ABSTRACT AND REFERENCES

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INVESTIGATION OF NI-AL HYDROXIDE WITH SILVER ADDITION AS AN ACTIVE SUBSTANCE OF ALKALINE BATTERIES (p. 6-11)

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Layered double hydroxides with different ratios of nickel and aluminum in the presence of Ag + ions and without silver have been synthesized: Ni:Al – 80:20 %, Ni:Al:Ag – 80:15:5 % and 75:15:5 %. The obtained nickel hydroxide powders have a structure similar to α-$Ni(OH)_2$ with a large number of crystal lattice defects. As a result of galvanostatic charge-discharge cycling, it was revealed that the addition of silver in the chemical synthesis stage increases the hydroxide utilization coefficient at fast discharges but decrease it at slow discharges. A possible mechanism that explains the influence of added silver during synthesis on discharge characteristics of hydroxide powders was proposed. The mechanism is that silver oxide, which is a semiconductor, is mixed with hydroxide and increases the specific conductivity of the powder. Increased electrical conductivity has a positive effect on charge effectiveness, because the initial phase has lower electrical conductivity than the oxidized form – NiOOH. Because the charge involves two processes – the main process of active material charging and evolution of molecular oxygen, the electrical conductivity would play a key role in the electrode charging. At low electrical conductivity and fast charge, the current would primarily be consumed by the side process of oxygen evolution. In case of slow charges, additional electrical conductivity due to the presence of silver oxide would not have a great effect on charge effectiveness, because under such conditions the own conductivity of hydroxide is sufficient. Additionally, the presence of silver oxide would decrease the hydroxide content, which in turn would decrease the utilization coefficient that is calculated from the total mass of the powder.

Keywords: nickel hydroxide, alkaline secondary battery, $Ni(OH)_2$, layered double hydroxide, silver oxide.

References

1. Battery Market Trends and Safety Aspects. Available at: https://www.celltech.se/fileadmin/user_upload/Celltech/Celltech_Sweden/Battery_Market_Trends_and_Safety_Aspects__Celltech_and_Etteplan_Seminar__20180117.pdf
2. Ten’kovcev, V. V., Center, B. I. (1985). Osnovy teorii i ekspluatacii germetichnyh nikel’-kadmievyh akkumulyatorov. Leningrad: Energoatomizdat, 96.
3. Kotok, V., Kovalenko, V. (2018). Definition of the aging process parameters for nickel hydroxide in the alkaline medium. Eastern-European Journal of Enterprise Technologies, 2 (12 (92)), 54–60. doi: 10.15587/1729-4061.2018.127764
4. Xiong, X., Ding, D., Chen, D., Waller, G., Bu, Y., Wang, Z., Liu, M. (2015). Three-dimensional ultrathin Ni(OH) 2 nanosheets grown on nickel foam for high-performance supercapacitors. Nano Energy, 11, 154–161. doi: 10.1016/j.nanoen.2014.10.029
5. Kotok, V., Kovalenko, V. (2017). The properties investigation of the faradaic supercapacitor electrode formed on foamed nickel substrate with polyvinyl alcohol using. Eastern-European Journal of Enterprise Technologies, 4 (12 (88)), 31–37. doi: 10.15587/1729-4061.2017.108839
6. 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
7. Nwanya, A. C., Offiah, S. U., Amaechi, I. C., Agbo, S., Ezugwu, S. C., Sone, B. T. et. al. (2015). Electrochromic and electrochemical supercapacitive properties of Room Temperature PVP capped $Ni(OH)_2$/NiO Thin Films. Electrochimica Acta, 171, 128–141. doi: 10.1016/j.electacta.2015.05.005
8. Kotok, V. A., Malyshev, V. V., Solovov, V. A., Kovalenko, V. L. (2017). Soft Electrochemical Etching of FTO-Coated Glass for Use in $Ni(OH)_2$-Based Electrochromic Devices. ECS Journal of Solid State Science and Technology, 6 (12), P772–P777. doi: 10.1149/2.0071712jss
9. Kotok, V. A., Kovalenko, V. L., Kovalenko, P. V., Solovov, V. A., Deabate, S., Mehdi, A. et. al. (2017). Advanced electrochromic $Ni(OH)_2$/PVA films formed by electrochemical template synthesis. ARPN Journal of Engineering and Applied Sciences, 12 (13), 3962–3977.
10. Solovov, V., Kovalenko, V., Nikolenko, N., Kotok, V., Vlasova, E. (2017). Influence of temperature on the characteristics of Ni(II), Ti(IV) layered double hydroxides synthesised by different methods. Eastern-European Journal of Enterprise Technologies, 1 (6 (85)), 16–22. doi: 10.15587/1729-4061.2017.90873
11. Schäfer, H.-J. (1987). Oxidation of organic compounds at the nickel hydroxide electrode. Topics in Current Chemistry, 101–129. doi: 10.1007/3-540-17871-6_13
12. Xing, Z., Gan, L., Wang, J., Yang, X. (2017). Experimental and theoretical insights into sustained water splitting with an electrodeposited nanoporous nickel hydroxide@nickel film as an electrocatalyst. Journal of Materials Chemistry A, 5 (17), 7744–7748. doi: 10.1039/c7ta01907f
13. Gao, M., Sheng, W., Zhuang, Z., Fang, Q., Gu, S., Jiang, J., Yan, Y. (2014). Efficient Water Oxidation Using Nanostructured α-Nickel-Hydroxide as an Electrocatalyst. Journal of the American Chemical Society, 136 (19), 7077–7084. doi: 10.1021/ja502128j
14. Jarosz, M., Socha, R. P., Jóźwik, P., Sulka, G. D. (2017). Amperometric glucose sensor based on the $Ni(OH)_2/Al(OH)_4$ – electrode obtained from a thin Ni 3 Al foil. Applied Surface Science, 408, 96–102. doi: 10.1016/j.apsusc.2017.02.188
15. Zhang, X., Huang, Y., Gu, A., Wang, G., Fang, B., Wu, H. (2012). Hydrogen Peroxide Sensor Based on Carbon Nanotubes/β-$Ni(OH)_2$ Nanocomposites. Chinese Journal of Chemistry, 30 (3), 501–506. doi: 10.1002/cjoc.201280022
16. Tang, C., Zhao, Z. L., Chen, J., Li, B., Chen, L., Li, C. M. (2017). Se-$Ni(OH)_2$-shelled vertically oriented NiSe nanowires as a superior electrocatalyst toward urea oxidation reaction of fuel cells. Electrochimica Acta, 248, 243–249. doi: 10.1016/j.electacta.2017.06.159
17. Ye, K., Zhang, H., Zhao, L., Huang, X., Cheng, K., Wang, G., Cao, D. (2016). Facile preparation of three-dimensional Ni(OH)2/Ni foam

anode with low cost and its application in a direct urea fuel cell. New Journal of Chemistry, 40 (10), 8673–8680. doi: 10.1039/c6nj01648k

18. Calderón, J. A., Jiménez, J. P., Zuleta, A. A. (2016). Improvement of the erosion-corrosion resistance of magnesium by electroless Ni-P/Ni$(OH)_2$-ceramic nanoparticle composite coatings. Surface and Coatings Technology, 304, 167–178. doi: 10.1016/j.surfcoat.2016.04.063
19. Yang, C.-C. (2002). Synthesis and characterization of active materials of Ni$(OH)_2$ powders. International Journal of Hydrogen Energy, 27 (10), 1071–1081. doi: 10.1016/s0360-3199(02)00013-7
20. Kovalenko, V., Kotok, V. (2017). Obtaining of Ni–Al layered double hydroxide by slit diaphragm electrolyzer. Eastern-European Journal of Enterprise Technologies, 2 (6 (86)), 11–17. doi: 10.15587/1729-4061.2017.95699
21. Zhao, L., Liu, Z., Jin, L. (2013). Preparation and electrochemical performance of nano-scale Ni$(OH)_2$ doped with zinc. Transactions of Nonferrous Metals Society of China, 23 (4), 1033–1038. doi: 10.1016/s1003-6326(13)62563-7
22. Xing, C., Musharavati, F., Li, H., Zalezhad, E., Hui, O. K. S., Bae, S., Cho, B.-Y. (2017). Synthesis, characterization, and properties of nickel-cobalt layered double hydroxide nanostructures. RSC Advances, 7 (62), 38945–38950. doi: 10.1039/c7ra06670h
23. Jayashree, R. S., Vishnu Kamath, P. (2002). Layered double hydroxides of Ni with Cr and Mn as candidate electrode materials for alkaline secondary cells. Journal of Power Sources, 107 (1), 120–124. doi: 10.1016/s0378-7753(01)00994-6
24. Li, X., Hao, X., Wang, Z., Abudula, A., Guan, G. (2017). In-situ intercalation of NiFe LDH materials: An efficient approach to improve electrocatalytic activity and stability for water splitting. Journal of Power Sources, 347, 193–200. doi: 10.1016/j.jpowsour.2017.02.062
25. Gong, M., Li, Y., Wang, H., Liang, Y., Wu, J. Z., Zhou, J. et. al. (2013). An Advanced Ni–Fe Layered Double Hydroxide Electrocatalyst for Water Oxidation. Journal of the American Chemical Society, 135 (23), 8452–8455. doi: 10.1021/ja4027715
26. Wang, X., Lin, Y., Su, Y., Zhang, B., Li, C., Wang, H., Wang, L. (2017). Design and synthesis of ternary-component layered double hydroxides for high-performance supercapacitors: understanding the role of trivalent metal ions. Electrochimica Acta, 225, 263–271. doi: 10.1016/j.electacta.2016.12.160
27. Duan, C., Zhao, J., Qin, L., Yang, L., Zhou, Y. (2017). Ternary Ni-Co-Mo oxy-hydroxide nanoflakes grown on carbon cloth for excellent supercapacitor electrodes. Materials Letters, 208, 65–68. doi: 10.1016/j.matlet.2017.05.052
28. Birjega, R., Vlad, A., Matei, A., Ion, V., Luculescu, C., Dinescu, M., Zavoianu, R. (2016). Growth and characterization of ternary Ni, Mg–Al and Ni–Al layered double hydroxides thin films deposited by pulsed laser deposition. Thin Solid Films, 614, 36–41. doi: 10.1016/j.tsf.2015.11.066
29. Motupally, S. (1995). Proton Diffusion in Nickel Hydroxide Films. Journal of The Electrochemical Society, 142 (5), 1401. doi: 10.1149/1.2048589
30. Liu, B., Wang, X. Y., Yuan, H. T., Zhang, Y. S., Song, D. Y., Zhou, Z. X. (1999). Physical and electrochemical characteristics of aluminium-substituted nickel hydroxide. Journal of Applied Electrochemistry, 29 (7), 853–858. doi: 10.1023/a:1003537900947
31. Kovalenko, V., Kotok, V. (2018). Comparative investigation of electrochemically synthesized (α+β) layered nickel hydroxide with mixture of α-Ni$(OH)_2$ and β-Ni$(OH)_2$. Eastern-European Journal of Enterprise Technologies, 2 (6 (92)), 16–22. doi: 10.15587/1729-4061.2018.125886
32. Kotok, V., Kovalenko, V., Malyshev, V. (2017). Comparison of oxygen evolution parameters on different types of nickel hydroxide. Eastern-European Journal of Enterprise Technologies, 5 (12 (89)), 12–19. doi: 10.15587/1729-4061.2017.109770

