.) (2008). Identification and elimination of problems in extrusion. St. Petersburg.: Profession, 328. [in Russian]
2. Rauvendal, K.; Malkin A. J. (Ed.) (2008). Polymer extrusion. St. Petersburg.: Profession, 768.
3. Tadmor, Z., Gogos, C. (1984). Theoretical Foundations of polymer processing. tr. from english Moscow, USSR, Chemistry, 632. [in Russian]
4. Hammarström, D. (2004). A Model for Simulation of Fiber Suspension Flows. KTH Mechanics, Royal Institute of Technology SE-10044 Stockholm, Sweden, 125.
5. Vinogradov, G. V., Malkin, A. J. (1977). Rheology of polymers. Moscow, USSR, Chemistry, 434.
6. Dyadichev, V. V., Levanichev, V. V., Tereshtchenko, T. M. (2003). Method description rheology of the polymer melt in a wide range of shear rates. Resource-saving technologies of production and fabrication of materials in mechanical engineering. Lugansk: publ EUNU. Dal, 68–72.
7. Wei, C., Yaqiang, S., Chunqian, L., Qian, L., Changyu, S. (2011). Effect of micro-viscosity and wall slip on polymer melt rheology inside micro-channel. Materials conference ANTEC 2011. Available at: http://www.plasticsengineering.org/polymeric/node/4897
8. Hatzikiriakos, S. G., Dealy, J. M. (1991). Wall slip of molten high density polyethylene. I. Sliding plate rheometer studies. Department of Chemical Engineering, McGill University, Montreal, Canada. Available at: http://www.chem.mtu.edu/~fmorriso/cm4655/Hazikiriakos_Dealy.pdf
9. Levanichev, V. (2013). Model of the polymer melt flow. Eastern-European Journal of Enterprise Technologies, 4/7(64), 39–41. Available at: http://journals.uran.ua/eejet/article/view/16685/14175

10. Levanichev, V. (2014). Study of multi-layer flow in coextrusion processes. TEKA Commission of motorization and power industry in agriculture, 14 (1), 144–153. Available at: http://www.pan-ol.lublin.pl/wydawnictwa/TMot14_1/Teka_14_1.pdf
11. Tager, A. A. (2007). Physical chemistry of polymers. 4th edition. Moscow, Scientific World, 576.
12. Brian Black, W. (2000). Wall slip and boundary effects in polymer shear flows. A dissertation at the University of Wisconsin – Madison. Available at: http://grahamgroup.che.wisc.edu/pub/black_dissert.pdf
13. Disco purge procedure for extrusion coaters (2010). The official website of the company Du Pont. Available at: http://www2.dupont.com/Nucrel/en_US/assets/downloads/disco_purge.pdf

STUDIES OF SOLUBILITY OF DICARBOXILIC ACID MIXTURES IN ORGANIC SOLVENTS (p. 17-20)

Oleksandr Prysiazhnyi, Pavlo Kozub, Lidiya Katkovnikova, Svetlana Kozub

Analysis of literary sources has resulted in the choice of the most perspective types of organic solvents for a technology of purifying mixtures of lower dicarboxylic acids from copper and vanadium compounds. We have obtained experimental data on the solubility of mixtures of lower dicarboxylic acids in acetone, ethyl acetate, and hexane. We have processed the data statistically and suggested a semi-empirical equation of solubility versus temperature. The calculated equation coefficients allowed determining the dependence of the dielectric constant of the studied solvents. The obtained data permit calculating the solubility of mixtures of lower dicarboxylic acids in a wide range of temperatures for other solvents by their physical and chemical properties. Comparing solution properties with the technological process conditions has shown that acetone (or other lower ketones) is an optimal solvent for purifying mixtures of lower dicarboxylic acids from copper and vanadium compounds.

Keywords: purification, vanadium, copper, adipic, glutaric, succinic, solubility, acetone, hexane, ethyl acetate.

References

1. Chen, Y. S., Zhou, Y. M., Wang, X. (2005). Market status and development trend of adipic acid, Leather Chemicals, 22 (5), 18–20.
2. Musser, M. T. (2000). Adipic Acid. Ullmann's Encyclopedia of Industrial Chemistry. doi: 10.1002/14356007.a01_269
3. Syire i poluproduktyi dlya lakokrasochnyih materialov (1978). Spravochnoe posobie pod red. Goldberga, 474.
4. Patent USA № US 4105856, C07C 69/34.
5. Stephen, H., Stephen, T. (1979). Solubility of Inorganic and Organic Compounds. Pergamon Press, 451.
6. Weiwei, S., Peisheng, M., Lihua, F., Zhengle, X. (2007). Solubility of Glutaric Acid in Cyclohexanone, Cyclohexanol, Their Five Mixtures and Acetic Acid. Chinese Journal of Chemical Engineering, 15 (2), 228–232. doi: 10.1016/s1004-9541(07)60063-9
7. Gaivoronskii, A. N., Granzhan, V. A. (2005). Solubility of Adipic Acid in Organic Solvents and Water. Russian Journal of Applied Chemistry, 78 (3), 404–408. doi: 10.1007/s11167-005-0305-0
8. Dongwei, W., Wenjiang, C. (2009). Solubility of Adipic Acid in Acetone, Chloroform, and Toluene. Journal of Chemical & Engineering Data, 54 (1), 152–153. doi: 10.1021/je8006887
9. Qiushuo, Y., Simon, B., Hongyuan, W. (2009). Solubility of Butanedioic Acid in Different Solvents at Temperatures between 283 K and 333 K. Journal of Chemical & Engineering Data, 54 (7), 2123–2125. doi: 10.1021/je900021g
10. Hu, Y.-H., Chen, Z.-G., Yang, W.-G., Shi, Y., Sun, H.-L., Li, Y.-L. (2013). Solubility of Succinic Acid in Ethanol Plus Water Systems from 278.15 K to 333.15 K. Journal of Solution Chemistry, 42 (1), 102–110. doi: 10.1007/s10953-012-9951-z
11. Vaysberg, A. (1950). Organicheskie rastvoriteli. Fizicheskie svoystva i metodyi ochischeniya. Moscow: izd-vo spravochnoy literaturyi, 518.
12. Yanyan, L., Yatao, W., Zhuoyuan, N., Jianfang, C., Qiaoye, W., Xunqiu, W. (2014). Solubilities of Adipic Acid and Succinic Acid in a Glutaric Acid and Acetone or n-Butanol Mixture. Journal of Chemical & Engineering Data, 59 (12), 4062–4069. doi: 10.1021/je500682v
13. Zhu, J. Q., Yu, Y. S., He, C. H. (1998). Application of λh equation in mixed solvents. J. Chem. Eng. Chinese Univ., 12 (4), 319–324.

