Int.J.Curr.Res.Aca.Rev.2026; 14(7): 112-117

EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 (Online) Volume 14 Number 7 (July-2026)

Journal homepage: http://www.ijcrar.com

doi: https://doi.org/10.20546/ijcrar.2026.1407.010

An Innovative Application of Bread Yeast

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Abstract

"One world, one health" encompasses not only human beings but all living things, including the environment. In this context, plastics surround us. They are part of our daily activities; however, their accumulation in the environment poses a health problem. Therefore, it is important to have strategies that facilitate the proper disposal of plastics, such as polystyrene. One strategy is the biodegradation of plastics using microorganisms such as bacteria and fungi. This paper shows some data related to the degradation of polystyrene using a novel strategy: baker's yeast.

Article Info

Received: 15 May 2026
Accepted: 22 June 2026
Available Online: 20 July 2026

Keywords

Biodegradation, *Saccharomyces cerevisiae*, yeast, plastic, pollution.

Introduction

As is well known, plastics revolutionized the world. Plastics are widely utilized in a wide range of applications, including packaging, healthcare, personal hygiene products, aviation components, and protective equipment. They also play a critical role in sectors such as fishing, agriculture, and sanitation (Khan *et al.,* 2024; Nawab *et al.,* 2026). However, their rapid accumulation has generated serious environmental problems.

The production of disposable plastic products has increased rapidly, far outpacing the world's ability to deal with them. Plastic waste can be found in every part of the world, from the deepest oceans to the highest mountains, and it is wreaking havoc on wildlife and ecosystems (Khan, 2023). While the extensive use of plastics has provided substantial benefits to society, their environmental footprint across the entire life cycle has become a growing concern. Every year, around 4.8-12.7 million tonnes of inadequately managed plastic waste enter the environment, with approximately 40 % comprising single-use plastics. These plastics, being highly persistent, have become a global environmental challenge. Additionally, the amount of plastic discharged into the aquatic ecosystem has been steadily increasing from 7000 to 35,000 tons and some studies even predict that by the end of 2060, it may reach 270 million tons (Ashrafy *et al.,* 2023; Benson *et al.,* 2022; Cozar *et al.,* 2014; Jambeck *et al.,* 2015; Lebreton and Andrady, 2019; Sharma *et al.,* 2023).

Many studies have reported the striking ability of certain microorganisms including bacteria and fungi in fast degradation of both bio-based and fossilbased polymers under stress conditions by producing exoenzymes and their products. Important microbial enzymes responsible for polymer biodegradation are proteases, lipases, and cutinases (Ahmed *et al.,* 2018). Therefore, this work shows some evidence of an innovative application of bread yeast (*Saccharomyces cerevisiae*) and its polystyrene biodegrading activity.

Materials and Methods

Source of material

In this study, the polystyrene fragments were obtained from of a commercial thermal container made of that material. It was obtained from a grocery company in Puebla, Mexico.

Biological material

The *Saccharomyces cerevisiae* strain was used. The strain of *S. cerevisiae* used was the yeast marketed for making bread. Bacterial strain was stored in cryovials at -40°C until analysis.

Culture

S. cerevisiae strain were cultivated in YAM1 liquid medium, containing (g/L): 0.2 g of K_2HPO_4, 0.6 g of KH_2PO_4, 0.2 g of $MgSO_4.7H_2O$, 0.02 g of $CaCl_2.2H_2O$, 0.01 g of $FeCl_3.6H_2O$, 0.1321 g of $(NH_4)_2SO_4$ and 5 g of casein peptone. The pH was ajusted to 6.5 with hydrochloric acid. The stationary cultures were grown at 30°C for 24 hours in glass tubes containing 5 mL of YAM1 broth and were used as precultures.

S. cerevisiae culture in presence of polystyrene

S. cerevisiae strain was grown in YAM1 liquid medium. For that, 2 mL of an active culture of *S. cerevisiae* (72-96 hrs of culture, Ab_{560nm}=5) were used to inoculate each 500 mL glass jar containing 100 mL of YAM1 liquid medium. Before inoculating the yeast, the YAM1 medium was supplemented with 0.5 g of fragments of sterile polystyrene. Polystyrene was autoclaved before use. Culture was grown at 30°C with agitation of 600 rpm (using a 1.5 cm magnetic stirrer) for 34 days. During this time some images from culture were recovered. All determinations were made in triplicate.