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MECHANOACTIVATION OF PORTLAND CEMENT IN THE TECHNOLOGY OF MANUFACTURING THE SELF-COMPACTING CONCRETE (p. 12-17)

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This paper examines the intensive separation technology for producing a self-compacting concrete (SCC). We substantiate the proposed technology of SCC production through the effective control over viscosity of cement-water compositions, which to a large extent ensure the mobility of concrete mixes. A separate preparation of cement-water compositions at a high-speed mixer with its subsequent mixing with fillers in a regular concrete mixer profoundly changes the priorities in the production technology of a concrete mix. We substantiate the idea on that the use of the separation technology could optimize the modes of high-speed mixing in order to separately prepare the highly concentrated cement-containing suspensions under conditions of intensive hydrodynamic impacts on them. Particular attention is paid to studying the effect of content of the superplasticizer of polycarboxylate type Relaxol-Super PC, microsilica, and polypropylene fibers, on effective viscosity of the cement-containing suspension. Comparative analysis of influence of the original formulation factors on its value is described. It was found that the mechanoactivation of a cement-containing suspension in the presence of the admixture Relaxol-Super PC leads to the complete destruction of its original structure, which is necessary for the uniform distribution of microsilica and polypropylene fibers in the volume.

We describe the features of grain composition, rendering exclusive fluidity to the concrete mix, as well as the possibility of laying it in the mold without vibration. The intensive separation technology makes it possible to obtain SCC with the F4, F5 grades for fluidity, and compressive strength at the age of 28 days not less than 55 MPa.

We have scientifically substantiated and experimentally confirmed the effectiveness of mechanical activation for the separation technology of self-compacting concrete mixes and the high-strength concretes based on them.

Keywords: mechanoactivation, self-compacting concrete, effective viscosity, superplasticizer, polycarboxylate, microsilica, polypropylene fibers.

References

1. Bazhenov, Yu. M. (2003). Tekhnologiya betona. Moscow: Izd-vo AVS, 500.
2. Aleksandrov, Ya. A. (2011). Vybor syr'evyh materialov dlya proizvodstva samouplotnyayushchihsya betonov. Tekhnologiya betonov, 3, 18–19.
3. Okamura, H., Ouchi, M. (2003). Self-Compacting Concrete. Journal of Advanced Concrete Technology, 1 (1), 5–15. doi: 10.3151/jact.1.5
4. Zaychenko, N. M., Serdyuk, A. I. (2013). Betony s vysokim soderzhaniem zolya dlya massivnyh zhelezobetonnyh konstrukciy. Visnyk DonNABA. Suchasni budivelni materialy, 1 (99), 137–144.
5. Berdov, G. I., Il'ina, L. V. (2010). Aktivaciya cementov deystviem mineral'nyh dobavok. Mezhdunarodniy zhurnal prikladnyh i fundamental'nyh issledovaniy, 9, 55–58.
6. Kamal, M. M., Safan, M. A., Etman, Z. A., Kasem, B. M. (2014). Mechanical properties of self-compacted fiber concrete mixes. HBRC Journal, 10 (1), 25–34. doi: 10.1016/j.hbrcj.2013.05.012

7. Barabash, I. V., Barabash, T. I., Shcherbina, O. S. (2015). Effektivnaya vyazkost' aktivirovannyh cementnyh suspenziy s dobavkoy domennogo shlaka. Mistobuduvannia ta terytorialne planuvannia, 546–550.
8. Ibragimov, R. A., Pimenov, S. I., Izotov, V. S. (2015). Vliyanie mekhanohimicheskoy aktivacii vyazhushchego na svoystvo melkozernistogo betona. Magazine of Civil Ingineering, 2, 63–69.
9. Vyrovoy, V. N., Barabash, I. V. et. al. (2014). Mekhanoaktivaciya v tekhnologii betona. Odessa: OGASA, 148.
10. Li, F. M. (1961). Himiya cementa i betona. Moscow: Stroyizdat, 645.
11. Ahverdov, I. N. (1981). Osnovy fiziki betona. Moscow: Stroyizdat, 464.
12. Batrakov, V. G. (1990). Modificirovannye betony. Moscow: Stroyizdat, 440.
13. Rebinder, P. A. (1979). Poverhnostnye yavleniya v dispersnyh sistemah. Moscow: Nauka, Izbrannye trudy, 384.
14. Rebinder, P. A. (1958). Fiziko-mekhanicheskaya mekhanika. Moscow, 64.
15. Ur'ev, N. B. (1980). Vysokokoncentirovannye dispersnye sistemy. Moscow: Himiya, 320.
16. Ur'ev, N. B. (1998). Dinamika strukturirovannyh dispersnyh system. Kolloidniy zhurnal, 60 (5), 662–683.
17. Ur'ev, N. B. (1988). Fiziko-mekhanicheskie osnovy tekhnologii dispersnyh sistem i materialov. Moscow: Himiya, 256.
18. Ur'ev, N. B., Dubinin, I. S. (1980). Kolloidnye cementnye rastvory. Leningrad: Stroyizdat, 192.
19. Butt, Yu. M., Sychev, M. M., Timashev, V. V. (1980). Himicheskaya tekhnologiya vyzhushchih materialov. Moscow: Vysshaya shkola, 472.
20. Nikiforov, A. P. (2002). Dobavki dlya betona. Sostoyanie i perspektivy. Budivelni materialy. Suchasni problemi betonu ta yoho tekhnolohiya, 186–190.
21. Fayner, M. Sh. (2001). Novye zakonomernosti v betonovedenii i ih pravticheskoe primenenie. Kyiv: Naukova dumka, 480.
22. Barabash, I. V., Vyrovoy, V. N. (2000). Mekhanizmy organizacii struktury mekhanoaktivirovannyh grubodispersnyh system. Zbirnyk «Kompozytsiyni materialy dlia budivnytstva. Visnyk – DDABA, 2 (22), 12–15.

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STUDY OF THE OXIDATION KINETICS OF NITRITE IONS BY POTASSIUM FERRATE(VI) (p. 18-25)

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The oxidation kinetics of nitrite to nitrate ions by potassium ferrate(VI) in a wide range of pH, from neutral to alkaline medium has been studied. Two series of kinetic experiments based on the different technologies for obtaining potassium ferrate(VI) were conducted. In the first series of experiments, crystalline potassium ferrate(VI) was prepared by the chemical synthesis. In the pH range 6.5–11, solid K_2FeO_4 was added to solutions of nitrite ions at known concentration and pH. Kinetic studies were performed under pH and ionic strength controlled conditions. Half times for these experiments ranged from milliseconds to a few minutes. In the second series of experiments, solutions of K_2FeO_4 were generated by the electrochemical synthesis. Alkaline solutions of potassium ferrate(VI) in 8.0 M KOH were obtained at t=20 °C by electrochemical dissolution of steel plates (S=10 cm^2) containing: C – 0.16 %; Mn – 0.43 %; Si – 0.04 %; S – 0.03 %; P – 0.04 %; the rest is Fe. The experiments were performed with fresh solutions of potassium ferrate(VI) and solutions, aged after the synthesis for several days. Kinetic studies were performed under nitrite concentrations controlled conditions. Half times in this case were in the range of several minutes to hours. It is found out that the maximum reaction rate is achieved by aging solution K_2FeO_4 after the synthesis for 8 days. Both methods show that the oxidation rate is controlled by the concentration of protonated ferrate, $HF_4O_4^-$. The dependence of the observed rate constants on pH, nitrite concentrations and ionic strength has been investigated. The true rate constants of reaction are found. Particular orders of the reaction by nitrite and ferrate ions and the overall order of the reaction are calculated. The oxidation rate constant of water by Fe(VI) is found. The studies presented in this paper are important because the oxidation kinetics of harmful inorganic and organic substances by ferrates(VI) of alkali metals is widely used to determine the optimal parameters of technological processes for the purification of surface water, industrial wastewater and air.