THE METHOD OF ADDITIVES IN DEVISING A GAS CHROMATOGRAPHIC METHOD TO DETERMINE IONOL AND WATER IN ENERGY OILS (p. 21-28)

Sergey Zaitsev, Victor Kyshnevsky, Irina Shulyak

The paper presents the results of devising a method of extraction and gas chromatography for determining the content of ionol and waterin petroleum energy oils (transformer, turbine, compressor, and engine oils). The research was aimed at higher accuracy and fidelity of the methods of extraction and gas chromatographic determining of antioxidant additives (ionol and water) concentration in petroleum energy oils. This could be achieved through a comparative trial of the analyzed energy oil by the method of adding definite amounts of ionol and wateras their solutions in respective liquid extractants. Meanwhile, the extractant added to the working sample of the analyzed energy oil must be ionol-free, and the content of the dissolved water must be minimal at the absence of free water.

We have identified the conditions for performing extraction and gas chromatography measurements. If the analyzed energy oil contains free water before identifying the ionol content, the oil is centrifuged for water separation and further dried with silica or sodium sulphate. The identified component is extracted from energy oil within 2 to 5 hours in the temperature range of 18–30 °C with stabilized temperature deviation range of no more than ±2 °C. Ionol is extracted from energy oil at the value of the "acid number" indicator of less than 0.1 mg of KOH per 1 g of the analyzed energy oil. If the "acid number" indicatoris higher, the energy oil is subject to preliminary silica purification for reducing the indicator value. After the purification, the "presence of water-soluble acids" indicator must have a "lack of water-soluble acids" characteristic at pH= 6.0–8.0 for the aqueous extract from the purified energy oil. While determining water content in energy oil, the liquid extractant and water must be mixed at a room temperature and in any ratio without segregation. The devised methods of measurements allow determining the analyzed components within one trial of energy oil with the use of one gas chromatograph equipped with evaporators, thermal conductivity detector, and a flame ionization detector. The devised methods can be applied to determine ionol and water concentration in fresh, maintenance and regenerated energy oils for monitoring their quality indicators.

Keywords: gas chromatography, extraction, energy oil, water, ionol, the method of additives / additive method.

References

1. SOU-N ITS 43.101: 2009 Acceptance, use and operation of transformer oils. Standards of Quality Assessment (2009). Kiev: KVITS: Ministry of Energy of Ukraine, 152.
2. Emsley, A. M., Xiao, X., Heywood, R. J., Ali, M. (2001). Degradation of cellulose insulation in power transformers. Pt. 3. Effects of oxygen and water on ageing in oil. IEE Proceedings - Science, Measurement and Technology, 147 (3), 115–110. doi: 10.1049/ip-smt:20000021.
3. SOU NAEK 085:2015 Ekspluatacija tehnologichnogo kompleksu. Turbinni olyvy dlja energetychnogo obladnannja AES. Pravyla ekspluatacii' (2015). Kiev: NAEK «Energoatom»: Standart derzhavnogo pidpryjemstva «Nacional'noi' atomnoi' energogenerujuchoi' kompanii' «Energoatom», 53.
4. Supervision and maintenance guide for mineral insulated oils in electrical equipment (2003). IEC publication 60422. Geneva, Switzerland, 15.
5. Fluids for electrotechnical applications Unused mineral insulating oils for transformers and switchgear (2012). IEC publication 60296:2012-02. Geneva, Switzerland, 44.
6. SOU NAEK 006:2011 Turbinni olyvy dlja energetychnogo obladnannja VP AES. Tehnichni vymogy do jakosti, umov pryjmannja ta zberigannja (2011). Kiev: NAEK «Energoatom»: Standart derzhavnogo pidpryjemstva «Nacional'noi' atomnoi' energogenerujuchoi' kompanii' «Energoatom», 50.
7. DSTU 2572-94 Produkty himicheskie organicheskie zhidkie. Gazohromatograficheskij metod opredelenija vody. Obshhie ukazanija (1994). Kiev: Gosstandart Ukrainy, 10.
8. RD 34.43.107-95. Metodicheskie ukazanija po opredeleniju soderzhanija vody i vozduha v transformatornom masle (1995). RAO "EJeS Rossii", AO VNIIJe. Moscow, 17.