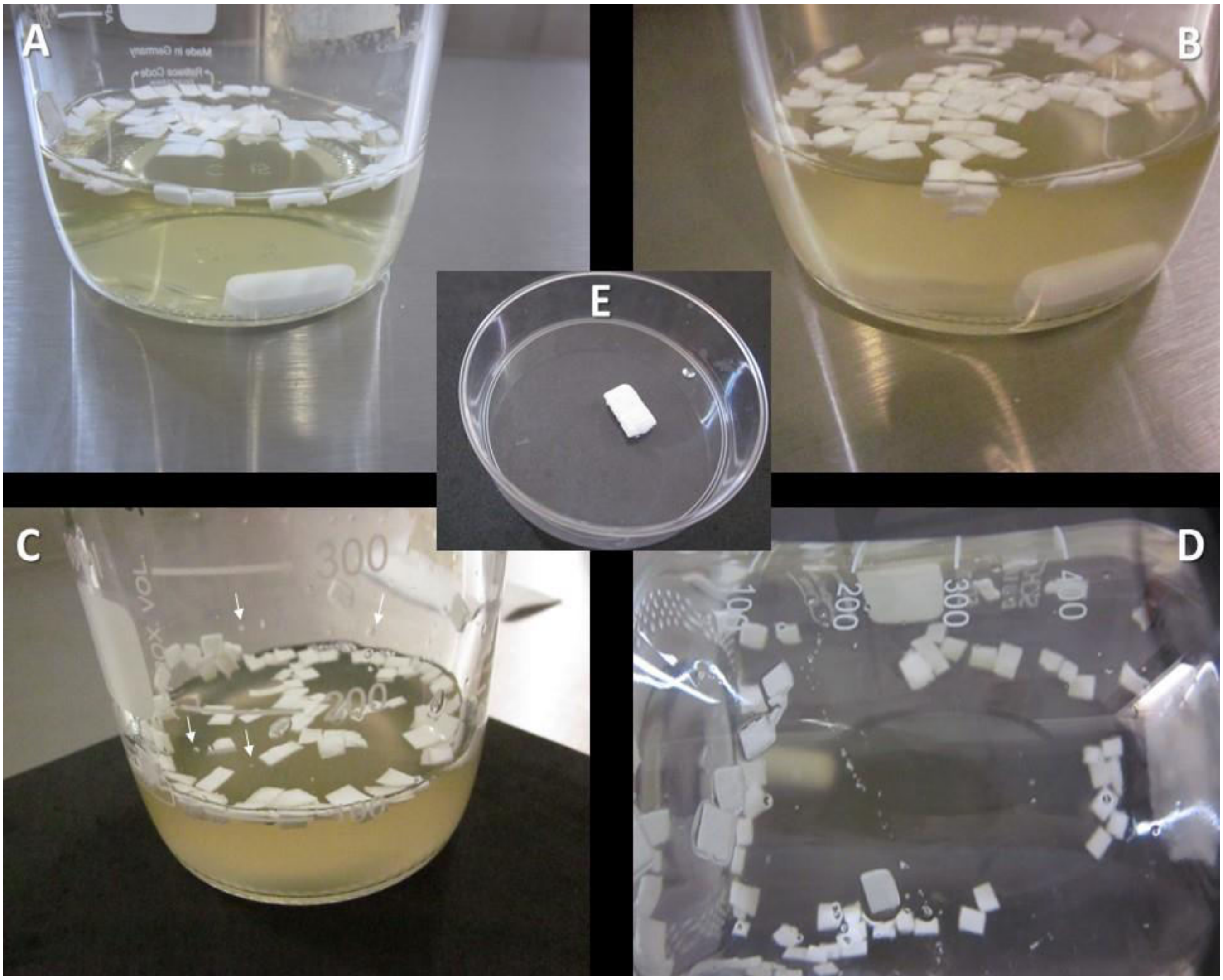
Results and Discussion

In this study, some data regarding the biodegradation capacity of polystyrene by *S. cerevisiae* were obtained. For this, polystyrene fragments were obtained from of a commercial thermal container. As indicated in Materials and Methods, *S. cerevisiae* strain were cultivated in YAM1 liquid medium, which consisted of a limited nutrient medium. A small amount of casein peptone was added as a growth initiator for *S. cerevisiae* and sterile polystyrene fragments were used as a source of carbon. The culture of yeast was performed in a 500 mL glass flask containing 100 mL of YAM1 culture medium. Culture was grown at 30°C for 34 days. The results are shown in Fig. 1. Fig. 1 contains several images of the *S. cerevisiae* culture in the presence of fragmented polystyrene. Day zero of the culture corresponded to moment of the addition of *S. cerevisiae* to YAM1 medium (Fig. 1A). After 2 days, the *S. cerevisiae* culture showed growth as can be seen in Fig. 1B, even though the yeast was grown in a nutrient-limited medium. As can be seen in Fig. 1C, the degradation of polystyrene became evident from day 20 of *S. cerevisiae* culture. This image shows small particles derived from the used polystyrene fragments. These particles were observed on the surface of the liquid culture medium and also adhered to the surface of the culture flask. The white arrows in Fig. 1C point to the small particles derived from the polystyrene fragments. Fig. 1D shows the *S. cerevisiae* culture at 34 days. As seen in this image, the degradation of the polystyrene increased. Smaller particles floated on the surface of culture medium and also adhered to the surface of the glass jar. It is important to consider that the biodegradation of polystyrene took place in a relatively short time (about 1 month). Upon observing the polystyrene fragments within the culture, they exhibited holes and cracks on their surface. A system was implemented to detect gas (CO_2) production during the process; however, it was observed that biodegradation did not produce gas (data not shown).