Keywords: potassium ferrate(VI), nitrite ions, oxidation kinetics, ferrate(VI) synthesis, alkaline solutions.

References

1. Manoli, K., Nakhla, G., Ray, A. K., Sharma, V. K. (2017). Oxidation of caffeine by acid-activated ferrate(VI): Effect of ions and natural organic matter. AIChE Journal, 63 (11), 4998–5006. doi: 10.1002/aic.15878
2. Homolková, M., Hrabák, P., Graham, N., Černík, M. (2016). A study of the reaction of ferrate with pentachlorophenol – kinetics and degradation products. Water Science and Technology, 75 (1), 189–195. doi: 10.2166/wst.2016.496
3. Sun, X., Zhang, Q., Liang, H., Ying, L., Xiangxu, M., Sharma, V. K. (2016). Ferrate(VI) as a greener oxidant: Electrochemical generation and treatment of phenol. Journal of Hazardous Materials, 319, 130–136. doi: 10.1016/j.jhazmat.2015.12.020
4. Kralchevska, R. P., Sharma, V. K., Machala, L., Zboril, R. (2016). Ferrates(Fe(VI), Fe(V), and Fe(IV)) oxidation of iodide: Formation of triiodide. Chemosphere, 144, 1156–1161. doi: 10.1016/j.chemosphere.2015.09.091
5. Yates, B. J., Zboril, R., Sharma, V. K. (2014). Engineering aspects of ferrate in water and wastewater treatment – a review. Journal of Environmental Science and Health, Part A, 49 (14), 1603–1614. doi: 10.1080/10934529.2014.950924
6. Sharma, V. K. (2013). Ferrate(VI) and ferrate(V) oxidation of organic compounds: Kinetics and mechanism. Coordination Chemistry Reviews, 257 (2), 495–510. doi: 10.1016/j.ccr.2012.04.014
7. Casbeer, E. M., Sharma, V. K., Zajickova, Z., Dionysiou, D. D. (2013). Kinetics and Mechanism of Oxidation of Tryptophan by Ferrate(VI). Environmental Science & Technology, 47 (9), 4572–4580. doi: 10.1021/es305283k

8. Wood, R. H. (1958). The Heat, Free Energy and Entropy of the Ferrate(VI) Ion. Journal of the American Chemical Society, 80 (9), 2038–2041. doi: 10.1021/ja01542a002
9. Yngard, R. A., Sharma, V. K., Filip, J., Zboril, R. (2008). Ferrate(VI) Oxidation of Weak-Acid Dissociable Cyanides. Environmental Science & Technology, 42 (8), 3005–3010. doi: 10.1021/es0720816
10. Denvir, A., Pletcher, D. (1996). Electrochemical generation of ferrate Part I: Dissolution of an iron wool bed anode. Journal of Applied Electrochemistry, 26 (8), 815–822. doi: 10.1007/bf00683743
11. Denvir, A., Pletcher, D. (1996). Electrochemical generation of ferrate Part 2: Influence of anode composition. Journal of Applied Electrochemistry, 26 (8), 823–827. doi: 10.1007/bf00683744
12. Golovko, D., Sharma, V., Pavlova, O., Belyanovskaya, E., Golovko, I., Suprunovich, V., Zboril, R. (2011). Determination of submillimolar concentration of ferrate(VI) in alkaline solutions by amperometric titration. Open Chemistry, 9 (5). doi: 10.2478/s11532-011-0069-8
13. Golovko, D. A., Sharma, V. K., Suprunovich, V. I., Pavlova, O. V., Golovko, I. D., Bouzek, K., Zboril, R. (2011). A Simple Potentiometric Titration Method to Determine Concentration of Ferrate(VI) in Strong Alkaline Solutions. Analytical Letters, 44 (7), 1333–1340. doi: 10.1080/00032719.2010.511748
14. Sharma, V. K. (2010). Oxidation of nitrogen-containing pollutants by novel ferrate(VI) technology: A review. Journal of Environmental Science and Health, Part A, 45 (6), 645–667. doi: 10.1080/10934521003648784
15. Osathaphan, K., Kittisarn, W., Chatchaitanawat, P., Yngard, R. A., Kim, H., Sharma, V. K. (2014). Oxidation of Ni(II)-cyano and Co(III)-cyano complexes by Ferrate(VI): Effect of pH. Journal of Environmental Science and Health, Part A, 49 (12), 1380–1384. doi: 10.1080/10934529.2014.928250
16. Sharma, V. K., Yngard, R. A., Cabelli, D. E., Clayton Baum, J. (2008). Ferrate(VI) and ferrate(V) oxidation of cyanide, thiocyanate, and copper(I) cyanide. Radiation Physics and Chemistry, 77 (6), 761–767. doi: 10.1016/j.radphyschem.2007.11.004
17. Costarramone, N., Kneip, A., Castetbon, A. (2004). Ferrate(VI) Oxidation of Cyanide in Water. Environmental Technology, 25 (8), 945–955. doi: 10.1080/09593330.2004.9619388
18. Johnson, M. D., Hornstein, B. J. (2003). The Kinetics and Mechanism of the Ferrate(VI) Oxidation of Hydroxylamines. Inorganic Chemistry, 42 (21), 6923–6928. doi: 10.1021/ic020705x
19. Golovko, D. A., Goncharova, I. V., Golovko, I. D., Belyanovskaya, E. A., Danilov, F. I. (2006). Absorption of NO and CO by the alkaline solutions of sodium ferrate. ACS National Meeting Book of Abstracts, 232, 716.
20. Carr, J. D. (2008). Kinetics and Product Identification of Oxidation by Ferrate(VI) of Water and Aqueous Nitrogen Containing Solutes. ACS Symposium Series, 189–196. doi: 10.1021/bk-2008-0985.ch013
21. Edwards, J. O., Mueller, J. J. (1962). The Rates of Oxidation of Nitrite Ion by Several Peroxides. Inorganic Chemistry, 1 (3), 696–699. doi: 10.1021/ic50003a050
22. Cachaza, J. M., Casado, J., Castro, A., Quintela, M. A. L. (1976). Kinetics of oxidation of nitrite by hypochlorite ions in aqueous basic solution. Canadian Journal of Chemistry, 54 (21), 3401–3406. doi: 10.1139/v76-488
23. Panigrahi, G. P., Nayak, R. (1983). Kinetic and mechanistic studies on the oxidation of nitrite by peroxomonophosphoric acid. International Journal of Chemical Kinetics, 15 (10), 989–995. doi: 10.1002/kin.550151004
24. Gan, W., Sharma, V. K., Zhang, X., Yang, L., Yang, X. (2015). Investigation of disinfection byproducts formation in ferrate(VI) pre-oxidation of NOM and its model compounds followed by chlorination. Journal of Hazardous Materials, 292, 197–204. doi: 10.1016/j.jhazmat.2015.02.037
25. Jiang, J.-Q., Durai, H. B. P., Winzenbacher, R., Petri, M., Seitz, W. (2014). Drinking water treatment byin situgenerated ferrate(VI). Desalination and Water Treatment, 55 (3), 731–739. doi: 10.1080/19443994.2014.938303
26. Thompson, G. W., Ockerman, L. T., Schreyer, J. M. (1951). Preparation and Purification of Potassium Ferrate. VI. Journal of the American Chemical Society, 73 (3), 1379–1381. doi: 10.1021/ja01147a536
27. Talaiekhozani, A., Talaei, M. R., Rezania, S. (2017). An overview on production and application of ferrate (VI) for chemical oxidation, coagulation and disinfection of water and wastewater. Journal of Environmental Chemical Engineering, 5 (2), 1828–1842. doi: 10.1016/j.jece.2017.03.025
28. Luo, Z., Strouse, M., Jiang, J.-Q., Sharma, V. K. (2011). Methodologies for the analytical determination of ferrate(VI): A Review. Journal of Environmental Science and Health, Part A, 46 (5), 453–460. doi: 10.1080/10934529.2011.551723
29. Venkatadri, A. S., Wagner, W. F., Bauer, H. H. (1971). Ferrate(VI) analysis by cyclic voltammetry. Analytical Chemistry, 43 (8), 1115–1119. doi: 10.1021/ac60303a036
30. Kelter, P. B., Carr, J. D. (1979). Noniterative method for computer evaluation of second-order kinetic data. Analytical Chemistry, 51 (11), 1825–1828. doi: 10.1021/ac50047a050
31. Kelter, P. B., Carr, J. D. (1979). A microcomputer compatible method of resolving rate constants in mixed first- and second-order kinetic rate laws. Analytical Chemistry, 51 (11), 1828–1834. doi: 10.1021/ac50047a051
32. Golovko, D., Golovko, I., Goncharova, I., Shevchenko, L. (2017). Usage of mother liquor recycling for the obtaining of Fe(VI) compounds. Eastern-European Journal of Enterprise Technologies, 3 (6 (87)), 55–59. doi: 10.15587/1729-4061.2017.101071
33. Golovko, D. A., Golovko, I. D., Shevchenko, L. V., Goncharova, I. V. (2017). Modernization of ferrate (VI) technology from the iron hydroxides. Technology audit and production reserves, 1 (3 (33)), 4–8. doi: 10.15587/2312-8372.2017.92565
34. Carr, J. D., Kelter, P. B., Tabatabai, A., Spichal, D., Erickson, J. E., McLaughin, C. W. (1985). Properties of ferrate(VI) in aqueous solution: an alternate oxidant in wastewater treatment. Proceedings of the Conference on Water Chlorination: Chemistry, Environmental Impact and Health Effects, 1285–1298.
35. Liu, H., Wang, D., Shan, J. (2016). Oxidation of Gabapentin by Potassium Ferrate (VI) in Alkaline Media-Kinetics and Mechanism Study. International Journal of Advanced Research in Chemical Science, 3 (5), 37–43. doi: 10.20431/2349-0403.0305005