9. Khelfane, I., Debche, A., Nacer, A., Beldjilali, A., Toudja, T., Moulai, H. (2014). Moisture and electrical discharges effect on naphthenic mineral oil properties. IET Science, Measurement & Technology, 8 (6), 588594. doi: 10.1049/iet-smt.2013.0262
10. Fofana, I., Bouslimi, Y., Hemmatjou, H., Volat, C., Tahiri, K. (2014). Relationship between static electrification of transformer oils with turbidity and spectrophotometry measurements. International Journal of Electrical Power & Energy Systems, 54, 3844. doi: 10.1016/j.ijepes.2013.06.037
11. Detection and determination of specified antioxidant additives in insulating oils (1979). IEC publication 60666:1979-01. Geneva, Switzerland, 24.
12. Lipshtejn, R. A., Shahnovich, M. I. (1983). Transformatornoe maslo. Third edition. Moscow: Jenergoatomizdat, 296.
13. Kaanagbara, L., Inyang, H. I., Wu, J., Hilger, H. (2010). Aromatic and aliphatic hydrocarbon balance in electric transformer oils. Fuel, 89 (10), 3114–3118. doi: 10.1016/j.fuel.2010.02.013
14. Georgiev, A., Karamancheva, I., Topalova, L. (2006). Evaluation of the antioxidation activity of ionol and piperidone towards transformer oil using FT-IR spectroscopy. Journal of Molecular Structure, 797 (1-3), 2533. doi: 10.1016/j.molstruc.2006.03.026
15. RD 34.43.208-95 Metodika kolichestvennogo himicheskogo analiza. Opredelenie soderzhanij prisadok v jenergeticheskih maslah metodom vysokojeffektivnoj zhidkostnoj hromatografi (1995). RAO "EJeS Rossii", AO VNIIJe. Moscow, 6.
16. ASTM Standard D 4768-96. Standard Test Method for Analysis of 2,6-Ditertiary-Butyl Para-Cresol and 2,6-Ditertiary-Butyl Phenol in Insulating Liquids by Gas Chromatography (1996). ASTM International, 3.
17. Zaitsev, S. V. Kishnevsky, V. A., Gulyaenko, B. A. (2013). Gas chromatographic determination of the distribution coefficients in the "transformer oil – ionol – extractant". Proceedings of Odessa Polytechnic University, 3 (42), 86–90.
18. Mosev a , E. V., Srednitskaya, N. I., Kolodko, T. M. (2000). Definition ionol in industrial oils. Abstracts of the Mezhdunarnoy scientific conference. Resource-Environmental Technology: renewal and saving energy, raw materials and materials. Grodno, 145–146.
19. Buzaev, V. V., Livov, Y. N., Smolenskaya, N. Y., Saposhnichov, Y. M. (1996). Gas chromatographic analysis of transformer oil content of air, water and ionol. Collection of articles. Methods and tools to assess the state of the power equipment. Issue 2. Petersbugsky Energy Institute for Advanced Studies; Ministry of Energy. St. Petersburg, 88–90.
20. Neustroeva, I. V. (2005). Guidelines for the preparation and holding of the chromatographic analysis ap p arat-software complex «Chromatec Crystal». Transformer oil. Determination of antioxidant additives ionol. SKB "Chromatec", Yoshkar-Ola, 33.
21. Zajcev, S. V., Kishnevskij, V. A., Savich, S. L. (2014). Development of methods for the gas chromatogrphic determination of the content of dissolved components in the energy oils. Eastern-European Journal of Enterprise Technologies, 6/6 (72), 3442. doi: 10.15587/1729-4061.2014.29389
22. Zajcev, S. V., Bol'shakov, D. A., Jankovskij, G. K. (2011). Metody opredelenija kojefficientov raspredelenija ionola v sisteme «transformatornoe maslo – ionol - jetanol». Vybor uslovij i procedur vypolnenija izmerenij. Jelektricheskie seti i sistemy, 5, 48–56.
23. Mak, T., Westerwaal, R. J., Slaman, M. et al. (2014). Optical fiber sensor for the continuous monitoring of hydrogen in oil. Sensors and Actuators B: Chemical, 190, 982989. doi: 10.1016/j.snb.2013.09.080
24. Treybal, R. E. (1963). Liguid Extraction. Second edition. New York, 720.
25. Khayam, U., Tsuchie, M., Thein, M., Hikita, M., Saito, T. (2013). Study on Dissolved Gas Due Tue Thermally Degraded Insulating Paper in Transformer Oil. Procedia Technology, 11, 257–262. doi:10.1016/j.protcy.2013.12.189
26. DSTU ISO 8466-1-2001 Vyznachennja gradujuval'noi' harakterystyky metodyk kil'kisnogo himichnogo analizu. Chastyna 1. Statystychne ocinjuvannja linijnoi' gradujuval'noi' harakterystyky (ISO 8466-1:1990, IDT) (2002). Kiev: Derzhstandart Ukrai'ny, 18.

DEVELOPMENT OF BIOTECHNOLOGY OF HYDROGEN SULFID REMOVAL FROM BIOGAS USING IMMOBILIZATION MATERIAL BASED ON PHOSPHOGYPSUM (p. 28-34)

Elizabeth Chernish, Leonid Plyatsuk

The paper focuses on the possibility of using phosphogypsum in the biotechnology processes of gas purification. The biomass of Thiobacillus sp. was immobilized on the granulated material of support medium consisting of dihydrate phosphogypsum. Desulfurization resulted in forming of acidophilic microorganisms association that is able to oxidize hydrogen sulfide to form elemental sulfur in an acidic environment. The granulated loading was based on phosphogypsum and has the following advantages: it has low cost; it stimulates the development of needful ecological-trophic groups of microorganisms; it creates favorable conditions for the formation of biofilm on their surface; the contact surface extends with a gas stream; it is capable of regeneration; it is resistant to higher acidity; it has the protection function blocking toxic components; it increases the yield of elemental sulfur. Optimum conditions of biological system of hydrogen sulfide removal from biogas were determined.

Keywords: biotechnology, hydrogen sulfide removal, biogas, phosphogypsum, immobilization of microorganisms, sulfur.

