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Study the Ability of *Penicillium Roqueforti* in Degradation of Plastic Low-Density Polyethylene (LDPE)

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Abstract

In this study, the fungus *Penicillium roqueforte* was isolated from the soil and tested for its ability to decompose light polyethylene. Two methods were used. In the first method, polyethylene was mixed with PDA medium at concentrations of 20 mg/mL and 40 mg/mL. The results showed that polyethylene was not a fungus inhibitor, but rather stimulated its growth. The second method focused on the growth elements in mushrooms whose carbon source is contained in polyethylene. Thus, the carbon source in the agricultural medium, PDA, was replaced by a polyethylene material. The rate of inhibition of fungal growth was about 23%. After that, and then again, the modified medium was used to isolate the fungi from several places from the air inside the building where the laboratory is and outside the building as well, and many fungi were isolated from them. "*Aspergillus niger, Aspergillus spp, Penicillium spp.*Polyethylene was extracted from the Media in which the fungi under study were grown and fungi isolated from the air, for the purpose of its thorough study by using an X-ray analyzer to determine the extent of decomposition of polyethylene. The results of the analysis showed that the fungus was able to break the polyethylene chain material, and the samples were also examined with FTIR and the results showed the ability of the fungus to oxidize polyethylene and thus the results showed the ability of the fungus to rid the environment of polyethylene difficult to decompose.

Introduction

Polyethylene is one of problems that face our lives on earth; the biggest problem of urine ethylene is the decomposition period, which takes a long time in the environment, causing long-term pollution. Polyethylene is a heat-resistant polymer with a variable crystal structure with extensive applications, and it is one of the most productive plastics in the world (13), producing tens of millions of tons worldwide each year. As of 2017, more than 100 million tons of polyethylene resins are produced annually, representing 34% of the total plastic market (13). The chemical formula for polyethylene is C_2H_4 n. Polyethylene is a highly resistant and inactive substance (12). There are two types of polyethylene:

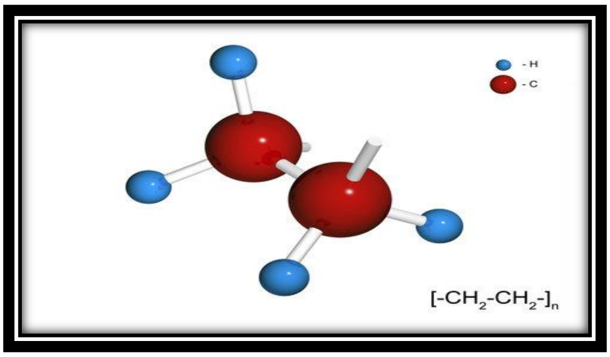

Figure 1: polyethylene

High density polyethylene (HDPE) -Low density polyethylene (LDPE)

Fungi are characterized by their production of vitally effective compounds, such as important medical drugs like antibiotics, penicillin, and syfalosporin (8) (10). Fungi are part of the ecosystem and interfere with microbiota, animals and plants in obtaining nutrients depending on the environmental conditions in the areas of their presence (5), In addition to the pharmacological importance of fungi in the production of Medicine (9). Fungi have enormous capabilities in industrial and vital journals that make them a goal to solve many problems, including environmental pollution problems (11) (7).

One of the capabilities of fungal is cellulose analysis by basidiomycetes that own a range of endoglucanase enzymes, cellobiohydrolase and β-glucosidase, (3). These are able to decompose synthetic compounds for example, POPs, polycyclic aromatic hydrocarbons, gasoline, toluene, ethyl benzene and zelin, pesticides, polyethylene and plastic. So far, fungi can also be the antidote to the problem of the amount of plastic residues that are out of control, with some types of mycelium producing enzymes that dismantle hydrogen and carbon bonds in plastics (6) (2). Fungi have the ability to interact with the environment in which they are found because they contain enzymes that break down the substances around them. The aim of the research is to demonstrate the ability of the fungus under study to analyze polyethylene and provide a solution to the environmental problem of plastic pollution in the environment