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SYNTHESIS OF MAGNETITE NANOPARTICLES STABILIZED BY POLYVINYLPYRROLIDONE AND ANALYSIS OF THEIR ABSORPTION BANDS (p. 26-32)

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We report results of studying the synthesis of magnetite nanoparticles. The formed dispersions were explored with the use of the spectrophotometric method. The spectra of optical absorption of nanomagnetite dispersions were analyzed using the theory of plasmon oscillations. Synthesis of nanoparticles was performed in the aqueous solution and with the use of 3.5 % polyvinylpyrrolidone as dispersed medium. The ratio of salts of ferrum (III)/(II) was 1.5:1. Working concentrations of reactive substances were chosen, which resulted in the formation of stable dispersions of nanoparticles with magnetic properties. It was shown that when changing the amount and the method of introduction of ammonia solution into the system, more stable dispersions of nanoparticles are formed. As a result of the research into surface plasmon resonance of magnetite nanoparticles dispersions, it was found that all synthesized solutions are characterized by a maximum of absorption at the wavelength of 350 nm, however, intensity of absorption bands directly depends on dimensions of the particles. Magnetite nanoparticles, synthesized with the use of 3.5 % polyvinylpyrrolidone (PVP) as dispersed medium, are characterized by existence of three bands at 350 nm, 950 nm, and 1,050 nm. The possible mechanism of stabilization of magnetite nanoparticles in polyvinylpyrrolidone was proposed. In the course of the study, it was found that polyvinylpyrrolidone, on the one hand, contributes to nucleation, and on the other hand, effectively stabilizes nanoparticles.

Keywords: nanoparticles, magnetite, plasmon resonance, polyvinylpyrrolidone (PVP), absorption bands, radius of nanoparticles, aggregation resistance.

References

1. Faraji, M., Yamini, Y., Rezaee, M. (2010). Magnetic nanoparticles: Synthesis, stabilization, functionalization, characterization, and applications. Journal of the Iranian Chemical Society, 7 (1), 1–37. doi: 10.1007/bf03245856
2. Weissleder, R., Stark, D., Engelstad, B., Bacon, B., Compton, C., White, D. et. al. (1989). Superparamagnetic iron oxide: pharmacokinetics and toxicity. American Journal of Roentgenology, 152 (1), 167–173. doi: 10.2214/ajr.152.1.167
3. Elmore, W. C. (1938). Ferromagnetic Colloid for Studying Magnetic Structures. Physical Review, 54 (4), 309–310. doi: 10.1103/physrev.54.309
4. Massart, R. (1981). Preparation of aqueous magnetic liquids in alkaline and acidic media. IEEE Transactions on Magnetics, 17 (2), 1247–1248. doi: 10.1109/tmag.1981.1061188
5. Baranov, D. A., Gubin, S. P. (2009). Magnitnye nanochasticy: dostizheniya i problemy himicheskogo sinteza. Nanosistemy, 1 (1-2), 129–147.
6. Bandhu, A., Mukherjee, S., Acharya, S., Modak, S., Brahma, S. K., Das, D., Chakrabarti, P. K. (2009). Dynamic magnetic behaviour and Mössbauer effect measurements of magnetite nanoparticles prepared by a new technique in the co-precipitation method. Solid State Communications, 149 (41-42), 1790–1794. doi: 10.1016/j.ssc.2009.07.018
7. Iwasaki, T., Kosaka, K., Yabuuchi, T., Watano, S., Yanagida, T., Kawai, T. (2009). Novel mechanochemical process for synthesis of magnetite nanoparticles using coprecipitation method. Advanced Powder Technology, 20 (6), 521–528. doi: 10.1016/j.apt.2009.06.002
8. Hu, J., Hu, X., Chen, A., Zhao, S. (2014). Directly aqueous synthesis of well-dispersed superparamagnetic Fe3O4 nanoparticles using ionic liquid-assisted co-precipitation method. Journal of Alloys and Compounds, 603, 1–6. doi: 10.1016/j.jallcom.2014.02.022
9. Wei, Y., Han, B., Hu, X., Lin, Y., Wang, X., Deng, X. (2012). Synthesis of Fe_3O_4 Nanoparticles and their Magnetic Properties. Procedia Engineering, 27, 632–637. doi: 10.1016/j.proeng.2011.12.498
10. Silva, V. A. J., Andrade, P. L., Silva, M. P. C., Bustamante D., A., De Los Santos Valladares, L., Albino Aguiar, J. (2013). Synthesis and characterization of Fe_3O_4 nanoparticles coated with fucan polysaccharides. Journal of Magnetism and Magnetic Materials, 343, 138–143. doi: 10.1016/j.jmmm.2013.04.062
11. Semeniuk, N. B., Kostiv, U. V., Dziaman, I. Z., Klym, Yu. V., Skorokhoda, V. Y. (2014). Osoblyvosti oderzhannia nanochastynok sribla u prysutnosti polivinilpirolidonu. Visnyk Natsionalnoho universytetu “Lvivska politekhnika”. Ser.: Khimiya, tekhnolohiya rechovyn ta yikh zastosuvannia, 787, 440–443. Available at: http://nbuv.gov.ua/UJRN/VNULPX_2014_787_86
12. Sapir, L., Stanley, C. B., Harries, D. (2016). Properties of Polyvinylpyrrolidone in a Deep Eutectic Solvent. The Journal of Physical Chemistry A, 120 (19), 3253–3259. doi: 10.1021/acs.jpca.5b11927
13. Klimov, V. V. (2010). Nanoplazmonika. Moscow: Fizmatlit, 480.
14. Boren, K., Hafmen, D. (1986). Pogloshchenie i rasseyanie sveta malymi chasticami. Moscow: Mir, 664.
15. Kelly, K. L., Coronado, E., Zhao, L. L., Schatz, G. C. (2003). The Optical Properties of Metal Nanoparticles: The Influence of Size, Shape, and Dielectric Environment. The Journal of Physical Chemistry B, 107 (3), 668–677. doi: 10.1021/jp026731y
16. Kreibig, U., Vollmer, M. (1995). Optical properties of metal clusters. Berlin: Springer-Verlag, 535. doi: 10.1007/978-3-662-09109-8
17. Koczkur, K. M., Mourdikoudis, S., Polavarapu, L., Skrabalak, S. E. (2015). Polyvinylpyrrolidone (PVP) in nanoparticle synthesis. Dalton Transactions, 44 (41), 17883–17905. doi: 10.1039/c5dt02964c
18. Yang, C.-C., Wan, C.-C., Wang, Y.-Y. (2006). The Role of Poly(N-vinyl-2-pyrrollidone) in Ag/Pd Nanoparticles Formation and Its Application to Electroless Deposition. Journal of The Electrochemical Society, 153 (5), J27. doi: 10.1149/1.2176917

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FORMATION OF OXIDE FUELS ON VT6 ALLOY IN THE CONDITIONS OF ANODIAL POLARIZATION IN SOLUTIONS H_2SO_4 (p. 33-38)

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We report results of research into a process of electrochemical oxidation of the titanium alloy VT6 in solutions of H_2SO_4. It is shown that the character of forming dependences for alloy samples depends on the magnitude of current density. At $j<0.5$ A·dm^{-2}, a continuous oxide film does not form at the surface of the alloy; the assigned value for voltage is not reached. At $j>0.5$ A·dm^{-2}, a continuous oxide film forms at the surface of the alloy; a linear character of dependences is observed. The films obtained under these conditions relate to the interferential-colored films. A film thickness limit is defined by the assigned magnitude of U and does not depend on other parameters of the electrolysis. For the series of identical values for U, dependence of τ–j has a linear shape. The color of the oxide film is determined by the value of voltage and does not depend on the current density and electrolyte concentration. We established a correspondence between a color of the film and the magnitude of U in the range of 10–100 V. This effect is due to the fact that the formation of a film at anodic polarization occurs in the presence of a gradient in the potential whose quantity for titanium is a constant magnitude. Increasing the assigned magnitude of U leads to a proportional increase in the maximum thickness of the oxide, which determines its color. Results of our study on determining the effect of electrolysis parameters on the characteristics of oxide films made it possible to substantiate the mode for obtaining TiO_2 films at the surface of the alloy VT6. The data obtained form the basis for the development of technology for electrochemical oxidation of titanium implants in order to render functional properties to their surface.