References

1. Geletukha, G. G., Kucheruk, P. P., Matveev, Yu. B. (2014). Prospects for production and use of biomethane in Ukraine. Analiticheskaya zapiska BAU, 11. Kiev: Bioenergeticheskaya assotsiatsiya Ukrainyi, 44.
2. Piatnichko, A. I., Ivanov, J. V., Krushnevich, T. K. (2010). Optimization of water-amine solutions as absorbents a unit of biomethane extraction from biogas. Tehnicheskie gazyi, 3, 26–29.
3. Idigenov, A. B., Filatov, M. I. (2013). Installation of the combined cleaning of biogas. Vestnik Saratovskogo gosudarstvennogo tehnicheskogo universiteta, 2 (71), 94–101.
4. Ramirez, M., Gómez, J., Cantero, D. (2009). Removal of hydrogen sulphide by immobilized Thiobacillus thioparus in a biofilter packed with polyurethane foam. Bioresource Technology, 100 (21), 4989–4995. doi: 10.1016/j.biortech.2009.05.022
5. Janssen, A. J., Ma, S. C., Lens, P., Lettinga, G. (1997). Performance of a sulfide oxidizing expanded bed reactor supplied with dissolved oxygen. Biotechnology and Bioengineering, 53 (1), 32–40. doi: 10.1002/(sici)1097-0290(19970105)53:1<32::aid-bit6>3.0.co;2-#
6. Ravichandra, P., Mugeraya, G., Gangagni Rao, A., Ramakrishna, M., Annapurna, J. (2007). Isolation of Thiobacillus sp from aerobic sludge of distillery and dairy effluent treatment plants and its sulfide oxidation activity at different concentrations. Journal of Environmental Biology, 28 (4), 819–823.
7. Park Byoung-Gi, C., Shin, W. S., Chung, J. S. (2008). Simultaneous biofiltration of H2S, NH3 and toluene using an inorganic polymeric composite. Environmental Engineering Research, 13 (1), 19–27. doi: 10.4491/eer.2008.13.1.019
8. Desulfurization technology THIOPAQ O&G. Information from the website of the enterprise «Paqell» (2014). Available at: http://www.paqell.com/ru/thiopaq/about-thiopaq-o-and-g/
9. Bakhareva, A. Yu., Yurchenko, V. A. (2013). Dangerous concentration of methane in gasiform emissions and methods of its reduction. Eastern-European Journal of Enterprise Technologies, 3/11(63), 8–11. Available at: http://journals.uran.ua/eejet/article/view/14587/12361
10. Xil'chevs'kij, V. K. (2007). Vidhody virobnitstva i spozhivannya ta yih vpliv na grunti I prirodnI vody [Waste production and consumption and their impact on soil and natural water]. Kiev: Vidavnicho-poligrafichniy tsentr "Kiyivskiy universitet", 152.
11. Abdrakipov, A. R., Barahnina, V. B., Jagafarova, G. G. (2010). Phosphogypsum use at the oil-field sewage bioclearing. Aktualnyie ekologicheskie problemyi: Sbornik nauchnyih trudov V mezhdunarodnoy nauchno-prakticheskoy konferentsii, 4–6.
12. Kaniskina, M. A., Terekhov, V. A., Semenova, T. A., Lisak, L. V. (2009). Influence of phosphogypsum on microorganisms soil-ground. Dokladyi po ekologicheskomu pochvovedeniyu, 1 (11), 62–78.
13. Kaniskin, M. A., Terehova, V. A., Yakovlev, A. S. (2007). Control humate detoxification of phosphogypsum waste by bioassay methods. Ekologiya i promyishlennost, 8, 48–51.
14. Belyuchenko, I. S. (2014). Complex composts and detoxication of agrolandscape systems. Nauchnyiy zhurnal KubGAU, 97 (03). Available at: http://ej.kubagro.ru/2014/03/pdf/59.pdf

SIMULATION THE GAS SIMULTANEOUS ADSORPTION OVER NATURAL AND MODIFIED ZEOLITE (p. 34-37)

Svitlana Prymyska, Yuri Beznosyk, Wladimir Reshetilowski

Adsorption is of great importance. The unique advantage of adsorption over other separation methods is the higher selectivity that

can be achieved by adsorbents. In addition, adsorption phenomena play a vital role in many solid-state reactions and biological mechanisms. In this work, the adsorption process of CO_2 on the clinoptilolite (Skorynskoho field, Transcarpathian region, Ukraine) and SO_2, NO, and CO_2 adsorption on K_2CO_3-modified – γ-alumina in a fixed-bed reactor were theoretical studied and simulated by computer-mathematic methods. The developed mathematical model based on the mass balance in gas and solid phase, the experimental saturation capacities, considering the activity of the adsorbent with respect to the gas by variable coefficients. The model presented by a normal linear system of differential equations with variable coefficients, it was solved by Taylor collocation method. The simulation shows that the data obtained by theoretical study are in agreement with data obtained in the simulation. According to Fisher Criterion the mathematic model adequate in 90 % for modified zeolite and in 75 % for natural zeolite, it can be explained by unordered structure of the natural zeolite. It follows that the offered model adequately describes the dynamics simultaneous adsorption of gases over zeolites. Thus even with a large number of simplifications and assumptions, it is possible to construct efficient mathematical model that can be used in exhaust system. The results indicate that, there is great sense to conduct further researches and simulations to reach the industrial level.

Keywords: adsorption, natural zeolite, modified zeolite, simulation.