Experimental procedure

The medium (PDA) is prepared and sterilized in an autoclave for 15 minutes. Antibiotics and antifungals are added. (18), (5)

Polyethylene is added to the medium in two ways:

1. Polyethylene is added to the medium at two concentrations: 20 mg/ml and 40 mg/ml.
2. The source of carbon, sugar, is replaced with polyethylene.
3. Fungi are planted in the prepared medium.
4. The prepared medium is used to isolate fungi from the air inside and outside the laboratory.
5. The medium is incubated for a week at a temperature of 26°C.
6. The degradation of polyethylene is measured using a Podwe XRD X-ray machine, model 2700AB from HAOYUAN Co., China.

Measurement with FTIR device (11), (9)

Figure 2: X-ray machine, 2700AB HAOYUAN co., china (4)" The number "4" at the end of the phrase may indicate that this is the fourth X-ray machine produced by this company.

X-ray machines are medical devices that use ionizing radiation to produce images of the inside of the body. They are commonly used in hospitals and medical clinics for a variety of diagnostic purposes, including detecting broken bones, cancer, and other conditions.

Results and discussion

The fungi isolated from the soil were characterized by microscopic and phenotypic characteristics (1); (15)

Table 1: Effect of adding polyethylene in a fungus (penicillium roqueforti) under 26° temperatures and for a weekroqueforti) under 26° temperatures and for a week.

	The concentration g/mL	**colony diameter**	**Percentage of inhibition%**
1	20	3.35	20
2	40	3.9	40
3	control	3.0	

Table (1) showed that adding polyethylene to the center of PDA at a temperature of 25°C had no inhibitory effect on growth and in fact resulted in an increase in growth compared to the control treatment. Table (2) shows that using media containing polyethylene as the source of carbon resulted in an inhibitory rate of approximately 33% for the development of *penicillium roqueforti* fungi. Table (2) shows the effect of culture medium on fungi using polyethylene as a source of carbon.

Table 2:. The effect of polyethylene in fungus penicillium roqueforti as the only source of carbon in the media under 26° temperatures and for a week

		colony diameter	**Percentage of inhibition%**
1	**fungus growth**	2	33
2	**Control**	3	-

Table 3: Isolating air fungi using the media of polyethylene (LDPE) the only source of carbon under 26° temperatures and for a week

	Isolation place	**fungi**
1	Isolation the air fungus inside of The building	Aspergillus niger Aspergillus spp Penicillium spp

2	Isolation the air fungus outside the The building	Niger Aspergillus Aspergillus spp Fusarium spp

In table (3) isolating air fungi using the media of polyethylene (LDPE) the only source of carbon under 26° temperatures and for a week, the same fungal media containing polyethylene was used to isolate fungi from inside and outside a building, and the isolated fungi included *Aspergillus niger*, *Penicillium spp*, and *Fusarium spp*, both inside and outside the building**.** Figure(3) showing polyethylene decomposition around a fungus *penicillium roqueforti*.

The X-ray spectrum of this model is the most gentle among random materials, and it clearly exhibits the characteristic of a continuous spectrum with the absence or weakness of linear spectrum appearances in this model. The background of the spectrum is almost completely high, which means that weak linear spectra may have been drowned out by the background area.

Figure 3: Showing polyethylene decomposition around a fungus penicillium roqueforti.

The highest occurrence of the spectrum occurs at the angle value of (2φ = 25, 27) which are the sites of the phase (Kα), which is known to naturally occur. (As shown in the figures 4,5,6 and7). Another weak peak appears at the value (2φ=44) which is likely to be the phase (Ko). This phase appears as a potential phase in cases of high vulnerability due to external formation factors.

