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IMPROVED TECHNOLOGY FOR PRODUCTION OF PE AND PP REGRANULATES

Aleksandar Jovanović[1*], Nataša Knežević[1], Natalija Čutović[1], Maja Đolić[1], Nevena Prlainović[1], Zlate Veličković[2], Marija Vuksanović[3]

[1]University of Belgrade, Faculty of Technology and Metallurgy, Karnegijeva 4, 11070 Belgrade, SERBIA

[2]University of Defense, Military Academy, Veljka Lukića Kurjaka 33, 11042 Belgrade, SERBIA

[3]University of Belgrade, National Institute of the Republic of Serbia, Institute of Nuclear Sciences, Mike Petrovića Alasa 12–14, 11000 Belgrade, SERBIA

[*]*aleksandarjovanovic.tmf@gmail.com*

Abstract

Management of waste polymers (polyethylene - PE and polypropylene - PP) represents one of the major obstacles in the field of environmental protection, which demands a most efficient and eco-friendly technological solution. Due to the high use of various plastic materials, the amount of landfilled or dissipated plastic waste is continuously growing. Therefore, this paper examines the possibilities of recycling these polymers, alongside obtaining granules of similar or advanced physico-mechanical characteristics to the commercially available ones. The applied technology consists of several consecutive processes (collecting, grinding, washing and extruding) where the obtained materials can later be incorporated into widely applicable products, such as foils, bin liners, bags, among others. In this way, high-quality products with great market potential are obtained, which will consequently contribute to lower extraction and less depletion of natural resources. Thus major problems may be solved optimally, consolidating the efficiency of improved eco-friendly technologies which is in line with environmental protection and sustainable waste management.

Keywords: polyethylene, polypropylene, recycling technology, plastic processing

INTRODUCTION

The field of environmental engineering, in the first-place environmental prevention and protection, is daily gaining more public attention. A special place is occupied by waste management due to the possibility of using generated mass to obtain products that can easily be reused or incorporated into new products, improving their initial properties. The benefits of recycling are reflected in the following: conservation of natural resources, decreased consumption of electricity and water, reduction of gas emissions into the ecosystem, etc.

The global polyethylene market size was USD 107.43 billion in 2019, and it is projected to reach USD 130.26 billion by 2027, exhibiting a compound annual growth rate (CAGR) of 3.4%, whereas, the CAGR for polypropylene is 5.2%, due to the market growth from USD 75.12 billion to estimated USD 108.57 billion, within a period of eight years [1,2]. From the above data, it can be concluded that the development of recycling processes can achieve significant economic benefits. Polyethylene is popular in industry branches related to packaging and construction, due to its good physicochemical and mechanical characteristics. PE is a plastic material that is the most widely produced while having the simplest basic structure out of all polymers (a repetition of CH_2 units). PE's key advantages include its low cost, strong electrical insulation, excellent chemical resistance, good processability, toughness, flexibility, and transparency in thin films of certain grades [3]. Even today, many applications still rely on virgin material instead of PE regranulate, such as LDPE. Regranulates are less expensive than virgin material, especially since PE regranulates available on the market have shown high discrepancies in quality and high impurity of constituents.

However, conventional production still prefers virgin material to eco-friendly regranulate. This tendency has to be emergency changed. With high-quality PP regranulates, high-quality cleaner production may be established respecting environmental protection and promoting the new concept of the circular economy. PE as one of the lightest and most adaptable polymers available, may go through a wide range of manufacturing procedures. Commercial PE is often a blend of 75% isotactic and 25% atactic, even though it comes in three different tactic forms. PE demand is continuously increasing, making it one of the most frequent kinds of microplastic discovered in the marine environment [4].

The paper focuses on the development of a novel technology for the production of regranulates based on PE and/or PP in order to improve their commercial competitiveness. Waste polymer preparation consists of three process operations: sorting, washing, and grinding. The new technology will boost productivity and flexibility, reduce energy consumption, make labor easier, and produce fewer waste byproducts. This will result in higher-quality regranulates, as well as improved filtration, homogenization, and degassing, making recycling more efficient and profitable.

The products obtained in this way possess a wide range of applications, because of their advanced mechanical and physicochemical properties. They can be used in the automotive industry, for the production of various profiles by extrusion or coextrusion. On the other hand, it can be used for the making of brushes, brooms, various types of fibers, trash cans and doormats.

