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Impact of fillers for acrylic compositions on their stability in aggressive mediums and adhesive strength

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Abstract

This paper aims to reveal the change of diffusion coefficient and permeability of the acrylic composition with different types of fillers (such as cement, sand, mica, and talc) in the various aggressive mediums. Also, the adhesive strength was determined as the maximal stress caused by detaching metal plate from the surface of the concrete. To evaluate the stability of the compositions, the samples of the acrylic compositions were saturated with acid and alkali solutions during a certain time. Basing on the mass change, the coefficients of diffusion, sorption, and permeability were calculated. The sand filled acrylic composition showed the least sorption (0.2%) and water permeability (0.008 $g \cdot cm^{-1} \cdot s^{-1}$), as well as the highest adhesion strength (53.2 MPa). However, all studied compositions satisfy the requirements of the current permeability standards, and they can be used for construction protection from the aggressive environment action. It is important for the durability of the structures as it will prolongate their operative time, as well as reduce the operating and repair costs.

1. Introduction

The prolongation of structure operational life is an important task for concrete and reinforced concrete constructions that operate under conditions of aggressive medium action, including water. In addition to the fact that water itself decreases the strength of solids, it acts as a carrier of aggressive agents, such as chloride ions, sulfate ions, which can initiate many chemical reactions and accelerate the destruction process of concrete structures. The polymer substances are extensively used for the protection of different constructions. Any usage of polymer composites in the outdoor environment is always connected with humidity action. Also, there is a potential possibility of salinization conditions for the riverside and marine structures as well as leaching corrosion that is dangerous for reinforcing steel in cement materials. That is why, it is especially important to find the most effective and impenetrable material among various polymers as well as to study the sorption and transport of distilled water, salt solution, and a simulated concrete pore solution in free films of vinyl ester, isophthalic polyester, and epoxy resins, all commercially important materials for use in structural composites [1]. Diffusion coefficients calculated from the mass uptake data revealed that, although the epoxy resin had the highest equilibrium uptake, it had the lowest diffusion coefficient. In recent years, the usage of fiber-reinforced polymer composites in civil engineering has been proposed as a solution to the deterioration of bridges, buildings, and other structures composed of traditional materials, such as steel, concrete, and wood. As it has been shown by Trykoz et al. [2], strip fiberglass reinforcement has all the necessary physical and mechanical properties and can be applied for spiral reinforcement of metal pipes in places with enhanced aggressive action of groundwater as well as in soils with a substantial value of leakage currents. For the marine reinforced concrete constructions, a reinforcement metal corrosion initiated by chloride is a factor that limits the operational life of the structure. A methodology is described for how the maximum required chloride diffusion coefficient of concrete for achieving an intended service life can simply be calculated as a function of concrete cover thickness over the reinforcement [3]. The principle is based on the usual mathematical solution to Fick's 2nd law of diffusion. As a rule, concrete with high seawater stability should have high compressive strength, a low chloride diffusion coefficient, and a high acceptable chloride level. Considering all these parameters simultaneously, it is possible to evaluate the degree of concrete durability based on 10-year results in a marine site [4]. Taking account of all the above-mentioned papers, a conclusion can be made that the direct proportion is observed between permeability and durability. The last can be estimated by the diffusion coefficient.

One more construction type which is subjected to intensive aggressive medium acts is the pipe for sewage transportation. Biogenic corrosion of concrete (biocorrosion) in the wastewater pipes occurs mainly due to the diffusion of aggressive solutions and the production of sulfuric acid by sulfur-oxidizing microorganisms [5]. To prevent concrete biocorrosion, the modification of the concrete mixtures is necessary or the application of an anti-corrosion layer with chemical or antimicrobial covering the internal pipe surface. This inhibits biological activity and ensures that the protective layer is created between the concrete surface and caustic solution. However, the short bio-resistant lifetime due to undesired leaching of biocides to the surrounding environment coupled with the coating's poor acid-resistant properties has increased demand for safe, more efficient, environmentally friendly, and long-lasting alternatives.

