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Regulation of destruction processes as a basis for the synthesis of durable plastics and their recycling

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ANNOTATION

The peculiarities of obtaining durable plastics are considered, taking into account the influence of their destruction processes under the influence of various factors, the possibility of using biodestruction for recycling and disposal of spent polymer materials is determined.

Key words: longevity of plastics, destruction processes, degradation processes, recycling, utilization, biodegradation.

1. INTRODUCTION

The positive characteristics of polymer materials, which make them popular and almost universal for the manufacture of construction products or individual elements of complex structures, are sufficient strength provided that permissible loads are observed, as well as reliability due to resistance to the influence of external factors, including corrosion. The duration of the use of plastics is significantly affected by their negative characteristics, such as sensitivity to elevated temperatures, low fire resistance, and aging due to long-term UV exposure [1].

If the corrosion resistance of polymer materials is sufficiently high, they can undergo aging processes with degradation of the material structure and loss of their properties. This can cause the formation of polymer-containing waste, including "secondary microplastic", represented by microgranules, which are formed as a result of the decomposition of plastic waste mainly under the influence of water and UV rays and which negatively affects the environment and the body of living beings [2].

One of the reasons for the long-term decomposition of plastic is the absence of natural "recyclers" - bacteria, and synthetic compounds decompose only mechanically (through grinding), chemically (due to possible interaction with active components, although most plastic products are inert), thermally (combustion, evaporation) and due to ultraviolet radiation. On the other hand, it is the chemical stability of plastics that determines the difficulty of recycling used polymer products, which is a serious environmental problem [3, 4].

Thus, a common problem is the relatively short-term use of plastics and a long period of their decomposition with limited opportunities for recycling and disposal, which negatively affects the ecological state of the environment.

2. PURPOSE

To investigate the impact of the processes of degradation and destruction of polymers on the technology of obtaining durable plastics and to consider the possibility of using biodestruction for recycling and utilization of spent polymer materials.

3. MAIN RESULTS

The impact of an aggressive environment on polymer materials is manifested in a change in their structure and properties, which in turn affects durability. At the same time, various destructive processes occur in polymers, blocking which can contribute to the formation of long-lasting, as well as solve environmental problems associated with additional costs of material and energy resources and reducing the volume of polymer waste in landfills. The intensity of destruction or the degree of corrosion resistance of polymeric materials depends on their properties, as well as the type and chemical composition of the aggressive environment. Corrosion of polymers can occur under the influence of various oxidizing agents, thermal, radiation, mechanical and other factors, as well as during chemical interaction with various aggressive environments. Most polymers are characterized by high chemical resistance, and the greatest resistance is shown by fluoroplastics, ethylene plastics, viniplasts, organosilicon and other resins that do not contain polar groups.

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Oxidative destruction of polymers occurs mainly under the influence of oxygen in the air, and in real conditions of use, polymer materials are affected by sunlight, moisture, and heat. These factors determine the aging of materials, and this process is activated by exposure to the ultraviolet part of the spectrum. Thermal oxidation (thermal destruction) of polymer materials occurs under the influence of heat, as well as under the simultaneous influence of heat and oxygen. Aging processes are especially fast under the combined influence of oxygen in the air, ultraviolet radiation and when the temperature of the environment increases. Reactions can develop in two directions: 1) under the action of destruction processes that lead to a decrease in the length of polymer molecules; 2) the second direction leads to the aggregation of molecules (joining of molecular links), which leads to a decrease in elasticity, an increase in the stiffness of the polymer and an increase not only in strength, but also in the fragility of products based on it.

Antiaging additives (phenols, amines) and stabilizers (salts of lead, cadmium, barium, calcium) are introduced into the composition of the polymer to prevent oxidative or thermal destruction. Stabilizers or additives against aging should not deteriorate the physical and mechanical properties of the polymer, and therefore they are introduced in a small amount (up to 2%). Complex plastic stabilizers - amines, phenols, carbon black - are used to slow down photo- and thermal aging. For polystyrene, the introduction of carbon black is especially effective, which acts as a filter for UV radiation and at the same time complicates thermal aging. Polystyrene insulation, which contains carbon compounds, usually loses its thermophysical properties more slowly under the influence of sunlight and heat, and also better resists heat transfer.

