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Biodegradation of PET (polyethylene terephthalate) by ligninolytic fungi

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Abstract

This article shows results of study on the biodegradation of PET used as substrate for the growth of ligninolytic fungi. The samples had dimensions of 4 cm², cut from bottles of carbonated soft drink virgin (before use in industry), were subjected to disinfection according to standard ASTM G22-76 (1990), subsequently inoculated into petri dishes with microorganisms fungi: *Pleurotus florida, Lentinula edodes* (Beck. Pegler) and *Ganoderma lucidum*. The determination of mass loss PET was based on method ASTM D5247-92 (1992), where the samples were weighed prior and subsequent of period of incubation, which was conducted in an incubator at 20°C for 120 days. Been realized still the analyzes of Differential Scanning Calorimetry (DSC) of samples of PET before and after the fungal degradation. According to the data obtained it was found that the fungi studied have potential for degradation of PET, because the masses of the samples were reduced.

Keywords: Biodegradation, ligninolytic fungi, Polyethylene terephthalate (PET).

1 INTRODUCTION

The plastic compose about 13.5% of the solid domestic waste in Brazil[1], because of their thermomechanical characteristics, is a widely used material. The polyethylene terephthalate (PET) is a thermoplastic with good mechanical strength, transparency and lightness, combined with its low cost of production, is very used in carbonated beverage industry[2]. After consumption, the generation of this waste is worrisome because, when discarded in nature without control can cause a range of social and environmental liabilities[3], such as pollution of water sources, loss of biodiversity caused by intake of these residues, as well as the proliferation of vectors diseases. In this context, it highlights the need to find alternatives for treatment and proper disposal of these wastes into the environment. Studies propose the use of microorganisms, such as bacteria and fungi in the treatment and bioremediation of contaminated areas[4], domestic and industrial effluents[5], waste from agribusinesses[6], and xenobiotic compounds.

It is known that fungi in nature can play a key role related to the mineralization of organic carbon and degradation of dead matter[7]. In this context, there are fungi of the genus *Pleurotus* that are known as causative agents of white rot of wood, because they have the ability to develop into waste containing cellulose, hemicellulose and lignin, exercising an important role in the carbon cycle[8]. *Ganoderma lucidum* has been studied mainly in Eastern countries, because of its numerous medicinal properties, and is capable of degrading complex lignolíticos components[9]. The Lentinula edodes (Beck. Pegler) popularly known as shiitake, an edible mushroom is one of the most consumed in the world, a basidiomycete, whose cultivation started in China, was introduced in Japan and has expanded to other countries, is found in nature as decomposer of dead trees or seeds, at seeds it acts as symbiont assisting in the germination process[10].

This study aim to analyze the results on the biodegradation of PET through its use as a substrate for the growth of three fungal strains, the *Pleurotus florida*, *Lentinula edodes* (Beck. Pegler) and *Ganoderma lucidum*, by determining the mass loss of PET according as methodology ASTM D5247-92 (1992). Also with the aid the analysis of differential scanning calorimetry (DSC) was determined the possible physical and chemical changes of the structure of PET.

2 MATERIALS AND METHODS

2.1 Samples of PET.

Samples were cut of virgin PET bottles, used in carbonated beverage industry, the square had 2 cm by 2 cm (4 cm²) and were sterilized according to ASTM G22-76 (1990).

2.2 Determination of the mass loss of the PET.

Determination of mass loss PET was based on the ASTM method D5247-92 (1992), where the samples were weighed previously and then treatment, posteriorly inoculated in Petri dishes containing potato dextrose agar (PDA) average with pH 5.68 ± 0.12 and the fungal strains studied. Subsequently were greenhouse incubated in (BOD) maintained 20 °C for a period of the 120 days, for further analysis. After the inoculation period, the PET samples were removed and cleaned according to the methodology ASTM D5247-92 (1992), were weighed again for comparison of results.

2.3 Differential Scanning Calorimetry (DSC).

The equipment used was the STA6000 PerkinElmer. For this study was used aluminum sample holder containing approximately 6.0 mg of sample, the first test was performed before the inoculation, and posteriorly more testing were performed after of inoculation properly cleaned samples (ASTM D5247-92 1992). The samples were subjected to a temperature variation of 50°C to 300°C with a heating rate (β) of 10°C min^{-1} and a nitrogen atmosphere with a flow of 20 mL/min^{-1}.

3 RESULTS AND DISCUSSION

Figure 1 shows the growth of fungal strains in interaction with PET, is observed a very distinct growth between strains.

