STUDY OF THE IMPACT OF THERMAL TRANSFORMATIONS OF FOAMABLE COMPOSITION COMPONENTS ON THEIR FIRE-THERMAL PROTECTION PROPERTIES

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Abstract: Comparative studies of the qualitative and quantitative composition of thermally expandable composites based on ethylene vinyl acetate copolymer have been carried out and the important role of mineral fillers in the formation of thermally insulating porous structures has been determined. Mineral silicates, thermally expandable graphite and/or fire-retardant gas-coke-forming systems, including amine, metal- and/or phosphorus-containing compounds, are used as fillers in the composites. To study the physicochemical, operational, thermal, and fire-thermal insulation properties, standard and original laboratory techniques were used. It has been established that the required fire-thermally insulating and operational properties of graphite containing expandable polymer composites can be achieved by the balanced presence of inert silicate and gas-coke-forming agents in their formulation. Optimization of the formulation makes it possible to simultaneously improve the elastic and physico-mechanical properties of both the initial thermoexpandable composites and their coke residues.

Keywords: thermally expandable polymer composite; gas-coke-forming system; thermally expandable graphite; inert fillers; fire-thermally insulating efficiency; physico-mechanical and thermal properties; flammability group

DOI: 10.30826/CE20130411

Figure Captions

Figure 1 The DSC (*a*) and TG (*b*) data for film-forming system (*1*) and thermofoamable compositions TFC1 (*2*), TFC5 (*3*), and TFC6 (*4*)

Figure 2 The DSC data for gas-coke-forming systems for TFC1 (*1*) and TFC5 (*2*) and fillers (mica+wollastonite) for TFC6 (*3*)

Table Captions

Table 1 Results of flammability tests according to GOST 12.1.044 of thermofoamable compositions (TFCs)

Table 2 Physico-chemical and physico-mechanical properties of TFCs and their thermolysis products

Table 3 Data from thermal studies of the film-forming system and thermofoamable compositions

References

1. Pavlovich, A. V., V. V. Vladenkov, V. N. Izyumsky, and S. L. Kil'chitskaya. 2012. Ognezashchitnye vspuchivayushchiesya pokrytiya po metallu [The fire-protective intumescent coatings for metal substrates]. *Lakokrasochnaya promyshlennost'* [Paint and Coatings Industry] 11:22–29.
2. Garashchenko, A. N., A. A. Berlin, and A. A. Kul'kov. 2019. Sposoby i sredstva obespecheniya trebuemykh pokazateley pozharobezopasnosti konstruktsiy iz polimernykh kompozitov (obzor) [Methods and means for providing required fire-safety indices of polymer composite structures]. *Pozharovzryvobezopasnost'* [Fire Explosion Safety] 28(2):9–30. doi: 10.18322/pvb/2019.28.02.9-30.
3. Strakhov, V. L., A. M. Krutov, and N. F. Davydkin. 2000. *Ognezashchita stroitel'nykh konstruktsiy* [Fire protection of building structures]. Moscow: TIMR. 473 p.
4. Sobur', S. V. 2008. *Ognezashchita materialov i konstruktsiy* [Fire protection of materials and structures]. Ser. Pozharnaya bezopasnost' predpriyatiya. [Ser. Fire safety of the enterprise]. Moscow: Pozhkniga. 200 p.
5. Kosachev, A. A., and B. B. Kolchev. 2014. Primenenie protivopozharnykh muft [Application of fire clutches]. *Stroyprofi* 1(18):50–55. Available at: http://stroyprofi.info/archive/11481 (accessed November 14, 2020).
6. Yasir, M., F. Ahmad, P. S. Yusoff, S. Ullah, and M. Jimenez. 2020. Latest trends for structural steel protection by using intumescent fire protective coatings: A review. *Surf. Eng.* 36(4):334–363. doi: 10.1080/02670844.2019.1636536.
7. Myuller, B., and U. Pot. 2007. *Lakokrasochnye materi-*

aly i pokrytiya. Printsipy sostavleniya retseptur [Paints and varnishes and coatings. Formulation principles]. Moscow: Peynt-media. 237 p.

