

Multifunctional single-layer coating on a base of silicon Sylgard-184 elastomer

V.G. Borisenko, E.V. Timakov, L.A. Andryushchenko, A.M. Kudin,
M.M. Goroneskul

*National University for Civil Defence of Ukraine,
94 Chernyshevskya Str., Kharkiv 61023, Ukraine, vitgbor7@gmail.com*

Silicone elastomer coatings are widely used to protect substrates from the negative effects of the atmosphere, especially fabrics, among which particularly stringent requirements are placed on the woven frame of a fire hose. In the last decade, there has been great interest in the development of polymer coatings that can simultaneously perform several functions, such as heat and fire protection, waterproofing, luminescent film, *etc.* The decorative function is also important, it is highly desirable that fire hoses have a bright color and were clearly visible under artificial lighting. As a rule, the protective coating is multilayer, each sublayer performs a specific function [1]. Such a coating structure leads to an increase in film thickness and product weight. Development of multifunctional protective coatings of minimum thickness is an urgent problem of modern technology [2].

It has been shown that number of sublayers in protective film can be reduced to one by combining several functions. It means that under certain conditions the thickness and weight of coating can be minimized. On a base of Sylgard-184 silicon elastomer a composition for single-layer protective coating is proposed for fire hoses. This composition contains Coumarin-7 as a luminescence dopant and a filler in form of halloysite nanotubes as an adhesion promoter.

It has been shown that proposed coating successfully protect the substrate against negative effects of UV-light and atmosphere oxygen and ozone. In addition to the protective function, such a coating successfully performs the function of a fire-retardant layer, a bright yellow decor, an adhesion promoter that prevents the coating from peeling off the lining, as well as a fluorescent film of green emission.

It is shown that the mechanical characteristics of the obtained samples do not change after climatic tests. This result, together with the improvement of the adhesion, as well as high weather and fire resistance of the samples, allows us to predict an increase in the service life of the fire hoses.

1. L. Andryushchenko, V. Borisenko, M. Goroneskul, A. Kudin. Emergency situations: prevention and elimination. **5**(2) (2021) 5.
2. M.M. Goroneskul, L.A. Andryushchenko, A.M. Kudin, *et al.* Method of application of luminescence coating. Patent 147605 UA. Bul. No **21** (26.05.2021).

Possible mechanism for increasing the fire resistance of a polymer coating filled with diatomaceous biosilica

A.M. Kudin¹, L.A. Andryushchenko¹, V.G. Borisenko¹, M.M. Goroneskul¹,
I. Wojtczak², W. Brzozowska³, E. Olewnik-Kruszkowska², M. Sprynskyy²

¹National University for Civil Defence of Ukraine,
94 Chernyshevska Str., Kharkiv 61023, Ukraine, a.m.kudin@gmail.com

²Nicolaus Copernicus University,
7 Gagarina Str., 87-100 Toruń, Poland, mspryn@umk.pl

³Institute of Marine and Environmental Sciences, University of Szczecin,
Mickiewicza 16, 70-383 Szczecin, Poland, weronika.brzozowska@phd.usz.edu.pl

Polymer coatings are widely used in various fields of technology to protect the substrate from the negative effects of the atmosphere. Usually, coatings perform several functions, in particular thermal and fire protection. It was recently shown [1] that introduction of diatomaceous biosilica to the silicone polymer significantly improves the heat resistance of the protective film. According to our data, it also increases the fire resistance of the coating.

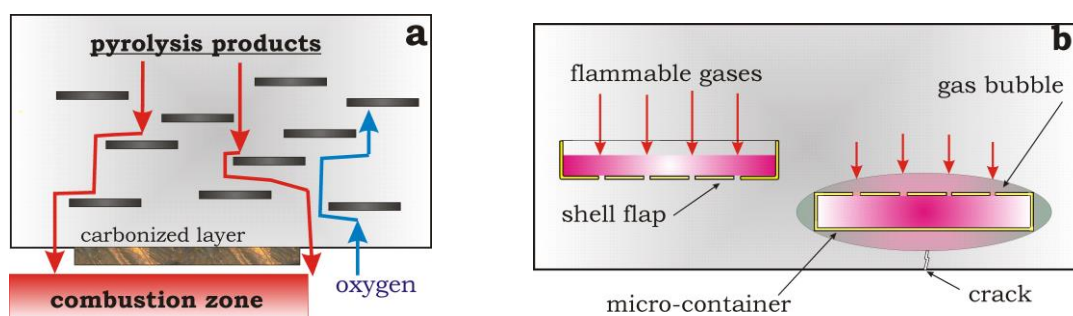


Fig. Scheme of the barrier (a) and the proposed mechanism (b) of flame retardation