Keywords: oxide films, titanium dioxide, implant, electrochemical oxidation, forming dependence.

References

1. Ellerbrock, D., Macdonald, D. D. (2014). Passivity of titanium, part 1: film growth model diagnostics. Journal of Solid State Electrochemistry, 18 (5), 1485–1493. doi: 10.1007/s10008-013-2334-6
2. Popa, M. V., Vasilescu, E., Drob, P., Anghel, M., Vasilescu, C., Mirza-Rosca, I., Santana Lopez, A. (2002). Anodic passivity of some titanium base alloys in aggressive environments. Materials and Corrosion, 53 (1), 51–55. doi: 10.1002/1521-4176(200201)53:1<51::aid-maco51>3.0.co;2-6
3. Garg, H., Bedi, G., Garg, A. (2012). Implant surface modifiations: a review. J. Clin. Diagn. Res., 6 (2), 319–324.
4. Liu, X., Chu, P., Ding, C. (2004). Surface modification of titanium, titanium alloys, and related materials for biomedical applications. Materials Science and Engineering: R: Reports, 47 (3-4), 49–121. doi: 10.1016/j.mser.2004.11.001
5. Mandracci, P., Mussano, F., Rivolo, P., Carossa, S. (2016). Surface Treatments and Functional Coatings for Biocompatibility Improvement and Bacterial Adhesion Reduction in Dental Implantology. Coatings, 6 (1), 7. doi: 10.3390/coatings6010007
6. John, A. A., Jaganathan, S. K., Supriyanto, E., Manikandan, A. (2016). Surface Modification of Titanium and its Alloys for the Enhancement of Osseointegration in Orthopaedics. Current Science, 111 (6), 1003. doi: 10.18520/cs/v111/i6/1003-1015
7. Diefenbeck, M., Mückley, T., Schrader, C., Schmidt, J., Zankovych, S., Bossert, J. et. al. (2011). The effect of plasma chemical oxidation of titanium alloy on bone-implant contact in rats. Biomaterials, 32 (32), 8041–8047. doi: 10.1016/j.biomaterials.2011.07.046
8. Park, E.-J., Song, Y.-H., Hwang, M.-J., Song, H.-J., Park, Y.-J. (2015). Surface Characterization and Osteoconductivity Evaluation of Micro/Nano Surface Formed on Titanium Using Anodic Oxidation Combined with H2O2 Etching and Hydrothermal Treatment. Journal of Nanoscience and Nanotechnology, 15 (8), 6133–6136. doi: 10.1166/jnn.2015.10469
9. Lubas, M., Sitarz, M., Jasinski, J. J., Jelen, P., Klita, L., Podsiad, P., Jasinski, J. (2014). Fabrication and characterization of oxygen – Diffused titanium using spectroscopy method. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 133, 883–886. doi: 10.1016/j.saa.2014.06.067
10. Sul, Y.-T., Johansson, C. B., Jeong, Y., Albrektsson, T. (2001). The electrochemical oxide growth behaviour on titanium in acid and alkaline electrolytes. Medical Engineering & Physics, 23 (5), 329–346. doi: 10.1016/s1350-4533(01)00050-9
11. Sul, E. T., Byon, E., Wennerberg, A. (2008). Surface characteristics of electrochemically oxidized implants and acid-etched implants: surface chemistry, morphology, pore configurations, oxide thickness, crystal structure, and roughness. Int. J. Oral Maxillofac. Implants, 23 (4), 631–640.
12. Fojt, J. (2012). Ti–6Al–4V alloy surface modification for medical applications. Applied Surface Science, 262, 163–167. doi: 10.1016/j.apsusc.2012.04.012
13. Veiga, C., Davim, J. P., Loureiro, A. J. R. (2012). Properties and applications of titanium alloys: a brief review. Rev. Adv. Mater. Sci., 2, 14–34.
14. Pilipenko, A. I., Pospelov, A. P., Kamarchuk, G. V., Bondarenko, I. S., Shablo, A. A., Bondarenko, S. I. (2011). Point-contact sensory nanostructure modeling. Functional materials, 18 (3), 324–327.
15. Pospelov, A. P., Pilipenko, A. I., Kamarchuk, G. V., Fisun, V. V., Yanson, I. K., Faulques, E. (2014). A New Method for Controlling the Quantized Growth of Dendritic Nanoscale Point Contacts via Switchover and Shell Effects. The Journal of Physical Chemistry C, 119 (1), 632–639. doi: 10.1021/jp506649u
16. Adya, N., Alam, M., Ravindranath, T., Mubeen, A., Saluja, B. (2005). Corrosion in titanium dental implants: literature review. The Journal of Indian Prosthodontic Society, 5 (3), 126. doi: 10.4103/0972-4052.17104
17. Mohammed, M. T., Khan, Z. A., Siddiquee, A. N. (2014). Surface Modifications of Titanium Materials for developing Corrosion Behavior in Human Body Environment: A Review. Procedia Materials Science, 6, 1610–1618. doi: 10.1016/j.mspro.2014.07.144
18. Wang, G., Li, J., Lv, K., Zhang, W., Ding, X., Yang, G. et. al. (2016). Surface thermal oxidation on titanium implants to enhance osteogenic activity and in vivo osseointegration. Scientific Reports, 6 (1). doi: 10.1038/srep31769
19. Hayle, S. T. (2014). Synthesis and Characterization of Titanium Oxide Nanomaterials Using Sol-Gel Method. American Journal of Nanoscience and Nanotechnology, 2 (1), 1. doi: 10.11648/j.nano.20140201.11
20. De Maeztu, M. A., Alava, J. I., Gay-Escoda, C. (2003). Ion implantation: surface treatment for improving the bone integration of titanium and Ti6Al4V dental implants. Clinical Oral Implants Research, 14 (1), 57–62. doi: 10.1034/j.1600-0501.2003.140108.x
21. Pilipenko, A., Pancheva, H., Reznichenko, A., Myrgorod, O., Miroshnichenko, N., Sincheskul, A. (2017). The study of inhibiting structural material corrosion in water recycling systems by sodium hydroxide. Eastern-European Journal of Enterprise Technologies, 2 (1 (86)), 21–28. doi: 10.15587/1729-4061.2017.95989
22. Pancheva, H., Reznichenko, A., Miroshnichenko, N., Sincheskul, A., Pilipenko, A., Loboichenko, V. (2017). Study into the influence of concentration of ions of chlorine and temperature of circulating water on the corrosion stability of carbon steel and cast iron. Eastern-European Journal of Enterprise Technologies, 4 (6 (88)), 59–64. doi: 10.15587/1729-4061.2017.108908
23. Sincheskul, A., Pancheva, H., Loboichenko, V., Avina, S., Khrystych, O., Pilipenko, A. (2017). Design of the modified oxide-nickel electrode with improved electrical characteristics. Eastern-European Journal of Enterprise Technologies, 5 (6 (89)), 23–28. doi: 10.15587/1729-4061.2017.112264
24. Blondeau, G., Froelicher, M., Froment, M., Hugot-Le-Goff, A. (1977). Structure and growth of anodic oxide films on titanium and TA6V alloy. Journal of the Less Common Metals, 56 (2), 215–222. doi: 10.1016/0022-5088(77)90043-1
25. Aladjem, A. (1973). Anodic oxidation of titanium and its alloys. Journal of Materials Science, 8 (5), 688–704. doi: 10.1007/bf00561225

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RESEARCH INTO STRUCTURE FORMATION AND PROPERTIES OF THE FIBERREINFORCED AERATED CONCRETE OBTAINED BY THE NONAUTOCLAVED HARDENING (p. 39-46)

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We have investigated the influence of the ratio cement:fly-ash and the temperature of mixing water on the properties of aerated concrete mixes and aerated concrete. It was established that the rational cement-fly ash ratio is 1:1; the mixing water temperature is 40 °C. Experimental research confirmed that the introduction of waste from salt processing and metakaolin to the formulation of binding compositions leads to the formation, rather than the metastable hexagonal calcium hydro-aluminates, of the stable compounds in the structure of partitions between pores of the hydrocalumite and hydrocarboaluminate type. That allowed the targeted structure formation of partitions between pores of the non-autoclaved aerated concrete, which improves the density of partitions and the strength of aerated concrete. It is shown that the introduction of polypropylene fibers to composition of aerated concrete does not affect the kinetics of swelling of the aerated concrete array. However, the introduction of polypropylene fibers improves the strength of aerated concrete based on the modified binding composition containing metakaolin by 47 %, the modified binding composition containing carbonate-containing waste – by 32 %. For the aerated concrete of the B1.5–B2 class of strength, at a density within 615–625 kg/m^3, the estimated coefficient of thermal conductivity is 0.16 W/(m·K), which makes it possible to reduce heat losses through external enclosures.

