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Creation of Polymer Compositions with Improved Performance Properties Based on Secondary Waste Raw Materials

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ABSTRACT

The classification and sources of formation of wastes of high-molecular materials are given. Particular attention is paid to the grinding and classification of composite polymer waste. The features of obtaining mixtures for the manufacture of compositions based on crushed and modified waste are noted.

The introduction of polymer materials based on macromolecular compounds in all sectors of the national economy has created the problem of recycling and recycling of polymer waste.

Currently, the problem of using polymer waste is relevant, both from an environmental and economic point of view. Particular attention should be paid to the processing of cross-linked elastomers, since their amount in the total mass of polymer waste is the largest part, and the methods of their processing and disposal still do not fully ensure their use in industry.

The main ways of recycling plastics and elastomers are sorting, cleaning, grinding, partial or complete destruction of waste.

Given the variety of ways to recycle polymers and elastomers, it is necessary to choose the most important aspects of their processing that affect the quality of the finished compositions. In our opinion, the most promising are the following areas in the processing of polymer waste and the creation of compositions:

- development of formulations for press mixtures made from modified polymers and elastomers by grinding in a high-speed grinder in the presence of reactive agents;
- development of formulations for compositions containing crushed waste polymers and cross-linked elastomers modified with solutions of low molecular weight polymers [1].

PVC (polyvinyl chloride) is the raw material used for the production of soles . This raw material is a composite material. It has such qualities as weightlessness, strength, anti-slip properties, as well as resistance to various temperature conditions and their differences. In our production, such raw materials are used for the manufacture of everyday shoes - women's

and men's cloth boots. The main purpose of these shoes is protection from low temperatures both indoors and outdoors during the cold season.

The performance of these functions is ensured by the main characteristics of PVC:

1. The high density of PVC determines the strength and increased wear resistance of the material. Our boots are suitable for various kinds of work, since the sole is not afraid of cuts, tears, abrasive coatings. Also, the material is not subject to deformation and is able to quickly restore its original shape, which greatly increases its service life.
2. Due to frost resistance (up to -35 degrees Celsius), such soles are ideal for winter shoes, for work in extreme conditions.
3. The thickness and density of the material make it possible to make a deep tread, thereby increasing grip on a slippery surface and ensuring stability when walking in the cold season.
4. The flexibility and resilience of the PVC sole make the shoes comfortable, reduce the likelihood of kinks [2].

As you know, polyvinyl chloride is a synthetic thermoplastic polar polymer. Polymerization product of vinyl chloride. White solid. It is produced in the form of a capillary- porous powder with a particle size of 100-200 microns, obtained by polymerization of vinyl chloride in bulk, suspension or emulsion. The powder is free-flowing and well processed. On the basis of polyvinyl chloride, hard (viniplast) and soft (compound) plastics, plastisols (pastes), and polyvinyl chloride fiber are obtained. Viniplast is used as a rigid structural material used in construction in the form of moldings , profiles, pipes. Plastic compound is used for the manufacture of films, hoses, oilcloth, linoleum.

Based on polyvinyl chloride (PVC), more than 3,000 types of composite materials and products are used in the electrical, light, food, automotive industries, mechanical engineering, shipbuilding, in the production of building materials, medical equipment, etc., due to its unique physical and mechanical, dielectric and other operational properties.

However, at present, the use of PVC is gradually limited, which is primarily due to environmental problems that arise during the operation of products, their disposal and recycling. During the aging of PVC-based polymers, along with the loss of physical and mechanical properties, there is a negative impact on the environment and humans, due to PVC dehydrochlorination processes , which increase at a temperature of 50–80 °C (highly toxic chlorine -containing polyaromatic compounds are formed).

Currently, there are the following ways of beneficial use of recycled polymer raw materials:

- ✓ combustion for the purpose of obtaining energy;
- ✓ thermal decomposition (pyrolysis, destruction, decomposition to initial monomers, etc.);
- ✓ reuse;
- ✓ recycling.

Waste incineration in incinerators is not a cost-effective disposal method, as it involves pre-sorting the waste. During combustion, there is an irretrievable loss of valuable chemical raw materials and environmental pollution with harmful substances in flue gases.

A significant place in the recycling of secondary polymeric raw materials is given to thermal decomposition as a method of converting EPS into low molecular weight compounds. An important place among them belongs to pyrolysis. *Pyrolysis* is the thermal decomposition of organic substances in order to obtain useful products. At lower temperatures (up to 600°C), mainly liquid products are formed, and above 600 °C , gaseous products, up to carbon black [3].

During processing, polymers are exposed to high temperatures, shear stresses and oxidation, which leads to a change in the structure of the material, its technological and operational properties. The change in the structure of the material is decisively influenced by thermal and thermal- oxidative processes.

PVC is one of the least stable industrial carbon chain polymers. The reaction of PVC destruction - dehydrochlorination begins already at temperatures above 100 ° C , and at 160 ° C the reaction proceeds very quickly. As a result of thermal oxidation of PVC, aggregative and disaggregative processes occur - cross-linking and destruction [4].

