Possible Mechanism for Increasing the Fire Resistance of a Polymer Coating Filled with Diatomaceous Biosilica

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Introduction. 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 [1]. It was recently shown [2] that introduction of diatomaceous biosilica (DB) to the silicone polymer significantly improves its heat resistance, see Fig. 1.

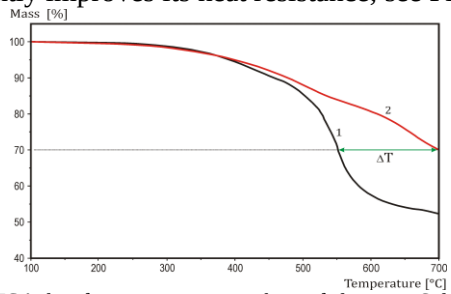

Fig. 1. TGA data for composition on a base of elastomer Sylgard-184 without filler (1) and Sylgard-184 with 3% of diatomaceous biosilica (2)

The goal of presentation is to study both the thermo- and fire- resistance of silicon coating on a base of Sylgard-184 compound with BD filler and propose the explanation of BD effect on characteristics of coating.

Experimental. Thermal resistance has been studied using TGA analysis, the SDT 2960 Simultaneous TGA-DTA by TA Instruments was used. Experiments were performed in nitrogen atmosphere with a heating rate of 10°C/min in the temperature range 20…700°C. Fire retardant tests has been carry out according for the UL 94 requirement, see Fig. 2a. In our case the sample of 17×21 cm size has been used. A propane gas flame with a height of 20 mm has been brought into contact with the specimen at an angle of 45°. The application point is at the center of specimen. Photo of samples with coating of "Sylgard+ BD" after testing are also presented at Fig. 2b and 2c.

Results and discussion. According to our data the protect coating on a base of elastomer Sylgard-184 with a DB filler increases also the fire resistance of the fabric. It can be concluded that the application of "Sylgard+DB" coating on aramid fabric leads to the fact that fabric retains its integrity after 360s of exposure to open flame. Moreover, the fabric partially retains elasticity even at the site of exposure to an open flame, i.e. in the region of maximum temperature. At the same time, the specimen without filler burns out after 240s. The term "burns through" here means the appearance of cracks and the subsequent destruction (shedding of the sample) of the tissue [3] in the area of exposure to an open flame.

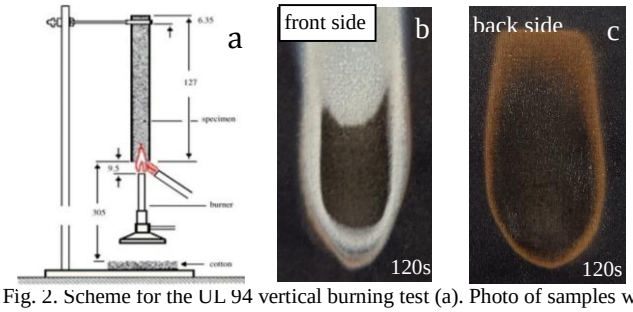

Fig. 2. Scheme for the UL 94 vertical burning test (a). Photo of samples with "Sylgard-184 + BD filler" after test: image of front (b) and back side (c)

On a base of obtained results the possible mechanism of DB effect on thermal and fire resistance is proposed, see Fig.3. According to the proposed mechanism, combustible gases can accumulate in a closed (semi-closed) volume of filler particles.

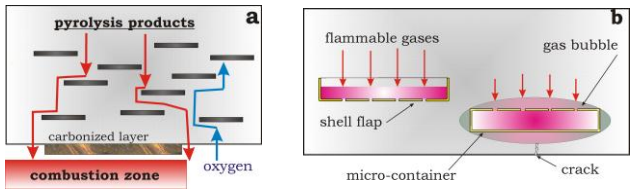

Fig.3. Scheme of the barrier (a) and the proposed mechanism (b) of flame retardation

The DB particles looks like a Petri dish. If the average distance between the particles is less than the thickness of the coating, then the primary sink for combustible gases will be not the film surface, but the micro-containers of a filler. With prolonged heating, a gas bubble may form in this place. The formation of gas bubbles slows down the process of mass loss and shifts the slope of curve 1 to the right in the Fig. 1. So, the filler of DB may be play a role of a flame retardant. This assumption needs a careful verification.

Conclusion. From considered results it can be concluded that protective coating on a base of elastomer Sylgard-184 with a filler of DB improves significantly the heat resistance of the protective film as well as the fire resistance of the fabric. It has been proposed a possible explanation of the effect and mechanism of it realization. According to proposed mechanism the filler serves as a natural sink for combustible decomposition products and prevent the oxygen diffusion into polymer and hinder the transport of gaseous products of pyrolysis to the gas phase.

1. Andryushchenko, L.A.; Borisenko, V.G.; Goroneskul M.M.; Kudin, A.M. (2021) Evacuation sign with luminescent coating on a base of elastomer Sylgard-184 // *Emergency Situations: prevention and elimination*, 5(2), 5-18.
2. Olewnik-Kruszkowska, E.; Brzozowska, W.; Adamczyk, A.; Gierszewska, M.; Wojtczak, I.; and Sprynskyy, M. (2020) Effect of Diatomaceous Biosilica and Talc on the Properties of Dielectric Elastomer Based Composites // *Energies*, 13. 5828-5845.
3. Technique for luminescence coating application. Patent UA 147605 A62B 3/00. No u202007407; date of priority 20.11.2020; date of publ. 26.05.2021; bull. No 21.