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ORIGINAL ARTICLE

Development of a Bioreactor-Based Model for low-density polyethylene (LDPE) Biodegradation by *Aspergillus brasiliensis*

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Abstract

Low-density polyethylene (LDPE) is a widely used polymer due to its chemical resistance, high flexibility, and mechanical properties. However, its low degradation rate, coupled with its low lifespan and widespread accumulation, poses significant environmental and public health concerns. This study presents a biodegradation model for LDPE using a suspension bioreactor, which could serve as a biological treatment alternative before polymer disposal. In our model, an initial culture of *Aspergillus brasiliensis* metabolized the carbon within the polymer structure and used it as an energy source, leading to LPDE biodegradation and mineralization. The procedure took place in a laboratory-scale bioreactor prototype under aerobic conditions and submerged liquid fermentation. After one month of culture, a biodegradation percentage of 1.89 ± 0.56 % was reached. The treated materials were analyzed by scanning electron microscopy (SEM) and fourier transform infrared spectroscopy (FTIR). We found evidence of biodegradation, colonization of the material, and biofilm formation. This research provides preliminary data on the biodegradation of LDPE under submerged liquid fermentation, marking an initial phase in the development of a prototype for polymer biodegradation.

Keywords: *Aspergillus brasiliensis*; biodegradation; low-density polyethylene (LDPE); Scanning Electron Microscopy (SEM); submerged liquid fermentation.

1. Introduction

The excessive use of plastics presents an environmental and ecological problem that affects both humans and the environment. Plastics rank among the top 10 materials collected from the oceans, and it is estimated that over 300 million tons of plastic waste are produced annually [1]. Unfortunately, only 7 % of plastic waste is recycled. The remaining 93 % accumulates in landfills, mountains, valleys, and aquatic ecosystems [2]. While polymeric materials are of great importance in industry settings and have a wide variety of applications due to their versatility, low cost, and easy processability [3] [4], they typically exhibit high chemical and weather resistance with low degradation rates, leading to adverse environmental effects. These negative impacts are exacerbated by final products with short life spans that are manufactured and consumed at high rates, generating alarming amounts of waste and pollutants that take between 100 and 1000 years to degrade [2, 3, 5].

Low-density polyethylene (LDPE) is one of the most widely produced polymers worldwide and is suitable for several industries due to its flexibility, resistance, and durability. LDPE accounts for 85 % of the waste that reaches the ocean. [1]. In Colombia, LDPE is primarily used for

manufacturing single-use products, resulting in over 23 million tons of waste that end up in oceans and landfills. This contributes to the 5 kg of plastic waste per meter found across coastlines worldwide [1]. The lack of treatment prior to disposal or proper strategies for reusage aggravates the problem, leading to toxic emissions, high operating costs, and increased energy consumption. [6, 7].

Current methods for the biodegradation of LDPE are classified into physical, chemical, and biological. Physical methods include photodegradation, where UV light causes morphological damages to the material, leading to its degradation [7]. Chemical methods rely on surfactant fatty acids that come into direct contact with the polymer and break the bonds that form the polymer chains [8]. Finally, biological methods aim to increase the biodegradation rate of these materials by using microorganisms capable of metabolizing the polymers as a carbon source, leading to complete mineralization [3, 8]. Biological processes can be performed through composting, mixed cultivation, or submerged liquid fermentation. The first two methods rely on nutrients present in the soil as carbon sources for the process. In the third method, LDPE is subjected to specific conditions of temperature, pH, and aeration to accelerate and enhance biodegradation [9]. Microorganisms, especially fungal cultures such as *Aspergillus*, *Penicillium, Pleurotus ostreatus,* and *Rhizopus oryzae* have been used to assist these processes [9, 10]. However, these methods have only been developed at a laboratory scale and have achieved minimal biodegradation percentages, typically ranging between 1 % and 3 %. These initial models have not relied on alternative engineering approaches, despite the availability of various techniques for degrading these residues. Moreover, the biological method involving enzyme activity has demonstrated microbial activity, mineralization, and colonization of the material.

This study aimed to fill the gaps in knowledge regarding submerged liquid fermentation - a novel approach mediated by microorganisms from the *Aspergillus* genus - and evaluate its effectiveness under controlled and specific conditions. We developed a biodegradation model of LDPE by *Aspergillus brasiliensis* in a laboratory-scale bioreactor and identified the different processes mediated by the fungi and the operating conditions that favor the colonization and biodegradation of the material. The experiments were conducted over a period of 30 days.

2. Materials and Methods

2.1. Microorganisms

The filamentous fungus *Aspergillus brasiliensis* used to mediate the biodegradation process was sourced from the Universidad Nacional de Colombia collection. The strain was preserved in Sabouraud Dextrose broth and 25 % glycerol at 4 °C in Eppendorf tubes [11]. We activated the strain by incubating it on solid Sabouraud Dextrose Agar for 7 days at 30 °C.

2.1.1. Purity test

The microorganism morphology was identified through microscopy. We took a culture sample and mixed it with drops of either distilled water or lactophenol blue before mounting it on a slide. The slides were then examined under the microscope at a 40× magnification [4]. All experiments were carried out with axenic biomass.