Many types of research were dedicated to the investigation of material penetration capability. Often, the addition of fine particles was proposed to reduce the concrete permeability and to obtain a denser structure. For example, in the research [6], in the ordinary concrete with Portland cement the sand part was replaced with mineral admixtures such as fly ash, limestone filler, sandstone filler, or silica fume. The results of the study of Atmaca et al. [7] indicated that an addition of 3% nano-silica to high strength lightweight concrete decreased the negative properties of lightweight coarse aggregate and led to the remarkable increase in mechanical properties while the sorptivity values have decreased up to 25%. The aim of the study of Shima et al. [8] was to increase the concrete durability with the usage of silica fume. The effective diffusion coefficients of the chloride ions of silica fume concrete were measured. Over a range of cement replacement ratio of silica fume from 4% to 8%, the effective diffusion coefficient was independent of silica fume content. Therefore, the replacement ratio of silica fume 4% was more desirable than 8% from a viewpoint of cost. Over a range of cement replacement ratio of fly ash from 15% to 30%, there was a little reduction of the effective diffusion coefficient. Therefore, silica fume was more effective than fly ash.

Concrete can be protected with covering which decreases the penetration of aggressive substances from external sources. Polymer composites (overlays, coatings, waterproofing, and bounding materials) are widely applied in the concrete repairing industry. In the opinion of Czarnecki [9], the adhesion is a fundamental challenge for concrete repair. But also, short time to exploitation readiness and many other polymer composites advantages are taken into consideration. Also, the advantages of the acrylic polymer have been described [9]. It confirms the rational choice of this material for the current investigation. The task of the study of Medeiros and Helene [10] was the efficiency investigation of some types of surface treatment such as hydrophobic agents, acrylic coating, polyurethane coating, and double systems in inhibiting chloride penetration in concrete. The results indicated that all tested surface protection significantly reduced the concrete sorptivity (reduction rate > 70%). The most effective coating for reducing the chloride diffusion coefficient was the polyurethane coating (reduction rate of 86%).

Recently, the concern with acrylic resin as a new repair material has been growing. The acrylic resin is of high quality, low viscosity, high elongation percentage, and so on [11]. Acrylic covers demonstrate good adherence to the concrete substrate and, also, show good alkali resistance [12]. One more useful feature of acrylic coatings is their significant stability to atmosphere action. That is why they have been selected as the protection materials for the concrete constructions. One of the disadvantages of a polymer is its shrinkage during curing. To prevent this negative phenomenon the fillers are added in the polymer compositions. Besides, with the helping of fillers, the material can be given special properties: fire or biocide resistance. For stone protection, an acrylic latex filled with zinc oxide has been developed [13]. One more important addition to coatings is titanium dioxide. This type of coating ensures a good balance between water vapour permeability and carbon dioxide resistance conforming to [12].

The influence of the fillers on permeability has been investigated in the following papers. Paint has great importance on concrete durability due to the advantage of being applied to both newly built and old structures, the latter being for maintenance and repair purposes [14]. The results showed a correlation between the paint pigment volume content and water permeability. Permeability is increasing when the pigment quantity is more than 40% [14]. The granulated blast furnace slag has been used for the modification of a building mortar [15]. The results indicated a good resistance to chloride diffusion of the mortars with the granulated blast furnace slag. During the study [16], the impact of the acrylic polymer addition on the permeability of four types of filled soils has been analyzed. The acrylic addition to the soils leads to a significant decrease in soil permeability. This serves as an improvement in the soil layers that affect the stability of the foundation, and it is very necessary for sensitive structures such as hydraulic structures (reservoir dams, earth dams, etc.).

