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Improving Degradation of Polyethylene /Acrylic Dextrose with Ground Nut Powder

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ABSTRACT

The novel bio-based additives in the present research were incorporated into LDPE, LDPE in about 5 wt% subsequently processed to produce films of 50μ thickness. The bio-based additive such as acrylic dextrose (2.5%) /ground nut surface powder (2.5 %) (ADGN) additives were successfully mixed and their performance on the photo and biodegradability of polyethylene films were studied under the influence of accelerated UV/sunlight. The percentage of biodegradation of the photodegraded film was analyzed by ASTMD 5338-98. The photodegraded film was subjected to biodegradation in the presence of Bacillus licheniformis isolated from a dump. The percentage of biodegradation is 32%.

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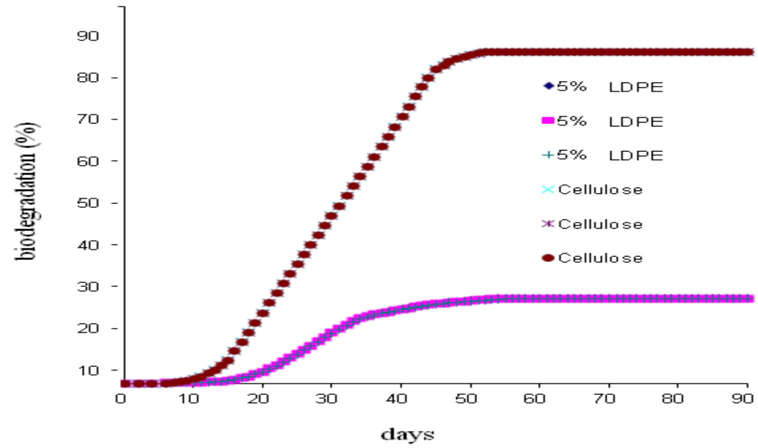
Graphical Abstract



Introduction

Plastics waste management remains a major environmental issue due to over population and rapid economic development. The complete degradation of plastics mainly polyethylene remains a challenge and the current work is focused on enhancing the biodegradation of polyethylene. The photodegradation followed by biodegradation of PE could be enhanced by the use of bio-based additives [1–7].

The photodegradation of a polymer and the effect of iron and calcium stearate was evaluated using different techninique. The growing use of plastics in agriculture has enabled farmers to increase their crop production. One major drawback of most polymers used in agriculture is the problem with their disposal, following their useful lifr-time [8–11]. Non degradable polymer, being resistive to degradation (depending on the polymer, additive, conditions etc) tend to accumulate as plastics waste, n of n of the soil and polluticreating serious problem of plastic waste management [12–17]. In case such as plastic waste ends up in landfills or it is buried soil, question are raised about their possible effect on the environment, whether the biodegrade at all and if they do, what is the rate biodegradation and what effect the product of biodegradation have on the environment, including the effect of the additive used. Possible degradation of agricultural plastic waste should not result in contamination of the soil and pollution of the environment [18–21].

In this research work low cost material additive incorporated in the polymer to produce to improve the degradation of polymer as per standradard.

Experimental

Material and methods

General purpose film grade LDPE has been used to prepare films. Acrylic dextrose and ground nut surface powder were used. One Mole of acrylic acid with one mole of dextrose in the presence of concentrated hydrochloric acid as a catalyst to produce acrylic dextrose was synthesized.

Blending and film preparation of LDPE

The acrylic dextrose/Ground nut was melt blended with LDPE at three different formulations 1, 3 & 5% respectively in (Haake, Rheomex OS, PTW16, Thermo scientific, Germany) Modular Torque Rheometer. The Modular Torque Rheometer blending was carried out at temperature range of 100-190 °C (from die to hopper) & a screw speed of 100 rpm. Subsequently, the pellets are dried in a dehumidifier at 70 °C for two hours to remove moisture. The pellets produced were subsequently dried & subjected to film cast process to produce films of 50 µ thicknesses.

Photodegradation

All blended samples were subjected to photodegradation studies using QUV UV Weather-o-meter.

Titration method of CO_2 determined test (ASTM D 5338)

The details of the biodegradation experiment are summarized below.