We performed purity tests to ensure that *Aspergillus brasiliensis* was the only biological agent present in the samples, thus minimizing the risk of cross-contamination during the biodegradation process. We took a sample of the mature microorganism and identified the morphological

characteristics of the selected strain, including the presence of septate hyaline hyphae, sexual reproduction (formation of ascospores inside the asci), and asexual reproduction (formation of conidia) [12].

We observed the characteristic morphological structure of this strain, including seriate conidia that are smaller than those found in other *Aspergillus* species. The conidial heads were globose and occasionally radiated, developing into several thick, smooth, and pale brown conidial columns [16].

This monitoring was done at the beginning of the inoculation process, during the biomass production process, and at the start and end of the biodegradation process.

2.1.2. Inoculum production

We inoculated 100 mL of Sabouraud Dextrose culture broth with the activated strain, distributing it evenly between two Erlenmeyer flasks, with each flask containing 5 discs of the mature microorganism. The flasks were incubated for 7 days at 30 °C in a shaker set to 100 rpm. The resulting pellets were used as inoculum for the biodegradation experiment [4, 11].

2.1.3. Evaluation of inoculum concentration by dry weight

To determine the biomass obtained during the inoculum production (Section 2.1.2), we followed a previously outlined procedure. We first homogenized the pellets with the help of a mincer. Then, we used 20 15-ml tubes to determine the dry weight of the produced biomass. We dried the tubes in the oven for 30 minutes at 100 °C before weighing them. The homogenized mixture was distributed across the tubes (13 mL in each tube). The tubes were centrifuged for 8 minutes at 6000 rpm to separate the broth and the biomass. The supernatant was discarded, and the biomass was dried in an oven at 90 °C for 3 days until a constant weight was achieved [4]. We used an Ohaus PA224 analytical balance with a sensitivity of 0.0001 g and maximum capacity of 220 g to evaluate the inoculum concentration by dry weight.

2.2. Adjustment of the LDPE

We chose 1-gauge commercial bags of LDPE sheets (4 cm × 4 cm) for this study. The aim was to demonstrate microbial activity without any prior treatment or grinding. This approach was chosen to avoid altering the physicochemical properties of the material. The LDPE sheets underwent sterilization with 40 minutes of UV light exposure, followed by air drying, to eliminate any potential external contamination before being introduced into the bioreactor. The 10 LDPE sheets were weighed at the beginning and at the end of the process to determine the level of biodegradation.

2.3. Bioreactor process

A laboratory-scale bioreactor was built to conduct the ex-situ biodegradation process of LDPE. The reactor contained 1800 mL of Sabouraud Dextrose broth and was equipped with specific features. Three holes were made at the base: the first for temperature measurement using a thermometer, the second for attaching a hose connected to a pump with a capacity of 90 L per hour, and the third equipped with a cap to facilitate the release of gases from the system.

The bioreactor was inoculated with 0.18 gL^{-1} of dry mass (obtained as related in section 2.1.1) before adding the LDPE sheets. We measured the temperature and pH every two days and used sodium hydroxide or glacial acetic acid (both at 1M) to keep the pH of the system between 5 and 6. The bioreactor was kept at room temperature throughout the experiment.

2.4. Sugar determination by qualitative and quantitative analysis

We performed a qualitative analysis of the reducing sugars present in the system using the Tollens and Fehling tests [14]. The tests were carried out at the beginning and the end of each of the three experiment replicates.

We performed the quantitative analysis for sugar determination following the Miller's method, also known as the dinitro salicylic acid method (DNS), which employs 3,5-dinitrosalicylic acid as an oxidizing agent [15, 16]. Briefly, 0.25 mL samples were collected in test tubes, followed by the addition of 0.25 mL of the DNS reagent. The mixture was placed in a water bath at 90 °C for 5 minutes. Then, the samples were cooled in ice buckets to stop the reaction. After cooling, we added 2.50 mL of stirring water to the sample and measured the absorbance at 540 nm using a spectrophotometer. Dextrose concentration was calculated based on the absorbance readings.

We established the calibration curve for the spectrophotometric analysis using different concentrations of dextrose and DNS reagent. We ensured that the absorbance values fell within the range of 0 to 1 [16]. This process allowed us to derive Equation 1, which we used to determine the concentration of sugars throughout the biodegradation process.

$$y = 0.982x + 0.0034 \quad R^2 = 0.9996 \tag{1}$$

2.5. Characterization of the material

2.5.1. Scanning Electron Microscopy (SEM)

We performed a SEM analysis at the Universidad Nacional de Colombia to assess the morphological changes that microorganism colonization caused in the LDPE sheets by the end of the biodegradation process in the laboratory-scale bioreactor.

We analyzed 1 cm × 1 cm samples from one sheet of each replicate experiment, along with a blank. The blank was a pristine sheet that had not undergone any treatment. Before the analysis, we conditioned the LDPE samples with a gold coating to ensure that the surface was unform. This step is crucial for achieving satisfactory characterization.

This analysis was performed in a ZEISS EVO 10 instrument with a maximum sample height of 100 mm, a maximum sample diameter of 230 mm, and a path of the motorized stage in the XYZ axes of 80 mm × 100 mm × 35 mm [17]. The results of the analysis are displayed at a scale of 100.0 µm and 1000× magnification.