MATERIALS AND METHODS

Processing of waste PE and PP

The entire process of recycling waste PE and PP (Figure 1) is presented in a set of operations that effectively contribute to the productivity of the process. The process of recycling plastic films begins with inspection and selection (stage 1), in order to remove any foreign materials, contaminants, or other plastics. Some dirtier or cross-contaminated materials may require flotation separation, in which certain types of plastic rise to the top of the flotation tank while others sink due to their higher densities [5]. After collecting and controlling, PE and PP waste further go into mill 1 for coarse grinding (Shredder – stage 2), then to mill 2 for fine grinding. Finally, the raw materials are washed, and plastic grind is led across the conveyor belt to the extruder where it is melted by heat and friction (stage 3). The molten plastic is filtered through a screen so that the remaining contaminants are removed. The final product in form of little pellets are obtained and ready for the market.

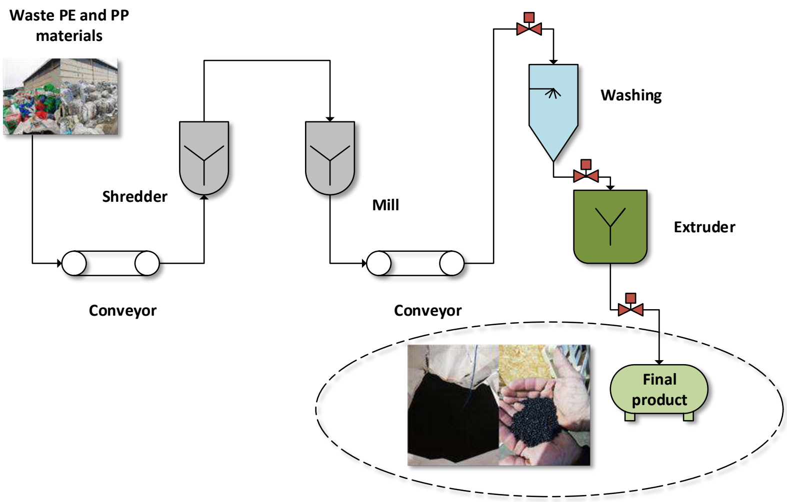

Figure 1 *The scheme of PE and PP waste processing*

RESULTS AND DISCUSSION

Tables 1 and 2 show results from mechanical and chemical examinations of commercial and recycled materials.

Table 1 *The physico-mechanical properties of commercial PE and PP materials*

Properties	PE	PP
Specific mass $\gamma_{s\,s}$	910–930 k N/m^3	900 k N/m^3
Glass Transition Temperature T_g	80 °C	100–120 °C
Thermal conductivity coefficient λ	0.13 W/m °C	0.88 W/m °C
Thermal coefficient of linear expansion αT	120–140 (x 10^{-60}C^{-1})	120 (x 10^{-60}C^{-1})
Tensile strength	7–15 (MPa)	33–35 (MPa)
Compressive strength	9–10 (MPa)	35 (MPa)
Elongation at break ε	300–700 (%)	20–300 (%)
Modulus of elasticity *E*	120–140 (MPa)	900–1400 (MPa)
The effect of ultraviolet rays *EUV:*	reduces its strength	without influence
Effect of chemical agents *ECA:*	it is dissolved by acids	it is dissolved by acids

Table 2 *The physico-mechanical properties of recycled PE and PP materials obtained using process schema shown in Figure 1*

Properties	PE	PP
Specific mass $\gamma_{s\,s}$	905–926 k N/m^3	870 k N/m^3
Glass Transition Temperature T_g	78 °C	93–114 °C
Thermal conductivity coefficient λ	0.10 W/m °C	0.82 W/m °C
Thermal coefficient of linear expansion αT	110–131 (x 10^{-60}C^{-1})	114 (x 10^{-60}C^{-1})
Tensile strength	5–11 (MPa)	26–29 (MPa)

***Table 2** – continued*

Compressive strength	6–9 (MPa)	30 (MPa)
Elongation at break ε	220–630 (%)	15–240 (%)
Modulus of elasticity *E*	110–127 (MPa)	800–1100 (MPa)
The effect of ultraviolet rays *EUV:*	reduces its strength	without influence
Effect of chemical agents *ECA:*	it is dissolved by acids	it is dissolved by acids

From the acquired data, it can be concluded that the obtained materials have the same characteristics as raw materials, thus showing that recycled regranulates can be used in their replacement. In this way, it is shown that recycling has just as a method for PE and PP waste processing with the final aim to protect natural resources.

CONCLUSION

This paper aimed to examine the physicochemical and mechanical characteristics of plastic materials acquired by recycling PE and PP waste, in order to produce their regranulates. The composition of the gained materials was examined by analyzing tensile strength, compressive strength, elongation at break, etc. Based on the presented results, it can be concluded that materials obtained by recycling PE and PP have shown good mechanical and chemical properties. In addition, due to the acceptable specific mass and glass transmission temperature, as well as good mechanical characteristics, regranulates obtained by recycling raw materials, will avoid numerous negative effects on the environment.

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