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Article 1

Rakhimova N. R., Rakhimov R. S., Khasanova L. A.

Feasibility of alkali-activated slag cements application for solidification of borate salt solutions

Rakhimova N. R. (rahimova.07@list.ru), Doctor of Technical Sciences, prof., *Rakhimov R. Z.*, Doctor of Technical Sciences, prof., *Khasanova, L. A.,* student, Kazan State University of Architecture and Engineering

Key words: radioactive wastes, alkali-activated slag cements, borates, conditioning, immobilization

Abstract

The article presents the results of research the possibility of alkali-activated slag cements for solidification of borate salt solutions, simulating liquid radioactive wastes of nuclear power plants, operating pressurized water reactors. The properties of the cement waste forms based on alkali-activated slag cements and borate salt solutions, depending on the content of the alkaline activator, salinity and pH of borate solutions.

References

1. Abdel Rahman R. O, Rakhimov R. Z, Rakhimova N. R., et al. *Cementitious Materials for Nuclear Waste Immobilization*. Chichester: Wiley, 2015, 237 p.
2. Ojovan M. I., Samanta S. K. Recent IAEA activities to support utilisation of cementitious materials in radioactive waste management / 1st Int. Symposium on Cement-Based Materials for Nuclear Wastes, Avignon, France, 3–5.06.2014. *Proceedings of NUWCEM,* 2014.
3. Roux C. Conditioning of Radioactive Concentrates with High Boron Content, Formulation and Characterization. *These de l'Universite Paris Sud.,* France, 1989, 112 p.
4. God G. K., Valeshko M. G. Korrelyatsiya form boratov, poluchennyh iz rastvorov s razlichnym pH [Correlation of the form of borates separating from solutions with the pH]. *Zhurnal neorganicheskoy khimii,* 1960, no, 5, pp. 634–639 (in Russian).
5. Eskander S. B., Tawfik M. E., Bayoumi T. A. Immobilization of borate waste simulate in cement-water extended polyester composite based on poly (ethylene terephthalate) waste. *Polymer plastic technology engineering*, 2006, no. 45, pp. 939–945.
6. Guerrero A., Goñi S. Efficiency of a blast furnace slag cement for immobilizing simulated borate radioactive liquid waste. *Waste Management*, 2002, no. 22(7), pp. 831–836.
7. Qina S., Junfeng L., Jianlong W. Effect of borate concentration on solidification of radioactive wastes by different cements**.** *Nuclear Engineering and Design*, 2011, no. 241, pp. 4341–4345.
8. Champenois J.-B. M., Dhoury D., Cau-dit-Coumes C., et al. Influence of sodium borate on the early age hydration of calcium sulfoaluminate cement. *Cement Concrete research*, 2015, no. 70, pp. 83–93.
9. Qina S., Jianlong W. Cementation of radioactive borate liquid waste produced in pressurized water reactors. *Nuclear Engineering and Design*, 2010, no. 240, pp. 3660–3664.
10. Hall D. A. The effect of retarders on the microstructure and mechanical properties of magnesia–phosphate cement mortar. *Cement and Concrete Research,* 2001, no. 31, pp. 455–465.
11. Hugo L., Cau-dit-Coumes C., Lambertin D., et al. Influence of boric acid on the hydration of magnesium phosphate cement at an early age. *Abstract book of the 14th International Congress on the Chemistry of Cement,* Volume II, 13–16.10.2015*,* Beijing, China, 610 p.
12. Yang J. Effect of borax on hydration and hardening properties of magnesium and potassium phosphate cement pastes. *Journal of Wuhan University of Technology Materials Science,* 2010, no. 25, pp. 613–618.
13. Palomo A., De la Fuente J. I. Alkali-activated cementitous materials: alternative matrices for the immobilisation of hazardous wastes, part I. Stabilisation of boron. *Cement and Concrete Research,* 2003, no. 33(2), pp. 281–288.
14. Rahimova N. R., Rahimov R. Z., Stoyanov O. V. Kompozitsionnye vyazhushhie dlya immobilizacii toksichnykh i radioaktivnykh othodov [Compositional binders for toxic and radioactive wastes immobilization]. *Vestnik Kazanskogo tekhnologicheskogo universiteta*, 2013, vol. 16, no. 4, pp. 175–182 (in Russian).
15. Rakhimova N. R., Rakhimov R. Z., Osin Y. N., et al. Solidification of nitrate solutions with alkali-activated slag and slag- metakaolin cements. *Journal of Nuclear Materials,* vol. 457, 2015, pp. 186–195.

