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Studies on the Mechanical and Degradation behavior of Polyethylene by using Jujube Seed Grinding Powder (JGP)

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ABSTRACT

The Jujube seed grinding powder (JGP) were incorporated into polyethylene (PE) by weight 5-15 wt % subsequently processed to produce films of 55 micron thickness. The JGP mixed with PE was prepared to make the film by melt mixing at various percentage. The study on photo and biodegradability of polyethylene films were studied under the influence of UV. The studies on mechanical properties were analyzed for JGP-PE. The percentage of biodegradation of JGP-PE on the UV exposed film was monitored for specified hour using standard composting condition as per ASTMD 5338.

GRAPHICAL ABSTRACT

Jujube seed powder

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Introduction

Biodegradable polymers can be effectively reduced as non-toxic soluble oligomers and carbon dioxide by the action of various microorganisms in the environment through multiple metabolic pathways [1-3]. In addition to solving the environmental waste-problem, biodegradable polymers have also found application in other areas of life, from medical to industrial applications ching et al [4]. Alariqui and collaborators still thinks that protests to both photo-antioxidant decomposition and microbial attack have led to the emergence of polymeric materials in the industry [5-10]. Plastics, used as packaging materials, reach the soil directly through the debris and due to its chemical structure; they resist weather effects. In the wake of environmental protection factors, photo and biodegradable polymers become important. Disposal of plastics is a serious problem, usually plastics are thrown into landfills or discarded as landfills to decompose or disintegrate. *khabbaz et.al.* [11] said their opposition to the degeneration would be a major drawback. Physical forces, ie, heating / cooling, freezing / thawing, or wetting / drying can cause mechanical damage such as cracking of polymeric materials [12].

Soil microorganisms can initiate depolymerization of many natural polymers, such as starch, cellulose and hemicellulose [1315]. One of the simplest ways to replace an existing polymer is to accelerate the process of degradation already underway. Different approaches to photo-formation and their biodegradable polyolefins have been adopted, including copolymerization with ketone or CO groups, photo-initiating metal complexes, and bioactive components [16]. These physical forces degrade the polymer surfaces and create new surfaces to react with chemical and biochemical agents, an important phenomenon in the degradation of solid polymers. Highdensity and low-density polyethylene are the most commonly used synthetic plastics. They are slow in degradation in natural environments and cause serious environmental problems. In this regard, there is increasing interest in the biodegradability of synthetic polymers using effective microorganisms [17-21]. Biodegradable polymers have two origins: native and synthetic. Native biopolymers contain proteins, polysaccharides, nucleic acid, and lipids, where synthetic polymers are formed because of extensive research and development. The degradation of all polymers follows a sequence in which the polymer is first converted into its monomers, after which the monomers are mineralized. Most polymers are too large to pass through the cellular membrane, so they must first be depolymerized to small monomers before they are absorbed into the microbial cells. The initial breakdown of a polymer can result in a variety of physical, chemical, and biological forces [19-21]. They secrete a variety of enzymes in the soil water, and then these enzymes begin the breakdown of the polymers. On the other hand, even fabricated polymers such as polycaprolactone are easily biodegradable. Such polymers are usually degraded by microbial enzymes. Today the use of LDPE has become an indispensable ingredient of human life. The physical and chemical properties of plastics make them ideal products for a wide variety of products and applications. To improve the environmental degradation of polyethylene, various approaches such as copolymerization or blending with any of these factors are affected [22].

Made of low-density polyethylene carbon and hydrogen polymers, it is remarkably resistant to biological decomposition. LDPE is believed to be catalyzed by microorganisms in the chain ends. Due to its high molecular weight and hydrophobicity, this process is slow and can take hundreds of years. The main problem is the degree of hydrophobicity of the LDPE chains, which directly affects the rates of depolymerization caused by enzymes. Various combinations are used to improve its hydrophilicity. Environmental degradation of sunlight and oxygen can lead to loss of tensile strength and complexity without mass loss, while degradation of mechanical forces can reduce large pieces of plastic. Biodegradability includes a biological agent used as the substrate for the development of organic polymer, so that the product of complete biodegradation is microbiology in the aerobic environment [23-29]. To evaluate the presence of a low-density polyethylene (LDPE) prooxidant agent (Magnisum stearate or calcium streate) and it's mechanical and thermal behaviour after submission to the electron beam (EB) radiation processing [30]. Prooxidant additives represent a promising solution to environmental pollution problems with PE film debris. Prooxidants accelerate photo- and thermo-oxidation and consequently polymer chain cleavage [31]. Samples of PE and PP with 2% resuscitation prooxidant additives were subjected to variable weathering [32]. In the chemical modification, the HV content of PHBV can be adjusted by controlling the amount of propanioic acid during the biosynthesis process [33]. The synergistic effects of the oxidation and biodegradability of a commercial PE-LLD film (with antioxidant additives) are first exposed to sunlight (abiotic) conditions, followed by thermal aging (abiotic) mild, then microbial (biological) [32,33]. Degradation of starch composite and pro-oxidation added polyolefins for 150 days in three different environments. Changes in the different physicochemical properties of the polymer have been monitored to elucidate the degradation process [23, 30, 34, 35]. The various parameters affect the biodegradation of plastics such as Temperature, humidity of air and moisture in the polymer, pH and solar energy, inherent polymer properties [36]. The Research work is focused on the improvement of biodegradation of PE incorporation of the JGP. The additive loadings are up to 15 wt% for polyethylene (PE), the study has been photo degradation and solid compost behavior towards the biodegradation of the PE film. The JGP –PE is the novelty work, the research work no one carried out.

