PHBV - COFFEE WASTE BIOCOMPOSITE AS A MATERIAL USED IN MANUFACTURING OF UTILITY PRODUCTS

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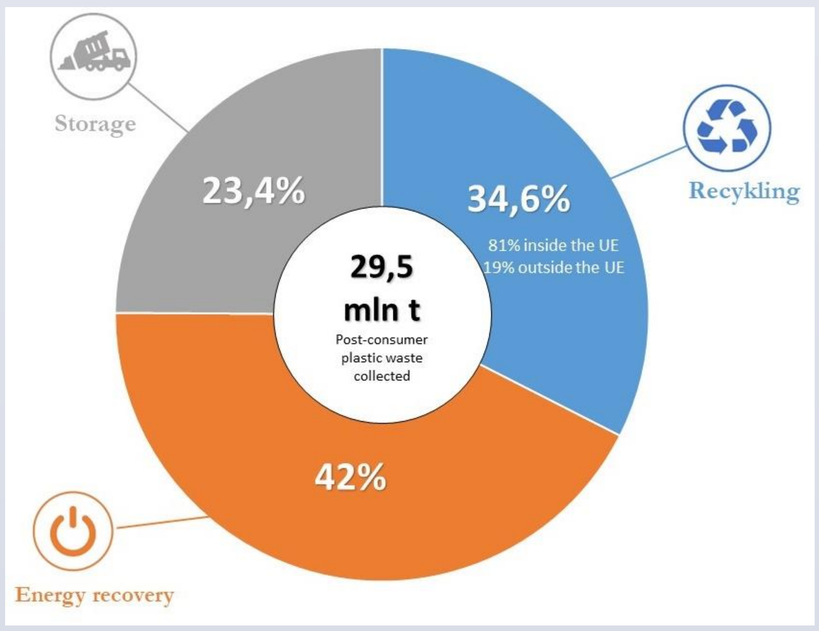
Abstract

An important problem of the modern world is the constantly increasing amount of plastic waste. It should be mentioned that these materials are mostly of petrochemical origin, are non-biodegradable and are recycled with varying degrees of success. PHBV (poly(3-hydroxybutyric acid-co-3-hydroxyvaleric acid)) belonging to the group of polyhydroxyalkanoates (PHA) is a polymer of natural origin, fully biodegradable. Due to high production costs, it is rarely used in injection molding technology, which currently has little commercialization potential. One of the methods of reducing production costs and improving the properties of the above-mentioned material is the use of used coffee grounds as a filler in the PHBV matrix. The authors of the invention have already carried out research in the context of the production, evaluation of the mechanical and processing properties of the PHBV-waste coffee grounds biocomposite. Improvement of selected mechanical, processing and functional properties of the biocomposite in relation to pure PHBV was found. The produced biocomposite can be used as a substitute for plastics of petrochemical origin in injection and extruded products, due to its origin and biodegradability.

Keywords: PHBV, biopolymer, used coffee grounds, injection molding, circular economy

The need to develop a modern biocomposite

In 2020, 367 million tons of plastics were produced in the world, and the demand for them in the European Union amounted to 49.1 million tons (for Poland it was 7.5% of the EU demand). The huge demand for these materials is associated with the problem of waste management, where post-consumer waste is considered a product after the end of the use phase. The collected waste can be divided into: recycled, waste from which we recover energy and waste stored in landfills. In 2020, 29.5 million tons of post-consumer plastic waste was collected in the European Union, 34.6% was recycled, 42% was energy recovered, and as much as 23.4% was landfilled (current Polish-language data from the report of the Plastics Europe Polska Foundation: "Tworzywa - Facts 2021 - Analysis of production, demand and recovery of plastics in Europe"). The introduction of new EU regulations in 2018 regarding the appropriate collection and processing of biodegradable and compostable polymers prompts the development of technologies for the development of new materials based on natural resources - materials of natural origin such as used coffee grounds and double-green polymers (such as PHBV), because after fulfilling their useful application, they can be decomposed into prime factors in the biodegradation process, which reduces production costs and supports pro-ecological activities regarding the life cycle of products and materials made of them.