Sample detail

Before and after brittle fragmented photo-degraded LDPE-ADGN additives.

Conditions of reaction mixtures

Origin of compost: Municipal and vegetable waste; Reaction temperature: 58 °C; Dry solid (%): 52%; Volatile solid (%): 20; Air flow rate: 100 mL/min; Test duration (day): 90 days; pH: 7.4; Reference material: Cellulose; Volume of reaction vessel: 3000 mL. The preparation and ageing of the compost for biodegradation of film samples was carried out as per the standard. The pH value for all the samples, control and blank was maintained. Barium Hydroxide solution (0.024 N) was prepared by dissolving 4 g of anhydrous barium hydroxide in 1000 mL of distilled water. The solution was filtered and the normality was determined by titrating against standard acid solution and stored in a sealed container as a clear solution to prevent absorption of CO_2 from air. About 5-20 L of 0.024 N barium hydroxide solutions was prepared at a time for running a series of tests. However, care was taken that a film of $BaCO_3$ does not form on the surface of the solution in the glass vessels, which would inhibit CO_2 diffusion into the absorbing medium.

Procedure

The composting vessels were incubated in diffuse light minimum for a period of 90 days & the temperature of the system was maintained at 58±2 °C. The CO_2 and O_2 concentrations were checked in the outgoing air daily with a minimum time interval of 6 hrs after the first week. The air flow was adjusted to maintain a CO_2 concentration of at least 2% volume to allow accurate determination of CO_2 level in the exhaust air. Composting vessels were shaken weekly to prevent extensive channeling which could provide uniform attack of microbes on test specimen and provide an even distribution of moisture. The incubation time was fixed for 90 days.

Carbon dioxide analysis

The carbon dioxide (CO_2) produced in each vessel reacted with $Ba(OH)_2$ and was precipitated as barium carbonate ($BaCO_3$). The amount of carbon dioxide produced was determined by titrating the remaining barium hydroxide with 0.05 N hydrochloric acid to a phenolphthalein end point. Because of the static incubation, the barium carbonate built up on the surface of the liquid was broken up periodically by shaking the vessel gently to ensure continued absorption of the evolved carbon dioxide. The hydroxide traps were removed and titrated before their capacity exceed. At the time of removal of the traps, the vessel was weighed to monitor moisture loss from the soil and allowed to sit open so that the air was refreshed before replacing fresh barium hydroxide and releasing the vessel. The carbon dioxide evolution rate reaches a plateau when all of the accessible carbon is oxidized. The test was terminated at this point. At the conclusion of the test, the pH and moisture and ash content of the soil is measured and recorded.

Results and discussion

Biodegradation of the LDPE with ADGN additives

As shown in Figure 1 conditions of reaction mixtures: Organ of compost; livestock excrement, Municipal and Vegetable waste used the method used for the determination of the biodegradability of the polyethylene was based on the International Standard (*ASTM D 5338-98*) that measures the evolved CO_2 amount from both the blank vessel without a sample and the sample vessel including a 10 g LDPE with ADGN samples. According ASTM D 5338 test procedure. Fragments occur progressively in the biodegradation of the photodegradaded films. Moreover, the biodegradation test results reveals that the LDPE-ADGN additives shows 30% of biodegradation on photodegradaded LDPE films when observed at the end of 90 days due to the saturated after 60 days of biodegradation.