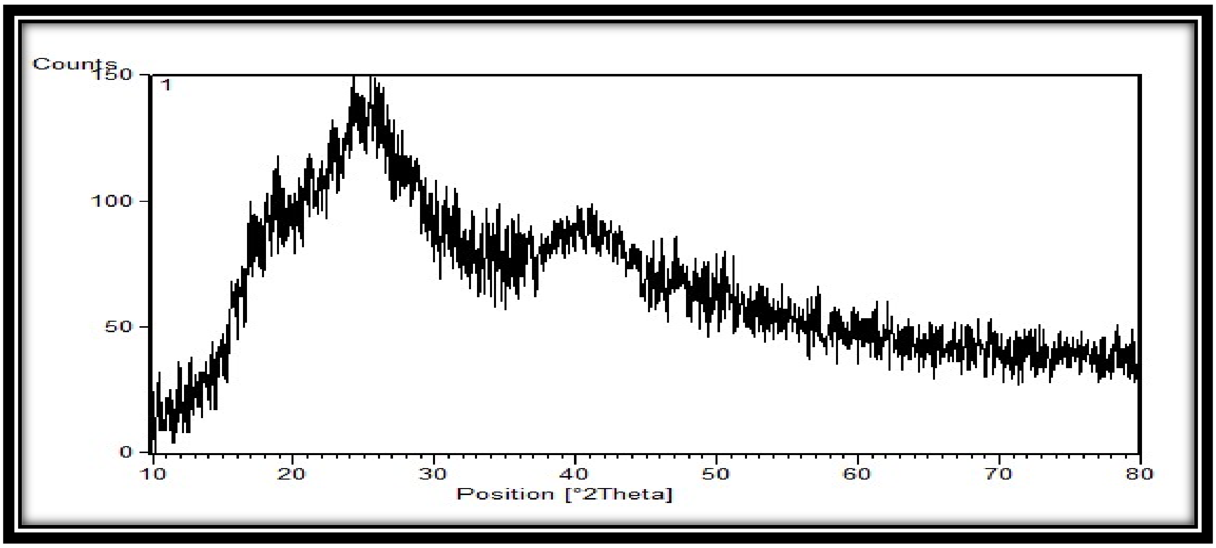

Figure 4: The X-ray of polyethylene (LDPE) (20) mg\ml.