8. Shatalin, S. S., A. V. Varlamov, O. A. Zybina, and S. S. Mnatsakanov. 2014. O svyazuyushchikh v ognezashchitnykh vspuchivayushchikhsya kompozitsiyakh [About binders in fire retardant intumescent compositions]. *Dizayn. Materialy. Tekhnologiya* [Design. Materials. Technology] 4(34):52–54.
9. Feng, C., M. Liang, W. Chen, J. Huang, and H. Liu. 2015. Flame retardancy and thermal degradation of intumescent flame retardant EVA composite with efficient charring agent. *J. Anal. Appl. Pyrol.* 113:266–273. doi: 10.1016/j.jaap.2015.01.021.
10. Berlin, A. A., S. A. Vol'fson, V. G. Oshmyan, and N. S. Enikolopova. 1990. *Printsipy sozdaniya kompozitsionnykh polimernykh materialov* [Principles of creation of composite polymeric materials]. Moscow: Khimiya. 240 p.
11. Gerasimova, L. G., and O. N. Skorokhodova. 2010. *Napolniteli dlya lakokrasochnoy promyshlennosti* [Fillers for the paint and varnish industry]. Moscow: LKM-press. 224 p.
12. Lobanova, M. S., V. F. Kablov, N. A. Keybal, S. N. Bondarenko, and A. N. Garashchenko. 2013. Ognezashchitnye vspuchivayushchiesya pokrytiya na osnove perkhlorvinilovoy smoly dlya stekloplastika [Flame retardant intumescent coatings based on perchlorovinyl resin for fiber-glass]. *Izvestiya YuFU. Tekhnicheskie nauki* [Izv. SFedU. Eng. Sci.] 8:207–210.
13. Kablov, V. F., O. M. Novopoltseva, V. G. Kochetkov, and A. G. Lapina. 2016. Osnovnye sposoby i mekhanizmy povysheniya ogneteplozashchitnoy stoykosti materialov [The main ways and mechanisms to improve fire- and heat resistance of materials]. *Izvestiya Volgogradskogo tekhnicheskogo universiteta* [B. Volgograd Technical University] 4:46–60.
14. Bourbigot, S., J. Sarazin, T. Bensabath, F. Samyn, and M. Jimenez. 2019. Intumescent polypropylene: Reaction to fire and mechanistic aspects. *Fire Safety J.* 105:261–269. doi: 10.1016/j.firesaf.2019.03.007.
15. Sorokina, N. E., V. V. Avdeev, A. S. Tikhomirov, M. A. Lutfullin, and M. I. Saidaminov. 2010. *Kompozitsionnye nanomaterialy na osnove interkalirovannogo grafita* [Composite nanomaterials based on intercalated graphite]. Moscow. 50 p.
16. Dasaria, A., Z.-Z. Yub , G.-P. Caic, and Y.-W. Maic 2013. Recent developments in the fire retardancy of polymeric materials. *Prog. Polym. Sci.* 38:1357–1387.
17. Nenakhov, S. A., and V. P. Pimenova. 2010. Fiziko-khimiya vspenivayushchikhsya ognezashchitnykh pokrytiy na osnove polifosfata ammoniya. Obzor literatury [Physico-chemical of foaming fire-retardant coatings based on ammonium polyphosphate. Review of the literature]. *Pozharovzryvobezopasnost'* [Fire Explosion Safety] 19(8):11–58.
18. Krasheninnikova, M. V. 2008. Tendentsii i perspektivy razrabotki kompozitsiy vspuchivayushchikhsya ognezashchitnykh pokrytiy dlya povysheniya predelov ognestoykosti stroitel'nykh konstruktsiy [Trends and prospects for the development of compositions of intumescent fire retardant coatings to increase the limits of fire resistance of building structures]. *Pozharovzryvobezopasnost'* [Fire Explosion Safety] 2:36–39.
