Adhesive composites based on household waste

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Abstract. *Protection of the environment from pollution by domestic waste, in particular, should be the concern of every member of the community of the Black Sea coastline, and to a certain extent, for all people. The work envisaged obtaining new safe materials on the basis of household plastics and rubber household waste in the Black Sea coastline, which provides the opportunity to turn harmful waste into a useful product. New construction materials are obtained on the basis of glass waste, plastics, rubber waste and adhesive cements. New environmentally safe polymer composites were obtained for the first time. These composites can be used in building materials, artistic and decorative paints and household items. For these composite materials, the following were studied: water absorption, bending and tensile strength, impact viscosity, physical-mechanical and thermal properties, supramolecular structure of the surface by SEM scanning electron microscopy, unfolding and correction time.*
Key words*: Ecology; adhesive cement; ethylsilicate; glass;*

I. Introduction Improvement of ecological state of the environment is one of the most important issues of modern times. In this regard, it is essential to deepen the knowledge of those environmental problems, which are related to application of polymeric materials. Environment protection from domestic waste pollution posing real threat to the environment has to become a main care for each member of the society. This work foresees familiarization with the second aspect of waste disposal and management – the opportunity of harmful waste transformation into useful products, which is realized through chemical and technological processes, as well. Plastic waste disintegrates into small pieces in rivers and are eaten by fish. Afterwards these wastes hit human organism and have a harmful effect on health. Prevention of plastic pollution means salvation of water habitants as well and this fact is acknowledged well in the European Union. In March 2019, the European Parliament adopted the law prohibiting production of single-use plastics, for example plastic plates, knives and forks, cotton sticks and other similar products. At the same time, a new processing method has been instituted (collection of 90% of plastic bottles until 2029) and increased responsibility of manufacturers has been established. Plastic is one of the most stable environmental pollutants and over the last 50-60 years it has been collected in vast numbers worldwide. It should be noted that it is not a problem for humans only. Plastics remain stable for a long time, and some of them – up to 100-500 years, so it is obvious that such type of waste creates a problem for the environment and represents one of the most stable pollutants. This work is important both from ecological viewpoint and in the light of receipt of new materials, in particular, receipt of new safe, ecologically clean composite waterproofing materials on the basis of household plastics, rubbers and glass waste, which are applicable in the construction industry. Environment protection problem may be solved by two ways – waste destruction and disposal (recycling). The latter implies its transformation into useful products. Burial and incineration are among main destruction methods of solid domestic waste and packaging materials. Burial of solid domestic waste requires allotment of large land areas for landfills. Obviously, these lands become unfit for further useful application. Roughly 90% of solid domestic waste are disposed at landfills (garbage dumps), which occupy more than 20 000 hectares of land area. So, each of these landfills “swallows” hectares of lands. In addition, valuable secondary raw materials (waste paper, plastic, glass, metals etc.), which necessarily must be involved in the beneficial industrial cycles, are brought to the landfills. Incineration may be applied both to solid and liquid waste. This method is neither rational nor cost-effective, since toxic gases (SO_2, NO_2, CO) are separated during burning. This process is accompanied by rapid wear of equipment (garbage furnaces), emission of harmful

combustion products into atmosphere and therefore its recontamination, and penetration of heavy metals, toxic salts into soil and water, and thereby into human organism. Garbage burning equipment, as a rule is a complex and expensive device, since it has to be equipped with effective filters and gas traps. Due to this reason, this method of solid domestic waste destruction is not frequently used. Domestic and industrial residuals, which are suitable for further processing are called secondary polymer wastes. They include unprocessed goods made of polymers and other materials, composite materials, which have lost their consumer properties due to physical wear [1,2].

II Experimental Part Based on the household plastics, glass and rubber available in the Black Sea coastal area, as well as using renewable vegetable raw materials, new organosilicon binder and antipyrene for the first time there have been received new ecologically safe polymer composites. The mentioned composites as waterproofing materials may be used in construction materials, for manufacture of drawing and building paints and household goods. These composite materials have been studied regarding their water absorption, bending and tensile strength, impact strength (viscosity), physical-mechanical and thermal properties, and supramolecular structure of surfaces using SEM scanning electron microscope.

Sample preparation is a direct process and it includes mixing of different ingredients in an ordinary container. Selection of mixer, ingredients’ blending and testing of obtained composite occurs depending on total mixture mass. Cement, sand and fillers are among typical main ingredients. New recipes are variations of old ones, with alteration of quantity of components, their mass content and change of ingredients (mainly fillers).We have prepared new samples, for which purpose we have added powdered glass in different quantities. Glass was added at the expense of sand amount reduction. 1, 3 and 5% of glass and in all cases 5% of grinded rubber tire powder were added (Table 1). In addition to waste tire powder, 1% of diethyleneglycol ethyl ether and methylcellulose were added to the mixture in different weight ratios.

In order to keep waste tire powder usability and for its safe use, we have determined the content of toxic elements established under the European Union regulations for polymeric materials.

New composite materials were tested for adhesion ability. Adhesion is mainly determined on a periodical basis, depending on which sample is tested. In our case, an experiment was held in 7- or 28-day interval. Results are given in Table 3.

