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Creating of anti-icing coatings based on nanoscale powders of silicon dioxide obtained from silicone waste

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Abstract

The capacity expansion, processing and consumption of silicone products generate the environmental and economic problems. There are many technological wastes such as cyclosiloxanes, linear or partially-structured siloxane polymers, wastes that generated during silicon rubber processing, when the products are formed by pressing, as well as silicone products with expired service life etc. Currently, the problem of reclamation in silicone production, through the creation of energy-saving technology and their production return in the form of new composite materials of various application is an urgent task. Having regard to the above, for combustion regime treatment of nanomaterials synthesis in flame with desired properties some studies were carried out to produce the nanosized powder of silicone dioxide during combustion process of silicone waste.

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1. Introduction

When producing composite anti-icing coatings, so the using of nanoparticles is provided the produced materials

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with unique anti-icing properties [1, 2]. At the present time, there some investigations on producing of anti-icing coatings based on superhydrophobic coatings with micro and nanostructured surface are carried out. In work [3, 4] there were created anti-icing composite materials with nanoparticle inclusions and fluoropolymer is used as binding material. In articles [5, 6] the property of anti-icing coatings on the basis of fluoropolymer with nanoparticle inclusions and texturized aluminum surfaces are hydrophobizated by monolayer of organosilane was studied. Superhydrophobic nanostructured surfaces are widely distributed in nature, for example the "lotus effect", when a drop of water rolls off from the superhydrophobic surface of lotus leaf. In case, when the water drops are firmly held on the lower side of the surface of solid body in suspended condition, it is called as “effect of rose leaf” [7]. Thus, the problem of producing anti-icing coating does not lose its relevance, and the investigations on improving of these materials are under way. In this article there are some researches concerning development of production nanomaterials methods with hydrophobic properties and nanomaterials with anti-icing coating.

2. Experimental

Anti-icing material property is directly depend on hydrophobic property of the surface. In this paper, for creation of polymeric anti-icing composite material the synthesis method of nanodispersed superhydrophobic powder during the process of silicone waste combustion was developed. Our method for producing of nanodispersed powder production is a simple. The method is based on combustion of silicone wastes (silicone supports, different forms made from silicone) and as the result it is formed a mechanically strong hydrophobic nanodispersed powder. The combustion method does not require additional energy consumptions and it allows to obtain nanodispersed powder with a contact angle more than 155 °. Thus, we developed a method that allows to obtain a nanodispersed powder with gray-white color, odourless and has no harmful effects on the skin. Figure 1 shows the picture of nanodispersed superhydrophobic powder is grounded in a thin layer at the surface of paper with water drops on its surface.

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Fig. 1. The appearance of obtained silicone wastes of nanodisprsed silica powder and behavior of water drops at the surface of chafed powder.

The method of obtaining anti-icing coating was developed using nanodispersed powder of silicon dioxide, ethyl acetate and polyurethane adhesive. An obtained surface has superhydrophobic properties with contact angle of 160º. In laboratory, the anti-icing coating was obtained as follows. Polyurethane glue with a volume of V = 0.3 ml is dissolved in 100 ml of ethyl acetate. Dissolution was performed in a water bath at a temperature of 60–70 °C during 10–15 min. The obtained solution was added with nanodispesed powder of silicone dioxide in different percentage ratio which is obtained by combustion of silicon waste. The obtained colloidal solution was applied to the surface with the help of spray bottle. Figure 2 shows the behavior of water drops at the surface of obtained anti-icing coating and at the surface of galvanized metal. It was revealed that for creation of anti-icing coating, the optimal ratio of silicone dioxide in colloidal solution ethyl acetate + polyurethane glue + silicon dioxide is 1.8%.

Fig. 2. Photo shows the behavior of water droplets on the surface of the resulting anti-icing coating.

3. Results and Discussion

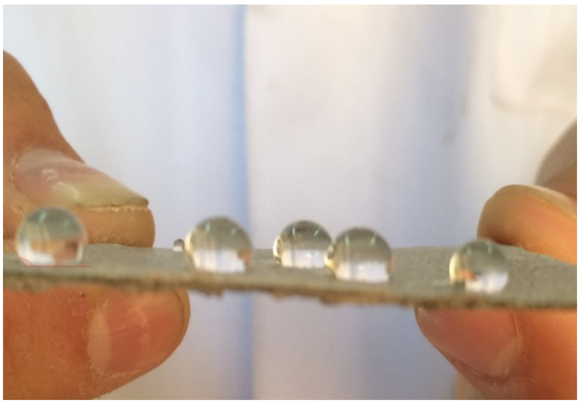
The obtained coating has superhydrophobic property. Some studies on rounding of water drops from anti-icing surface with different angles were carried out. As the result of researches it was determined that minimum angle for complete rounding of water drops from the surface of anti-icing coating is 35º. The studies were carried out in cold chamber at a temperature of - 15 °C with frequency dripping of water drops to 0.5, with path length on anti-icing surface of 40 cm.

Conducted studies have shown that when the angle of slope is less than 35º the formation of ice sheet is formed, which is easily turn away from the surface at imposing of small force and at melting is roll down easily from anti-icing surface in the form of water drops without damage of coating structure. When angle of slope is more than 35º the formation of ice sheet is absent completely. As a result of conducted researches concerning icing of ice sheet at subfreezing temperatures is also founded, this coating does not lose anti-icing and anti-adhesive properties during multiple cycles of cooling and heating. In practice, there are some problems concerning protecting against water absorption and further destruction of exposed surfaces of porous building materials in unfinished buildings and constructions due to expansion of ice at freezing of porewater.