16. Cau-dit-Coumes C., Courtois S. Cementation of a low-level radioactive waste of complex chemistry Investigation of the combined action of borate, chloride, sulfate and phosphate on cement hydration using response surface methodology. *Cement and Concrete Research,* 2003, no. 33, pp. 305–316.
17. Shi C., Day R. L. A calorimetric study of early hydration of alkali-slag cements. *Cement and Concrete Research,* 1995, no. 25(6), pp. 1333–1346.
18. Shi C. Early hydration and microstructure development of alkali-activated slag pastes. *10th International Congress on the Chemistry of Cement*, Gothenburg, Sweden, 1997, 3–099, 8 p.

Article 2

Musafirova G. J., Musafirov E. V., Lyshchik M. V.
Block foam glass based on cullet, dolomite and liquid glass
Musafirova G. J. (musafirova_gy@grsu.by), Candidate of Technical Sciences, *Musafirov E. V., C*andidate of Physico-Mathematical Sciences, *Lyshchik M. V.*, undergraduate, Yanka Kupala State University of Grodno, Belarus

Key words: glass waste, wood charcoal, dolomite powder, chalk, water glass, block foam glass

Abstract

The optimum composition of raw materials for reception of block foam glass on the basis of a waste of a glass with dolomite powder use as gas developing agent (up to 1,0% from mass of a waste of a glass) and the water glass use as structure modifying agent (2,5–3,0% from mass of a waste of a glass) is obtained. Samples of block foam glass of heat-insulating and structural appointment (mass specific gravity is 270–300 kg/m^3, compression strength is 2,0–2,1 MPa, water absorption is up to 3,0%) are obtained.

References

1. Lotov V. A. Perspektivnye teploizolyatsionnye materialy s zhestkoy strukturoy [Advanced insulation materials with a rigid structure]. *Stroitel'nye materialy*, 2004, no. 11, pp. 8–9 (in Russian).
2. Ketov A. A., Tolmachev A. V. Penosteklo – tekhnologicheskie realii i rynok [Foam glass – technological and market realities]. *Stroitel'nye materialy*, 2015, no. 1, pp. 17–23 (in Russian).
3. Onishchuk V. I., Zhernovaya N. V., Min'ko N. I., et al. Stroitel'nye materialy na osnove stekloboya [Construction materials based on cullet]. *Steklo i keramika*, 1999, vol. 56, no. 1, pp. 5–7 (in Russian).
4. Musafirova G. Ya., Grushevskaya E. N., Musafirov E. V., et al. Modifikatsiya cementnogo vyazhushhego dispersnoy dobavkoj vtorichnogo poliamida [Modification of cement binder by the dispersed additive of secondary polyamide]. *Tekhnika i tekhnologiya silikatov*, 2015, vol. 22, no. 3, pp. 2–5 (in Russian).
5. Cherkasov A. V. Maloyenergoemkaya tekhnologiya vyazhushhikh kompoziciy s upravlyaemym rasshireniem na osnove magniysoderzhashhikh materialov [Low power technology of binding compositions with a controlled expansion of the magnesium-based materials]. *Dissert. kand*. *tekhn. nauk*. − Belgorod, 2006, 17 p (in Russian).
6. Jur'ev Yu. L. *Drevesnyy ugol'. Spravochnik* [Charcoal. Directory]. Ekaterinburg: Sokrat, 2007, 184 p (in Russian).
7. Smoliy V. A., Kosarev A. S., Yatsenko E. A. Zavisimost' reakcionnoy i vspenivayushhey sposobnosti kompozitsiy organicheskikh i neorganicheskikh poroobrazovateley yacheistogo teploizolyatsionnogo stroitel'nogo steklomateriala ot ikh sootnosheniya i svoystv [Dependence of the reaction and foaming ability of compositions organic and inorganic porous steam generators of cellular heat-insulating construction glass material from their ratio and properties]. *Tekhnika i tekhnologiya silikatov*, 2015, vol. 22, no. 4, pp. 7–12 (in Russian).
8. Patent RF 2060238. *Sposob izgotovleniya vspuchennogo silikatnogo materiala* [Method of manufacturing exfoliated silicate material]. Kozlov V. E., Pasechnik I. V., Goremykin A. V., et al. Declared 21.02.1995. Published 20.05.1996. Bulletin no. 16 (in Russian).
9. Lyshchik M. V., Musafirova G. Ya. Penosteklo – ehkologichnyy i energosberegayushhiy material [Foam glass – eco-friendly and energy-saving material]. *Stroitel'stvo i vosstanovlenie iskusstvennykh sooruzhenii*: *materialy IV Mezhdunar. nauch.-prakt. konf. Gomel'*: BelGUT, 2015, pp. 271–276 (in Russian).

