ABSTRACT AND REFERENCES

TECHNOLOGY OF ORGANIC AND INORGANIC SUBSTANCES

DOI: 10.15587/1729-4061.2017.90810

OPTIMIZATION OF NICKEL HYDROXIDE ELECTRODE OF THE HYBRID SUPERCAPACITOR (p. 4-9)

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Nickel hydroxide is an active material for a wide range of chemical power sources: various types of alkaline accumulators and hybrid supercapacitors. In order to obtain maximum electrode capacity and charge efficiency, the optimization of the electrode composition i.e. the content of activating and electroconductive additives and the binder is needed. The amount of these compounds is governed by various factors, the influence of which is different and often non-linear.

The factors that can affect the specific capacity and are determined by the binder content have been reviewed. The effect of these factors has been demonstrated experimentally. The influence of the binder content has been studied. The study has been carried out using polytetrafluoroethylene suspension as a binder, and components used in the manufacturing of accumulators: industrial sample of nickel hydroxide "Bochemie", and electroconductive additive GAK-1.

The optimal binder content in active mass has been determined to be 2 %. It has been demonstrated that PTFE content of 1 % in active mass is insufficient for good contact of active mass with the electrode, resulting in a maximum capacity of 11 F/g at 40 mA/cm^2. The PTFE concentration of 3 % is excessive and under high current densities leads to screening of active material particles, with a maximum capacity of 67 F/g at 20 мА/cm^2. The best result for specific capacity has been achieved with PTFE content of 2 % and current density of 40 mA/cm^2 – 67 F/g.

After analyzing the acquired data, it has been assumed that optimal binder content may depend on the particular type of hydroxide, namely its structure and morphology.

Keywords: nickel hydroxide, nickel oxide electrode, specific capacity, supercapacitor, discharge, polytetrafluoroethylene, adhesion.

References

1. Simon, P., Gogotsi, Y. (2008). Materials for electrochemical capacitors. Nature Materials, 7 (11), 845–854. doi: 10.1038/nmat2297
2. Burke, A. (2007). R&D considerations for the performance and application of electrochemical capacitors. Electrochimica Acta, 53 (3), 1083–1091. doi: 10.1016/j.electacta.2007.01.011
3. Lang, J.-W., Kong, L.-B., Wu, W.-J., Liu, M., Luo, Y.-C., Kang, L. (2008). A facile approach to the preparation of loose-packed $Ni(OH)_2$ nanoflake materials for electrochemical capacitors. Journal of Solid State Electrochemistry, 13 (2), 333–340. doi: 10.1007/s10008-008-0560-0
4. Lang, J.-W., Kong, L.-B., Liu, M., Luo, Y.-C., Kang, L. (2009). Asymmetric supercapacitors based on stabilized α-$Ni(OH)_2$ and activated carbon. Journal of Solid State Electrochemistry, 14 (8), 1533–1539. doi: 10.1007/s10008-009-0984-1
5. Aghazadeh, M., Ghaemi, M., Sabour, B., Dalvand, S. (2014). Electrochemical preparation of α-$Ni(OH)_2$ ultrafine nanoparticles for high-performance supercapacitors. Journal of Solid State Electrochemistry, 18 (6), 1569–1584. doi: 10.1007/s10008-014-2381-7
6. Zheng, C., Liu, X., Chen, Z., Wu, Z., Fang, D. (2014). Excellent supercapacitive performance of a reduced graphene oxide/$Ni(OH)_2$ composite synthesized by a facile hydrothermal route. Journal of Central South University, 21 (7), 2596–2603. doi: 10.1007/s11771-014-2218-7
7. Wang, B., Williams, G. R., Chang, Z., Jiang, M., Liu, J., Lei, X., Sun, X. (2014). Hierarchical NiAl Layered Double Hydroxide/Multiwalled Carbon Nanotube/Nickel Foam Electrodes with Excellent Pseudocapacitive Properties. ACS Applied Materials & Interfaces, 6 (18), 16304–16311. doi: 10.1021/am504530e
8. Zhu, Z. (2016). Effects of Various Binders on Supercapacitor Performances. International Journal of Electrochemical Science, 8270–8279. doi: 10.20964/2016.10.04
9. Baroutaji, A., Carton, J. G., Oladoye, A. M., Stokes, J., Twomey, B., Olabi, A. G. (2016). Ex-situ evaluation of PTFE coated metals in a proton exchange membrane fuel cell environment. Surface and Coatings Technology. doi: 10.1016/j.surfcoat.2016.11.105
10. Sudaroli, B. M., Kolar, A. K. (2016). An experimental study on the effect of membrane thickness and PTFE (polytetrafluoroethylene) loading on methanol crossover in direct methanol fuel cell. Energy, 98, 204–214. doi: 10.1016/j.energy.2015.12.101
11. Zhu, Y., Cao, C., Tao, S., Chu, W., Wu, Z., Li, Y. (2014). Ultrathin Nickel Hydroxide and Oxide Nanosheets: Synthesis, Characterizations and Excellent Supercapacitor Performances. Scientific Reports, 4, 5787. doi: 10.1038/srep05787
12. Hu, M., Lei, L. (2006). Effects of particle size on the electrochemical performances of a layered double hydroxide, $[Ni_4Al(OH)_{10}]NO_3$. Journal of Solid State Electrochemistry, 11 (6), 847–852. doi: 10.1007/s10008-006-0231-y
13. Lei, L., Hu, M., Gao, X., Sun, Y. (2008). The effect of the interlayer anions on the electrochemical performance of layered double hydroxide electrode materials. Electrochimica Acta, 54 (2), 671–676. doi: 10.1016/j.electacta.2008.07.004
14. Kovalenko, V. L., Kotok, V. A. (2015). The synthesis of nickel hydroxide by electrolysis from nickel nitrate solution in the slit diaphragm electrolyzer. Electrochemical properties. Collection of research papers of National mining university, 49, 181–186.
15. Kotok, V. A., Koshel, N. D., Kovalenko, V. L., Grechanuk, A. A. (2008). The stability of aluminium-substituted alpha-nickel hydroxide. First Regional Symposium on Electrochemistry of South-East Europe "RSE-SEE". Croatia Rovinj, 201–203.
16. Kovalenko, V. L., Kotok, V. A., Bolotin, A. V. (2015). Method Development for Synthesis of Nickel Hydroxide with High Crystallinity. Providing the Study of the Characteristics of the Obtained Substance for Using with Accumulator and supercapacitors. Collectrion of research papers of National mining university, 48, 202–208.
17. Kovalenko, V., Kotok, V., Bolotin, O. (2016). Definition of factors influencing on $Ni(OH)_2$ electrochemical characteristics for supercapacitors. Eastern-European Journal of Enterprise Technologies, 5 (6 (83)), 17–22. doi: 10.15587/1729-4061.2016.79406
18. Kovalenko, V. L., Kotok, V. A., Sykchin, A. A., Mudryi, I. A., Anan-chenko, B. A., Burkov, A. A. et. al. (2016). Nickel hydroxide obtained by high-temperature two-step synthesis as an effective material for supercapacitor applications. Journal of Solid State Electrochemistry. doi: 10.1007/s10008-016-3405-2

19. Rajamathi, M., Vishnu Kamath, P., Seshadri, R. (2000). Polymorphism in nickel hydroxide: role of interstratification. Journal of Materials Chemistry, 10 (2), 503–506. doi: 10.1039/a905651c
20. Becker, M. D., Cuscueta, D. J., Salva, H. R., Rodriguez Nieto, F., Ghilarducci, A. A., Visintin, A. (2012). Oxygen Evolution Nickel Hydroxide Electrodes in a Ni-MH Battery Prototype. Journal of New Materials for Electrochemical Systems, 15 (4), 277–282.
21. Wang, X. (2004). Oxygen catalytic evolution reaction on nickel hydroxide electrode modified by electroless cobalt coating. International Journal of Hydrogen Energy, 29 (9), 967–972. doi: 10.1016/j.ijhydene.2003.05.001

DOI: 10.15587/1729-4061.2017.91110

INFLUENCE OF COMPLEX ACTIVATORS OF SINTERING ON CREATING RADIOTRANSPARENT CERAMICS IN $SrO–Al_2O_3–SiO_2$ (p. 10-15)

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The study has solved the problem of obtaining densely sintered ceramics at a low firing temperature on the basis of the system $SrO–Al_2O_3–SiO_2$. This was made possible after researching the influence of complex activators of sintering, selected among fluorides of alkali metals, and an oxide combination of stannum and lithium on the process of synthesizing strontium anorthite ceramics.