Thus, there is reason to assert the possibility of the targeted control over the processes of forming a strong structure of partitions between pores using the modified binding compositions containing supplementary cementitious materials. The application of polypropylene fibers enables the reinforcement of aerated-concrete array, forming a strong structural frame of partitions between pores, and ensuring greater strength of the non-autoclaved aerated concrete.

Keywords: non-autoclaved aerated concrete, kinetics of swelling, density, strength, polypropylene fiber.

References

1. Poroshenko zatverdyv ratyfikatsiyu Paryzkoi klimatychnoi uhody (2016). Dzerkalo tyzhnia. Ukraina. 2016. Available at: https://dt.ua/UKRAINE/poroshenko-zatverdiv-ratifikaciyu-parizkoyi-klimatichnoyi-ugodi-215094_.html
2. Sanytskyi, M. A., Pozniak, O. R., Marushchak, U. D. (2013). Enerhozberihaiuchi tekhnolohiyi v budivnytstvi. Lviv, 236.
3. Kearsley, E. P., Wainwright, P. J. (2001). Porosity and permeability of foamed concrete. Cement and Concrete Research, 31 (5), 805–812. doi: 10.1016/s0008-8846(01)00490-2
4. Sanytsky, M., Pozniak, O., Roussyn, B., Szymanek, A., Szymanska, J. (2011). Concrete based on modified cementitious system with fine ground mineral additives. Non- traditional cement & concrete, Proceedings of the 4th International Conference, 85–92.
5. Shishkina, A. (2016). Study of the effect of micelle-forming surfactants on the strength of cellular reactive powder concrete. Eastern-European Journal of Enterprise Technologies, 2 (6 (80)), 66–78. doi: 10.15587/1729-4061.2016.63706
6. Prabha, P., Bhuvaneshwari, B., Palani, G. (2015). Nano Modified Foam Concrete. The Masterbuilder, 168–174.
7. Marushchak, U., Sanytsky, M., Mazurak, T., Olevych, Y. (2016). Research of nanomodified portland cement compositions with high early age strength. Eastern-European Journal of Enterprise Technologies, 6 (6 (84)), 50–57. doi: 10.15587/1729-4061.2016.84175
8. Karakurt, C., Kurama, H., Topçu, İ. B. (2010). Utilization of natural zeolite in aerated concrete production. Cement and Concrete Composites, 32 (1), 1–8. doi: 10.1016/j.cemconcomp.2009.10.002
9. Wang, C., Lin, X., Wang, D., He, M., Zhang, S. (2018). Utilization of oil-based drilling cuttings pyrolysis residues of shale gas for the preparation of non-autoclaved aerated concrete. Construction and Building Materials, 162, 359–368. doi: 10.1016/j.conbuildmat.2017.11.151
10. Namsone, E., Šahmenko, G., Korjakins, A. (2017). Durability Properties of High Performance Foamed Concrete. Procedia Engineering, 172, 760–767. doi: 10.1016/j.proeng.2017.02.120
11. Belov,V., Rushdi, A. (2015). Razrabotka optimalnykh sostavov neavtoklavnogo gazobetona. Cement i yego primeneniye, 6, 92–97.
12. Aliabdo, A. A., Abd-Elmoaty, A.-E. M., Hassan, H. H. (2014). Utilization of crushed clay brick in cellular concrete production. Alexandria Engineering Journal, 53 (1), 119–130. doi: 10.1016/j.aej.2013.11.005
13. Mirza, W. H., Al-Noury, S. I. (1986). Utilisation of Saudi sands for aerated concrete production. International Journal of Cement Composites and Lightweight Concrete, 8 (2), 81–85. doi: 10.1016/0262-5075(86)90002-3
14. Esmaily, H., Nuranian, H. (2012). Non-autoclaved high strength cellular concrete from alkali activated slag. Construction and Building Materials, 26 (1), 200–206. doi: 10.1016/j.conbuildmat.2011.06.010
15. Drochytka, R., Helanová, E. (2015). Development of Microstructure of the Fly Ash Aerated Concrete in time. Procedia Engineering, 108, 624–631. doi: 10.1016/j.proeng.2015.06.189
16. Kuryatnikov, Yu. Yu., Ali, R. A., Vinogradova, V. A., Saharova, O. V. Optimizaciya struktury svyazuyushchey matricy gazobetona s ispol'zovaniem karbonatnogo napolnitelya. Stroitel'stvo i stroitel'nye tekhnologii. Available at: http://eprints.tstu.tver.ru/135/1/2.pdf
17. Yang, L., Yan, Y., Hu, Z. (2013). Utilization of phosphogypsum for the preparation of non-autoclaved aerated concrete. Construction and Building Materials, 44, 600–606. doi: 10.1016/j.conbuildmat.2013.03.070
18. Hezhev, T. A., Puharenko, Yu. V., Hashukaev, M. N. (2003). Yacheistye fibrobetony na osnove vulkanicheskih gornyh porod. Izvestiya vysshih uchebnyh zavedeniy. Severo-Kavkazskiy region. Tekhnicheskie nauki, 3, 37–39.
19. Sokolova, S. N., Mitina, N. (2009). A Untersuchungen zum Einfluss von Dispersfuellern auf die bautechnischen Eigenschaften von Porenbeton. Ibausil, 1193–1198.
20. Abdul Rahim, N. H., Mohamad, N., Abdul Samad, A. A., Goh, W. I., Jamaluddin, N. (2017). Flexural Behaviour of Precast Aerated Concrete Panel (PACP) with Added Fibrous Material: An Overview. MATEC Web of Conferences, 103, 02005. doi: 10.1051/matecconf/201710302005
21. Fomicheva, G. N. (2005). Matematicheskoe opisanie processa polucheniya gazobetona na al'bitofirovom napolnitele. Novye stroitel'nye tekhnologii, 196–199.
22. Martynov, V. I., Vyrovoy, V. N., Orlov, D. A., Vetoh, A. M. (2006). Strukturoobrazovanie i svoystva yacheistyh betonov. Resursoekonomni materialy, konstruktsiyi, budivli ta sporudy, 14, 90–96.

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STUDY OF THE EFFECT OF MICELLAR CATALYSIS ON THE STRENGTH OF ALKALINE REACTIVE POWDER CONCRETE (p. 46-51)

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Under certain conditions, an increase in the rate of hydration of the binding substance increases the strength of concrete at compression. This is especially true for the reactive powder concretes.

We studied the effect of surface-active substances, capable of forming micelles, on the rate of formation and the resulting magnitude of strength at compression of the alkaline reactive powder concretes. A particular feature of our research was studying the simultaneous action of surface-active substance that forms micelles and a reactive powder or a filler on the change in the strength of concretes. It was found that the specified micellar solutions and reaction powders change the character of formation of strength of the alkaline reactive powder concretes. The rate of strength formation over the early stages increases due to the micellar catalysis of hydration of blast-furnace granular slag, while their enhanced compressive strength is maintained at the late stages of hardening.

Strength of the alkaline reactive powder concretes, when applying the surface-active substances that form micelles, reaches 260 % of the strength of such concretes without any additives.

It was proved that the micellar catalysis could be used to control the hardening processes of a binding substance, consisting of blast-furnace granular slag and an alkaline component, and to form the strength of the resulting artificial stone. That shortens the time required for concrete to achieve the designed strength and improves the absolute magnitude of the compressive strength of such concretes at the age of 28 days.

Keywords: blast-furnace granular slag, alkali, micellar catalysis, concrete strength, powder concrete, micelles, surface-active substances.