Plastics and climate change are two of the defining challenges of our century. Both arise from our dependence on fossil fuels, both contribute to destabilizing the Earth system, and both have breached what many scientists describe as the planet's "safe operating space" (Kelly *et al.,* 2025; Persson *et al.,* 2022; Rittschof, 2025; Rockström *et al.,* 2009; Villarrubia-Gómez *et al.,* 2024; Zheng and Suh, 2019). Polystyrene is widely used in various products owing to its high tensile strength, swelling ability, stable chemical properties, regeneration properties, large surface area, and economic feasibility. However, the widespread use of polystyrene plastics in the food chain has raised global concerns regarding marine and human health. Polystyrene is extensively used at the industrial level because of its low cost and chemical stability mainly in scrubs, handwashing soaps, cleansers toothpaste, or biomedical products (Dauvergne, 2018; Napper *et al.,* 2015; Sharma and Chatterjee, 2017; Siddiqui *et al.,* 2023; Weber *et al.,* 2020). Given this problem of plastic accumulation, different alternatives for its degradation are being explored. One of them is biodegradation which is the natural breakdown of materials by living organisms. It offers a sustainable approach to managing plastic waste. However, the complex structure and inherent resistance of polystyrene pose challenges to its biodegradation. Recent research has focused on exploring microbial degradation, enzymatic breakdown and abiotic degradation (Hou and Majumder, 2021; Lin and Liu, 2021; Liu, 2023; Ojeda *et al.,* 2009; Tang *et al.,* 2017). In this study, some data regarding the biodegradation capacity of polystyrene by *S. cerevisiae* were obtained. As shown in Results, the degradation of polystyrene became evident from day 20 of *S. cerevisiae* culture. At this time, small particles derived from the used polystyrene fragments. The particles were observed on the surface of the liquid culture medium and also adhered to the surface of the culture flask. 34 days after culturing *S. cerevisiae*, the degradation of the polystyrene increased considerably. Natural degradation rate of plastics is exceedingly slow and it is estimated to take approximately 500 years for complete degradation to occur. When exposed to the environment, plastic wastes become microplastics, which contaminate soil and water bodies, and have been implicated in endocrine system disorders and various diseases (Kim *et al.,* 2024; MacLeod *et al.,* 2021). In the present study, the biodegradation of polystyrene took place in a relatively short time (about 1 month). Other authors have reported that *Gordonia* sp. achieved 7.73% polystyrene degradation over 30 days and *Exiguobacterium* sp. achieved 7.4% polystyrene degradation over 28 days (Yang *et al.,* 2015; Kim *et al.,* 2021; Liu *et al.,* 2023). Microbial degradation has recently emerged as a promising approach for plastic waste management. Microorganisms provide an environmental friendly solution for degrading plastics at room temperature and atmospheric pressure (Kim *et al.,* 2024; Tournier *et al.,* 2023). Ongoing research is focused on identifying microorganisms capable of degrading plastics in various environments, including the digestive systems of insects, marine ecosystems, and landfills (Kim *et al.,* 2024). On the other hand, in the present study *S. cerevisiae* was cultured in a nutrient-limited medium; YAM1 medium was supplemented with a small amount of