The tests have proved that it is technologically advisable to use the complex sintering activators LiF–NaF and $SnO_2–Li_2O$ due to their low-temperature eutectics and beneficial effects on the structure and properties of strontium ceramics.

The experiments were used to study the impact of the complex sintering activators of a fluxing action in the amounts of 1–3 wt. %, with eutectic ratios of the components, on the low-temperature synthesis of strontium anorthite. The tests have confirmed the possibility of activating the reaction that produces the intermediate phase of silicate strontium, which reduces the temperature of firing strontium anorthite ceramics. The resulting ceramic material, based on a crystalline phase, is strontium anorthite, which was obtained at a synthesis temperature of 1,250 °C after adding 2 wt. % of $Li_2CO_3+SnO_2$ to the composition "0" with the following properties: water absorption – 5.52 %, apparent density – 2.88 g/cm^3, the dielectric constant – 9.7, and the dielectric loss tangent – 0.06.

Keywords: strontium anorthite, sintering enhancer, radio transparent ceramic eutectic, the dielectric permittivity.

References

1. Lisachuk, G. V., Krivobok, R. V., Zaharov, A. V., Fedorenko, E. Ju., Trusova, Ju. D. (2014). Perspektivnye radioprozrachnye keramicheskie materialy dlja raketnoj i kosmicheskoj tehniki. Visnyk NTU «KhPI». Serija: Himija, himichna tehnologija ta ekologija, 28, 72–79.
2. Romashin, A. G., Gajdachuk, V. E., Karpov, Ja. S., Rusin, M. Ju. (2003). Radioprozrachnye obtekateli letatel'nyh apparatov. Proektirovanie, konstrukcionnye materialy, tehnologija proizvodstva, ispytanija. Kharkiv: Nac. ajerokosm. un-t «Har'k. aviac. in-t», 239.
3. Talmy, I. G., Haught, D. A. (1990). Pat. 5642868 US, Int. Cl.6 B 64 C 1/10. Ceramic material. declareted: 02.05.1990, published: 01.07.1997, 5.
4. Krzmanc, M. M., Valant, M., Suvorov, D. (2007). The synthesis and microwave dielectric properties of $Sr_xBa_{1-x}Al_2Si_2O_8$ and $Ca_yBa_{1-y}Al_2Si_2O_8$ ceramics. Journal of the European Ceramic Society, 27 (2-3), 1181–1185. doi: 10.1016/j.jeurceramsoc.2006.05.017
5. Bansal, N. P., Drummond, C. H. (1993). Kinetics of Hexacelsian-to-Celsian Phase Transformation in $SrAl_2Si_2O_8$. Journal of the American Ceramic Society, 76 (5), 1321–1324. doi: 10.1111/j.1151-2916.1993.tb03758.x
6. Sung, Y. M., Kwak, W. C. (2002). Influence of various heating procedures on the sintered density of Sr-celsian glass-ceramic. Journal of materials science letters, 21 (11), 841–843.
7. Uvarova, N. E., Orlova, L. A., Popovich, N. V. (2008). Nizkotemperaturnyj sintez besshhelochnoj aljumosilikatnoj steklokeramiki. Uspehi v himii i himicheskoj tehnologii, 22 (7 (87)), 59–62.
8. Shhegoleva, N. E., Grashhenkov, D. V., Sarkisov, P. D., Orlova, L. A., Popovich, N. V. (2012). Vlijanie dobavok V_2O_3 i R_2O_5 na kristallizacionnuju sposobnost' stroncijaljumosilikatnogo stekla. Tehnika i tehnologija silikatov, 19 (2), 7–14.
9. Talmy, I. G., Zaykosk, J. A. (1995). Pat. US 5641440 A. Int. Cl.6 C04B 33/34. Sintering aids for producing $BaO·Al_2O_3·2SiO_2$ and Sr $O·Al_2O_3·2SiO_2$ ceramic materials. declareted: 26.07.1995, published: 24.06.1997, 5.
10. Lisachuk, G. V., Kryvobok, R. V., Fedorenko, O. Ju., Zaharov, A. V., Chefranov, Je. V., Prytkina, M. S., Revuc'kyj, V. I. (2014). Osoblyvosti syntezu radioprozoroi' keramiky iz zadanymy radiofizychnymy vlastyvostjamy. Zbirnyk naukovyh prac' PAT "UkrNDIvognetryviv im. A. S. Berezhnogo", 114, 133–144.
11. Ptacek, P., Soukal, F., Opravil, T., Bartonickova, E., Wasserbauer, J. (2016). The formation of feldspar strontian ($SrAl_2Si_2O_8$) via ceramic route: Reaction mechanism, kinetics and thermodynamics of the process. Ceramics International, 42 (7), 8170–8178. doi: 10.1016/j.ceramint.2016.02.024
12. Nikiforova, Je. M., Eromasov, R. G., Stupko, T. V., Raeva, O. V., Shestakov, I. Ja. (2013). Ispol'zovanie ftorsoderzhashhih mineralizatorov v silikatnyh sistemah. Sovremennye problemy nauki i obrazovanija, 1, 192.
13. Appen, A. A. (1974). Himija stekla. Leningrad: Himija, 352.
14. Bragina, L. L. et. al.; Bragina, L. L., Zubehin, A. P. (Eds.) (2003). Tehnologija jemali i zashhitnyh pokrytij. Kharkiv: NTU «KhPI», 484.
15. Sangster, J. M., Pelton, A. D. System LiF-NaF; Composite. Phase Equilibrium Diagrams of Oxide Systems NIST Standart Reference Database 31 vol. 01. fig. 07487, 1987 1 elektron. opt. disk (CD-ROM): kol'or. Sistem. vimogi: 128 Mb RAM; 200 Mb available HDD; CD-ROM Windows 98/Me/2000/NT/XP.
16. Sangster, J. M., Pelton, A. D. System KF-LiF; Composite. Phase Equilibrium Diagrams of Oxide Systems NIST Standart Reference Database 31 vol. 01. fig. 07473, 1987 1 elektron. opt. disk (CD-ROM): kol'or. Sistem. vimogi: 128 Mb RAM; 200 Mb available HDD; CD-ROM Windows 98/Me/2000/NT/XP.
17. Sangster, J. M., Pelton, A. D. System KF-NaF; Composite. Phase Equilibrium Diagrams of Oxide Systems NIST Standart Reference Database 31 vol. 01. fig. 07475, 1987 1 elektron. opt. disk (CD-ROM).

Sistem. vimogi: 128 Mb RAM; 200 Mb available HDD; CD-ROM Windows 98/Me/2000/NT/XP.