The choice between the epoxy resin and acrylic polymer has been based on the following. Polymer-modified cement can be as an adhesive in situations that require an enhanced bond to substrates (i.e., tile adhesives, patching, and waterproofing mortars) and used in repair and injection works necessitating improved durability and adhesion to embedded steel bars [17]. A large number of concrete structures have been strengthened with using epoxy adhesives. However, the rapid deterioration of the mechanical properties of epoxy-based polymer matrix at elevated temperature, and the hazardous effects of toxic fumes during the application made the need of replacing this polymer with a new cementitious bonding agent to enhance the performance of concrete structures in high-temperature environments and reduce the environmental and health hazards [18]. Cement mortar reinforced by short carbon fibres was improved by using acrylic dispersion as an admixture in the amount of 15% by mass of cement [19]. This improved the tensile properties, particularly strength and ductility. Grouting is a common technical method with many applications, e.g. it is used for soil stabilization and strengthening, for reduction of water ingress to underground facilities or of the water loss through a dam foundation, etc. [20]. The results of this study indicated that the addition of acrylic resin or methyl methacrylate co-polymer emulsion in the cement-clay grout improves significantly the compressive strength, shear bond strength, stability, resistance to wet-dry cycles and resistance to sulphate attack. It confirms the rational choice of this material for the current investigation.

Therefore, knowledge about sorption characteristics, such as absorption and sorptivity, is great importance since they affect the durability and other properties. There is not enough data in the literature sources about the influence of the fillers in the acrylic compositions on their penetrating ability and adhesive strength. Our paper aims to reveal how the different types of fillers in the various aggressive medium affect the diffusion coefficient and penetrating ability of the acrylic composition. Also, it is important to evaluate the adhesive ability of the waterproof coating to the concrete surface.

2. Materials and methods

The essence of the methods is the mass determination of the standard samples after keeping in an aggressive medium during a certain time conforming to ISO 175:2010 standard [21]. The studied samples are the mix of the polymer binder and filler. As a binder for waterproof composition, the polymer-monomer cold-curing plastic has been chosen. This composition consists of two ingredients: a powder polymer (polymethyl-methacrylate) and a liquid monomer (methacrylic methyl ester). This mixture is characterized by high processability and low labor intensity of preparation, low and adjustable viscosity, satisfactory physical and mechanical properties of the cured product. For the current investigation, the modification admixtures such as cement, sand, mica, and talc have been used. Before mixing, the fillers have been oven-dried at 105°C for 48 h to remove any trace of moisture. Mica and talc have been powdered to finely dispersed state. Their particle size was not more than 15 mm. The sand particle size was 0.15 mm. Five sample batches of acryl compositions have been prepared. The first sample batch is made of acryl plastic without filler, the second one-with quartz sand as a filler, the third one-with quartz sand and mica, the forth one - with quartz sand and talc, the fifth one-with Portland cement as a filler. After blending manually, the curing of the acrylic sample is occurred spontaneously under normal temperature due to the polymerisation process. The compositions are given in Table 1.

Table 1. Filled acrylic polymer compositions.

Components, pts. wt.						
No. composition	**liquid poly methyl methacrylate**	**powdered methacrylic methyl ester**	**sand**	**cement**	**mica**	**talc**
1	100	100				
2	100	100	150			
3	100	100	150		7	
4	100	100	150			8
5	100	100		150		

As it is seen from Table 1, the compositions have two types of filler - with a bigger size of the particles (sand, cement) and with a smaller size of the particles (mica, talc). The filler with bigger particles is used to reduce the shrinkage deformations and the cost of the composition. The filler with smaller particles is applied to fill the pores between the bigger particles. In this case, the more compact structure is formed with lower water absorption than others.

To measure the mass changes, 10 samples have been made of each of the 5 compositions. The samples had a disk form with a diameter 50±1 mm and thickness 3±0.2 mm. After drying, each sample has been weighed with an accuracy of 0.001 g. After that, the specimens have been placed in the closed capacity so that they have been completely immersed into a liquid medium and held under temperature 20±2°C. Water, 5% nitric acid solution, 10% hydrochloric acid solution, 10% sulfuric acid solution, 10% sodium hydroxide solution, and used machine oil have all been used as liquid mediums. The chemical agents and their concentrations were chosen on the assumption of the expected conditions of the coating operation. The test duration was determined by the time that is necessary for the sorption equibalance establishment. The intermediate measurements of the sample masses have been executed after 12, 24, 36, 48, 72, 96, and 120 h, then each day.