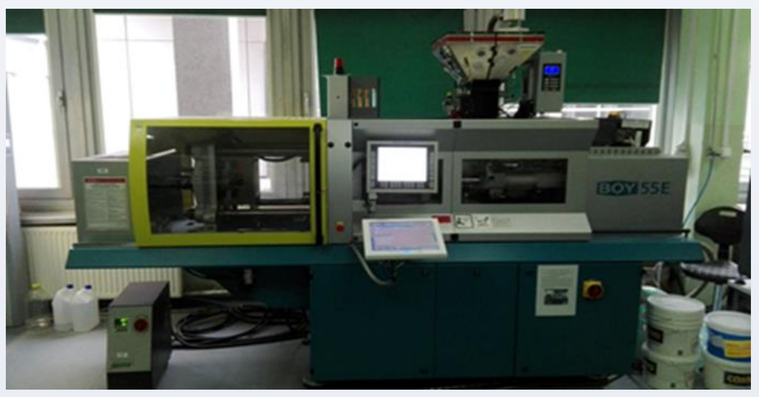
The problem of plastic waste management

Biocomposite manufacturing method

The biocomposite was extruded using a Zamak twin-screw and single-screw extruder at adjustable temperature values in individual heating zones. The extruded biocomposite was granulated on a stand equipped with a cooling bath and a granulator. In the extrusion process, granulate was obtained, which was used for injection molding.

Injection molding of biocomposite samples

A DrBoy 55E injection molding machine equipped with the Priamus system for monitoring and controlling the injection molding process was used for the injection molding process. The tests used an injection mold with inserts intended for uniaxial tensile testing (according to the PN-EN ISO 527 standard),



DrBoy 55E injection molding machine used in biocomposite processing

Biocomposite compact (used coffee grounds 45% by weight)

Selected biocomposite properties

Based on the pre-implementation tests, it was found that a biocomposite containing up to 45% wt. filler, reducing the price of the biocomposite by up to approx. 40%, improving the hardness by approx. 10%, reducing the processing shrinkage of injection molded products by approx. 10% compared to pure PHBV. At this point, it should be remembered about the natural origin of the polymer biocomposite, which is biodegradable.

Advantages of biocomposite and possibilities of its application/commercialization

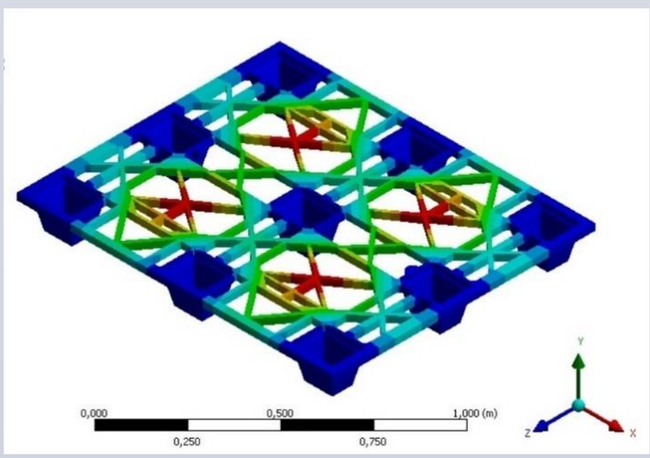
The produced biocomposite can be widely used in the production of products manufactured in injection and extrusion technology. In this context, the biocomposite protected by a patent may be made available in the form of the sale of rights and the granting of a license for the method of obtaining it.

After the development of a modern biocomposite, a significant improvement in most of the mechanical, processing and functional properties of the biocomposite was found in relation to pure PHBV. The above-mentioned advantages/properties contribute to increasing the chances of its commercialization in the context of its use as a substitute for non-biodegradable plastics of petrochemical origin.

The developed material can be used for the production of products for a specific purpose. Directions of searching for the possibility of using the above-mentioned materials focused on the production of a functional product that would meet the following criteria:

- wears out after some time of use,
- it is not repaired after damage,
- can function as a loaded product during use,
- may have direct contact with living organisms.

Ultimately, considering the criteria, this biocomposite may be used e.g. in the production of: plastic pallets, crates for fruit/vegetables, containers for hospital waste such as swabs, etc., elements protecting the electronics sold in cartons and packaging, disposable cutlery. The recipient of the solution may be companies producing details of the above. purpose in the injection molding process.



Visualization of the maximum deflection of a pallet made of biocomposite during utility

Acknowledgments

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