18. Sangster, J. M., Pelton, A. D. System KF-LiF-NaF; Composite. Phase Equilibrium Diagrams of Oxide Systems NIST Standart Reference Database 31 vol. 01. fig. 07615, 1987 1 elektron. opt. disk (CD-ROM): kol'or. Sistem. vimogi: 128 Mb RAM; 200 Mb available HDD; CD-ROM Windows 98/Me/2000/NT/XP.
19. Martel, L. C., Roth, R. S. System System Li_2SnO_3-Li_2O. 1:1=Li_2SnO_3; 4:1=Li_8SnO_6; Composite. Phase Equilibrium Diagrams of Oxide Systems NIST Standart Reference Database 31 vol. 01. fig. 09191, 1981 1 elektron. opt. disk (CD-ROM): kol'or. Sistem. vimogi: 128 Mb RAM; 200 Mb available HDD; CD-ROM Windows 98/Me/2000/NT/XP.
20. Lisachuk, G. V., Krivobok, R. V., Zaharov, A. V., Fedorenko, E. Ju., Pitak, Ja. N. (2015). Prognoznaja ocenka fazovogo sostava i svojstv radioprozrachnoj keramiki na osnove sistemy SrO-Al_2O_3-SiO_2. Stroitel'nye materialy i izdelija, 1, 20–22.
21. Shukla, A. (2012). Development of a critically evaluated thermodynamic database for the systems containing alkaline-earth oxides. Montreal, 350.

DOI: 10.15587/1729-4061.2017.90873

INFLUENCE OF TEMPERATURE ON THE CHARACTERISTICS OF Ni(II), Ti(IV) LAYERED DOUBLE HYDROXIDES SYNTHESISED BY DIFFERENT METHODS (p. 16-22)

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The influence of temperature on the characteristics of Ni(II)–Ti(IV) LDH was investigated in the work.

Ni(II)–Ti(IV) layered double hydroxides were synthesized from a solution of Ni^{2+} and Ti^{4+} with the cationic ratio of Ni^{2+}/Ti^{4+}=5 by using three coprecipitation techniques: titration, coprecipitation at high supersaturation and homogeneous coprecipitation. The prepared samples were characterized by means of X-ray diffraction (XRD), Thermogravimetric analysis (TGA) and Differential scanning calorimetry (DSC).

By means of XRD, it was revealed that all samples prepared using titration and coprecipitation at high supersaturation at 65 and 20 °C correspond to Ni-Ti LDH structure. Elevated temperature during sample preparation using titration and coprecipitation at high supersaturation did not have a significant effect on phase composition, but affected the crystallinity. According to XRD results, the sample prepared using homogeneous coprecipitation at 70 °C had a significant content of β-$Ni(OH)_2$. Increasing the synthesis temperature to 80 °C has led to the almost complete disappearance of β-$Ni(OH)_2$ reflections.

By means of TGA and DSC, it was found that titration method leads to formation of samples with higher thermal stability than those prepared by high supersaturation. Elevated temperature and hydrothermal treatment leads to higher thermal stability of the samples. Samples prepared by homogeneous coprecipitation show complicated behavior during thermal decomposition, confirming the presence of cyanate ions in the interlayer gallery.

Keywords: layered double hydroxide, nickel, titanium, coprecipitation at high supersaturation, homogeneous coprecipitation.

References

1. Fan, G., Li, F., Evans, D. G., Duan, X. (2014). Catalytic applications of layered double hydroxides: recent advances and perspectives. Chem. Soc. Rev., 43 (20), 7040–7066. doi: 10.1039/c4cs00160e
2. Shu, X., Zhang, W., He, J., Gao, F., Zhu, Y. (2006). Formation of Ni–Ti-layered double hydroxides using homogeneous precipitation method. Solid State Sciences, 8 (6), 634–639. doi: 10.1016/j.solidstatesciences.2006.02.029
3. Zhang, W. H., Guo, X. D., He, J., Qian, Z. Y. (2008). Preparation of Ni(II)/Ti(IV) layered double hydroxide at high supersaturation. Journal of the European Ceramic Society, 28 (8), 1623–1629. doi: 10.1016/j.jeurceramsoc.2007.11.016
4. Saber, O. (2007). Preparation and characterization of a new nano layered material, Co–Zr LDH. Journal of Materials Science, 42 (23), 9905–9912. doi: 10.1007/s10853-007-2097-5
5. Saber, O., Tagaya, H. (2005). Preparation of new layered double hydroxide, Co-V LDH. Rev. Adv. Mater. Sci., 10, 59–63.
6. Yang, L. J., Gao, X. P., Wu, Q. D., Zhu, H. Y., Pan, G. L. (2007). Phase Distribution and Electrochemical Properties of Al-Substituted Nickel Hydroxides. The Journal of Physical Chemistry C, 111 (12), 4614–4619. doi: 10.1021/jp0655468
7. Jayashree, R. S., Kamath, P. V., Subbanna, G. N. (2000). The Effect of Crystallinity on the Reversible Discharge Capacity of Nickel Hydroxide. Journal of The Electrochemical Society, 147 (6), 2029. doi: 10.1149/1.1393480
8. Min, S., Zhao, C., Chen, G., Qian, X. (2014). One-pot hydrothermal synthesis of reduced graphene oxide/$Ni(OH)_2$ films on nickel foam for high performance supercapacitors. Electrochimica Acta, 115, 155–164. doi: 10.1016/j.electacta.2013.10.140
9. Gu, Y., Lu, Z., Chang, Z., Liu, J., Lei, X., Li, Y., Sun, X. (2013). NiTi layered double hydroxide thin films for advanced pseudocapacitor electrodes. Journal of Materials Chemistry A, 1 (36), 10655. doi: 10.1039/c3ta10954b
10. Kovalenko, V., Kotok, V., Bolotin, O. (2016). Definition of factors influencing on $Ni(OH)_2$ electrochemical characteristics for supercapacitors. Eastern-European Journal of Enterprise Technologies, 5 (6 (83)), 17–22. doi: 10.15587/1729-4061.2016.79406
11. Vidales-Hurtado, M. A., Mendoza-Galvan, A. (2008). Electrochromism in nickel oxide-based thin films obtained by chemical bath deposition. Solid State Ionics, 179 (35-36), 2065–2068. doi: 10.1016/j.ssi.2008.07.003
12. Mondal, D., Villemure, G. (2012). Improved reversibility of color changes in electrochromic Ni–Al layered double hydroxide films in presence of electroactive anions. Journal of Electroanalytical Chemistry, 687, 58–63. doi: 10.1016/j.jelechem.2012.09.046
13. Vidotti, M., Cordoba de Torresi, S. I. (2009). Electrostatic layer-by-layer and electrophoretic depositions as methods for electrochromic nanoparticle immobilization. Electrochimica Acta, 54 (10), 2800–2804. doi: 10.1016/j.electacta.2008.11.032
14. Hassan, H. B., Hamid, Z. A. (2011). Electrodeposited Ni–Cr_2O_3 nanocomposite anodes for ethanol electrooxidation. International

