International Journal of Advanced Research in Science, Engineering and Technology

Vol. 12, Issue 7, July 2025

ISSN: 2350-0328

IJARSET IMPACT FACTOR 7.150

Investigation of the Application of Materials Obtained from Polymer Waste Recycling in Biotechnological Processes

Shodiev A.F., Pardaboyeva S.N

Navoi State University of Mining and Technologies

I.INTRODUCTION

In recent years, the growing demand for polymer products and the expansion of their application areas have led to an increase in the volume of waste generated from these materials. This, in turn, has made the recycling and conversion of such waste into high value-added products a pressing issue. Especially in the fields of biological systems and industrial biotechnology, there is a rising demand for sustainable, functional, environmentally friendly, and safe materials. From this perspective, the development of composite coating materials based on recycled polymer waste serves not only environmental protection but also contributes to economic efficiency.

Biotechnological processes—particularly reactions such as fermentation and biosynthesis within bioreactor systems—greatly depend on the physicochemical and biological properties of the reactor's internal surfaces. Therefore, there is an increasing demand for coating materials that are chemically stable and have no adverse effects on microorganisms. It is possible to obtain suitable coating materials for biotechnological processes by recycling thermoplastic polymer wastes such as polyethylene, polypropylene, and PET using modern modification methods.

Today, biotechnology is one of the steadily developing sectors at the industrial level, with a growing need for specialized environments and reactor conditions for processes such as fermentation, biosynthesis, and the cultivation of microorganisms. In particular, the inner surface of bioreactors must meet specific requirements—chemical stability, corrosion resistance, and most importantly, the absence of harmful effects on microorganisms. These requirements are driving the search for new materials in this field.

From this point of view, the creation of environmentally safe, biologically compatible, and technologically advanced coating materials from polymer waste is one of the most urgent scientific and practical challenges. This not only contributes to environmental protection but also enhances the efficiency of industrial biotechnology and transforms waste into economically valuable resources.

II. RESEARCH OBJECTIVE

The aim of this study is to develop environmentally safe and biologically compatible coating materials based on polymer waste, and to investigate their effectiveness in biotechnological reactor systems.

In this research, composite materials based on secondary polyethylene terephthalate (PET) and technical starch were synthesized in order to obtain biologically active coating materials through the recycling of polymer waste. At the initial stage, PET was hydrolyzed using an alkali to extract terephthalic acid, as outlined in the following table.

Table 1
Hydrolysis of Polyethylene Terephthalate (PET)

T/r	PET content (%)	NaOH content (%)	Total mass (g)	Time (min)	Temperature (°C)
1.	80	20	100	120-160	90-95
2.	75	25			
3.	70	30			
4.	65	35			
5	60	40			

International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

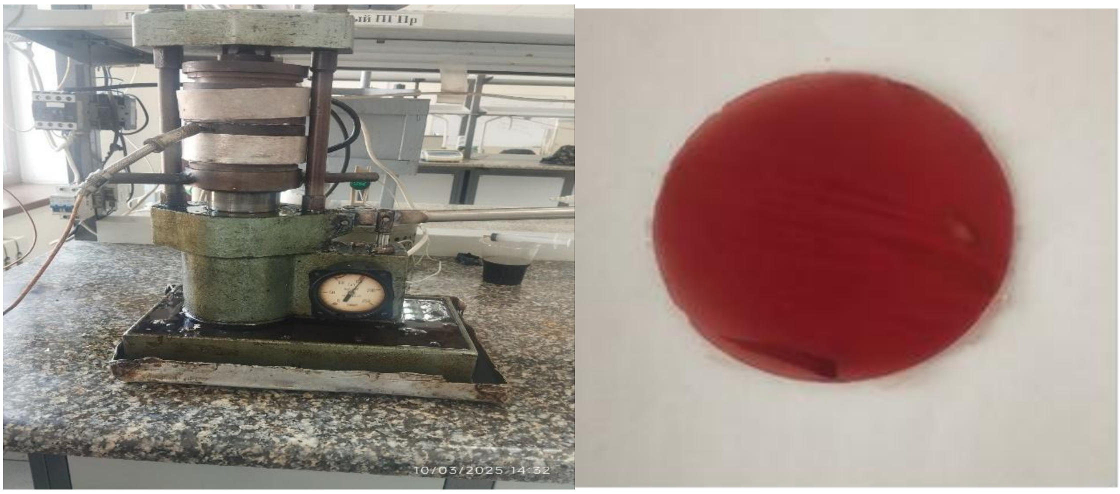
Vol. 12, Issue 7, July 2025

Alkaline hydrolysis process

A single-neck, round-bottom flask with a volume of 500 ml was charged with 300 g of a 40% aqueous solution of sodium hydroxide. A thermometer and a mechanical stirrer were inserted into the flask. Then, 60 g of secondary PET, previously cut into small pieces, was added. The mixture was heated at a temperature of 90–100 °C under constant stirring for 2–3 hours. During the reaction, a thick, white substance formed, which was then cooled and diluted with distilled water until a clear and transparent solution was obtained. At this stage, a disodium salt of terephthalic acid—soluble in water—was formed.