2.5.2. Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR analysis was performed in the laboratories of the ECCI University. We used a sample of undegraded material and two samples that underwent mineralization by the microorganism. Each sample was 4 cm × 4 cm. The following features were analyzed across the samples: carbonyl group occurring at 2850 cm^{-1}, torsional movement in the C−C bonds occurring at 1400 cm^{-1}, and the presence of four consecutive CH_2 carbons at 700 cm^{-1}. We measured the level of transmittance using a compact FTIR spectrometer (Bruker) [18].

3. Results and Discussion

3.1. Inoculum concentration

The reactors were inoculated with 200 ml of cell suspension in 1800 ml of medium (working volume). The amount of biomass of each inoculum was obtained by the dry wight technique [11]. The dry biomass inoculated for each replicate is shown in Table 1.

Table 1. Compilation of the initial inoculum concentrations across three bioreactor runs.

Replicates	Dry biomass (g)
Replicate 1	2.72
Replicate 2	2.49
Replicate 3	2.47
Mean	2.56
Standard deviation	0.14

We followed the same method to determine the final dry weight of the culture medium used in the biodegradation process in the bioreactor. The average total dry weight recovered for the three replicates was 5.64 ± 0.14 g of dry mass.

3.2. Biodegradation process in bioreactor

The prototype bioreactor containing 1800 mL of Sabouraud Dextrose liquid culture medium was sterilized at 121 °C, 15 psi for 35 minutes and inoculated with 0.18 gL^{-1} of dry mass suspended in 200 mL of culture. The inoculation process was performed in the laminar flow cabin at room temperature.

After 7 days of incubation at room temperature, we noticed a considerable production of *Aspergillus brasiliensis* pellets, which suggested that the fungus was using the nutrients present in the culture broth for its development. After this initial growth period, we added 10 previously weighed LDPE sheets to the bioreactor to start the biodegradation process. At this time, we recorded the initial temperature and pH.

Two weeks into the biodegradation process, we observed efficient microorganism growth, indicating that the fungus was efficiently using the culture medium as a carbon source. During the third and fourth weeks of the biodegradation process, the microorganism continued to develop satisfactorily in the medium. Over the weeks, the system gradually darkened, evidencing the pigmentation of the conidia in the mature biomass [19]. Furthermore, the LPDE sheets showed signs of enzymatic activity, suggesting that the fungus could use the material as a carbon source (**Figure 1**).

A typical biodegradation process starts with the microorganism colonizing the culture medium and producing enzymes that cause the material to break down into small fragments. These fragments enter the cells of the fungus where they are used as carbon and energy sources [20]. Therefore, we assessed the functional hydroxyl and carbonyl groups of the polymeric chain of LDPE to determine the extent of biodegradation.

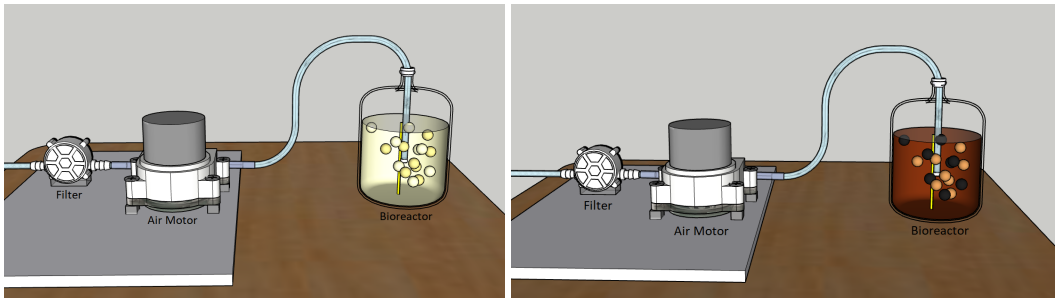

Figure 1. Assembly of the Bioreactor with Inoculum Addition 1) Beginning of Bioreactor Incubation (0 weeks); 2) End of bioreactor incubation (4 weeks).

One week into the process, we observed evidence of material colonization on the surface of the bioreactor. This suggested that the degradation of the polymeric chain was supporting fungal growth, leading to alterations in the material's physical and morphological properties, including weight reduction.

The biodegradation process led to the following physical changes in the LDPE sheets: biofilm formation, which occurs in the first phase of degradation, [21] and alterations in the roughness and shape of the material. The observed changes suggested colonization by *Aspergillus brasiliensis* (**Figure 2**). This confirmed that the pH, aeration, and temperature conditions were suitable for the growth of the microorganism during the biodegradation process. After the biodegradation process, the sheets were dried at room temperature before their final weighing.

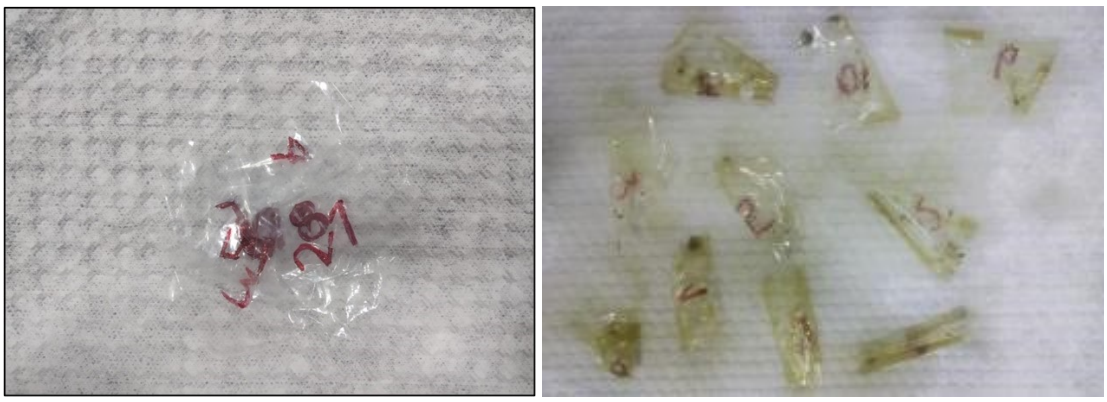

Figure 2. Low-density polyethylene sheets before and after the biodegradation process. 1) Before the biodegradation process; 2) After the biodegradation process