19. Antonov, A. V., I. S. Reshetnikov, and N. A. Khalturinskij. 1999. Combustion of coke-forming polymeric systems. *Russ. Chem. Rev.* 68(7):605–614.
20. Strakhov, V. L., A. N. Garashchenko, G. V. Kuznetsov, and V. P. Rudzinskii. 2001. Mathematical simulation of thermophysical and thermochemical processes during combustion of intumescent fire-protective coatings. *Combust. Explo. Shock Waves* 37(2):178–186.
21. Bogdanova, V. V., and O. I. Kobets. 2018. Ogne-termozashchitnye svoystva termovspenivayushchikhsya kompozitov na osnove poliolefinov v zavisimosti ot prirody i soderzhaniya napolniteley [Fire-thermo-insulating properties of intumescent composites based on polyolefins depending on nature and content of fillers]. *Polimernye materialy i tekhnologii* [Polymer Materials Technologies] 4(4):64–71. doi: 10.32864/polymmattech-2018-4-4-64-71.
22. Zybina, O. A., A. V. Varlamov, N. S. Chernova, and S. S. Mnatsakanov. 2009. On the role and transformations of components of intumescent fire-retardant paint-and-varnish formulations in the course of thermolysis. *Russ. J. Appl. Chem.* 82(4):1542–1546.
23. Weil, E. D. 2011. Fire-protective and flame-retardant coatings — a state-of-the-art review. *J. Fire Sci.* 29:259–286. doi: 10.1177/0734904110395469.
24. Mitina, E. L., and S. L. Barbot'ko. 2012. Vliyanie antipirenov na goryuchest' dekorativnykh rezin na osnove kombinatsii butadien-stirol'nogo i butadienovogo kauchukov [Influence of fire retardants on the flammability of decorative rubbers based on a combination of styrene–butadiene and butadiene rubbers]. *Klei. Germetiki. Tekhnologii* 3:1–9.
25. Ranta-Korpi, M., J. Konttinen, A. Saarimaa, and M. Rodriguez. 2014. Ash forming elements in plastics and rubbers / Ed. P. Vainikka. Finland: VTT Technical Research Center. 131 p.
26. Rudakova, T. A., Yu. M. Yevtushenko, Yu. A. Grigoryev, and A. A. Batrakov. 2015. Puti snizheniya temperatury penoobrazovaniya v sisteme polifosfat ammoniya – pentaeritrit v intumestsentnykh sistemakh [Ways of reducing the temperature of foaming in the system ammonium polyphosphate – pentaerythritol in intumescent systems]. *Pozharovzryvobezopasnost'* [Fire Explosion Safety] 24(3):24–31.
27. GOST 11722-78. 1979. Rezina gubchataya. Metod opredeleniya ostatochnogo szhatiya [Spongy rubber. Compression set method]. Moscow: Izdatel'stvo standartov. 12 p.
28. GOST 12.1.044-89 (ISO 4589-84). 2006. Sistema standartov bezopasnosti truda. Pozharovzryvoopasnost' veshchestv i materialov. Nomenklatura pokazateley i metody ikh opredeleniya [Occupational safety standards system. Fire and explosion hazard of substances and materials.

Nomenclature of indicators and methods for their determination]. Moscow: Standartinform. 104 p.

29. GOST R 53306-2009. 2009. Uzly peresecheniya ograzhdayushchikh stroitel'nykh konstruktsiy truboprovodami iz polimernykh materialov. Metod ispytaniy na ognestoykost' [Nodes of intersection of enclosing building structures with pipelines made of polymeric materials. Fire resistance test method]. Moscow: Standartinform. 7 p.

Received November 14, 2020

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