Journal of Hydrogen Energy, 36 (8), 5117–5127. doi: 10.1016/j.ijhydene.2011.01.024
15. Wang, Y., Zhang, D., Peng, W., Liu, L., Li, M. (2011). Electrocatalytic oxidation of methanol at Ni–Al layered double hydroxide film modified electrode in alkaline medium. Electrochimica Acta, 56 (16), 5754–5758. doi: 10.1016/j.electacta.2011.04.049
16. Huang, W., Li, Z. L., Peng, Y. D., Chen, S., Zheng, J. F., Niu, Z. J. (2005). Oscillatory electrocatalytic oxidation of methanol on an $Ni(OH)_2$ film electrode. Journal of Solid State Electrochemistry, 9 (5), 284–289. doi: 10.1007/s10008-004-0599-5
17. Lee, Y., Choi, J. H., Jeon, H. J., Choi, K. M., Lee, J. W., Kang, J. K. (2011). Titanium-embedded layered double hydroxides as highly efficient water oxidation photocatalysts under visible light. Energy & Environmental Science, 4 (3), 914. doi: 10.1039/c0ee00285b
18. Li, B., Zhao, Y., Zhang, S., Gao, W., Wei, M. (2013). Visible-Light-Responsive Photocatalysts toward Water Oxidation Based on NiTi-Layered Double Hydroxide/Reduced Graphene Oxide Composite Materials. ACS Applied Materials & Interfaces, 5 (20), 10233–10239. doi: 10.1021/am402995d
19. Azuma, S., Kawamura, G., Muto, H., Kakuta, N., Matsuda, A. (2014). Preparation of Layered Double Hydroxide and its Graphene Composite Films as Electrodes for Photoelectrochemical Cells. Key Engineering Materials, 616, 129–133. doi: 10.4028/www.scientific.net/kem.616.129
20. Gao, Z., Du, B., Zhang, G., Gao, Y., Li, Z., Zhang, H., Duan, X. (2011). Adsorption of Pentachlorophenol from Aqueous Solution on Dodecylbenzenesulfonate Modified Nickel–Titanium Layered Double Hydroxide Nanocomposites. Industrial & Engineering Chemistry Research, 50 (9), 5334–5345. doi: 10.1021/ie101766e
21. Shu, X., He, J., Chen, D. (2008). Visible-Light-Induced Photocatalyst Based on Nickel Titanate Nanoparticles. Industrial & Engineering Chemistry Research, 47 (14), 4750–4753. doi: 10.1021/ie071619d
22. Shu, X., He, J., Chen, D., Wang, Y. (2008). Tailoring of Phase Composition and Photoresponsive Properties of Ti-Containing Nanocomposites from Layered Precursor. The Journal of Physical Chemistry C, 112 (11), 4151–4158. doi: 10.1021/jp711091m
23. Burmistr, M. V., Boiko, V. S., Lipko, E. O., Gerasimenko, K. O., Gomza, Y. P., Vesnin, R. L. et. al. (2014). Antifriction and Construction Materials Based on Modified Phenol-Formaldehyde Resins Reinforced with Mineral and Synthetic Fibrous Fillers. Mechanics of Composite Materials, 50 (2), 213–222. doi: 10.1007/s11029-014-9408-0
24. Ciocan, C. E., Dumitriu, E., Cacciaguerra, T., Fajula, F., Hulea, V. (2012). New approach for synthesis of Mo-containing LDH based catalysts. Catalysis Today, 198 (1), 239–245. doi: 10.1016/j.cattod.2012.04.071
25. He, J., Shi, H., Shu, X., Li, M. (2009). On the nature of Ti(IV)-pillared layered metal hydroxides prepared from green, water-soluble Ti-peroxide. AIChE Journal, 56 (5), 1352–1362. doi: 10.1002/aic.12029
26. Liu, Y., Murata, K., Hanaoka, T., Inaba, M., Sakanishi, K. (2007). Syntheses of new peroxo-polyoxometalates intercalated layered double hydroxides for propene epoxidation by molecular oxygen in methanol. Journal of Catalysis, 248 (2), 277–287. doi: 10.1016/j.jcat.2007.03.025
27. Zhang, Y., Su, J., Wang, X., Pan, Q., Qu, W. (2012). Polyoxometallates Intercallated MgAl Layered Double Hydroxide and Its Photocatalytic Performance. Journal of Materials Scineces and Engineering B, 2 (1), 59–63.
28. Kulyukhin, S. A., Krasavina, E. P., Rumer, I. A. (2015). Sorption of 137Cs from aqueous solutions onto layered double hydroxides containing the Fe(CN) 64- ion in the interlayer space. Radiochemistry, 57 (1), 69–72. doi: 10.1134/s1066362215010105
29. Kovalenko, V. L., Kotok, V. A., Sykchin, A. A., Mudryi, I. A., Ananchenko, B. A., Burkov, A. A. et. al. (2016). Nickel hydroxide obtained by high-temperature two-step synthesis as an effective material for supercapacitor applications. Journal of Solid State Electrochemistry. doi: 10.1007/s10008-016-3405-2
30. Kovalenko, V. L., Kotok, V. A. (2015). The synthesis of nickel hydroxide by electrolysis from nickel nitrate solution in the slit diaphragm electrolyzer. Electrochemical properties. Collection of research papers of National mining university, 49, 181–186.
31. Kovalenko, V. L., Kotok, V. A., Bolotin, A. V. (2015). Method Development for Synthesis of Nickel Hydroxide with High Crystallinity. Providing the Study of the Characteristics of the Obtained Substance for Using with Accumulators and supercapacitors. Collection of research papers of National mining university, 48, 202–208.
32. He, J., Wei, M., Li, B., Kang, Y., Evans, D. G., Duan, X. (2005). Preparation of layered double hydroxides. Springer Berlin Heidelberg, 89–119. doi: 10.1007/430_006
33. Nikolenko, N. V., Kalashnykova, A. N., Solovov, V. A., Kostyniuk, A. O., Bayahia, H., Goutenoire, F. (2016). Peroxide-based route for the synthesis of zinc titanate powder. Arabian Journal of Chemistr. doi: 10.1016/j.arabjc.2016.06.018
34. Zhao, Y., Chen, P., Zhang, B., Su, D. S., Zhang, S., Tian, L. et. al. (2012). Highly Dispersed TiO 6 Units in a Layered Double Hydroxide for Water Splitting. Chemistry – A European Journal, 18 (38), 11949–11958. doi: 10.1002/chem.201201065
35. Chen, Z., Yang, W., Zhou, J., Lv, H., Liu, J., Cen, K. (2010). HNCO hydrolysis performance in urea-water solution thermohydrolysis process with and without catalysts. Journal of Zhejiang University-SCIENCE A, 11 (11), 849–856. doi: 10.1631/jzus.a0900798
36. Schaber, P. M., Colson, J., Higgins, S., Thielen, D., Anspach, B., Brauer, J. (2004). Thermal decomposition (pyrolysis) of urea in an open reaction vessel. Thermochimica Acta, 424 (1-2), 131–142. doi: 10.1016/j.tca.2004.05.018
37. Lei, L., Hu, M., Gao, X., Sun, Y. (2008). The effect of the interlayer anions on the electrochemical performance of layered double hydroxide electrode materials. Electrochimica Acta, 54 (2), 671–676. doi: 10.1016/j.electacta.2008.07.004
38. Zhao, C., Ju, P., Wang, S., Zhang, Y., Min, S., Qian, X. (2016). One-step hydrothermal preparation of TiO_2/RGO/$Ni(OH)_2$/NF electrode with high performance for supercapacitors. Electrochimica Acta, 218, 216–227. doi: 10.1016/j.electacta.2016.09.122

DOI: 10.15587/1729-4061.2017.92423

ANALYSIS OF THE EFFECT OF CHALK MODIFICATION ON THE PECULIARITIES OF ITS INTERACTION WITH ACRYLIC FILM FORMER (p. 23-27)

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We performed analysis of the processes of interaction in the systems of chalks with a modifier (potassium methylsiliconate)

and acrylic film forming material. The studies were conducted with the help of infrared spectroscopy. The purpose of the work was to estimate the level of development in the processes of interaction in the examined systems.

Quantitative parameters of the basic characteristic bands in charge of the valence vibrations of reactive groups of chalks and film forming agent are determined. The shifts in characteristic bands of the IR spectra, changes in their intensity are indicated.

The results of present work testify to the fact that in the systems chalk – potassium methylsiliconate – acrylic film forming agent, the processes of interaction proceed with the participation of adsorbed water, bonds C=O and C–O of chalks. We also noted intensive inculcation of polymer (by the intensity of bands characteristic for the C–H bonds) by 2–8 times with the use of modified chalks in comparison with the starting ones.

An increase in the interaction between chalks and the film-forming agent by the modification of this filler is of interest for creating functional composite materials as it provides for an improvement in their properties.