Filtration and Drying of the Precipitate

The resulting solution was further diluted with 500 ml of water and neutralized using hydrochloric acid (HCl). The precipitate was separated by filtration. The filtered solid was dried in a thermostat at 50 °C for 24 hours. The dried terephthalic acid was then ground into a fine powder.



Pressing and Film Formation Process

In the next stage, the dried terephthalic acid was mixed with technical starch in various ratios and processed using a press machine to produce a coating material, i.e., film. Prior to mixing, both components were in powdered form and were blended in dry conditions. The ratios were selected as follows:

International Journal of Advanced Research in Science, Engineering and Technology

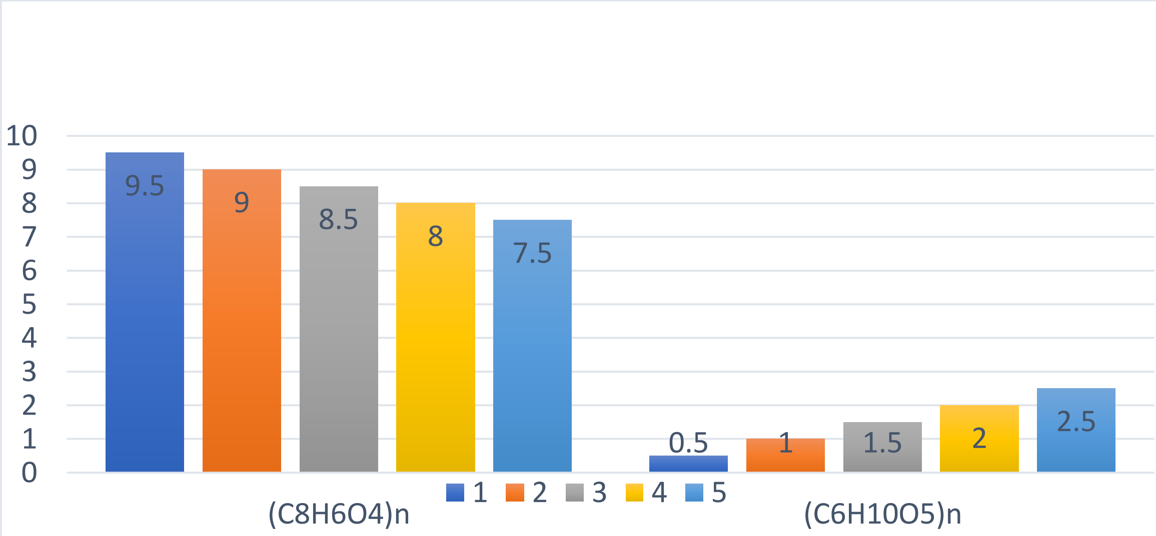
Vol. 12, Issue 7, July 2025

ISSN: 2350-0328

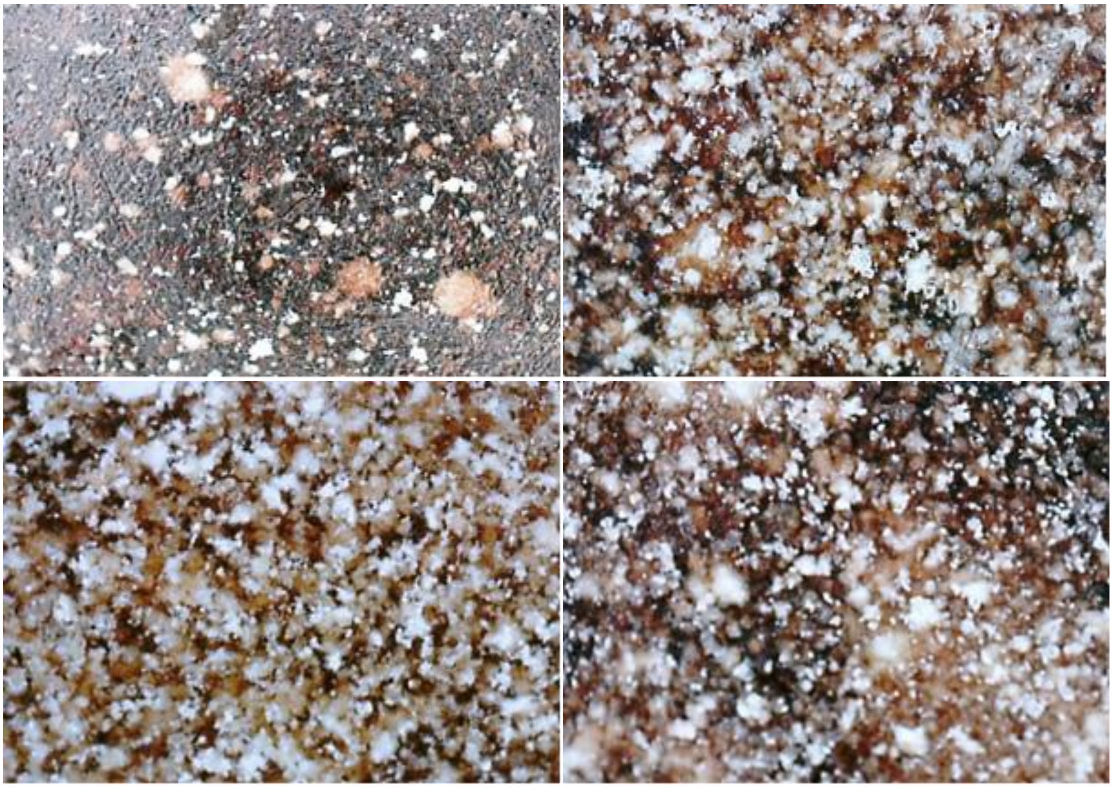
IJARSET IMPACT FACTOR 7.150

Table 2
Composite Material Ratios

Chemical Formula	Mass Ratio of Terephthalic Acid and Technical Starch (g)				
	№1	№2	№3	№4	№5
$(C_8H_6O_4)_n$	9,5	9,0	8,5	8,0	7,5
$(C_6H_{10}O_5)_n$	0.5	1,0	1,5	2,0	2,5



Each composite sample was processed using a pressing method on an RM-0.5 device at a temperature of 80–90 °C and under a pressure of 14.7 MPa. As a result, starch–terephthalic acid biocomposite films were obtained. The resulting samples were subjected to analysis of their physical-mechanical, surface, and microbiological properties.



Microscopic examination of the results obtained

International Journal of Advanced Research in Science, Engineering and Technology

ISSN: 2350-0328

Vol. 12, Issue 7, July 2025

III.CONCLUSION

In this study, the potential for obtaining environmentally safe coating materials suitable for biotechnological processes was investigated through the recycling of secondary polyethylene terephthalate (PET) waste via hydrolytic degradation. As a result of the hydrolysis reaction carried out at 90–100 °C in the presence of sodium hydroxide, the disodium salt of terephthalic acid was formed from PET. Upon neutralization and drying, pure terephthalic acid was successfully extracted. The obtained terephthalic acid was mixed with technical starch in various mass ratios (from 9.5:0.5 g to 7.5:2.5 g), and composite film samples were produced by pressing at a temperature of 80–90 °C. The resulting films varied in structure and quality. Experimental results showed that samples with ratios No. 2 and No. 3 demonstrated optimal composition and physical properties, forming smooth, dense, and flexible films. This indicates that a balanced ratio of PET-derived component and starch yields better performance.