Article 3

Molchan N. V., Krivoborodov Yu. R., Fertikov V. I.
The interaction of water with oxides, forming hydroxides and crystal hydrates
Molchan N. V. (nimolchan@mail.ru), Candidate of Pharmaceutical Sciences, Researce & Production Center «Pharmaceutical Protection», Khimki, Moscow region; *Krivoborodov Yu. R.,* Doctor of Technical Sciences, prof., D. Mendeleev University of Chemical Technology, Moscow; *Fertikov V. I.*, Candidate of Biological Sciences, All-Russia Institute of Light Alloys, Moscow

Key words: concentration of electrons, density, enthalpy, hydroxides, crystalline hydrates, structure

Abstract

It is given the technique of calculation of the coefficients of compaction and electron concentration to the crystalline hydrates and hydroxides on the basis of reference data on the density of matter in the condensed state. The obtained data allow to analyze the mechanism of formation of the structure of hydroxides and crystalline hydrates to further predict the characteristics of the created materials. Revealed a number of dependencies with correlation coefficients above critical. On the basis of the conducted calculations it is proposed to use the coefficient of consolidation and the concentration of electrons as the structural characteristics of materials.

References

1. Molchan N. V., Fertikov V. I. Determination of Concentration of Electrons for Description of the Structure of Materials, with Sulfides as an Example. *Journal of Materials Sciences and Applications*, 2015, vol. 1, no. 2, pp. 38-44.
2. Molchan N. V., Fertikov V. I. Kontsentratsiya ehlektronov kak strukturnaya kharakteristika oksidov [Concentration of electrons as a structural characteristic of oxides]. *Tekhnika i tekhnologiya silikatov*, 2016, vol. 23, no. 2, pp. 8–13 (in Russian).
3. Molchan N. V., Fertikov V. I. Interrelation of Thermodynamic Parameters and Structural Characteristics, with Halides of Groups 1 and 2 Elements as an Example. *American Journal of Chemistry and Application*, 2016, vol. 3, no. 5, pp. 28–32.
4. *Kratkaya entsiklopediya po structure materialov* [Brief encyclopedia on the structure of materials]. Ed. by D. V. Martin. Moscow: Tekhnosfera, 2011, 608 p (in Russian).
5. Sirotkin O. S. *Osnovy innovatsionnogo materialovedeniya* [Fundamentals of materials innovation]. Moscow*:* INFRA-M, 2011, 158 p (in Russian).
6. Molchan N., Eliseev D., Fertikov V. Control of Nickel Alloy Structural Change by the Atomic Emission Spectroscopy Method. *American Journal of Analytical Chemistry*, 2016, vol. 7, no. 9, pp. 633–641.
7. International Centre for Diffraction Data. *JCPDS PCPDFWIN*, 2002. V. 2.03.
8. *Novyy spravochnik khimika i tekhnologa. Osnovnye svoystva neorganicheskikh, organicheskikh i elementoorga-nicheskikh soedineniy* [The new reference book for chemist and technologist. The basic properties of inorganic, organic and element organic compounds]. St.-Petersburg: Professional, 2007, 1276 p (in Russian).
9. Babichev A. P., Babushkina N. A., Bratkovskiy A. M., et al. *Fizicheskie velichiny: spravochnik* [Physical quantities: reference book]. Ed. by I. S. Grigor’ev, E. Z. Meylikhov. Moscow: Energoatomizdat, 1991, 1232 p (in Russian).
10. Molchan N. V., Fertikov V. I. Metod ocenki reakcionnoj sposobnosti vodoroda, bora, ugleroda i azota [Method of evaluating the reactivity of hydrogen, boron, carbon and nitrogen]. *Tekhnologiya legkikh splavov*, 2009, no. 2, pp. 47–56 (in Russian).
11. Molchan N. V., Fertikov V. I. Szhimaemost' veshhestv i razmery atomov [Compressibility of substances and sizes of atoms]. *Materialovedenie*, 2011, no. 6, pp. 2–6 (in Russian).
12. Lidin R. A., Andreeva L. L., Molochko L. L. *Konstanty neorganicheskih veshchestv: spravochnik* [Constants of inorganic substances: reference book]. Ed. by R. A. Lidin. Moscow: Drofa, 2006, 685 p (in Russian).
13. Myuller P., Noyman P., Shtorm R. *Tablitsy po matematicheskoy statistike* [Tables of Mathematical Statistics]. Moscow: Finansy i statistika, 1982, 278 p (in Russian).