Mechanical destruction of polymers occurs under the influence of loads that exceed the strength limit of materials. Such destruction can be accelerated in the presence of air oxygen. The mechanical properties are significantly affected by the content of fillers. The strength and rigidity of plastics increases especially when they are filled and simultaneously reinforced with fibrous and layered fillers. Chemical destruction of polymeric materials occurs when they interact with chemical reagents, for example, heterochain polymers (polyamides, thiols, siloxanes, polyesters, etc.) are relatively easily decomposed under the action of hot water, acids, alkalis.

The mechanism of destruction of many polymers is chain. This makes it possible to propose as effective methods of inhibition of the processes of destruction, breaking of chains, reducing the probability of their nucleation. A big role in this is played by fillers, which cease to be inert materials and take part in chemical processes. Thermoplastics most often contain 15...40%, and reactive plastics - 30...80% of fillers. Powder-like (wood flour, chalk, kaolin, talc, quartz sand) and fibrous (glass, carbon, wood, metal fibers) materials are used as fillers. In this way, various composite materials of increased durability are usually created, including fiberglass.

Halide derivatives (polyvinyl chloride, chlorinated paraffin), organosilicon compounds (silicones), as well as flame retardants (ammonium phosphoric acid) can be used to increase the non-flammability of construction plastics. For construction plastics, the issues of stability of properties over time are of particular importance. In such cases, the introduction of only fillers may not be enough, and then, in addition to choosing the most resistant, inhibitors are added to the composition of such polymers (polystyrene, polymethyl methacrylate) - substances capable of sharply slowing down chain processes. Effective inhibitors include wood-resin antioxidants enriched with phenols, as well as benzophenol derivatives, some amines, and stearates of lead, calcium, and barium. Increasing the elasticity (reducing brittleness) of polymers can be achieved by using "grafted" polymers, choosing the appropriate side chains and the most suitable monomers, and also by introducing non-volatile high-boiling organic liquids that cause the polymer to swell. As plasticizers, esters of alcohols and acids (phthalic, phosphate), phosphates, dimethyl phthalate, butyl stearate, etc. are used.

The high coefficient of constructive quality of plastic, which was so sought after by its inventors and which was considered one of its advantages, in the long run turned out to be one of its main disadvantages and now threatens to litter the entire planet, causing significant damage to animal and plant life.

Biological destruction of polymers occurs under the action of microorganisms, insects and animals, which reduce the hygiene of products and worsen their appearance: they contribute to the creation of stains of gray, green, black, purple or pink colors that cannot be removed.

Microorganisms can break down plastic by producing enzymes that break the chemical bonds within the material, for example they can break down PVC, PE, PP, PS, etc. Plastics with simpler molecular structures tend to be more susceptible to microbial degradation than others. The use of plastic with high microbial resistance or the addition of antimicrobial additives (antiseptics) is effective.

Therefore, one of the ways to solve the environmental problem of polymer waste accumulation is the development of biodegradable plastics. Such materials are broken down by living organisms into water, biomass, carbon dioxide or methane in a relatively short period of time (usually a few weeks to a year). Depending on the type of biodegradable plastic, different methods of obtaining it are used: in the production of plastic based on polyhydroxyalkanoates (PHA), fermentation is carried out, during which microorganisms convert sugars or lipids into biopolymers; production based on polylactic acid (PLA) involves the conversion of raw materials into monomers (such as lactic acid), which are then polymerized to create long polymer chains. After obtaining the polymer, it is melted and, by extrusion, turned into granules for further use. Biodegradable plastic pellets are used in various forming methods: injection molding, film blowing.

Currently, all the technologies of biodegradable plastics produced and studied can be divided into four groups; 1) polymers extracted from biomass and natural polymers: starch, cellulose, proteins; 2) polymers produced by microorganisms during their vital activity (polyhydroxyalkanoates, bacterial cellulose); 3) polymers artificially synthesized from natural monomers (for example, polylactides); 4) traditional synthetic plastics with biodegradable additives introduced into them. The production of biopolymers is more expensive compared to traditional plastics, which is due to the higher cost of raw materials and production processes.

4. CONCLUSIONS

Blocking various types of destruction opens up new opportunities to increase the service life of polymeric materials, on the other hand, the use of biological destruction with the involvement of new technologies and new types of microorganisms will contribute to solving the issue of utilization and recycling of spent polymeric materials not only for household purposes, but also for construction purposes, including structural, which will significantly improve the environment.

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