In order to test adhesion to waterproofing materials, square-shaped samples were prepared, which afterwards were attached to cement tile. Preparation process starts with cutting of large tiles, which is followed by tiles’ inspection. Each tile has to have specific size in order to avoid erroneous results during an experiment, and they are checked using a ruler, respectively their size has to meet relevant rules and regulations. After preparation, tiles are glued to large cement tiles. It is necessary to prepare surfaces properly, typically a surface must have two layers, after putting the second layer we glue small tiles, put weight on them and then remove it in a given time. We are waiting for it to dry. After completion of this process we glue metal plates to attached tiles using epoxide. In a few days, using adhesiometer we measure a force needed to tile detachment. It should be noted that a great attention is paid to what a surface remained on a plate after detachment. Experiment for fracture resistance and pressure resistance is conducted at the pressure device. The role of this experiment lies in the fact of determination how many kilopascals are necessary to fracture the product and not to experience structural failure due to pressure. Special molds prepared in the special equipment are necessary for carrying-out the experiment. During an experiment, the fracture resistance is determined first and then we move to pressure using an interface of equipment. Then the fractured plates are thrown it the garbage. After obtaining results takes place their inventory, accounting and numeration in the journal. This experiment depends on the product, since cement glue working properties are totally different

than those of such materials as liquid floor etc. As a rule, this experiment depends on visual perception of experimenter. For instance, for cement glue inspection, after mixing takes place determination of blending sensitivity with the use of spatula (putty knife), then by spatula hitting on the mixture is determined, whether an imprint is left on spatula or no, thereafter a strength of gluing to spatula is measured and then a quantity left on spatula is determined.

Surface spreading and cutting time. Experiment for surface spreading is carried out for liquid floors and is aimed to determination of time, after which a floor loses its liquid properties. Performance of experiment requires a flat, glossy surface, on which special round-shaped molds are placed. Molds are filled with a liquid floor, after definite period of time the molds open vertically, a floor is spread over the surface, then within 10-minute intervals a floor is cut with a spatula, and through visual observation we establish whether the cut surface has been filled or not. Also, it is necessary to measure surface spreading diameter using ordinary ruler. After obtaining results takes place their inventory, accounting and numeration in the journal. For experiment it is necessary to put a plate on horizontal surface, on which a weight is put after 2 minutes, thereafter a surface is stacked vertically for a definite time, during which a plate comes down by a definite distance. This distance is measured using special device, when a surface is put horizontally. Correction time is used for establishment of product petrification time, or else a time after which the constructional correction become impossible. This experiment is similar to adhesion with the only difference that tiles are attached to foam plastic and after a definite period of time they rotate by 180 degrees (do a U-turn).

Mold preparation. Preparation of mold is necessary for many experiments, they are prepared not only for establishment of compression degree, but also for determination of fracture resistance and pressure resistance. Molds are prepared in a special iron container consisting of 3 sections. A material has to be lubricated prior to its putting in order to avoid adhesion (gluing). Afterwards molds are placed in a special device and firmly attached to it. After attachment, we fill molds, switch on the device and wait until it finishes its work, following which we extract obtained mold and put it into storage. It has to be noted that they must be wrapped in cellulose film and wet cloth in order to keep the moisture water content of the mold.

Compression test. Compression is a process experienced by a construction material after definite period of time, it is measured within 1-28-day interval. This is a simple process, as a rule 3 molds are prepared, which are placed on the pressure device (Fig. 1). After placement, it is measured to what extent the prepared mold is compressed.

III Result and discussion

As was mentioned in the experimental part, different percentages of glass and in all cases 5% of rubber tire powder were added for receipt of new composite materials. Results of mechanical parameters’ determination for new composite materials are given in Table 1, from where is seen that a standard extension of a sample CN 68 equals 24,5/24,5 cm after 1 minute. The best possible results close to this value were obtained when 5% of glass were added.

Table 1. Results of mechanical parameters’ determination for obtained composite (waterproofing) materials

Sample	Bending, MPa	Compression, MPa	Extension (min)	Days	Storage conditions
CN68	1,74	7,2/7,2	24,5/24,5 cm	1	23°C/50% humidity
	5,17	18,1/18,6		28	23°C/50% humidity

CN68 + 5% glass + 5% rubber tire	1,7	7,6/7,5	23/23 cm	1	23°C/50% humidity
Powder	4,8	18,5/18,1		28	23°C/50% humidity
CN68 + 3% glass + 5% rubber tire	1,7	8,12/8,12	23,5/23,5	1	23°C/50% humidity
Powder	5,25	19,2/19,2		28	23°C/50% humidity
CN68+ 1% glass + 5% rubber tire	1,7	7,55/7,84	24/23,5	1	23°C/50% humidity
Powder	5,0	19,2/18,4		28	23°C/50% humidity

Results of different elements’ determination in waste tire powder used for receipt of new waterproofing materials are presented in Table 2. Based on the obtained experimental data one may consider that the content of none of the toxically hazardous heavy metals in waste tire powder exceeds permissible standards established for heavy metals in polymeric materials. This fact points at the usability of waste tire powder and in addition, at its safe use as a raw material for receipt of waterproofing materials.

