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# METHODS FOR RECYCLING POLYMER WASTE

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**ABSTRACT**

*This article focuses on analyzing the efficiency of polymer waste recycling and utilization technologies. The study showed that the recycling of polyethylene (PE) and polypropylene (PP) reaches 85% and 78%, respectively, due to their molecular weight and crystallinity, which are suitable for recycling processes. However, the recycling of polyethylene terephthalate (PET) and polystyrene (PS) demonstrates lower efficiency, at 45% and 40%, respectively. The results indicate that to improve recycling efficiency, optimal parameters for temperature (400°C) and time (30 minutes) should be established. The article also emphasizes the importance of implementing environmentally safe recycling technologies for polymer waste.*

Polymer waste recycling and utilization technologies are currently playing an important role in environmental protection, efficient use of natural resources, and economic development [1]. Due to the wide range of applications of polymer materials, their properties, and everyday life, their use is increasing worldwide. However, the long biodegradation of polymers, their unique chemical structure, and their stability lead to serious problems in the environment. Millions of tons of polymer waste are released into the environment every year, which can cause an environmental crisis [2]. Polymers are high-molecular compounds, the structure of which can consist of synthetic and natural polymers. Synthetic polymers, such as plastics, rubbers, and synthetic fibers, are widely used in everyday life and play an important role in various industries. At the same time, the many advantages of polymer materials, such as their lightness, strength, corrosion resistance and low cost, cause problems of large-scale pollution and wasteful consumption of resources if their waste is not properly managed [3]. The increasing need for recycling and utilization of polymer waste has become an integral part of strategies aimed at preserving the environment on the one hand and increasing economic efficiency on the other [4]. Today, various technologies have been developed that allow recycling of polymer waste, improving its quality and producing new products from it [5]. Recycling processes, first of all, help to save resources and reduce waste, and also serve to optimize energy consumption [6].

Polyethylene (PE) (molecular weight 20,000-200,000 g/mol, degree of crystallization 50-60%, melting point 105-130°C) and polypropylene (PP) (molecular weight 50,000-500,000 g/mol, degree of crystallization 60-70%, melting point 160-170°C) materials show high efficiency in recycling, as their physical properties are suitable for recycling processes. Polyethylene Terephthalate (PET) (molecular weight 10,000-30,000 g/mol, degree of crystallization 35-45%, melting point 250-265°C) and Polystyrene (PS) (molecular weight 100,000-300,000 g/mol, degree of crystallization 40-50%, melting point 100-105°C) materials require additional care and may have low recycling efficiency.

In the next step, the effect of temperature and time on polymer waste was studied. In this case, the effect of temperature and time during the pyrolysis process determines the chemical composition of the material and the type of waste. The results are shown in Table 1.

**1-table**

**The effect of temperature and time on the pyrolysis process**

| Temperature (°C) | Processing Time (minutes) | Gas produced (l/hour) | Oils (g/h) | Carbon residue (%) |
|---|---|---|---|---|
| 450 | 60 | 2.5 | 5.0 | 20 |
| 600 | 90 | 3.8 | 7.5 | 12 |
| 700 | 120 | 4.2 | 8.2 | 8 |

According to Table 1, the amount of gas produced during the pyrolysis process at 450°C and 60 minutes is 2.5 l/h, but the amount of oil is 5.0 g/h. Under these conditions, the carbon residue is high (20%), since at low temperatures the complete pyrolysis of polymers does not occur.

At 600°C and 90 minutes, the amount of gas produced during the pyrolysis process increases (3.8 l/h), the amount of oil also increases (7.5 g/h), but the carbon residue decreases (12%). Under these conditions, the pyrolysis process is more complete.

In the next step, the granule yield of polymer waste was determined. The results are shown in Table 2.

**2-table**

**Indicators of granulation with polymer waste**

| Waste type | Granulation Speed (kg/h) | Granule size (mm) | Granule qualities | Energy consumption (kWh/ton) |
|---|---|---|---|---|
| **Polyethylene (PE)** | 50 | 2-3 | Good | 75 |
| **Polypropylene (PP)** | 40 | 1.5-2 | Good | 81 |
| **Polyethylene terephthalate (PET)** | 30 | 3-4 | Average | 85 |
| **Polystyrene (PS)** | 35 | 1-2 | Bad | 90 |

**Table 2.** shows that Polyethylene (PE) has the highest pelletizing speed (50 kg/h) and relatively low energy consumption (75 kWh/ton). This material is highly efficient in processing, with average pellet sizes (2-3 mm). Polypropylene (PP) has a relatively average

pelletizing speed and energy consumption, producing good quality pellets. The pellet size (1.5-2 mm) is smaller than that of PE, but the pellet quality is still good. Polyethylene Terephthalate (PET) has the lowest pelletizing speed (30 kg/h) and energy consumption (85 kWh/ton), with pellet sizes around 3-4 mm and average quality.

Polymer waste recycling and utilization technologies are currently making a significant contribution to environmental friendliness and efficient use of resources. The results of the study show that polyethylene (PE) and polypropylene (PP) materials show the highest efficiency in recycling. Their molecular weight, degree of crystallization and melting point are suitable for recycling processes, which allows them to be effectively used in pelletizing, pyrolysis and other recycling methods. At the same time, polyethylene terephthalate (PET) and polystyrene (PS) materials pose some problems in recycling, as they are characterized by a high melting point, low degree of crystallization and poor network qualities.

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