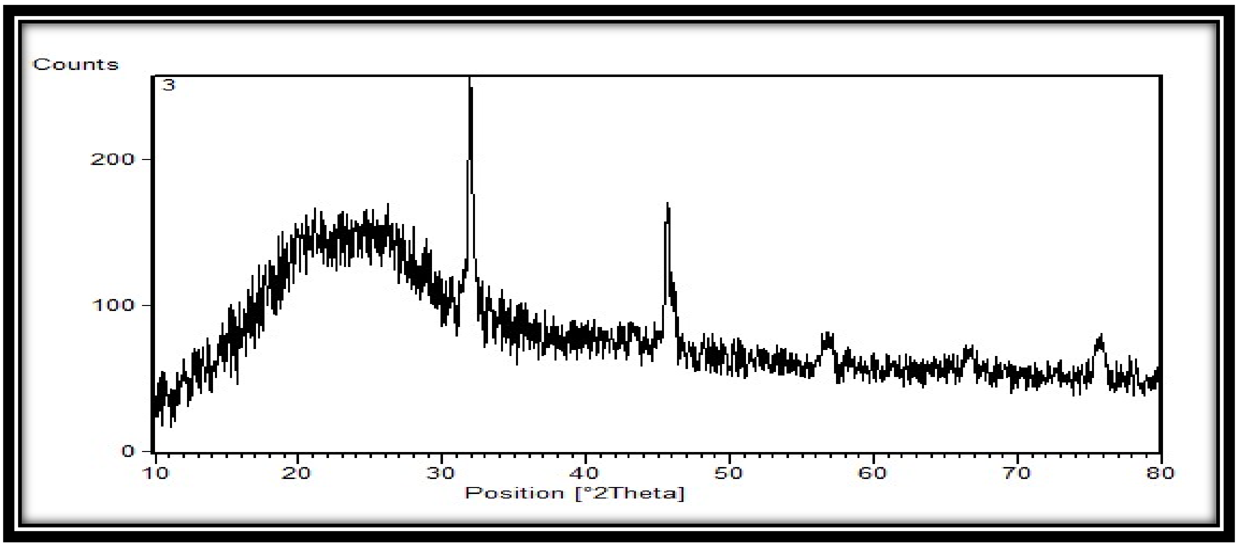

Figure 5: The X-ray of polyethylene (LDPE) (40) mg\ml

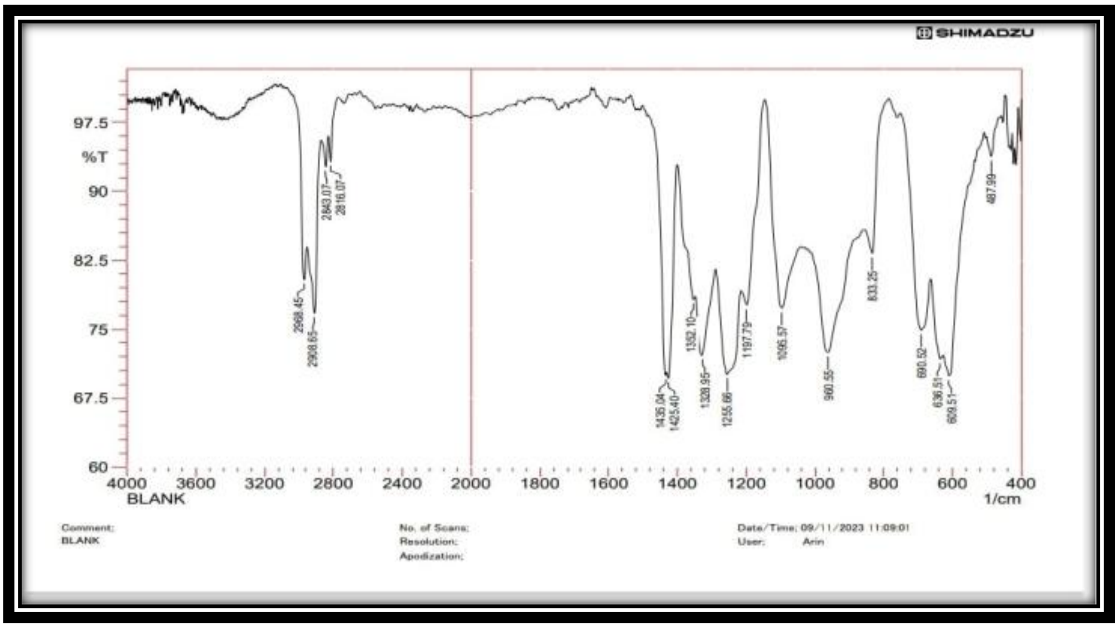

Figure 6: Measurement of polyethylene of the polyethylene control sample by device FTIR.