References

1. Prymyska, S. O, Beznosyk, Yu. O, Reshetilowski, W. P. (2014). Numerical study of the nitrogen oxides adsorption and storage. Eastern-European Journal of Enterprise Technologies, 2/6 (68), 46–49. doi: 10.15587/1729-4061.2014.22399
2. Nouh, S. A, Lau, K. K, Shariff, A. M. (2010). Modeling and simulation of fixed bed adsorption column using Integrated CFD Approach. Journal of Applied Sciences, 10 (24), 3229–3235. doi: 10.3923/jas.2010.3229.3235
3. Wang, F, Huang, S, Teng, J. (2007). Experiment and Modeling of Pure and Binary Adsorption of n-Butane and Butene-1 on ZSM-5 Zeolites with Different Si/Al Ratios. Chinese Journal of Chemical Engineering, 15 (3), 376–386. doi: 10.1016/s1004-9541(07)60095-0
4. Petryk, M, Leclerc, S, Canet, D, Fraissard, J. (2007). Mathematical modeling and visualization of gas transport in a zeolite bed using a slice selection procedure. The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application Diffusion Fundamentals, 4 (11), 1–23.
5. Petryk, M. Shabliy, O, Leniyk, M, Vasylyuk, P. (2006). Mathematical Modeling and Research for Diffusion Process in Multilayer and Nanoporous Media. Diffusion Process in Multilayer and Nanoporous Media. Fluid Transport in Nanoporous Materials. NATO Science Series, Series II: Mathematics, Physics and Chemistry, 219, 685–655. doi: 10.1007/1-4020-4382-1_34
6. Bowman, R. S. (2003). Applications of surfactant-modified zeolites to environmental remediation. Microporous and Mesoporous Materials, 61 (1-3), 43–56. doi: 10.1016/s1387-1811(03)00354-8
7. Brathwaite, R. L. (2003). Geological and mineralogical characterization of zeolites in lacustrine tuffs, Ngakuru, Taupo Volcanic Zone, New Zealand. Clays and Clay Minerals, 51 (6), 589–598. doi: 10.1346/ccmn.2003.0510601
8. Yi, H., Huang, B., Tang, X., Li, K., Yuan, Q., Lai, R., Wang, P. (2014). Simultaneous Adsorption of SO_2, NO, and CO_2 by K_2CO_3-Modified γ-Alumina. Chemical Engineering & Technology, 37/6, 1049–1054. doi: 10.1002/ceat.201300749
9. Bensitle, M. (2012). Comparative study of SO2 adsorption on metal oxides. Journal of the Chemical Society Faraday Transactions, 88 (19), 2931–2936. doi: 10.1039/ft9928802931
10. Prymyska, S., Beznosyk, Yu, Reschetilowski, W., Räuchle K., Toufar, H. (2009). Simulation the behaviour of the dynamic adsorption of NOx over synthetic zeolites. ACHEMA – Frankfurt am Main.
11. Statyukha, G., Prymyska, S., Beznosyk, Yu., Reshetilowski, W. (2010). Studies of carbon dioxide and nitrogen monoxide removal from exhaust gas through adsorption on molecular sieves. CHISA2010. Prague, Czech Republic.
12. Novak, V., Mayhzhak-Kutsemba, I., Humnytskyy, J. M. (2004). Adsorption of carbon dioxide on natural zeolite. Lviv Polytechnic National University Institutional Repository, 2, 113–115.

COMPREHENSIVE EVALUATION OF ENVIRONMENTAL HAZARD FACTORS AT DISPOSAL OF WASTE USING THE "ECOPYROGENESIS" TECHNOLOGY (p. 38-44)

Lyudmila Markina, Inna Timchenko

The article considers the nature of the technological processes at the utilization of waste management technology "Ecopyrogenesis" on the basis of which the environmental hazard factors of technology, possible emergency situations, taking into account the industrial and fire hazard. The methods of reduction of the hazards to the environment and the effects of hazards impact are determined. The procedure based on the expert method of hierarchy analysis including the operations on the elimination of the possible incorrect decisions of experts is developed. The ranking of the environment threats according to the criteria (probability of occurrence of an environmental hazard, expected effects from the impact of the factor, quality level of the implemented technical or technological solutions to prevent the performance of this factor). The evaluation results in the identification of the most hazardous technological components of the installation, which then will help to form an optimal scheme of risk control for the purpose of their minimization. At this, the synthesis of new optimal technical and technological solutions at the design stage of such complexes will allow one to significantly reduce the possibility of emergency situations and increase the reliability of operation of all the complex of equipment of the "Ecopyrogenesis" technology.

Keywords: waste, utilization, ecological hazard, pyrolysis, emergency situations, hierarchy analysis method, "Ecopyrogenesis" technology, hazardous factors evaluation, environmental hazard ranking, risk minimization.

References

1. Lloyd, A. C. (2006). Technology Evaluation and Economic Analysis of Waste Tire Pyrolysis, Gasification, and Liquefaction. University of California Riverside, Integrated Waste Management Board, 97.
2. Scheirs, J., Kaminsky, W. (2006). Feeds tock Recycling and Pyrolys is of Waste plastics: Converting Waste Plastics into Diesel and Other Fuels. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, WestSussex, 785. doi: 10.1002/0470021543
3. Boiko, T. V., Bendiuh, V. T., Komarysta, B. M. (2012). Risk assessment of industrial enterprises in the design stage to the sustainable development strategy. Eastern-European Journal of Enterprise technologies, 2/14 (56), 13–17. Available at: http://journals.uran.ua/eejet/article/view/3948/3616
4. Ploshchai, F. V. (2012). Parametrychnyi analiz ryzykiv v proektakh utylizatsii shakhtnoho metanu. Eastern-European Journal of Enterprise Technologies, 1/11 (55), 53–55.
5. Nema, S. K., Ganeshprasad, K. S. (2005). Plasma pyrolysis of medical waste. Current science, Bengaluru, 83 (3), 271–278.
6. Yufit, S. S. (2009). Alternativnye tekhnologii pererabotki bytovykh otkhodov. Nauchno-prakticheskiy zhurnal «Tverdye bytovye otkhody», 1, 36–41.
7. Markina, L. N. (2011). Razrabotka novoy tekhnologii energosberezheniya i ekologicheskoy bezopasnosti pri utilizatsii organicheskikh otkhodov metodom Yekopirogenezisa. Zbirnyk naukovykh prats NUK, 4, 156–163.
8. Ryzhkov, S. S., Markina, L. M., Myroshnychenko, M. V. (2012). Ekolohichna bezpeka produktiv ekopirohenezisu ta vykorystannia yikh yak alternatyvnoho palyva. Ekolohichna bezpeka, 2, 98–103.
9. Rizhkov, S. S., Markina, L. M., Rudyuk, M. V., Oshchip, O. V. (2011). Analiz protsessov destruktsii dioksinov i tyazhelykh uglevodorodov pri mnogokonturnom tsirkulyatsionnom pirolize tverdykh bytovykh otkhodov. Energotekhnologii i resursosberezhenie, 6, 43-48.
10. Saati, T. (2012) Prinyatie resheniy – metod analiza ierarhiy. Moskow: Radio i svyaz Publ., 278.
11. Ryzhkov, S. S., Timchenko, I. V. (2012). Expert system of estimation for the environmental risk levels of hazardous facilities of a shipbuilding plant. Visnik NUK, 2 (14). Available at: http://ev.nuos.edu.ua.
12. Faynzilberg, L. S. (2002). Bayesova shema prinyatiya kollektivnyh resheniy v usloviyah protivorechiy. Problemy upravleniya i informatiki, 3, 112–122.