Material and method

The materials used for Jujube seed grinding powder, Jujube powder purchased from Chennai market (in Koyambedu) it act various functional group present in the seed. It acts as degradation behaviors on the sunlight. PE film grade purchased from Reliance Petrochemical Pvt Ltd. In Chennai branch. Jujube seed were prepared for grinding by using cryogenic grinder for Hosokowa alpin made in Germany.

Haake Poly Lab (Film Preparation)

PE were blended with JGP at various percentatage such as 5, 10 and 15% by using film extrusion polylab, Thermo Scientific, Germany. Mixing was carried out at a temperature range of 105-195°C for PE at a screw speed of 85-135 rpm. The film was prepared by using film die for all the three percentages of additives. The film thickness was maintained at 55 microns thickness by controlling the speed of the nip rollers and output rate.

UV light degradation

The PE with JGP were subjected to on UV Q Lab. Films of 25 mm width were used to evaluate the degradation phenomenon. PE- JGP were exposed to two different test cycles of UV, irradiation and condensation as presented in the table 1

Table 1. UV light degradation test

Test Method	ASTM D 5208
Exposure Range	313 nm UV –B
Film Dimensions	50 micron thickness, 27.5cm X 2.5cm
Duration of Exposure	144 hrs as per standard

Mechanical properties (Tensile Strength ASTM D 882)

Tensile properties of PE-JGP have been evaluated on UV exposure as per ASTM D 882. The specimen dimension of 150x 25 x 0.050 mm universal testing machine using LLOYD instrument ltd, UK. The tests were carried out at a cross level head speed of 500mm/min and gauge length of 50mm. The test was carried out both machine and Transverse direction.

Compost Biodegradation

ASTMD 5338 test method to determine under laboratory conditions, the aerobic biodegradation of plastics materials exposed to a controlled composting environment. The ASTMD 5338 standard strictly were maintained the various parameters such as temperature, pH, nutrient level, humidity all the condition has been followed for the JGP–PE samples [36]. The rate of degradation is monitored as well.

Result Discussion

The tensile strength, Elongation at break of PE films having JGP is presented in Table 2. The incorporation of JGP up to 15 wt%, slight increase the tensile strength due to the JGP with PE. After the UV exposure for 68 hrs there is no much change in the mechanical properties. However, the exposure to UV radiation for 130 hrs there was a significant reduction in mechanical properties due to the photo light degradation of PE in the presence of JGP additives.

Table 2. The mechanical properties of JGP-PE

S.NO	Sample Details	Tensile strength (Kg/cm^2)		Elongation (%)	
		MD	TD	MD	TD
1	PE	24.00	19.00	222.00	360.00
2	PE for 218 Quv	21.00	19.00	201.00	303.00
3	5% **JGP-PE**	25.00	20.00	225.00	364.00
4	10% **JGP-PE**	26.00	21.00	227.00	365.00
5	15% **JGP** -PE	27.00	21.10	230.00	368.00
6	5% **JGP -PE** on UV	18.00	15.00	21.50	40.00
7	10% **JGP-PE** on UV	16.00	13.85	17.90	29.20
8	15% **JGP-PE** on UV	13.0	14.00	5.00	23.22

The biodegradation test (ASTM D 5338)

The JGP additives was studied in this research work act as photodegradable as well as biodegradable agents.

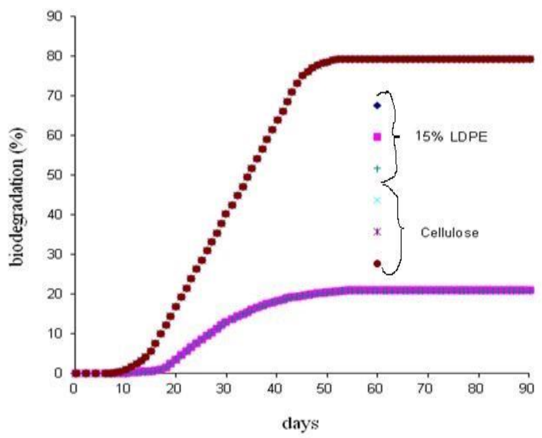

Fig.1 The percentage of biodegradation JGP-PE

The biodegradation results show that the biodegradation of the photo degraded film of PE with Jujube seed grinding powder film fragments (under accelerated UV for the specified hours) occurs progressively and up to 20% at the end of 90 days when extrapolated to 100% for the cellulose.

The films with higher photo degradation i.e., which contain higher amount of additive show higher percentage of biodegradation. As per ASTMD 5338, the percentage of Biodegradation is 20% as shown in **Fig. 1**

Conclusion

In this study, we have used 15% JGP additive enough as a good photodegradable additive, the 15% additive the photodegraded film that makes PE more susceptible to microbial attack. The photo-degraded product when subject to ASTMD 5338 standard compost condition at 58^{0}C, the behavior has results at 20% in 90 days.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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