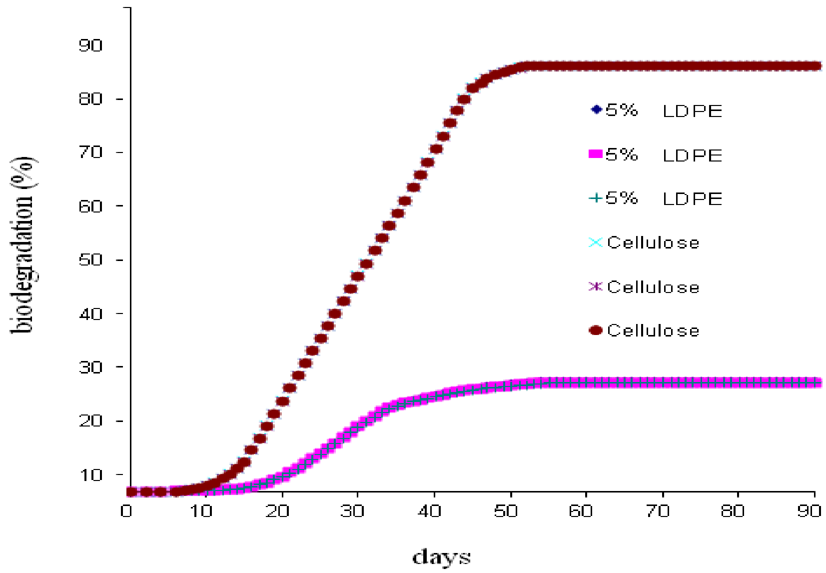


Figure 1. The percentage of biodegradation of LDPE with 5% ADGN additives as per ASTM D 5338

Glycogenisis process in Cytosol for Degradation of LDPE

The unsaturated dextrose additives of LDPE after the biotic exposure and the biotic exposure of the photo degraded film up to the level of 90 days in standard solid compost treatment. The unsaturated dextrose (Acrylic dextrose) additives metabolism is the glycolytic or Embden-Meyerhof-pathway and the second is the Krebs cycle (Also called the citric acid or tricarboxylic acid cycle) and third is the series of membrane-bound electron transport oxidations coupled to oxidative phosphorylation. Respiration takes place when the unsaturated dextrose is oxidized shorter ageing and completely to CO_2 and H_2O. In aerobic respiration, molecular O_2 serves as the terminal acceptor of Electrons. The fragmentation of the LDPE molecules is very much visible where in complete utilization of the additive as energy source for the growth of the microorganism is evident.

Conclusion

LDPE with ADGN additive shows improvement in photo degradation rates. After the photo degradation subjected to biodegradation, the percentage of biodegradation was 30% up to the level of 90 days as per ASTM D 5338. The result after the level of 60 days the percentage of biodegradation is saturated.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

[1] C. Abrusci, *Int. Biodeterior. Biodegr*, 2011, **65**:451

[2] Bevington, JC, *J. Eur Polym*., 1998, **34**:539

[3] B. Magagula, Poly. Deg. Stab., 2009, **94**:947

[4] M. Dauria, R. Racioppi, *J. Photochem. Photobiol.*, 1998, **112**:145

[5] E. Eltayeb. *Iranian Polym. J.*, 2009, **18**:753

[6] G.D. Flavia, *Polymeros: Ciencia Technologia*, 2009, **19**:313

[7] J. V. Gulmine. *Poly. Deg. Stab*., 2003, **385**:97

[8] I. Jakubowicz. *Poly. Deg. Stab*., 2003, **80**:39

[9] F. Khabbaz, A.C. Albersson, S. Karlson. *Poly. Deg. Stab*., 1999, **63**:127

[10] L.K. Jie, A.K.L. Cheng. *Natural Prod. Lett.*, 1993, **3**:65

[11] M. Koutny. *Poly. Deg. Stab*., 2006, **64**:1243

[12] N.B. Vogt. *Poly. Deg. Stab*., 2009, **94**:659

[13] Q. Yan. *Chinese J. Polym. Sci.*, 2007, **25**:341

[14] F.S. Qureshi, *J polym. Eng*., 1990, **9**:67

[15] R. Bagheri. *Radiat. Phys. Chem*., 2009, **78**:765

[16] P.K. Roy, *Poly. Deg. Stab*., 2007, **92**:1151

[17] T. Ojeda. *Poly. Deg. Stab*., 2011, **96**:703

[18] T. Ojeda, *Poly. Deg. Stab.,* 2009, **94**:2128

[19] T. Muthukumar, *Poly. Deg. Stab.,* 2010, **95**:1988

[20] T. Yamashita. *Poly. Degrad. Stability*., 1998, **118**:165

[21] A.U. Santhoskumar, K. Palanivelu. *Int. J. Polym. Mater. PO.*, 2012, **61**:793

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