Keywords: organosilicon modifier, surface modification, acrylic polymer, interphase interaction, IR spectroscopy.

References

1. Talbert, R. (2007). Paint technology handbook. New York: CRC Press, 217. doi: 10.1201/9781420017786
2. Merezhko, N., Sviderskyi, V., Komakha, V., Shulga, O.; Salerno-Kochan, R. (Ed.) (2014). Expanding of raw material base of mineral fillers for waterdispersion paints in Ukraine. Commodity Science in Research and Practice – Nonfood products' quality and innovations. Cracow: Polish Society of Commodity Science, 113–117.
3. Goldschmidt, A., Streitberger, H.J. (2007). BASF Handbook on Basics of Coatings Technology. Munster/Germany: Vincentz Network, 769.
4. Birdi, K. S. (Ed.) (2015). Handbook of Surface and Colloid Chemistry. New York: CRC Press, 708. doi: 10.1201/b18633
5. Zhiyuan, Y., Yanjun, T., Junhua, Z. (2013). Surface modification of $CaCO_3$ nanoparticles with silane coupling agent for improvement of the interfacial compatibility with styrenebutadiene rubber (SBR) latex. Chalcogenide Letters, 10 (4), 131–141.
6. Xu, X., Tao, X., Zheng, Q. (2008). Influence of surface-modification for calcium carbonate on the interaction between the fillers and polydimethylsiloxane. Chinese Journal of Polymer Science, 26 (02), 145. doi: 10.1142/s0256767908002777
7. Cui, Z.-G., Cui, Y.-Z., Cui, C.-F., Chen, Z.,Binks, B. P. (2010). Aqueous Foams Stabilized byin SituSurface Activation of $CaCO_3$ Nanoparticles via Adsorption of Anionic Surfactant. Langmuir, 26 (15), 12567–12574. doi: 10.1021/la1016559
8. Brok, T., Grotjeklaus, M., Mishke, P. (2007). Evropejskoe rukovodstvo po lakokrasochnym materialam i pokrytijam. Moscow: Standart, 548.
9. Song, E., Kim, D., Kim, B. J., Lim, J. (2014). Surface modification of $CaCO_3$ nanoparticles by alkylbenzene sulfonic acid surfactant. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 461, 1–10. doi: 10.1016/j.colsurfa.2014.07.020
10. Deshmukh, G. S., Pathak, S. U., Peshwe, D. R., Ekhe, J. D. (2010). Effect of uncoated calcium carbonate and stearic acid coated calcium carbonate on mechanical, thermal and structural properties of poly(butylene terephthalate) (PBT)/calcium carbonate composites. Bulletin of Materials Science, 33 (3), 277–284. doi: 10.1007/s12034-010-0043-7
11. Komaha, V. O., Sviders'kyj, V. A. (2015). Procesy vzajemodii' v systemi «modyfikovanyj karbonatnyj napovnjuvach – plivkoutvorjuvach». Tovary i rynky, 1, 135–141.
12. Komaha, V. O., Sviders'kyj, V. A. (2015). Energetychnyj stan poverhni modyfikovanyh karbonatnyh napovnjuvachiv. Visnyk Chernigivs'kogo derzhavnogo tehnologichnogo universytetu. Serija «Tehnichni nauky», 1 (77), 43–49.
13. Nakamoto, K. (2008). Infrared and Raman Spectra of Inorganic and Coordination Compounds. Canada: Wiley, 432. doi: 10.1002/9780470405840

DOI: 10.15587/1729-4061.2017.91390

THE DEVELOPMENT OF A MAGNETICALLY OPERATED BIOSORBENT BASED ON THE YEAST SACCHAROMYCES CEREVISIAE FOR REMOVING COPPER CATIONS Cu^{2+} (p. 28-34)

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The study has revealed that the process of obtaining a magnetically operated biosorbent depends on the medium pH, the strength of the permanent magnetic field of the installation for multivortical MHD stirring, the ratio of the mass of the nanosized magnetite to the yeast S. cerevisiae, and the process duration. The isotherms of copper cations sorption by magnetically operated biosorbents were obtained depending on the production duration. Tests were conducted to determine the magnetic susceptibility of the magnetically operated biosorbents.

The experiment results provide conclusions on the optimal parameters of the magnetically operated biosorbent production in terms of biosorption characteristics.

The study has disclosed an optimal magnetically operated biosorbent of copper cations based on the yeast S. cerevisiae under the following parameters of the production process: the external permanent magnetic field – 240 kA/m, the medium pH=2.5 with adding nitric acid according to previous studies, the ratio of the magnetite Fe_3O_4 to the yeast biomass – 1 % w/w, the duration of preparing the sorbent – 2 minutes, and the maximum sorption capacity – 25.5±0.5 mg Cu^{2+}/g of the biosorbent dry mass.

The conducted tests have proved an opportunity to make biosorption by the yeast S. cerevisiae, and it is possible to remove the waste biosorbent by high gradient magnetic separation. The optimal conditions of production and the effectiveness of both the sorption capacity and the magnetic susceptibility make it possible to develop an efficient technology of wastewater cleaning from heavy metal cations.

Keywords: magnetic fluid, magnetohydrodynamic stirring, magnetically operated biosorbent, biosorption, magnetic susceptibility.

References

1. Wang, J., Chen, C. (2009). Biosorbents for heavy metals removal and their future. Biotechnology Advances, 27 (2), 195–226. doi: 10.1016/j.biotechadv.2008.11.002
2. Azevedo, R. B., Silva, L. P., Lemos, A. P. C., Bao, S. N., Lacava, Z. G. M., Safarik, I. et. al. (2003). Morphological study of saccharomyces cerevisiae cells treated with magnetic fluid. IEEE Transactions on Magnetics, 39 (5), 2660–2662. doi: 10.1109/tmag.2003.815547
3. Safarik, I., Safarikova, M. (2007). Magnetically modified microbial cells: A new type of magnetic adsorbents. China Particuology, 5 (1-2), 19–25. doi: 10.1016/j.cpart.2006.12.003