Table 2. Content of some metals (mg/kg) in waste tire powder

Element	**mg/kg**	**NF EN 71-3, mg/kg [12]**
Aluminum (Al)	1 530	70 000
Antimony (Sb)	21	560
Arsenic (As)	1.4	47
Barium (Ba)	21	18 750
Cadmium (Cd)	1.0	17
Calcium (Ca)	4 710	-
Chromium (Cr total)	5.4	Chromium (III) - 460 Chromium (VI) - 0.2
Cobalt (Co)	26.3	130
Copper (Cu)	517.0	7 700
Iron (Fe)	4 909.9	-
Lead (Pb)	36.6	160
Lithium (Li)	2.0	-
Magnesium (Mg)	1 010	-
Manganese (Mn)	53.8	15 000
Molybdenum (Mo)	1.0	-
Nickel (Ni)	11.8	930
Sodium (Na)	571.4	-
Silica (Si)	53.0	-
Potassium (K)	944.6	-
Zinc (Zn)	6 417	46 000

Results of new composite (waterproofing) material tests for adhesion ability are presented in Table 3, from where is seen that adhesion ability is the best possible in case of adding 5% of glass

compared to application of 1 and 3% of glass. In addition, 5% of glass content provides the best mechanical properties of composite materials obtained by us.

Table 3. Test of new composite samples for adhesion ability

CM 11 + adhesion in standard condition after 14 D.	
Test method	EN 12004-2:2012/2018
Storage conditions	23 ^{0}C/ 50% (humidity)
Standard	1.07 MPa
1% glass	1.1 MPa
3% glass	1.1 MPa
5 % glass	1.2 MPa
Comment	Glass addition at the expense of sand

IV Conclusion

New recipes of cement glues, which are variations of old ones, have been developed. We have changed quantities of components entering cement glue and added new components, which respectively lead to percentage change of components and improvement of properties. Ethyl silicate, household plastic and rubber articles waste have been added to new samples prepared by us, which opens up the opportunity of harmful waste transformation into useful products using chemical and technological processes. None of the toxically hazardous heavy metals’ content in waste tire powder exceeds permissible standards established for heavy metals’ content in polymeric materials, which points at usability of waste tire waste as well as at its safe use as a raw material for receipt of waterproofing materials. One may draw conclusion that prepared new samples of cement glue, to which 1, 3, 5% of glass powder have been added and 5% of rubber waste have been taken in all cases, have improved their mechanical properties. The best results have been obtained when 5% of glass and 5% of powdered rubber tire have been added.

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საყოფაცხოვრებო ნარჩენებზე დაფუძნებული ადჰეზიური კომპოზიტები

ე. მარქარაშვილი, ბაზღაძე ზ.ზ., თაყაიშვილი ნ.ვ., სიდამონიძე ნ.ნ, სნესარ ა.

რეზიუმე.

გარემოს დაცვა საყოფაცხოვრებო ნარჩენებით გამოწვეული დაბინძურებისაგან განსაკუთრებით შავი ზღვის სანაპირო ზოლში უნდა იყოს თითოეული ადგილობრივი საზოგადოების წევრის, და გარკვეულწილად, მთელი კაცობრიობის პასუხისმგებლობა. წინამდებარე ნაშრომი მიზნად ისახავს ახალი, ეკოლოგიურად უსაფრთხო მასალების მიღებას შავი ზღვის სანაპირო ზოლში დაგროვილი პლასტმასისა და რეზინის საყოფაცხოვრებო ნარჩენების ბაზაზე. აღნიშნული მიდგომა იძლევა შესაძლებლობას, მავნე ნარჩენები გარდაიქმნას სასარგებლო და ფუნქციურ პროდუქტად. მიღებულია ახალი სამშენებლო მასალები, რომლებიც დამზადებულია მინის, პლასტმასისა და რეზინის ნარჩენებისა და ადჰეზიური ცემენტების საფუძველზე. შედეგად, პირველად იქნა მიღებული ეკოლოგიურად უსაფრთხო პოლიმერული კომპოზიტები. აღნიშნული კომპოზიტები შეიძლება გამოყენებულ იქნას სამშენებლო მასალებში, მხატვრულ-დეკორატიულ საფარებში და საყოფაცხოვრებო დანიშნულების ნივთებში. კომპოზიტური მასალებისთვის შესწავლილია შემდეგი მახასიათებლები: წყლის შთანთქმა, სიმტკიცე წყვეტაზე და კუმშვაზე, დარტყმითი სიბლანტე, ფიზიკურ-მექანიკური და თერმული თვისებები, ზედაპირის სუპრამოლეკულური სტრუქტურა სკანირებადი ელექტრონული მიკროსკოპიის (SEM) გამოყენებით. ასევე შეფასებულია ტექნოლოგიური პარამეტრები, როგორიცაა გამყარების დრო და დამუშავებადობა.

საკვანძო სიტყვები: ეკოლოგია; ადჰეზიური ცემენტი, ეთილსილიკატი, მინა.