The determination of the adhesive strength of the tested specimens was performed according to EN 1015-12 standard [22] with the application of a pull-off tester. The adhesive strength was determined as the maximal stress caused by detaching metal plate (stamp) from the surface of the concrete (Figure 1(a)).

The strength Class C16/20 concrete was used as a base surface for the adhesive strength tests. The concrete sample size was 100×100×100 mm (Figure 1(b)). The metal plate was glued to the surface of the tested concrete sample by the filled acrylic composition. The coating around the stamp was cut with a special cutter.

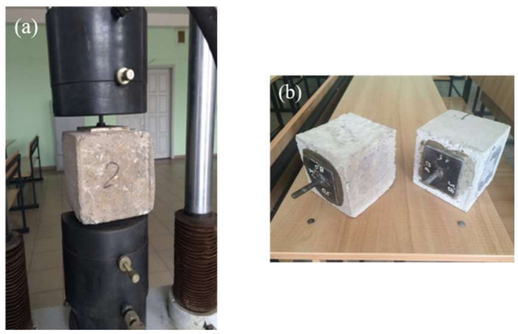

Figure 1. Test method (a) and samples (b) for determination of the adhesive strength.

After curing each stamp was detached from the surface. The applied pull-off tester with a test plate diameter being equal to 50 mm allowed for ±1% accuracy for the whole range of the measured values.The adhesion strength was calculated by the formula

$$P = \frac{N}{F} \quad (1)$$

where N is the detaching load, N; F is the stamp area, m^2.

To evaluate the specimen's permeability, their water sorption has been investigated. After each test period, the mass change (ΔM,%) is defined by the formula

$$\Delta M = \frac{M_1\text{-}M}{M} \cdot 100 \quad (2)$$

where M is the tested sample mass before immersion into the chemical reagent, g; M_1 is the tested sample mass after holding into the chemical reagent, g.

According to the test results, the dependency graph of the absorption water amount on the keeping time $\Delta M=f(\tau)$ is built. The time during which the mass quantity increases to the value $M_{max}/2$ is determined according to the graph. Then the diffusion coefficients of the chemical agents in the samples are calculated (D, cm^2·s^{-1})

$$D = 0{,}0494\left(\tau_0/\delta^2\right)^{-1} \quad (3)$$

where τ_0 is the time during which the sample mass increases to $M_{max}/2$, s; M_{max} is the tested sample mass after the sorption equibalance establishment, g; δ is the sample thickness, cm.

This approach is similar to that described in [3]. In this research, the required diffusion coefficient of chloride-ions into concrete was calculated as a thickness function of the concrete coating. The principle is based on the usual mathematical solution to Fick's second law of diffusion. The chemical reagent mass which is absorbed by the test specimen is calculated by the formula

$$M_p = M_{max}\text{-}M. \quad (4)$$

The test specimen volume after absorption is calculated by the formula

$$V_{max} = (\pi \cdot d^2 \cdot \delta)/4 \ , \quad (5)$$

where d is the disk diameter, cm; δ is the sample thickness, cm.

The sorption coefficient of the chemical reagents in the samples is calculated by the formula

$$S = M_p/V_{max}. \quad (6)$$

The permeability coefficient of the chemical reagents through the samples is calculated by the formula

$$P = D \cdot S, \quad (7)$$

where D is the diffusion coefficient, cm^2·s^{-1}; S is the sorption coefficient, g·cm^{-3}.

3. Results and discussion

The experimental results are given in Figure 2. It shows the water sorption kinetics by the samples.

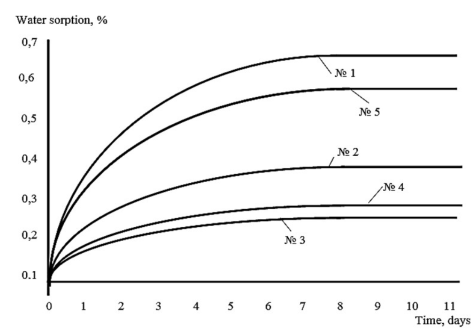

Figure 2. Water sorption kinetics of filled acrylic polymer compositions for different compositions (according to Table 1).