Article 4

Potapova E. N.
Implementation of projects on integrated environmental permits to Russian enterprises in the form of a business game

Potapova E. N. (55pen@mail.ru), Doctor of Technical Sciences, prof., D. Mendeleev University of Chemical Technology, Moscow

Key words: environmental protection, best available techniques, complex ecological permissions

Abstract

Reviewed the proposed procedure for issuing integrated environmental permits in the Russian Federation. Working out the order and procedures for issuing integrated permits is currently implemented in the format of «business games». Examples of some of the business games.

References

1. Mezentsev O. V, Skobelev D. A. Vnedrenie nailuchshikh dostupnykh tehnologiy kak element sistemy kompleksnogo predotvrashheniya i kontrolya za negativnym vozdeystviem na okruzhayushhuyu sredu [Implementation of the best available technologies as part of an integrated system of prevention and control over the negative impact on the environment]. *Nailuchshie dostupnye tekhnologii. Primenenie v razlichnykh otraslyah promyshlennosti. Sbornik statey.* M.: Izd-vo «Pero», 2014, pp. 24–31 (in Russian).
2. Potapova E. N. Kontsepciya perehoda k normirovaniyu negativnogo vozdeystviya na okruzhayushhuyu sredu na osnove nailuchshikh dostupnykh tekhnologiy [The concept of transition to rationing of negative impact to environment on the basis of the best available technologies]. *Tekhnika i tekhnologiya silikatov,* 2016, vol. 2, no. 2. pp. 2–8 (in Russian).
3. Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and Control. *Official Journal*, 1996, vol. 39, 10 October 1996, L 257, pp. 0026–0040.
4. Directive 2010/75/EC on industrial emissions (integrated pollution prevention and control) [Electronic resource]. URL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:334:0017:0119:EN:PDF (accessed 25.12.2015).
5. *Federal'nyy zakon Rossiyskoy Federatsii ot 10 yanvarja 2002 g. № 7-FZ «Ob ohrane okruzhayushhey sredy» (s izmeneniyami na 3 iyulya 2016 goda.).* [The federal law of the Russian Federation of January 10, 2002 No. 7-FZ «About environmental protection» (with changes on July 3, 2016)] (in Russian).
6. *Federal'nyy zakon Rossiyskoy Federatsii ot 21 iyulya 2014 g. N 219-FZ «O vnesenii izmeneniy v Federal'nyy zakon «Ob ohrane okruzhajushhey sredy» i otdel'nye zakonodatel'nye akty Rossiyskoy Federatsii».* [The federal law of the Russian Federation of July 21, 2014 N 219-FZ «About modification of the Federal law» About environmental protection» and separate acts of the Russian Federation»] (in Russian).
7. *Postanovlenie Pravitel'stva RF № 1029 ot 28 sentyabrya 2015 g. «Ob utverzhdenii kriteriev otnesenyya ob'ektov, okazyvayushhikh negativnoe vozdeystvie na OS, k ob'ektam I, II, III i IV kategoriy».* [RF Government Decree № 1029 of September 28, 2015 «On approval of the criteria for classifying objects that have a negative impact on the environment, to the objects I, II, III and IV categories»] (in Russian).
8. *Informatsionno-tekhnicheskiy spravochnik po nailuchshim dostupnym tekhnologjyam* [Information and technical reference book on the best available tekhnologii]. [Elektronnyy resurs]. URL: http://www.gost.ru/wps/portal/pages/directions?WCM_GLOBAL_CONTEXT=/gost/GOSTRU/directions/ndt/ndt/ sprav_NDT_2015 (accessed 25.12.2015) (in Russian).
9. Guseva T. V., Molchanova Ya. P., Begak M. V., et al. Nailuchshie dostupnye tekhnologii v proizvodstve keramicheskikh izdeliy: potentsial'nye vozmozhnosti i riski [Best available technology in the production of ceramic products: the potential opportunities and threats Best Available Technologies]. *Nailuchshie dostupnye tekhnologii. Primenenie v razlichnyh otrasljah promyshlennosti. Sbornik statej 2.* M.: Izd-vo «Pero», 2015, pp. 87–92 (in Russian).
10. *Nailuchshie dostupnye tekhnologii i kompleksnye ekologicheskie razresheniya: perspektivy primeneniya v Rossii: pod red. M. V. Begaka* [Best available techniques and integrated environmental permits: application prospects in Russia. Ed. M. V. Begak]. M.: OOO «YurinfoR-Press», 2010, 220 p (in Russian).
11. Begak M. V., Guseva T. V., Molchanova Ya. P., et al. Challenges of the Environmental Reform in Russia*. 16 International Multidisciplinary scientific Geoconference SGEM 2016, 30 June – 6 July 2016*, Albena, Bulgaria. – Book 5, vol. 1, pp. 133–140.