3.2.1. Temperature

Temperature is a crucial variable that can influence the extent of biodegradation within the bioreactor. We used a thermometer to monitor the temperature of the system every two days for 4 weeks. The temperature range was 18 to 20 °C for the second and third replicates (**Figure 3**). These temperatures differed from those of the location where the study was carried out. This indicates that the average temperature values for LDPE sheet biodegradation were conducive to microorganism growth [22].

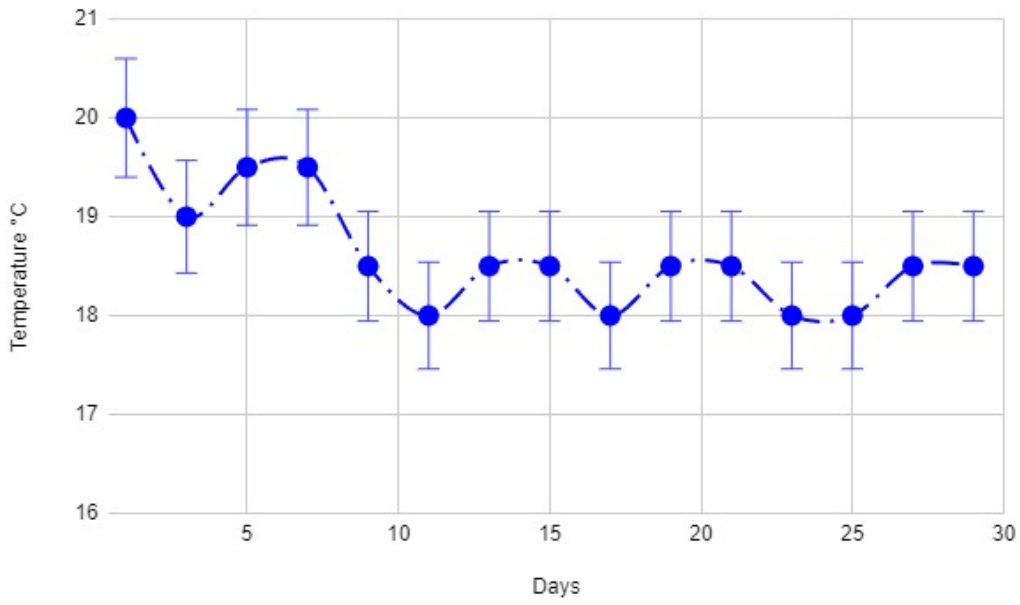

Figure 3. Average temperature during the biodegradation time in three replicates of a submerged liquid fermentation experiment.

3.2.2. pH

We monitored the pH of the system every two days and controlled it to ensure a range between 5 and 6. The initial pH was 5.40, 5.61, and 5.57 for each of the three replicates (**Figure 4**). This value increased every day due to the metabolic processes of the microorganism [11]. A pH of 5.60 has been reported as optimal for both the culture of *Aspergillus brasiliensis* and the colonization of the material because at this value, there is an increase in the activity of depolymerizing enzymes [22, 23].

3.3. Sugar determination

Throughout the biodegradation process, we monitored the sugar content of the system using a combination of qualitative and quantitative analyses. The depletion of dextrose in the culture medium was associated with fungal growth.

3.3.1. Qualitative analysis

We chose the Tollens and Fehling tests as the qualitative analyses to determine the presence or absence of reducing dextrose.

The results of the Tollens test indicated the presence of reducing sugars in the medium of the three replicates at the beginning of the experiment, as evidenced by the appearance of a silver mirror. However, by the end of the process (week 4), none of the samples exhibited the silver mirror, indicating that the microorganism had consumed the dextrose present in the culture medium. This dextrose depletion prompted the microorganism to use LPDE as a source of energy, initiating the biodegradation process.