4. Jianlong, W. (2002). Biosorption of copper(II) by chemically modified biomass of Saccharomyces cerevisiae. Process Biochemistry, 37 (8), 847–850. doi: 10.1016/s0032-9592(01)00284-9
5. Yu, J.-X., Wang, L.-Y., Chi, R.-A., Zhang, Y.-F., Xu, Z.-G., Guo, J. (2012). A simple method to prepare magnetic modified beer yeast and its application for cationic dye adsorption. Environmental Science and Pollution Research, 20 (1), 543–551. doi: 10.1007/s11356-012-0903-3
6. Yang, S. H., Lee, T., Seo, E., Ko, E. H., Choi, I. S., Kim, B.-S. (2011). Interfacing Living Yeast Cells with Graphene Oxide Nanosheaths. Macromolecular Bioscience, 12 (1), 61–66. doi: 10.1002/mabi.201100268
7. Morais, J. P. M. G., Azevedo, R. B., Silva, L. P., Lacava, Z. G. M., Bao, S. N., Silva, O. et. al. (2004). Magnetic resonance investigation of magnetic–labeled baker's yeast cells. Journal of Magnetism and Magnetic Materials, 272-276, 2400–2401. doi: 10.1016/j.jmmm.2003.12.998
8. Gorobets, S., Gorobets, O., Goyko, I., Mazur, S. (2004). Magnetohydrodynamic mixer of an electrolyte solution. Physica Status Solidi (c), 1 (12), 3455–3457. doi: 10.1002/pssc.200405478
9. Gorobets, S. V., Karpenko, Yu. V., Marinchenko, L. V. (2010). Vikoristannya magnitokerovanih drizhdzhiv S. serevisiae dlya viluchennya ioniv midi. Bulletin of Donetsk National University. Series A: Natural Sciences, 14 (1), 230–236.
10. Wang, J., Chen, C. (2006). Biosorption of heavy metals by Saccharomyces cerevisiae: A review. Biotechnology Advances, 24 (5), 427–451. doi: 10.1016/j.biotechadv.2006.03.001
11. Santoso, U. T., Rodiansono, R., Junaidi, A. B., Umaningrum, D. (2015). Synthesis of Chitosan-Coated Magnetic Microparticle Using Glutaraldehyde as Crosslinker and PEG as Spacer Arm and Its Application as Adsorbent of Peat Humic Acid. Journal of Wetlands Environmental Management, 3 (1), 22–27.
12. Peng, Q., Liu, Y., Zeng, G., Xu, W., Yang, C., Zhang, J. (2010). Biosorption of copper(II) by immobilizing Saccharomyces cerevisiae on the surface of chitosan-coated magnetic nanoparticles from aqueous solution. Journal of Hazardous Materials, 177 (1-3), 676–682. doi: 10.1016/j.jhazmat.2009.12.084
13. Song, R., Bai, B., Puma, G. L., Wang, H., Suo, Y. (2015). Biosorption of azo dyes by raspberry-like Fe3O4@yeast magnetic microspheres and their efficient regeneration using heterogeneous Fenton-like catalytic processes over an up-flow packed reactor. Reaction Kinetics, Mechanisms and Catalysis, 115 (2), 547–562. doi: 10.1007/s11144-015-0854-z
14. Li, T., Liu, Y., Peng, Q., Hu, X., Liao, T., Wang, H., Lu, M. (2013). Removal of lead(II) from aqueous solution with ethylenediamine-modified yeast biomass coated with magnetic chitosan microparticles: Kinetic and equilibrium modeling. Chemical Engineering Journal, 214, 189–197. doi: 10.1016/j.cej.2012.10.055
15. Berovic, M., Berlot, M., Kralj, S., Makovec, D. (2014). A new method for the rapid separation of magnetized yeast in sparkling wine. Biochemical Engineering Journal, 88, 77–84. doi: 10.1016/j.bej.2014.03.014
16. Xu, M., Zhang, Y., Zhang, Z., Shen, Y., Zhao, M., Pan, G. (2011). Study on the adsorption of Ca^{2+}, Cd^{2+} and Pb^{2+} by magnetic Fe_3O_4 yeast treated with EDTA dianhydride. Chemical Engineering Journal, 168 (2), 737–745. doi: 10.1016/j.cej.2011.01.069
17. Bau, H. H., Zhong, J., Yi, M. (2001). A minute magneto hydro dynamic (MHD) mixer. Sensors and Actuators B: Chemical, 79 (2-3), 207–215. doi: 10.1016/s0925-4005(01)00851-6
18. Marques, P. A. S. S., Rosa, M. F., Pinheiro, H. M. (2000). pH effects on the removal of Cu2+, Cd2+ and Pb2+ from aqueous solution by waste brewery biomass. Bioprocess Engineering, 23 (2), 135–141. doi: 10.1007/pl00009118
19. Gorobec', S. V., Karpenko, Ju. V. (2013). Vzajemozv'jazok elektroforetychnoi' ruhlyvosti magnitokerovanogo biosorbentu i jogo sorbcijnoi' jemnosti. Water treatment technologies technical, biological and ecological aspects. Kyiv: NTUU "KPI", 69.
20. Nishida, K., Silver, P. A.; Gray, J. V. (Ed.) (2012). Induction of Biogenic Magnetization and Redox Control by a Component of the Target of Rapamycin Complex 1 Signaling Pathway. PLoS Biology, 10 (2), e1001269. doi: 10.1371/journal.pbio.1001269
21. Gorobets, S. V., Karpenko, Y. V. (2009). Intensification of sorption ability of yeast S. cerevisiae using multivortical magnetohydrodynamic mixing. Elektronyka y sviaz, 1 (2-3), 191–195.
22. Gorobets, S. V., Gorobets, O. Y., Dvoynenko, O. K., Mykhailenko, N. O. (2010). Wastewater purification from cuprum (II) ions by magnetically operated biosorbent using high-gradient ferromagnetic fields. Research Bulletin of NTUU "Kyiv Polytechnic Institute", 3, 21–25.
23. Sluiter, A., Hames, B., Hyman, D. et. al. (2008). Determination of total solids in biomass and total dissolved solids in liquid process samples. National Renewable Energy Laboratory, 1–6.
24. Dvoynenko, O. K., Gorobets, S. V., Kuznetsov Y. O., Gorobets, O. Y. (2010). Doslidzhennya mahnitnoyi spryynyatlyvosti dribnodyspersnykh poroshkiv na osnovi Fe i Fe_3O_4. Bulletin of Donetsk National University. Series A: Natural Sciences, 14 (1), 169–173.
25. Gorobets, S. V., Gorobets, O. Y., Demianenko, I. V., Nikolaenko, R. N. (2013). Self-organization of magnetite nanoparticles in providing Saccharomyces cerevisiae Yeasts with magnetic properties. Journal of Magnetism and Magnetic Materials, 337-338, 53–57. doi: 10.1016/j.jmmm.2013.01.004
26. Gorobets, S. V., Ukrayinets, A. I., Gulyy, I. S. et. al. (2000). Eksperymentalne doslidzhennya rukhu Sach. cerevisiae ta dribnodyspersnykh chastynok v okoli feromahnitnykh nasadok u postiynomu mahnitnomu poli. Kharchova promyslovist, 45, 149–156.
27. Gorobets, S. V., Gorobets, Yu., Goyko, I. Yu., Kasatkina, T. P. (2004). Intensification of the extraction process of copper and chromium (VI) ions from the solutions in a magnetic field. Functional Materials, 11 (4), 793–797.

DOI: 10.15587/1729-4061.2017.91821

EXAMINING QUALITY OF MATERIAL FOR THE SYNTHESIS OF PHOTONIC CRYSTALS BY THE METHOD OF SEDIMENTATION ANALYSIS (p. 35-41)

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A problem of using tetraethoxysilane with different storage periods as a raw material in the production of photonic crystals is examined. Present work is conducted for the purpose of reducing expenditures for the synthesis of photonic crystals. By comparing the results of modeling and experimental data, we substantiated the feasibility of sedimentation quality control of material for the synthesis of photonic crystals. The given method provides for an error in determining variation coefficient in the diameter of particles not exceeding 1.5 %. We have proven an unambiguous dependence between the shape of sedimentation curves and quality of the fractional composition of suspension for the synthesis of photonic crystals.

A practical feasibility of this method is confirmed based on the example of using tetraethoxysilane with different storage periods. It was established that the boundary period of storage of purified tetraethoxysilane is 96 hours. Exceeding this period leads to the formation of particles with variation coefficient in their diameter larger than 6 %. The latter is unacceptable in the production of photonic crystals. Obtained data make it possible to increase the periods between fractional distillation of tetraethoxysilane to 96 hours. This will lead to a decrease in costs in the production of photonic crystals and will improve economic efficiency in the industry.

Keywords: photonic crystal, tetraethoxysilane, sedimentation, torsion scales, spherical particles, the Stцber method.