DEWATERING COAL POLYDISPERSE SUSPENSIONS (p. 44-49)

Andrey Shkop

In modern conditions, one of the most pressing problems in coal preparation is improving the technique and technology of dewatering small-class coal polydisperse suspensions, formed at coal-preparation plants. Within this problem, interrelated problems of reducing the loss of useful components, preventing the negative impact of processing enterprises on the environment, reducing the cost of excavating slurry from outside slurry storages are considered.

The approach to selecting equipment based on agreed optimization criteria of the coal preparation product dewatering process is examined in the paper. Performance indicators of different dewatering equipment: sediment moisture; ash content; solid phase retention efficiency in the sediment; solids content in the liquid separation product, and its ash content; coal preparation effect accompanying dewatering process were analyzed.

The technological parameters of vacuum filters, sedimentation centrifuges, filtering centrifuges, and settling and filtering centrifuges were reviewed. This equipment is used for dewatering anthracite and steam coal. Comparative analysis of the equipment is based on the results of experiments conducted at the coal-preparation plants.

Keywords: coal, dewatering equipment, flotation concentrate, flotation waste, slurry, moisture, ash content, efficiency.

References

1. Blagova, I. S., Kotkina, A. M., Zarubina, L. S. (1981). Spravochnik po obogashcheniiu uglei. Moscow: Nedra, 615.
2. Borts, M. A., Gupalo, Y. P. (1972). Obazvozhivanie khvostov flotatsii ugleobogatitelnikh fabrik. Moscow: Nedra, 302.
3. Garkyshyn, Y. K. (2001). Sovremenooe sostoianye teoryi mechanycheskogo obezvogivaniia i metodov ego intensifikatsii. Zbagachennia korysnykh kopalen. Nauk. tekh. Zb, 12 (53), 39–47.
4. Panfilov, V. K., Matsak, A. F., Troshin, G. P. (2003). Obogashchenie antratsitovogo shlama na tsentrifugakh. Ugol Ukraini, 5 (557), 35–42.
5. Matsak, A. F., Mishanina, A . V., Shkop, A. A. (2007). Obogashchenie ugolnogo shlama na osaditelnikh tsentrifugakh. Gornaya promishlennost, 2 (71), 42–48.
6. Khaidakin, V. I., Korneva, V. N., Troshin, A. G. (2003). Priminenie tsentrobegnikh apparatov v ugolnoy promishlennosti. Zbagachennya korisnich kopalen. Nauk. tekh. Zb., 17 (58), 85–89.
7. Patrakeev, V. I., Peichev, I. D., Uvarov, I. I. (2003). Pererabotka technogennogo suria na ZOF "Chervonozavodskaia". Zbagachennya korisnich kopalen. Nauk. tekh. Zb., 17 (58), 96–100.
8. Bochkov, Y. N., Zarubin, L. C. (1966). Ozenka effektivnosti meckhanicheskikh sposobov obezvozhivaniia ugolnoy melochi. Teoriya i praktika obezvozhivaniia ugolnoy melochi. MUN. Moscow: Nauka, 5–19.
9. Borz, M. A., Bochkov, Y. N., Zarubyn, L. S. (1970). Shnekovye osadytelnye tsentryfugy dlia ugolnoy promyshlennosty. Moscow: Nedra, 278.
10. Barskiy, M. D. (1978). Optimizatsiia protsessov razdelenie zernistich materialov. Moscow: Nedra, 254.

INVESTIGATION OF THE INTERACTION OF SODIUM HYPOCHLORITE WITH OLEFINS IN CAVITATION FIELDS (p. 49-54)

Zenoviy Znak, Nadiya Hnatyshyn

The interaction of sodium hypochlorite as a component of wastewater production of caustic soda and chlorine compounds from olefinic C_4–C_7 number contained in wastewater olefinic production was investigated.

The processes of neutralization of sodium hypochlorite, which are implemented in the industry, are very energy-intensive or require large amounts of reagents. That is why it was suggested to intensify the interaction of sodium hypochlorite with olefins by using cavitation fields.

Based on the experimental results the main kinetic parameters of the process was calculated: the rate constant, order of reaction temperature coefficient. It is assumed that the process is carried out for a radical mechanism.

It was found out that as increasing temperature and power ultrasonic emitter rate constant of the reaction between sodium hypochlorite and olefins increases. In this case the duration of process and unit costs of energy for the decomposition of sodium hypochlorite was reduced.

The results will be used to develop energy-efficient process simultaneous neutralization of hypochloritic and olefinic wastewater generated in related industries.

Keywords: sodium hypochlorite, olefins, waste water, ultrasonic radiation, cavitation, destruction, oxidation.