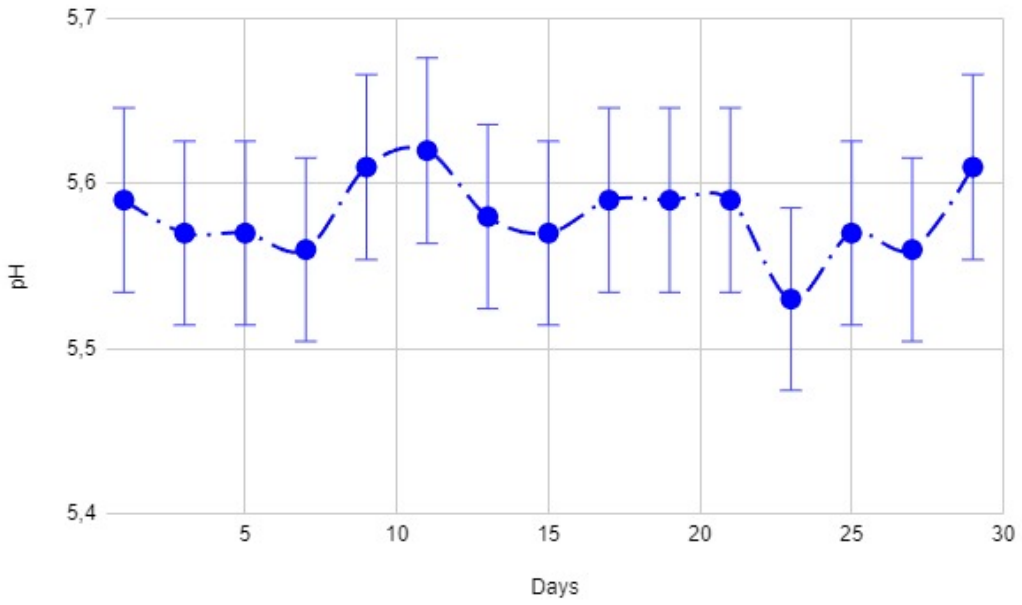

Figure 4. pH variation during the biodegradation process in three replicates of a submerged liquid fermentation experiment.

The results of the Fehling's test aligned with those of the Tollens test. Initially, the samples displayed a characteristic brick red color, indicating the presence of reducing sugars. However, by the end of the process, the samples exhibited a blue coloration, suggesting the absence of available sugars.

3.3.2. Quantitative analysis using the DNS technique

The quantitative analysis revealed that the dextrose concentration at the beginning of the process (week 1) was 13.37 gL^{-1}. By the end of the process (week 4), the dextrose concentration decreased to 0.02 gL^{-1} for replicate 1 and 0.01 gL^{-1} for replicates 2 and 3 (Table 2). These findings corroborate our observations during the qualitative tests and indicate that, once there was no sugar available in the culture medium, the microorganism used LDPE as an alternative carbon source. Thus, carrying out the degradation process.

Table 2. Dextrose concertation at the beginning (week 1) and at the end (week 4) of the biodegradation process across three replicates.

	Dextrose concentration (g/L)
T Initial process (week 1)	13.37
T Final bioreactor (Replicate 1)	1.49×10^{-2}
T Final bioreactor (Replicate 2)	1.18×10^{-2}
T Final bioreactor (Replicate 3)	8.83×10^{-3}

3.4. Biodegradation percentage

The degradation process mediated by fungi starts with the formation of a biofilm, which is a matrix of exopolysaccharides that promotes the adhesion of fungal hyphae to the material's surface. In a subsequent stage, the fungi secrete enzymes such as oxidases, peroxidases, and hydrolases, which break down the chemical structure of the polymer [30].

We assessed the degree of biodegradation by measuring the percentage of weight loss of each LDPE sheet after the experiment. We weighed the LDPE sheets at the beginning and end of the biodegradation process, and applied equation 2 to calculate the percentage of weight loss [11]. We compiled the results obtained after 30 days.

$$\% \text{ Biodegradation} = \frac{P_f - P_i}{P_i} \times 100. \tag{2}$$

The average biodegradation percentage of the three replicates was 1.89 ± 0.56 % (**Figure 5**), with some variations observed across the different sheets. This variability could be due to inadequate mixing within the bioreactor, which might hinder the homogeneous distribution of the substrate and thus affect the colonization by microorganisms. Nonetheless, these results demonstrate that the operating conditions (temperature, pH, and aeration) allowed the microorganism to use the LPDE sheets as a carbon source, thus supporting fungal growth and mineralizing the polymer. It is important to note that these findings represent an initial exploration of the complexities involved in the microbial degradation of synthetic materials.