Article 5

Zaw Ye Maw Oo
High-porous permeable cellular materials of the corundum ceramics
Zaw Ye Maw Oo (zawyemawoo@gmail.com), doctoral candidate, D. Mendeleev University of Chemical Technology of Russia, Moscow

Key words: ceramics, open porosity, cellular materials, strength, granular powders

Abstract

The resulting samples are highly porous materials with cellular structure on the basis of alumina GN-1, with a grain size of 40-60 microns and the reinforcing component of porcelain PFL-1. The most durable samples with cell sizes of approximately 0.3–0.5 and 0.8–1 mm, respectively, was obtained from a composition of 50% alumina and 50% of the porcelain after firing at 1450 °C. These samples had a porosity of 88-94%, the compressive strength is 2.3 to 3.5 MPa. The open porosity in the jumpers was 40-50%, the average pore radius is in the jumpers of 1-2 μm.

References

1. Berkman A. S. *Poristaja pronicaemaja keramika* [Porous permeable ceramics]. M.: Strojizdat, 1969. – 170 p (in Russian).

2. Twigg M. V., Richardson J. D., et al. Preparation and properties of ceramic foam catalyst supports. *Preparation of catalysts VI (Elsevier Amsterdam, The Netherland)*. 1994, pp. 345–359.
3. Belyakov A. V., Bakunow V. S. Evolyutsiya struktury v peredelakh tekhnologii keramiki [Evolution of the structure within the ceramic technology]. *Novye ogneupory,* 2006, no. 2, pp. 55–62 (in Russian).
4. Bruno G., Pozdnyakova I., Efremov A. M., et al. Thermal and mechanical response of industrial porous ceramics. *Mater. Sci. Forum,* 2010, vol. 652, pp. 191–196.
5. Zhao C. Y. Review on thermal transport in high porosity cellular metal foams with open cells. *International journal of heat and mass transfer,* 2012, vol. 55, no. 13, pp. 3612–3638.
6. Gibson L. J., Ashby M. F. Cellular solids, structures and properties. Pergamon press, Oxford, UK. 1988, 111 p.
7. Official site. Production and trading company «GZHEL CERAMICS» [Elektronnyy resurs]. URL: http://ceramgzhel.ru/poleznaya-infor/markirovka-keramicheskix.html.
8. Sabrina S. A., Denilson A. S. Physico-chemical analysis of flexible polyurethane foams containing commercial calcium carbonats. *Materials research,* 2008, vol. 11, no. 4, pp. 8–12
9. Lin Y. M., Li C. W., Wang C. A. Effects of mullite content on the properties and microstructures of porous Anorthi-mullite composite ceramics. *Journal of inorganic materials*, 2011, vol. 26, no. 10, pp. 1095–1100.