A known barrier mechanism for increasing the fire resistance of polymers is characteristic of fillers in the form of plates or scales. Flakes of the filler prevent the oxygen diffusion into polymer and hinder the transport of gaseous products of pyrolysis, see scheme in Fig. a. Particles of diatomic biosilica (shells of algae) are micro-containers with a diameter of $\sim 4 \mu\text{m}$. Individual shell flaps, which are similar in shape to a Petri dish, are perforated with an ordered system of pores 150-200 nm in diameter. The filler serves as a natural sink for combustible decomposition products, as shown in Fig. b. If the average distance between the particles is less than the thickness of the sample, then the primary sink for combustible gases will be not the film surface, but the filler particles, which play the role of a flame retardant.

1. E. Olewnik-Kruszkowska, W. Brzozowska, A. Adamczyk, M. Gierszewska, I. Wojtczak, M. Sprynskyy. *Energies*. **13** (2020) 5828.

Thermal and fire resistance of luminescent coating on a base of silicon elastomer with diatomaceous biosilica filler

A.M. Kudin¹, L.A. Andryushchenko¹, V.G. Borisenko¹, M.M. Goroneskul¹, I. Wojtczak², W. Brzozowska³, E. Olewnik-Kruszkowska², M. Sprynskyy²

¹National University for Civil Defence of Ukraine,
94 Chernyshevska Str., Kharkiv 61023, Ukraine, a.m.kudin@gmail.com

²Nicolaus Copernicus University,
7 Gagarina Str., 87-100 Toruń, Poland, mspryn@umk.pl

³Institute of Marine and Environmental Sciences, University of Szczecin,
Mickiewicza 16, 70-383 Szczecin, Poland, weronika.brzozowska@phd.usz.edu.pl

Protective luminescent coatings are widely used in various fields of technology, in particular, to create evacuation sign systems. The multifunctionality of coating (as luminescent film, fire protection, insulation against negative effects of the atmosphere, decor layer, *etc.*) is usually achieved by increasing the number of its layers. Ensuring thermal and fire resistance of sign systems in harsh operating conditions is an urgent problem of modern materials science. It is clear that the fire resistance of the protective coating should be no less than the stability of the polymer substrate, preferably without increasing the thickness and weight of the coating. The realization of this goal involves the use of fillers capable of performing several functions [1].

It has been shown [2] that Diatomaceous Biosilica is a promising filler. The introduction of such additive into the Sylgard-184 polymer slows down the process of polymer thermal decomposition, so the $T_{30\%}$ (temperature which corresponds to 30% of the mass loss) increases by more than 140°C. In addition, the additive has intensive green luminescence. The undoubted advantage of the filler is also that it significantly improves the elastic properties of the polymer base, primarily the tensile strength of the resulting protective film.

Based on the transparent in UV-range silicon SKTN-med elastomer with a noted filler (2 and 5 w.% of Diatomaceous Biosilica), heat- and fire-retardant protective coatings were obtained. Samples exhibit strong green fluorescence at $\lambda_{em} = 530$ nm, which is excited by UV-light at $\lambda_{ex} = 265$ nm. Standard fire tests showed ignition time of ~200 s vs. 120 s for unfilled samples. It should be noted that weight of composition with filler decrease compare to pure SKTN-med due to small density of Diatomaceous Biosilica powder. This circumstance favorably distinguishes a promising filler from traditional ones.

1. L. Andryushchenko, V. Borisenko, M. Goroneskul, A. Kudin. Emergency situations: Prevention and Elimination. **5** 2 (2021) 5.
2. E. Olewnik-Kruszkowska, W. Brzozowska, A. Adamczyk, M. Gierszewska, I. Wojtczak, M. Sprynskyy. Energies. **13** (2020) 5828.