peptone to support yeast growth and polystyrene was used as a source of carbon. Similarly, *Pseudomonas aeruginosa* has been reported to be able to degrade polystyrene. These studies have used liquid carbon-free basal medium and mineral salts (Kim *et al.,* 2020; Yang *et al.,* 2015). Several microorganisms (fungi and bacteria, including the gut microorganisms of insect larvae) have been demonstrated to degrade polystyrene waste under laboratory conditions. The microorganisms break the polymer into simple monomer compounds at a very slow rate and further use the byproducts formed as their energy source (Choi *et al.,* 2024; Kaviarasia *et al.,* 2026; Yang *et al.,* 2015). Microbial enzymes are involved in the biodegrada tion of the majority of plastic wastes. Some of the microbial enzymes, including hydrolases, oxidoreductases, dehalogenases, and oxygenases, are responsible for the degradation of most of the harmful chemical substances in the environment. The major bacterial and fungal enzymes involved in the biodegradation of polystyrene by vinyl side chain reaction include styrene monooxygenase, styrene oxide isomerase, flavin adenine dinu cleotide reductase, and phenyl acetaldehyde dehydrogenase. Such enzymes as laccases, cutinases, manganese peroxidases, and lignin peroxidases are fungal enzymes that take part in the plastic biodegradation (Akhtar *et al.,* 2022; Bhardwaj *et al.,* 2013; Kaviarasia *et al.,* 2026; Saravanan *et al.,* 2021; Temporiti *et al.,* 2022). Anbarani *et al.,* (2023) reported the use of *S. cerevisiae* in removing polystyrene from aqueous solutions. *S. cerevisiae* was studied as a biocoagulant due to its advantages such as ease of use, non-toxicity, large-scale cultivability and low cost. However, few studies exist on the ability of *S. cerevisiae*, a commonly used yeast, to biodegrade polystyrene waste, which is a serious environmental pollution problem. Further research is needed to understand the mechanism or mechanisms involved in the biodegradation of polystyrene using *S. cerevisiae*.

In conclusion, Modern lifestyles have generated various environmental problems. One of these is the excessive use of plastics and their accumulation in natural environments. Therefore, solutions to this problem are being sought. Polystyrene represents one of these issues, and biodegradation appears to be a biological method for reducing its presence in the environment. This work showed data regarding the biodegradation of polystyrene using baker's yeast, *S. cerevisiae*. However, further studies are needed to delve deeper into the biodegradation mechanisms involved.

Fig.1 The biodegradation of polystyrene by *S. cerevisiae*. A. Culture of *S. cerevisiae* (day 0). B. Culture of *S. cerevisiae* (day 2). C. Culture of *S. cerevisiae* (day 20). D. Culture of *S. cerevisiae* (day 34). E. Sterile polystyrene fragment (control).



Conflict of interest

The authors declare that they have no conflict of interest.

Declaration of competing interest

The authors declare that they have no potential competing financial interests.

Acknowledgements

Thank to Facultad de Medicina-BUAP and Grupo de Académicos de Puebla SC for the facilities provided for the development of this work.

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How to cite this article:

Flores-Encarnación M. and Jiménez-Flores Y. A. 2026. An Innovative Application of Bread Yeast. *Int.J.Curr.Res.Aca.Rev.* 14(7), 112-117. doi: https://doi.org/10.20546/ijcrar.2026.1407.010