The efficiency of anti-icing coating is based on nanosized silicon dioxide for protection of bricks surface, brand M-75. Figure 3 shows the behavior of water drops and frozen drops at the surface of anti-icing coating is applied to the brick is in upright position. The anti-icing coating is applied by spray is inflated with the air. Conducted researches have shown that anti-icing coating have good adhesion with the surface of brick, and when spraying the water to the surface is delayed at the surface in the form of drops and protects against the penetration of moisture to the volume of the brick.

Fig. 3. shows the behavior of water drops at the surface of anti-icing coating is applied to brick.

The slate roof protection for a long time is one of the most popular and cheapest ways to build. Studies have been conducted on the use of the obtained nano-sized silicon dioxide to create a de-icing coating for roofing slate. Figure 4 shows the behavior of water droplets on a surface coated with slate coating De-Icing. The anti-icing coating is applied on the slate a spray.



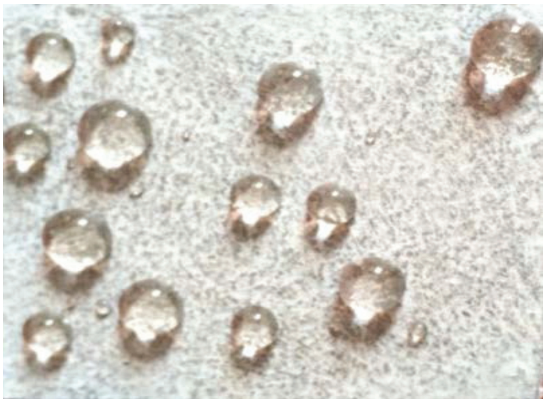


Fig. 4. The behavior of water drops at the surface is coated with anti-icing slate coating

Figure 5 shows an electron micrograph and results of elemental analysis as well as obtained nanosized powder which has been obtained in the process of combustion of silicone material wastes. The results showed that the powder consists of 77% silica SiO_2 and 23% C. The particle size of the carbon powder in the range between 300–400 nm, and it has a superhydrophobic properties.

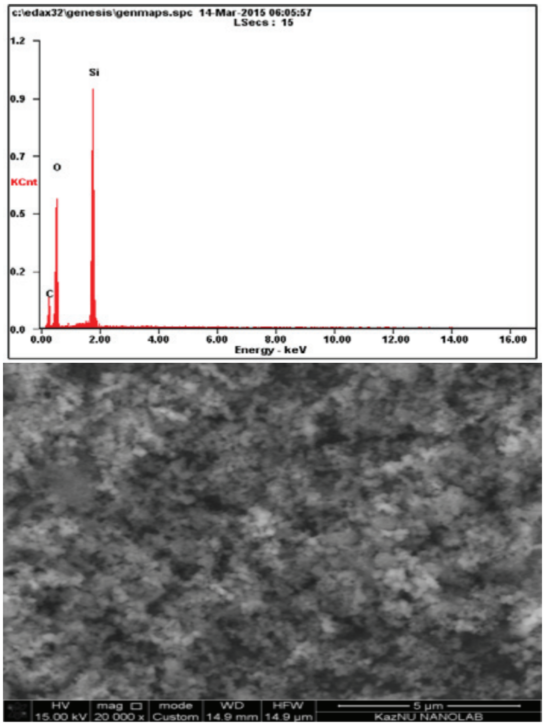


Fig. 5. An electron micrograph and EDAX analysis of the powder obtained from waste silicone.

Figure 6 shows the X-ray powder obtained by combustion of silicon waste. X-ray analysis showed that there is not any presence of crystal phases at amorphous phase.

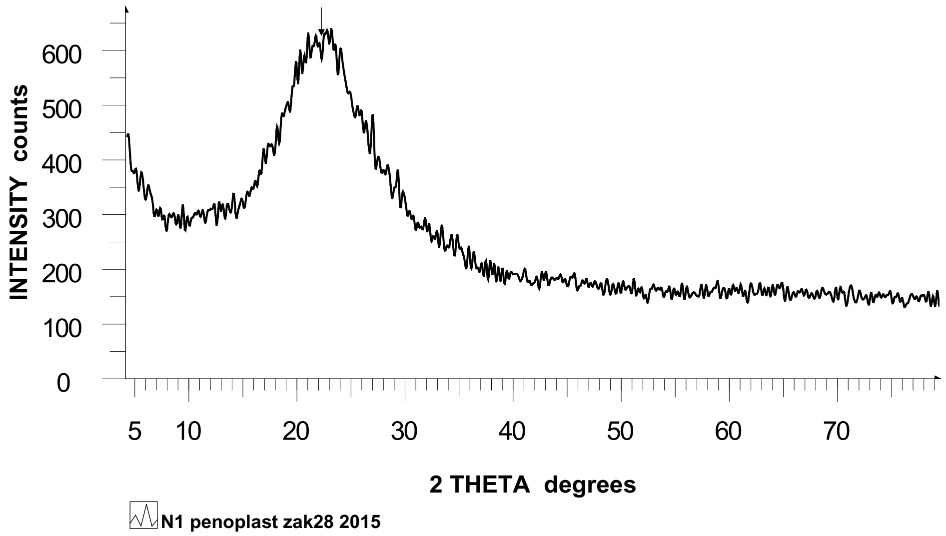


Fig. 5. X-ray powder analysis of silicone waste.

4. Conclusion

The method for preparation of nanodispersion superhydrophobic silicon dioxide by combustion of silicone waste is developed. Anti-icing coating on the basis of nanosized powder of silicon dioxide is developed. Superhydrophobic property of obtained coatings is contributed to low adhesion of the surface with ice, snow and other crystalline forms of water.

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