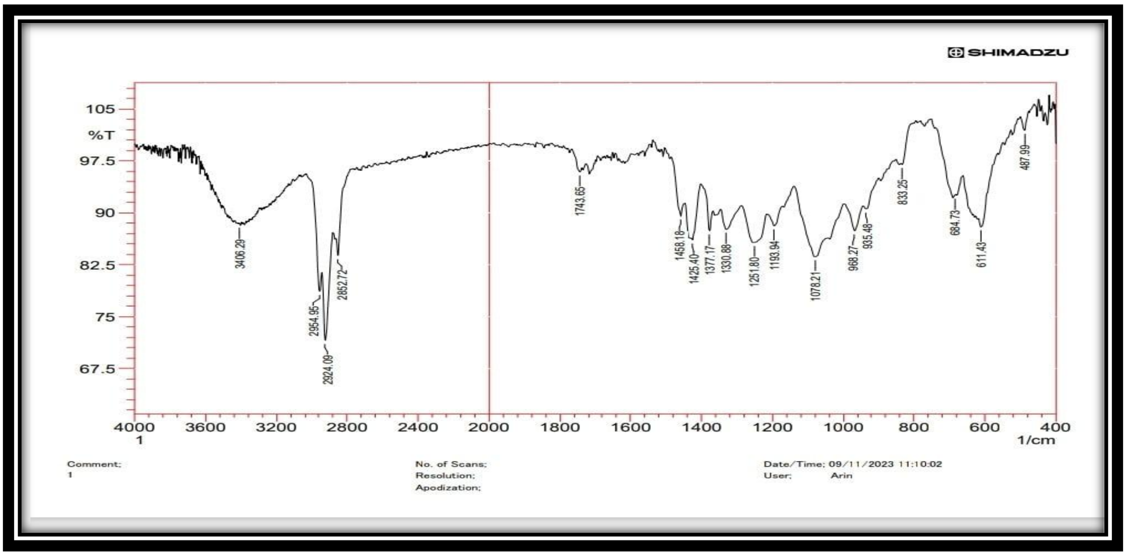

Figure 7: Measurement the effect of fungi of polye (Ghatge, S., et.al.,2020). Ethylene sample by device (concentration 20 mg/ml) FTIR.

A general decrease in spectrum intensity means a decrease or disappearance of secondary phases, and the model is based on the basic initial phase. There is no distinct interval in the spectrum, which indicates the complete randomness of the material and the absence of a crystallized axis in it.

The values of high intensity are within the range of (150), and the values of minimum severity are within (50), which means that the material has multi-axis properties. The mid-peak width is very large, which means that the quantitative sizes of the material are very large and may reach the limits of the micrometer. There is no sharp peak in the spectrum, which means very weak crystallization. This is consistent with the randomness of the substance. (2)

All notes mentioned in Form 1 appeared in Form 2, the additional notes are the appearance of a linear spectrum at the sites (2φ=34,48,56,77). This case indicates the uniqueness of certain components of random compositions which have disintegrated into crystallized compositions.

The value of crystallized structure atoms reaches the limit (300), which means that the crystallized material is highly concentrated within the concentrations of the entire material.

The analysis of x-rays showed the presence of fungi in polyethylene, while the comparison of x-ray spectral pre-treatment with mushrooms revealed the presence of highly crystallized linear spectra within the random spectrum indicating that random composition components were disintegrated and a highly crystallized substance was obtained. This was evident in the halo of decomposition around the fungus in the picture. From the various industrial and everyday uses of polyethylene such as the production of carrying bags, milk jugs, detergent cans, butter cans, garbage containers, and water pipes (Blackwell ,2011), it is likely that fungi, particularly those belonging to the genus Rhizopus, have adapted to obtain their food from organic matter found in soil or from the decay of plants or other substances. The most common varieties found in soil are those belonging to the genera *Aspergillus, Penicillium, Mucor, Fusarium, Trichoderma, and Cladosporium* (6);(16). That is why the *penicillium roqueforti* fungus was isolated from soil and tested for its effect on polyethylene analysis. To address one of the environmental problems caused by non-degradable plastics, one of the fungi isolated from soil was selected, namely *Penicillium* (12) (14).

The ends of the peak are very precise that they indicate very high crystallization. The mid-peak width is very low, which means a highly coordinated crystallized formulation. The appearance of linear areas in the spectrum indicates the disintegration of random composition into crystallized compositions of the composition components subjected to examination.

The results showed the ability of fungi to disassemble and analyze polyethylene, as described in the x-ray analysis. The ability of fungi to analyze by adding them to the implantation medium was first and foremost as a source of carbon in the same media. Fungi (*Aspergillus niger, Penicillium spp, Fusarium spp)* have been isolated from the air both inside and outside the building (17)

Fungi isolated from the air from inside the building and outside the building of the college demonstrate the ability of these fungi to analyze polyethylene (*19); (20.*); (11). Many strains belonging to the genus Penicillium are capable of degrading plastic, including P. *chrysogenum, P. oxalicum, P. simplicissimum,* isolated from soil, and *Penicillium spp,* isolated from seawater that have shown the possibility of polyethylene decomposition. Other different species belonging to the genus aspergillus are also potential plastic degradation factors, such as A. flavus, isolated from soil and the marine environment which has shown the possibility of polyethylene and plastic degradation (18) (17). The promising management of plastic waste recycling is a global problem due to its negative effects on life on Earth and has utilized various techniques, including infrared spectroscopy (FTIR). Polyethylene is a heat-resistant polymer with a variable crystal structure that has widespread applications and decomposition by fungi, which may indicate that this problem can be solved in the environment (4);(8).