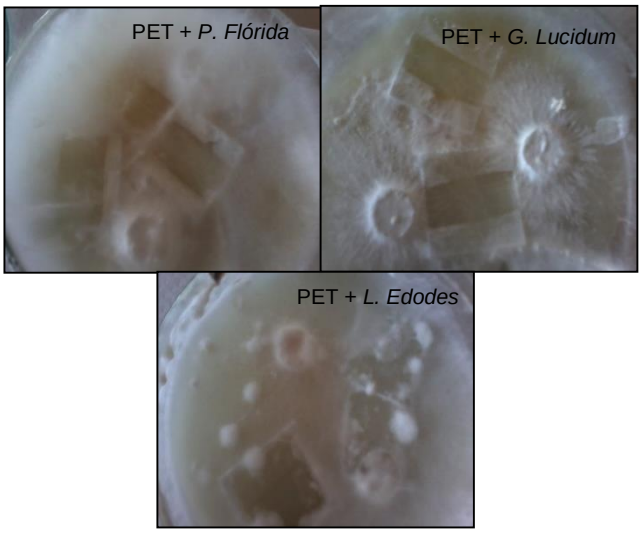

Figure 1. Trials with fungal strains in interaction with PET.

The calculation of the percentage of mass loss can be observed in Table 1.

Tabela 1. Determining the mass loss of PET in percentage (%).

Fungi + PET	Initial weight (g)	Final weight (g)	Mass loss (%)
Lentinus edodes	0,6705±0,004	0,6653±0,006	**0,7755**
Pleurotus Flórida	0,6708±0,003	0,6583±0,004	**1,8634**
Ganoderma Lucidum	0,6796±0,002	0,6749±0,005	**0,6915**

The results for the test corroborate those obtained by Silva[11], because the percentage of mass loss, is similar to those obtained by the authoress in testing solid state fermentation and submerged fermentation with the fungus *Pleurotus 001* and *Pleurotus Thailand* to 90 days the percentage of mass loss ranged from 0.36% to 1.8% loss of molar mass of PET bottle grade. Sousa[12], in study with Amazonian basidiomycetes was observed that in all PET samples there occurs decrease in mass after incubation with the fungal strains tested in different periods in stationary submerged fermentation.

According to DSC analysis were determined temperature and enthalpy of melting of PET samples studied, illustrated in Figure 2.

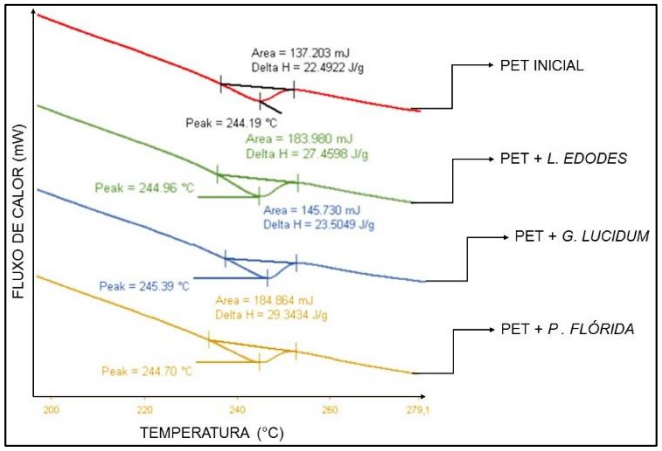

Figure 2. DSC samples of the initial PET and subsequent fungal degradation.

The value of the melting enthalpy of the PET 100% crystalline is approximately 120 $J.g^{-1}$ ([13]), the PET sample initial had a specific ΔHf 22 $J.g^{-1}$ it is considered that the studied sample of PET is approximately 18% crystalline. It further observed that after the use of PET as substrate for fungi, the *G. lucidum* has achieved a ΔHf of 23 $J.g^{-1}$, the *P. florida* has achieved a ΔHf of 29 J.g-*1* and the *L. edodes* has shown a ΔHf of 27 $J.g^{-1}$, these increases suggest a potential use of the amorphous part of the samples by the fungus, therefore, it is assumed that degradation left the samples of PET most crystalline.

4 CONCLUSIONS

Through this research it can be seen that the strains fungal lignocellulolytic used *Pleurotus florida*, *Lentinula edodes* (Beck. Pegler) and *Ganoderma lucidum*, showed affinity with the medium containing PET, a source of synthetic carbon. It is also considered very important the study of conditions optimal for of microorganisms growth coupled with combinations of different treatments that can help and even maximize this degradative process.

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