References

1. Falikman, V. R. (2011). Novye effektivnye vysokofuncional'nye betony. Beton i zhelezobeton, 2, 78–84.
2. Erdem, T. K., Kırca, Ö. (2008). Use of binary and ternary blends in high strength concrete. Construction and Building Materials, 22 (7), 1477–1483. doi: 10.1016/j.conbuildmat.2007.03.026
3. Krivenko, P. V., Petropavlovskiy, O. N., Lakusta, S. O. (2015). Rol' tekhnologicheskih faktorov v formirovanii struktury i svoystv shlakoshchelochnyh betonov. Visnyk Odeskoi derzhavnoi akademiyi budivnytstva ta arkhitektury, 57, 233–242.
4. Shishkin, A. A. (2014). Shchelochnye reakcionnye poroshkovye betony. Stroitel'stvo unikal'nyh zdaniy i sooruzheniy, 2 (17), 56–65.
5. Shishkin, A. A., Shishkina, A. A. (2016). Study of the nanocatalysis effect on the strength formation of reactive powder concrete. Eastern-European Journal of Enterprise Technologies, 1 (6 (79)), 55–60. doi: 10.15587/1729-4061.2016.58718
6. Shishkina, A. A. (2016). Study of the effect of micelle-forming surfactants on the strength of cellular reactive powder concrete. Eastern-European Journal of Enterprise Technologies, 2 (6 (80)), 66–70. doi: 10.15587/1729-4061.2016.63706
7. Cao, J., Chung, D. D. L. (2004). Use of fly ash as an admixture for electromagnetic interference shielding. Cement and Concrete Research, 34 (10), 1889–1892. doi: 10.1016/j.cemconres.2004.02.003
8. Tolstoy, A., Lesovik, V., Zagorodnyuk, L., Kovaleva, I. (2015). Powder concretes with technogenic materials. Vestnik MGSU, 11, 101–109. doi: 10.22227/1997-0935.2015.11.101-109
9. Menéndez, G., Bonavetti, V., Irassar, E. F. (2003). Strength development of ternary blended cement with limestone filler and blast-furnace slag. Cement and Concrete Composites, 25 (1), 61–67. doi: 10.1016/s0958-9465(01)00056-7
10. Gruber, K. A., Ramlochan, T., Boddy, A., Hooton, R. D., Thomas, M. D. A. (2001). Increasing concrete durability with high-reactivity metakaolin. Cement and Concrete Composites, 23 (6), 479–484. doi: 10.1016/s0958-9465(00)00097-4
11. Shishkin, A. (2016). Study of the effect of compounds of transition elements on the micellar catalysis of strength formation of reactive powder concrete. Eastern-European Journal of Enterprise Technologies, 2 (6 (80)), 60–65. doi: 10.15587/1729-4061.2016.63957
12. Sheynich, L. A. (2002). Special'nye betony i kompozicionnye materialy. Budivelni konstruktsiyi. Mizhvidomchyi naukovo-tekhnichnyi zbirnyk, 56, 367–377.
13. Shishkin, A., Shishkina, A., Vatin, N. (2014). Low-Shrinkage Alcohol Cement Concrete. Applied Mechanics and Materials, 633-634, 917–921. doi: 10.4028/www.scientific.net/amm.633-634.917
14. Termkhajornkit, P., Nawa, T., Nakai, M., Saito, T. (2005). Effect of fly ash on autogenous shrinkage. Cement and Concrete Research, 35 (3), 473–482. doi: 10.1016/j.cemconres.2004.07.010

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RESEARCH OF THE TREATMENT OF DEPLETED NICKELPLATING ELECTROLYTES BY THE FERRITIZATION METHOD (p. 52-60)

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Considerable attention has been paid recently to the development of comprehensive recycling of industrial wastewater, which provides for an appropriate degree of purification for both organization of circulation water supply, and subsequent disposal of waste of water treatment. The improved ferritization process, which allows decreasing original concentration of nickel ions in depleted electrolytes of nickel plating from 50–100 g/dm^3 to <0.2 mg/dm^3, was presented. The experimental ferrite-reactor with the use of the traditional thermal and electromagnetic pulse method of activation of ferritization process in the range of generating frequencies of up to 0.9 kHz was developed. Economic benefits of the use of the electromagnetic pulse activation compared to the high temperature one were identified. Kinetics of extraction of nickel and iron ions from aqueous solutions was explored. The impact of the basic technological parameters of ferritization at different ways of activation was experimentally determined. The most effective results of treatment of highly concentrated wastewater were achieved using the electromagnetic pulse (T=20 °C) and thermal (T=70 °C) way of activation of the ferritization process at the original ration of concentration Fe^{2+}/Ni^{2+} within 3/1–4/1, total concentration of ions of heavy metals of 20–25 g/dm^3, original pH of the reaction mixture of 9.5 and duration of ferritization process of 15 min. Research into phase composition and physical properties of ferritization sediments was performed. Comparative analysis of sediment volumes at different ways of compaction was carried out. Sediments are mainly characterized by the crystalline structure, ferromagnetic properties, and considerable chemical resistance. This provides for actual environmental ways of recycling, which makes it possible to avoid the loss of valuable and, at the same time, toxic metal – nickel. The proposed comprehensive process of recycling liquid industrial waste prevents pollution of the environment, ensures effective and efficient use of water, raw materials, and power in the system of galvanic production.

Keywords: wastewater treatment, ferritization, industrial production, electrolytes of nickel plating, heavy metals, waste, disposal.

References

1. Rubanov, Yu. K., Tokach, Yu. E., Nechaev, A. F., Ognev, M. N. (2009). The galvanic productions waste waters and sludges processing with the heavy metals ions extraction. European Journal of Natural History, 6, 79–80.
2. Fu, F., Wang, Q. (2011). Removal of heavy metal ions from wastewaters: A review. Journal of Environmental Management, 92 (3), 407–418. doi: 10.1016/j.jenvman.2010.11.011
3. Lu, H.-C., Chang, J.-E., Shih, P.-H., Chiang, L.-C. (2008). Stabilization of copper sludge by high-temperature CuFe2O4 synthesis process. Journal of Hazardous Materials, 150 (3), 504–509. doi: 10.1016/j.jhazmat.2007.04.130
4. Petrick, L., Dubowski, Y., Klas, S., Lahav, O. (2008). Stable Incorporation of Co^{2+} into Ferrite Structure at Ambient Temperature: Effect of Operational Parameters. Water, Air, and Soil Pollution, 190 (1-4), 245–257. doi: 10.1007/s11270-007-9597-4
5. Pritosiwi, G. (2012). Removal of Metal Ions from Synthetic und Galvanic Wastewater by Their Incorporation Into Ferrites. Harburg: Die Technische Universität Hamburg-Harburg, 194.
6. Kochetov, G., Zorya, D., Grinenko, J. (2010). Integrated treatment of rinsing copper-containing wastewater. Civil and Environmental Engineering, 1 (4), 301–305.
7. Heuss-Aßbichler, S., John, M., Klapper, D., Bläß, U. W., Kochetov, G. (2016). Recovery of copper as zero-valent phase and/or copper oxide nanoparticles from wastewater by ferritization. Journal of Environmental Management, 181, 1–7. doi: 10.1016/j.jenvman.2016.05.053
8. Tu, Y.-J., Chang, C.-K., You, C.-F., Wang, S.-L. (2012). Treatment of complex heavy metal wastewater using a multi-staged ferrite process. Journal of Hazardous Materials, 209-210, 379–384. doi: 10.1016/j.jhazmat.2012.01.050
9. Yadollahpour, A., Rashidi, S., Ghotbeddin, Z., Rezaee, Z. (2014). Electromagnetic Fields for the Treatments of Wastewater: A Review of Applications and Future Opportunities. Journal of Pure and Applied Microbiology, 8 (5), 3711–3719.
10. Kochetov, G., Samchenko, D., Naumenko, I. (2014). Improvement of the ferritisation method for removal of nickel compounds from wastewater. Givil and Environmental Engineering, 5 (4), 143–148.
11. Faber, X., Thompson, B. (2016). Corrigendum to “On the field of definition of a cubic rational function and its critical points” [J. Number Theory 167 (2016) 1–6]. Journal of Number Theory, 169, 439–440. doi: 10.1016/j.jnt.2016.06.002
12. Kochetov, G. M., Samchenko, D. N., Potapenko, L. I. (2016). Kinetics ferritic wastewater treatment. Problems of water supply, drainage and hydraulics, 26, 118–122.
13. Lu, J., Liu, F., Luo, X. (2014). Selection of image features for steganalysis based on the Fisher criterion. Digital Investigation, 11 (1), 57–66. doi: 10.1016/j.diin.2013.12.001
14. Tokach, Y. E., Rubanov, Y. K., Pivovarova, N. A., Balyatinskaya, L. N. (2013). Galvanic Sludge Recycling with the Extraction of Valuable Components. Middle-East. Journal of Scientific Research, 18 (11), 1646–1655.
15. Frolov, L. A., Pivovarov, A. A., Baskevich, A. S., Kushnerev, A. I. (2014). Structure and properties of nickel ferrites produced by glow discharge in the Fe^{2+}-Ni_2+-SO_4^{2-}-OH^- system. Russian Journal of Applied Chemistry, 87 (8), 1054–1059. doi: 10.1134/s1070427214080084
16. Ozmen, M., Can, K., Arslan, G., Tor, A., Cengeloglu, Y., Ersoz, M. (2010). Adsorption of Cu(II) from aqueous solution by using modified Fe_3O_4 magnetic nanoparticles. Desalination, 254 (1-3), 162–169. doi: 10.1016/j.desal.2009.11.043
17. Gawande, M. B., Branco, P. S., Varma, R. S. (2013). Nano-magnetite (Fe3O4) as a support for recyclable catalysts in the development of sustainable methodologies. Chemical Society Reviews, 42 (8), 3371. doi: 10.1002/chin.201326221
18. Gunjakar, J. L., More, A. M., Gurav, K. V., Lokhande, C. D. (2008). Chemical synthesis of spinel nickel ferrite (NiFe2O4) nano-sheets. Applied Surface Science, 254 (18), 5844–5848. doi: 10.1016/j.apsusc.2008.03.065
19. Kryvenko, P., Hailin, C., Petropavlovskyi, O., Weng, L., Kovalchuk, O. (2016). Applicability of alkali-activated cement for immobilization of low-level radioactive waste in ion-exchange resins. Eastern-European Journal of Enterprise Technologies, 1 (6 (79)), 40–45. doi: 10.15587/1729-4061.2016.59489
20. Krivenko, P., Kovalchuk, O., Pasko, A. (2018). Utilization of Industrial Waste Water Treatment Residues in Alkali Activated Cement and Concretes. Key Engineering Materials, 761, 35–38. doi: 10.4028/www.scientific.net/kem.761.35
21. Alonso, M. M., Pasko, A., Gascó, C., Suarez, J. A., Kovalchuk, O., Krivenko, P., Puertas, F. (2018). Radioactivity and Pb and Ni immobilization in SCM-bearing alkali-activated matrices. Construction and Building Materials, 159, 745–754. doi: 10.1016/j.conbuildmat.2017.11.119
22. Ntumba Malenga, E., Mulaba-Bafubiandi, A. F., Nheta, W. (2015). Alkaline leaching of nickel bearing ammonium jarosite precipitate using KOH, NaOH and NH4OH in the presence of EDTA and Na2S. Hydrometallurgy, 155, 69–78. doi: 10.1016/j.hydromet.2015.04.004
23. Polshettiwar, V., Luque, R., Fihri, A., Zhu, H., Bouhrara, M., Basset, J.-M. (2011). Magnetically Recoverable Nanocatalysts. Chemical Reviews, 111 (5), 3036–3075. doi: 10.1021/cr100230z

