SHIELDING SILICATE COATING MODIFIED WITH MULTI-WALLED CARBON NANOTUBE DISPERSION

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Abstract. A facade coating with decorative and protective functions has developed using the fine microfillers and an additive. The facade coating has the increased sustainability and additional properties compared to existing paints. The coating is capable of absorbing up to 42 % of electro-magnetic radiation due to addition of the additive based on carbon nanotubes in the amount of 7 %.

Key words: silicate paint, sodium silicate, Portland cement, multi-walled carbon nanotubes, shielding.

1. Introduction

At present the market of domestic and foreign finishing facade compositions is mainly represented by coatings that perform either a decorative or protective function. At the same time it does not offer any finishing paint and lacquer materials that combine several functions.

Traditionally, ceramic facing brick has been used as a multifunctional material decorated with a versatile color palette due to 3D pigment coloring, engobing, and glazing. The disadvantage of these methods of coloring is high requirements to the quality of the raw clay feedstock which is important for regions that do not have the reserves of raw materials required for the production of brick of a versatile color palette (including the Udmurt Republic, Izhevsk).

Also, high-quality finishing coatings are in demand after performing restoration work on masonry and building structures (Belentsov and Smirnova, 2018; Duarte *et al.*, 2020; Kazanskaya and Belentsov, 2019; Kharitonov *et al.*, 2017; Bessmertnyi *et al.*, 2015). In this case it is necessary to use secondary mineral resources in the production of finishing materials (Kummer, 2017; Kazanskaya and Smirnova, 2018; Rahmadina *et al.* 2019; Samchenko *et al.*, 2019). They can contribute to increased weather resistance, vapor permeability and other properties of the coating (Nenadálová *et al.*, 2016; Smirnova, 2019; Ivanovna *et al.*, 2016; Smirnova, 2018a). As a rule inorganic-based coatings have a multicomponent composition that requires a scientific approach when choosing components and their ratios (Pagliolico *et al.*, 2019; Savchuk *et al.*, 2018; Smirnova, 2018b, 2018c; Plugin *et al.*, 2017; Plugin *et al.*, 2019).

Thus the goal of the research is to develop a decorative facade coating that provides high adhesive strength to increase weather resistance and durability of the coating. In this case the coating should have the effect of absorption of electromagnetic radiation to reduce the impact on biological objects and protect information.

The analysis of published papers has revealed that the optimal method of protection such as against technogenic radiation is the use of coatings for the decoration of facades and interiors (Saienko *et al.*, 2019; Lu *et al.*, 2018; Tkach *et al.*, 2018; Zheng *et al.*, 2019). The use of the functional additive of nanostructuring carbon-containing particles in the composition of such coatings leads to the effect of the absorption of technogenic radiation (Shafigullin and Kupriyanov, 2015; Namita *et al.*, 2008; Chung, 2001).

2. Materials and Methods

In this paper the developed cement-silicate composition modified with micro- and nanodispersed additives is considered. The binder includes sodium silicate, Portland cement, the aqueous solution of sodium phosphate as an inhibitor, and ultrafine titanium dioxide, expanded perlite sand and a multi-walled carbon nanotube (MWCNT) suspension. To provide the desired shade of the silicate composition, alkali-resistant pigments used in the form of coloring paste were used. The shielding properties of carbon nanotubes are ensured by their good conductivity. The low specific gravity and the possibility of obtaining thin transparent films on their basis, which do not change the appearance of the shielded object, make them easy to use as a protective coating (Wang *et al.*, 2013).

Engineering parameters of the developed silicate coating and methods for their determination meet standard “GOST 33290-2015. Paint and lacquer materials used in construction. Specifications”. Facade silicate coating has the following physical and technical characteristics: viscosity is 32 sec; pH of the medium is pH=12.33; film resistance to static effect of water is 8 hours; hiding power depending on the pigment used is 200-520 g/m^2; adhesion according to the cross cut method is 2 points; sustainability (depending on the inhibitor concentration) is 20-120 min; vapor permeability of the paint layer is V=411 $g/m^2 \cdot day$; the thickness of the air layer with equivalent vapor permeability is Sd=0.05 m; water absorption is W=0.91 $kg/m^2 \cdot h^{0,5}$; frost resistance of the silicate coating is 75 cycles (Shaybadullina *et al.*, 2018a, 2018b).

3. Testing the developed silicate coating

The shielding properties were determined in samples with a substrate of silicate glass with the thickness of 3.2 mm and the size of 350x350 mm, on which the developed coating with the functional additive was applied. According to the measurement results, the specific resistance of the composition was found to increase with the decreasing concentration of carbon nanotubes (Fig. 1).