The main raw materials for the production of PVC are chlorine, obtained by electrolysis of sodium chloride solution, and ethylene. The PVC production process can be briefly described as follows: during electrolysis, common salt dissolved in water is decomposed into chlorine, caustic soda and hydrogen under the influence of an electric charge. Separately, ethylene is produced from oil or gas through a process called cracking. The next step is the combination of ethylene and chlorine. As a result, ethylene dichloride is obtained , from which vinyl chloride monomer is then produced, which is the basic element in the production of polyvinyl chloride (PVC). During polymerization, vinyl chloride monomer molecules combine to form long PVC chains. The resulting PVC granulate is also, in fact, a raw material - various substances are added to it to give the material a wide variety of properties. This is what allows PVC to be used in almost every area of our daily life [5].

There are many problems associated with the disposal of polymer waste. They have their own specifics, but they cannot be considered undecidable.

However, the solution is impossible without organizing the collection, sorting and primary processing of depreciated materials and products;

without developing a system of prices for secondary raw materials, stimulating enterprises to process them;

without creating effective methods for processing secondary polymeric raw materials, as well as methods for modifying it in order to improve quality;

without creating special equipment for its processing; without developing a range of products manufactured from recycled polymer raw materials.

Homogeneous industrial waste, as a rule, is recycled, and in cases where only thin layers of material are subjected to deep aging [6].

In some cases, it is recommended to use an abrasive tool to remove the degraded layer with subsequent processing of the material into products that are not inferior in properties to products obtained from the original materials.

To separate the polymer from the metal (wires, cables), a pneumatic method is used. Typically, isolated plasticized PVC can be used as low voltage wire insulation or injection molded products. To remove metal and mineral inclusions, the experience of the milling industry based on the use of the induction method, the method of separation by magnetic properties can be used. To separate aluminum foil from thermoplastic, heating in water at 95–100 °C is used.

It is proposed to immerse unusable containers with labels in liquid nitrogen or oxygen with a temperature not exceeding -50 ° C to make the labels or adhesive brittle, which will then allow them to be easily crushed and separate a homogeneous material, such as paper.

An energy-saving method for the dry preparation of plastic waste using a compactor. The method is recommended for processing artificial leather (IR) waste, PVC linoleums and includes a number of technological operations: grinding, separation of textile fibers, plasticization, homogenization, compaction and granulation; additives may also be added. The lining fibers are

separated three times - after the first knife crushing, after compaction and secondary knife crushing. A molding mass is obtained which can be processed by injection molding, which still contains fibrous components which do not interfere with processing, but serve as a filler that reinforces the material [7].

Thermodynamic modeling of PVC degradation processes allowed us to propose two options for conducting PVC thermal utilization processes that ensure their environmental safety.

I. Pyrolysis of PVC at a temperature of 700-800 K , followed by neutralization of the resulting hydrogen chloride by its interaction with calcium oxide at 400-500 K and post-combustion of the neutralized gas with atmospheric oxygen at 1000-1100 K. Filters containing lump quicklime can be used to neutralize pyrolysis gases .

II. Pyrolysis of PVC in the presence of calcium oxide at 600-800 K. Pyrolysis gases containing methane and hydrogen, which have a high calorific value, can be used as fuel to maintain the required temperature in the pyrolysis furnace. If it is impossible to utilize the resulting gases for the complete conversion of organic compounds, they must be burned at 1100–1200 K before being released into the atmosphere.

To experimentally substantiate the proposed PVC recycling method, developed on the basis of thermodynamic modeling of the polymer degradation process, two series of tests were carried out in a laboratory pyrolysis furnace for the thermal processing of a PVC-containing fraction of medical waste and polymeric materials used in the automotive industry.

Findings

1. It is shown that the modification of elastomeric waste during grinding makes it possible to obtain high-quality rubber crumb due to the grafting of functional groups as a result of mechano -chemical processes occurring during the destruction of polymers.
2. A method has been developed for diffusion surface modification of elastomer wastes during the swelling of vulcanizates in solutions of low molecular weight rubbers and initial mixtures. It is shown that diffusion modification contributes to the formation of an additional vulcanization network at the waste-polymer matrix interface.
3. Designs of grinding devices for polymer, elastomer and hard fiber materials have been developed. Dependences of the sizes and quality of the crushed material on technical parameters of grinders are established . It is shown that the design with an oscillating motion of the rotor is the most effective.
4. It has been theoretically and experimentally established that the power expended on grinding elastic materials in high-speed grinders depends on the Debort criterion (the product of the relaxation period of a highly elastic material and the frequency of dynamic loading of the material being ground).
5. An economical device for the aerodynamic separation of crushed rubber-fabric materials has been developed, which makes it possible to effectively separate the textile and polymer components of composite materials without additional energy costs.

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