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MATHEMATICAL MODEL OF OBTAINING A HYDROCARBON FUEL BASED ON THE FISCHER-TROPSCH PATHWAY IN A STATIONARY LAYER OF THE COBALTBASED CATALYST (p. 60-70)

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Studying the kinetics of the Fischer-Tropsch process is a rather important task, since this process is very sensitive to the temperature mode, as well as to the characteristics of the catalyst. In addition, a given process is accompanied by many side reactions that negatively affect the rate and selectivity of the reaction. The Fischer-Tropsch synthesis is an alternative source for obtaining high-quality fuel from coal or biomass rather than petroleum. Therefore, investigating the kinetics of the Fischer-Tropsch reaction, in order to improve the selectivity and activity of catalysts, and to determine the rate constants of chemical reactions, is a relevant problem.

The choice of the catalyst is one of the main factors affecting the quality and product yield for the Fischer-Tropsch synthesis. We fabricated two samples of cobalt catalysts for conducting the experi-

ments. The first sample of the catalyst Co/γ-Al_2O_3 contains cobalt nanoparticles of the same size. The second sample of the catalyst (Co)/γ-Al_2O_3 was obtained by the method of impregnating the carrier with a solution of cobalt nitrate. The catalyst, obtained through the method of impregnation of (Co)/γ-Al_2O_3, demonstrated a higher activity, larger by an order of magnitude than the monodispersed catalysts. However, the monodispersed catalyst showed high selectivity for the lower hydrocarbons.

In order to calculate the kinetics of the Fischer-Tropsch process and to find the reaction rate constants, we developed a software module in the programming environment MS Visual Studio 2017 in the programming language C# using the .NET Framework v4.6 technologies.

By using the developed program module, we calculated reaction rate constants of the Fischer-Tropsch process. After analyzing the data obtained, one can see that the relative error is within 2...3 %, demonstrating the adequacy of the proposed model to solve the inverse problem of chemical kinetics. Therefore, we can state that a given model for the calculation of rate constants could be applied to study the Fischer-Tropsch process.

Keywords: Fischer-Tropsch reaction, cobalt catalyst, inverse problem of kinetics, rate constant.

References

1. Mordkovich, V. Z., Sineva, L. V., Kul'chakovskaya, E. V., Asalieva, E. Yu. (2015). Chetyre pokoleniya tekhnologii polucheniya sinteticheskogo zhidkogo topliva na osnove sinteza Fishera-Tropsha. Kataliz v neftepererabatyvayushchey promyshlennosti, 15 (5), 23–45.
2. Slivinskiy, E. V., Kuz'min, A. E., Abramova, A. V., Kliger, G. A., Loktev, S. M. (1998). Sintez Fishera-Tropsha: sovremennoe sostoyanie i principy sozdaniya katalizatorov (obzor). Neftekhimiya, 38, 243–268.
3. Dry, M. E.; Anderson, R. B., Boudard, M. (Eds.) (1981). The Fischer–Tropsch Synthesis. Catalysis, Science and Technology, 1, 159–256.
4. Schulz, H. (1999). Short history and present trends of Fischer–Tropsch synthesis. Applied Catalysis A: General, 186 (1-2), 3–12. doi: 10.1016/s0926-860x(99)00160-x
5. Krylov, O. V. (2004). Geterogennyy kataliz. Moscow, 679.
6. Lapidus, A. L., Krylova, A. Yu. (2000). O mekhanizme obrazovaniya zhidkih uglevodorodov iz CO i H_2 na kobal'tovyh katalizatorah. Rossiyskiy himicheskiy zhurnal, 44 (1), 43–56.
7. Rofer-DePoorter, C. K. (1981). A comprehensive mechanism for the Fischer-Tropsch synthesis. Chemical Reviews, 81 (5), 447–474. doi: 10.1021/cr00045a002
8. Brunner, K. M., Duncan, J. C., Harrison, L. D., Pratt, K. E., Peguin, R. P. S., Bartholomew, C. H., Hecker, W. C. (2012). A Trickle Fixed-Bed Recycle Reactor Model for the Fischer-Tropsch Synthesis. International Journal of Chemical Reactor Engineering, 10 (1). doi: 10.1515/1542-6580.2840
9. Tristantini, D., Lögdberg, S., Gevert, B., Borg, Ø., Holmen, A. (2007). The effect of synthesis gas composition on the Fischer–Tropsch synthesis over Co/γ-Al_2O_3 and Co–Re/γ-Al_2O_3 catalysts. Fuel Processing Technology, 88 (7), 643–649. doi: 10.1016/j.fuproc.2007.01.012
10. Davis, B. H. (2007). Fischer−Tropsch Synthesis: Comparison of Performances of Iron and Cobalt Catalysts. Industrial & Engineering Chemistry Research, 46 (26), 8938–8945. doi: 10.1021/ie0712434
11. Patzlaff, J., Liu, Y., Graffmann, C., Gaube, J. (1999). Studies on product distributions of iron and cobalt catalyzed Fischer-Tropsch synthesis. Applied Catalysis A: General, 186 (1-2), 109–119. doi: 10.1016/s0926-860x(99)00167-2
12. Patzlaff, J., Liu, Y., Graffmann, C., Gaube, J. (2002). Interpretation and kinetic modeling of product distributions of cobalt catalyzed Fischer–Tropsch synthesis. Catalysis Today, 71 (3-4), 381–394. doi: 10.1016/s0920-5861(01)00465-5
13. Zhou, L., Froment, G. F., Yang, Y., Li, Y. (2016). Advanced fundamental modeling of the kinetics of Fischer-Tropsch synthesis. AIChE Journal, 62 (5), 1668–1682. doi: 10.1002/aic.15141
14. Sun, Y., Yang, G., Zhang, L., Sun, Z. (2017). Fischer-Tropsch synthesis in a microchannel reactor using mesoporous silica supported bimetallic Co-Ni catalyst: Process optimization and kinetic modeling. Chemical Engineering and Processing: Process Intensification, 119, 44–61. doi: 10.1016/j.cep.2017.05.017
15. Arsalanfara, M., Mirzaeib, A. A., Bozorgzadehc, H. R., Samimid, A. (2014). A review of Fischer-Tropsch synthesis on the cobalt based catalysts. Phys. Chem. Res., 2 (2), 179–201.
16. Mosayebi, A., Haghtalab, A. (2015). The comprehensive kinetic modeling of the Fischer–Tropsch synthesis over Co@Ru/γ-Al_2O_3 core-shell structure catalyst. Chemical Engineering Journal, 259, 191–204. doi: 10.1016/j.cej.2014.07.040
17. Mosayebi, A., Abedini, R. (2017). Detailed kinetic study of Fischer – Tropsch synthesis for gasoline production over Co–Ni/HZSM-5 nano-structure catalyst. International Journal of Hydrogen Energy, 42 (44), 27013–27023. doi: 10.1016/j.ijhydene.2017.09.060
18. Pyatnickiy, Yu. I., Lunev, N. K. (2001). Kineticheskoe modelirovanie processa Fishera-Tropsha. Kataliz i neftekhimiya, 9-10, 1–4.
19. Skoretska, I., Beznosyk, Y. (2017). Modeling the heterogeneous catalytic recovery processes of aldehydes and ketones. Eastern-European Journal of Enterprise Technologies, 3 (6 (87)), 36–43. doi: 10.15587/1729-4061.2017.99755
20. Bezdenezhnyh, A. A. (1973). Inzhenernye metody sostavleniya uravneniy skorostey reakciy i rascheta kineticheskih konstant. Leningrad: Himiya, 256.
21. Zakharchuk, Y., Beznosyk, Y. (2018). Research and modeling of the heterogeneous process of production the hydrocarbon fuel according to the Fischer-Tropsch scheme. 6th International Scientific-Practical Conference "Modeling and simulation for chemistry, technologies and sustainable development systems – MSCT-6". Kyiv, 139–145.