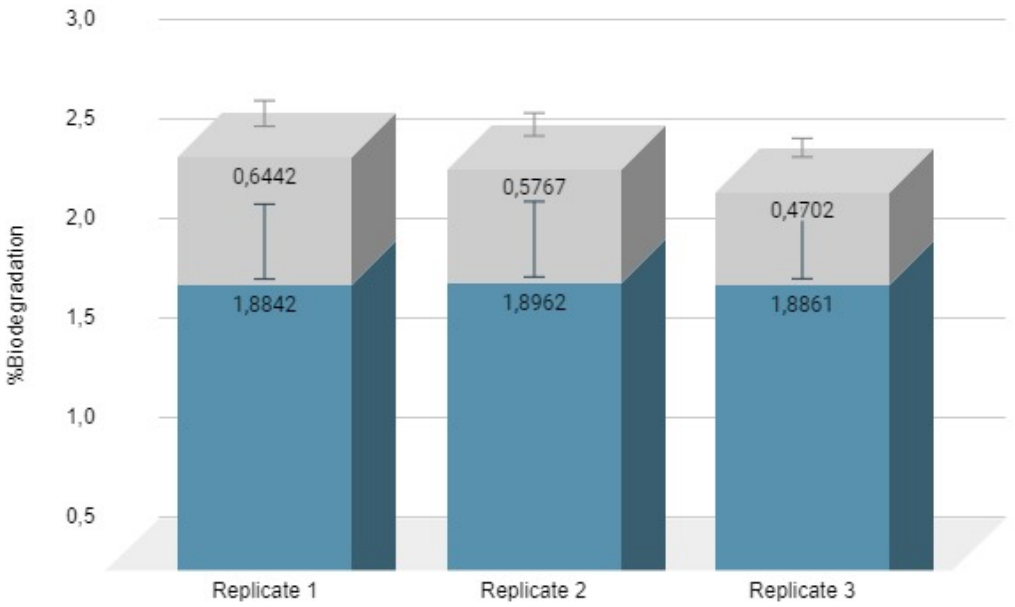

Figure 5. Average Biodegradation Percentage during Submerged Liquid Fermentation

We compared our results to those of Malachova K, et al., who reported biodegradation rates of 0.50 ± 0.40 % and 1.30 ± 0.40 % for untreated and UV-treated LDPE samples, respectively. In their study, LDPE samples were colonized by *Trichoderma humatum* in submerged liquid fermentation [20]. Calcetero L obtained biodegradation percentages of 1.53 % and 0.62 % in UV-treated and untreated LDPE sheets, respectively. These experiments involved colonization by *Aspergillus brasiliensis* in earthworm humus [4].

López & Morales-Fonseca obtained a biodegradation percentage of 3.60 % after 10 weeks of degradation mediated by *Aspergillus brasiliensis* in the soil [24]. The biodegradation process reported in our study showed comparable results to those of previous studies, even without UV light treatment. The average biodegradation percentage of 1.89 ± 0.56 % across the three replicates demonstrates a significant achievement compared to previous studies conducted by engineered processes.

3.5. Characterization of the material

To further evaluate the morphological changes of LDPE due to the biodegradation process, we performed scanning microscopy and atomic force microscopy analyses. These evaluations aimed to determine how fungal colonization affected the material's surface and confirm the feasibility of the process.

3.5.1. Scanning Electron Microscopy

The untreated LDPE samples (Material 1) exhibited a consistent pattern with no discernible variations in structure or texture. However, the samples subjected to liquid fermentation showed clear signs of the biodegradation process and fungal action. For instance, Material 2 displayed a rough and irregular texture, alongside porosity and rupture. Material 3 exhibited structural breaks within one of the pores, indicating visible changes in texture. Furthermore, Material 4 distinctly exhibited the structural breakdown of the polymer, evidenced by the presence of holes and cavities. This sample also evidenced biofilm formation on the material's surface, attributed to the presence and penetration of hyphae and conidia.

The results of the SEM analysis are presented at a scale of 100.0 µm and 1000× magnification. (**Figure 6**).

The results of the SEM analysis confirmed the microorganism's capacity to degrade the polymer, evidenced by the structural breakdown and physical alterations observed in the LDPE sheets. The formation of biofilm and the expression of enzyme complexes probably facilitated the breakdown of polymer bonds. Notably, these changes occurred without any previous treatment of the samples, solely through submerged liquid fermentation. during this process, the microorganisms were deprived of sufficient carbon sources in the culture medium and had to degrade the LDPE chains to ensure growth.

As previously mentioned, the formation of biofilm marks the initial stage of the biodegradation process. During this process, conidia and hyphae colonize the material and secrete extracellular components, consisting mainly of carbohydrates. These components form a matrix that supports the hyphae, which ultimately constitute the biofilm [25, 26].

In our study, biofilm formation was evidenced by the presence of homogeneous deposits and accumulations. The movement of the culture medium, the suitable operating conditions (aeration, temperature, and pH), and the availability of adequate carbon, nitrogen, and energy sources essential for proper growth likely favored the process [27, 28]. However, the adherence of hyphae to LDPE sheets and the consequent biofilm formation led to an increase in the final mass of the material. Therefore, we included a washing step to remove the biofilm, which caused a higher biodegradation percentage than that achieved solely through drying at room temperature [29, 30].