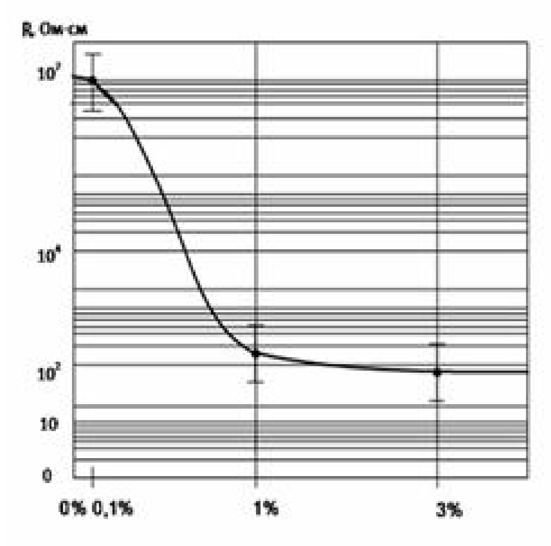

Fig. 1. Specific resistance of the composition depending on the concentration of carbon nanotubes .

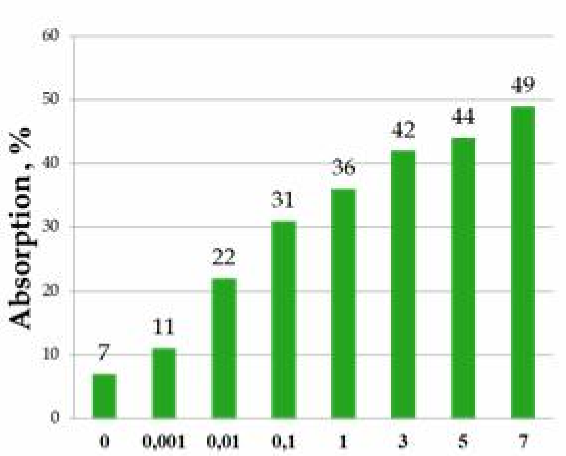

Fig. 2. Effective absorption capacity depending on the concentration of carbon nanotubes.

Effective absorption capacity increases with the increasing concentration of functional additives (Fig. 2).

The introduction of the functional additive based on multi-walled carbon nanotubes into the silicate coating in the amount of 7 % leads to the increase of the absorption of electromagnetic radiation up to 42 % (Fig. 2) compared to the unmodified sample.

The facade coating was tested at the factory producing ceramic bricks of Altair LLC in Izhevsk and at the construction site for a residential building. To apply the silicate coating fragments of brickwork were erected with dimensions of 1000x1000 mm and the thickness of 120 mm. In the process of application, compositions were used both without MWCNTs and with MWCNT dispersion. The coating modified with MWCNTs after application had a more uniform and even surface compared to the traditional composition without nanotubes.

Fig. 3. Application of the silicate top coat with a spray gun and general view of the walls after painting

The developed facade silicate coating was also used to paint the walls of the boiler room of a residential building in Vesennaya st., 9, Pervomayskoye countryside (Fig. 3-4).

The paint was applied in 3 layers on a dry basis which was previously cleaned of dust and dirt. The facades were painted at +15 °C. The MWCNT dispersion was used in the composition of the top coating (3rd layer). A thin layer of pigment-free facade silicate coating was applied as a primer layer, providing the required adhesion for the subsequent application of the top coat. Each subsequent layer of the pigmented facade silicate coating was applied on the painted surface after complete drying (1-2 hours).

Fig. 4. The designed color scheme of the facades of a residential building with the painted place being indicated.

The introduction of MWCNT dispersion into the applied silicate coating led to the improvement of the technological properties of the coating. At the same time the viscosity of the paintwork was reduced due to the structural modification of the components of the silicate composition. When the silicate coating modified with carbon nanotubes cures, it is possible to stimulate the structure formation of compositions along with the formation of a denser and nanotube-reinforced structure. This allows improving its physic-technical properties while giving the coating a shielding effect from technogenic electromagnetic radiation.

4. Conclusion

The developed silicate coating modified with a complex additive has the following main physical and technical properties: hiding power depending on the pigment used is 200-520 g/m^2; sustainability (depending on the moderator concentration) is 20-120 min; frost resistance of the silicate coating is 75 cycles.

The application of the silicate coating on the surface of freshly burnt ceramic bricks under industrial conditions showed the possibility of replacing the existing technology of applying a polymer coating with the developed silicate composition. The advantage of the developed silicate coating is the absence of thermal processes associated with fixing the paint, the simplicity of the application technology using spray guns, the possibility of creating a textured layer, and ensuring equal linear expansion coefficients of the substrate and coating.

Testing coating in the construction site confirmed the technological effectiveness of the application and the high productivity of painting work when applying the silicate coating. The applied silicate coating confirmed the sustainability of the composition under the environmental conditions when exposed to atmospheric precipitation.

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