ADHESIVE CEMENTS 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: adhesive cement; ethylsilicate; glass.

Improvement of the 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 a 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 organisms and have a harmful effect on health. Prevention of plastic pollution means salvation of water inhabitants 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 plastic, for example plastic plates, knives and forks, ear 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 [1-6].

The environmental 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 methods of destruction of solid domestic waste and packing 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 land. 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 the atmosphere and therefore its recontamination, and penetration of heavy metals, toxic salts into soil and water, and thereby into human organisms. 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 [7-12].

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 a 7- or 28-day interval. Results are given in Table 1. 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 an adhesiometer we measure a force needed to tile detachment. It should be noted that great attention is paid to what surface remains on a plate after detachment. As it 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 it is seen that a standard extension of a sample CN 68 equals to 24,5/24,5 cm after 1 minute. The best possible results close to this value are obtained when 5% of glass was 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
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 it 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

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 the 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 tires have been added.

References

1. Hernandez R. J., Selke S. E. M., and Culter J. D., Plastics Packaging, Hanser, Munich, 2000.
2. Hunger H. K., Industrial Organic Pigments, VCH, Weinheim, 1993.
3. Sorokin M.F., Lyalyushko K.A., Practicum in chemistry and technology of film-forming substances. M. Chemistry, 1971, p. 246. (in Russian)
4. Puri VP., Effect of crystallinity and degree of polymerization of cellulose on enzymatic saccharification. // Biotechnol Bioeng 26, 1984, pp. 1219-22.
5. Okonko I.O., Adeola O.T., Aloysius F.E., Damilola AO, Adewale OA. Utilization of food wastes for sustainable development, electronic. // J Environ Agric Food Chem 8, 2007, pp. 263-86.
6. Torres F.G., Cubillas M.I., Study of the interfacial properties of natural fiber reinforced polyethylene, Polymer Testing, 24, 6, 2005, pp. 694-698. http://dx.doi.org/10.1016/j.polymertesting.2005.05.004.
7. Gorlovsky I.F., Bocharova A.M., Suvorova V.D., Laboratory practicum on pigment chemistry and technology. // L., Chemistry, 1978, p. 223. (in Russian).
8. Bagazhkov S.G., Sukhanova N.A., Practicum on lacquer coating technology. // M. Chemistry, 1982. p. 240. (in Russian).
9. Yakovlev A.D., Powder paint. // L., Chemistry, 1987, p. 216. (in Russian).
10. Karyakina M.I., Poptsov V.E., Polymeric coating technology. // M. Chemistry, 1983, p. 335. (in Russian).
11. Microwave plasma atomic emission spectroscopy (MP-AES), January 2021. Agilent.
12. European Standard, Supersedes EN 71-3:2013, October 2014, https://law.resource.org/pub/eu/toys/en.71.3.2015.html