References

1. Znak, Z. O., Hnatyshyn, N. M. (2010). Intensification of thermal decomposition of sodium and calcium hypochlorite. Eastern-European Journal of Enterprise Technologies, 6/6 (48), 40–43. Available at: http://journals.uran.ua/eejet/article/view/3345/3146
2. Zapolskyi, A. K., Mishkova-Klymenko, N. A., Astrelin, I. M., Bryk, M. T., Hvozdiak, P. I., Kniazkova, T. V. (2000). Fizyko-khimichni osnovy tekhnolohii ochyshchennia stichnykh vod. Kiev: Libra. 552.
3. Frank, A. M. (2012). Disinfection with Liquid Sodium Hypochlorite: Principles, Methods, and Lessons Learned. Florida Water Resources Journal, 4–8.
4. Lister, M. W. (2011). Decomposition of sodium hypochlorite; the catalyzed reaction. Canadian Journal of Chemistry, 34 (4), 479–488. doi: 10.1139/v56-069
5. Church, J. A. (1994). Kinetics of the uncatalyzed and Cu(II)-catalyzed decomposition of sodium hypochlorite. Industrial & Engineering Chemistry Research, 33 (2), 239–245. doi: 10.1021/ie00026a010
6. Kim, K.-W., Lee, E.-H., Chung, D.-Y., Moon, J.-K., Shin, H.-S., Kim, J.-S., Shin, D.-W. (2012). Manufacture characteristics of metal oxide–hydroxides for the catalytic decomposition of a sodium hypochlorite solution. Chemical Engineering Journal, 200-202, 52–58. doi: 10.1016/j.cej.2012.06.026
7. Moorhouse, J. (2001). Modern Chlor-Alkali Technology. Chichester: MPG Books ltd., 48. doi: 10.1002/9780470999479
8. Bolton, J. R., Smith, D. W. (2007). Photolysis of aqueous free chlorine species (HOCl and OCl–) with 254 nm ultraviolet light. Journal of Environmental Engineering and Science, 6 (3), 277–284. doi: 10.1139/s06-052
9. Bikbulatov, I. H. (2000). Bezothodnoe proizvodstvo hlorgidrinov. Moscow: Himiya, 167.
10. Kolesnikov, I. V. (1991). Ustoychivost realnyih rastvorov gipohlorita natriya. Him. prom., 6, 361–365.
11. Kardashev, T. A. (1991). Fizicheskie metodyi intensifikatsii protsessov himicheskoy tehnologii. Moscow: Himiya, 208.
12. Roberts, Dzh., Kaserio, M. (1978). Osnovy organicheskoy himii. Vol. 2. Moscow: Mir, 888.

THE COMPUTERIZED SYSTEM WITH THE RECONFIGURABLE ARCHITECTURE FOR MONITORING ENVIRONMENTAL PARAMETERS (p. 55-59)

Georgij Vorobets, Ruslan Hurzhui, Mykola Kuz

The approach and technology for synthesizing universal hardware for monitoring a wide range of environmental parameters - climate, radiation, concentration of pollutant and other were proposed. The methodology of dividing the functions of initial registration of information signals and their subsequent digital processing has allowed to unify requirements for the measuring transducers and computational tools, used in the system. Expanding the functionality of the system and simplifying its technical implementation was achieved by using structural-modular organization, intelligent sensors and measuring transducers, as well as computer tools with the reconfigurable architecture. The proposed technique of parallel processing of intelligent sensor identification codes in CPU and data collection coprocessor allows to increase input data sorting speed by two times, consequently, increase the number of information channels for recording environmental parameters. Also, the option of the developed basic computer tools for the sanitary control of production facilities was considered.

Keywords: environmental monitoring information-measuring system, intelligent measuring transducer, parallel code processing.

References

1. Jakunina, I. V., Popov, N. S. (2009). Metody i pribory kontrolja okruzhajushhej sredy. Jekologicheskij monitoring : uchebnoe posobie. Tambov: Izd-vo Tamb. gos. tehn. un-ta, 188.
2. Shabashkevich, B. G., Dobrovol's'kij, Ju. G., Jur'ev V. G. et. al. (2013). Komp'juterizovanij radiometr-dozimetr ul'trafioletovogo viprominjuvannja Tenzor-31M. Naukovij visnik Chernivec'kogo nacional'nogo universitetu imeni Jurija Fed'kovicha. Serija: Komp'juterni sistemi ta komponenti, 4 (2), 8993.
3. Vujcik, V., Gotra, Z. Ju., Grygor'jev, V. V. et. al.; Z. Ju. Gotra (Ed.) (2002). Mikroelektronni sensory fizychnyh velychyn : Naukovo-navchal'ne vydannja. V 3 tomah. Vol. 1. Lviv: Liga-Pres, 475.
4. Nauchno-proizvodstvennaja firma "Tenzor". Available at: http://tenzor.ua/main/about/o-firme.html
5. Metodychni rekomendacii' z pytan' stvorennja system monitoryngu dovkillja regional'nogo rivnja. Nakaz Ministerstva navkolyshn'ogo pryrodnogo seredovyshha Ukrai'ny vid 16 grudnja 2005, № 467. Available at: http://gov.ua
6. Tema vypusku: Zlojakisni puhlyny shkiry - na drugomu misci v Ukrai'ni sered onkozahvorjuvan' (2010). Zdorov'ja, 31 (166), 1217.
7. Meteoobservatorija MGU. Programma UF monitoring. Available at: http://www.momsu.ru/ufr.html
8. Yankee Environmental Systems, Inc. (YES. Available at: http://www.yesinc.com/
9. UV-B Monitoring and Research Program. Colorado State University. Available at: http://uvb.nrel.colostate.edu/UVB/index.jsf
10. Tarasova, V. V., Malynovs'kyj, A. S., Rybak, M. F., Tarasova, V. V. (Ed.) (2007). Ekologichna standartyzacija i normuvannja antropogennogo navantazhennja na pryrodne seredovyshhe. Kiev: Centr uchbovoi' literatury, 276.
11. Klymenko, M. O., Pryshhepa, A. M., Voznjuk, N. M. (2006). Monitoryng dovkillja. Kiev: Vydavnychyj centr "Akademija", 360.
12. Vorobec', G. I., Voropajeva, S. L., Kuz', M. A., Nikolajev, A. M. (2011). Strukturna organizacija systemy monitoryngu. Naukovyj visnyk Chernivec'kogo nacional'nogo universytetu imeni Jurija Fed'kovycha. Serija: Komp'juterni systemy ta komponenty, 2 (1), 120123.
13. Bolchini, C., Carminati, M., Miele, A., Quintarelli, E. (2013). A Framework to Model Self-Adaptive Computing Systems. Proc. NASA/ESA Conference on Adaptive Hardware and Systems, 7178.
14. Berthold, O. (2012). Self-reconfiguring System-on-Chip using Linux on a Virtex-5 FPGA. Diplomarbeit zur Erlangung des akademischen Grades Diplominfor-matiker Humboldt-Universität zu Berlin, 107.
15. Palagin, A. V., Opanasenko, V. M. (2011). Design and Application of the PLD-Based Reconfigurable Devices. Design of Digital Systems and Devices. Series: Lecture Note in Electrical Engineering, 79, 5991. doi: 10.1007/978-3-642-17545-9_3