Article 6

Belyakov A. V., Zaw Ye Maw Oo, Popova N. A., Ye Aung Min

The gas permeability of the porous alumina ceramics with reinforcing additives based on corundum and systems SiC–MgO

Belyakov A. V. (av_bel@bk.ru), Doctor of Technical Sciences, prof., *Zaw Ye Maw Oo***,** doctoral candidate, Popova N. A**.,** senior lecturer, *Ye Aung Min,* graduate student, D. Mendeleev University of Chemical Technology of Russia, Moscow

Key words: ceramics, open porosity, strength, grainy powders, electrofusion corundum, ceramic filters, gas permeability

Abstract

Studied solid porous permeable ceramics obtained the selection of granular compositions filled with electrofusion corundum brands F600 (100–120 μm), F360 (40–60 μm) and F120 (10–20 μm). As the reinforcing binders, which was added in an amount of 3 and 5 wt. % in excess of 100%, applied fine powders of corundum (about 2 μm) doped with 0,25 wt. % MgO and a mixture of SiC powders (particle size 3–4 μm), and MgO (particle size1–2 μm) at a ratio of 2:1.Compositions of grainy mass prepared with different ratios of filler at fractions 10–20, 40–60 and 100–120 μm: 40/10/50 and 80/15/5. Samples were pressed by a pressure of 25 MPa and fired at 1450, 1500 and 1550 °C. The flexural strength of sintered samples varied from 5,7 to 36 MPa, open porosity – from 28,5 to 43,7%, and the gas permeability coefficient for compositions with a binder of systems SiC–MgO (2:1) – from 0,93 to 1,7 μm^2 and binder of Al_2O_3 (MgO) – 1,62 to 0,9 μm^2. The resulting perspective ceramics for use as filters and membranes of ceramic substrates.

References

1. Berkman, A. S. *Poristaja pronicaemaja keramika* [Porous permeable ceramics]. M.: Stroyizdat, 1969, 170 p (in Russian).
2. Feng, H., Zhaoxiang H. High gas permeability of SiC porous ceramics reinforced by mullitebibers. *Journal of the European Ceramic Society,* 2016, vol. 36, no. 16, pp. 3909–3917.
3. Bruno G., Pozdnyakova I., Efremov A. M., et al. Thermal and mechanical response of industrial porous ceramics. *Mater. Sci. Forum*, 2010, vol. 652, pp. 191–196.
4. Guzman I. Ya. *Vysokoogneupornaya poristaya keramika* [High-refractory porous ceramics]. M.: Metallurgy, 1971, 283 p (in Russian).
5. Andrianov N. T., Belkevich V. L., Belyakov A. V., et al. *Praktikum po khimicheskoy tekhnologii keramiki: ucheb. posobie dlya vuzov: pod red. I. Ya. Guzmana* [Workshop on chemical technology of ceramicsю. The allowance for high schools. Edited by I. Ya. Guzman]. M.: OOO RIF «Stroimaterialy», 2005, 336 p (in Russian).
6. Belyakov A. V., Bakunov V. S. Evolyutsiya struktury v peredelakh tekhnologii keramiki [Structural evolution in ceramic technology and processing]. *Novye ogneupory* , 2006, vol. 47, no. 1, pp. 48–52.(in Russian)
7. Belyakov A. V. Eevolyutsiya struktury v peredelakh tekhnologii keramiki [Structure evolution in ceramic technology and processing]. *Novye ogneupory,* 2006, no. 2, pp. 55–62 (in Russian).
8. Guzman I. Ya., Sysoev E. P. *Tekhnologiya poristykh keramicheskikh materialov i izdeliy* [Technology of porous ceramic materials and products]. Tula: Priokskoe book publishing house, 1975, 196 p (in Russian).

9. Tomilina E. M., Pronina O. V., Lukin E. S., et al. Poristaya prochnaya keramika na osnove oksida alyuminiya [Durable porous ceramics based on aluminum oxide]. *Steklo i keramika*, 2000, vol. 57, no. 6, pp. 23–24 (in Russian).