References

1. Woldering, L. A., Tjerkstra, R. W., Vos, W. L. (2011). Photonic Crystal Fabrication. Encyclopedia of Materials: Science and Technology, 1–5. doi: 10.1016/b978-0-08-043152-9.02228-4
2. Jiang, P., Bertone, J. F., Hwang, K. S., Colvin, V. L. (1999). Single-Crystal Colloidal Multilayers of Controlled Thickness. Chemistry of Materials, 11 (8), 2132–2140. doi: 10.1021/cm990080+
3. Zhokhov, A. A., Masalov, V. M., Sukhinina, N. S., Matveev, D. V., Dolganov, P. V., Dolganov, V. K., Emelchenko, G. A. (2015). Photonic crystal microspheres. Optical Materials, 49, 208–212. doi: 10.1016/j.optmat.2015.09.019
4. Plumere, N., Ruff, A., Speiser, B., Feldmann, V., Mayer, H. A. (2012). Stцber silica particles as basis for redox modifications: Particle shape, size, polydispersity, and porosity. Journal of Colloid and Interface Science, 368 (1), 208–219. doi: 10.1016/j.jcis.2011.10.070
5. Arantes, T. M., Pinto, A. H., Leite, E. R., Longo, E., Camargo, E. R. (2012). Synthesis and optimization of colloidal silica nanoparticles and their functionalization with methacrylic acid. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 415, 209–217. doi: 10.1016/j.colsurfa.2012.09.041
6. Santamaria Razo, D. A., Pallavidino, L., Garrone, E., Geobaldo, F., Descrovi, E., Chiodoni, A., Giorgis, F. (2008). A version of Stober synthesis enabling the facile prediction of silica nanospheres size for the fabrication of opal photonic crystals. Journal of Nanoparticle Research, 10 (7), 1225–1229. doi: 10.1007/s11051-008-9373-4
7. Tadanaga, K., Morita, K., Mori, K., Tatsumisago, M. (2013). Synthesis of monodispersed silica nanoparticles with high concentration by the Stцber process. Journal of Sol-Gel Science and Technology, 68 (2), 341–345. doi: 10.1007/s10971-013-3175-6
8. Gao, W., Rigout, M., Owens, H. (2016). Facile control of silica nanoparticles using a novel solvent varying method for the fabrication of artificial opal photonic crystals. Journal of Nanoparticle Research, 18 (12). doi: 10.1007/s11051-016-3691-8
9. Masalov, V. M., Sukhinina, N. S., Emel'chenko, G. A. (2011). Colloidal particles of silicon dioxide for the formation of opal-like structures. Physics of the Solid State, 53 (6), 1135–1139. doi: 10.1134/s1063783411060229
10. Grinberg, E. E., Amelina, A. E., Kuznecov, A. I., Levin, Ju. I., Kotov, D. V., Rjabenko, E. A. (2013). Pat. No. 2537302 RU. Sposob ochistki tetrajetoksisilana. MPK7 C07F7/04, C07F7/20. No. 2013140008/04; declareted: 29.08.2013; published: 27.12.2014, Bul. No. 36, 6.
11. Trohimova, E. Ju., Aleksenskij, A. E., Grudinkin, S. A., Korkin, I. V., Kurdjukov, D. A., Golubev, V. G. (2011). Vlijanie predvaritel'noj obrabotki tetrajetoksisilana na sintez kolloidnyh chastic amorfnogo dioksida kremnija. Kolloidnyj zhurnal, 73 (4), 535–539.
12. Potapov, V. V., Kamashev, D. V. (2006). Sintez blagorodnogo opala v gidrotermal'nom rastvore. Fizika i himija stekla, 32 (1), 124–136.
13. Baryshev, A. V., Kaplyanskii, A. A., Kosobukin, V. A., Samusev, K. B., Usvyat, D. E., Limonov, M. F. (2004). Photonic band-gap structure: From spectroscopy towards visualization. Physical Review B, 70 (11). doi: 10.1103/physrevb.70.113104
14. Gupalo, Ju. P. (1962). O nekotoryh zakonomernostjah psevdoozhizhennogo sloja i stesnennogo padenija. Inzhenerno-fizicheskij zhurnal, 5 (2), 96–99.
15. Ratnikov, V. V. (1997). Opredelenie poristosti sinteticheskih opalov i poristogo kremnija rentgenovskim metodom. Fizika tverdogo tela, 39 (5), 956–958.

DOI: 10.15587/1729-4061.2017.92034

DEVELOPMENT OF MICELLAR SYSTEM FOR THE DECONTAMINATION OF ORGANOPHOSPHORUS COMPOUNDS TO CLEAN TECHNOLOGICAL EQUIPMENT (p. 42-49)

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An analysis of composition of commercially available cleaning products, used in pharmaceutical enterprises today, was carried out, based on which it was found that they do not guarantee effective cleaning of equipment from organophosphorus compounds. It was concluded that the development of new composition of the cleaning agent, which effectively decontaminates organophosphorus compounds from surfaces of the equipment, is a pressing issue for ecologically safe manufacture of products containing substances of organophosphorus nature.

A new system of micellar inactivation of active pharmaceutical ingredients of organophosphorus nature was developed. We conducted a study into the destruction of methylparathion by using the micellar system, which includes water, cetylpyridine chloride, hydrogen peroxide and boric acid. A concentration of cetylpyridine chloride, at which the largest constant of first-order reaction rate occurred, was established. It is shown that adding the activator, boric acid, increases the reaction rate by 2.5 times.

Based on these studies, the composition of a model cleaning agent for cleaning technological equipment was proposed. An assessment of internal risks for quality of production stations when producing medicinal agent based on organophosphorus compounds in the form of eye drops was carried out. Production station was given the highest rating of internal risk – 3.

We carried out an analysis of risks for cleaning reactor for preparing solutions RVD-630 in case of using the micellar system

developed to decontaminate from residues of active pharmaceutical ingredients of organophosphorus nature.

The obtained results might be used for devising the concept of validation of cleaning the reactor in the preparation of solutions. This is an important step in providing cleanliness of technological equipment under conditions of producing medicines based on organophosphorus compounds as active pharmaceutical ingredients at operating pharmaceutical enterprises.

Keywords: decontamination, micellar system, organophosphorus compounds, cleaning of technological equipment, quality risks.