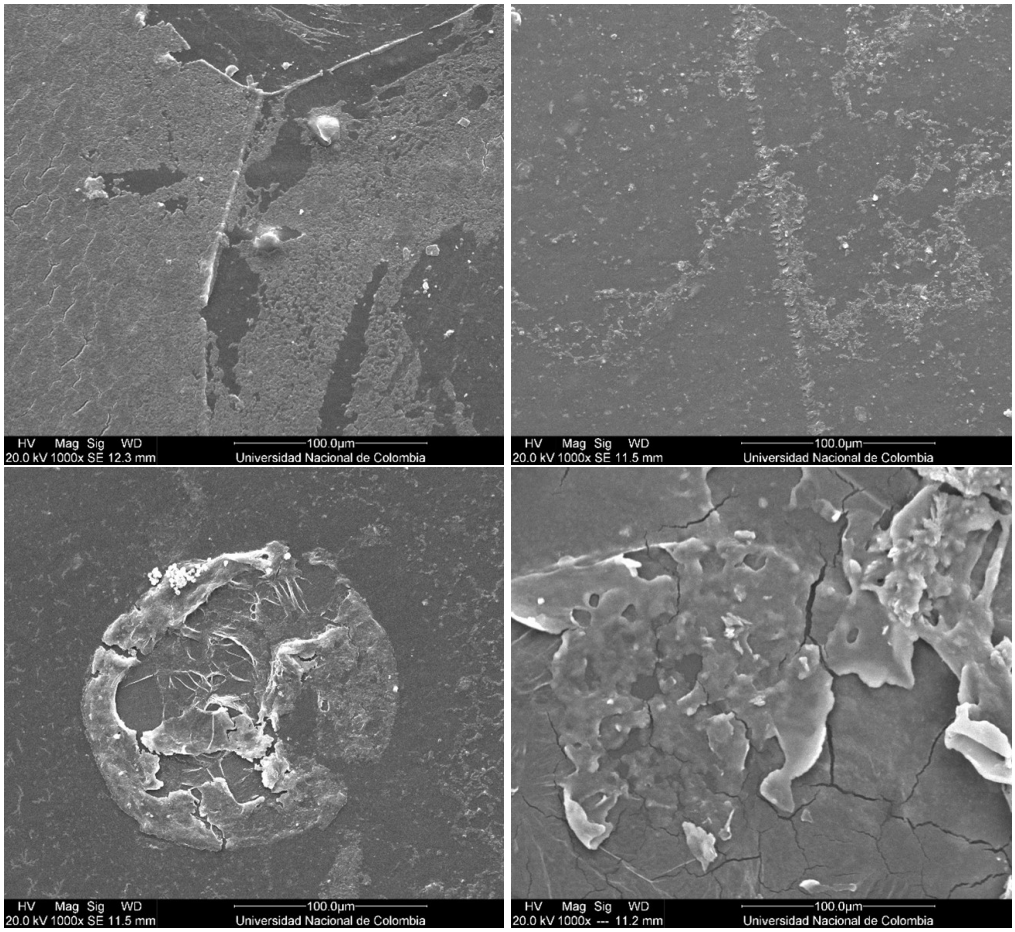

Figure 6. Results of the SEM analysis: Untreated LDPE (Material 1). Replicates of LDPE after submerged liquid fermentation (Materials 2, 3, 4). Scale: 100.0 µm and 1000× magnification.

3.5.2. Fourier Transform Infrared Spectroscopy

Samples 1, 2, and 3 presented a carbonyl band at 2850 cm^{-1}, which corresponds to the symmetric and asymmetric stretching vibrations of the C−H groups in all three samples. Additionally, we observed torsional movements in the C−C bonds at 1400 cm^{-1} and bending movements caused by the bonding of at least four consecutive carbons CH2 at 700 cm^{-1}. These findings confirm that the LDPE samples were appropriately treated for the study. The biodegradation of the material was evidenced by a reduction in the intensity of the carbonyl peak between 2400 and 2100 cm^{-1}, as well as around 500 cm^{-1} (black arrows) (**Figure 7**). This reduction is attributed to the enzymatic activity of microorganisms on the material [26, 31].

Comparing our results with those of previous studies, we found similarities in the spectra, which confirmed that the material analyzed was LDPE. This material was degraded by the microorganism, resulting in weight loss [33]. However, given the 30-day biodegradation period, there was no evidence of monomer breakdown in the material. We recommend extending the biodegradation period in future studies to demonstrate this breakdown through FTIR characterization.