Measurement of plastic samples with the concentration (LDPE) 40 mg/ml by FTIR device.

A measurement was added to the FTIR device to clarify the effect of fungus in polyethylene and through the forms of measurement show the ability of the fungus to oxidize polyethylene and this is very clear with the presence of new chemical bonds that belong to a group (C=0) and the hydroxyl group (OH). This package increases with increasing concentration of polyethylenes in the nutrient medium of the fungus with the lifespan of the fungus which takes seven days and the forms obtained show a significant change in the properties of polyethylene due to the process by which oxidation was done with the help of the fungus (13). The results of the device have confirmed the ability of the fungus under study to deal with the fungus by oxidizing polyethylene and this was clearly shown in the form of a number of control treatment in which the group (OH) and group (C=0) did not appear, while they were at concentrations of 20 and 40 mg / ml.

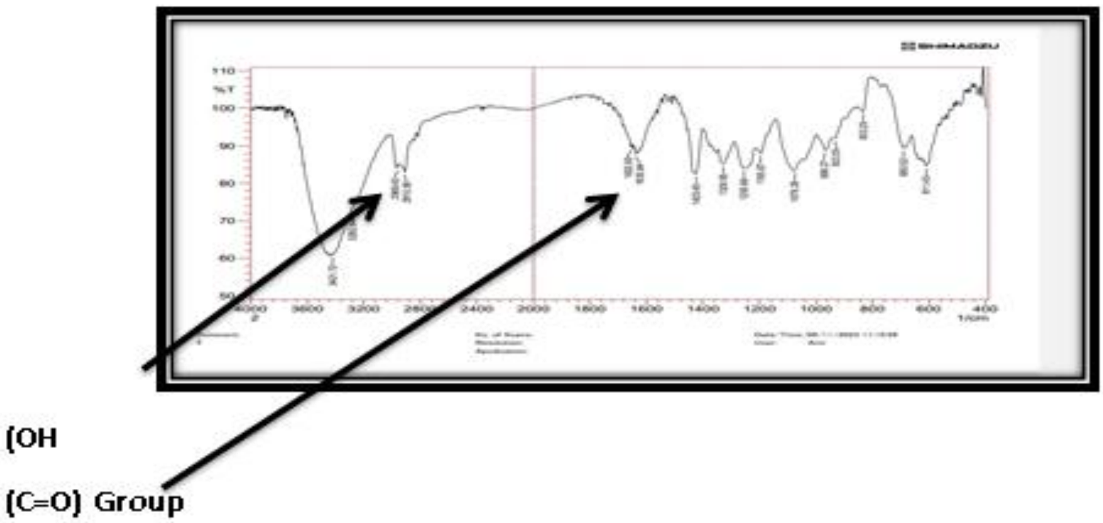

Figure 8: Measurement the effect of fungi of polyethylene sample by device (concentration 40 mg/ml) FTIR.

Conclusion

In conclusion, the results of this study suggest that the fungus *Penicillium roqueforti* has the ability to decompose light polyethylene. This was determined through two methods of testing. In the first method, the addition of polyethylene to PDA medium at concentrations of 20 mg/ml and 40 mg/ml did not inhibit the growth of the fungus, but rather stimulated it. In the second method, the carbon source in the PDA medium was replaced with polyethylene, which resulted in a growth inhibition rate of about 23%. X-ray analysis of polyethylene isolated from agricultural media that supported the growth of the fungus showed that the fungus was able to break down the polyethylene chain material. These findings have potential implications for the management of plastic waste and the development of biodegradable plastics. The samples were also examined with FTIR and the results showed the ability of the fungus to oxidize polyethylene.

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