The analysis of the graph indicates that the most intensive water sorption is taking place during the first 2 days. Then the sorption is becoming slower and it ends on the 8-th days, after that the sorption equibalance establishes. The tests of the specimens modified with mica and talc (third and fourth sets) exhibit the least water sorption, 0.17 and 0.21% respectively. The greatest water sorption constitutes 0.64% for the non-filled compositions (No. 1). The water sorption of the fifth compositi

All studied compositions are recommended for usage as the waterproof covers of the concrete and reinforced concrete constructions that operate under partially or fully moisten conditions as well as in the dry indoor spaces since the water sorption value is satisfactory for the mentioned coating types. Based on economic feasibility and material accessibility, the sand of fine fraction 0.14 mm can be recommended as the filler. However, the water sorption is not an accurate criterion for the assessment of the waterproof covering. The penetration capability is a more precise measure for protective compositions. For this aim, the coefficients of diffusion, sorption, and permeability have been calculated in the different aggressive mediums by formulas (3), (6), and (7). Chemical reagent absorption has been calculated by the formula (4). The calculated results are given in Table 2.

As it is shown in Table 2, the longtime action of the aggressive mediums does not affect the physical and mechanical properties of the sand-filled acrylic composition much. The permeability indicators are many times smaller than the non-filled composition (No. 1) for all aggressive mediums. These diffusion coefficients are in compliance with the data obtained by Erdoğdu et al. [23].

However, a distinctly defined dependence of the coefficient on the aggressive medium types is not observed. The used machine oil possesses the smallest coefficients of diffusion, sorption, and permeability. It can be explained by its molecule size, which can be bigger than the coat capillary pore sizes. The oil molecules can seal those pores. Other results do not have a clear tendency to increase or decrease. For example, 10% sodium hydroxide solution possesses the greatest value diffusion coefficient (0.9×10^{-7} $cm^2\cdot s^{-1}$) but a low sorption coefficient (0.02 $g\cdot cm^{-3}$) and an average permeability coefficient (0.018×10^{-7} $g\cdot cm^{-1}\cdot s^{-1}$). Comparing the 10% hydrochloric acid solution with the 5% nitric acid solution, it can be seen that their diffusion coefficients differ by a factor 1.5, while their sorption coefficients are equal, and the permeability coefficients are different.

Table 2. Coefficients of diffusion, sorption, and permeability (calculated by formulas #3, #6, and #7 respectively).

No.	**Chemical reagent**	**Coefficients**			**Chemical reagent absorption M_p, g**	
		diffusion $D\times10^7$, $cm^2\cdot s^{-1}$	**sorption S, $g\cdot cm^{-3}$**	**permeability $P\times10^7$, $g\cdot cm^{-1}\cdot s^{-1}$**	**Composition No. 2**	**Composition No. 1**
1	Water	0.35	0.024	0.008	0.33	2.20
2	Used machine oil	0.21	0.012	0.003	0.24	1.30
3	10% hydrochloric acid solution	0.45	0.052	0.023	0.77	3.95
4	10% sulfuric acid solution	0.39	0.027	0.011	0.79	3.85
5	5% nitric acid solution	0.63	0.059	0.037	0.68	3.50
6	10% sodium hydroxide solution	0.90	0.020	0.018	0.43	1.55

Such ambiguity of the results is observed in other author's works. The diffusion coefficients were calculated with the usage of the mass absorption data in the study [1]. It was shown that epoxy resin possesses the highest equilibrium adsorption but the lowest diffusion coefficient. It is generally suggested that cement-based material diffusion behaves according to Fick's law of diffusion. However, the results in [24] have shown that Fick's law cannot completely describe the sorption process in such materials. According to Vedalakshmi et al. [25], the estimate of the chloride diffusion coefficient calculated using Fick's law either overestimates or underestimates the time before corrosion begins. The authors [26] consider the capillary porosity as a factor that does not affect the cement paste permeability significantly. The connectivity of the capillary pores is the most important parameter which defines water permeability of the cement paste.