Refrences

1. Rans'kyj, A. P., Petruk, R. V. (2012). Pat. No. 69634 UA. Sposib pererobky vysokotoksychnogo fosforovmisnogo pestycydnogo preparatu dymetoat. MPK B09B 3/00. No. u201111880; declareted: 10.10.2011; published: 10.05.2012, Bul. No. 9.
2. Bessarabov, V. I., Vahitova, L. M., Kuz'mina, G. I., Baula, O. P., Pal'chevs'ka, T. A., Matvijenko, K. V. et. al. (2016) Okysnjuval'ni vlastyvosti peroksydu vodnju v systemah dekontaminacii' zastarilyh fosfororganichnyh pestycydiv. Himichna promyslovist' Ukrai'ny, 5-6, 74–78.
3. Vahitova, L. N., Matvienko, K. V., Taran, N. A., Rybak, V. V., Burdina, Ja. F. (2014). Kineticheskaja model' reakcij gidroliza i pergidroliza paraoksona v mikrojemul'sii. Naukovi praci DonNTU. Serija: Himija i himichna tehnologija, 2 (23), 121–127.
4. Vahitova, L. N., Matvienko, K. V., Skrypka, A. V., Lahtarenko, N. V. (2010). Nukleofil'naja reakcionnaja sposobnost' peroksid-aniona v mikrojemul'sijah tipa "maslo v vode" v processah razlozhenija jefirov fosfornoj i toluolsul'fonovoj kislot. Teoreticheskaja i jeksperimental'naja himija, 46 (1), 1–7.
5. Vakhitova, L. N., Lakhtarenko, N. V., Popov, A. F. (2015). Kinetics of the Oxidation of Methyl Phenyl Sulfide by Peroxoborate Anions. Theoretical and Experimental Chemistry, 51 (5), 307–313. doi: 10.1007/s11237-015-9430-x
6. Eddleston, M., Buckley, N. A., Eyer, P., Dawson, A. H. (2008). Management of acute organophosphorus pesticide poisoning. The Lancet, 371 (9612), 597–607. doi: 10.1016/s0140-6736(07)61202-1
7. Holstov, V. I. (2010). Himicheskoe razoruzhenie. Praktika obespechenija vypolnenija konvencionnyh objazatel'stv po zapreshheniju himicheskogo oruzhija i ego unichtozheniju. Rossijskij himicheskij zhurnal, LIV (4), 5–9.
8. Chemical Stockpile Disposal Program (2003). Parsons. Available at: https://www.parsons.com/Media%20Library/0903_CSDP.pdf
9. Efremenko, E. N., Zav'jalova, N. V. et. al. (2010). Jekologicheski bezopasnaja biodegradacija reakcionnyh mass, obrazujushhihsja pri unichtozhenii fosfororganicheskih otravljajushhih veshhestv. Zh. Ros. him. Ob-va im. D. I. Mendeleeva, 54 (4), 19–24.
10. Wong, K.-Y., Gao, J. (2007). The Reaction Mechanism of Paraoxon Hydrolysis by Phosphotriesterase from Combined QM/MM Simulations. Biochemistry, 46 (46), 13352–13369. doi: 10.1021/bi700460c
11. Model systems in hydrolysis of organophosphates. Available at: http://uir.unisa.ac.za/bitstream/handle/10500/1252/02dissertation.pdf?sequence=1
12. Kim, K., Tsay, O. G., Atwood, D. A., Churchill, D. G. (2011). Destruction and Detection of Chemical Warfare Agents. Chemical Reviews, 111 (9), 5345–5403. doi: 10.1021/cr100193y
13. Singh, B., Prasad, G., Pandey, K., Danikhel, R., Vijayaraghavan, R. (2010). Decontamination of Chemical Warfare Agents. Defence Science Journal, 60 (4), 428–441. doi: 10.14429/dsj.60.487
14. Compilation of Community Procedures on Inspections and Exchange of Information (2014). European Commission Health &consumer protection directorate-general, 253.
15. LeBlanc, D. A. (2000). Validated cleaning technologies for pharmaceutical manufacturing. CRC Press, 289. doi: 10.1201/b14410
16. Konstrukcija sistem CIP/SIP i ih sravnenie s sistemami COP/SOP. Eshhe bol'she podrobnostej o steril'nom proizvodstve (2014). Farmacevticheskaja otrasl', 4 (45), 96–100. Available at: http://promoboz.com/uploads/articles/87.pdf
17. ArtLajf-Tehno. Available at: http://www.artlife-techno.ru/

DOI: 10.15587/1729-4061.2017.92368

AN INVESTIGATION OF OBTAINING PATTERNS, STRUCTURE AND DIFFUSION PROPERTIES OF BIOMEDICAL PURPOSE HYDROGEL MEMBRANES (p. 50-55)

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The obtaining patterns of hydrogel membrane coatings based on 2-hydroxyethylmethacrylate/polyvinylpyrrolidone copolymers were investigated. Temperature modes of their synthesis were justified and efficient initiating system – a complex of polyvinylpyrrolidone with iron sulfate, which allows low-temperature synthesis was selected. The structural parameters of the grid and membrane permeability for model substances (electrolytes) and medicines (on the example of sodium diclofenac) were studied. The interrelation of structure and composition of hydrogels with their diffusion-transport properties was established. The mechanism of components transfer from encapsulated hydrogel particles through the membrane was described. This mechanism includes the steps of swelling of the hydrogel membrane, molecular diffusion inside the capsule, mass transfer through the membrane to the surrounding solution. The model of mass transfer of the ensemble of spherical particles coated with a polymeric hydrogel shell was proposed. The model makes it possible to predict the duration and rate of release of the target component from encapsulated particles. The process flow diagram of hydrogel membrane coatings forming was developed to create encapsulated forms of sustained drug release.

Keywords: hydrogel membrane, 2-hydroxyethylmethacrylate, polyvinylpyrrolidone, structural grid, encapsulation, mass transfer, sustained release.

Refrences

1. Donbrow, M. (Ed.) (1991). Microcapsules and Nanoparticles in Medicine and Pharmacy. London: CRC Press, 362.
2. Srivastava, A., Yadav, T., Sharma, S., Nayak, A., Akanksha Kumari, A., Mishra, N. (2016). Polymers in Drug Delivery. Journal of Biosciences and Medicines, 04 (01), 69–84. doi: 10.4236/jbm.2016.41009
3. Lin, Y.-H., Liang, H.-F., Chung, C.-K., Chen, M.-C., Sung, H. W. (2005). Physically crosslinked alginate/N,O-carboxymethyl chi-

tosan hydrogels with calcium for oral delivery of protein drugs. Biomaterials, 26 (14), 2105–2113. doi: 10.1016/j.biomaterials.2004.06.011

4. Mahdavinia, G. R., Etemadi, H., Soleymani, F. (2015). Magnetic/pH-responsive beads based on caboxymethyl chitosan and κ-carrageenan and controlled drug release. Carbohydrate Polymers, 128, 112–121. doi: 10.1016/j.carbpol.2015.04.022
5. Sun, J., Chen, J., Yang, L., Wang, S., Li, Z., Wu, H. (2007). Synthesis and characterization of a pH-sensitive hydrogel made of pyruvic-acid-modified chitosan. Journal of Biomaterials Science, Polymer Edition, 18 (1), 35–44. doi: 10.1163/156856207779146132
6. Milasinovic, N., Krusic, M. K., Knezevic-Jugovic, Z., Filipovic, J. (2010). Hydrogels of N-isopropylacrylamide copolymers with controlled release of a model protein. International Journal of Pharmaceutics, 383 (1-2), 53–61. doi: 10.1016/j.ijpharm.2009.09.001
7. Ostrecova, N. I., Adamjan, A. A., Kopyl'cov, A. A., Nikolaeva-Fedorova, A. B. (2003). Poliakrilamidnye geli, ih bezopasnost' i jeffektivnost' (obzor). Annaly plasticheskoj, rekonstruktivnoj i jesteticheskoj hirurgii, 3, 72–87. Available at: http://www.borovikov.ru/articles_professional_8_3.htm
8. Suberlyak, O. V., Semenyuk, N. B., Dudok, G. D., Skorokhoda, V. I. (2012). Regular trends in synthesis of sorption-active granular copolymers of methacrylic acid esters with polyvinylpyrrolidone. Russian Journal of Applied Chemistry, 85 (5), 830–838. doi: 10.1134/s1070427212050254
9. Suberlyak, O. V., Mel'nyk, Y. Y., Skorokhoda, V. I. (2015). Regularities of Preparation and Properties of Hydrogel Membranes. Materials Science, 50 (6), 889–896. doi: 10.1007/s11003-015-9798-8
10. Seljakova, V., Kashevarova, Ju. (1982). Metody analiza akrilatov i metakrilatov. Moscow: Khimija, 170.
11. Dubjaga, V. P., Perepechkin, L. P., Katalevskij, E. E. (1981). Polimernye membrany. Moscow: Khimija, 232.
12. Rejtlinger, S. A. (1974). Pronicaemost' polimernyh materialov. Moscow: Khimija, 272.
13. Shvarc, A. G., Grigorovskaja, V. A. (1965). K voprosu ob ocenke koncentracii poperechnyh svjazej vulkanizatov. Kolloidnyj zhurnal, 27 (1), 30–34.
14. Suberljak, O. V., Skorohoda, V. J., Demchuk, I. A., Mel'nyk, Ju. Ja., Groshovyj, T. A. (2007). Ridkostrukturovani gidrogelevi membrany dlja system kontrol'ovanogo vyvil'nennja. Farmacevtychnyj chasopys, 3, 39–43. Available at: http://ojs.tdmu.edu.ua/index.php/pharm-chas/article/view/3175/2965
15. Matrosov, A. M. (2001). Marle 6. Reshenie zadach vysshej matematiki i mehaniki. Sankt-Peterburg: BHV-Peterburg, 528.