IMPROVING THE PROTECTIVE EFFICIENCY OF ELASTOMERIC FILTER RESPIRATORS (p. 60-64)

Vasil Golinko, Sergey Cheberiachko, Yurii Cheberiachko, Dmytro Radchuk

A hypothesis regarding the fact that the protection factor in filter respirators of one protection class should be increased while a decrease in resistance of their filters (without changing the penetration coefficient value) was worked out. Calculations of the protection factor of two produced types of respirators with the different resistance of the filters were performed. It is shown that a decrease in resistance of respirator filters, other things being equal, leads to an increase in their protective efficiency, allowing staff, working in respirators, to reduce the energy required for hard work, as well as increase the usage period of respirators or their usage area in terms of air pollution. The experimental results show that the decrease in resistance of dust respirator filters by three times, other things being equal, leads to an almost double increase in their protective efficiency.

Keywords: filter respirator, breathing resistance, performance, protective efficiency, exhalation valve.

References

1. Warren, R., Zhuang, Z. (1998). Performance Measurements of Half–Facepiece Respirators: Developing Probability Estimates to Evaluate the Adequacy of an APF of 10 American Industrial Hygiene Association Journal, 59 (11), 796–801. doi: 10.1080/15428119891010983
2. Kirillov, V. F., Bunchev, A. A., Chirkin, A. V. (2013). O sredstvakh individual'noy zashchity organov dykhaniya rabotayushchikh (obzor literatury). FGBU «NII Meditsiny truda» Rossiyskoy akademii meditsinskikh nauk Meditsina truda i promyshlennaya ekologiya, 4, 25–31.
3. Myers, W. R., Zhuang, Z., Nelson, T. (1996). Field Performance Measurements of Half-Facepiece Respirators–Foundry Operations. American Industrial Hygiene Association Journal, 57 (2), 166–174. doi: 10.1202/0002-8894(1996)057<0166:fpmohr>2.0.co;2
4. Cohen, H. J. (1984). Determining and validating the adequacy of airpurifying respirators used in industry Part I – Evaluating the Performance of a Disposable Respirator for Protection Against Mercury Vapor. International Society for Respiratory Protection Journal of the International Society for Respiratory Protection, 2 (3), 296–304.
5. Galvin, K., Selvin, S., Spear, R. C. (1990). Variability in protection afforded by half–mask respirators against styrene exposure in the field. American Industrial Hygiene Association Journal, 51 (12), 625–639. doi: 10.1080/15298669091370266
6. Zhuang, Z, Bradtmiller, B. (2005). Head-and-Face anthropometric survey of U.S. respirator users. Journal of Occupational and Environmental Hygiene, 2 (11), 567–576. doi: 10.1080/15459620500324727
7. Campbell, D. L. (1984). The theoretical effect of filter resistance and filter penetration on respirator protection factors. J. Int. Soc. Respir. Prot., 2, 198–204.
8. Nelson, T. J., Colton, C. E. (2000). The effect of inhalation resistance on facepiece leakage. AIHAJ, 61 (1), 102–105. doi: 10.1202/0002-8894(2000)061<0102:teoiro>2.0.co;2
9. Clayton, M. P., Bancroft, B., Rajan, B. A. (2002). Review of Assigned Protection Factors of Various Types and Classes of Respiratory Protective Equipment with Reference their Measured Breathing Resistances The Annals of Occupational Hygiene, 46 (6), 537–547. doi: 10.1093/annhyg/mef071
10. Nicas, M., Neuhaus, J. (2004) Variability in respiratory protection and the assigned protection factor. Journal of Occupational and Environmental Hygiene, 1 (2), 99–109. doi: 10.1080/15459620490275821
11. British Standards Institution (1997). BS 4275: Guide to implementing an effective respiratory protective device program. London: British Standards Institution.
12. Benjamin, Y., Liu, H., Lee, J.-K. (1993). Haskelle Mullins & Susan G. Danisch. Respirator Leak Detection by Ultrafine Aerosols: A Predictive Model and Experimental Study Aerosol Science and Technology, 19 (1), 15–26.
13. Oestenstad, R. K., Dillion, H. K., Perkins, L .L. (1990). Distribution of faceseal leak sites in a half-mask respirator and their association with facial dimensions. American Industrial Hygiene Association Journal, 51 (5), 285–290. doi: 10.1080/15298669091369664
14. Krishnan, U., Willeke, K., Juozaitis, A., Lehtimäki, M., Szewczyk, K. (1994). Development of dichotomous flow quantitative fit test for half-mask and full-facepiece respirators. American Industrial Hygiene Association Journal, 55 (3), 223–229. doi: 10.1080/15428119491019069
15. Caretti, D. M., Whitley, J. A. (1998). Exercise performance during inspiratory resistance breathing under exhaustive constant load work. Ergonomics, 41 (4), 501–511. doi: 10.1080/001401398186973
16. Nelson, T. J., Skretvedt, O. T., Loschiavo, J. G., Dixon, S. W. (1984). Development of an improved qualitative fit test using isoamyl acetate. J. Int. Soc. Respir. Prot., 2 (4), 225–228.