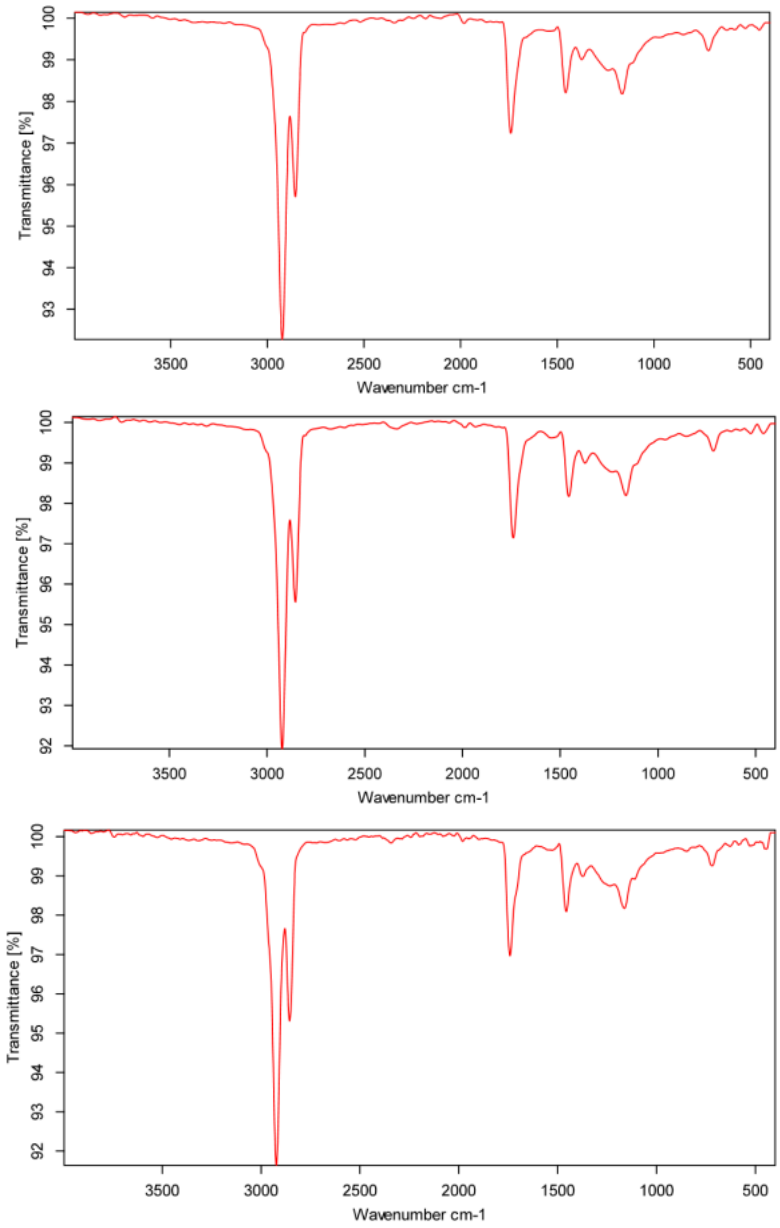

Figure 7. FTIR analysis results for sample 1 (untreated material), as well as samples 2 and 3 (material that underwent biodegrdation).

4. Conclusions

In this study, we presented a model for the biodegradation of LDPE sheets by *Aspergillus brasiliensis* under submerged liquid fermentation for one month. The quantitative and qualitative characterization evidenced that the depletion of the carbon source initially present in the culture medium stimulated the breakdown of the polymer to sustain viability and the formation of fungal biomass throughout the entire incubation period. Characterization analyses, such as SEM and FTIR, identified the presence of cracks and structural ruptures in the material, which were caused by the formation of biofilm and subsequent enzymatic degradation. This led to a weight loss of around 1.89 % in the sheets.

Overall, these results suggest that *Aspergillus brasiliensis* can adhere to LDPE sheets, colonize them, and metabolize the polymer as a carbon source under submerged liquid fermentation conditions. This study presents initial findings regarding the biodegradation process with this specific species under the mentioned conditions. Research like this contributes to our understanding of microbial degradation of plastic waste. This offers and alternative strategy to manage the disposal of these polymers, which are widely used as packaging materials around the world.

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6. Conflict of interest

The authors report no conflict of interest.

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Desarrollo de un modelo basado en un biorreactor para la biodegradación de polietileno de baja densidad (PEBD) por *Aspergillus brasiliensis*

Resumen: El polietileno de baja densidad (LDPE) es un polímero ampliamente utilizado debido a su resistencia química, alta flexibilidad y propiedades mecánicas. Sin embargo, su baja tasa de degradación, junto con su corta vida útil y acumulación generalizada, genera considerables problemas ambientales y de salud pública. En este estudio se presenta un modelo de biodegradación de LDPE en un biorreactor en suspensión, el cual podría servir como alternativa de tratamiento biológico antes de descartar el polímero. En nuestro modelo, un cultivo inicial de *Aspergillus brasiliensis* metabolizó el carbono presente en la estructura del polímero y lo utilizó como fuente de energía, lo que llevó a la biodegradación y mineralización del LPDE. El procedimiento se llevó a cabo en un prototipo de biorreactor a escala de laboratorio en condiciones aeróbicas y bajo fermentación líquida sumergida. Después de un mes de cultivo, se alcanzó un porcentaje de biodegradación de 1.89 ± 0.56 %. Los materiales tratados se analizaron mediante microscopía electrónica de barrido (SEM) y espectroscopía infrarroja por transformada de Fourier (FTIR). Encontramos evidencia de biodegradación, colonización del material y formación de biofilm. Esta investigación proporciona datos preliminares sobre la biodegradación del LDPE bajo fermentación líquida sumergida, marcando una fase inicial en el desarrollo de un prototipo para la biodegradación de polímeros.

Palabras Clave: *Aspergillus brasiliensis*; biodegradación; fermentación líquida sumergida; microscopía electrónica de barrido (SEM); polietileno de baja densidad (LDPE).

Desenvolvimento de um modelo baseado em biorreator para a biodegradação de polietileno de baixa densidade (PEBD) por *Aspergillus brasiliensis*

Resumo: O polietileno de baixa densidade (LDPE) é um polímero amplamente utilizado devido à sua resistência química, alta flexibilidade e propriedades mecânicas. No entanto, sua baixa taxa de degradação, assim como sua curta vida útil e acumulação generalizada, leva a consideráveis problemas ambientais e de saúde pública. Neste estudo, apresentamos um modelo de biodegradação do LPDE em um biorreator em suspensão, que poderia servir como uma alternativa de tratamento biológico antes do descarte do polímero. Em nosso modelo, uma cultura inicial de *Aspergillus brasiliensis* metabolizou o carbono presente na estrutura do polímero, utilizando-o como fonte de energia, levando à biodegradação e mineralização do LPDE. O procedimento foi realizado em um protótipo de biorreator em escala de laboratório em condições aeróbias e sob fermentação líquida submersa. Após um mês de cultivo, obteve-se uma percentagem de biodegradação de 1.89 ± 0.56 %. Os materiais tratados foram analisados por microscopia eletrônica de varredura (SEM) e espectroscopia no infravermelho com transformada de Fourier (FTIR). Observamos evidências de biodegradação, colonização do material e formação de biofilme. Esta pesquisa fornece dados preliminares sobre a biodegradação de LDPE sob fermentação líquida submersa, marcando uma fase inicial no desenvolvimento de um protótipo para biodegradação de polímeros.

Palavras-chave: *Aspergillus brasiliensis*; biodegradação; fermentação líquida submersa; microscopia eletrônica de varredura (SEM); polietileno de baixa densidade (LDPE).

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