This approach represents an effective method for obtaining high value-added products through the recycling of polymer waste and offers a promising solution for the development of environmentally friendly coating materials for biotechnological reactors.

REFERENCES

1. Saade Abdalkareem Jasim, Jaafaru Sani Mohammed, Rangaswamy Roopashree, Mohammad Y. Alshahrani, Aanchal Sharma, Abhishek Sharma, Shodiyev Asliddin, Masoumeh Beig Unraveling the global landscape of *Elizabethkingia* antibiotic resistance: A systematic review and meta-analysis Published: May 30, 2025 https://doi.org/10.1371/journal.pone.0323313
2. Nazarov A.A., Khasanov A.B. Biopolymers and their application in biotechnology. – Tashkent: Fan, 2020. – 148 p.
3. Islomov Sh.Sh., Mamadzhanov Zh.R. Composite materials based on polymeric waste. Polymer Journal, 2021. – №3. – P. 45–52.
4. Khalilov N.K. Physical and Mechanical Properties of Modified Polymer Composites. Polymeric Materials and Technologies, 2022. – №4. – P. 30–37.
5. Gulomova N.A., Turaev F.R. Investigation of composite materials based on polyethylene terephthalate and starch. // Uzbek Chemical Journal, 2023. – №2. – P. 55–60.
6. GOST 34376.2-2017. Plastics. Method for determining tensile properties.
7. Karimova D.X., Saidova G.T. Bio-based polymer blends for environmentally safe applications. // International Journal of Polymer Science, 2021. – Vol. 9(1). – P. 12–18.
8. Sharipov U.A., Mavlonova D.S. Hydrolysis of polyethylene terephthalate waste using alkaline medium. // Chemical Technology Journal, 2022. – Vol. 14(3). – P. 80–86.
9. Ganiyeva M.S. Kompozitsion materiallarning ekologik xavfsizligi va biokompatibilligi. – O'zbekiston Biotexnologiya Jurnali, 2024. – №1. – B. 22–28.
10. Andrievsky B.R. Advanced composite materials: synthesis, structure, properties. – Moscow: Nauka, 2018. – 236 p.
11. Khamraev A.A. Formation of polymer composites by pressure pressing method. Journal of Engineering Science, 2023. – No. 4. – pp. 90–97.

AUTHOR'S BIOGRAPHY

Shodiev Asliddin Fakhriddin ogli — PhD in Technical Sciences, Navoi State University of Mining and Technologies

Pardaboyeva Sokhibjamol Navruzovna — Master's Degree Holder, Navoi State University of Mining and Technologies