Two effects have been taken into account when interpreting the experimental data obtained by Caré [27]: the interfacial zone effect and tortuosity due to aggregates. These two competing effects were quantitatively determined with the usage of the composition materials theory. It was shown the diffusion coefficient changes depending on the volume content of the interfacial zone and the tortuosity. In our opinion, precisely the interfacial interaction theory should be used for describing the diffusion and permeability processes. Nevertheless, the acrylic compositions possess sufficient strength, chemical stability and can be used as a waterproof material for the concrete construction under action conditions of the aggressive mediums.

The acrylic binders, like all polymer materials containing fine aggregates and admixtures, are heterogeneous systems with a highly-developed surface and complicated structure. The aggregates and additives in the glue compounds are referred to active and inactive. The active ones are able to affect the submolecular formations change, relaxation time, thermodynamic parameters. The inactive ones reduce the cost and change the colour of the polymer compositions, but they cannot change the physical and mechanical properties. Being structural centres, active aggregates possess an orienting effect on the polymer and form ordered thin films. These surface films possess better mechanical properties in comparison to the polymer. When a little amount of the active aggregate and admixtures (5-10%) was added, the binding intermolecular regularity is broken due to the surface layers formation. The system leaves the equilibrium condition and increases its own free energy while the package density decreases. When there is too much fill the polymer chains and networks form from the filler particles which connect between themselves through the polymer interlayers. The bigger the filler concentration the bigger the filled composition strength. The strength grows together with the active surface value to the definite maximum which corresponds to the limit oriented bimolecular binder layer.

The active surface centres cause surface properties of both inorganic and organic disperse materials. Polymer molecules adsorb on the surface of the silica filler and form a layer with an ordered macromolecular structure. The layer and its bond with the filler are stronger than the polymer. The active centres orienting influence spreads to 200 nm from solid surface and determines a rather large action radius which reduces with distance from the surface. The long-range action of the active centres affects the polymerization processes a lot and structure formation of the polymer acrylic composition. The hydroxyl groups OH are the active centres on the quartz filler surface. On the other hand, the polymethylmethacrylate molecules have the C=O functional groups as is shown in Figure 3.

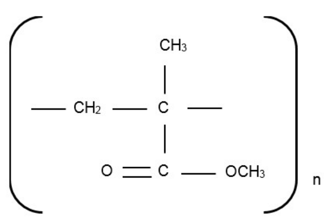

Figure 3. The polymethylmethacrylate molecules.

The bond between polymer and filler is provided by dipole-dipole interaction between the hydroxyl groups and the functional groups as well as hydrogen bonds (Figure 4). On this visual, R is the hydrocarbonic part of the polymethylmethacrylate molecules and the dotted lines indicate hydrogen bonds.

This scheme gives the base for theoretical confirmation of the strength properties of the filled acrylic composition which consists of polymethylmethacrylate and quartz sand. These two materials possess electrical surface features due to the surface charges (active centres) and dipole functional groups. The investigation of such kind of interaction has been performed using the infrared (IR) spectroscopy method (Figure 5).

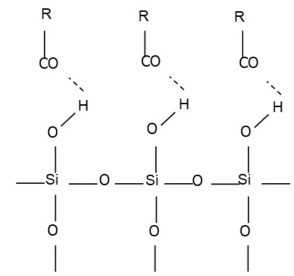

Figure 4. Interaction of the active surface centres SiO_2 with the polymer functional groups.

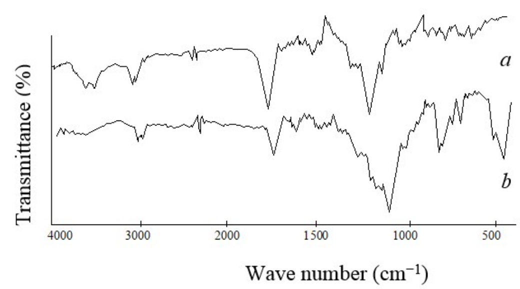

Figure 5. Infrared spectra of the non-filled (a) and filled (b) composition.

