Review _____ *Thematic Section:* Research into New Technologies.
Reference Object Identifier – ROI: jbc-02/17-52-10-56 *Subsection:* Composite Materials.
Publication is available for discussion in the framework of the on-line Internet conference "*Butlerov readings*".
http://butlerov.com/readings/
Submitted on October 21, 2017.

Biodegradable polymer composite materials using natural rubber

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Keywords: natural rubber, biodegradation, polymer composite materials.

Abstract

Currently, the production of polymers in the world amounts to 290 million tons per year, the demand for which is steadily growing. In view of the high resistance of polymeric materials to degradation, the amount of polymer waste and waste products polluting the environment is growing sympathetically.

Burning or pyrolysis of polymer waste to some extent solves the problem of their accumulation in landfills, but does not contribute to improving the ecological situation. Recycling is more environmentally friendly, but in this case considerable labor and energy costs are required for sorting and processing. It should be noted that recycling is carried out a limited number of times, after which the problem of burial or burning of these materials again arises.

The solution to the above problem is the creation, including structural biodegradable polymers and products based on it. Such polymers should have a high level of performance and at the same time have the ability to biodegrade in conditions of deposition.

Microbial degradation is one of the alternative and potentially possible ways of synthetic polymers utilization. The ability of polymers to decompose and assimilate by microorganisms depends on a number of their structural characteristics. The most important are the chemical nature of the polymer, the molecular weight, the branching of the macrochain (the presence and nature of the side groups), the supramolecular structure, the flexibility of macromolecules.

The main ways to increase the rate of biological degradation of polymers are directed to the introduction, by copolymerization, to the structure of the backbone of units sensitive to the action of destructive agents, or to the creation of composite materials based on a mixture of a carbon chain polymer with natural or synthetic biodegradable polymers.

One way to create materials that are capable of biodegradation is the introduction of a natural or synthetic biodegradable polymer into a matrix of synthetic polymers. In general, polyolefins are used as a matrix in such mixtures, and the dispersed phase is starch, as the cheapest one, and polyhydroxybutyral is considered to be the most accessible of synthetic biodegradable polymers.

Natural rubber (NR) is one of the biodegradable polymers that produced by plants and not accumulating in nature. In the general case, the NR latex composition in % mass is: polyisoprene (25-35), proteins (1.0-1.8), carbohydrates (1.0-1.2), neutral lipids (0.4-1.1) polar lipids (0.5-0.6), inorganic components (0.4-0.6), amino acids and amides (0.4), water (50-70).

Microbial degradation of NR was investigated during the last 100 years, which made it possible to assert that bacteria, as well as fungi, are capable of decomposing NR. Many bacterial strains have been described that are able to use NR and NR-based rubber as the sole source of carbon and energy.

Most studies are devoted to the study of biodegradation of either purified NR or NR rubber tires pieces, but there are no studies of untreated NR. The undoubted advantage is the absence of costly purification steps from substances that accompany traditional NR technology. The use of crude NR in polymer compositions in a mixture with synthetic polymers indicates its enhanced degradation capacity.

Moreover, the same method is applicable not only to NR, but also conventionally degradable polymers: PA, polyurethanes, polyesters, and the like. At the same time, the main complex of parameters of the polymer composite is preserved. NR as an additive to biodegradable polymers contributes to their degradability. As a result of the conducted studies on the effect of microorganisms on NR, it was found that crude NR due to the presence of non-rubber components that promote biodegradation of polymers is one of the promising additives for reducing the decomposition time of polymer compositions.

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