The non-filled composition (No. 1 in Table 1) exhibited bands for stretching vibrations C = O around 1700 cm^{-1} and the doublet at 1240 cm^{-1}. Three distinct regions were observed on this IR spectrum: the band at 2800-3000 cm^{-1} assigned to C–H asymmetric stretching vibrations in O–CH_3 bonds and CH3 bonds, CH_3 symmetric stretching vibrations in O–CH_3 bonds. The wide band at 3500 cm^{-1}, associated with the vibrations in H–OH, was caused by intermolecular hydrogen bonds. Bands at 1060 cm^{-1} и 1125 cm^{-1} are assigned to C–O stretching vibrations flat zigzag chain. The distinct doublet around 1190-1150 cm^{-1} was caused by C–O–C asymmetric stretching vibrations. The symmetric stretching vibrations of this group were at 828 cm^{-1}.

The filled composition (No. 2 in Table 1) exhibited the most intensive bands in the region 500-1200 cm^{-1} for SiO_2. The presence of quartz is corroborated by the bands at 500-1100 cm^{-1} (Si-O stretching vibrations), the doublet 785-795 cm^{-1} (Si-O-Si tetrahedra stretching vibrations), the bands at 705 cm^{-1} and 420-560 cm^{-1} (Si-O-Si stretching vibrations). It was noted that the position of the quartz bands remained unvaried. On the contrary, the positions of some polymer bands shifted essentially comparing with the non-filled compositions. The following changes occurred in the IR spectrum: 1) the band at 1728 cm^{-1} has been divided into two peaks; 2) the band at 1152 cm^{-1} has been expanded (C–O–C stretching vibrations); 3) the group of bands at 1220-1242 cm^{-1} has been expanded significantly (C = O stretching vibrations). The band at 1100-1000 cm^{-1} expanded and shifted to 1150 cm^{-1}, denoting the interaction between the active centres on the filler surface and dipole functional groups of polymers.

The results of the IR spectra studies indicate the change of the intermolecular interaction in the polymer. It allows to confirm the theoretical estimation of the adhesion interaction that defines the strength characteristics of the filled acrylic compound. The structure begins to form due to electrical attraction negatively charged functional groups (OH^-) and positively charged active centres (H^+). During the polymerisation process, the polymer molecules curl up into the shape of globules and form a supramolecular structure of the filled composition. As the polymer net grows, the porous space between the quartz grains is filled by the globules. A microstructure of the filled composition is formed which is characterised a big density and strength.

Adhesion to concrete surfaces is an important characteristic that determines the properties of waterproof covering. In this study, the adhesion properties of the filled acrylic cover have been investigated with the metal stamp detaching method. The stamps have been glued to the concrete surface with the usage of the different compositions according to Table 1. In all cases, the destructions occurred on concrete but not on the coatings. The following values of the adhesion strength were calculated using formula (1): composition No. 1 - 29.8 MPa; composition No. 2 - 43.0 MPa; composition No. 3 - 53.2 MP

4. Conclusions

The aim of this work was to study the impact of fillers on the stability of the acrylic compositions in aggressive mediums and adhesive strength. The results showed that

1. Sand as a filler of the acrylic composition decreases the absorbed water mass 6.7 times compared to the non-filled polymer.

2. The absorbed masses of the aggressive reagents have reduced 5 times, apart from 10% sodium hydroxide solution in which the mass of the absorbed reagent decreased 3.6 times. It is the most aggressive medium for the acrylic composition, based on the diffusion coefficient value.

3. The highest strength value has been obtained for the acrylic compound which is filled sand and mica. In this case, the detaching stress reaches 53.2 MPa.

4. The filled acrylic compositions demonstrate low water sorption ability, high stability in the aggressive mediums, and acceptable adhesion strength. Waterproof acrylic based compositions with fillers are acceptable protective covers that can be used to prevent penetration of chemical substances into the concrete.

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